Habitat Mapping for Red Grouse Management on Ballydangan Bog, County Roscommon

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This research was carried out in the Department of Geography at the National University of Ireland, Galway. All views expressed are those of the authors.

The findings of this research are based upon the authors' interpretations of the material collected and data from field surveys. All attempts have been made to ensure the accuracy of both the results and the interpretation. However, other interpretations may be possible from this information. It is the responsibility of the reader to draw their own conclusions from the data and from this report.

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Summary

In 2009, Moore Gun Club initiated a red grouse (*Lagopus lagopus hibernicus*) conservation and habitat management project to identify and implement community-based conservation strategies to improve the ecological conditions for red grouse on Ballydangan Bog, County Roscommon.

In an attempt to support management efforts, this study uses geographic information system (GIS) software as a mapping tool to create landscape-scale maps of the heather habitat found within the Ballydangan Bog project site. It is envisaged that the habitat mapping study will provide Moore Gun Club and Roscommon Regional Game Council with guidance in order to:

a) Determine the suitability of specific areas as potential red grouse habitat
b) Prioritise areas in need of habitat management
c) Evaluate areas that may impact management efforts

Some of the mapping variables include categorising the age, height and cover of the heather habitat. Since the maps are GIS-based, they can easily be shared, updated and overlaid with other landscape/ecological features such as management locations and bird counts.

Monitoring, evaluation and active dissemination of the results and/or lessons learnt will remain integral parts of the mapping study and its aftermath.

Contents

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1. Introduction

In 2009, Moore Gun Club initiated a red grouse (*Lagopus lagopus hibernicus*) conservation and habitat management project to identify and implement community-based conservation strategies to improve the ecological conditions for red grouse on Ballydangan Bog, County Roscommon. The plan establishes a process to achieve red grouse management objectives and provides a framework that sets out concrete conservation efforts for the long-term conservation of red grouse through various management strategies. Some objectives include maintaining the distribution and diversity of heather quality, increased predator control, along with territory management as well as increased awareness and education (see Scallan, 2009).

In an attempt to improve the overall management plan and conservation objectives, this study sets out to characterise the heather habitat on Ballydangan Bog.

Aims of the Study

More specifically, this study aims to:

- Classify and map the distribution of heather in terms of age, height and cover
- Prioritise areas in need of habitat management
- Catalogue red grouse droppings
- Use geographic information system (GIS) software as a mapping tool to produce landscape-scale habitat maps of the project site.

The report is divided into four main parts. First, it describes the habitat requirements and management issues relating to red grouse in Ireland. In this context, it considers a number of studies which look at red grouse diet, habitat utilisation, breeding and management. Second, the report describes the geological and ecological conditions of the Ballydangan Bog project site. Third, it discusses the sampling method used in the study which is followed by the results section. Here, the report illustrates the results of the fieldwork using GIS landscape-scale maps of the project site. Finally, the report concludes with a recommendations section.

2. Literature Review

In order to set the results of this study in their wider management perspective, it is important to understand the habitat requirements and management issues relating to red grouse in Ireland. In this context, the following section looks at research examining red grouse diet, habitat utilisation, breeding and management. It is hoped that this background information can guide the management decisions which emerge from the study.

Habitat Management for Red Grouse

Heather-dominated moorland in Ireland is of national and international importance for nature conservation. Six European heath and mire plant communities are virtually confined to Britain and Ireland and seventy others are better developed here than elsewhere (Tharme *et al*., 2001).

Ling heather (*Calluna vulgaris*) is crucial in the life cycle of red grouse. A diversity of different aged heather stands is required. Red grouse require tall heather for nesting and shelter as well as young heather shoots, flowers and seeds for food. Berries such as bilberry and some insects are also eaten.

In order to maintain a large number of grouse, a moor must be carefully managed; this may involve the application of fertilisers, drainage where there is excessive water logging, and above all rotational burning/cutting of heather to ensure a continuous succession of young heather shoots which is more nutritious as food. The balance between burnt/cut and unburnt/uncut ground is critical, since old, deep heather is needed for shelter and nesting (Sharrock, 1976).

Grouse moor management typically consists of burning/cutting heather in rotation, so that the moor becomes a diverse patchwork of different-aged heather (Lack, 1986). The traditional way of managing heather moorland is to burn the vegetation periodically in small patches (Savory, 1978). This alters the structure of the heather and the young heather which regenerates after burning/cutting is more nutritious than old heather (Thomas, 1956). The value of burning for maintaining high grouse stocks has been confirmed by survey (Picozzi, 1968) and by experiment (Miller *et al*., 1970). In addition, heather is more nutritious when it grows above rich base rocks such as limestone or epidiorite.

It has been suggested by Tharme *et al*. (2001) that heather management for grouse contributes to biodiversity conservation in several ways. For example, in Scotland, Hudson (1992) found a correlation between golden plover (*Pluvialis apricaria*) abundance and both grouse bags and gamekeeper density. Haworth and Thompson (1990) found that golden plover, curlew (*Numenius arquata),* and redshank (*Tringa tetanus*) were more frequent in upland areas managed by gamekeepers. Similarly, Tharme *et al*. (2001) found that densities of breeding golden plover and lapwing were five times higher and those of red grouse and curlew twice as high on grouse moors as on other moors. The conservation benefits of grouse management come from the combined effects of heather management and predator control (see Scallan, 2008).

Characteristics of Heather Utilisation by Red Grouse

As previously discussed, heather usually dominates the vegetation on moors occupied by red grouse and it provides the birds with shelter, cover and food. A number of studies in Scotland have shown that red grouse are highly selective feeders with heather comprising between 60-100% of the birds' diet, depending on the season (Jenkins *et al*., 1963). According to Eastman (1964) heather provides 95% of the birds' food in September-March, falling to a minimum of 50% in May-June.

The only research conducted into red grouse diet in Ireland was undertaken by Lance and Mahon (1975) in Glenamoy, County Mayo. This research analysed fecal remains from red grouse in Glenamoy and compared the results with similar analysis for moorland in north-east Scotland. Their results suggested that the percentage of heather in Irish grouse remained high throughout the year and did not vary significantly among areas of bog which differed in percentage cover of heather. The mean amount of heather (98%) in feces was very similar to the mean intake of heather (96%) which Eastman and Jenkins (1970) estimated for a Scottish moor where food plants other than heather were scarce. In addition, grouse chicks on Glenamoy were taking an essentially adult diet at one month of age.

Research by Savory (1978) in north-east Scotland on Spyhill moor examined the food consumption of red grouse in relation to the age and production of heather. His research indicated that the grouse on Syphill preferred to feed on heather aged 3-5 years in autumn, 3-8 years in winter and 2-5 years in spring, and always avoided the youngest and oldest material. Preferences for particular age classes were also related to the heather's height and cover, as well as to its food value (young heather being more nutritious than old). Similarly, the research showed that the annual heather intake of a grouse was at most, 25 kg (dry weight), if it ate only heather, and at least 18 kg if it ate other plants.

By applying this figure to the density of birds present and to an estimate of heather productivity, it was calculated that grouse ate only 1.4% to 2.5% of the total annual production of heather shoots and flowers on Syphill moor. Given the nature of the results of Savory's (1978) research, it appears that grouse have a vast excess of food and it seems unlikely that their breeding densities could be limited by the total quantity of heather present. Moss (1969) and Miller and Watson (1978a) have also confirmed this supposition by independent estimates of the birds' annual food requirements, i.e. that grouse eat very little of the total amount of heather available.

In other research by Savory (1986), the utilisation of different ages of heather on three Scottish moors was measured by collecting red grouse fecal droppings regularly from heather patches of different ages. This research indicated that grouse preferred heather 10-30cm in height and spend most of their time in heather cover 25cm high. Differences between outer, middle and inner plots on patches at one of the moors indicated that grouse are reluctant to move far into patches of tall, dense heather where these areas are next to shorter material.

In relation to heather age, Savory's (1986) work indicated that grouse avoided heather aged less than two years and more than eight years and spent most of their time in heather about 10-37cm high. The height of a standing grouse is roughly 30cm and that

of a squatting one is 15cm. Taller heather over eight years old would probably restrict their vision and movement and would be difficult to feed from and this may be why the birds avoided it (Moss *et al*., 1972). Conversely, very young heather and newly burned ground would probably expose the birds to predators and bad weather. However, work by Savoury (1986) on Spyhill indicated that birds sometimes preferred two and three year old heather which would have given poor cover and which were below the preferred height for feeding (Moss *et al*., 1972). Hence, differences in height can only partly explain the observed heather preferences. The birds' liking for the younger heather is probably associated with its high nutrient content (Thomas, 1956).

Savory's (1986) research also illustrated a relationship between seasonal variations in habitat utilisation by red grouse. For example, in summer, when birds were with their young and moulting heavily, they became very secretive and spent most of their time in heather tall enough to hide them from predators; and in winter, when the weather was often bad, they again spent more time in older heather which presumably gave better shelter. According to Moss (1972), in spring, when grouse are preparing to breed, their nutritional requirements are high and they select heather which is richer in nitrogen and phosphorus (but not in calcium) than that eaten in winter.

Research by Miller *et al*. (1966) investigated whether the breeding density of red grouse could be compared with the performance of their main food plant, heather, at seventeen study areas in north-east Scotland. The results showed that in moors where the grouse breeding densities were highest, there was most heather. In addition, the high grouse breeding density was associated with especially young heather and low breeding density with very old heather. Hence, the average breeding densities of grouse in the study sites were correlated by the age of the heather as well as the amount (percentage cover).

In relation to red grouse territory and heather, Miller and Watson (1978b) have shown that the lower the nutrient content of heather, the bigger the grouse territory and the more intensely the birds select richer shoots. In a similar context, analysis of green heather shoots have shown that the protein, phosphorus and calcium content declines as the plants get older (Thomas, 1956). Consequently, a well-managed moor with an abundance of young, nutritious heather might be expected to support more grouse than a moor with old and sparse heather.

Research by Lance (1983) examined the selection of feeding sites by four hen red grouse during the breeding season through radio-tracking research to find out how they used their potential feeding areas. His research indicated that as the breeding season approached, they switched from wide ranging movements to localised feeding in places where their staple food, heather, was richer in nitrogen. Lance (1983) concluded that the less travel during feeding, the less exposure there would be to predation, the less time and energy that would be spent on travel and the greater the time for carefully selecting the richest shoots in the stand. The feeding by the hen grouse also became slower and more deliberate in manner, and tended to continue later into the morning.

