

# **Development of a Biodiversity Management Plan for a Cumbrian Tourism and Leisure Complex**

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The plan was developed by a post graduate student at Lancaster University  
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### Abstract

The Langdale Estate is a 35 acre hotel and leisure complex within the Langdale Valley of Cumbria. The estate would like the site to be environmentally managed to maximise its contribution to biodiversity and have asked for a biodiversity survey of the land to be carried out. Biodiversity can be managed through Biodiversity Action Plans. These plans will identify priority species which may demonstrate low abundance and put together management plans which will manipulate the site in an attempt to maintain or increase biodiversity.

Surveys were carried out for birds, butterflies, bees, amphibians, reptiles, vegetation and mammals. The site was divided into two areas, the first, the main estate which comprises of the hotel, restaurants, lodges and the country club, the second is Birch Hill Wood and Elterwater grassland, 4 hectares of woodland and 1.6 hectares of grassland which was previously grazed by sheep.

The survey results show that the site contains 27 species of birds, 4 species of butterfly, 3 species of bumblebees, 3 different plant communities and 8 species of mammals. Of these, 5 species and 2 habitats are listed under national and local biodiversity action plans; marsh tit, spotted flycatcher, song thrush, house sparrow and common pipistrelle, oak - birch woodland and developing grassland and have been incorporated in a Langdale biodiversity action plan.

The diversity of species present on site is varied; birds show a modest number of species whereas other groups such as the butterfly do not. Management of the site can change the existing structure into a more inhabitable one to maintain or increase the current level of biodiversity. A reduction in shrub layer of the woodland and the introduction of new plant species to the grassland will provide more habitats for butterflies whereas the removal of non native shrubs and the planting of native ones will provide more food resources for birds and mammals. Carrying out the suggested management strategies will help develop diversity richness within the estate, especially those that will benefit the species listed on the Langdale Biodiversity Action Plan.

*Keywords* —Biodiversity, management, conservation, Cumbria, Biodiversity Action Plans.

*Word count* —8461.

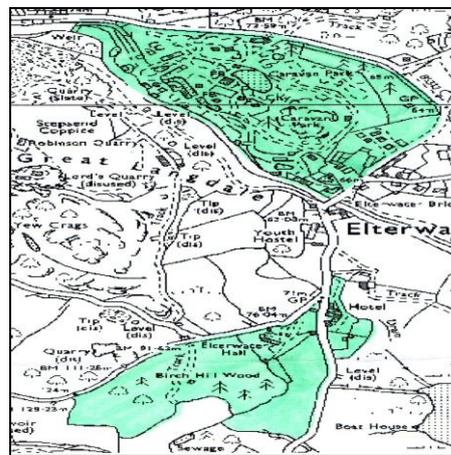
## INTRODUCTION

Within Britain the countryside and wildlife conjure up images of tranquillity and recreation. It is these qualities that enable it to provide economic and social values for the people through recreational activities and organisations such as the wildlife trust. Conservation is important as it works towards preserving and enhancing the wildlife around us, making people aware of the full diversity plants and animals Britain has to offer. Conserving rare species brings about public interest and involvement which in turn generates income with establishments such as nature reserves. Conservation also provides educational values, teaching the next generation the consequences of not protecting our heritage.

The Lansdale Estate is a hotel and leisure complex within the Langdale Valley of Cumbria (Figure 1). It lies 5km west of Ambleside, on the northern bank of the Great Langdale Beck west of Elterwater (Figure 2) within a designated Area of Outstanding Natural Beauty (AONB). The main estate is comprised of 35 acres of natural woodland, streams and tarns. The complex itself has a hotel, country club and timeshare lodges (Jecock et al.,2003).



**Figure 1.** A map of North West England displaying the location of the Langdale Estate



**Figure 2.** A map of Elterwater. Areas shaded green display in detail the Langdale Estate land.

The history of the site can be traced back to the 17<sup>th</sup> Century, when Cumbria was renowned for its sheep farming, and Langdale Estate started out as a Woolen Mill. Wool from local flocks was processed by the mill which was driven by a water wheel powered by the Great Langdale Beck<sup>1</sup>. In 1823, a local entrepreneur David Huddleston bought the site and turned the mill over to manufacturing gunpowder (Jecock et al., 2003). The Elterwater Gunpowder Works was one of seven powder manufacturers within southern Cumbria. The Lake District provided an ideal location for gunpowder works due to the extensive rivers providing an ample head of water for driving the factories and the woodland surroundings a perfect barrier to enclose any explosions.

