Birds, Burning and Grouse Moor Management

A Report on Behalf of the Moors for the Future Partnership

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ABSTRACT

This study examines the impact that gamekeepering and heather burning may have on the density of the birdlife in the Peak District National Park.

First, the habitat composition on areas of managed grouse moor is compared to areas which are not managed for grouse. Relationships between the management of the land and the proportion of it burned are also examined. The densities of typical upland moorland birds measured in 1990 and 2004 is related to keeper presence/density, habitat composition and proportion of areas burnt as was the change in species density from 1990-2004. The density of birds of prey recorded in 2004 is also examined.

It is shown that the habitat composition on moors managed for grouse within the PDNP is significantly different to those moors which are not; with higher proportions of heath and mire communities found on grouse moor. The proportion of managed grouse moors which are burned is also significantly higher than on areas with no specific grouse management.

Dunlin* and golden plover* are associated with areas which are managed by keepers; however the density of many passerines including whinchat* are lower on moors which are keepered. Habitat has a significant effect on the species investigated including: dunlin*, golden plover*, skylark, twite**, wheatear and whinchat* the last four choosing to occupy habitat which may not typically be found on a grouse moor.

The densities of curlew*** lapwing** and ring ouzel* are higher on moors that had a larger proportion of their habitat burned; one of the major tasks a moorland keeper will undertake. However the density of species including twite** skylark and wheatear declined as the proportion of their habitat burned increases. Three raptors, the peregrine falcon, short-eared owl and kestrel, have higher densities on areas managed for grouse, with merlin* density higher on areas which have higher proportions of burning.

*** Peak District National Park SPA designation species, ** Peak District National Park Biodiversity Action Plan species, Both *****

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LIST OF ACRONYMS

BAP- Biodiversity Action Plan

CAP – Common Agricultural Policy

CBD – Convention on Biological Diversity

CEH – Centre for Ecology and Hydrology

DEFRA – Department of Environment, Food and Rural Affairs

EN- English Nature

FC – Forestry Commission

FE – Forest Enterprise

GIS- Geographic Information System

ITE – Institute of Terrestrial Ecology

JNCC- Joint Nature Conservation Council

LBAP- Local Biodiversity Action Plan

LFA – Less Favoured Areas

MFF- Moors for the Future

NP- National Park

NNR- National Nature Reserve

PDNPA- Peak District National Park Authority

PDNP - Peak District National Park

SAC- Special Area of Conservation

SPA- Special Protection Area

SSSI- Site of special Scientific Interest

CHAPTER ONE: INTRODUCTION

The Peak District National Park (PDNP) is the oldest National Park in the UK, and is important both nationally and internationally for its landscape and associated assemblage of birds, many of which are present within their most southerly British location within the PDNP. Gamekeepering within the Peak District, specifically burning areas of heather (*Calluna vulgaris*) moorland for the benefit of Red Grouse (*Lagopus lagopus*), has been an established part of land management within the park since at least the 1880's (**Tapper, 1992).**

The relationship of gamekeepering and heather burning on the populations of typical upland moorland birds has been previously examined. These studies have been based on areas of moorland which are widely distributed and only related by their habitat composition (heather dominated moorland), not their geographic position. The 1990 English Nature (EN)/2004Moors for the Future (MFF) upland bird surveys provided an opportunity to study the relationships between gamekeepering and birdlife over a defined area with a relatively uniform habitat.

This study will examine effects of gamekeepering, habitat and burning on the density of birds within the PDNP, using the unique data provided from 1990 and 2004 bird surveys of the National Park, keepered and un-keepered estate boundaries and heather burn locations within the PDNP..

CHAPTER TWO: BACKGROUND TO THE PEAK DISTRICT NATIONAL PARK

2.1 Location and Purpose of the Peak District National Park

The Peak District National Park (PDNPA) is located on the south tip of the Pennines with much of its area within Derbyshire, although parts of Staffordshire, Yorkshire, Lancashire and Cheshire are included within its boundaries. Figure 2.1 shows the boundary of the PDNP.

(Source: PDNPA, 2006.)

Figure 2.1: Location of the Peak District National Park, UK.

The PDNP was established in 1951 as part of the National Parks and Access to the Countryside Act 1949. The purpose of the park was updated in the 1995 Environment Act which was broken into two aims:

- To conserve and enhance the natural beauty, wildlife and cultural heritage of the National Parks; and

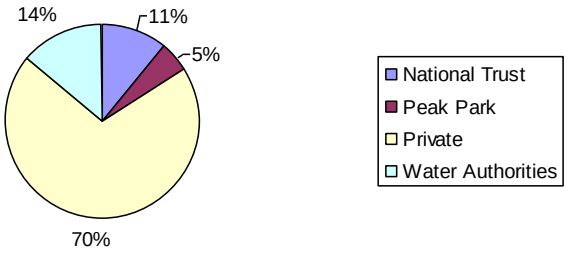
- To promote opportunities for the public understanding and enjoyment of the special qualities of the park (PDNPA, 2006).

The park covers 1,438 km², and is home to around 38,000 people living in 125 parishes. It is also a major tourist attraction, providing 2500 km of footpaths to over 22 million local, national and international visitors a year. One third of England's population live within an hour of the PDNP (PDNPA, 2006).

The National Park is broken up into three distinct natural areas referred to as the Dark, White and South West Peaks (English Nature, 2001). The differences in the areas derive from the underling geology which includes mudstone and shale/grit in the dark peak to limestone in the white peak. The resulting vegetation gives the areas a unique appearance with moorland vegetation covering large proportions of the dark and south west peaks and rolling grasslands the dominating the habitat in the white peak area. (NPA, 2006) Specific PDNP habitats are discussed in chapter 4.3.

2.2 Ownership and Land Management within the Peak District

Over 70% of the PDNP is privately owned, with 14% of the park owned by the water authorities (Figure 2.2). A further 11% is in the possession of the National Trust leaving the remainder - 5 % - in the hands of the Peak District National Park Authority.



(Source: PDNPA, 2006.)

Figure 2.2: Land Ownership within the PDNPA.

Although the land is owned as above, control over the management of the PDNP is often put in the hands of tenant farmers who rent the land for sheep farming (See section 3.1) or by individuals who own the sporting rights to the land. In particular, the moors which host

valuable stocks of grouse may be managed by gamekeepers (See section 3.5). Sporting rights are often held separately from the ownership of the land due to their high economic value (PDNPA, 2006).

2.3 Designations within the Peak District

The Peak District is important at local, national and international levels due to quality of the landscape and the diversity of wildlife which it encompasses (Carr and Middleton, 2004). This means that a plethora of designations are in place over much of the Peak District in order to ensure environmentally friendly land management. The main designations are discussed below, with specific areas of each designation detailed in Table 2.1.

Table 2.1: Area and percentage of the PDNP covered by each designation scheme.

Category	Area (ha)	Percentage of Park
National Park	143,754	100
SSSI	50,013	34.8
Natura 2000 sites, of which:	47,022	32.7
SAC	45,727	31.8
SPA	44,978	31.3
NNR	356	0.25
LBAP	185,694	100

(Source: PDNPA, 2006.)

2.3.1 National Park Status

The Peak district was designated as a National Park in 1951 under the 1949 National Parks and Access to the Countryside Act. The aim of this designation was to conserve and enhance the natural beauty, wildlife and cultural heritage of the area, whilst promoting opportunities for the public understanding and enjoyment of the special qualities of the area (NPA, 2006).

2.3.2 Sites of Special Scientific Interest

Fifty-one Sites of Special Scientific Interest (SSSI's) are present, covering over 35% of the Peak District. These areas are designated by English Nature for their biological, geographical or geomorphologic features (English Nature, 2006).

2.3.3 European Legislation

The protection which the SSSI's enjoy within the park are reinforced with further designations deriving from the EC Council Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC) (The Habitats Directive), and the EC Council Directive on the conservation of wild birds (79/409/EEC) (The Birds Directive). The Habitats and Birds Directives lists flora and fauna of specific international importance (JNCC, 2006).

The resulting designation schemes come under the title of Natura 2000 and are divided into two specific groups:

2.3.4 Special Areas of Conservation (SAC's)

SAC's are designated to protect and enhance specific habitats which are internationally important. Within the PDNP examples are semi-dry grasslands, (*Festuco-Brometalia*), heather (*Calluna vulgaris*) dominated moorland, blanket bog and rare woodlands. There are also specific species which SAC's are designed to protect. An example within the PDNP is the white clawed crayfish (*Austropotamobius pallipes*) (JNCC, 2006).

2.3.5 Special Protection Areas (SPA's)

SPA's are designated to protect areas which support internationally important populations of birds. The PDNP is important for mainly moorland species which include Golden Plover (*Pluvialis apricaria),* Dunlin (*Calidris alpine),* Curlew (*Numenius arquata*), Merlin (*Falco columbarius*), Ring Ouzel (*Turdus torquatus*) and Whinchat (*Saxicola rubetra)* (Sim *et al*, 2005).

Specifically within the PDNP there are two SAC's; The Peak District Dales and The South Pennine Moors and one SPA; The Peak District Moors. The specific important habitats and avian species are discussed in chapters 4.4 and 5.2 respectively.

2.3.6 National Nature Reserve

The park also plays host to a National Nature Reserve (NNR) which covers a small percentage of the Derbyshire Dales. The NNR is designated due to its national importance in terms of landscape and wildlife, and is managed by the land owners through national or international funding.

2.3.7 Peak District Biodiversity Action Plan (BAP)

The BAP process is derived from the Convention on Biological Diversity (CBD) which the UK signed up to at the Earth summit in Rio de Janeiro in 1992. Each participating country is expected to implement a national action plan which encompasses the ideals of conservation and sustainability. The Biodiversity Acton Plan is the mechanism by which the agreement is ratified (JNCC, 2006).

The PDNP was identified as being a valuable natural resource within the UK and was therefore listed as an area which the BAP could be used. The whole of the Dark, White and South west peaks come under the Plan which identifies species and habitats of importance, in need of conservation. These include; Twite, (*Carduelis flavirostris*), Lapwing (*Vanellus vanellus*) and Curlew (*Numenius arquata*) (JNCC, 2006).

2.3.8 Environmentally Sensitive Areas

The Environmentally Sensitive Areas (ESA) scheme is a designation which covers approximately 52% of the PDNP. (DEFRA, 2006) The scheme was adopted nationally in 1986; with the North Peak becoming an ESA in 1988 and the South West Peak designated in 1992. (PDNPA, 2006) The aim of the scheme in both areas is to conserve and enhance the landscape by encouraging farmers to manage land in ways which benefit wildlife, landscape and historic features. The incentive of annual payments over a 10 year period is made available to those who participate (DEFRA, 2006).

Moorland management in the both the North and South West peaks is a particular focus of the schemes, with grazing, sheep distribution, heather burning, heather regeneration given particular attention. Within the grass-dominated South West Peak ESA the management of traditional inbye land is an important aspect of the scheme (DEFRA, 2006).

2.3.9 Less Favoured Area (LFA)

DEFRA (2006) and English Nature (2001) state that there are large areas of the English uplands where it is increasingly difficult to sustain agricultural processes, (usually sheep farming) which have shaped the existing landscapes. These areas are known as Less Favoured Areas (LFA's).

In order for the environment as well as the economics and social status of an area to be sustained the government (DEFRA) offers incentives to farmers in LFA's to subsidise agricultural processes. A typical example is the Hill Farm Allowance (HFA) which supports beef and sheep farmers. Payments are based on areas of land which are managed in environmentally friendly ways instead of payments for over production (DEFRA, 2006).

2.4 Other PDNP Management Authorities

Although they may not own specific areas of land there are a number of Non-Governmental-Organisations (NGO's) which ensure that the PDNP is managed to a high standard. Many of the NGO's carry out research which will lead to change in policy within the PDNP or affect the management of the land. Moors for the Future (MFF) is a good example of an NGO that commissions and carries out specific research into many aspects of the PDNP's flora and fauna including studies on heather management, and moorland birds (Carr and Middleton, 2004). Other NGO's which carry out research within the PDNP include:

- Heather Trust
- Moorland Assosiation
- Royal Society for the Protection of Birds
- Derbyshire; Staffordshire; Yorkshire Wildlife Trusts
- Game Conservancy Trust
- Countryside Alliance

CHAPTER THREE: TYPICAL UPLAND LAND USES

3.1 Introduction

This chapter will discuss the typical land uses which are present within the uplands. A specific emphasis will however be put on the effect of the land uses practised within the PDNP and their affect on landscape and biodiversity.

3.2 Sheep Farming

The PDNPA (2006) describe a typical farm in the Dark Peak area of the National Park as composed of a substantial area of high moorland on which to graze sheep, and smaller areas of improved grassland on the lowlands (inbye land) which often play host to smaller quantities of cattle**.**

Sheep farming has been a major land use within the English uplands since the 12th - 14th century when monks initiated the intensive sheep flocks. (PDNPA, 2006). Since at least the 1880's the sheep farmers have coexisted with grouse moors with beneficial burning and predator control keeping the two land uses from conflict. (Tapper, 1999)

Substantial changes in the manner of farming have only really occurred throughout the last century, following the Second World War. The introduction of the National Agricultural Policy, followed by the Common Agricultural Policy (CAP), encouraged farmers to produce extensive amounts of food (Tapper, 1999). In the case of the PDNP this meant increased sheep densities on the moorland as well as cattle on the inbye land (PDNPA, 2006).

Fuller and Gough (1999) describe the levels of sheep farming in the uplands of Britain as increasing between the mid 1970's and 80's with Baines *et al*. (2002) showing that the number of sheep which grazed the upland Less Favoured Areas (LFA's) increased by 35% between 1980 and 2000. Much of the decline can be attributed to Ministry of Agriculture Fisheries and Food (MAFF - now DEFRA, Department for the Environment, Food and Rural Affairs) protocols in the 1980's. These focused on increased production of food and gifted farmers headage subsidies without fully considering the environmental impacts (PDNPA, 2006).

Due to increased grazing densities, much of the upland heather-dominated moorland, including that within the PDNP, became increasingly degraded (Hudson, 1982; Hudson, 1985;

Welch, 1997). Hartley and Mitchell (2005) state the largest declines in heather moorland (typically 40-50%) were when nitrogen and intensive grazing were combined. Hudson (1995) shows that the addition of another grazing mammal e.g. deer (*Cervus elaphus scoticus*) and/or rabbit (*Oryctolagus cuniculus*) would increase the rate of heather decline. The exception to this statement is cattle, which have preference for grasses and may therefore slow the rate of grass succession (Hudson, 1995).

The bird assemblage was also negatively affected by sheep farming through the loss of habitat, (Fuller and Gough, 1999; Jenkins and Watson, 2001). This included the red grouse; a valuable source of revenue to the uplands (Hudson and Newborn, 1995). Baines (1996) asserts that the heavily grazed moors also supported 41% less invertebrates which would reduce food supply for grouse chicks. Hudson (1995) supports this argument by stating that reductions in cover by large herbivores reduces habitat for insects, and has an effect on grouse numbers. There is however another consideration made by from Baines and Warren (2002) who state that increased grazing is beneficial for black grouse; however the same authors concede the point that grazing is probably detrimental to many bird species.

The last two decades have seen a change in the climate of British agriculture with more thought being given to the state of the environment (Tapper, 1999). Government schemes enable farmers to gain payments specifically for keeping land in good agricultural **and** environmental condition (DEFRA, 2006). Within the LFA's of the PDNP farmers are now actively encouraged and paid to reduce stocking densities of sheep and cattle through an Environmentally Sensitive Area (ESA) scheme as well as participating in DEFRA's Hill Farm Allowance scheme which provides area payments for considering the environment (DEFRA , 2006).

3.3 Tourism

The UK has seen a massive increase in tourism, particularly within the last 50 years. (Wall, 2006) It is suggested by Hudson (1982) that the uplands of England have always been a popular recreation location due to the quality of the attractions and the proximity of the population to recreational opportunities. Within the uplands, five National Parks have been designated (Lake District, Peak District, North York Moors, Yorkshire Dales and Northumberland) which provide a variety of landscapes for the population to visit (PDNPA, 2006).

Tourism is a major land use in the PDNP with 16 million people living within an hour of the park borders, many of whom make up part of the 22 million day visitors which the park attracts each year (MFF, 2006). Since the 1920's when the recreational value of the Peak Park moorlands began to be realised, tourism has coexisted with the other land uses including grouse shooting (PDNPA, 2006). Table 3.1 shows the increase in visitors in the PDNP from 1986-1996 above and below the A57.

Table 3.1: Mean number of visitors North and South of the A57 in the PDNP from 1986-1996).

	Mean Daily Number of Visitors	
	1986	1996
South of A57*	58.0 (8.9)	119.8 (10.4)
North of A57**	212.2 (23.0)	214.4 (17.6)

(Original Source: Pearce-Higgins and Yalden, 1997.)

***Some grouse moor, South West, White Peak.**
****Predominately grouse moors on Dark Peak.**

Finney *et al.* (2005) recognises the increase in recreation in the British uplands and highlights the issue of increasing public access in the form of the Countryside and Rights of Way (CROW) act. Finney *et al.* (2005) goes on to state that there may be an impact of the recent legislation on the upland bird assemblage including species of international importance.

Hanworth and Thompson (1990) associate SPA designation species including curlew, golden plover and dunlin with low disturbance; increasing visitors would therefore have the potential to decrease populations. It is however pointed out by Pearce-Higgins and Yalden (1997) and Finney *et al.* (2005) that by simply providing adequate footpaths there is a decreased chance of disturbance to any breeding birds. Hudson (1982) also shows that levels of visitors had no effect on the bags of grouse which were shot in the uplands.

A negative aspect of foot traffic is highlighted by Hudson (1982) who points out that dogs off the lead have the potential to disturb ground nesting birds to a far greater extent than humans. Table 3.2 shows that within the PDNP the proportion of dogs on a lead has increased from 1986-1996. The proportion of dogs running wild, however, has also increased. This situation could have the potential to disturb the birdlife (Pearce-Higgins and Yalden, 1997).

Table 3.2: Observations of dogs on leads, off leads and running wild in the PDNP 1986-1996.

Year	On lead	Off lead	Running Wild	Total
1986	94 (33.6%)	162 (57.9%)	24 (8.6%)	280
1996	118 (42.4%)	121 (43.5%)	39 (14.0%)	278

(Source: Pearce Higgins and Yalden, 1997.)

3.4 Water Management

Water management is a constant feature of the uplands due to the continuous human need for this service (English Nature, 2001). The water companies own substantial amounts of land throughout the UK which have been acquired in order to protect the quality of the water which is being supplied to an increasing population (Yorkshire Water, 2006).

Within the PDNP there are 55 reservoirs which are above 2 hectares in size and collectively supply over 450 million litres of water to surrounding major cities including Manchester, Sheffield, Derby and Nottingham (PDNPA, 2006). The Derwent valley plays host to three of the largest reservoirs; Howden, Derwent and Ladybower which together cover a massive 340 hectares. Other reservoirs are found in the Goyt and Loxley valleys (PDNPA, 2006).

It is the water companies (Yorkshire water, Severn Trent water) who own the reservoirs and a large proportion of the surrounding catchment's, with approximately 15% of the park under their control (PDNPA, 2006). The reason the water companies own much of the land was to control the water quality going into their reservoirs; however there is now little need for monitoring due to improved treatment works (Yorkshire Water, 2006).

As well as being water reserves the reservoirs have a dual role as a tourist attraction, with over two million visitors attracted to the water bodies each year (PDNPA, 2006). Water and tourism is a good example of co-existing land uses with the public's access to the reservoirs also being protected under the Water Act of 1973 (PDNPA, 2006).

3.5 Forestry

It was pointed out by Tapper (2005) that the entire British upland area was once covered by trees and it was the early hunters (9000-4500 BC) that began to clear the forest through accidental and later planned fire. Tapper (2005), goes on to state that large clearings in the woodland were made to make way for grazing which also paved the way for the establishment of species including heather (*Calluna vulgaris*) which was originally a forest floor species.

The British uplands are usually described as 'treeless' especially when compared to sites at similar altitudes in Europe (Tapper, 2005). After the Second World War the potential of the uplands for plantations was realised. The existing government, with the aid of the Forestry Commission (FC) initiated large scale plantings on substantial tracts of the heather moorland (Forestry Commission, 2006). Subsidies were provided to make the woodland option attractive to landowners (Tapper, 1999).

The planting regime continued until the 1980's when the value of the heather moorland and its associated bird assemblage was taken into account (Tapper, 1999). This was however after much of the damage had occurred with Hudson (1992) highlighting the fact that 20% of the uplands had become afforested, with heather moorland the main victim. It is stated by Gibbons *et al.* (1993) that forestry has the potential to seriously affect the breeding success of the golden plover (*Pluvialis apricaria*); an SPA designation species, with Hudson (1992) asserting that this may be due to its characteristics as a predator habitat.

Specifically within the PDNP there are large amounts of woodland much of which is owned by the water companies and Forest Enterprise (FE), a substantial proportion of which is situated within the Derwent valley (PDNPA, 2006). The NPA own and manage 480 hectares themselves primarily for wildlife and recreation. The Forestry Commission (2006) pointed out that inappropriate plantations, an example of which is in the Goyt valley, will be felled under a new ten year conservation-based management plan in line with environmentally friendly practice.

3.6 Grouse Shooting

Grouse shooting in the uplands of Britain has been especially prevalent in the last 100 years, (Hudson, 1995, Tapper, 1999) where over 47,300 km² of moorland and pastures (747 estates) have been recorded in the past as being under management for grouse shooting (Hudson, 1995).

There are two main forms of grouse shooting. The first method is 'driven' and is briefly described by Hudson (1992) as a line of 8-10 guns shooting birds which are driven towards and over them by a line of beaters. The second method is 'walked up' and is described as any number of people, walking through the moorland, often with dogs which will point and flush the birds to shoot (Hudson, 1992).

The rise in popularity of grouse shooting can be largely attributed to the advancement in shotgun technology with the invention and adoption of the breech loading shotgun (Tapper, 1999). It may also owe a debt to Queen Victoria who purchased the Balmoral estates around the turn of the century, making the sport popular amongst the British gentry (Hudson, 1995). Tapper (1999) goes on to state that the numbers of gamekeepers increased as the sport became more fashionable.

The end of the Second World War signalled the beginning of a decline in the numbers of grouse and the popularity of the sport. Tapper (1999) suggests that increased sheep farming, especially in the uplands, and forestry activity in conjunction with government incentives are partly to blame for the reduction in grouse numbers by 82% between 1911 and 1980.

There may also be argument that reduced numbers of gamekeepers after the war years lead to an increase in predators (especially the red fox *Vulpes vulpes*) which in turn may have had a much greater effect on the abundance of grouse (Hudson and Newborn, 1995).

3.6.1 Economics

It is suggested by Hudson (1995) that grouse shooting can bring considerable economic benefits to the English uplands. The benefits are largely seen within local hotels, B+B's, shops and restaurants. It is pointed out by Robertson (2002) that grouse moors themselves typically

run at a financial loss which is offset by the sporting benefit received by the owner of the sporting rights.