In Glenamoy, County Mayo, Watson and O'Hare (1979) conducted experiments between 1968 and 1971 to find out whether the low densities of red grouse on Irish blanket bog could be increased by experiments to improve the poor heather growth. Before the habitat treatment commenced, densities of red grouse averaged only 5 per

km² in spring, ranging from 0-12 per km². However, fertilising (with draining and fencing) increased the heather's production, nutritional value and ground coverage. In addition, grouse density in spring increased five-fold and hen grouse reared larger broods and concentrated on the treated plots. In relation to breeding, though not significant, Watson and O'Hare (1979) also suggested that hens on fertilised ground were more likely to rear young and avoid hen robbing.

In general, the research by Watson and O'Hare (1979) showed that grouse preferred the experimental plots but this preference did not appear until the heather abundance increased (which happened in the second growing season). However, to raise grouse densities to Scottish standards, they concluded that management areas would have to be bigger. In order to explain the possible reasons for grouse being scarce in Mayo during the study, they suggested that population gains on vacant areas were possibly due to immigration. Similarly, the grouse losses on areas of higher density were more than likely due to emigration to areas of lower density. However, this explanation is speculative as Watson and O'Hare (1979) had no strong evidence to show that emigration and immigration occurred.

After 1971, the beneficial effects of the experimental treatments at Glenamoy began to weaken (Lance, 1976). It was established through nutrient analysis of the heather that the effects of the fertiliser was wearing off. Fertiliser was re-applied to plots but grouse numbers continued to fall. At the onset of the decline of grouse numbers in 1971, predation began increasing and it was concluded by Lance (1976) that the rise in the number of predators could have been sufficient for the decline but this theory was never investigated scientifically (Finnerty, 2008).

3. Study Area - Ballydangan Bog

Project Location

Ballydangan Bog is located approximately 8km north-east of Ballinasloe in the townlands of Thomastown, Clonbuila and Ballydangan. The entire bog is about 1,100 hectares and is divided in the centre by the main Dublin/Galway railway line. The N6 Ballinasloe/Athlone road runs just south of the site. The project site is about 630 hectares in size (see Figure 3.2).

Site Biogeographic Specifications:

- Minimum Altitude (m): 65
- Maximum Altitude (m): 70
- Longitude: 8° 7' 17"W
- Latitude: 53° 22' 14"N
- Normal Grid Ref: M 919 355

Legal Status

The majority of the site is owned by Bord na Móna and was purchased with a view towards carrying out commercial peat extraction. The land bordering the site is in private ownership.

Figure 3.1 Satellite photograph of Ballydangan Bog (2000 image)

Source: NPWS (2008)

Figure 3.2 Satellite photograph of the Ballydangan Bog project site (2005 image)

Source: Ordinance Survey Ireland (2009)

Figure 3.3 Photo taken from the south of the site with good heather cover

Figure 3.4 Brendan Canning (Ecologist) and Pat Dunning (Moore Gun Club) on the project site

Biological Features

Habitats and Vegetation

In general, the site is geomorphologically representative of the majority of midland raised bogs containing species such as Ling Heather (*Calluna vulgaris*), Cross-leaved Heath (*Erica tetralix*), Deergrass (*Tricopherum cespitosum*), Common and Hare's-tail Cottongrasses (*Eriophorum angustifolium* and *E. vaginatum*) and Bog Asphodel (*Narthecium ossifragum*). In addition, there are numerous of stands of Bog-myrtle (*Myrica gale*) scattered over the bog.

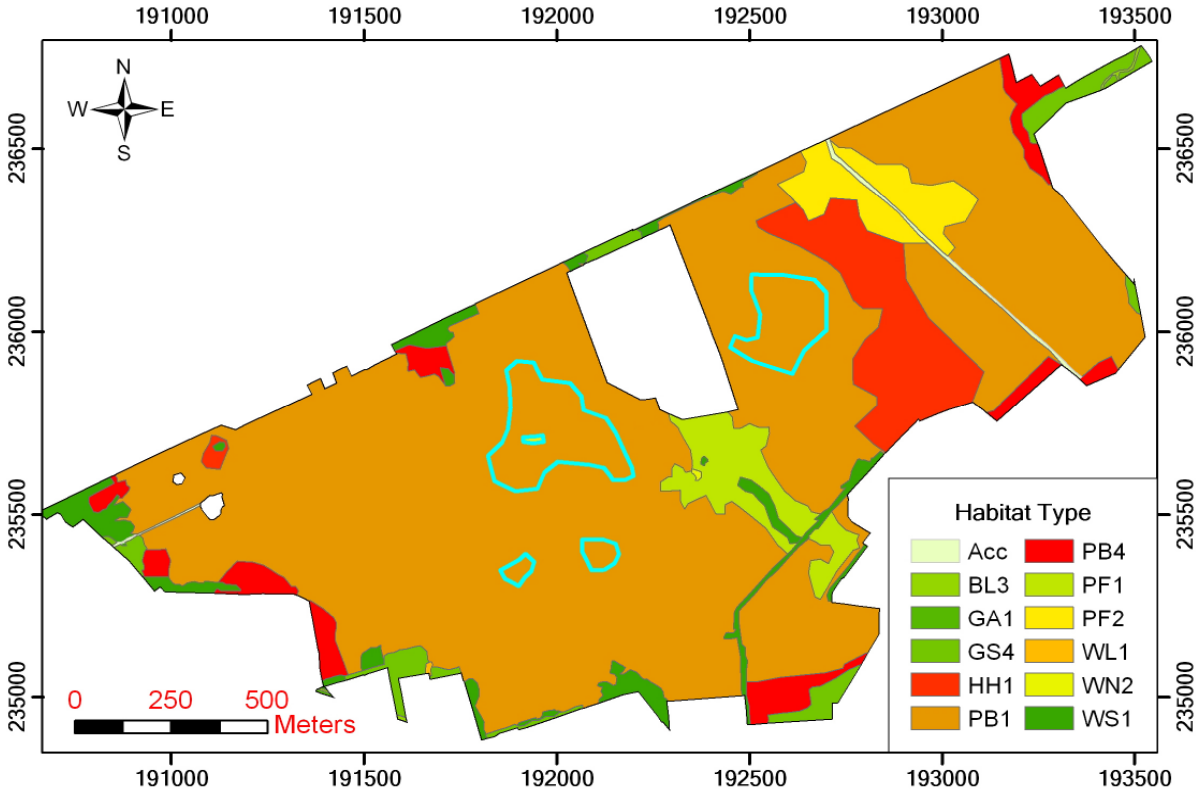
The vegetation in the interior of the site is representative of an active raised bog, though the abundance of Ling Heather remains high. For clarity, the term 'active raised bog' is used to describe sites that are wet and actively peat-forming, where the percentage cover of bog mosses (*Sphagnum* spp.) is high, and where some or all of the following features occur: hummocks, pools, wet flats, *Sphagnum* lawns, flushes and soaks. However, the majority of the site supports a relatively large area of degraded raised bog that is still capable of regeneration, which surrounds and protects the active core of the raised bog within the site. This habitat corresponds to those areas of bog whose hydrology has been adversely affected by peat cutting, drainage and other land use activities, but which are capable of regeneration.

The main drainage operation on Ballydangan Bog took place in the 1970s. At the time, Bord na Móna considered the site to have potential as a peat-production bog. Consequently, the entire site was drained through an extensive ditching network and this has had a large impact on the hydrology and vegetation structure of the site. The

exterior of the site is drier as more of the drains are exposed and still functioning. Towards the interior of the site, the drains have become mostly enclosed making it wetter and parts of the bog appear to be actively peat-forming.

Rhynchosporion habitat occurs in many of the wet depressions, pool edges and other erosion channels alongside the species: White Beak-sedge (*Rhynchospora alba*), Bog Asphodel (*Narthecium ossifragum*), Sundews (*Drosera* spp.), Deergrass (*Tricopherum cespitosum*) and Carnation Sedge (*Carex panicea*). Cutover bog occurs around the margins of the site, some sections of which flood at times, and there is a very small area of commercial forestry on the north side of the railway line.

Figure 3.5 GIS map of project site indicating potentially active raised bog parts of the site (in light blue colour)



Source: GIS data from Bord na Móna

Colour legend:	Orange (BP1)	Raised Bog
	Bright Blue	Raised Bog (potentially active)
	Red (HH1)	Dry Heath
	Light Green (PF1)	Rich Fen and Flush
	Dark Yellow (PF2)	Poor Fen and Flush
	Dark Green (WS1)	Scrub

Fauna

Birds

Many bird species have been recorded on the site including: Red Grouse (*Lagopus lagopus hibernicus*), Snipe (*Gallinago gallinago*), Jack Snipe (*Lymnocryptes minimus*), Curlew (*Numenius arquata*), Meadow Pipit (*Anthus pratensis*), Skylark (*Alauda arvensis*) and Lapwing (*Vanellus vanellus*). Pheasant (*Phasianus colchicus*) and Woodcock (*Scolopax rusticola*) occur at the site margins. Other birds that frequent the site include Sparrowhawk (*Accipiter nisus*), Kestrel (*Falco tinnunculus*), Hen Harrier (*Circus cyaneus*) and occasionally Merlin (*Falco columbarius*).

Mammals

The Irish Hare (*Lepus timidus hibernicus*) is common on the site and there is evidence of Badger (*Meles meles*) and Fox (*Vulpes vulpes*). Irish Hare and Badger are listed as internationally important in the Irish Red Data Book.

Amphibians and Reptiles

The Common Frog (*Rana temporaria*) occurs on the site, which is listed under Annex V of the EU Habitats Directive and is listed as internationally important in the Irish Red Data Book.

Results of Baseline Wildlife Count

Table 3.1 Results of First Wildlife Count by Moore Gun Club

Species	**Sightings**	**Remarks**
Red Grouse *Lagopus scoticus hibernicus*	3	All flushed by setters
Snipe *Gallinago gallinago*	59	
Jack Snipe *Lymnocryptes minimus*	2	
Golden Plover *Pluvialis apricaria*	31	In flock
Lapwing *Vanellus vanellus*	23	In flock
Skylark *Alauda arvensis*	4	
Rook *Corvus frugilegus*	7	
Raven *Corvus corax*	1	
Hooded Crow *Corvus corone cornix*	7	Observed passing over bog
Magpie *Pica pica*	5	
Wren *Troglodytes troglodytes*	1	
Irish Hare *Lepus timidus hibernicus*	1	
Pheasant *Phasianus colchicus*	1	On site boundary
Kestrel *Falco tinnunculus*	1	
Hen harrier *Circus cyaneus*	1	Observed passing over bog

Date: Sunday, 4th October 2009. Weather Conditions: Fine. Visibility: Good.