After World War 1 the demand for gunpowder fell dramatically causing the collapse of the Cumbrian gunpowder industry. In 1930 the site was forced to close and shortly afterwards was purchased by a local landowner who developed the land into a small hotel and cottages (Jecock et al., 2003). In 1981 the site was taken over by the Langdale Partnership who introduced the notion of timeshare properties on the site. The site was turned into a luxury hotel and log cabin complex<sup>1</sup>. In 1987 Scottish & Newcastle Breweries took over for 9 years and in 1997 the time share holders of the log cabins bought out the brewery and became the owners<sup>1</sup>.

For 12 years now the site has been controlled by the time share holders effectively becoming the owners, who have decided that the estate should be environmentally managed to maximise its contribution to biodiversity, and become an area that will blend back into its natural surroundings. To begin this vision, the estate has asked for a biodiversity survey of the land to be undertaken, the scope of which will include surveys of mammals, birds, amphibians, reptiles and vegetation. Once it is known which species are present with their related abundance, a Biodiversity Action Plan (BAP) can be prepared to conserve those species present.

Biodiversity means the variety of life which includes all living organisms, as well as biodiversity stating what is around us, it links in with possibilities to maintain that variety and how to increase it. It is this definition that brings about Biodiversity Action Plans (Cumbria Biodiversity Partnership, 2001). The BAP is a way of conserving wildlife by identifying conservation priorities within habitats and species. Once priority species, such as locally declining song birds, have been identified, targets can be made and worked towards, ensuring a greater sustainability within the environment. Having set targets, progress needs to be monitored to ensure they are realistic and that work is continually effective in conserving the environment (Cumbria Biodiversity Partnership, 2001).

By carrying out a Biodiversity Action Plan for Langdale Estate the diversity of the site can be measured and key species related to local and national plans enabling the provision of management strategies to maintain and enhance the biodiversity. Key species of the Langdale

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<sup>1</sup> Estate information obtained from [www.langdale.co.uk](http://www.langdale.co.uk) on 22/02/08

Estate will be those most amiable and interesting to the public and easily surveyed. They are discussed below.

### Birds

Birds are an ideal measure of biodiversity as they are widely distributed and easily surveyed (Bibby, 2000). Reviewing population trends, data collected between 1994 and 2007 shows 27 species have significantly declined by more than 25% and 46 species have significantly increased by more than 25% (Risely et al., 2007). Several woodland species and migrating birds have shown declines in numbers. This may be due to habitat deterioration, climate change effecting migration schedules, or hunting pressure in the wintering grounds. One particular study by Hewson et al. (2007) has analysed survey data and calculated declines and increases of woodland bird species between the mid 1980's and 2004. During this period 8 species have shown a decline of greater than 25 percent, and 12 species showed an increase larger than 25 percent. This previous data illustrates that populations fluctuate from year to year, although some species such as the spotted flycatcher *Muscicapa striata* continue to decline indicating that birds are very versatile and need monitoring to keep current with population trends.

Table 1 shows all the species previously recorded within the 10km grid square that the Langdale Estate lies within and therefore maybe recorded during the present study. The National BAP identifies 60 bird species, of which 2; curlew *Numenius arquata* and spotted flycatcher have been mentioned in Table 1<sup>2</sup>.

**Table 1.** A list of all bird species recorded in grid square NY32 in 2007 by the British Trust for Ornithology<sup>3</sup>.