Robertson (2001) goes on to imply that recent times have called for commercialisation of the grouse moors which have potential to provide income for the owner. It is common for a client to pay £50 – 70 for a brace of driven grouse with £20-40 expected for walked up shooting (Hudson and Newborn, 1995). With this in mind, grouse moors are increasingly being looked at as businesses and not just sporting assets for the owner.

It is the view of Tapper (2005) that it is not only the grouse moor owners that are benefiting from the substantial investment in grouse shooting but nature conservation as a whole.

3.6.2 Keepering

Hudson and Newborn (1995) assert that a keeper is vital to a productive grouse moor with Tapper (1999) confirming that the majority of gamebird shooting in the UK could not occur without the influence that a gamekeeper exerts on the land. There are few examples contradicting this with Baines (1996) proposing that black grouse (*Tetreo tetrix*) breeding success is not related to the presence of a keeper.

Unlike density of birds on a typical red-legged partridge (*Alectoris rufa*) or pheasant (*Phasianus colchicus*) shoot, grouse numbers can't be artificially buffered by introducing reared birds (Hudson and Rands, 1988). This means that the environment which the grouse inhabit must be enhanced to give the birds the best chance of breeding thereby producing a shootable surplus. Hudson (1982) states that grouse can be efficiently harvested using driven shooting when the densities are around 60 birds/ km².

Hudson (1995) and Tapper (1999) both assert that predator control and habitat management, specifically through appropriate heather burning regimes, are vital to the success of a grouse moor, these two gamekeepering tasks are detailed below:

3.6.3 Predator control

Tapper (1999) highlights the main predation threats on moors managed for grouse as coming from the Red Fox (*Vulpes vulpes*) Carrion Crow (*Corvus corone*), Stoats (*Mustela erminia*)

Weasels (*Mustela nivalis*) and from the assemblage of raptors. However; Hudson (1995) points out that only the killing of foxes, carrion crows, stoats and weasels is legal with the raptors enjoying protection under the wildlife and countryside act 1981.

Hudson and Newborn (1995) highlight the fact that although stoats and weasels provide a threat to the ground nesting bird populations, this threat is not significant when compared to the predation capabilities of crows, foxes and some raptors.

Red Fox (*Vulpes vulpes*)

Seymour *et al.* (2003) describes the fox as the most prolific nocturnal predator with Tapper (1999) confirming that a major part of its diet is small game birds which includes red grouse. It is believed that the population of foxes is stable and possibly increasing which may be due to a major reduction in natural predators (Golden Eagle, Wolf, Lynx) as well as an increase in the urban fox population which have adapted to thrive alongside humans (Tapper, 1999).

Hudson (1995) noted that moorland with fox control had higher levels of grouse, irrespective of heather management. The same author goes on to suggest that there are increased numbers of foxes in Scotland due to decreasing numbers of gamekeepers.

There are specific ways of carrying out fox control which are described by the British Association for Shooting and Conservation (BASC) (2006) as shooting and snaring. 'Shooting' with a small bore rifle is often carried out at night when the fox is active; a high powered lamp is used to identify the species. 'Snaring' is a non lethal method of trapping and holding the animal around its neck until it can be humanely dispatched.

Carrion Crow

Tapper (1999) describes the Carrion Crow as being widespread, common and increasing in range and number within the UK. Cox *et al.* (2004) states that the crow is a frequent egg predator, which makes it a particular threat to the populations of red grouse on moorland; a favored habitat. Moorland locations are also often associated with high levels of sheep farming

which provide the crow with further food opportunity through the increased levels of carrion (Tapper, 1999).

The habitat requirements of the Crow are described in more detail within chapter 5.3.9 which describes the adaptability of the species with the major requirements being food availability and roost/nesting location.

Green *et al.* (1987) conclude that the predation of the eggs of ground nesting birds is an important factor in determining their future populations. It is because of this that the crow is persecuted by gamekeepers. It is recommended by Hudson and Newborn (1995) that continuous crow control should be undertaken on all land on which a serious shoot is undertaken; although Tapper (1999) shows that gamekeepering only has a regional effect on the national population of the species.

BASC (2006) describe the methods of reducing numbers of Carrion Crows as shooting and trapping. 'Shooting' is often undertaken with small bore rifles as and when a gamekeeper has opportunity. 'Trapping' is a more structured approach to crow control with a variety of traps being used to attract either territorial or flock motivated birds. The birds will be humanely dispatched once they are caught.

3.6.4 Raptors on Grouse Moors

There are a range of raptors which use moorland habitat; These include; Merlin (*Falco columbarius*), Hen Harrier (*Circus cyaneus*), Buzzard (*Buteo buteo*), Goshawk (*Accipiter gentilis*), Sparrowhawk (*Accipiter nisus*) and Peregrine Falcon (*Falco peregrinus*). Out of these species a particular research focus has been on the Hen Harrier (Tapper, 1999; Tapper and Hughes, 2002).

Raptors are often linked to grouse shooting under a negative light which is mainly due to the persecution which gamekeepers have been know to exude on them (Tapper, 1999). Indeed Green and Etheridge (1999) describe the breeding success of the hen harrier to be much less on moorland managed for grouse, suggesting that persecution is the main cause. Watson and Thirgood (2001) support the statement by suggesting that illegal persecution of hen harriers is ongoing, and a limiting factor in translocating birds to active grouse moors.

It can be argued that there is reason behind the illegal control of birds of prey with Redpath (2001) describing the loss of 25% of grouse on a Scottish moor as down to raptors and Tapper (1999) specifically mentioning the hen harrier as being responsible for drastically decreasing the numbers of grouse on a moor.(Tapper and Hughes, 2002).

Of the main raptors listed above, the Peregrine and Goshawk are major threats to fully grown grouse with Sparrowhawks and Buzzards known to take adults on the rare occaision (Tapper 1999). Merlin's (Petty *et al.* 1995) and Hen Harrier's (Smith *et al.* 2001) are specialist small bird and mammal feeders which can have a larger effect on grouse chicks rather than adult birds.

3.6.5 Predation of Other Upland Bird Species

On a grouse moor it is important to recognize that the grouse themselves will not provide the only food source.

Foxes in particular will have an effect on most ground-nesting birds. (Tapper, Potts, Brockless, 1996). This includes waders, who nest on the ground. Seymour *et al.* (2003) states that in areas of particularly high wader density the fox will spend extended periods of time looking for clutches or chicks. However; Berg *et al.* (1992) points out that the risk of the lapwing (*Vanellus vanellus*) being predated in a large colony is less than that of individuals.

Predation of eggs of many ground-nesting birds is often by carrion crows and even inland gulls (*Larus fuscus)*. Parr (1993) undertook an experiment removing crows and gulls from a lapwing breeding colony which resulted in no change in lapwing density; however a change was observed with other passerines. This result was mostly attributed to the non-removal of the fox which may have been the dominant predator.

Passerines are at less risk from ground-based and egg-focused predators due to their often inaccessible nests and the difficulty with which they are caught. The majority of the raptors will however regularly take small birds with the possible exception of the Buzzard (Tapper, 1999). The Sparrowhawk, Merlin and Hen Harrier are described by Cramp (1977) as specialist small bird feeders. Smith *et al.* (2001) describes the relationship between the Meadow Pipit (*Anthus pratensis)* a particularly prevalent passerine in the PDNP, and the Hen Harrier as

being related. The Meadow Pipit density was seen as being a good indicator of Hen Harrier abundance.

3.6.6 Grouse Habitat

Grouse moors are generally dominated by heather (*Calluna vulgaris*) which is the principal requirement in the diet of the mature red grouse (Tapper, 1999). Hudson (1992) states that the distribution of red grouse is limited and contained by the strongholds of heather moorland which Tapper (1999) identifies as being found primarily in the British uplands.

In order that the habitat is enhanced for the benefit of the grouse to breed, feed and shelter from the elements and predators it must be maintained. Hudson and Newborn (1995) recommend suitable management tasks which include heather burning, cutting, and re-seeding as well as bracken control; usually on an annual basis. Conversely; it is however the view of Thirgood *et al.* (2002) that providing grouse with adequate cover from aerial predators e.g. hen harriers has no effect on the populations. The same authors continue by stating that solutions such as removing passerine habitat would discourage the raptors out of the breeding season possibly causing them to relocate.

3.6.7 Burning

Burning for grouse and sheep is an activity which has been occurring in the uplands since at least the 1800's (Tapper, 1999; Hudson and Newborn, 1995). The original practice of burning allowed both grouse and sheep to coexist in a mutually beneficial manner which was ongoing until grazing pressure became too much in many areas (Tapper, 1999).

Tharme *et al.* (2001) and Hudson (1992) concluded that heather burning has a positive effect on the populations of red grouse. Hudson and Newborn (1995) describe the process of heather burning as removing the leggy, degenerate, woody growth which has little nutrition value, and replacing it with nutritionally superior young plants. The same authors go on to state that each burn (30m wide and up to 200m long) should be rotationally burnt every 8-30 years with a proportion of the moor being burnt each year.

Burning on a yearly basis ensures that a mosaic of heather heights is maintained, providing optimum, feeding, breeding and sheltering habitat for grouse. Burning also ensures that heather is not out competed by grass species e.g. purple moor grass (*Molinia caerulea (L.)*)

which would replace the heather, degrading the habitat for grouse (Hudson and Newborn, 1995). It is proposed by Ross *et al.* (2003) that on wet heathland, burning encouraged purple moor grass and land managers should be cautious that it does not dominate in the first three years.

Hudson (1992) also states that the burning of heather is beneficial to sheep which may graze the moor. Burning patches of heather within the bulk of the moor will attract sheep from moorland edge and therefore disperse any potential negative impact of grazing. Negative impacts of burning are observed by Smith *et al.* (2001) who found that assemblages of bird species declined with the amount of heather burnt.

3.6.8 Cutting

Cutting basically performs the same function as heather burning by removing the unwanted mature heather from the moorland allowing the young heather to establish (Hudson 1992). It is however the view of Calvo *et al.* (2002) that cutting does not encourage as much regeneration as burning. Miller and Miles (1970) suggest that the best regeneration results are gained from cutting in the spring, where as burning in the autumn encourages more seedlings. Cutting also involves increased cost with machinery being used to perform the action; whereas burning is cost effective with low financial input (Hudson 1992). It is argued by Hudson and Newborn (1995) that cutting can occur in a wider variety of weather conditions.

3.6.9 Re-seeding

In the past 10 years there has been a focus on the reseeding of moorland which has been degraded/eroded by factors such as overgrazing, or has been dominated by grasses e.g. purple moor grass (Henderson *et al* 2004).

The conservation activities are in part due to the acknowledgement of heather dominated moorland as an internationally important habitat (Stillman and Brown, 1994), as well as an increased demand for grouse shooting which may have increased potential for revenue (Hudson and Newborn, 1995).

Bayfield (1980) found that it is possible to successfully re-seed heather up to an altitude of 850m. Specifically within the PDNP there has been a significant amount of re-seeding. A recognised example of this is the 'Howden' moor which is owned by the National Trust and has been largely reverted from grasses to heather dominated moor over a ten -year period (Pers comm. Eyres 2005).

3.6.10 Bracken Control

Pakeman *et al.* (2002) describes bracken (*Pteridium aquilinum*) encroachment as a significant problem in the moorland environment. Within the North York Moors National Park 86% of the estates were controlling bracken for sporting purposes with a further 14% controlling with sheep in mind. (Graham, 2001) Pakeman *et al.* (2002) suggests that herbicides are the best method of controlling the plant on moorland as it has no significant effect on the health of any heather which is present. Tong *et al.* (2005) experimented with restoration of moorland within the North Peak ESA. The study concluded that it is possible to achieve bracken control with a variety of species (including heather) establishing in its stead. The study did however highlight the difficulty of establishing mire communities which tend to have a complicated composition.

Added to the main management techniques described above Hudson (1995) suggests that young plantations are beneficial for black grouse (*Tetrao tetrix*) with the same author in 1992 highlighting the need for land drains to be maintained in order to provide water points, and encourage a range of invertebrates for grouse chicks.

CHAPTER FOUR: UPLAND HABITATS

4.1 Definitions of Upland

Uplands are classified by English Nature (2001) and Macdonald *et al* (2001) as being generally above 250m; however much confusion exists on a specific boundary between upland and lowlands.

4.2 Moorland

Sim *et al* (2005) states that much of the British uplands is composed of moorland while Stillman and Brown (1993) suggested a figure of 30-35% land cover. The Institute of Terrestrial Ecology (ITE) (1990), now known as the Centre for Ecology and Hydrology (CEH) found that of the area classified as upland vegetation; 32% was estimated to comprise bog, 37% heathland and 31% grassland. It was however found by Tharme *et al.* (2001) that on moors managed for grouse the majority of the moorland comprised heath (76%), with grasses representing 12% and bog 8% of the respective moor area.

Tapper (1999) defines moorland as semi-natural with (Darlington, 1978) describing moorland soils as peaty and acidic, with high amounts of precipitation occurring over the naturally high lying areas. Darlington (1978) goes on to define the moorlands into three separate groups; 1) heather (*Calluna vulgaris*) dominated moor, often with bilberry (*Vaccinium myrtilus*) on dry soils; 2) bilberry dominated moor, often on deeper peaty soils at higher altitude, and 3) cotton grass *Eriophorum* dominated moor often with a wet sandy soil layer.

English Nature (2001) updated the definitions into four distinct habitats:

4.1.1 Dry dwarf shrub heath

This is habitat usually found above 600m, and the intensive agricultural line. It is dominated by dwarf shrubs particularly heather, (*Calluna vulgaris*) bilberry, (*Vaccinium myrtilus*)

crowberry, (*Vaccinium vitis-idaea)* and bearberry (*Arctostaphylos uva-ursi*). The community is associated with mineral rich and thin peaty soils.

4.1.2 Wet heath

Habitat found on peaty soils around 0.5m deep. Dominant species include cross leaved heath (*Erica tetralix),* with other dwarf shrub species e.g. bilberry and heather not uncommon. Bryophytes are frequently found in abundance alongside purple moor grass (*Molina caerulea*) and heath rush (*Juncus squarrosus*).

4.1.3 Mire

There are many mire types within the uplands with Rodwell (1991) describing 38 categories within the NVC. A particularly prevalent community is blanket bog which is a wet habitat, generally nutrient poor and covers a wide range of unconfined peatlands. Many of the species found here are also listed within Annex I of the Habitats Directive (English Nature, 2001)

4.1.4 Grasslands

Grasslands within the unenclosed uplands are divided into acid, calcareous and neutral. Acid grasslands are the most prevalent, deriving from tight grazing of dwarf shrubs. Species including sheep's fescue, (*Festuca ovina*) common bent, (*Agrostis capillaries*) and mat grass (*Nardus stricta*) are common but nutrient poor. Purple moor grass and rush pasture are also common within moorland swards.

Of the moorland categories, heath and mire contain species which are of international importance (English Nature, 2001). Of particular importance is the heather moorland community which Thompson *et al.* (1994) summarises into 19 plant communities. 5 of the communities are only found within the UK, with a further 6 having better representation in Britain than elsewhere. Of the 19 species 13 are listed within the habitats directive. Simpson *et al.* (1998) groups heather moorland into different stages which can be seen in Table 4.1

Heather Type	Definition
Newly Burnt Heather	Less than 2 years old
Pioneer	Less than 15cm tall
Building	15-30cm tall
Mature	30-40cm tall
Degenerate	Greater than 40cm tall
Suppressed	Heather kept short by climatic conditions
Blanket Bog	Normally waterlogged

Table 4.1: Stages of heather establishment.

(Source: Simpson et al. 1998.)

There is also a range of other habitats which comprise smaller proportions of the uplands which include inbye land and woodland. (English Nature, 2001)

4.1.5 Inbye land

Inbye land is described as areas of enclosed uplands or croftland within the hill farming communities of the uplands. The land typically divides the unenclosed moorlands above and the intensive agricultural lands below. The inbye lands are often farmed at lower intensities than agricultural systems and are therefore ideal habitats for many birds some of which are internationally important (English Nature, 2001).

4.1.6 Woodlands

Woodlands were once the single major habitat over the British uplands and it is still a feature which is present and which was increasing until the 1980's. It is suggested that the uplands of Britain are relatively treeless compared to some comparable locations in Europe (Tapper, 1999; 2005). (Upland forestry is discussed further in chapter 3.4.)

4.2 Habitat Change in the Uplands

There has been increasing change in upland habitats since early hunters began clearing the blanket woodland to make hunting, and later stock-rearing, a simpler task (Tapper, 1999; 2005). Woodland floor species including heather (*Calluna vulgaris*) established within the open areas, enjoying great success as a shrub of the open landscape.

The last century has seen much of the major change in the uplands with the Second World War initiating a production-orientated nation (Tapper, 1999). Thompson *et al.* (1994) states that woodland increased from 6% in the 1930's to 30% in the 1980's with heather reducing by 34% in the same period. Hudson (1982) and Hudson and Newborn (1995) assert that over intensive sheep farming as a result of government incentives was a major factor in degrading much of the moorland. It is the view of Fuller and Gough (1999) that the bird assemblage was negatively affected by the change to intensive land uses. Specific changes in the major land uses are discussed in chapter 3.

More recent environmentally friendly thinking by the government may give rise to another change in the upland land management which will provide a more conservation orientated upland landscape. Designations such as Environmentally Sensitive Areas, Sites of Specific Scientific Interest, Special Protection Areas and Special Areas of Conservation, will provide valuable funding to maintain and restore the environmental value of the uplands (DEFRA, 2006). It is the view of Tapper (1999) and Baines *et al* (2002) that there should be a mosaic of habitats within the uplands to support the maximum amount of species.

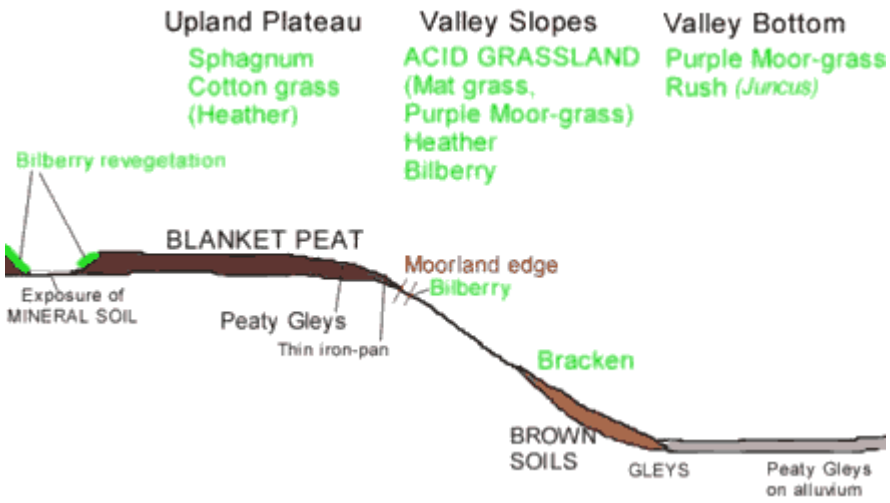
4.3 Habitat within the Peak District National Park

The PDNP is a sound example of an upland environment which includes significant proportions of important habitat. The National Park is divided roughly into three distinctive areas; the Dark, White and South West Peaks. The areas are described by the PDNPA (2006).

4.3.1 Dark Peak

The Dark Peak is a characteristic British moorland area with tracts of open heather, bilberry and cotton grass moorland with the additional presence of acid grassland (Purple moor grass)

at lower altitudes (Fig. 4.1). Some valleys of the Dark Peak have also been utilised as reservoirs and play host to strips of woodland along their slopes. Grit stone outcrops and ridges (Fig. 4.2) are a common feature throughout the entire landscape.

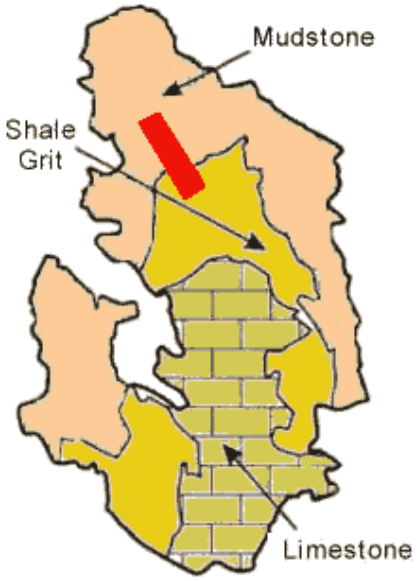


(Source: PDNPA, 2006.)

Figure 4.1: Vegetation and soils on the Dark Peak.

4.3.2 White Peak

The White Peak is a direct contrast to the Dark Peak with rolling grass dales based on a carboniferous limestone plateau (Fig. 4.2) at a typical height of 350m.The landscape is cut with seasonally fast flowing rivers and elm woodlands. The grasslands are comprised of intensive pasture for dairy farming as well as a small number of traditional hay meadows.



(Source: PDNPA, 2006.)

Figure 4.2: Underlying geology of the PDNP.

4.3.3 South West Peak

The South West Peak contains a plateau of moorland which falls down to pastures and hay meadows in the south. Softer valleys can be observed with characteristic upland rivers and streams. Isolated grit stone ridges (Fig.4.2) are still present but not in the numbers which are seen in the north of the district. Multiple land uses can be observed with shooting and sheep grazing on the moorland and some stock rearing on the lower ground.

4.4 Important Habitats

Within the PDNP there are two areas of specific habitat importance known as Special Areas of Conservation (SAC's); The Peak District Dales and The South Pennine Moors. The habitats include flora and fauna which have been identified as under threat on a European or International scale. The species are listed within annex 1 of the habitats directive (JNCC, 2006).

The Peak District Dales SAC was designated due to the presence of two important habitats:

1) Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*). This habitat is unparalleled within the UK due to its unique mosaic of heavily grazed grass, tall herb rich vegetation, calcareous scrub and *Tilio-Acerion* forests (JNCC, 2006).

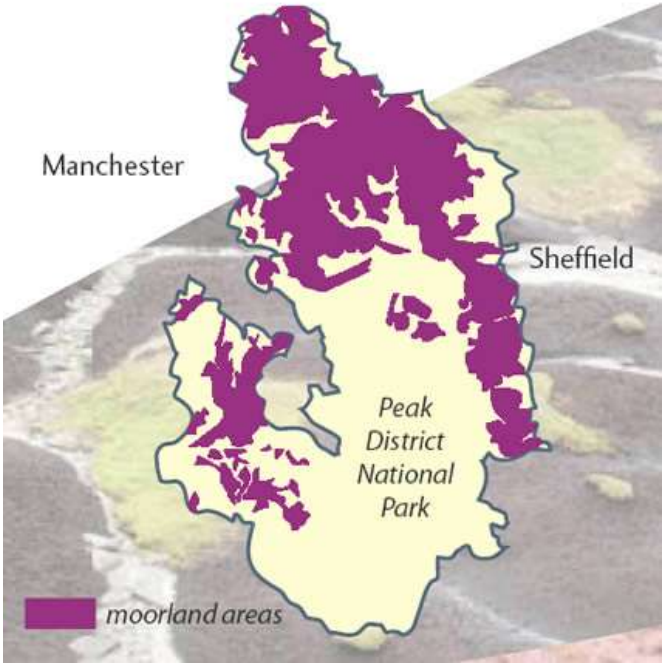
2) *Tilio-Acerion* forests: Woodland largely dominated by ash (*Fraxinus excelsior*) included in a unique succession. It is also host to uncommon woodland plants including green hellebore (*Helleborus viridis)* and mezereon (*Daphne mezereum*) (JNCC, 2006).