Table 3.2 Results of Second Wildlife Count by Moore Gun Club

Species	**Sightings**	**Remarks**
Red Grouse *Lagopus scoticus hibernicus*	5	All flushed by setters
Snipe *Gallinago gallinago*	78	
Jack Snipe *Lymnocryptes minimus*	2	
Golden Plover *Pluvialis apricaria*	50	In flock
Lapwing *Vanellus vanellus*	65	In flock
Skylark *Alauda arvensis*	3	
Rook *Corvus frugilegus*	2	
Hooded Crow *Corvus corone cornix*	3	Observed passing over bog
Magpie *Pica pica*	4	
Irish Hare *Lepus timidus hibernicus*	3	
Pheasant *Phasianus colchicus*	8	Near site boundaries
Hen harrier *Circus cyaneus*	1	Observed passing over bog
Grey heron *Ardea cinerea*	1	

Date: Sunday, 18th October 2009. Weather Conditions: Fine with light westerly breeze. Visibility: Good.

Status of grouse population

As noted from the wildlife counts, red grouse occur on Ballydangan Bog at a very low density. Currently, there is on average one bird per square kilometer. However, it would appear that there is sufficient habitat to support up to three or four grouse pairs per square kilometer in the study area. In addition, the greater bog site has the potential to accommodate a good population of birds and the project may expand if grouse begin to disperse out of the proposed project site. Repeat surveys in 2010 and 2011 would give an indication of the true status of red grouse on the site and ideally brood counts would also help clarify the situation.

Historical status of red grouse population

Anecdotal evidence from farmers and members of Moore Gun Club suggest that the population of red grouse on the site was relatively good in the 1980s and early 1990s. However, it appears that red grouse have suffered from a number of factors on the site. The initial drainage operation would have affected the habitat on the entire bog. Further anecdotal evidence suggests that grouse chicks were commonly found dead in freshly dug-out drains.

In 2002, a large fire broke out on the south-east part of the project site. The fire consequently burned about 150 hectares of heather habitat which would have further marginalised the grouse population on the site. Another important factor is undoubtedly the neglect of any habitat management. This has resulted in heather becoming too tall, woody, and rank in certain areas, with limited feeding areas for red grouse.

The impact of predators on the site

It is believed that predators are responsible for causing significant red grouse mortality on the site. Reports from Moore Gun Club indicate that about 35 foxes are shot annually around the site boundaries. Fox droppings have also been found throughout the site on several occasions. A high number of magpies and grey crows have been observed on the site on the majority of visits. Members of Moore Gun Club shoot on average 100 magpies and grey crows in the club annually which indicates a high corvid population in the area. In addition, over 25 mink were killed adjacent to the site last year and tracks and prints have also been observed on the majority of water courses on the site boundaries.

Land Use

Drainage

As previously discussed, the site was extensively drained with a view to carry out commercial peat extraction. Anecdotal evidence suggests that red grouse chick mortality was high immediately after drainage took place. Watson and Moss (2008) argue that extensive draining damages flushes that were prime habitats for chicks of red grouse and wading birds. Despite this, many sites managed for red grouse are still being drained as a management strategy (e.g. see Hudson, 1992).

Figure 3.6 Example of drainage system on Ballydangan Bog

Peat cutting

A limited amount of peat-cutting occurs around the margins of the site. The main areas affected are the south-east side of the site.

Agriculture

Cattle are grazed in the lowland wet grassland areas near the boundaries of the site. Some small areas of cutover bog on the site margins have been reclaimed for agriculture.

Timber extraction

There is a very small area of commercial forestry north of the railway line.

Game shooting

Moore Gun Club has maintained a strict no-shooting/hunting policy on the site. There are numerous signs at entry points to the site to prevent other people from attempting to enter the bog for game shooting purposes. According to representatives of Moore Gun Club, the site has not being used for shooting in the last ten years.

Burning

According to the findings of a study by Fernandez *et al*. (2005), burning is a frequent activity occurring on many raised bogs in Ireland. Their research showed that burning occurred at 24 of the 48 raised bogs which they surveyed over a ten-year period. Burning is mainly associated with peat extraction and thus is more frequent in those sites where a lot of turf-cutting takes place where the bog surface is burnt to facilitate marginal cutting. Although the damage to bog vegetation depends on the intensity and frequency of burning, it generally decreases the *Sphagnum* cover and thus the capacity to generate new peat.

About seven years ago, a large section on the south-east of the project site was burned. As a consequence, the vegetation took a number of years to recover which undoubtedly affected the red grouse population on the site. Watson and Moss (2008) argue that wild fires on bogs often cause soil erosion, and in dry conditions they become too hot, consuming topsoil and greatly delaying the recovery of heather.

Table 3.3 Human activities affecting Ballydangan Bog

Activity	Location	Intensity
Fertilisation	Outside	Low influence
Grazing	Inside	Low influence
Grazing	Outside	Medium influence
Forest Planting	Inside	Low influence
Forest Planting	Outside	Low influence
Burning	Inside	Medium influence
Peat extraction	Inside	Low influence
Peat extraction	Outside	Medium influence
Improved access to site	Inside	Medium influence
Drainage	Inside	High influence
Drainage	Outside	Medium influence

Table 3.4 Management on the site which might have affected red grouse

Land Use	Effects
Draining	More heath, less cotton grass and fewer flushes. Chick mortality.
Under-burning or no burning	Heather too tall and dense.
Infrequent burning	Less heather, more grass and bracken.
Wide fires	Poor cover, soil erosion.
Fencing	Possibly killed grouse.
Fertilising	Destroys heather.

Physical Features

Climate

Although no meteorological measurements have been made near Ballydangan Bog, rainfall data from the Ferbane, Athlone rainfall station for the years 1951-1980 indicates that the area receives approximately 883mm of precipitation annually (NPWS, 2009). The meteorological data for Ferbane (1951-1981) is summarised in Table 3.5.

Table 3.5 Rainfall data for Ferbane weather station (1951-1981)

Rainfall (P)	883 mm/yr
Actual evapo-transpiration (AE)	> 466.5/yr.
Potential recharge (PR)	< 416mm/yr.
Rain days > 0.2 mm (annual 1951 – 1980)	207 days
Annual mean daily air temperature (1951 - 1980)	9.5 degrees C
Annual mean hourly wind speed (1962 - 1984)	c. 4m/s (prevailing SW)

Geology and geomorphology

Ballydangan Bog is a relatively flat (slightly dome-shaped) bog that marginally slopes towards the edges. The subsoil geology of this bog and the surrounding area is dominated by two types of till. Sections of drains at the boundaries of the site indicate that the outer limits of the bog are underlain by stony tills. Cutover drains to the south-east show the till to have a clayey matrix. The area is most probably predominantly underlain by Carboniferous limestone as described by Kelly *et al*. (1995).

Hydrology and water quality

Ballydangan Bog lies in a groundwater recharge zone. The underlying Carboniferous limestone would have a low permeability. The entire site is traversed by drains and consequently the site is well drained.

4. Methodology

Sampling - General Principles

The complex spatial nature of vegetation presents a number of problems when designing sampling schemes for a landscape. As the majority of plant communities are distributed over large areas and sometimes in several regions, vegetation types need to be defined using data preferably covering a range of environmental variability. Thus, effective sampling for vegetation mapping projects requires adequate representation within plant communities to allow for geographical variability. In general, vegetation types differ in their relationship to numerous variables and each sample area will consist of different sizes and levels of biological complexity. Therefore, all aspects of a sampling design need to be flexible to fit area-specific ecological and topographical conditions.

There are a variety of different sampling methods which attempt to provide as much information about a vegetation population as possible in such a way that inferences can be made about the total population. However, the most common vegetation sampling methods are random and systematic sampling.

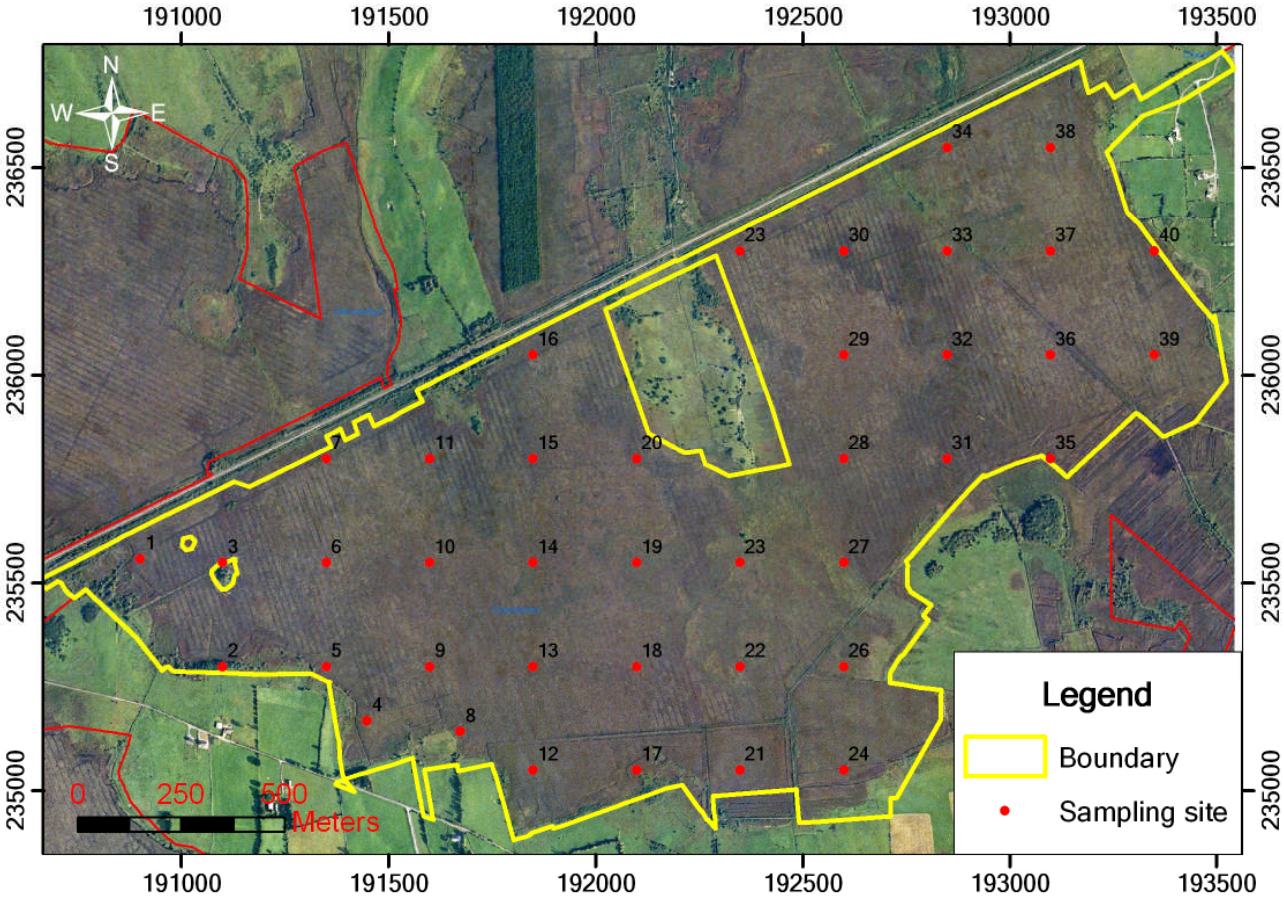
Random sampling meets the following criteria: 1) each combination of a specified number of sampling units has an equal probability of being selected; and 2) the selection of any one sampling unit is in no way linked to the selection of another (McCall, 1982). However, random sampling methods have being criticised because there is potential to leave some areas of a study area unsampled. This can be especially problematic in areas where vegetation is clumped. Gillison and Brewer (1985) argue that randomisation procedures may be counterproductive to the intent of ecological surveys, especially where the occurrence of the natural vegetation pattern is known to be non-random.