Common Name	Scientific Name	Common Name	Scientific Name
Blackbird	<i>Turdus merula</i>	Meadow pipit	<i>Anthus pratensis</i>
Blackcap	<i>Sylvia atricapilla</i>	Mistle thrush	<i>Turdus viscivorus</i>
Black-headed gull	<i>Larus ridibundus</i>	Mute swan	<i>Cygnus olor</i>
Blue Tit	<i>Cyanistes caeruleus</i>	Nuthatch	<i>Sitta europaea</i>
Buzzard	<i>Buteo buteo</i>	Oystercatcher	<i>Haematopus ostralegus</i>
Canada goose	<i>Branta canadensis</i>	Pheasant	<i>Phasianus colchicus</i>
Carriion crow	<i>Corvus corone</i>	Pied wagtail	<i>Motacilla alba</i>
Chaffinch	<i>Fringilla coelebs</i>	Robin	<i>Erithacus rubecula</i>
Chiffchaff	<i>Phylloscopus collybita</i>	Rook	<i>Corvus frugilegus</i>
Cormorant	<i>Phalacrocorax carbo</i>	Sedge warbler	<i>Acrocephalus schoenobaenus</i>
Curlew	<i>Numenius arquata</i>	Siskin	<i>Carduelis spinus</i>

<sup>2</sup> Data obtained from [www.ukbap.org.uk](http://www.ukbap.org.uk) on 15/07/08

<sup>3</sup> Data obtained from [www.bto.org/birdtrack](http://www.bto.org/birdtrack) on 18/07/08.

Dipper	<i>Cinclus cinclus</i>	Skylark	<i>Alauda arvensis</i>
Dunnock	<i>Prunella modularis</i>	Sparrow hawk	<i>Accipiter nisus</i>
Garden warbler	<i>Sylvia borin</i>	Spotted flycatcher	<i>Muscicapa striata</i>
Goldcrest	<i>Regulus regulus</i>	Stock dove	<i>Columba oenas</i>
Goosander	<i>Mergus merganser</i>	Swallow	<i>Hirundo rustica</i>
Great spotted woodpecker	<i>Dendrocopos major</i>	Swift	<i>Apus apus</i>
Great tit	<i>Parus major</i>	Tawny owl	<i>Strix aluco</i>
Grey heron	<i>Ardea cinerea</i>	Treecreeper	<i>Certhia familiaris</i>
Grey wagtail	<i>Motacilla cinerea</i>	Tufted duck	<i>Aythya fuligula</i>
Greylag goose	<i>Anser anser</i>	Wheatear	<i>Oenanthe oenanthe</i>
House martin	<i>Delichon urbica</i>	Whitethroat	<i>Sylvia communis</i>
Jackdaw	<i>Corvus monedula</i>	Willow warbler	<i>Phylloscopus trochilus</i>
Lesser black-backed gull	<i>Larus fuscus</i>	Woodpigeon	<i>Columba palumbus</i>
Magpie	<i>Pica pica</i>	Wren	<i>Troglodytes troglodytes</i>
Mallard	<i>Anas platyrhynchos</i>		

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### *Reptiles and Amphibians*

Numbers of reptiles and amphibians have declined over the last 50 years within the United Kingdom<sup>4</sup>. The natterjack toad *Epidalea calamita*, sand lizard *Lacerta agilis* and smooth snake *Coronella austriaca* are classed as endangered. Due to the few species within the reptile and amphibian group conservation is essential to prevent extinction.

There are 12 native species of amphibians and reptiles within Britain including newts, toads, frogs, lizards and snakes. Britain has 2 alien species which have established populations and become permanent residents, the marsh frog *Rana ridibunda* and the edible frog *Rana esculenta*. According to the 1973 atlas of reptiles and amphibians, southern Cumbria should present common toad *Bufo bufo*, common frog *Rana temporaria*, great crested newt *Triturus cristatus*, smooth newt *Triturus vulgaris*, slow worm *Anguis fragilis*, common lizard *Lacerta vivipara*, grass snake *Natrix natrix* and adder *Vipera berus* (Arnold, 1973). The NBN gateway dataset for species recorded within the 10km square surrounding the estate agrees with the 1973 atlas but also adds the palmate newt *Triturus helveticus* to the list<sup>5</sup>. The 1995 Atlas of reptiles and amphibians indicates that the great crested newt and the smooth newt have disappeared from southern Cumbria but all other species previously mentioned are still present (Arnold, 1995). Reasons for declining numbers in amphibians and reptiles are loss of habitat. An important habitat for reptiles and amphibians especially the natterjack toad is heathlands which have shown a national decrease over the years (Nature conservancy council, 1987). The national BAP identifies 10 species of reptiles and

<sup>4</sup> Data obtained from [www.narrs.org.uk](http://www.narrs.org.uk) on 15/03/08

<sup>5</sup> Data obtained from [www.nbn.org.uk](http://www.nbn.org.uk) on 15/07/08

amphibians<sup>2</sup> (Appendix A). The Cumbria BAP identifies the natterjack toad and great crested newt as priority species (Cumbria Biodiversity Partnership, 2001).