As well as the habitats, the SAC is also host to White Clawed Crayfish (*Austropotamobius pallipes*) which are present in the *River* Dove classified as a high quality upland limestone river. The crayfish is listed in annex 2 of the habitats directive (JNCC, 2006).

Added to the primary habitats and species used for designation, the area is also recognised as an important stronghold for European dry heaths, Calaminarian grasslands, Alkaline fens**,** Calcareous and calcshist screes of the montane to alpine levels and Calcareous rocky slopes with chasmophytic vegetation. Further important species which are present include the Brook Lamprey (*Lampetra planeri*) and Bullheads (*Cottus gobio*) (JNCC, 2006).

The South Pennine Moors SAC was designated due to the presence of three important habitats:

1) European Dry Heaths: This habitat covers vast areas of the peak district and is largely composed of heather (*Calluna vulgaris*) (Fig.4.3). The mass of heathland represents the most southerly habitat of its type in the uplands. Dry heath is habitat for a diverse range of invertebrates and a broad assemblage of bird species (JNCC, 2006).



(Source: PDNPA, 2006.)

Figure 4.3: Moorland coverage within the PDNP.

2) Blanket Bog: This habitat is the most south easterly of its kind in Europe. It is characteristically composed of Cotton Grass (*Eriophorum vaginatum*) in the wetter areas. Where the bog is drier there is significant representation of Crowberry (*Empetrum nigrum*), Heather (*Calluna vulgaris*) and Bilberry (*Vaccinium myrtillus*). Substantial areas of the Blanket bog are eroding leaving vast areas of bare peat (JNCC, 2006).

3) Old Sessile Oak (*Quercus petraea*) woods with *Ilex* and *Blechnum*: This habitat occurs around the moorland fringe and is commonly found on slopes. The woodland is found on drier soils and is enriched by alder *(Alnus glutinosa*) stands alongside rivers and streams (JNCC, 2006).

The South Pennine Moors SAC is not designated for any non-avian fauna.

CHAPTER FIVE: UPLAND BIRDS

5.1 Introduction to Upland Birds

Eighteen species of birds of European or international significance are found within the British uplands (Thompson *et al.* 1994). Many of these species are declining in the uplands most noticeably the waders (Sim *et al.* 2001). Declines are often attributed to the over intensification of the land through increased grazing and afforestation which occurred post Second World War (Tapper 1999; 2005).

5.2 Important Birds within the PDNP

5.2.1 Special Protection Area Designation Species

Within the PDNP there are a six species included under annex 1 of the 'Birds Directive' which are present in important numbers. These are; Golden Plover (*Pluvialis apricaria),* Dunlin (*Calidris alpine),* Curlew (*Numenius arquata*), Merlin (*Falco columbarius*), Ring Ouzel (*Turdus torquatus*) and Whinchat (*Saxicola rubetra)* (Sim *et al,* 2005) It was a result of the presence and abundance of the above six species that the Peak District Moors Special Protection Area (SPA) was designated (DEFRA, 2006).

There are also annex 1 species which are present in small numbers within the PDNP, and therefore do not form part of the SPA designation criteria, these include: Black Grouse (*Tetrao tetrix*), Short-eared Owl (*Asio flammeus*), Peregrine Falcon (*Falco peregrinus*) and Hen Harrier (*Circus cyaneus*) (Carr and Middleton, 2004).

5.2.2 PDNP Biodiversity Action Plan Species

As well as species which are recognised on a large scale, there are also birds which are seen by the Peak District National Park Authorities as being of specific regional/local importance and are designated under the PDNP's Biodiversity Action Plan (BAP). These include the Curlew (SPA species), Twite (*Carduelis flavirostris*) and the Lapwing (*Vanellus vanellus*) (PDNPA, 2006).

5.2.3 Grouse moor associated birds

Added to these species, a significant proportion of the PDNP is managed for Red Grouse (*Lagopus lagopus*) shooting, making it one of the most characteristic and abundant birds of the area. (Carr and Middleton, 2004) Another member of the bird assemblage within the PDNP is the Carrion Crow (*Corvus corone*). It is an important predator often feeding on grouse nests as well as preying on young lambs (Hudson, 1992; Hudson and Newborn, 1995).

5.2.4 Red, Amber and Green listed Species

The Red, Amber and Green listing system was applied to all birds within the UK. A steering group comprised of both governmental and non-governmental bodies was established to collectively group research and viewpoints, in order to define species of conservation concern. A red listed status (40 species) would relate to species which are globally threatened with historical decline (1800-1995) with rapid reductions in breeding and range (> 50%) in the last 25 years. Amber and green listings applied to species with relatively less threatened populations (BTO, 2006).

The PDNP has many red and amber listed species within it, the most important of which are already listed under other designations above (PDNPA, 2006).

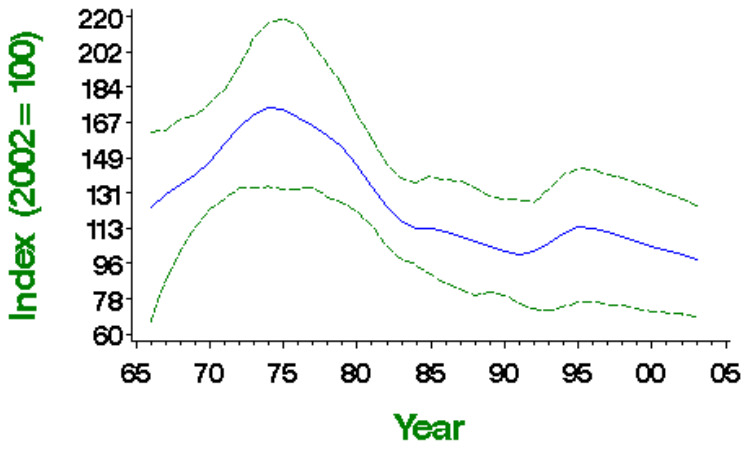
The important upland moorland birds identified above are examined in detail in section 5.3 with other characteristic birds of the PDNP. Specifically the upland and PDNP population status of these species are summarized along with the habitat requirements of each species.

5.3 Accounts of specific Upland Moorland Birds within the PDNP

5.3.1 Curlew (*Numenius arquata*)

Conservation Importance - Amber list, Annex 1 of the Birds Directive, PDNP BAP.

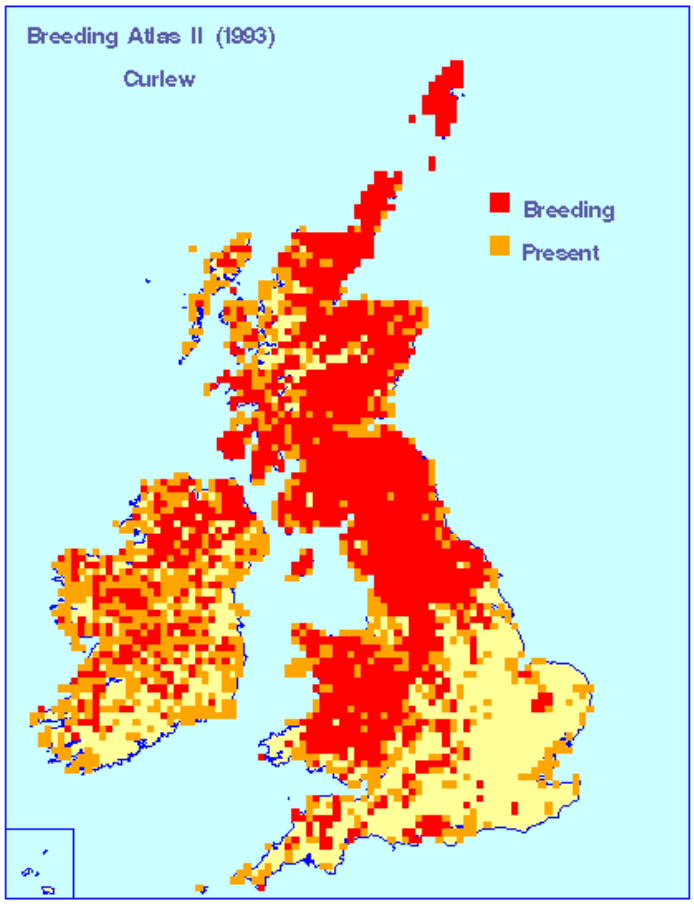
The Curlew is the largest European wader and has undergone historical declines (Fig 5.1) and is therefore a specific conservation concern (BTO, 2006). The decline is often attributed to declines in traditional hay meadows (Cramp, 1977) and to nest predation pressure from Carrion crows (*Corvus corone*) and Ravens (*Corvus corax*) (Gibbons *et al*, 1993).



(Source: BTO, 2006.)

Figure 5.1: CBC/BBS Curlew (*Numenius arquata)* population From 1967-2004.

This distinctive wader prefers a range of unimproved upland habitats (Fig 5.2), including heather (*Calluna vulgaris*) moorland and inbye land. (Tharme *et al.* 2001; Stillman and Brown, 1994) , mixed grasses (Jenkins and Watson, 2001; Baines, 1992) and peat. It is stated by Cramp (1977) that this species particularly favours recently burnt stretches of moorland.



(Source: BTO, 2006.)

Figure 5.2: Distribution of Curlew (*Numenius arquata)* in 1993 in the UK.

Tharme *et al.* (2001) describes Curlew density as being twice as high on managed grouse moors with the Carr and Middleton (2004) suggesting that the most favoured locations are moorland sites in close proximity to inbye land. There is also evidence that Curlew have a preference for lower ground - below 100m (Stillman and Brown, 1994; Gibbons *et al*. 1993).

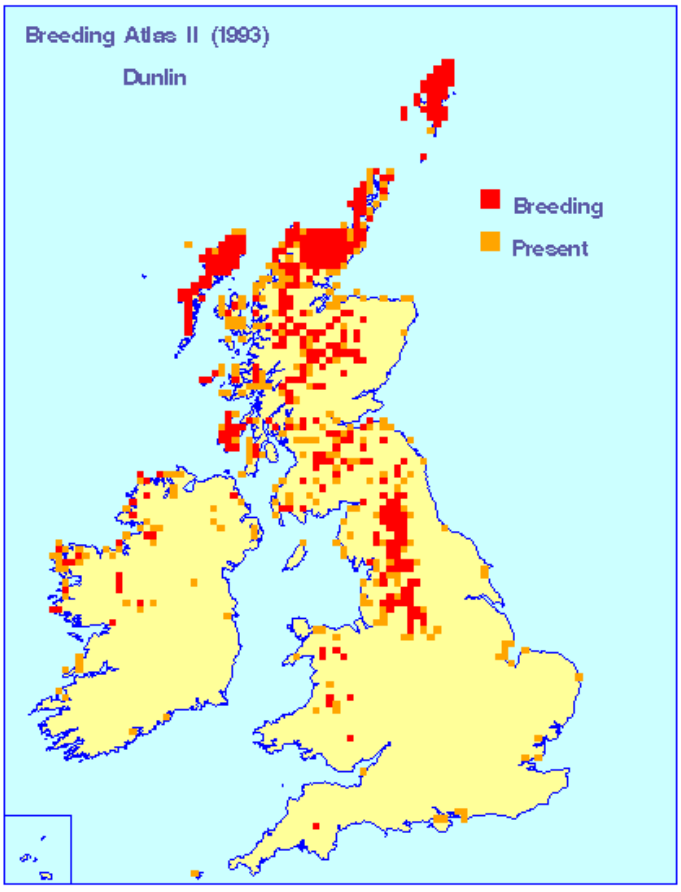
Sim *et al.* (2005) highlights the decline in the Curlew throughout the British Uplands during the last 10-20 years. This decline is however not applicable to the South Pennines where a substantial increase in the species has been observed. This increase is in line with the findings of Stillman and Brown (1994) who asserted that the population in the South Pennines was improving. Within the PDNP this trend was observed between 1990 and 2004, with an increase of 194 pairs over the area (Carr and Middleton, 2004).

5.3.2 Dunlin (*Calidris alpine*)

Conservation Importance- Amber listed, Annex 1 of the Birds Directive.

The BTO (2006) included Dunlin on their amber list due its declining status in the UK (Gibbons *et al*. 1993) and labelled it as species of conservation concern. The status of the species is often associated with afforestation of the upland moors which may be due to advances in forestry technology (Lavers and Haines-Young, 1996; Gibbons *et al*. 1993).

The Dunlin is a typical seasonal bird of the British upland moorlands (Fig. 5.3) which favours areas of wet blanket bog. (Stillman and Brown, 1994). Cramp (1977) states that Dunlin generally avoids shrubby plants although it does have associations with areas of short burnt heather.



(Source: BTO, 2006.)

Figure 5.3: CBC/BBS Distribution of Dunlin (*Calidris alpine)* in 1993 in the UK.

Sim *et al.* (2005) provided evidence of a decline of the Dunlin in the British uplands, including the South Pennines. This decline is also observed within the PDNP where the numbers of

Dunlin have reduced from 91 pairs in 1990 to 67 pairs over the same area in 2004. It is however stated by Carr and Middleton (2004) that the Dunlin may be a scarce and localised breeder within the PDNP and is found exclusively on wet blanket bog.

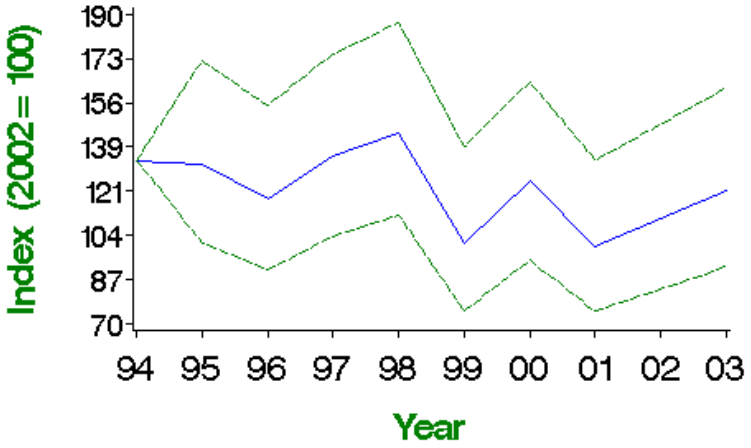
5.3.3 Golden Plover (*Pluvialis apricaria*)

Conservation Importance- Amber listed, Annex 1 of the Birds Directive

The Golden Plover is commonly associated with unenclosed upland including moors and peatlands. (Cramp, 1977) Gibbons *et al.* (1993) describes the associations with recently burned moorland which the plovers can easily run on. This is also the view of Stillman and Brown (1994) who state that the plover avoids tall vegetation and is commonly found at higher altitudes.

Tharme *et al.* (2001) indicates that the Golden plover is associated with levels of gamekeepering; the density of this species was five times higher on moors managed for grouse than on those moors not so managed. This view is supported by Gibbons *et al*. (1993) who showed that the species is related to the presence of keepering activities. There is also evidence that afforestation negatively affects the levels of the species (Gibbons *et al*. 1993).

Gibbons *et al.* (1993) states that the South Pennines support the most southerly populations of golden plover in the Uplands, described as stable by Sim *et al.* (2005). The population within the UK between 1994 and 2003 (Fig. 5.4) is also recorded by the British Bird Survey as stable (BTO, 2006). Within the PDNP, the population of plover has slightly decreased although this is not significant. In fact the densities of species are described by Carr and Middleton (2004) as amongst the highest in Britain especially on cotton grass/crowberry (*Eriophorum vaginatum*) dominated moorland.



(Source: BTO, 2006.)

Figure 5.4: BBS Golden Plover (*Pluvialis apricaria)* population From 1994 -2004.

5.3.4 Merlin (*Falco columbarius*)

Conservation Importance- Amber listed, Annex 1 of the Birds Directive.

Merlins have suffered a historic decline throughout Europe (BTO, 2006). These declines may be due to the loss of heather moorland to grass-dominated habitat as well as increased afforestation (Gibbons *et al*, 1993). It is however suggested by Cramp (1977) and Little *et al*. (1995) that merlin have been known to utilise woodland edge as nesting sites, specifically disused carrion crow (*Corvus corone*) nests. Gibbons *et al.* (1993) and Tapper (1999) also highlight the use of pesticides as contributing to merlin decline.

Merlins are associated with steep areas of Heather (*Calluna*) and Bracken (*Pterdium*) (Hanworth and Thompson, 1990) and prefer to nest on the ground in heather dominated upland moorland (Gibbons *et al*, 1993). Stillman and Brown (1993) recommend that tall heather is also a likely component of typical merlin habitat. Gibbons *et al.* 1993 asserts that that the level of gamekeepering on moorland may affect the species, due to possible persecution by gamekeepers.

Both Gibbons *et al*. (1993) and Cramp (1977) state that the merlin feeds primarily on small moorland birds such as skylark (*Alauda arvensis*) and meadow pipit (*Anthus pratensis)* and will hunt them over wide expanses of open moorland.

Stillman and Brown (1994) show merlin as being in higher than average proportions within the South Pennines. Carr and Middleton (2004) record the levels of merlins in the PDNP study area as seven breeding pairs with eight unconfirmed in 1990, with six pairs and 31 unconfirmed in 2004. This may suggest an increase. It is also the view of Carr and Middleton (2004) that the merlin is a rare breeder in the district and does not favour woodland habitats.

5.3.5 Short Eared Owl *(Asio flammeus)*

Conservation Importance- Amber listed, Annex 1 of the Birds Directive.

The short eared owl has suffered a historic decline but is recently showing signs of increasing in number (BTO, 2006). Declines have been attributed to the loss of moorland to woodland (Gibbons *et al.* 1993); however; Cramp (1977) suggests that young woodland is often an excellent habitat due to its open grassy nature and freedom from grazing and persecution.

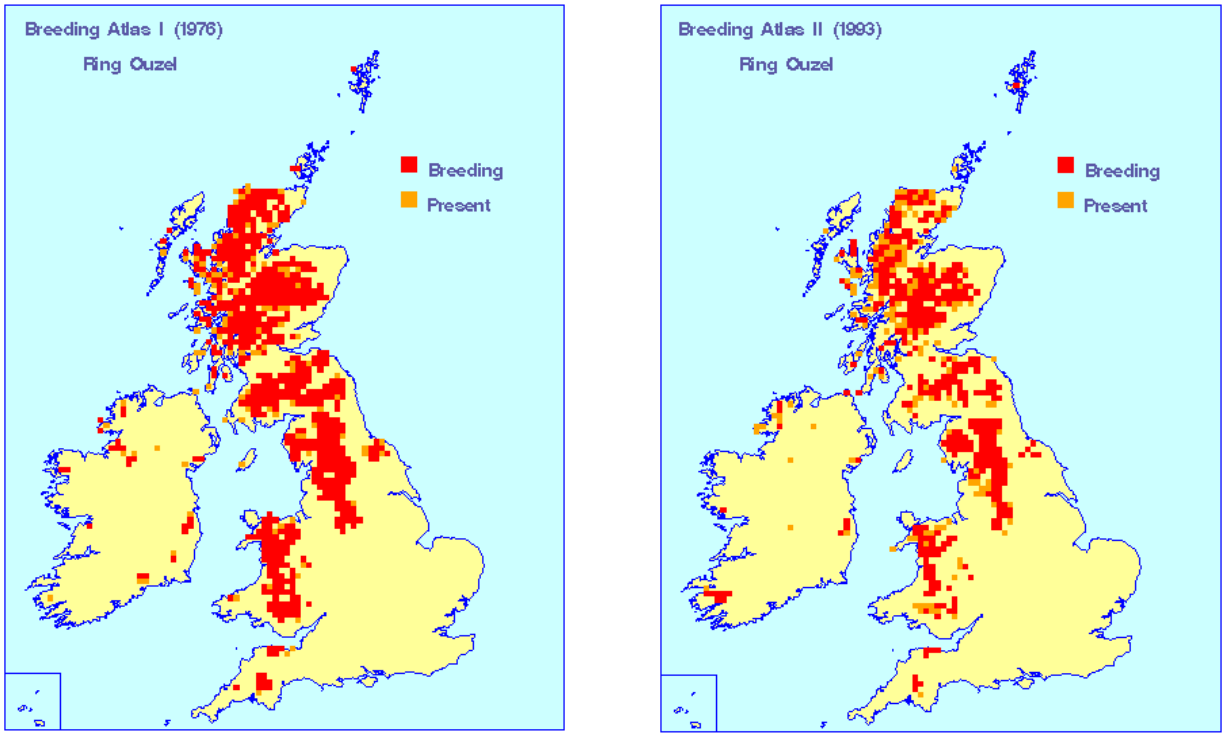
The short-eared owl is associated heavily with tracts of open moorland (Gibbons *et al.* 1993; Stillman and Brown, 1994) with Hanworth and Thompson (1990) stating that the species avoids blanket bog with a tendency for drier habitat, preferring grass and sedge. It is the belief of Gibbons *et al.* (1993) that the abundance of small mammals is a vital habitat requirement, with Cramp (1977) supporting the point by asserting that the abundance of prey is vital to the abundance of the owl.

Cramp (1977) suggests that in order for the species to thrive it should be undisturbed by man. Gibbons *et al.* (1993) agrees and adds that freedom from other predators is also a habitat requirement. Within the PDNP study area Carr and Middleton (2004) describe the bird as a rare breeder; however the results from the bird survey give a positive outlook for the species. In 1990 five breeding pairs were recorded with 18 pairs recorded over the same area in 2004; a substantial increase (Carr and Middleton, 2004).

5.3.6 Ring Ouzel (*Turdus torquatus*)

Conservation Importance- Red listed, Annex 1 of the Birds Directive.

The ring ouzel is a summer visitor to the PDNP and has suffered an historic population decline (BTO, 2006, Figure 5.5) Wotton *et al* (2002) notes the reduction in range of the ring ouzel as 27% between 1968-72 and 1988-91. Declines on specific study plots over time are also noted by Henderson *et al.* (2004). The declines are generally attributed to the decrease of heather dominated moorland, a favoured habitat.(Gibbons *et al.* 1993) There is also evidence provided by Cramp (1997) that in lower altitudes the backbird (*Turdus merula*) may be having a detrimental effect on the abundance of the species.



(Source: BTO, 2006.)

Figure 5.5: CBC/BBS distribution of Ring Ouzel (*Turdus torquatus*) from 1976-1993 in the UK.

Ring ouzels have strong associations with moorland habitat above 250m, which may include both heather (*Calluna*) and bracken (*Pterdium*) (Henderson *et al*. 2004) It is also stated by Gibbons *et al.* (1993), Wotton *et al.* (2002) and Cramp (1977) that small, stunted trees are also a desirable habitat requirement. The species will nest under stands of heather or in small trees

(Wooton *et al*. 2002). Gibbons *et al.* (1993) also suggest that upland ring ouzels will nest in crags, gullies, and cloughs and will fly considerable distance to reach open moor, especially when feeding young.