Systematic sampling usually involves inserting sampling points on a grid and hence, the points are therefore easier to locate and relocate. According to Elinzga *et al*. (1998), systematic samples, if well designed, can safely be analysed as a simple random sample. However, systematic sampling is analogous to random sampling mainly because populations in random order are rare in biology. Some authors have criticised systematic sampling for the possibility of overlooking certain ecological characteristics because most natural populations of plants exhibit a clumped spatial distribution. On the other hand, Milne (1959) analysed data taken from random and systematic samples of 50 totally enumerated biological populations and found that there were no errors introduced. Elzinga *et al.* (1998) argue that computer-stimulated sampling suggests that applying systematic sampling designs can result in more precise estimates than simple random sampling when sampling clumped distributions (the most common situation in vegetation populations).

In this context, this project used a systematic sampling method to survey the heather habitat on Ballydangan Bog. The systematic sampling approach was based on the grid squares of the Ordinance Survey Discovery Series Maps (1:50,000). This method distributed the systematic sampling points evenly throughout the project site. Each sampling point was spaced approximately 250 meters from the next with maximum interspersion of sampling units throughout the study area. To complement the systematic sampling method, some random samples were taken indiscriminately in the

field. This combined sampling method aimed to get the best possible interspersion of sampling units while at the same time generating data efficiently.

Figure 4.1 Systematic sampling sites



Sampling Site Description

A system of geographic grid references, based on the Irish national grid reference system, was applied to record the GPS location of each sampling site. Each sampling site was 100 square meters in size (10×10 meters).

Classification of Heather Habitat

At each sampling site, assessments were made in relation to the following:

Heather Cover

Heather cover was defined in terms of the proportion of ground occupied by heather from a vertical projection in each sampling site. Within each site, data was collected through 100sqm visual estimations[1]. Estimates of cover were placed in scales of value from 0-100 percent.

Heather Height

Heather height was measured in seven random locations within each sampling site. The average height of the heather was then estimated to the nearest scale of 5cm ranging from 5-70cm in height.

Heather Age

A number of studies in Scotland have developed techniques to age heather. According to Savory (1978), one can age heather up to 7 or 8 years old by counting the 'coronets' of small leaves at the tips of each years growth, and older plants by cutting the base of the stem and counting annual rings. In this study, the age was estimated by assessing ten heather plants picked at random in each sampling site. The heather was assigned to one of four growth phases: 1) pioneer {1-5 years}, 2) building {6-10 years}, 3) mature {11-15 years}, 4) degenerate {15+ years}.

Red Grouse Droppings

A GPS reading was taken in locations where red grouse droppings were observed during the fieldwork.

GIS

Geographic information system (GIS) software is used for storage, retrieval, mapping and analysis of geographical data. In recent years, GIS has become a popular tool used to aid in the decision-making process for the management of biodiversity. Through the use of GIS, managers can be provided with data that is spatially represented with the distinct advantage of being able to overlay different data sets in order to provide more information. Using GIS also allows problem areas such habitat damage, poor habitat quality and other different habitat characteristics to be visualised in greater detail. Similarly, it provides a method of planning which is more accurate, efficient and effective, ultimately producing an easier way to complete habitat management plans that promote the sustainability of resources (Neale and McGrath, 2009).

[1] Some academics have scrutinised the use of visual estimations because the data may be inaccurate as different observers may obtain different results or the same observer may get different results when he/she repeats the sampling process. However, in order to strengthen the data collected from the visual estimates, each researcher made an independent reading and then conferred (in some cases discussed) their results if the estimates differed. However, in the majority of instances, the visual estimations obtained in this study complemented each other.

This project used GIS to combine the sampling data which was collected in the field with satellite imagery and aerial photography. The raw data was stored in Microsoft Excel and basic statistical parameters were calculated using this software. All maps were produced and spatial interpolation was performed using ArcGIS (version 9.2) software. The inverse distance weighted (IDW) method was applied to produce the spatial distribution maps of heather cover, age and height.

Spatial analysis software was also used to classify habitat characteristics based on aerial photographs. This technique proved useful in identifying areas of the project site that had been previously affected by uncontrolled burning

5. Results

Heather Cover

As previously discussed, heather is very important for red grouse feeding, nesting and shelter. Field surveys by Miller *et al*. (1966) have shown that the breeding densities of grouse on different moors in Scotland were correlated positively with the amount of heather cover present. Information relating to the estimated percentage of total heather cover on Ballydangan is presented in Table 5.1 and illustrated using GIS in Figure 5.1 and Figure 5.2.

Table 5.1 Estimated heather cover on Ballydangan Bog

<30%	30-40%	40-50%	50-60%	60+%
2.8%	**46.1%**	**24.8%**	**17.1%**	**9.2%**

Table 5.1 indicates that only 2.8% of the area of Ballydangan bog had less than 30% heather cover. Most of the heather (88%) on the site was within the 30-60% range. Surprisingly, only 9.2% of the heather was found to be in the 60-100% category. Although these results indicate that the entire site is dominated by heather to some degree, there remains a noticeable lack of heather with cover greater than 60%. This is probably due to the combined effects of the site's geomorphological situation and subsequent land management processes (i.e. ditching which affected the site's hydrological status). The original ditching process which took place in the 1970s appears to have created a relatively mono-cultured heather distribution on the site. Other conditions which may be affecting the heather cover on the site are exposure (mainly climatic), frequency of burning and a lack of heather management in recent decades.

Figure 5.1 Heather cover on Ballydangan Bog

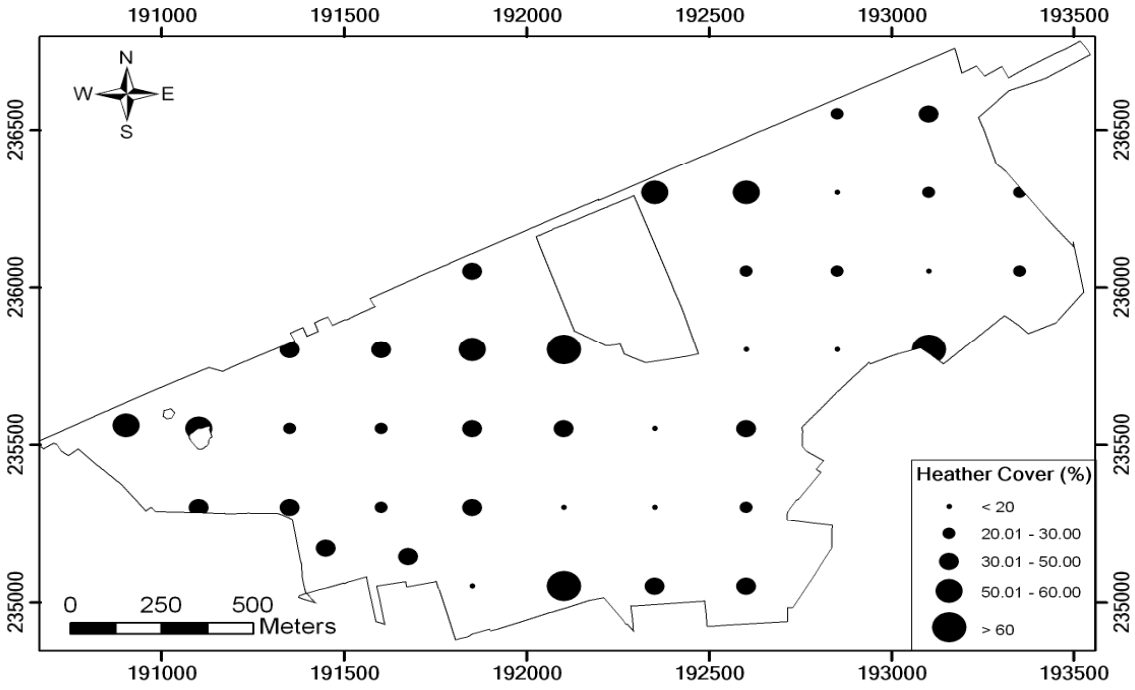
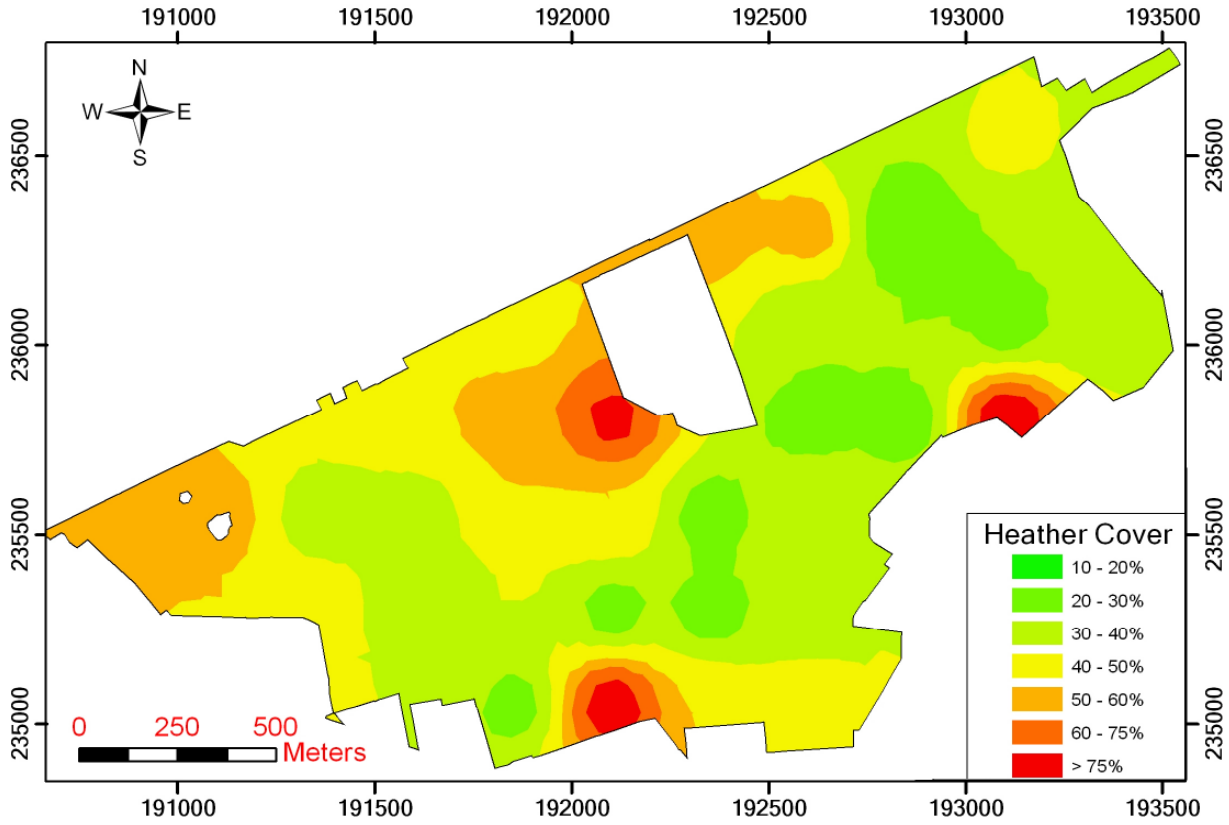