### *Butterflies and Bumblebees*

Britain's Butterflies are declining and have been for 2 decades. Studies by Butterfly Conservation in 2007 discovered that three quarters of the UK's 59 resident species are declining. 21 species have declined by over 30 percent in the last 25 years and 15 species are displaying range spreading due to climate change (Fox et al., 2007). In 2007 the National Biodiversity Action Plan was revised and with this revision 24 butterflies were placed on the priority species list in contrast to the 11 that were listed in 1995. In order to be placed on the list the butterfly has to have declined by a minimum of 25 percent. According to the Millennium Atlas of Butterflies 13 species of butterfly have been recorded within the area surrounding Langdale Estate (Table 2) (Asher et al, 2001), of which mountain ringlet *Erebia epiphron*, small heath *Coenonympha pamphilus* and small pearl-bordered fritillary *Boloria selene* have been identified in the National BAP<sup>2</sup>. None of the species recorded within the Langdale area have been listed on the Cumbria BAP however it does identify high brown fritillary *Argynnis adippe*, marsh fritillary *Euphydryas aurinia* and pearl-bordered fritillary *Boloria euphrosyne* (Cumbria Biodiversity Partnership, 2001).

**Table 2.** A list of all species likely to be found within the Langdale Area according to Millennium Atlas of Butterflies (Asher et al., 2001).

Common Name	Scientific Names	Common Name	Scientific Name
Camberwell beauty	<i>Nymphalis antiopa</i>	Painted lady	<i>Vanessa cardui</i>
European peacock	<i>Inachis io</i>	Red admiral	<i>Vanessa atalanta</i>
Green veined white	<i>Pieris napi</i>	Small heath	<i>Coenonympha pamphilus</i>
Large skipper	<i>Ochlodes faunus</i>	Small pearl bordered fritillary	<i>Boloria selene</i>
Meadow brown	<i>Maniola jurtina</i>	Small tortoiseshell	<i>Aglais urticae</i>
Mountain ringlet	<i>Erebia epiphron</i>	Small white	<i>Pieris rapae</i>
Orange tip	<i>Anthocharis cardamines</i>		

Bumblebees have also suffered from national decline over the past 50 years. This is mainly due to decline of suitable feeding grounds and a change in diets (Williams, 2005). Bumblebees feed mainly on nectar and pollen provided by flowering plants, which have been reduced by the disappearance of unimproved grasslands and hay meadows. Within Britain there are 25 species of bumblebee with 9 of these under threat of extinction<sup>6</sup>. The bumblebee

<sup>6</sup> Data obtained from [www.bumblebeeconservationtrust.co.uk](http://www.bumblebeeconservationtrust.co.uk) on 1/08/07

atlas of 1975 recorded 6 species within Southern Cumbria, white-tailed *Bombus lucorum*, buff tailed *Bombus terrestris*, early *Bombus pratorum*, garden *Bombus hortorum*, common carder *Bombus pascuorum* and northern white tailed *Bombus magnus* (Alford, 1975). The Cumbria BAP does not identify any bumblebees as priority species and none of the species likely to be found within the study site are listed on the National BAP<sup>2</sup> (Cumbria Biodiversity Partnership, 2001).

### Mammals

There is very little data available on the overall population trends of British Mammals; this is partly due to the difficulty in measuring their densities (Harris et al, 1995). Within Britain there are 62 species of land mammals (including bats), 40 species are native and 22 species are alien species<sup>7</sup>. Between 1995 and 2005 the UK saw a positive 40% increase of native mammals and a 22% decrease in national abundances, showing that some species are declining but the majority show stable or increasing populations. The national BAP has identified 12 species of terrestrial mammals as under threat and in need of conservation measures<sup>2</sup> (Appendix B). Within Cumbria however only 1 has been identified as needing to be conserved and that is the water vole *Arvicola terrestris* (Cumbria Biodiversity Partnership, 2001). Of the 62 species of mammals within Britain, those likely to be encountered within Southern Cumbria are listed in Table 3.