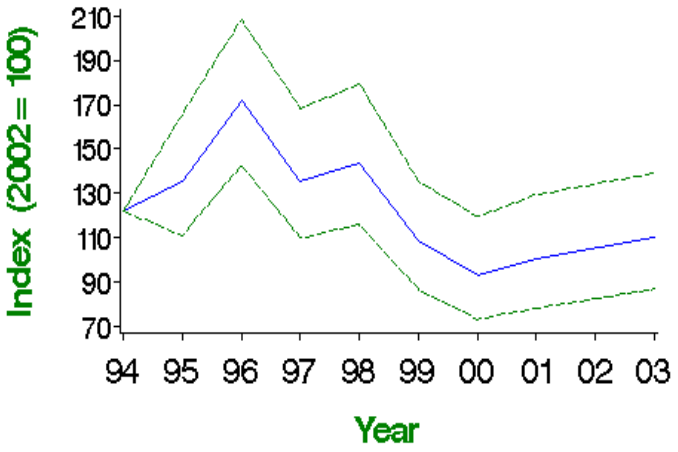
Sim *et al.* (2005) describes the upland population of ring ouzels as declining between 1988-91 and 1999. The data from the MFF bird survey would support this, with the ring ouzel decreasing by 15 pairs on the same study area from 1990 to 2004. The species was commonly found on areas of moorland edge (Carr and Middleton, 2004).

5.3.7 Whinchat (*Saxicola rubetra)*

Conservation Importance- Annex 1 of the Birds Directive.

The whinchat is a common summer visitor to the British uplands and has suffered declines along with many other passerines due to agricultural intensification. (Gibbons *et al.* 1993; Britschgi *et al.* 2006) Figure 5.6 illustrates the overall decline in the species from 1994-2003. (BTO, 2006) In an experiment conducted by Henderson *et al*. (2004) it was found that whinchat were found on less than half of the number of plots which they were originally recorded. Figure 5.7 highlights the UK locations where the species has suffered loss of breeding sites.

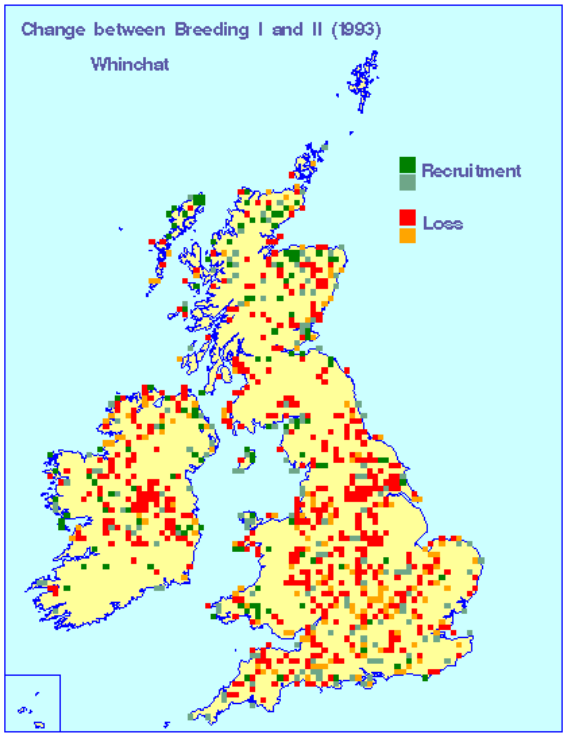
Cramp (1977) and Stillman and Brown (1994) state that the whinchat has associations with bracken (*Pterdium*)and other tall herb species up to 500m, and is not dependant on moorland; although the species may be commonly found there. Britschgi *et al* (2006) concluded that the loss of traditional hay meadows were detrimental to the abundance of the species with Cramp (1977) stating that the species can also be associated with ‘less rough’ grassy inbye areas of the uplands. Tharme *et al.* (2001) found that the whinchat had greater abundance on moorland not managed for grouse shooting.



(Source: BTO, 2006.)

Figure 5.6: BBS Whinchat (*Saxicola rubetra*) numbers from 1994-2003.

Sim *et al.* (2005) describes an increase in the species in the South Pennines stating that birds are almost totally biased towards bracken on lower slopes. The Carr and Middleton (2004) report supports the findings with an increase of 38 pairs over the same area between 1990 and 2004. Carr and Middleton (2004) emphasises the importance of the upland population in light of lowland population decreases.



(Source: BTO, 2006.)

Figure 5.7: CBC/BBS Whinchat (*Saxicola rubetra*) Change in Breeding Populations (1993).

5.3.8 Twite (*Carduelis flavirostris*)

Importance- Red listed, PDNP BAP.

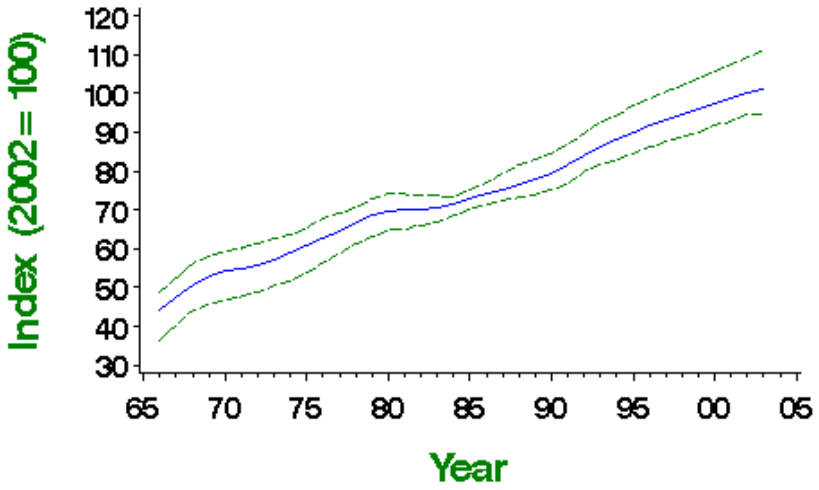
The twite is an important summer visitor to the uplands of Britain where it makes use of burnt heather (*Calluna*) amoungst other habitats. (Gibbons *et al*. 1993) It is a red listed species due to its historical decline (BTO, 2006). Fuller *et al.* (2002) concluded that by the 1990's numbers in the uplands were much lower than in the 1970's. Commonly the twite decline is attributed to a reduction in the quality of inbye/semi-improved land which is a result of overgrazing (Gibbons *et al*, 1993). Hanworth and Thompson (1990) also relate the decline to the loss of heather (*Calluna*) and Bracken (*Pterdium*) moorland which is a favoured habitat.

Gibbons *et al.* (1993) identifies the important twite habitats as heather moorland and crofting land with Stillman and Brown (1994) and Brown (1995) stating that lower slopes with a range of topography is preferred by the species. Cramp (1977) suggests that treeless habitats are opted for, with nesting habitat locally available either within bracken or heather stands. Brown (1995) suggests that the optimal habitat may be found close to or on moorland edge.

Sim *et al.* (2005) describes the species as declining in the South Pennines with Carr and Middleton (2004) supporting the findings by observing a decrease of 121 pairs on the same area from 1990 to 2004. Brown *et al.* (1995) also observes a decrease in twite numbers over the Pennines and attributes the decline to unsuitable land management practices.

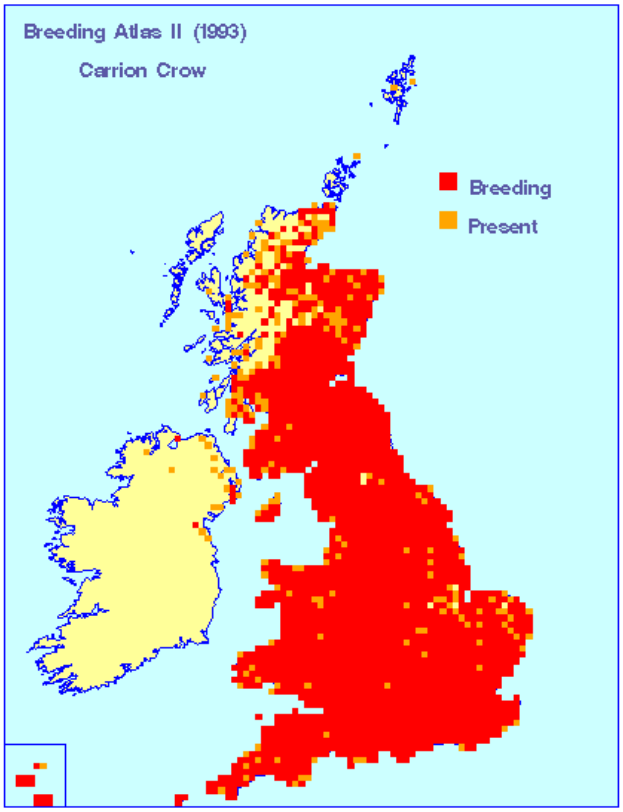
5.3.9 Carrion Crow (*Corvus corone*)

The carrion crow is widespread and increasing throughout Britain (Tapper, 1999) (Fig. 5.8 and 5.9) and is a versatile omnivorous species feeding on a wide range of foods including carrion, eggs, grain, and insects (Gibbons *et al*. 1993). Green (1987) concluded that the species has increased in number with the affrorestation of the uplands; particularly of moorland. Tapper (1999) relates the increase to an increase of populations in urban areas.



(Source: BTO, 2006.)

Figure 5.8: CBC/BBS Carrion Crow (*Corvus corone*) numbers from 1967-2003.



(Source: BTO, 2006.)

Figure 5.9 : Carrion Crow (*Corvus corone*) Distribution in 1993.

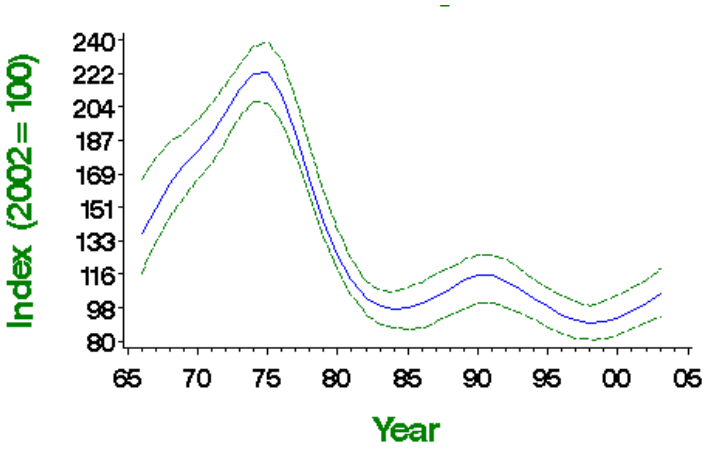
The species is found in a range of habitats including farmyards, woodlands and moorland and have been recorded as nesting in trees, bushes, buildings, rock ledges and in patches of heather on moorland (Gibbons *et al.* 1993). Cramp (1977) describes the ideal nesting habitat as small copses in close proximity to open areas in which to locate food.

Tharme *et al.* (2001) found that crows were more prolific on moorland which was not managed for grouse with Baines (1996) agreeing by stating that the presence of a gamekeeper was associated with three times less carrion crows. Within the PDNP it is proposed by Carr and Middleton (2004) that crows have possibly become a rare breeder. It is suggested that the levels of gamekeepering are a likely cause. Over the same area between 1990 and 2004 the numbers of Carrion Crows were reduced by 106, which is a substantial decrease (Carr and Middleton, 2004).

5.3.10 Reed bunting (*Emberiza schoeniclus*)

Conservation Importance - Red listed.

The reed bunting has suffered a historic long-term decline (Gibbons *et al*. 1993), which can be seen in Figure 5.10. The decline, as with many other upland passerines, is attributed to agricultural intensification specifically the introduction of herbicides to arable fields which are a favoured habitat (Gibbons *et al*. 1993). Fuller *et al.* (2002) describes the numbers of reed buntings in the Pennines as far lower in 1990 than in 1970.



(Source: BTO, 2006.)

Figure 5.10: CBC/BBS Reed Bunting (*Emberiza schoeniclus*) numbers from 1967-2003.

The species is generally related to moist, low lying areas (Cramp, 1977) with Gibbons *et al* . (1993) and Cramp (1977) identifying stunted trees, shrubs and bracken, often within boggy areas, as a required habitat. Dense woodland is avoided (Gibbons *et al.* 1993). The species will feed in a variety of habitats including young plantations and agricultural fields, often opting for rape (Carr and Middleton, 2004).

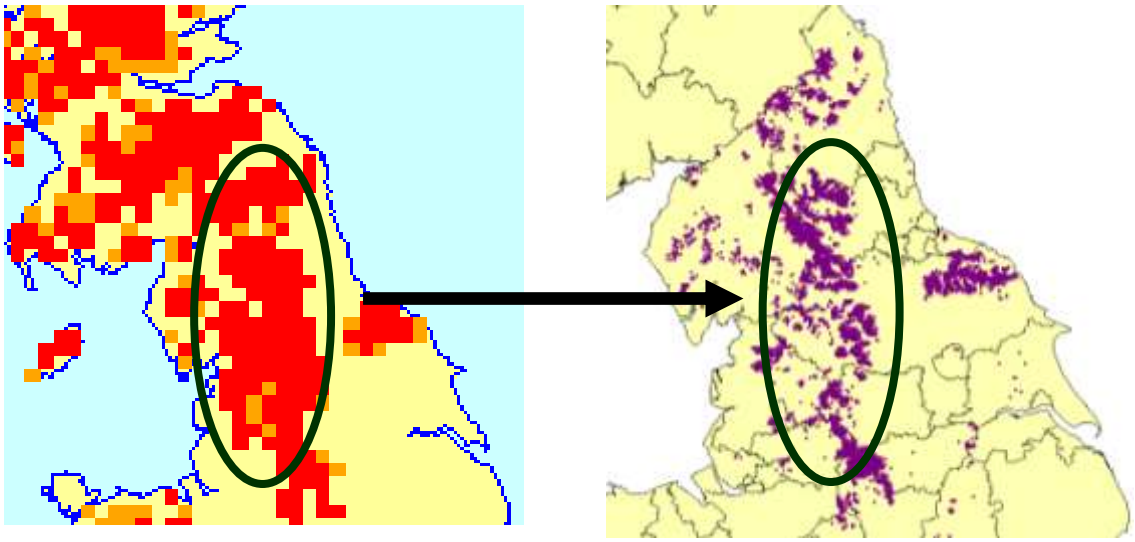
Within the PDNP the species has colonised and bucked the trend with an increase of 127 pairs over the same area between 1990 and 2004 (Carr and Middleton, 2004). The increase is interesting, as the species is largely absent from the moorland areas which comprise a significant proportion of the National Park (Carr and Middleton, 2004).

5.3.11 Red Grouse (*Lagopus lagopus*)

Conservation Concern – Amber listed.

The red grouse has under gone significant declines, specifically since the end of the Second World War (Tapper, 1999; Robertson *et al.* 2001). Tapper (1999) states that the decline between 1911 and 1980 was 82%. The decline can be attributed to many factors including overgrazing, (Gibbons *et al*. 1993; Jenkins and Watson, 2001; Hudson 1995; 1992) affrorestation, (Hudson and Newborn, 1995; Tapper, 1999) increased predation, (Smith *et al*. 2001; Hudson and Newborn, 1995) and decreases in gamekeepers (Tapper, 1999; Hudson, 1992).

The species is described as an exclusive upland moorland bird (Gibbons *et al*. 1993; Robertson *et al.* 2001; Stillman and Brown, 1994) with Smith *et al.* (2001) concluding that on 69 sites in upland Britain, grouse density was related to habitat. Gibbons *et al.* (1993) and Hudson and Newborn (1995) assert that the species range is determined by the distribution of heather dominated moorland which is its primary food source. The distribution of grouse in northern England matches that of heather moorland (Figure 5.11). It is stated by Gibbons *et al.* (1993) that in order for grouse to thrive they are dependent on keepering, specifically the reduction of crows and foxes. Tharme *et al.* (2001) found that grouse density was twice as high on moorland managed specifically for them.



(Source: Adapted from BBS Distribution map (BTO, 2006) and Countryside Survey (2000).)

Figure 5.11: Comparison of Red Grouse (*Lagopus lagopus*) distribution and Heather (*Calluna vulgaris*) moorland cover in the uplands of England.

It is acknowledged by Hudson, 1992; Hudson and Newborn, 1995 and Tapper, 1999 that seasonal variation due to disease is a common occurrence within red grouse populations. The main diseases being:

1) Louping ill – a disease carried by ticks which attach themselves to grouse chicks, (Dobson and Hudson, 1995) resulting in up to 80% of clutch loss (GCT, 2006). Tapper (1999) summarises the problem of Louping ill as occurring on 1 in 3 grouse moors.

2) Nematode worm (*Trichostrongylus tenuis*) – a disease which causes strongylosis (GCT, 2006), and affects breeding success as well as possibly causing adult mortality (Hudson, 1992; Hudson and Newborn, 1995).

Within the PDNP grouse are one of the most abundant birds which is not surprising considering the amount of habitat managed specifically for them. A massive increase from 2337 individuals in 1990 to 5416 over the same count area in 2004 is recorded (MFF, 2006). MFF state that management appears key to the success of the species with a definite preference of the heather moorland.

5.3.12 Peregrine Falcon (*Falco peregrinus*)

Conservation Importance – Amber listed , Listed on Annex 1 of birds directive.

The peregrine is an adaptable bird which has undergone massive declines specifically in England throughout the last century (Cramp, 1977). The declines can be attributed to lack of suitable nest sites as well as introduction (later removal) of organochlorine insecticides which affected many raptors (Gibbons *et al*. 1993; Cramp, 1977). Thirgood *et al*. (2000) suggests persecution is another probable cause for the reduction in range of the species.

Gibbons *et al.* (1993) states that peregrines prefer open stretches of land with availability of suitable habitat and prey. Cramp (1977) states that human interference and large stretches of water are opted against, with the need for a source of food the overriding factor in habitat preference. Peregrines will nest on cliffs and crags although they have also been known to utilise buildings, trees, and ground locations (Cramp, 1977).

Within the Peak district there has been a reverse in the decline in the species with an increase in 18 pairs over the same area between 1990 and 2004.

5.3.13 Lapwing (*Vanellus vanellus*)

Conservation Importance – Amber listed, PDNP BAP species.

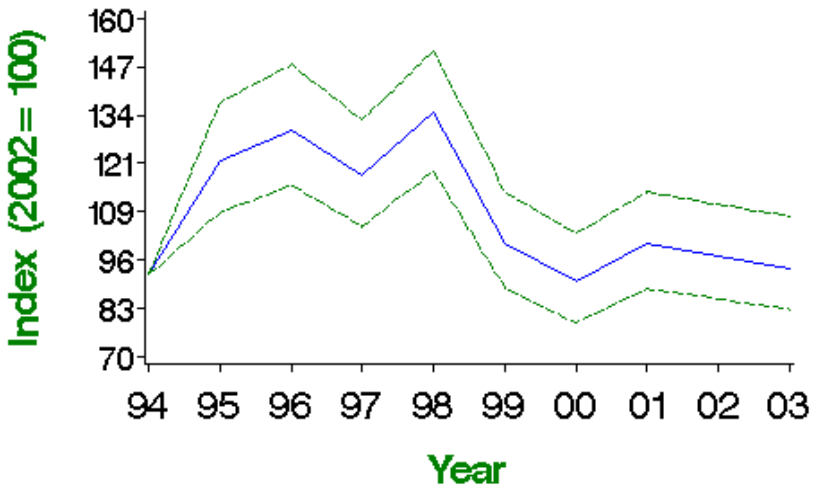
Wilson *et al.* (2001) found a 49% decline in lapwing numbers in the eleven years from 1989-2000, which forms part of a longer historical decline. This reduction is largely attributable to the decrease of mixed farming which provides the ideal habitat for breeding (Gibbons *et al.* 1993; Cramp, 1977). Wilson *et al.* (2001) also attributes the decline to a change from rough grassland into semi-improved grassland and an increase in autumn sown cereals. Cramp (1977) highlighted that a reduction in range of the lapwing was not apparent in the early 70's, even though a decrease in abundance had occurred.

Ideal lapwing habitat encompasses open, hedgeless, treeless country which has a proportion of both pastoral and arable farming (Gibbons *et al.* 1993). Soil which is nutrient rich and can support a wide variety of invertebrates is also seen as more suitable for the species (Cramp, 1977) Short vegetation is also preferred, with recently burnt heather moorland a habitat not uncommonly chosen (Gibbons et al. 1993).

Sim *et al.* (2001) concludes that a significant reduction in the lapwing occurred in the South Pennines; however Carr and Middleton (2004) show an increase in lapwings in the PDNP, detailing a rise of 80 pairs from 1990 to 2004 over the same count area.

5.3.14 Northern Wheatear (*Oenanthe oenanthe*)

The northern wheatear is a species which has suffered a historical decline alongside many other upland passerines (BTO, 2006, Figure 5.12). Henderson *et al.* (2004) found an 80% decrease in species population on marginal grassland areas of the British uplands. The decline has been attributed to a loss of nesting burrows (often in unused rabbit warrens) through increased ploughing of land as well as a decline in rabbit numbers due to myxomatosis (Gibbons *et al*. 1993).



(Source: BTO, 2006.)

Figure 5.12: BBS Northern Wheatear (*Oenanthe oenanthe*) decline from 1994-2003.

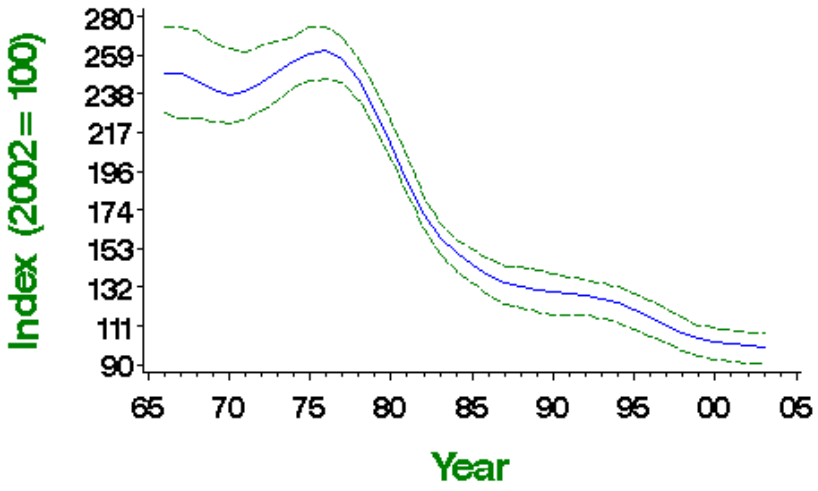
The species inhabits areas of short tight grassland which are above 300m often grazed by sheep (Gibbons *et al*. 1993). Moorland will also be utilised where areas of grassland are in close proximity (Henderson *et al.* 2004). Trees, especially woodlands are actively opted against (Cramp (1977); Gibbons *et al*. 1995), whereas perching rocks and reduced disturbance are seen as ideal habitat features (Cramp, 1977).