Figure 5.2 Heather cover on Ballydangan Bog



Heather Height

Heather height was measured in seven random locations within each sampling site. The average height was then estimated to the nearest scale of 5cm. The estimated height of the heather on Ballydangan is outlined in Table 5.2 and illustrated in Figure 5.3 and Figure 5.4.

Table 5.2 Estimated heather height on Ballydangan Bog

0-15cm	15-20cm	20-25cm	25-30cm	30-35cm	35+cm
2.8%	**6.9%**	**56.6%**	**13.8%**	**13.8%**	**6.0%**

The results indicate that 84% of heather is within the 20-35cm range in height. A study by Savory (1974) of heather utilisation at different moors in north-east Scotland indicated that grouse preferences were strongly associated with the heather's height and that grouse usually avoided heather over 35cm high. The results of this study indicate that approximately 6% of the heather on site is above 35cm. Hence, in terms of grouse mobility, there does not appear to be any major areas of the site which would deter grouse based on heather height. In terms of management, Hudson and Newborn (1995) state mature heather is that which grows to be half way up your wellington boot; if it has reached the top of your boot it should be managed as a priority.

Figure 5.3 Heather height on Ballydangan Bog

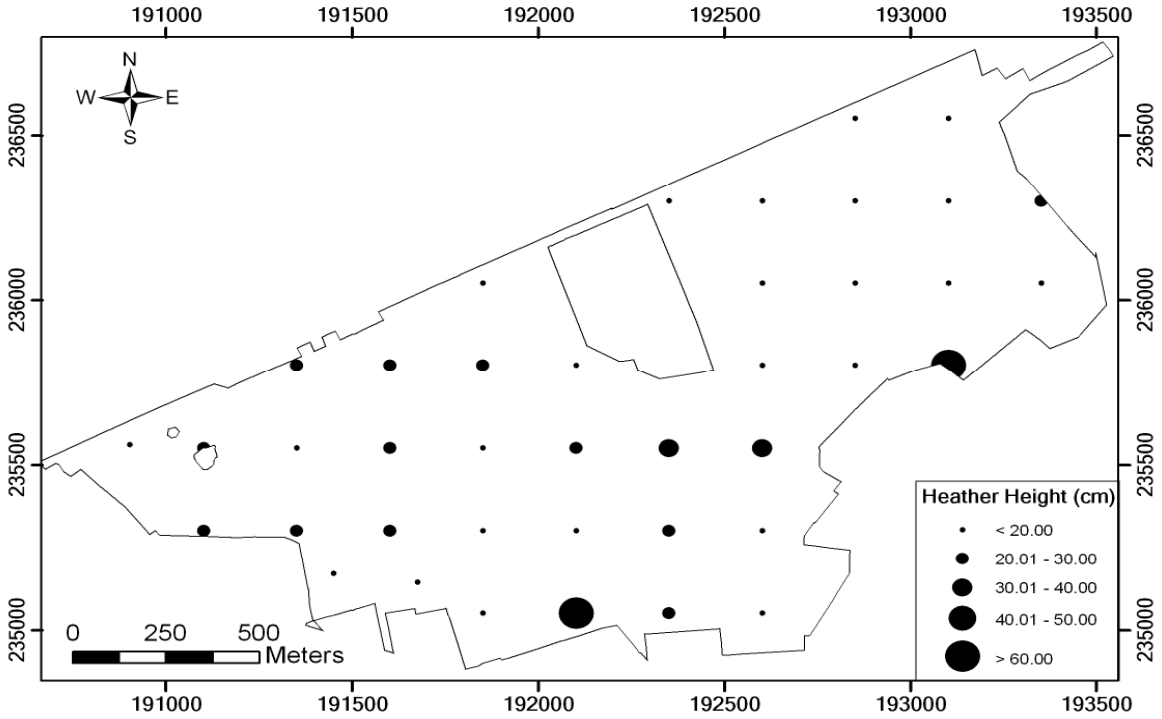
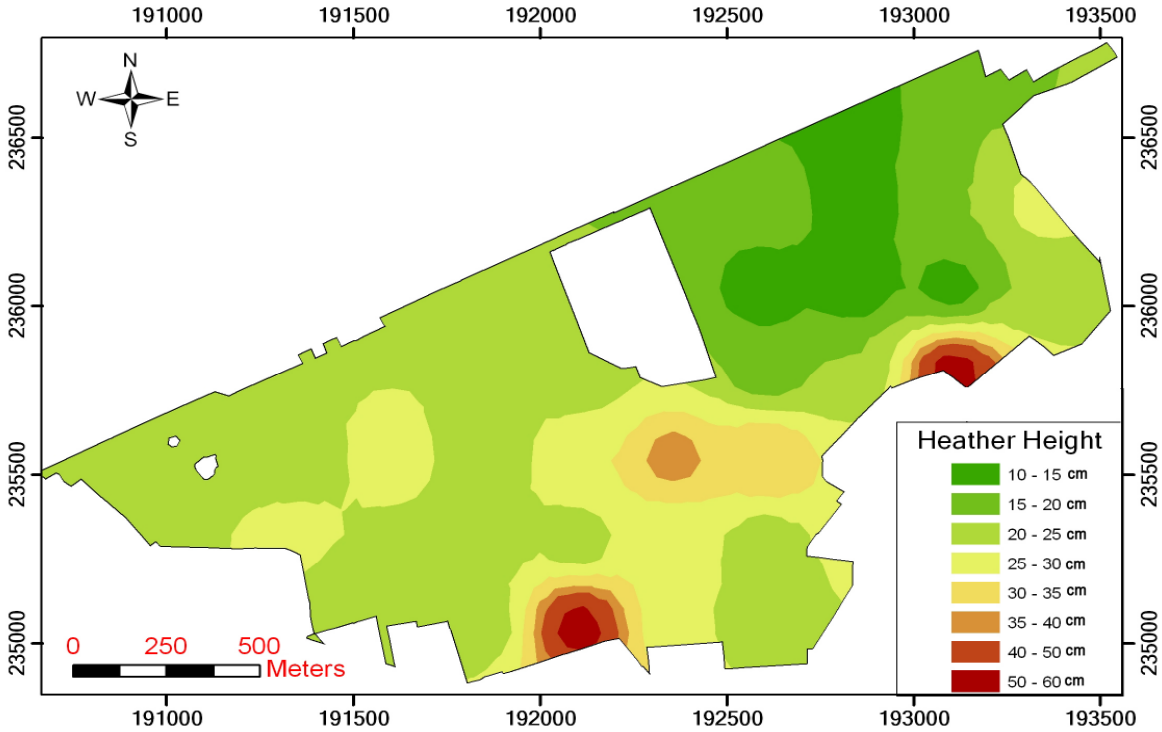


Figure 5.4 Heather height on Ballydangan Bog



These results also indicate that in the areas where heather height was between 0-10cm, there was evidence of previous burning. Furthermore, some of the heather which was burned showed positive signs of regenerating (see Figure 5.5).

Figure 5.5 Heather regrowth on a burnt part of the site

Heather Age

The age of the heather was estimated by calculating growth years using Savory's (1978) technique (described in the methodology) on seven plants picked at random in each sampling site. The heather was assigned to one of four growth phases: *Pioneer, Building, Mature* and *Degenerate*. The total estimated age of the heather on Ballydangan is outlined in Table 5.3 and illustrated in Figure 5.6, Figure 5.7, Figure 5.8 and Figure 5.9.

Table 5.3 Estimated age of heather on Ballydangan Bog

Pioneer (1-5 years)	Building (6-10 years)	Mature (11-15years)	Degenerate (16+ years)
3%	**21%**	**58%**	**18%**

The results illustrate that there is a significantly uneven distribution of age classes of heather on the project site. Most importantly, there is a notable absence of pioneer heather throughout the site. This is alarming because young heather is nutritionally superior to old heather, having more nitrogen, phosphorus and potassium.

Research by Savory (1978) in north-east Scotland on Spyhill moor examined the food consumption of red grouse in relation to the age and production of heather. His research indicated that the grouse on Syphill preferred to feed on heather aged 3-5 years in autumn, 3-8 years in winter and 2-5 years in spring, and always avoided the youngest and oldest material. Preferences for particular age classes were also related to the

heather's height and cover, as well as to its food value (young heather being more nutritious than old).

On Ballydangan bog, the only main observable areas with an abundance of pioneer heather present were in the burnt parts of the site. Encouragingly, there were also a number of grouse droppings present on these burnt areas. This is understandable as there is a noticeable lack of pioneer heather elsewhere on the site; stressing the urgent need for heather management.