**Table 3.** Mammal species likely to be found in southern Cumbria including the Langdale Estate area (Arnold, 1993).

Common Name	Scientific Name	Common Name	Scientific Name
Badger	<i>Meles meles</i>	Mole	<i>Talpa europaea</i>
Bank vole	<i>Clethrionomys glareolus</i>	Otter	<i>Lutra lutra</i>
Brown rat	<i>Rattus norvegicus</i>	Pipistrelle bat	<i>Pipistrellus pipistrellus</i>
Common shrew	<i>Sorex araneus</i>	Rabbit	<i>Oryctolagus cuniculus</i>
Dormouse	<i>Muscardinus avellanarius</i>	Red deer	<i>Cervus elaphus</i>
Field vole	<i>Microtus agrestis</i>	Red squirrel	<i>Sciurus vulgaris</i>
Fox	<i>Vulpes vulpes</i>	Roe deer	<i>Capreolus capreolus</i>
Grey squirrel	<i>Sciurus carolinensis</i>	Stoat	<i>Mustela erminea</i>
Hedgehog	<i>Erinaceus europaeus</i>	Water vole	<i>Arvicola terrestris</i>
Mink	<i>Mustela vison</i>	Weasel	<i>Mustela nivalis</i>

<sup>7</sup> Data obtained from [www.jncc.gov.uk/page-1757](http://www.jncc.gov.uk/page-1757) on 2/08/07

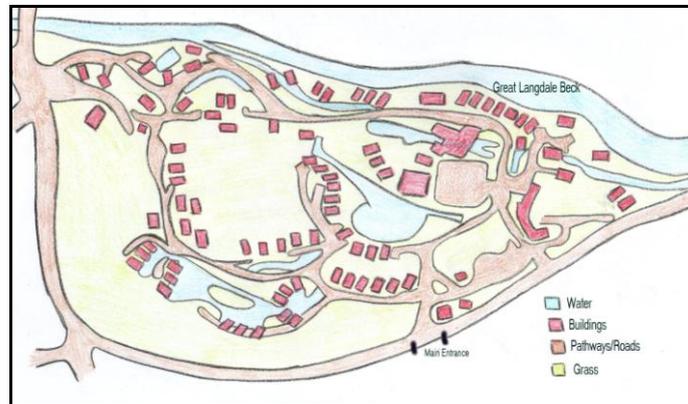
### *Bats*

Bat populations make up one third of all mammal species, which in the UK have been declining for the past 60 years. Today most bat populations are stable and showing signs of recovering, with the exception of the greater horseshoe bat *Rhinolophus ferrumequinum*, which has declined annually by 6.8% between 1997 and 2003 (Batterby, 2005). The main reasons for declining bat populations are declining populations of insect prey which is due to a number of factors such as an increase in agriculture where insecticides are used and the loss of wetland habitats and hedgerows, which also pose a threat, due to the reduction of insect rich feeding sites. As well as prey abundance effecting bat populations, the availability of roosting sites has reduced over the years causing further decline<sup>2</sup>. Monitoring of the Estate has been ongoing for 15 years and has recorded a bat roost within the main complex of the site. Reports of this site have recorded brandt's bats *Myotis brandii*, deubenton bats *Myotis daubentoni*, common pipistrelles *Pipistrelle pipistrellus*, natterer's bats *Myotis nattereri*, whiskered bats *Myotis mystacinus* and noctules *Nyctalus noctula* (pers comm. J Martin). The 1995 atlas of British Mammals identifies pipistrelle as being present within Southern Cumbria (Arnold, 1995a). Of those likely to be found on site, soprano pipistrelle is listed on the current National BAP list<sup>2</sup> (Appendix B), the Cumbria BAP lists all bats as priority species (Cumbria Biodiversity Partnership, 2001).