MFF (2006) describe the species as a characteristic bird of the PDNP. However; Sim *et al* (2005) observed a decline in species number throughout the South Pennines. This is view consistent with the Carr and Middleton (2004) findings, where a decrease of 64 pairs was observed over the same count area between 1990 and 2004.

5.3.15 Skylark (*Alauda arvensis*)

Conservation Importance - Red listed.

The Skylark has undergone declines specifically within the last thirty years (Chamberlin *et al.* 1999; Cramp, 1977, Fig 5.13). Gibbons *et al.* (1993) suggests that numbers nationally have decreased by half; however no major reduction in range has occurred. The decrease in numbers is largely attributed to agricultural intensification and precision farming techniques, (Chamberlin *et al.* 1999; Donald *et al.* 2002) with an increase in autumn sown crops reducing the available food over the winter (Gibbons *et al*. 1993).



(Source: BTO, 2006.)

Figure 5.13: CBC/BBS Skylark (*Alauda arvensis)* population from 1967-2003.

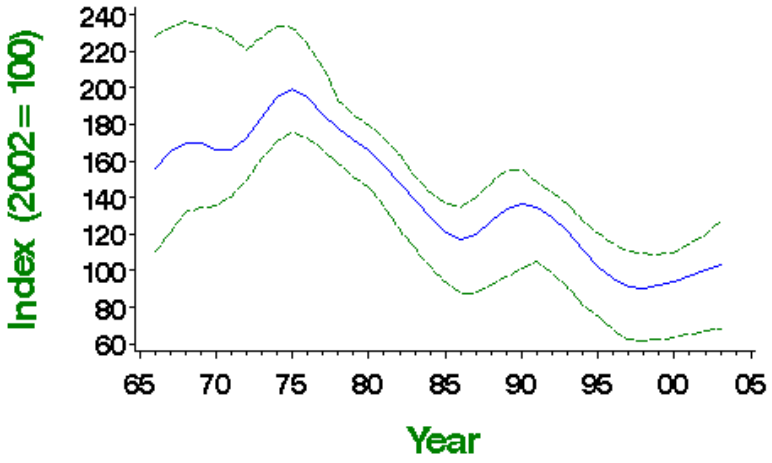
Cramp (1977) states that the skylark is a versatile bird in terms of its habitat; although Gibbons *et al.* (1993) highlights the species preference for arable fields, with Chamberlin *et al.* (1999) concluding that moorland and set-aside played host to nationally important numbers of the species. Donald *et al.* (2002) concluded that predator control within the habitat could increase bird numbers, with an increase of 28.4% in nest survival recorded on one farm where predators were managed.

Sim *et al.* (2005) asserts that the uplands support 13-15% of the skylark population which does not appear to have been severely affected by detrimental factors. However; a non-significant reduction was however recorded in the South Pennines. Carr and Middleton (2004) also recorded a small decrease in numbers from 6 birds/ km² to 3.5 birds/ km². The birds in the PDNP were seen as preferring areas dominated by acid grassland.

5.3.16 Meadow pipit (*Anthus pratensis*)

Conservation Importance – Amber listed.

Figure 5.14 from the BTO (2006) shows meadow pipit declines since the mid 1970's, which is described by Gibbons *et al.* (1993) as a significant and quick decrease in numbers. The reasons for the species decline are attributed to conversion of grass to arable land as well as the later stages of afforestation (Cramp, 1977).



(Source: BTO, 2006.)

Figure 5.14: CBC/BBS Meadow Pipit (*Anthus pratensis)* population from 1967-2003.

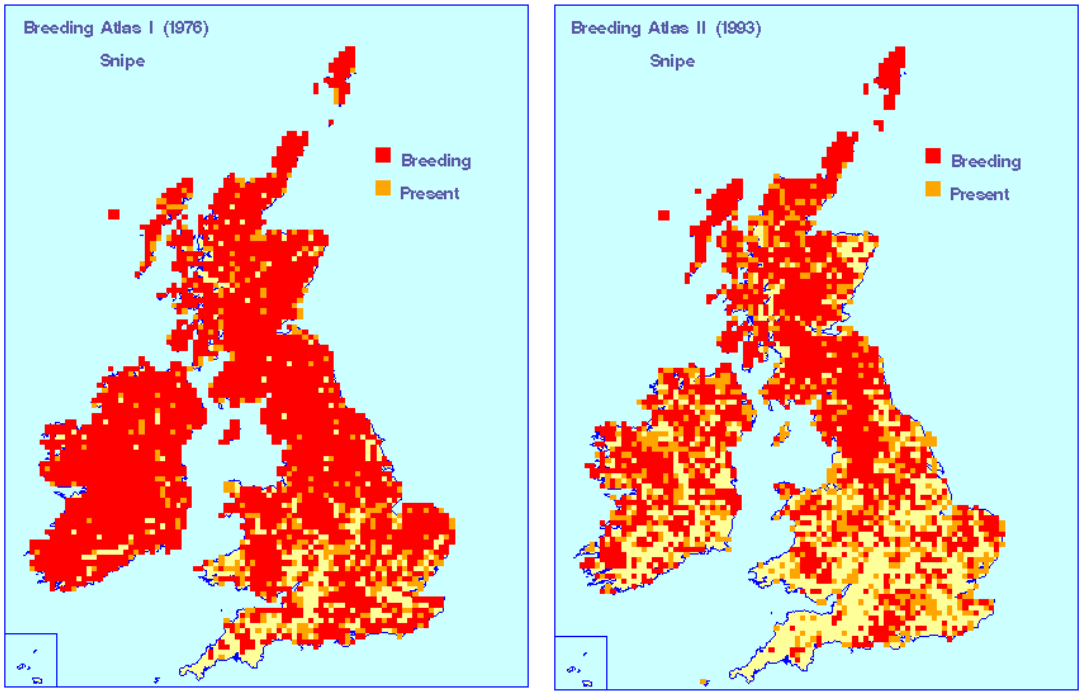
It is stated by Gibbons et al. (1993) that the meadow pipit has a high adaptability when it comes to habitat (much like the skylark) and will inhabit areas ranging from young trees to heather moorland and grassland. Hudson (1992) found that meadow pipits increase with numbers of grouse on moorland with Smith *et al.* (2001) suggesting that the birds are in high abundance on grouse moors providing a source of prey for many raptors. Tharme *et al.* (2001) found that meadow pipits preferred areas which were not managed for sporting purposes with Brown and Stillman (1993) highlighting the species preference for rough grassland and bracken instead of a dominant heather sward which has a negative effect on species density.

Sim *et al.* (2005) concluded that meadow pipits had undergone a significant decline within the South Pennines which is supported by the findings of Carr and Middleton (2004) who found a decline from 10,410 birds in 1990 to 8432 over the same survey area in 2004. Even with the decline the meadow pipit was still the most common bird in the study area with no particular habitat preference.

5.3.17 Snipe (*Gallinago gallinago*)

Conservation Importance - Amber listed.

Gibbons *et al.* (1993) states that snipe have declined since the 1980's much of which has been due to the decreases in distribution in southern areas of England. The change in distribution of breeding pairs can be clearly seen from Figure 5.15 (BTO, 2006). Wilson *et al.* (2005) found that between 1985 and 1992 a 61 % decline in snipe numbers occurred. The decrease in numbers may be associated with peat drainage and extraction as well as increased drainage systems on arable land (Henderson *et al*. 2002).



(Source: BTO. 2006.)

Figure 5.15: Distribution of Snipe (*Gallinago gallinago)* in the UK in 1976 and 1993.

Cramp (1977) suggests that wet pastures, marshes are ideal snipe habitat with Gibbons *et al.* (1993) stating that marginal moorland areas, particularly wet bogs are typical feeding grounds due to their moist nature making it easy for the birds to probe for food. Brown and Stillman (1993) conclude that snipe are found in marginally lower numbers on bogs compared to other known habitats, with heather moorland having a negative effect on abundance.

Sim *et al.* (2005) found a non-significant decrease in the numbers of snipe in the South Pennines. This finding was not supported by the findings of MFF (2004) who observed an increase in snipe numbers from 56 pairs in 1990 to 135 over the same area in 2004. It is however pointed out that surveying snipe over such a large area is near impossible with the Brown and Shepard method, (Henderson *et al.* 2002) due to their cryptic nature. This may affect the results of the counts.

CHAPTER SIX: LITERATURE REVIEW OUTCOMES

6.1 Gaps in Knowledge and Opportunities for Research

This review of current literature highlights some gaps in knowledge:

Specific studies have been carried out before which examine the relationship between keepers with the abundance of upland birds e.g. Tharme *et al.* (2001) and Smith *et al*. (2001). However; the studies look at sites which are spread throughout the English uplands or Scottish lowlands which are linked only by their land use (grouse moor) or by habitat composition (heather-dominated moor) not their geographical location. The impact of burning has also not been considered alongside the game keeping activity in many of the previous studies.

The PDNP is the most southerly host to many upland moorland vegetation communities (Thompson *et al.* 1994) as well as the red grouse which the land is typically managed for. The PDNP has perhaps not been included in previous studies due to it 'edge of range' location and could therefore provide new evidence when looking at keeper: bird relationships. Specific research within the PDNP has been carried out by non-governmental organisations (GCT, MFF) which could be used to explore gaps in knowledge.

The Peak District Moors SPA has been designated for multiple avian species including the merlin, a moorland raptor. Heather moorland within the Peak District, is also considered internationally important and has The South Pennine Moors SAC specifically designated for it. Examining the relationships of the internationally important birds and habitat is an opportunity which should taken?

6.2 Conclusions of Literature Review

The review of current literature highlighted a gap in the knowledge of gamekeeper and burning relationships with birds in the PDNP and the uplands. Specifically no study has been carried out examining the relationships of birds and gamekeepers on a group of moorlands with a close geographical link. The PDNP provides a location where keepering for grouse shooting is present on some areas of moorland and absent on others. An opportunity for comparison therefore exists. Internationally important vegetation and birds are also present, some at the edge of range in the PDNP which would add an interesting international aspect to a study. Data available from the GCT and MFF as well as government (DEFRA) data is available which could be used within a study.

CHAPTER SEVEN: MATERIALS AND METHODS

From the review of current literature a gap in knowledge has been established which can be addressed with the following question and objectives:

7.1 Research Question:

Does gamekeepering activity and moorland heather burning have an effect of the densities of the birds within the Peak District National Park, England?

7.1.1 Research objectives:

- Identify the habitat composition of land managed and not managed for grouse.
- Identify relationships between burned moorland and land managed and not managed for grouse.
- Identify relationships between bird densities and land managed and not managed for grouse and burned moorland.

7.1.2 Null Hypothesis

Gamekeepering activity and moor burning will have no significant effect on the densities of the birds in the Peak District National Park.

7.2 Data

7.2.1 Gamekeeper and Estate Data

In 1999-2003 the Game Conservancy Trust undertook a "Mapping Country Sports" project. This project involved contacting individuals and estates who participate in country sports (including moorland gamekeepers and managers) to establish the amount of management occurring, and the area on which it was taking place. From this project and a series of structured interviews with key Peak District managers, a GIS-enabled database of Peak District moorland parcels managed for red grouse shooting was created. Twenty-nine estates/shoots were identified within the bound of the Peak District/Moors for the Future boundary which undertook grouse moor management, one of which did not manage for grouse

in 1990. In 2004, 64% of the moorland area of the Peak District National Park was managed as grouse moors

7.2.2 Bird Survey Data

In 1990 Brown and Shepard (Brown and Shepard, 1990) undertook a bird survey on behalf of the Peak District National Park (PDNP) to document the distribution and abundance of different upland avian species within the park. This survey was repeated in 2004 by Moors For the Future (Carr and Middleton, 2004) to provide an insight into the distribution and abundance of the bird life in 2004, and to give a direct comparison of change over the 14 year interval.

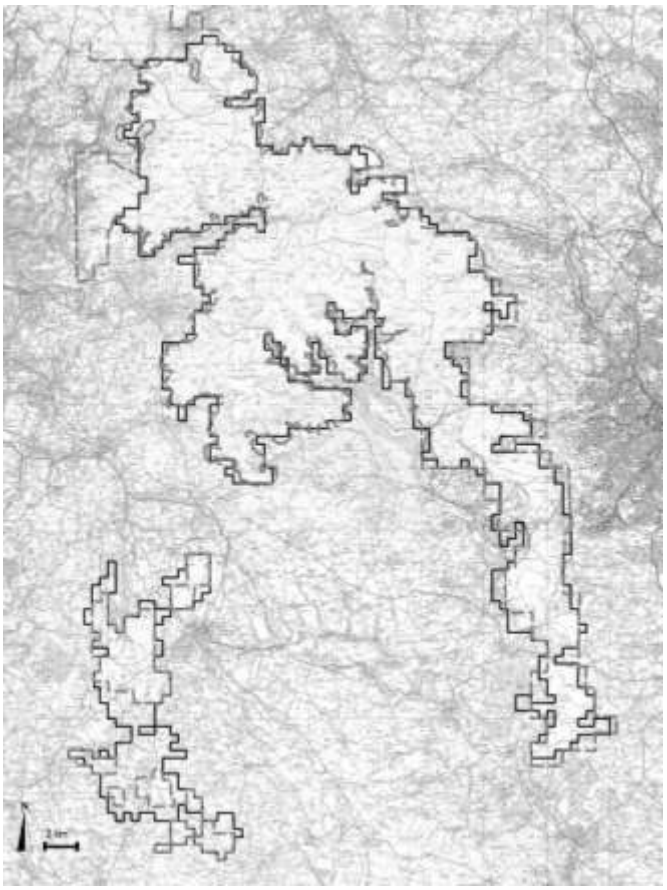
The count areas and techniques were not exactly the same in 1990 and 2004 due to access agreements. This study has taken into account this variation when comparing bird densities in both surveys, disregarding areas which were not surveyed in both when comparing the data from the two surveys.

The Brown and Shepard wader-specific method of surveying was used in 1990 and in 2004. This involved observers walking a series of pre-determined routes through each km square that covered the censused area and recording all birds present along with relevant behaviour. There were three species which were not surveyed using this method. Red grouse, skylark and meadow pipit numbers were tallied on a km^2 basis which is the preferred method of surveying red grouse. It should be noted that in 2004 all of the species of birds present were recorded whereas in 1990 they were not. This leaves a group of typical moorland species, surveyed at both times, which are examined here in detail.

In addition to the bird survey data provided by MFF in digital format, raptor data was extracted from published maps in the Breeding Birds of the Peak District Moorlands report (Carr and Middleton, 2004). This data consisted of the number of raptor sightings within 2 x 2 km tetrads covering the 2004 survey area.

The majority of the managed moorland parcels are individual estates which are within the boundary of the two bird surveys (Fig. 7.1), with a total of 29 identified in this study. There are however some areas of moor which are known or assumed to be un-keepered, most

notably around Kinder Scout which have been grouped as five specific parcels on a geographical basis.



(Source: Carr and Middleton, 2004.)

Figure 7.1: Outline of the 2004 PDNP Bird Survey Area.

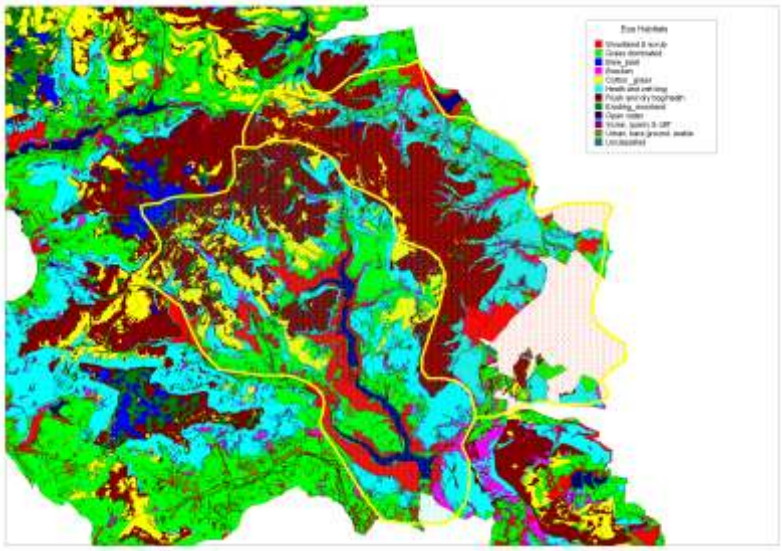
Further details on the survey methods can be obtained from Moors for the Future.

7.2.3 Burning Data

A GIS-enabled database of moorland burn sites was also provided by the Moors For the Future Partnership. The database was constructed from 2001 Get Mapping aerial photography and details over 90km² of burnt moor. The Burning data was used in comparison with the 1990 and 2004 bird surveys, as it was taken to represent the area within the Peak District with a high degree of burning management. It was also used when analysing the change in bird density from 1990 to 2004.

7.2.4 Habitat Data

The habitat data used in the analysis was in the form of the Environmentally Sensitive Area (ESA) map from DEFRA, 1988 (Fig. 7.2). This habitat data was considered to be the best available for the Peak District at the time, and was used in the analyses with both the 1990 and 2004 bird surveys (but see Pearce-Higgins et al. 2006). The data is stored in a digital format which can be used within a Geographic Information System (GIS). In order to better analyse the habitats within the multivariate analysis (compositional analysis), the 38 habitat types which were included in the ESA map needed to be grouped (Table 7.1). This was firstly done by grouping the data into 11 sub-groups. The eleven sub-groups were then grouped further into 4 main habitat types; Grasses and Tall-herbs, Heath and Mire, Woodland and Other. The groupings were based on those used for Phase 1 Habitat Survey (JNCC 1990).



(Source: DEFRA 2006.)

Figure 7.2: A section of the PDNP habitat map.

Table 7.1: Grouping of ESA Habitats for Analysis.

Habitat	Sub Habitat	Habitat
Woodland	Woodland and Scrub	Broad leaved plantation
		Broad leaved semi natural plantation
		Coniferous plantation
		Coniferous plantation
		Mixed plantation
		Mixed semi-natural woodland
		Recently felled coniferous plantation
		Recently felled coniferous plantation
		Scrub
		Woodland
Grasses	Grassland and Marsh	Amenity grassland
		Dry Grassland
		Improved Grassland
		Juncus dominated Marshy grass
		Molinia dominated grassland
		Semi improved acid grassland
		Semi improved acid rough pasture
		Semi improved neutral grassland
		Semi improved neutral rough pasture
		Short term ley neutral /arable
		Unimproved acid grassland
	Tall Herb + Fern	Acid flush
		Continuous bracken
Heath and Mire	Cotton grass moorland	Cotton grass moorland
	Heathland	Dry dwarf shrub heath heather dominated
		Dry dwarf shrub heath non-heather dominant
		Wet heath/acid grass
	Eroding Moorland	Eroding Moorland
	Mire	Dry bog heather dominated
		Dry bog non-heather dominant
		Wet Bog
Other	Open Water	Open water
	Rock exposure and waste	Cliff
		Quarry
		Scree
	Misc	Bare Ground
		Urban
	Bare Peat	Bare Peat

7.3 Data Manipulation within the Geographic Information System (GIS)

A GIS was used to manipulate the available data, as it is the most efficient method of dealing with mapped bird counts and associated data (Woodhouse *et al.* 2000). MapInfo version 8.0 was used to perform the following actions:

The moorland parcels, 1km squares and 2x2km² tetrads were entered/opened in the GIS to create MapInfo tables. The GIS was then used to update the area (km^2) within the moorland parcels (Areas for 1km Squares and 2x2km km² Tetrads already known).

Each of these tables was then updated with the following:

Keeper Status/Density

Keeper status yes/no and number of keepers were attached to each moor polygon. For each 1 km square or tetrad, the area covered by the overlying gamekeepered estate boundary(ies) was calculated.

Habitat Data

The grouped habitat data was overlayed with the moor parcels, squares and tetrads in order to calculate the proportion of each habitat within the individual areas.

Bird Data

The bird survey data from both 1990 and 2004 was overlaid with the moorland parcels squares and tetrads in order to calculate the numbers of birds within each individual area.

A weighted average for meadow pipit, red grouse and skylark within the individual moor boundaries was calculated due to the manner in which their numbers were recorded in the 1990 and 2004 surveys.

Burning data

The burning data set was overlaid with the parcels, squares and tetrads in order to calculate the proportion burnt within the individual areas.

After calculations were completed in the GIS all data was exported as text files into Ms Excel and then into the appropriate statistical packages.

7.4 Statistical Analysis

7.4.1 Habitat Data

Compositional Analysis

Compositional analysis (Aitchison 1986, Aebischer *et al*, 1993) was used to test for habitat differences between moorland areas which were keepered for grouse and those which were not. The test involves a log ratio transformation followed by a MANOVA. This technique allows the analysis of proportional data, overcoming the unit-sum constraint inherent in compositions, namely that the proportions sum to one.

T-Test

A t-test was used to examine the relationship between the proportion of each moorland parcel burned (transformed to angles) and the presence of a keeper on the land.

The compositional analysis and t-test was performed in Systat version 10© SPSS. Inc

7.4.2 Bird, Burning, Habitat and Keeper Data

Generalised Linear Models (GLM)

The numbers of each bird species recorded on the moorland area were examined using Generalised Linear Models (GLM) (Mcullagh and Nelder, 1989) with a poisson error and logarithmic link function, with keepering status (yes/no) as a factor, the proportion of area burned, and the proportion of all four habitat groups (testing for an association with habitat) entered into the model as explanatory variables, first individually and then using a model where all three were entered in order to test the relative importance of each explanatory variable. The ln-transformed area of the estate surveyed in the appropriate year was used as an offset. . Predictions for keeper status were formed by setting offset to 0 (1 km^2) and averaging over the other variables.

A similar approach was used to analyse changes in bird density between the two survey dates, 1990 and 2004. Effectively we used an analysis of covariance to examine the interaction

between time and each of the variables of interest (habitat, burning and keepering) controlling for time and location. This was undertaken using Generalised Linear Models with a poisson error and logarithmic link function and with the ln-transformed area of the estate surveyed in both years as an offset. This method allowed for the inclusion of estate where either there were no birds of certain species seen in the initial survey but where birds had been found in the subsequent survey or where the number of birds had declined. Predictions for keeper status were formed by setting offset to 0 (1 km^2) and averaging over the other variables for the two time periods, with the proportional difference in density between the two areas calculated to illustrate the relative change in density between the two types of estates.

Generalized Linear Mixed Models (GLMM)

We also analysed the count data using 1km^2 grid squares spread across the surveyed area, instead of estate boundaries. We used a Generalized Linear Mixed Model (GLMM) which took into account spatial variation (Gilmor *et al.* 1997). The irregular grid technique was used with an anisotropic model to control for spatial autocorrelation, habitat was entered in as random variables and the effect of keepering and burning on bird density was examined simultaneously, using a poisson error distribution with a logarithmic link function.