Figure 5.6 Pioneer heather on a recently burnt area and degenerate heather

Figure 5.7 Distribution of pioneer and building heather on the project site

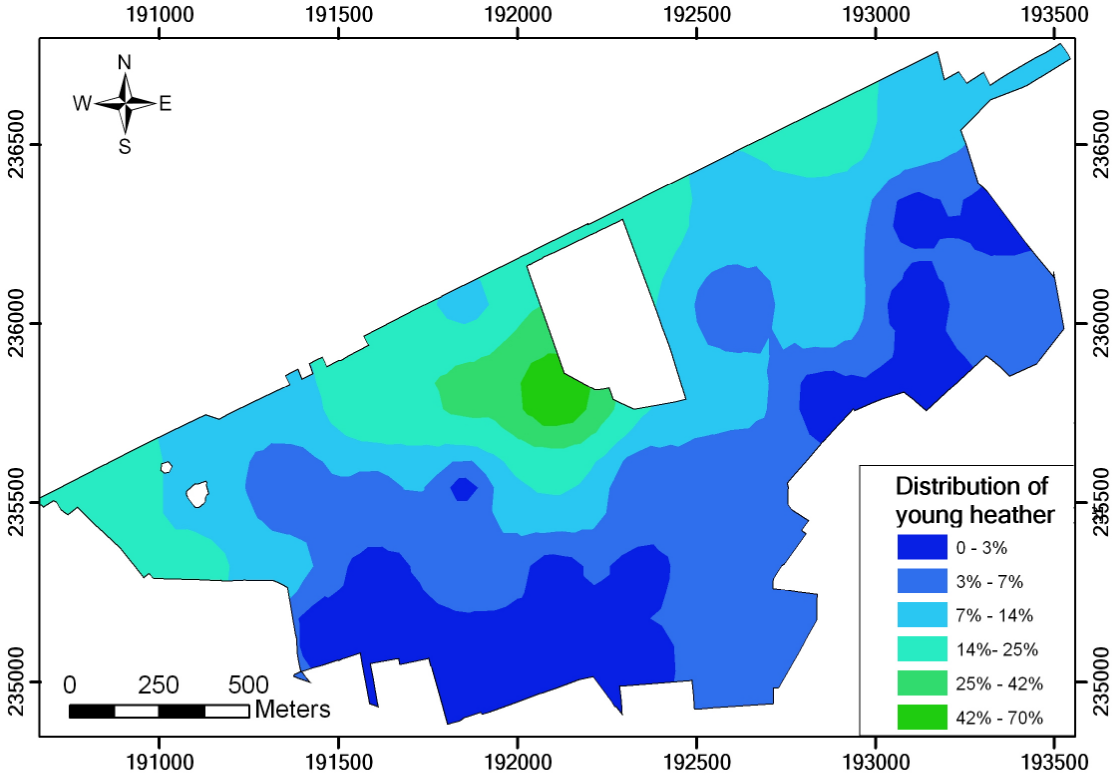


Figure 5.8 Heather age overlaid on heather cover map

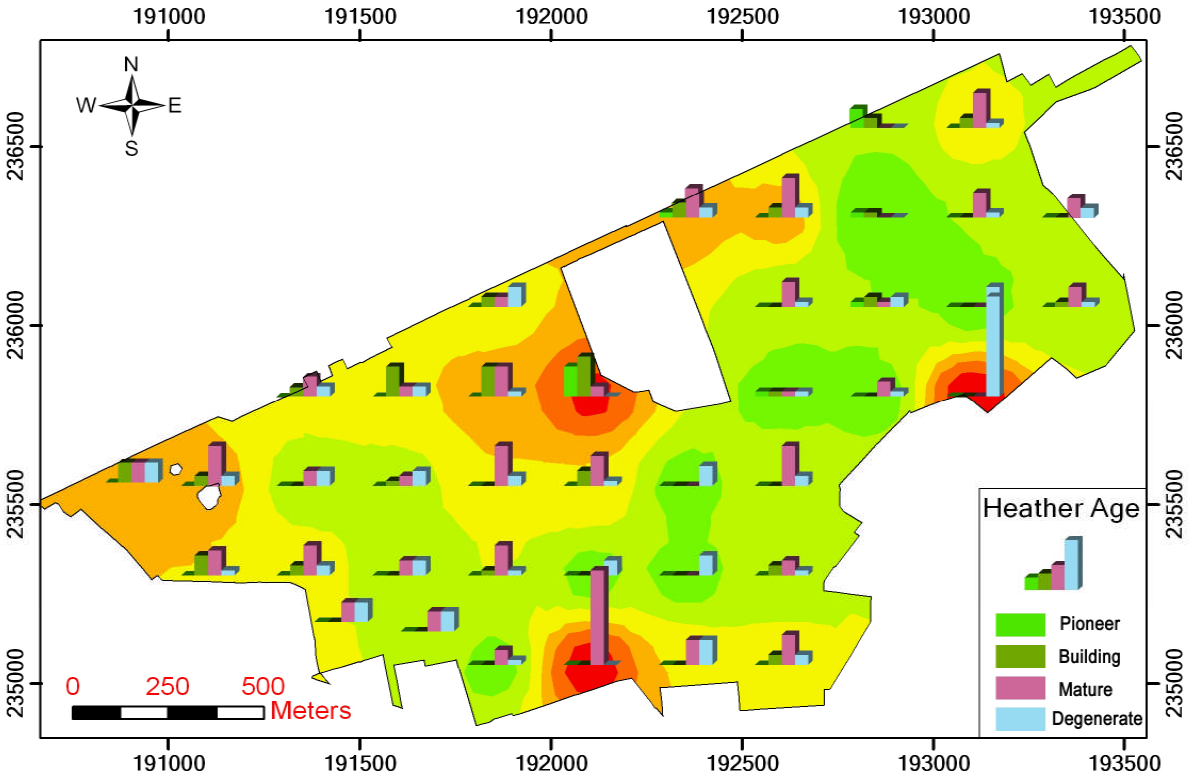
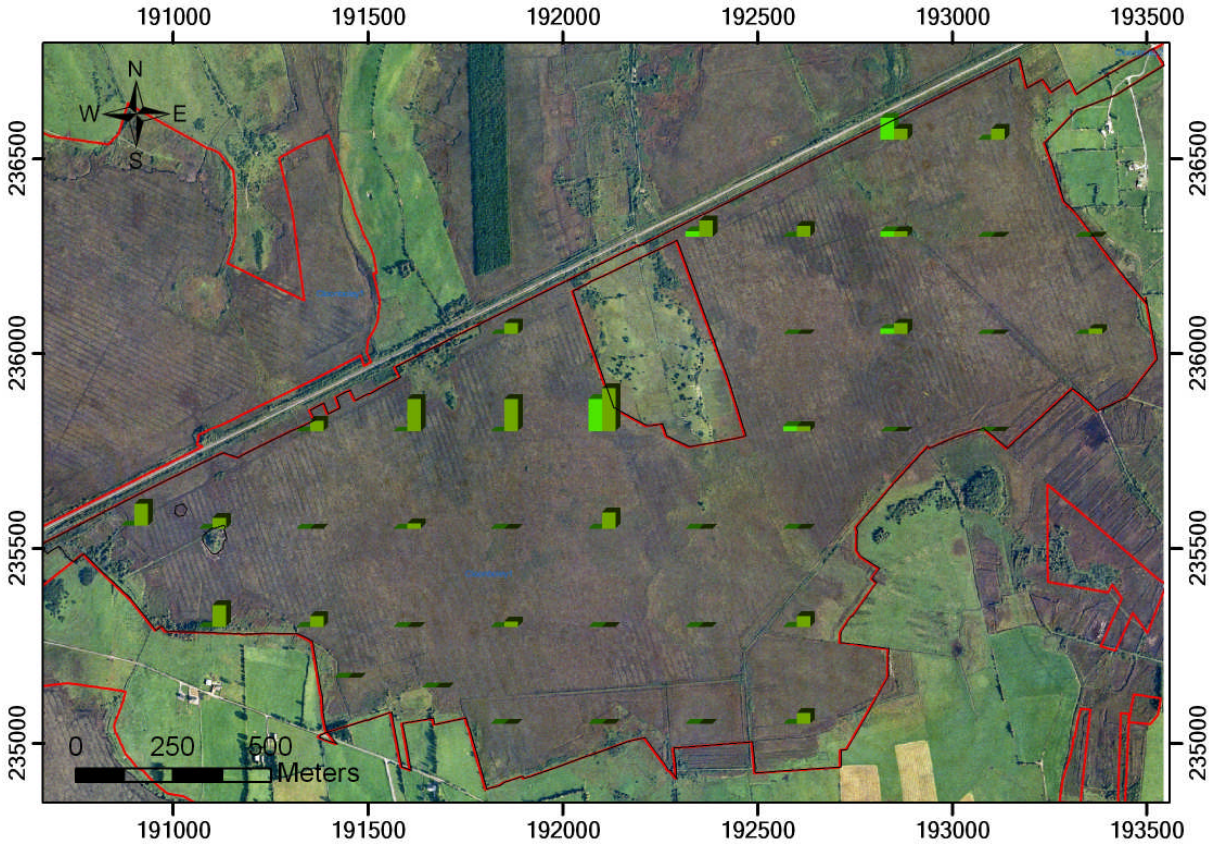


Figure 5.9 Distribution of pioneer and building heather on Ballydangan Bog



Uncontrolled Burning

About seven years ago, a large section on the south-east side of the project site was burned. As a consequence, the vegetation took a number of years to recover which undoubtedly affected the red grouse population on the site. Watson and Moss (2008) argue that wild uncontrolled fires on bogs often cause soil erosion, and in dry conditions they become too hot, consuming topsoil and greatly delaying the recovery of heather.

The following images use spatial analysis software to classify habitat variation based on aerial photography. They are useful in highlighting the areas which appear to be affected by fire damage.

Figure 5.10 GIS map using geo-statistics to highlight burnt areas of the site

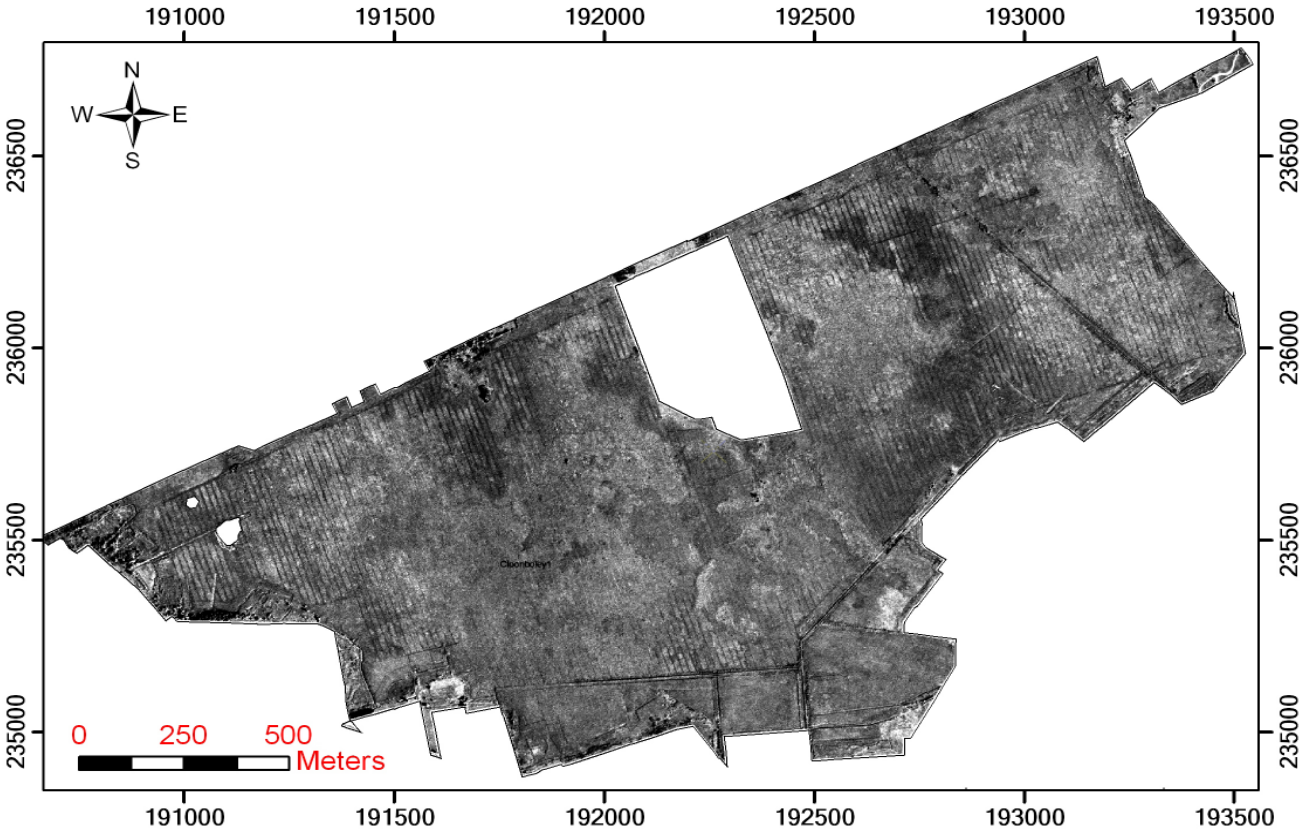
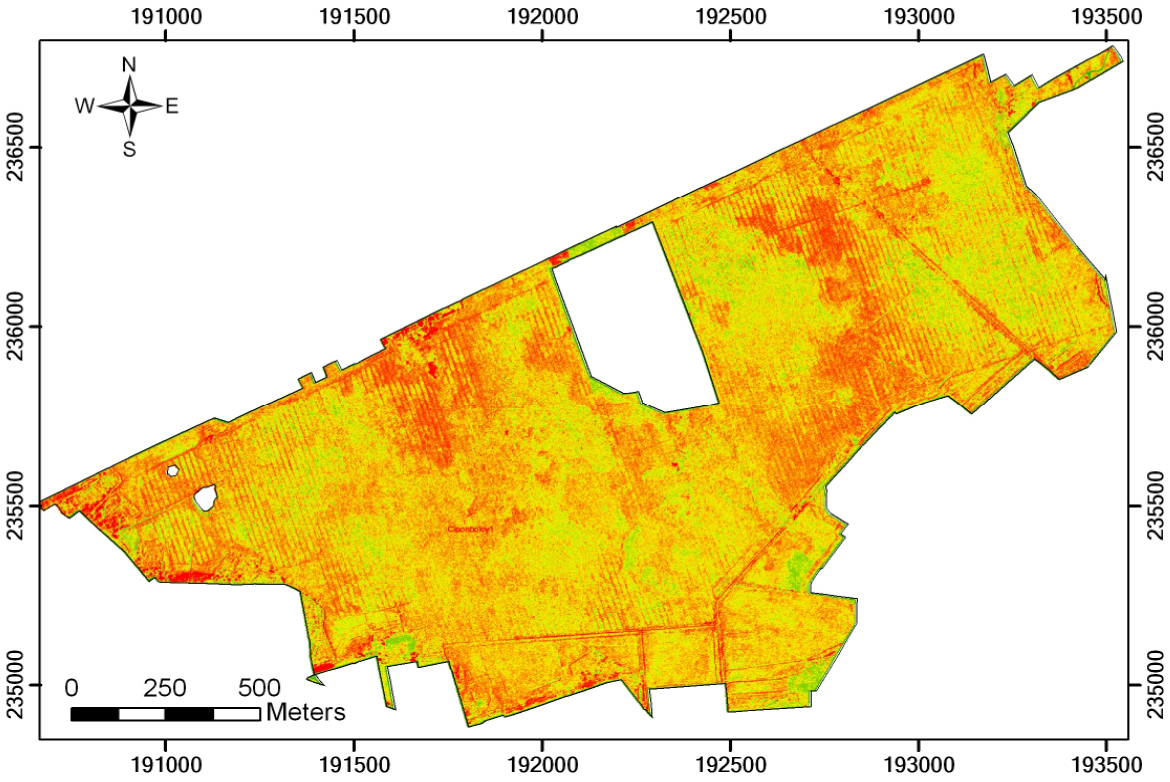


Figure 5.11 GIS map using geo-statistics to highlight burnt areas of the site



Feces

While carrying out fieldwork, any sightings of red grouse droppings were noted and the location was recorded. Some examples of grouse droppings can be seen in Figure 5.12. The GIS map illustrating the distribution of grouse droppings can be seen in Figure 5.13.

Figure 5.12 Examples of grouse droppings on Ballydangan Bog

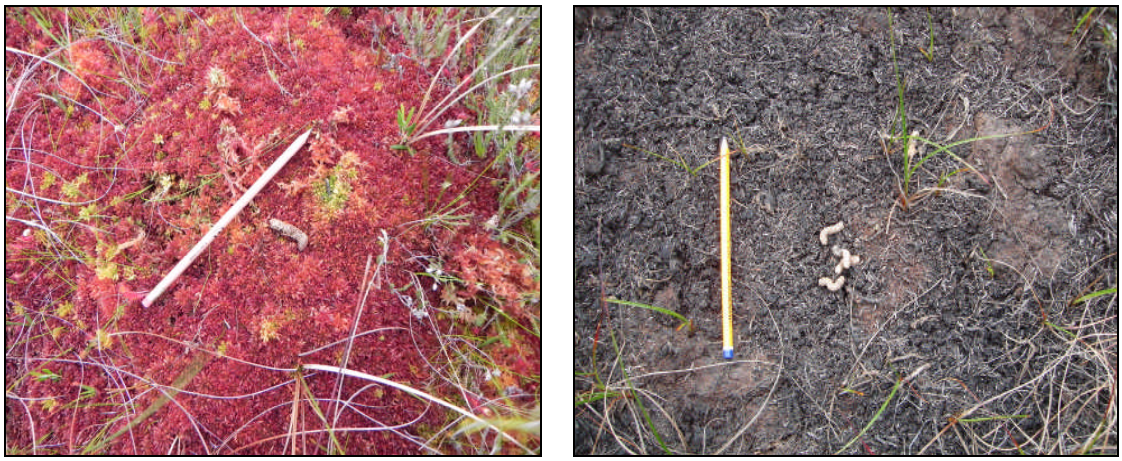


Figure 5.13 Distribution of droppings (bird symbols) and potential management sites (marked in black) on Ballydangan Bog

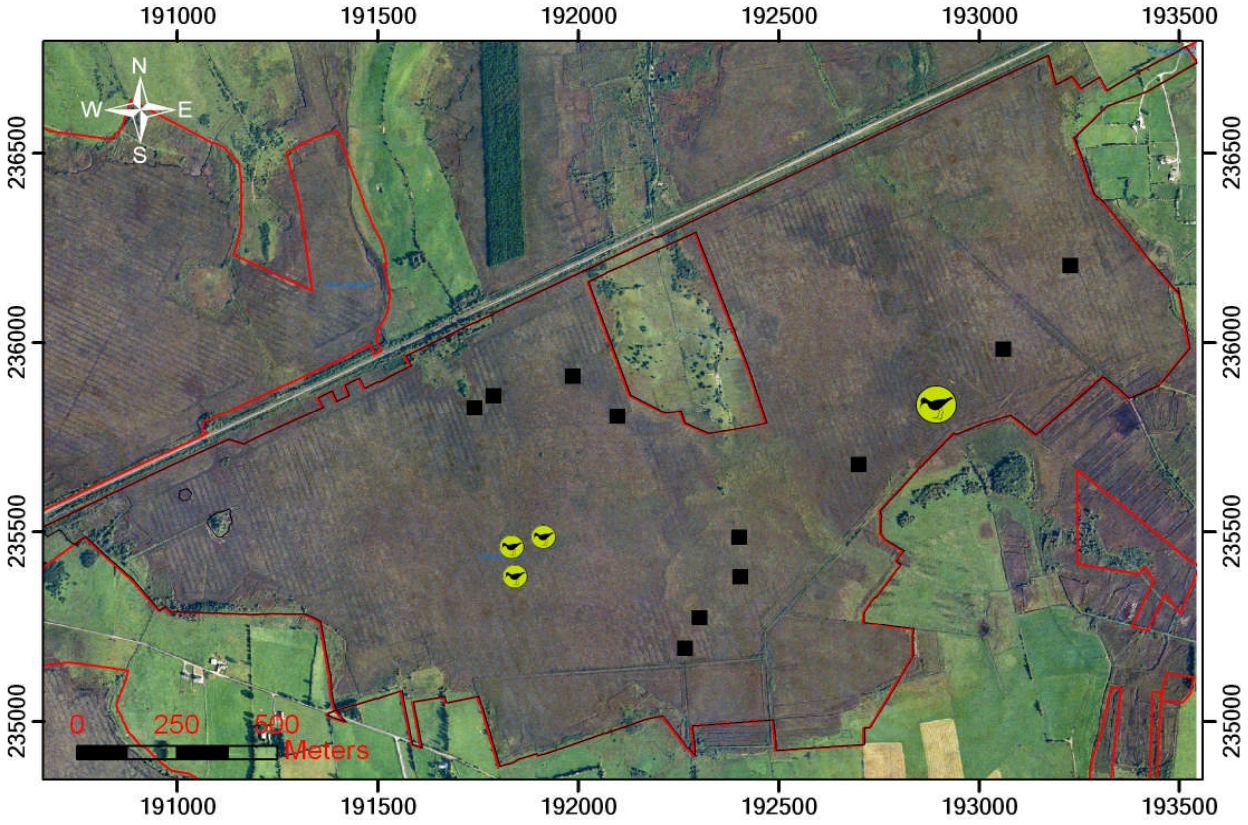


Figure 5.13 indicates that the droppings were found in four specific areas of the site. The area to the east of the site (marked with a large bird) was previously burned in an uncontrolled fire which was subsequently extinguished by a member of Moore Gun Club. In this particular area, which measures about 200 meters squared, there was an abundance of pioneer heather with numerous red grouse droppings present (see Figure 5.5 on page 28). This undoubtedly indicates that the red grouse on the project site have a preference for pioneer heather.