Keepering was entered into the analysis as the proportion of each 1km square covered by estates with grouse shooting. Burning was entered as the proportion of each square within the burn polygons.

This was completed for the 1990 and 2004 surveys as well as the difference between the two, where the GLMM procedure was used as above, examining the interaction between time and each of the each of the variables of interest (habitat, burning and keepering) controlling for time and location of each square. Only the areas surveyed in both years was used for the analysis of difference.

The GLM and GLMM analysis examine the relationship between bird density and keepering and moorland burning at two spatial scales. The GLM does this on a moorland/estate parcel basis with the GLMM doing so on a 1km^2 basis.

Raptor Data

Data for the raptors in the study area was analysed using the Generalized Linear Mixed Model in a similar way to the other species. The analysis was only done for the 2004 survey data only.

These analyses were performed in Genstat version 8 © 2005, Laws Agricultural Trust

CHAPTER EIGHT: RESULTS

8.1 Introduction

In this chapter, the significant relationships between recorded bird densities and habitat composition, keeper presence/density and proportion of area burned which were analyzed within the Generalised Linear Model and Generalized Linear Mixed Model analysis are detailed. These results should be interpreted whilst also considering the results from the compositional analysis of differently managed grouse moors and a t-test examining the relationship between burned area and management.

The breeding bird survey of the Peak District moorlands recorded all of the avian species which were present (Carr and Middleton, 2004), many of these species are not specific upland moorland birds and will therefore not be discussed in detail within the following results or discussion sections. The results from the analysis for the non-upland birds is however included within Appendix 1.

Specific upland moorland birds are defined by Tharme *et al.* (2001) and Sim *et al.* 2005 as the following species:

Charadriiforms (Wading birds)	Curlew, Common Sandpiper, Dunlin, Golden Plover, Lapwing, Snipe, Redshank, Greenshank
Passeriformes (Song, Perching Birds)	Carrion crow, Skylark, Meadow Pipit, Whinchat, Wheatear, Twite, Ring Ouzel,
Galliformes (Ground based, Gamebirds)	Red Grouse, Black Grouse

Lack of numbers in the 1990 or 2004 survey for some of the species resulted in their results not being taken further and discussed within the study. These include greenshank and black grouse, with common sandpiper and redshank poorly represented in the Peak District – the results of analysis of these two species can be found in Appendix 1.

8.2 Compositional Analysis

There were differences between the areas of moorland not managed for grouse and the managed moors keepered specifically for grouse within the Peak District. Grouse moors had a higher proportion of heath and mire, while the other moors had a higher proportion of grasses.. This difference in habitat composition was significant ($P < 0.001$).

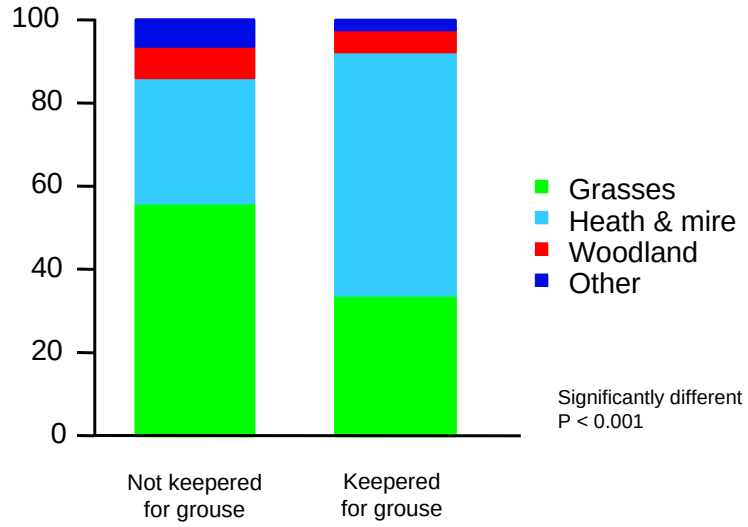


Figure 8.1: Habitat composition on differently managed moors.

8.3 T-Test

The proportion of area burned was higher on keepered land ($t_{32} = 2.43$, $P = 0.020$, Figure 7.2).

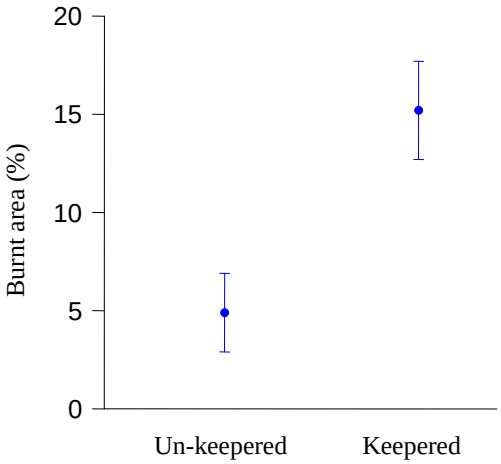


Figure 8.2 : Proportion of area burned on keepered and un-keepered land.

8.4 GLM analysis of bird densities in 2004 (keeper status)

8.4.1 Charadriiforms (Waders)

Of the waders surveyed in 2004 only the density of dunlin ($P < 0.001$) and golden plover ($P < 0.05$) within an estate were significantly related to habitat on its own (Table 8.1). Both dunlin ($P < 0.001$) and golden plover ($P < 0.001$) density were also significantly positively related to the presence of a keeper when considered separately. Densities of golden plover and dunlin were higher on keepered land. None of the wader densities were related independently to the proportions of each moor that was burned. With keeper presence, habitat composition and proportion of area burned all considered simultaneously; only dunlin density ($P < 0.01$) was still significantly related to habitat (Table 8.1). The density of both dunlin ($P < 0.01$) and golden plover ($P < 0.001$) were significantly positively related to keeper presence (Figures 8.3 C & D). Lapwing density was positively related to increased proportions of the area burnt ($P < 0.05$) (Table 8.1).

8.4.2 Passeriformes (Song, Perching Birds)

Of the passerines surveyed in 2004, the densities of carrion crow ($P < 0.05$), reed bunting ($P < 0.001$), wheatear ($P < 0.05$) and whinchat ($P < 0.05$) were all negatively related to the presence of a keeper considered on its own (Table 8.1). Skylark density was positively related to the presence of a keeper on its own. Habitat composition considered alone was a significant factor affecting the densities of skylark ($P < 0.01$), twite ($P < 0.01$), wheatear ($P < 0.05$) and whinchat ($P < 0.05$). Considered independently from habitat composition and keeper presence, increasing the proportion of habitat burned has a significant negative effect on the densities of skylark ($P < 0.001$), twite ($P < 0.05$) and wheatear ($P < 0.05$). Ring ouzel density ($P < 0.001$) was positively linked to an increase in proportion of area burned considered independently (Table 8.3). With keeper presence, habitat composition and proportion of area burned all considered simultaneously within the model, the densities of twite ($P < 0.05$) and whinchat ($P < 0.05$) were significantly related to habitat composition, with densities of reed bunting ($P < 0.001$) significantly negatively related to keeper presence (Figure 8.3 H). The densities of ring ouzel were positively associated with burning (Table 8.1). The densities of all species examined for keepered and un-keepered land are shown in Figure 8.3.

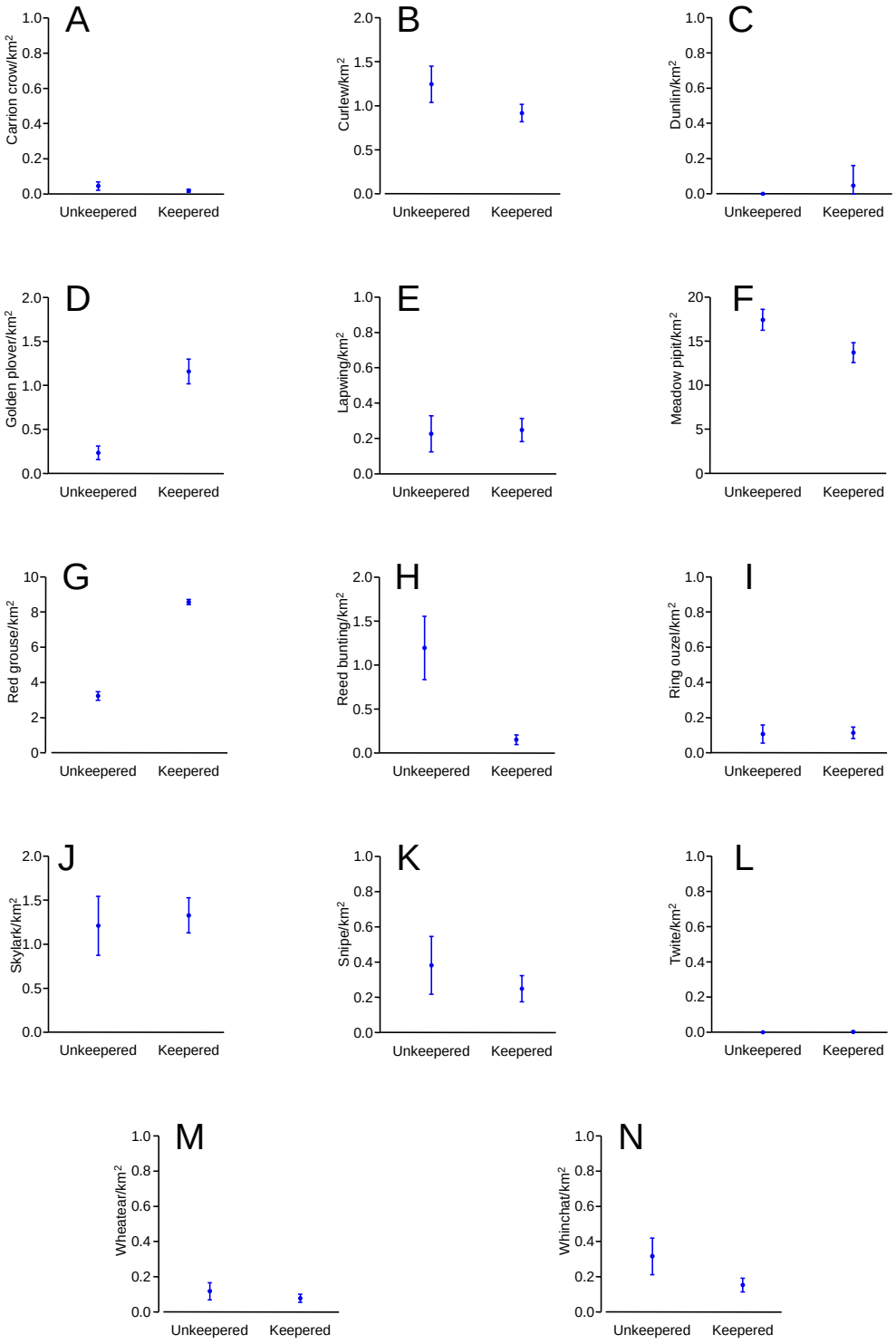
8.4.3 Galliformes (Ground based, Gamebirds)

Both keeper presence ($P < 0.001$) and proportion of habitat burned ($P < 0.001$) on their own have had a significant positive effect on the density of red grouse in 2004 (Table 8.1). Habitat considered independently also had a significant effect on the density of this species ($P < 0.05$). Considering all factors together revealed that the proportion of habitat burned ($P < 0.05$) and keeper presence ($P < 0.01$) were positively associated with the density of the red grouse (Figure 8.3 G).

Table 8.1: General linear model analysis of habitat and keeper status on moorland area in 2004.

Common name	Habitat on its own (N = 4)	Keeper on own (N = 2)	Burning on own	Model of habitat, keeper and burning	Habitat, controlling for keeper & burning	Keeper, controlling for habitat & burning		Burning controlling for habitat and keeper	
	$F_{4,35}$	$F_{1,38}$	$F_{1,33}$	$F_{6,33}$	$F_{4,33}$	$F_{1,33}$	Relationship	$F_{1,33}$	Relationship
Carrion Crow	2.18	6.43*	3.52	1.65	0.70	1.71	-	0.22	+
Curlew	0.75	0.81	0.54	1.12	1.10	1.97	-	1.88	-
Dunlin	6.31***	13.28***	0.35	6.73***	4.21**	9.62**	++	0.04	-
Golden Plover	2.74*	19.15***	0.46	7.38***	2.54	25.76***	+++	0.02	-
Lapwing	1.11	0.45	0.54	1.80	2.22	0.03	+	5.89*	+
Meadow Pipit	0.49	0.03	0.13	0.51	0.70	1.11	+	0.01	+
Red grouse	3.86*	23.34***	18.61***	6.78***	0.83	9.85**	++	6.31*	+
Reed Bunting	1.15	13.17***	0.72	3.96**	2.12	17.12***	---	0.09	+
Ring Ouzel	0.13	0.32	14.46***	4.39**	2.18	0.01	+	25.43***	+++
Skylark	4.61**	5.17*	17.30***	3.92**	1.22	0.05	+	3.91	-
Snipe	1.78	3.47	0.61	1.45	1.30	0.55	-	1.03	+
Twite	4.91**	1.21	4.73*	4.04**	3.26*	3.54	+	0.16	-
Wheatear	2.73*	5.71*	7.36*	2.07	0.72	0.58	-	1.24	-
Whinchat	3.79*	5.37*	0.45	3.43*	3.45*	2.59	-	1.88	+

* P <0.05 ** P < 0.01 ***P < 0.001



Figures 8.3 A-N Predicted mean densities of upland birds on un-keepered and keepered land in 2004 controlling for habitat and burning.

8.5 GLM analysis of bird densities in 1990

8.5.1 Charadriiforms

For waders surveyed in 1990, only the density of the curlew ($P < 0.05$) was significantly related to habitat composition when considered independently of keeper presence and burned proportion of area (Table 8.2). Keeper presence considered on its own had significant positive associations with densities of dunlin ($P < 0.001$) and lapwing ($P < 0.05$) and a negative association with curlew density ($P < 0.05$. Table 8.2). Lapwing density was positively related ($P < 0.05$) to the proportion of a moor that was managed through burning on its own. When keeper presence, habitat composition and proportion of area burned were all simultaneously considered within the model the density of dunlin ($P < 0.05$) was significantly related to habitat composition. The densities of dunlin ($P < 0.05$), and golden plover ($P < 0.001$), had positive associations with keeper presence (Figure 8.4 C & D) while snipe ($P < 0.001$) and curlew ($P < 0.05$) had negative relationships with the presence of a keeper (Table 8.2, Figure 8.4 K & B). Lapwing ($P < 0.05$) and snipe ($P > 0.01$) densities were significantly positively related to the proportion of each moor that was managed with burning.

8.5.2 Passeriformes

Amongst the passerines surveyed in 1990, the density of skylark ($P < 0.001$) showed a significant relationship with habitat considered on its own (Table 8.2). Keeper presence in 1990, considered independently, had a significant negative effect on reed bunting ($P < 0.05$) and twite ($P < 0.05$) densities and a positive relationship with meadow pipit density ($P < 0.01$, Table 8.2). With keeper presence, habitat composition and proportion of area burned all simultaneously considered within the model the densities of skylark ($P < 0.05$) and reed bunting ($P < 0.05$) were all related to habitat composition. Keeper presence had a significant positive effect on ring ouzel density ($P < 0.0$, Figure 8.4 I) with significant negative associations for carrion crow ($P < 0.001$) and reed bunting ($P < 0.01$, Table 8.2 Figure 8.4 A & H). The density of whinchat was significantly positively related to the proportion of a moor managed with burning.

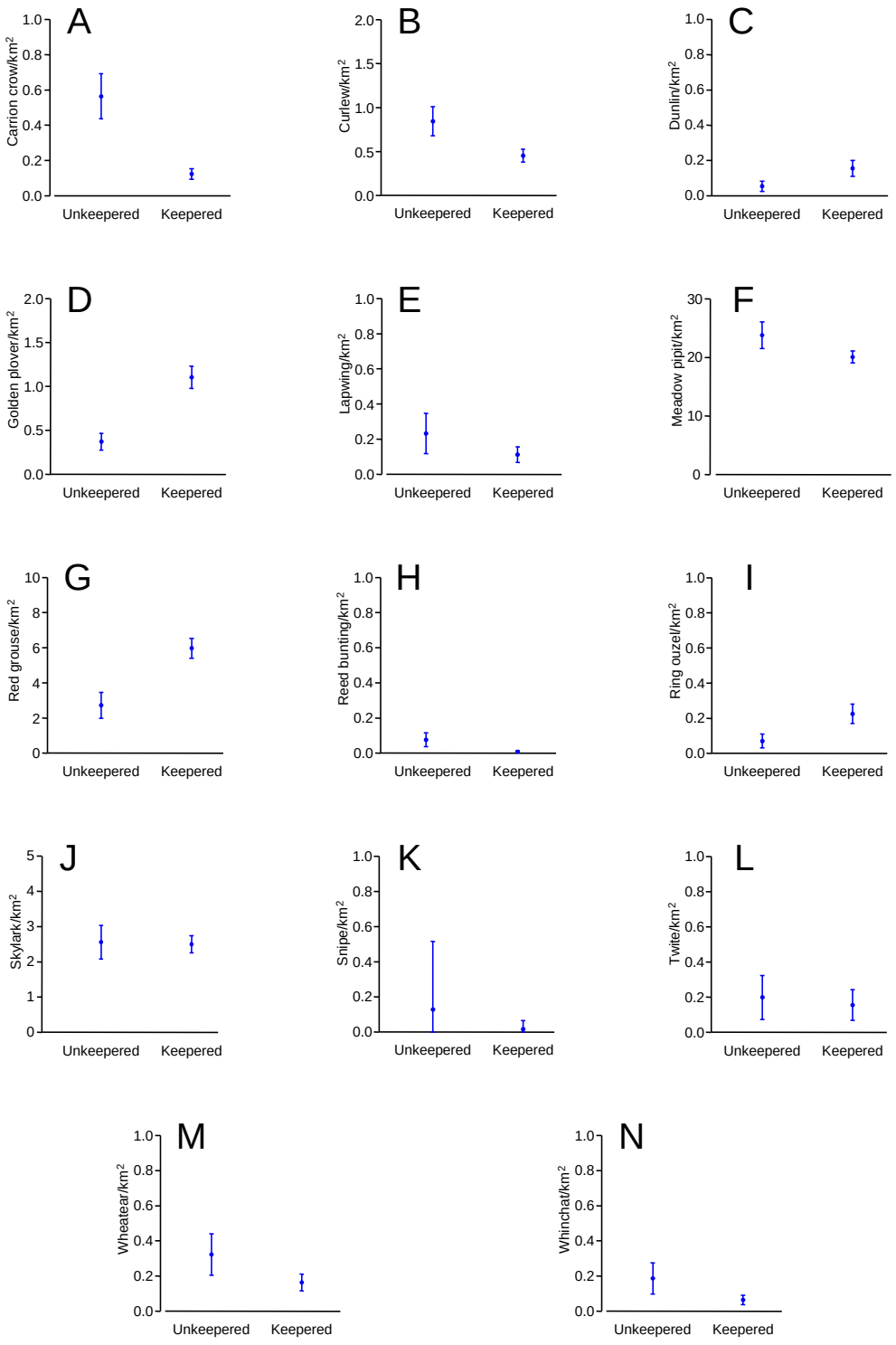
8.5.3 Galliformes

The proportion of habitat burned ($P < 0.05$) on its own have had a significant positive effect on the density of red grouse in 1990 (Table 8.2). Habitat considered independently also had a significant effect on the density of this species ($P < 0.05$). Considering all factors together revealed that keeper presence ($P < 0.05$) was positively associated with the density of the red grouse (Figure 8.4 G).

Table 8.2: General linear model analysis of habitat and keeper status on moorland area in 1990

Common name	Habitat on its own (N = 4)	Keeper on own (N = 2)	Burning on own	Model of habitat, keeper and burning	Habitat, controlling for keeper and burning	Keeper, controlling for habitat and burning		Burning controlling for habitat and keeper	
	$F_{4,33}$	$F_{1,36}$	$F_{1,33}$	$F_{6,31}$	$F_{4,35}$	$F_{1,32}$	Relationship	$F_{1,32}$	Relationship
Carrion Crow	0.70	2.28	0.28	3.20	1.16	17.96***	---	0.01	+
Curlew	3.93*	7.32*	0.55	1.55	1.72	5.52*	-	0.27	-
Dunlin	2.24	14.01***	0.01	3.66**	2.89*	4.45*	+	0.22	+
Golden Plover	0.44	0.01	0.43	5.09***	1.69	17.22***	+++	0.27	-
Lapwing	1.41	4.37*	5.82*	1.18	0.04	1.08	-	4.44*	+
Meadow Pipit	0.12	12.81**	11.88**	3.75**	2.17	1.97	-	2.92	+
Red grouse	3.13*	0.39	4.92*	3.37*	1.31	7.39*	+	0.08	+
Reed Bunting	1.52	6.87*	0.01	3.83**	2.77*	12.76**	--	2.59	+
Ring Ouzel	0.78	3.69	0.12	1.30	0.73	4.42*	+	0.13	-
Skylark	8.16***	2.40	14.37***	5.05**	3.18*	0.01	-	1.57	-
Snipe	3.13*	0.05	3.44	5.99***	2.53	20.64***	---	10.79**	++
Twite	2.05	4.72*	4.96*	2.17	1.82	0.16	-	0.79	-
Wheatear	1.69	1.62	0.23	1.81	1.44	1.81	-	0.50	+
Whinchat	1.94	0.42	4.17*	3.17*	1.24	2.41	-	7.64*	+

* P <0.05 ** P < 0.01 ***P < 0.001



Figures 8.4 A-N Predicted means densities of upland birds on un-keepered and keepered land in 1990 controlling for habitat and burning.

8.6 GLM analysis of change in density for birds surveyed in 1990 to 2004

8.6.1 Charadriiforms

With keeper presence, habitat composition and proportion of area burned all considered simultaneously within the model, only the change in density of dunlin was significantly negatively affected by habitat ($P < 0.05$), positively related to keeper presence ($P < 0.05$) and negatively to burning ($P < 0.01$, Table 8.3, Figure 8.5 C).

8.6.2 Passeriformes

For the passerines, with keeper presence, habitat composition and proportion of area burned all considered simultaneously within the model, the change in the density of carrion crow ($P < 0.05$) from 1990 to 2004 was significantly related to habitat composition (Table 8.3). The change in density of the ring ouzel was significantly related to habitat composition ($P < 0.05$), as well as being positively associated with the proportion of a moor managed with burning ($P < 0.001$, Table 8.3).