However, it is difficult to distinguish the freshness of the droppings. Research carried out in Connemara National Park by Finnerty (2008) indicates that red grouse droppings can last up to up to 29 weeks depending on the weather.

6. Recommendations

Heather Management

As previously discussed, habitat management for red grouse typically consists of burning/cutting heather on a rotational basis, so that the moor becomes a diverse patchwork of different-aged heather (Lack, 1986). The traditional way of managing heather moorland is to burn the heather periodically in small patches (Savory, 1978). This alters the structure of the heather, and the young heather which regenerates after burning/cutting is more nutritious than old heather (Thomas, 1956).

Miller (1968) suggests that good stocks of red grouse can be maintained by burning heather regularly in well-spaced narrow strips or small patches on a 10-12 year rotation. Lovat (1911) gives very practical instructions on how to attain this effect. There should be no very large areas, either newly burned or devoid of vegetation, or else with rank old heather. Where large areas of over 200m wide are burned, grouse do not colonise all the ground for several years until the heather has grown enough to provide cover. Research by Picozzi (1968) compared patterns of moor burning with the number of red grouse shot on estates in Scotland. His results indicated that the most grouse were shot on estates which had the most fires and the smallest index of fire size.

According to Savory's (1978) research, red grouse usually avoid areas where the heather exceeds 35cm in height. Hence, the best management for keeping grouse numbers high would probably be to prevent the heather reaching a height which the birds avoid.

Potential Benefits of Heather Management for Red Grouse on Ballydangan Bog

- Cutting should sustain the heather habitat for red grouse by preventing the replacement of heather by other vegetation.

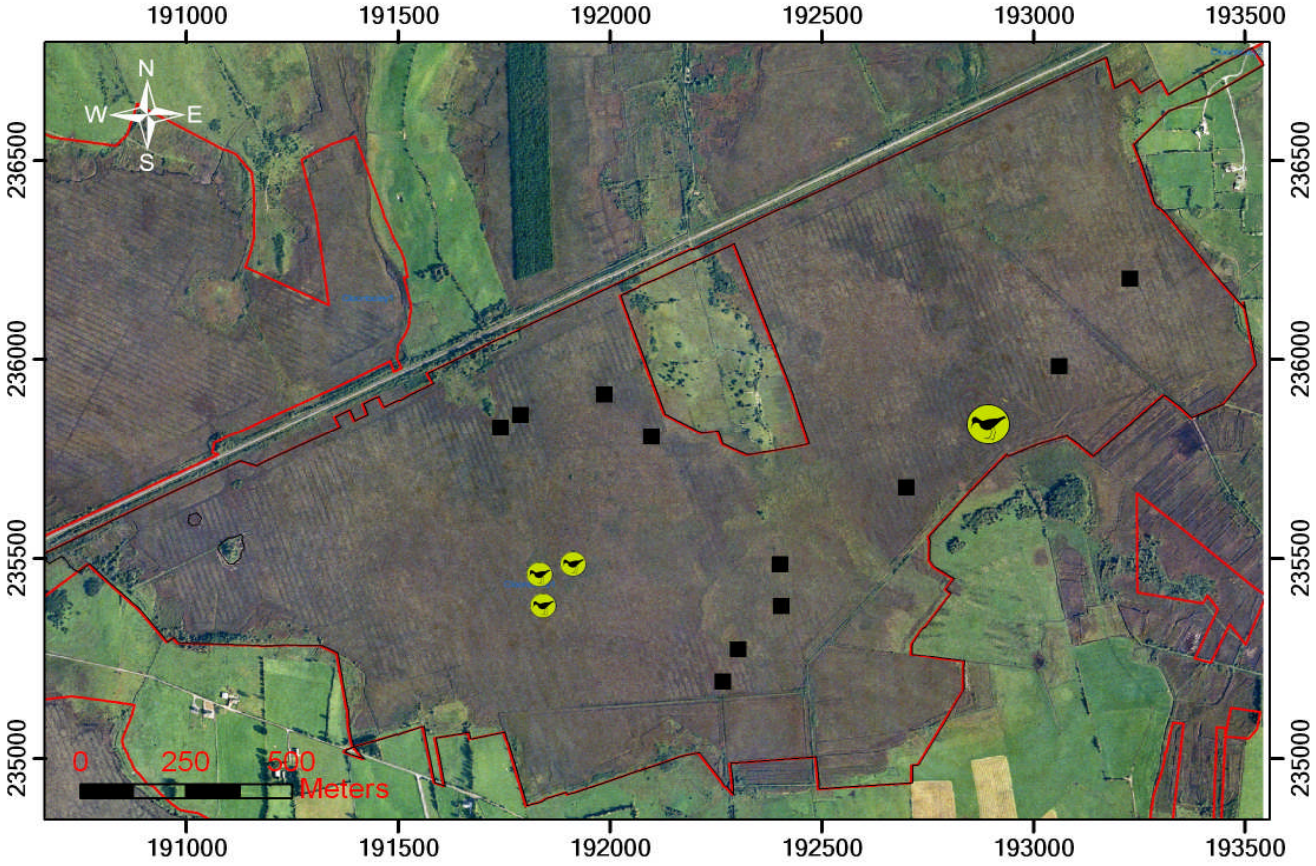
- Cutting will provide edges which are used as reference points by territorial cocks and are selected by hens for nesting.

- Young heather is nutritionally superior to old heather, having more nitrogen, phosphorus and potassium.

- Cutting will provide fire breaks and reduce the risks of large-scale fire (Hudson and Newborn, 1995).

The following GIS map (Figure 6.1) illustrates the locations of the potential management areas on the project site.

Figure 6.1 Potential cutting sites on Ballydangan Bog (marked in black)



Objectives for Heather Management on Ballydangan Bog

- To cut long narrow strips of mature heather on a rotational basis. In Scotland, mature heather is that which grows to be half way up your wellington boot; if it has reached the top of your boot it should be burnt/cut as a priority.

- When cutting heather, it is important that the strips do not exceed 22m in width as grouse are reluctant to stray further than 13m from heather stands with good cover. Strips can be up to 100m in length.

- In areas on Ballydangan Bog where the heather is old and tall in height, cutting should take place in well-spaced narrow strips or small patches.

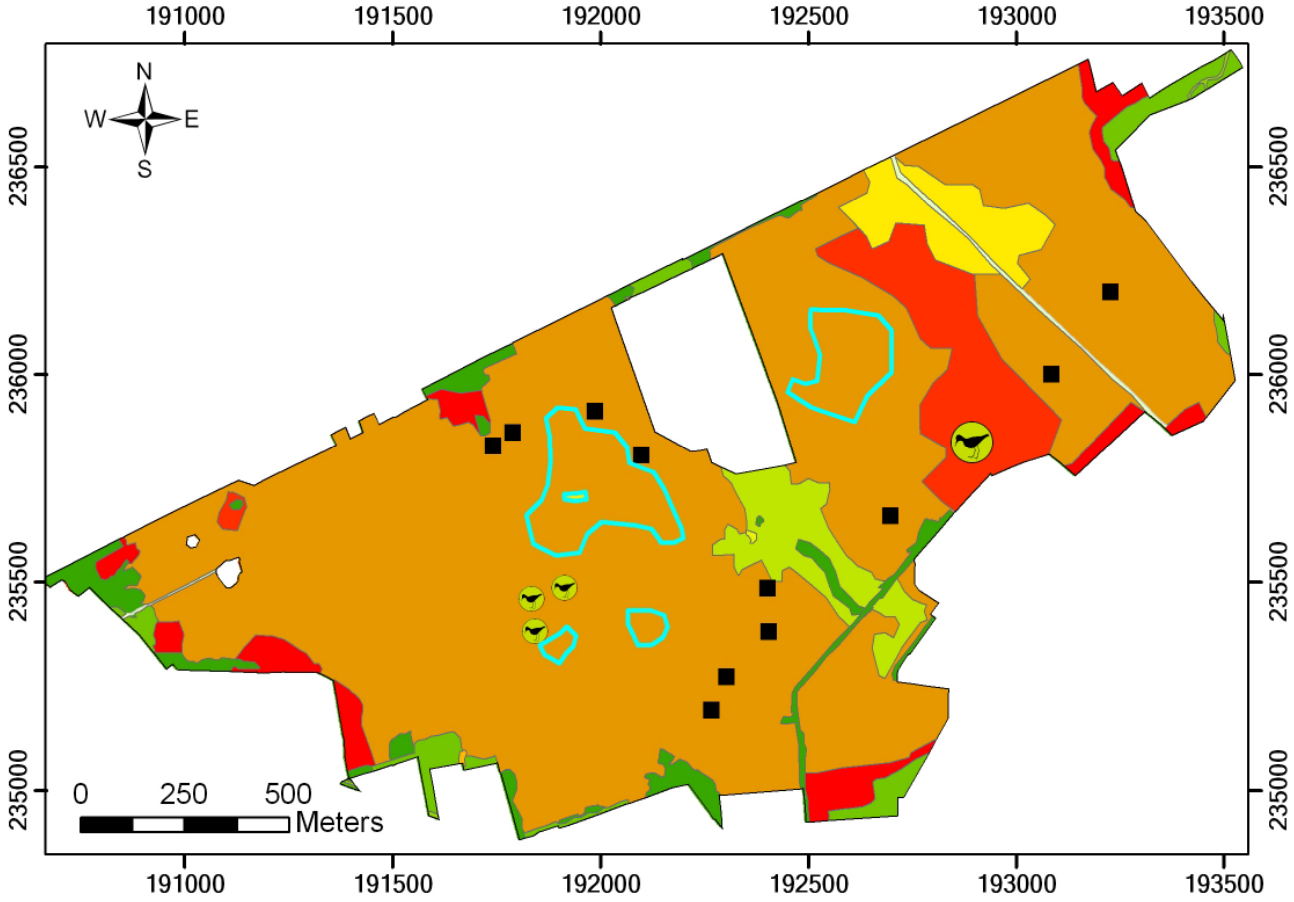
- Appendix 11 (page 51) provides a detailed index of the GPS reference points for the selected management sites on Ballydangan Bog.

- Avoid areas where heather is naturally short through wind exposure or wet.

- Avoid areas of wet blanket bog.

- Avoid areas of conservation value (See Figure 6.2)

Figure 6.2 Sensitive areas (marked in blue) and potential cutting sites (black squares) on Ballydangan Bog



Source: GIS data from Bord na Móna

- Figure 6.2 illustrates that the selected management areas do not directly impinge on the areas noted as being potentially active raised bog.

- Any managed areas on the site should be marked by GPS and this database should be continually updated throughout the duration of the project.

- The Rule of Heather Management: Select where to manage and what to manage. Be selective (Hudson and Newborn, 1995).

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