8.6.3 Galliformes

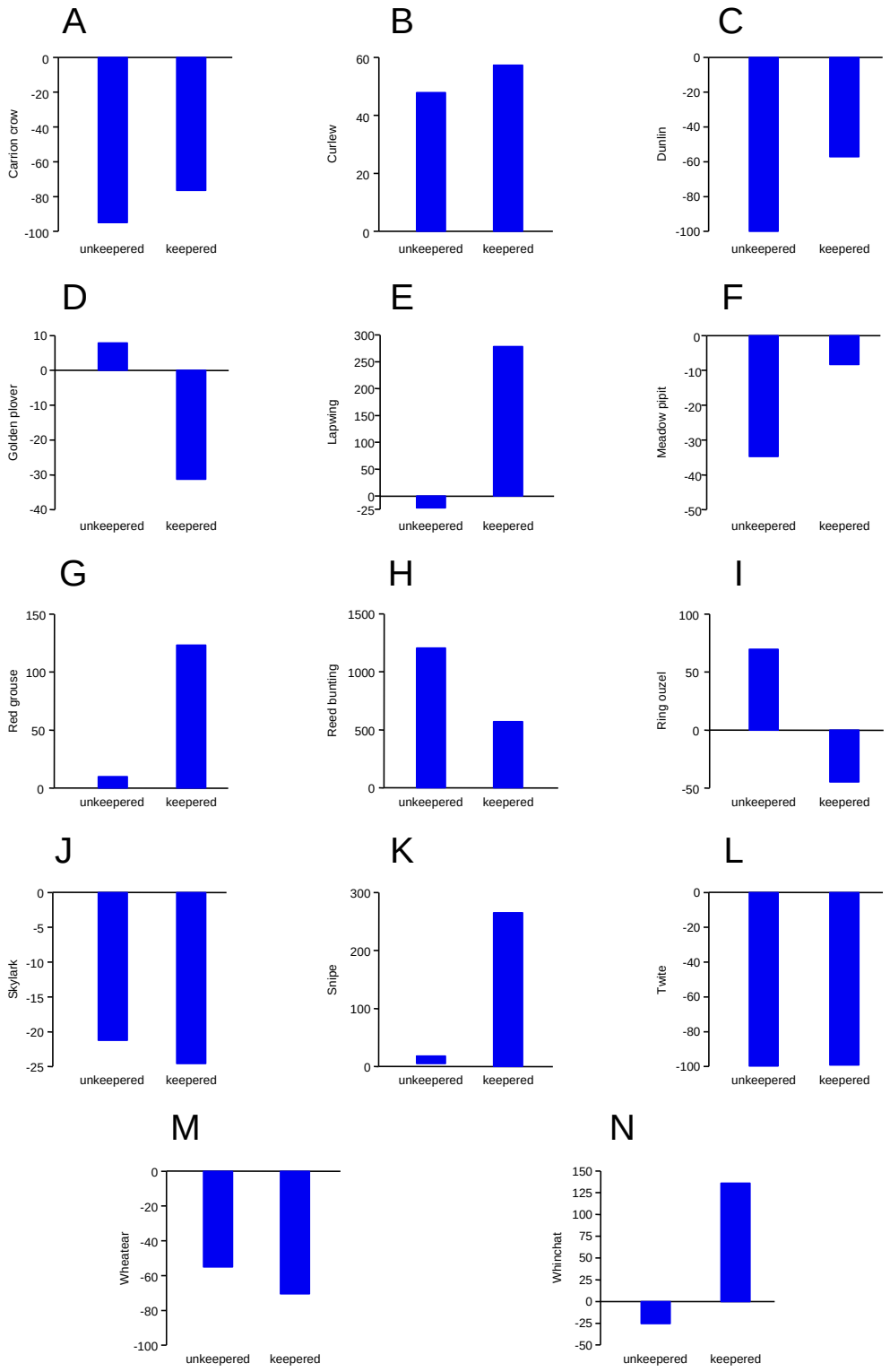
The change in red grouse density from 1990 to 2004, with keeper presence, habitat composition and proportion of area burned all considered simultaneously within the model, was positively associated with the proportion of habitat burned ($P < 0.05$, Table 8.3, Figure 8.5 G).

On the request of the Moors for the Future Team we reanalysed this portion of the results, including as a separate category in habitat composition (Appendix Table D). The only significant results that changed were in regard to burning, with the change in density of dunlin and red grouse no longer significantly related to the proportion of the area burnt.

Table 8.3: Change in bird density from 1990 to 2004 on an estate basis

Common name	Model of habitat and keeper & burning	Habitat, controlling for keeper & burning	Keeper, controlling for habitat & burning		Burning controlling for habitat & keeper	
	$F_{43,30}$	$F_{4,30}$	$F_{1,30}$	Relationship	$F_{1,30}$	Relationship
Carrion Crow	9.29***	3.43*	2.83	+	2.38	-
Curlew	3.18***	0.71	0.04	+	0.68	+
Dunlin	10.36***	3.68*	4.38*	+	9.81**	--
Golden Plover	7.02***	2.33	1.31	-	0.52	-
Lapwing	3.60***	2.03	2.68	+	0.76	-
Meadow pipit	2.40**	2.45	2.45	+	0.48	-
Red grouse	8.87***	0.47	2.41	+	5.74*	+
Reed Bunting	12.66***	0.71	0.78	-	0.03	-
Ring Ouzel	2.96**	1.64	1.72	-	8.64**	++
Skylark	5.25***	0.50	0.02	-	2.01	-
Snipe	2.93**	0.29	1.64	+	4.19	-
Twite	42.32***	2.82*	2.41	+	16.24***	---
Wheatear	2.87**	0.95	0.22	-	1.45	-
Whinchat	3.56***	2.00	2.10	+	2.05	-

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$



Figures 8.5 A-N. Change from 1990 to 2004 (% of predicted density) of upland birds on un-keepered and keepered land controlling for habitat and burning.

8.7 GLM analysis for bird densities in 2004 (keeper density)

8.7.1 Charadriiforms

Keeper density considered on its own showed a significant positive effect on only dunlin density ($P < 0.05$, Table 8.4). With keeper density, habitat composition and proportion of area burned all considered simultaneously within the model, only the density of dunlin ($P < 0.001$) was related to habitat composition and significantly positively related to the density of keepers ($P < 0.01$). The proportion of an area burnt was significantly negatively related to the density of the lapwing, controlling for keeper density and habitat (Table 8.4). Comparing the results here with those for keeper presence (Table 8.1), most were similar, with the exception of the positive effect of keeper presence on golden plover density, where the density of keepers within an estate was not significantly related to the density of golden plover.

8.7.2 Passeriformes

The density of keepers on moors; considered on its own, had significant negative effects on the densities of the carrion crow ($P < 0.05$), reed bunting ($P <0.01$) and skylark ($P < 0.001$) with the density of the wheatear ($P < 0.05$) showing a significant positive association (Table 8.4). With keeper density, habitat composition and proportion of area burned all considered simultaneously within the model, twite ($P < 0.01$) and whinchat ($P < 0.05$) densities were significantly related to habitat composition, with the densities of reed bunting ($P < 0.001$) and skylark ($P < 0.05$) significantly negatively related to keeper density (Table 8.4). The proportion of an area burned continued to show a significant positive association with the density of ring ouzel ($P < 0.001$, Table 8.4). Comparing the results here to those from keeper presence (Table 8.1), the results for reed bunting and ring ouzel are similar, with the significant negative relationship with skylark density and keeper density here not apparent in the analysis of keeper presence.

8.7.3 Galliformes

The density of red grouse was significantly positively related to the density of keepers ($P < 0.01$) on its own (Table 8.4). When habitat composition, keeper density and proportion of area burned were considered simultaneously in the model only the proportion of the area burned ($P < 0.05$) was seen to have a significant effect on the density of red grouse. The main difference

in the results here, compared to those from the analysis of the presence of a keeper (Table 8.1), was the lack of a significant increase in red grouse density with keeper density.

Table 8.4: General Linear Model analysis of habitat density and keeper density in 2004.

Common name	Keeper significance on own	Model of habitat & keeper	Habitat, controlling for keeper & burning	Keeper, controlling for habitat & burning		Burning controlling for keeper & habitat	
	$F_{1,36}$	$F_{6, 31}$	$F_{4,35}$	$F_{1, 31}$	Relationship	$F_{1,31}$	Relationship
Carrion Crow	7.10*	1.45	0.44	0.73	-	0.10	-
Curlew	0.20	0.80	1.07	0.30	+	1.31	+
Dunlin	5.41*	6.63***	6.33***	9.79**	++	0.07	-
Golden Plover	0.84	2.08	2.37	1.62	+	0.12	-
Lapwing	0.14	1.92	2.51	1.03	+	5.49*	+
Meadow Pipit	0.16	1.03	1.43	4.06	-	0.05	+
Red Grouse	8.18**	4.38**	0.89	1.83	+	4.86*	+
Reed Bunting	8.90**	3.43*	2.43	14.52***	---	0.01	+
Ring Ouzel	0.01	4.66**	0.95	1.77	-	26.24***	++
Skylark	13.04***	5.49***	1.24	5.27*	-	2.97	-
Snipe	2.73	1.26	1.21	0.05	-	0.99	+
Twite	2.30	3.84**	4.12**	3.35	-	0.49	-
Wheatear	5.37*	1.83	0.67	0.01	+	1.00	-
Whinchat	2.70	2.67*	3.18*	0.21	-	1.58	+

* $P < 0.05$ ** $P < 0.01$ *** $P \leq 0.001$

8.8 GLMM analysis of bird densities in 2004

Of the waders surveyed in 2004, golden plover ($P < 0.001$) and dunlin ($P < 0.001$) had a significant positive association with the proportion of each surveyed 1km square that was within a keepered moor. (Table 8.5) Golden plover numbers ($P < 0.001$) also showed a significant negative association with proportion of its area burned, while curlew numbers were ($P < 0.01$) positively related to burning within its habitat. Amongst the passerines reed bunting ($P < 0.001$) and wheatear ($P < 0.05$) were the only two species surveyed in 2004 to show significant associations with the area of each surveyed 1km square within a keepered moor; both species were negatively related to keepering for grouse (Table 8.5). In 2004, no passerine densities were associated with burning. Red grouse numbers were significantly positively related to the proportion of habitat burned ($P < 0.05$) and to the proportion of each surveyed 1km square that was within a keepered moor ($P < 0.01$).

Table 8.5: Results from Generalized Linear Mixed Models (GLMM) analysis for 2004.

Common name	Keepering		Burning	
	Wald Statistic	Relationship	Wald Statistic	Relationship
Carrion crow	1.95	-	0.47	+
Curlew	0.19	-	7.23**	++
Dunlin	22.67***	+++	3.70	-
Golden plover	35.14***	+++	32.49***	---
Lapwing	0.54	+	0.56	+
Meadow pipit	0.82	-	0.66	-
Red grouse	68.16**	++	6.33*	+
Reed bunting	49.40***	---	0.83	-
Ring ouzel	0.01	+	0.14	+
Skylark	0.20	-	1.92	-
Snipe	1.10	-	0.94	+
Twite	1.58	+	1.64	-
Wheatear	5.01*	-	0.13	-
Whinchat	1.38	-	0.96	-

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

8.9 GLMM analysis of bird densities in 1990

Of the waders surveyed in 1990, numbers of dunlin ($P < 0.001$) and golden plover ($P < 0.001$) had significant positive associations with the proportion of area of a 1km square covered by keepered land, while dunlin ($P < 0.01$) had a significant negative association with the proportion burned (Table 8.6). Four passerines species surveyed in 1990 showed significant negative associations with the proportion of area covered by keepered land; carrion crow ($P < 0.001$), reed bunting ($P < 0.05$) wheatear ($P < 0.001$) and whinchat ($P < 0.001$). Red grouse numbers in 1990 were higher ($P < 0.001$) where the proportion of a km square covered by keepered land was higher (Table 8.6). Meadow pipit density was positively ($P < 0.05$) associated with burning.

Table 8.6: Results from Generalized Linear Mixed Models (GLMM) analysis for 1990.

Common name	Keepering		Burning	
	Wald Statistic	Relationship	Wald Statistic	Relationship
Carrion crow	27.58***	---	1.34	+
Curlew	3.39	-	0.52	-
Dunlin	22.30***	+++	8.12**	--
Golden plover	17.55***	+++	2.20	-
Lapwing	0.81	+	0.92	+
Meadow pipit	0.19	-	5.13*	+
Red grouse	10.86***	+++	0.12	+
Reed bunting	2.56*	-	0.59	+
Ring ouzel	4.23*	+	3.84	-
Skylark	0.40	-	0.36	-
Snipe	3.04	-	1.69	+
Twite	7.99**	++	1.17	+
Wheatear	21.12***	---	0.46	-
Whinchat	12.33***	---	0.02	+

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

8.10 GLMM analysis for change in bird density from 1990 - 2004

Two of the changes in wader density from 1990 to 2004 were significantly related the proportion of a 1km square covered by keepered land, dunlin ($P < 0.001$) and golden plover ($P < 0.01$, Table 8.7). The change in the densities of two other species, Curlew ($P < 0.01$) and Lapwing ($P < 0.05$) were positively related to the proportion of a 1km square that was managed via burning, whilst the change in snipe ($P < 0.05$) was negatively related to this. For passerines, the change in density of whinchat ($P < 0.01$) and ring ouzel ($P < 0.01$) were positively related to areas covered by keepered land (Table 8.7). The change in density of meadow pipits ($P < 0.05$), reed bunting ($P < 0.01$), skylark ($P < 0.05$), wheatear ($P < 0.001$) and whinchat ($P < 0.001$) were negatively related to the proportion of an area burned. The ring ouzel ($P < 0.01$) was positively related to the proportion of an area burned. The change in red grouse density from 1990 to 2004 was positively linked to the area that was covered by keepered land ($P < 0.001$, Table 8.7).

Table 8.7: Results from Generalized Linear Mixed Models (GLMM) analysis for 1990-2004 density change.

Common name	Keepering		Burning	
	Wald Statistic	Relationship	Wald Statistic	Relationship
Carrion crow	0.61	+	0.45	+
Curlew	3.63	+	9.47**	++
Dunlin	19.10***	+++	0.74	-
Golden plover	9.60**	++	1.73	-
Lapwing	2.48	+	6.50*	+
Meadow pipit	0.25	-	6.63*	-
Red grouse	16.12***	+++	1.12	+
Reed bunting	0.17	-	7.29**	--
Ring ouzel	9.96**	--	8.13**	++
Skylark	0.01	-	5.37*	-
Snipe	0.12	-	4.55*	-
Twite	0.02	+	0.01	-
Wheatear	0.70	+	15.69***	---
Whinchat	7.77**	++	38.22***	---

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Again, on the request of the Moors for the Future team we reanalysed this section, including cottongrass as a separate category within habitat composition (Appendix, Table I). Here the

only difference was that the positive relationship between the area of a square that was keepered and the change in lapwing density was now significant.

8.11 GLMM analysis with bird of prey densities in 2004

The densities of peregrine falcon ($P < 0.001$), kestrel ($P < 0.01$), and short-eared owl ($P < 0.05$) were all significantly positively related to the area of each surveyed 2x2km^2 tetrad within a keepered moor. Larger densities of merlin ($P < 0.001$) were found in tetrads with higher proportions of burning (Table 8.8).

Table 8.8: Results from Generalized Linear Mixed Models (GLMM) analysis for 2004 Birds of Prey

Common name	Keepering		Burning	
	Wald statistic	Relationship	Wald statistic	Relationship
Buzzard	1.21	+	0.14	+
Goshawk	1.78	+	1.41	+
Hen harrier	1.40	+	3.42	+
Hobby	No model fitted			
Kestrel	12.77***	+++	0.06	-
Little Owl	0.39	-	0.94	-
Long eared owl	No model fitted			
Merlin	0.14	-	16.20***	+++
Peregrine	19.47***	+++	0.69	-
Short Eared Owl	7.15**	++	0.60	+
Sparrowhawk	2.77	+	2.70	-

$P < 0.05$ ** $P < 0.01$ *** $P \leq 0.001$

CHAPTER NINE: DISCUSSION OF RESULTS

9.1 Compositional Analysis

The results from the compositional analysis showed that within the PDNP the moors managed for grouse had significantly higher proportions of heath and mire when compared to moors not managed for grouse. Past research supports this result, stating that the moors managed for grouse will typically include areas of heather dominated moorland a major source of food for the grouse (Tapper, 1999; Hudson 1992), defined by English Nature (2001) as heath. Heather dominated moorland is also a unique habitat which can be manipulated through management tasks e.g. cutting and burning to achieve optimal conditions for the grouse (Hudson and Newborn, 1995). Robertson et al. (2001) found that areas that had retained grouse shooting retained heather cover.

9.2 T-Test

The T-Test showed a significant association between the areas of moorland which were managed for grouse shooting in the PDNP and the increasing proportions of land burned. Tapper (1999) highlights the fact that grouse managers are actively encouraged to burn heather on a rotation system to provide grouse with an optimal habitat. Tharme *et al.* (2001) and Hudson and Newborn (1995) concluded that heather burning had a positive effect on the populations of red grouse. Hudson and Newborn (1995) emphasise that burning will have an effect on other upland birds which could suggest that all burning which may occur is not necessarily geared towards grouse populations. However, Robertson (2001) implies that there may be no direct economic gain from burning areas of land without subsequently shooting the grouse.

9.3 General Linear Model Analysis -Charadriiforms

9.3.1 Keeper Presence/ Density

In 1990 and 2004 dunlin and golden plover, two species which are often found in similar habitat, (Gibbons *et al.* 1993) were significantly positively associated with gamekeeper presence. The density of the dunlin was also positively associated with gamekeeper density in 2004. Tharme *et al.* (2001) also found that golden plover had a preference for areas managed for grouse, recording numbers five times higher on keepered land. However; Stillman and Brown (1994) associate dunlin and golden plover with areas of blanket bog, not heather moorland which is the dominant habitat occurring on moors managed for grouse (Tapper, 1999). Seymor *et al.* (2003) suggests that foxes in particular will predate the nests of waders on moorland. The increased densities of the waders could therefore be due to the legal control of predators on the moorland areas.

The change in density of dunlin from 1990 and 2004 area was significantly less on keepered areas than on unkeepered ones. Seymor *et al.* (2003) suggests that predators which are controlled on keepered areas can negatively affect the density of moorland birds. However; Cramp *et al.* (1977) states that dunlin generally avoid heather dominated areas which are a dominant feature of moors managed for grouse.

9.3.2 Habitat Composition

In 1990, the densities of dunlin, curlew and snipe were all significantly related to habitat, with dunlin and golden plover significantly related to habitat in 2004. Carr and Middleton (2004) state that within the PDNP the majority of dunlin, golden plover and snipe are found on wet bog and grassy areas with the curlew found in unimproved marginal land often on the moorland edge. Gibbons *et al.* (1993) also found that dunlin, snipe and golden plover are related to mire. Stillman and Brown (1994) associated the abundance of dunlin and golden plover with short vegetation and burnt heather patches whilst suggesting that the curlew may also be found on heather.

9.3.3 Proportion of Area Burned

In 2004 and 1990 the proportion of an area burned (controlling for habitat composition and keeper presence) had a significant positive effect on lapwing density. Gibbons *et al.* (1993) also concluded that lapwings have a preference for short vegetation especially areas of recently burnt heather in the uplands. Increases in lapwing density have been observed in the PDNP from 1990 to 2004 (Carr and Middleton, 2004). It is possible that the increase in species could be due to an increase in appropriate burning which is a substantial part of the ESA scheme now in place over significant areas of the PDNP (DEFRA, 2006).

In contrast to the results found above, the change in dunlin density between 1990 and 2004 was significantly negatively related to burning, with a greater loss of dunlin in areas with more burning. Cramp *et al.* (1977) state that the dunlin will generally avoid the shrubby areas only opting for heather in its short burnt state, this result appears to contradict this statement. Carr and Middleton (2004) would also argue that within the PDNP dunlin prefer grassy areas not necessarily typical of a grouse moor.

9.4 General Linear Model Analysis - Passeriformes

9.4.1 Keeper Presence/Density

In 2004 the carrion crow, reed bunting, wheatear and skylark were all significantly negatively related to the presence of a keeper and to keeper density, with the whinchat showing the same result for keeper status only. In 1990 the carrion crow and reed bunting were also significantly negatively related. It is well documented that the numbers of the carrion crow are controlled by gamekeepers due to their predation on the eggs of grouse (Cox *et al.* 2004). Tharme *et al.* (2001) and Baines (1996) both document that the density of carrion crow is higher on un-keepered land. Reed bunting has a preference for grassland, arable crops and young plantations (Gibbons *et al.* 1993) with the wheatear opting for grazed swards. (Henderson *et al.* 2004). The skylark like the reed bunting also has an affinity for arable fields especially the set-aside areas which are an increasingly common feature on farmland Gibbons *et al.* (1993). It is suggested by Stillman and Brown (1994) that the whinchat is a bird which is not dependent on moorland and will often choose bracken as a favoured habitat. For many of the

smaller passerines it is clear that moorland is not their habitat of choice, although it is not completely avoided. Instead grassland, bracken and arable land are more likely to be opted for and therefore support higher densities of the passerines.

9.4.2 Habitat Composition

In 2004 the densities of skylark, twite, wheatear and whinchat were all significantly related to their habitat with the skylark demonstrating a similar result in 1990. Within the PDNP, MFF (2004) relate skylark densities to upland acid grassland which is commonly used for sheep grazing (English Nature, 2001). Whinchat and twite are described by MFF (2004), Stillman and Brown, (1994) and Hanworth and Thompson (1990) as being associated with areas of bracken. Bracken dominated communities are not usually tolerated for on areas of moor which are managed for grouse, due to its invasive often replacing stands of heather (Pakeman *et al.* 2002). Within the PDNP, wheatear prefer rocky areas often close to moorland (Carr and Middleton, 2004; Gibbons *et al.* 1993). Henderson *et al.* (2004) also found that areas of marginal land with grass, moorland and roosting sites are the preferred habitat for the wheatear.

The change in carrion crow density from 1990 to 2004 is significantly related to habitat with a greater decrease in crow numbers on un-keepered areas. Crows will often opt for trees within their habitat to use for perching and nesting (Gibbons *et al*. 1993). It was noted by (Tapper, 1999) that crows are versatile in their habitat requirements which would make a reasoned argument for the decrease in population in the PDNP especially difficult on un-keepered land.

9.4.3 Proportion of Area Burned

In 2004 the ring ouzel was significantly positively related to proportion burned within its habitat. Henderson *et al.* (2004) stated that moorland is a key habitat for the species, suggesting that reductions in moorland area were a cause of species decline. Hudson and Newborn (1995) affirm that a variety of heather heights will benefit grouse as well as other species, which appeared to include the ring ouzel.

It is believed that the ring ouzel has affinities for burning which may be occurring in greater amounts since 1990 due to the ESA scheme (DEFRA, 2006) and increased interest in grouse

moor management for commercial gains. (Tapper, 2005) An explanation for ring ouzel decline on keepered land is therefore not apparent and would require further examination.

In 2004 skylark, twite and wheatear densities are negatively associated with the proportion of burning in their habitats which was the same for the skylark and twite in 1990. Wheatear inhabit areas of moorland (Henderson *et al.* 2004) although they also prefers areas of short grassland in close proximity to moorland (Gibbons *et al.* 1993). Large areas of burnt moor may be within the mass of the dark and south west peaks, some distance away from the grasslands, and therefore may not be utilised by the species. Cramp *et al*. (1977) states that the skylark is a versatile bird in terms of habitat; although Carr and Middleton (2004) suggest that within the PDNP the species shows preference for acid grassland. Again, the areas of acid grassland may not be located in close proximity to areas of heather moorland, where substantial burning takes place. The result for the twite contradicts the findings of both Hanworth and Brown (1990) and Gibbons *et al*.(1993) who state that the species has an affinity for heather moorland where much of the burning within the PDNP takes place. Brown (1995) suggests that the moorland edge is often favoured by the twite which will not be burned as frequently as the heather moorland if at all.

9.5 General Linear Model Analysis - Galliformes

9.5.1 Keeper Presence/Density

In 2004 the red grouse was significantly positively related to keeper presence and keeper density. This view is supported by Tharme *et al* (2001) and Smith *et al* (2001) who found more grouse on moors which were managed specifically for them. It is suggested by Tapper (1999) and Hudson (1992) that predator control and burning are specific activities which aid the density of the grouse and which are undertaken by moorland keepers

9.5.2 Habitat Composition

In 2004 grouse density was also significantly related to habitat, being mainly on the heather moorland, as also found by the Carr and Middleton (2004). Tapper (1999) and Hudson (1992) support these findings by stating that grouse area strongly associated with, and restricted by the amount of heather moorland in the UK. Specific heather management e.g. burning and

cutting for grouse will improve the habitat for the species, therefore encouraging numbers (Hudson, 1992; Hudson and Newborn 1995; Tapper 1999; 2005).

9.5.3 Proportion of Area Burned

The density of the red grouse was also significantly positively associated with the proportion of its habitat burnt. Tharme *et al.* (2001) also found that heather burning had a positive effect on the populations of this species with Hudson and Newborn (1995) and Tapper (1999) recommending that the process of burning should be an integral part of red grouse management. The ESA scheme may have encouraged landowners to burn areas of heather in a more structured manner and reduce grazing densities on land, both of which will have improved the habitat for the species (DEFRA, 2006; Tapper, 1999; 2005).

9.6 Generalized Linear Mixed Models (GLMM) Analysis -Charadriiforms

9.6.1 Keepering

In 1990 and in 2004 the densities of dunlin and the golden plover were significantly positively associated with the presence of a keeper which would conform to the results from the GLM analysis previously discussed in section 9.3.

9.6.2 Burning

In 2004 golden plover was significantly negatively affected by the proportion burnt in its habitat which is a result which does not appear in the GLM analysis. Carr and Middleton (2004) record the species as favouring cotton grass/crowberry dominated moorland within the PDNP which may explain why the species is not found on burnt areas. It is however the view of Gibbons *et al*. (1993) that plovers do like areas of burnt heather with Tharme *et al.* (2001) suggesting that plovers are found in greater proportions on moors managed for grouse, where heather is typically burnt (Tapper, 1999).

The curlew in 2004 was significantly positively related to the proportion of its habitat burnt which contradicts the findings of the GLM which did not find the same significant relationship. It is suggested by Hudson and Newborn (1995) that burning will benefit other moorland birds as well as the grouse, with Tharme *et al.* (2001) concluding that curlew density is higher on moors managed for grouse, which typically host burning activities. Carr and

Middleton (2004) however, state that the species is largely absent from the high plateaus of the PDNP where a large proportion of moor burning will take place, opting for marginal areas which include both inbye and moorland edges.

9.7 Generalized Linear Mixed Models (GLMM) Analysis - Passeriformes

9.7.1 Keepering

In 1990 the carrion crow, reed bunting, whinchat and wheatear are all significantly negatively related to keeper presence. This result is found for both the carrion crow and reed bunting but not the wheatear and whinchat in 2004 GLM analysis in section 9.3.

In 2004 the reed bunting and wheatear are significantly negatively related to keeper presence which also conforms to the findings of the GLM discussed in section 9.3.

The change in density of the whinchat between 1990 and 2004 was significantly positively related to keeper presence a result not seen in the GLM analysis. The whinchat is known to have an affinity for stands of bracken which are not typically found on keepered grouse moors. (Stillman and Brown, 1990). Sim *et al.* (2005) also states that within the south Pennines the whinchat has a great affinity for bracken. It is however suggested by Stillman and Brown (1994) that although not dependent on it, the whinchat will occupy areas of heather moorland.

The opposite effect has been observed with the ring ouzel which is seen to be negatively affected by the presence of a keeper. There is strong evidence from both Wooton *et al.* (2002) and Henderson *et al*. (2004) that the species is a bird with strong affinities for the open moor often nesting under heather. It is however suggested by Gibbons *et al.* (1993) that the ring ouzel will fly long distances to reach moorland often from areas with bare rock or stunted trees for roosting.

9.3.2 Burning

The density of the meadow pipit in both 1990 and 2004 can be significantly negatively attributed to the area of its habitat burned. This is a result not observed in the GLM analysis. Gibbons *et al*. (1993) and Carr and Middleton (2004) state that meadow pipits have a high

variability in habitat preference although Brown and Stillman (1993) highlight the species preference for bracken and rough grassland and assert that the species declines with increases in heather dominated swards. Burning will occur on heather dominated land (Hudson and Newborn, 1995; Tapper, 1999) which the meadow pipit may avoid.

One-kilometre squares with more burning had lower densities of meadow pipit, reed bunting, skylark, wheatear and whinchat in 2004 versus 1990. None of these results were seen within the GLM analysis. We have demonstrated in this study (See 8.2) as has Hudson (1992) that burning is a feature of moors managed for grouse. It is generally agreed that whinchat, wheatear, reed bunting, skylark and meadow pipit have affinities for grasses and bracken and arable land (Cramp *et al.* 1977) and are not dependent on moorland habitat. However meadow pipit, and to some extent skylark (Gibbons *et al.* 1993), are known to be indiscriminate in their habitat choice and are unlikely to avoid moorland burning activity entirely.

The opposite effect was observed with ring ouzel whose change in density was positively related to the proportion of habitat burned. This matched what was found in the GLM analysis (see 9.4).

9.8 Generalized Linear Mixed Models (GLMM) Analysis - Galliformes

9.8.1 Keepering and Burning

In 1990 and 2004 the number of red grouse were significantly positively related to the area covered by keepered estates which was also observed in the 1990 and 2004 GLM analysis. It is highlighted by Carr and Middleton (2004) that the grouse in the PDNP are found primarily on heather moorland which is a habitat managed specifically for them. (Hudson, 1992)

The change in density of the species from 1990 to 2004 was also significantly positively associated with area covered by keepers and proportion of its habitat burnt; a result which is discussed in section 9.3

9.10 Birds of Prey

9.10.1 Keepering

In 2004 the densities of the peregrine, short-eared, owl and kestrel all increased in comparison to 1990 and were significantly positively related to the areas covered by keepered estates. Of the three the peregrine and the short-eared owl are identified by Tapper (1999) and Gibbons *et al.* (1993) as having a clear preference for moorland due to the open landscape and undisturbed characteristics.

Peregrine in the PDNP were recorded by Carr and Middleton (2004) as undergoing an increase of 18 pairs from 1990 to 2004 which is a recovery following a national decline in the species (Gibbons *et al.* 1993). The rocks and crags of the PDNP may provide suitable nesting habitat for the species (Cramp, 1973). The availability of prey, especially in the form of the small bird life, is also a characteristic of the PDNP which may appeal to peregrine.

The short-eared owl is also recorded as increasing within the PDNP study area (Carr and Middleton, 2004) which may be due to the undisturbed nature of much of the moorland (Cramp, 1977) (especially the dark peak). It is suggested by Hanworth and Thompson (1990) that the species prefers drier habitats such as grass and sedge, over which to hunt small mammals. The heather moorland managed for grouse also provides a dry habitat for short-eared owls to hunt over (Gibbons *et al.* 1993) thus explaining their preference for keepered land which has higher proportions of heath and mire in the PDNP.

It has been suggested by Thirgood *et al* (2000), Green and Etheridge (1999), Watson and Thirgood (2001) and Tapper (1999; 2005) that persecution of birds of prey is a reason for their decrease in population. In the PDNP the three species (two specific to moorland) are increasing in density. The density of the species in 2004 can be significantly positively linked to the areas which are managed for grouse by keepers who have been accused of persecuting them in the past.

None of the birds of prey were found to be negatively linked to the area covered by keepered land.

9.10.2 Burning

Of all the birds of prey the merlin densities shows a significant positive relationship with areas of burnt moorland. The merlin, a typical moorland predator (Gibbons *et al.* 1993) is heavily associated with heather dominated habitat (Hanworth and Thompson, 1990) often nesting in the taller vegetation (Stillman and Brown, 1993). Hudson and Newborn (1995) also suggest that heather burning benefits a range of birdlife which may include the merlin as well as small birds which it can utilise as prey. Within the PDNP the areas of burnt moorland are significantly associated with areas which have a keeper present. (See section 9.2)

CHAPTER TEN: CONCLUSION

The Peak District National Park covers an internationally recognised and protected landscape with its associated assemblage of birds (Thompson, 1994). Grouse shooting is an important land use within the PDNP, covering 64% of the moorland area of the Park, and has a long tradition going back to at least the 1880's (Tapper, 1999). The effect of habitat management for grouse on other upland bird species has been studied previously over large areas of the uplands. The results from this study both collaborate and contradict the findings of previous work.

The results from this study show that gamekeepering activity and moor burning do have some significant effects on the density of birds in the Peak District.

Within the PDNP the habitat composition of areas which are managed for grouse is significantly different to areas without grouse shooting. Higher proportions of heath and mire can be found on the keepered areas. There is also significantly more burning on the areas that are managed for grouse.

Of the waders, densities of both the dunlin* and golden plover* were significantly higher on managed grouse moors in both 1990 and 2004. Curlew*** and Snipe density were lower on grouse moors in 1990 but this was not the case in 2004. Dunlin* and golden plover* density was also significantly associated with habitat in 1990 and 2004, as noted by Carr and Middleton (2004). The most interesting find was that the relative decrease in dunlin* density between 1990 and 2004 was less on gamekeepered areas than on non-gamekeepered areas. We found some evidence that lapwing** benefit from burning, both in 1990 and 2004. There was evidence, on a localised scale, that increases in curlew*** density between 1990 and 2004 may be related to burning activity, whilst the opposite was true for dunlin*.

Amongst passerines, reed bunting densities were consistently lower (both 1990 and 2004) on areas that were managed for grouse. The decline in twite** density within the PDNP between 1990 and 2004 was higher in areas with more burning, but there was no relationship with gamekeepering itself. The opposite was true for ring ouzel, with declines of this species less

on areas that had a higher proportion of burning. Skylark, twite**, wheatear and whinchat* densities are all significantly explained by habitat favouring landscapes that includes a high proportion of grasses and tall herbs such as bracken **(**Carr and Middleton, 2004). On a local level, the effect of burning was still positive for ring ouzel* although skylark and wheatear densities were negatively related to the proportion of their habitat burnt.

The density of red grouse within the PDNP has increased from 1990 to 2004. We found this to be significantly and positively related to the amount of habitat burnt. The density of grouse in 2004 was also positively associated with the level of keepering within its habitat.

Sightings of peregrine falcon, short eared-owl and kestrel have all increased in the PDNP. The densities of these sightings in 2004 can be positively associated with areas that are managed for grouse. The merlin* has increased in the PDNP with the density of sightings in 2004 significantly related to areas with a high proportion of burning.

Within the PDNP there are a range of avian species (many internationally recognised) which inhabit the diverse range of habitats which the PDNP hosts. The current agricultural climate provides an opportunity to gain payment for environmentally aware land management (through agri-environment schemes) which should be used to deliver environmental protection and enhancement to all habitats within the PDNP. Ensuring that a range of habitats are available will ensure the biodiversity of the PDNP for years to come. Our results indicate some effects of both gamekeepering and the use of controlled burning on this biodiversity. It should be possible to utilise grouse moors management for the benefit of biodiversity in general, especially as regards upland wader species.

* Peak District National Park SPA designation species

** Peak District National Park Biodiversity Action Plan species

*** Both

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APPENDIX 1

Table A - General linear model analysis of habitat, burning and keeper status on moorland area in 2004.

Common name	Habitat on its own (4)	Keeper on own (2)	Burning on own	Model of habitat, keeper and burning	Habitat, controlling for keeper &burning	Keeper, controlling for habitat & burning		Burning controlling for habitat & keeper	
	$F_{4,35}$	$F_{1,38}$	$F_{1,33}$	$F_{6,33}$	$F_{4,33}$	$F_{1,33}$	Relationship	$F_{1,33}$	Relationship
Canada Goose	3.57**	1.32	7.30*	3.53**	1.60	3.51	+	0.98	-
Chaffinch	0.56	5.02*	0.28	1.94	0.80	5.79	-	4.14	+
Common Sandpiper	6.01***	0.61	14.23***	7.96***	4.71**	3.67	+	3.05	-
Cuckoo	0.63	3.02	6.80*	2.00	1.10	2.82	-	5.16*	-
Dipper	0.72	0.05	0.01	0.60	0.89	0.20	+	0.65	+
Grey Wagtail	1.67	0.29	6.13	1.69	1.00	2.17	+	0.74	-
Linnet	0.79	10.92**	0.35	5.06***	3.76*	24.24***	---	0.04	-
Mallard	2.19	0.01	3.65	1.98	1.81	0.01	+	2.89	-
Mistle Thrush	3.58*	0.01	4.35*	2.38	2.23	0.14	+	0.33	-
Pheasant	0.93	3.99	0.45	3.53**	2.97*	15.92***	---	0.49	+
Pied Wagtail	2.79*	1.51	4.73*	2.69*	2.61	1.06	-	3.63	-
Raven	0.66	0.71	0.09	0.81	1.05	2.21	+	0.02	+
Redstart	1.02	0.13	0.03	1.37	1.99	1.31	+	3.44	+
Stock Dove	2.66*	0.45	2.32	2.23	2.21	2.42	+	0.13	+
Stonechat	0.10	2.79	1.97	0.97	0.64	3.24	-	2.04	-
Tree Pipit	2.78*	6.98*	2.49	2.15	1.35	1.80	-	0.15	-
Willow Warbler	1.52	0.99	2.43	4.98***	5.15**	14.01***	---	9.78**	+++
Wren	1.63	0.72	3.38	1.16	0.91	0.13	-	0.57	+

- $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

- **Table B - General linear model analysis of habitat and keeper status on moorland area in 1990.**

Common name	Habitat on its own	Keeper on its own	Burning on its own	Model of habitat burning & keeper	Habitat, controlling for keeper & burning	Keeper, controlling for habitat & burning		Burning, controlling for habitat & keeper	
	$F_{4,33}$	$F_{1,36}$	$F_{1,36}$	$F_{6,31}$	$F_{4,35}$	$F_{1,33}$	Relationship	$F_{1,33}$	Relationship
Canada Goose	4.49**	0.03	10.51**	4.29**	2.69	0.01	+	5.50*	-
Common Sandpiper	2.49	0.16	0.53	2.76*	3.80*	5.25*	+	2.27	+
Cuckoo	0.22	1.03	1.30	0.98	0.43	1.93	-	3.40	+
Dipper	2.06	8.38**	2.11	2.36	1.28	4.98*	+	0.08	-
Grey Wagtail	0.32	2.32	0.70	0.62	0.38	2.00	+	0.24	+
Redshank	12.40***	0.03	5.08*	17.24***	20.86***	20.45***	+++	8.55**	++

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Table C- Change in bird density from 1990 to 2004 on an estate basis.

Common name	Model of habitat and keeper and burning	Habitat, controlling for keeper & burning	Keeper, controlling for habitat & burning		Burning controlling for habitat & keeper	
	$F_{43,30}$	$F_{4,30}$	$F_{1,30}$	Relationship	$F_{1,30}$	Relationship
Canada Goose	243766.09***	452354.73***	2.24	-	452354.73***	+++
Common Sandpiper	7.16***	0.58	0.54	-	5.02*	-
Cuckoo	3.31***	2.31	0.64	-	17.65***	---
Dipper	9.38***	20.74***	0.01	-	37.56***	+++
Grey Wagtail	3.31***	4.78**	8.10**	++	1.28	+
Redshank	628705.45***	304583.36***	12.44**	++	7.13*	-

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Table D - Change in bird density from 1990 to 2004 on an estate basis, using cottongrass as a separate habitat.

Common name	Model of habitat and keeper & burning	Habitat, controlling for keeper & burning	Keeper, controlling for habitat & burning		Burning controlling for habitat & keeper	
	$F_{44,29}$	$F_{5,29}$	$F_{1,29}$	Relationship	$F_{1,29}$	Relationship
Carrion crow	8.78***	2.65*	2.52	+	1.43	-
Cuckoo	3.22***	1.96	0.58	-	10.42*	-
Curlew	3.00**	0.55	0.03	+	0.47	+
Dipper	4.21***	19.56***	0.60	-	40.24***	+
Dunlin	10.03***	3.04*	4.67*	+	2.61	-
Grey wagtail	3.18***	3.84**	7.90**	++	0.38	+
Golden plover	7.41***	2.62*	0.96	-	0.08	+
Lapwing	3.61***	1.94	3.52	+	0.41	-
Meadow pipit	2.33**	2.07	2.42	+	0.04	-
Red grouse	8.71***	0.59	2.61	+	2.12	+
Reed bunting	13.34***	1.24	1.51	-	0.67	-
Ring ouzel	2.79**	1.27	1.65	-	7.71*	+
Skylark	4.99***	0.42	0.01	-	1.19	-
Snipe	3.17***	0.92	2.21	+	0.97	-
Twite	55.06***	5.14**	1.37	+	32.19***	-
Wheatear	2.79**	0.88	0.15	-	0.64	-
Whinchat	3.51***	1.82	2.31	+	1.65	-

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Table E - General Linear Model analysis of habitat density and keeper density in 2004.

Common name	Habitat on its own (4)	Keeper on own (2)	Burning on own	Model of habitat, keeper and burning	Habitat, controlling for keeper &burning	Keeper, controlling for habitat & burning		Burning controlling for habitat & keeper	
	$F_{4,33}$	$F_{1,36}$	$F_{1,33}$	$F_{6,31}$	$F_{4,35}$	$F_{1,31}$	Relationship	$F_{1,31}$	Relationship
Canada Goose	3.57**	0.05	7.30*	3.03*	2.18	1.95	+	2.07	-
Chaffinch	0.56	5.99*	0.28	2.81*	1.10	10.65**	--	4.84*	+
Common Sandpiper	6.01***	1.20	14.23***	6.45***	4.85**	0.49	+	9.26**	--
Cuckoo	0.63	1.03	6.80*	1.38	0.56	0.16	-	5.19*	-
Dipper	0.72	0.19	0.01	0.54	0.76	0.02	-	0.58	+
Grey Wagtail	1.67	1.85	6.13	1.23	0.48	0.27	+	1.00	-
Linnet	0.79	0.98	0.35	1.11	1.41	2.99	-	0.45	-
Mallard	2.19	1.40	3.65	2.23	2.33	1.57	-	2.87	-
Mistle Thrush	3.58*	1.26	4.35*	2.26	2.22	0.06	+	0.44	-
Pheasant	0.93	0.04	0.45	0.69	0.93	0.71	-	0.03	+
Pied Wagtail	2.79*	2.27	4.73*	2.34	2.15	0.13	-	2.96	-
Raven	0.66	0.37	0.09	0.47	0.62	0.45	+	0.01	-
Redstart	1.02	5.40*	0.03	1.62	0.41	2.94	-	2.50	+
Stock Dove	2.66*	0.69	2.32	1.62	1.83	0.06	+	0.11	-
Stonechat	0.10	4.87*	1.97	1.64	1.21	7.00*	-	1.67	-
Tree Pipit	2.78*	13.54***	2.49	2.70*	0.82	4.80*	-	0.07	-
Willow Warbler	1.52	0.03	2.43	1.90	2.07	0.57	-	4.56*	+
Wren	1.63	2.38	3.38	1.15	0.80	0.10	+	0.44	+

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Table F - Results from Restricted Maximum Likelihood Model (REML) analysis for 2004.

Common name	Keepering		Burning	
	Wald Statistic	Relationship	Wald Statistic	Relationship
Canada Goose	4.00*	+	0.17	-
Chaffinch	0.92	-	1.23	-
Common Sandpiper	6.39*	+	1.14	-
Cuckoo	1.51	-	0.01	+
Dipper	0.01	+	14.58***	+
Grey Wagtail	4.74*	+	2.85	-
Linnet	27.39***	-	0.01	-
Mallard	0.36	+	0.04	-
Mistle Thrush	0.12	+	0.23	+
Pheasant	5.64*	-	0.16	+
Pied Wagtail	0.14	-	0.64	-
Raven	3.94*	+	2.53	-
Stock Dove	2.93	+	1.51	-
Stonechat	2.78	-	0.23	-
Tree Pipit	5.40*	-	0.01	-
Whitethroat	0.01	-	0.79	-
Willow Warbler	0.70	-	0.12	+
Woodcock	0.01	+	3.35	+
Woodpigeon	1.34	-	0.05	-
Wren	0.45	+	2.83	+

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Table G - Results from Restricted Maximum Likelihood Model (REML) analysis for 1990.

Common name	Keepering		Burning	
	Wald Statistic	Relationship	Wald Statistic	Relationship
Canada Goose	0.08	+	0.01	-
Common Sandpiper	0.89	+	0.34	+
Cuckoo	0.01	-	0.17	+
Dipper	1.11	+	0.96	+
Grey Wagtail	1.88	+	5.40*	+
Redshank	0.01	-	0.01	-

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Table H - Results from Restricted Maximum Likelihood Model (REML) analysis for 1990-2004 density change.

Common name	Keepering		Burning	
	Wald Statistic	relationship	Wald Statistic	relationship
Canada Goose	8.34**	++	0.01	+
Common Sandpiper	18.00***	+++	0.02	-
Cuckoo	0.74	-	2.42	+
Grey Wagtail	0.22	+	445.69	---
Redshank	0.41	+	0.01	+

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$

Table I - Results from Restricted Maximum Likelihood Model (REML) analysis for 1990-2004 density change, including cottongrass as a habitat category.

Common name	Keepering		Burning	
	Wald Statistic	Relationship	Wald Statistic	Relationship
Canada Goose	7.73**	++	0.01	+
Carrion crow	0.70	+	0.72	+
Common Sandpiper	0.01	+	0.01	-
Curlew	3.43	+	8.30**	++
Cuckoo	46.04***	---	6.67*	+
Dunlin	15.73***	+++	0.55	-
Grey Wagtail	0.18	+	444.55***	---
Golden plover	8.16**	++	1.65	-
Lapwing	4.47*	+	8.58**	++
Meadow pipit	0.23	-	6.97**	--
Red grouse	16.76***	+++	0.98	+
Redshank	0.41	+	0.01	+
Reed bunting	0.17	-	7.29**	--
Ring ouzel	9.96**	--	8.13**	++
Skylark	0.08	-	4.01*	-
Snipe	0.12	-	4.55*	-
Twite	0.04	+	0.02	-
Wheatear	0.85	+	15.90***	---
Whinchat	7.77**	++	38.22***	---

* $P < 0.05$ ** $P < 0.01$ ***$P \leq 0.001$