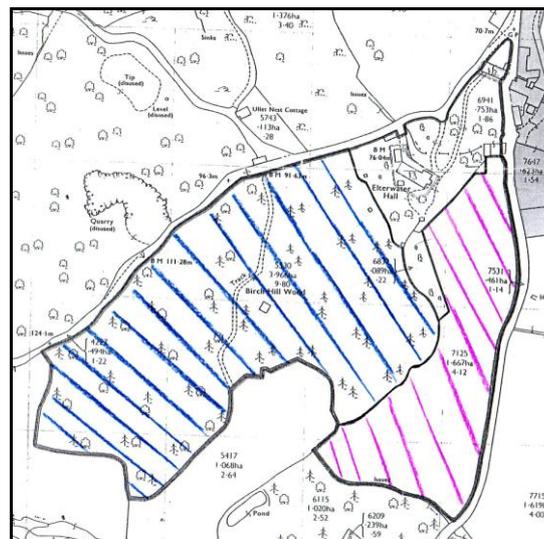
The aim of this study is to identify and provide ecological management methodologies for Langdale Estate, advising on a Biodiversity Action Plan for the 35 acre site. Included within the aims, will be surveys related to bird, mammal, reptile, amphibian and vegetation populations. Results from these surveys will enable the provision of a management plan, including detailed plans of low, medium and high intensity approaches. Any findings will be compared to the national BAP and the Cumbria BAP.

## METHODS

The study site was divided into 2 areas. The larger area of the estate (Figure 3) holds the main complex including the hotel, lodges and restaurants and is 5 hectares in size. The smaller area is Birch Hill Wood which is 4 hectares in size along with Elterwater Hall with previously grazed grassland which is 1.7 hectares in size (Figure 4). Each area was surveyed separately. Birch Hill Wood currently has a path for a nature trail which will be used where possible for safe manoeuvring within the wood and also to reduce disturbance to the woodland.



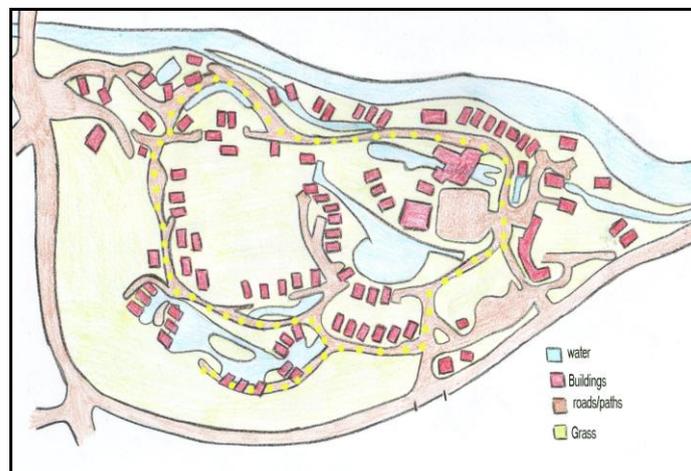
**Figure 3.** The main estate which holds privately owned lodges, main hotel and sports complex and sits beside the great Langdale beck.



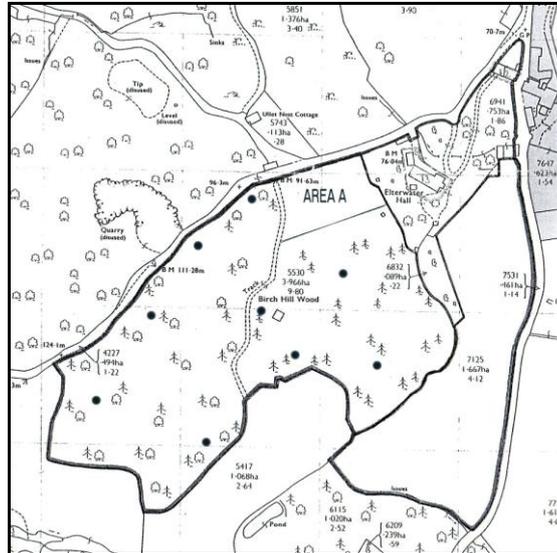
**Figure 4.** Birch Hill Wood (blue hatched area) lies north of the Main Estate and along side is Elterwater grassland (pink hatched area). The square in the middle of Birch Hill Wood is the location of a hide.

*Bird Surveys*

Figure 5 shows the planned Line transect surveys carried out on the main estate utilising methods discussed by Bibby et al (1998) which involved walking a set route throughout the study site recording species both seen and heard. For the smaller woodland, a point count survey was carried out. This method is better suited due to the changing habits encountered in this type of environment. Figure 6 shows the location of the point stations. Observations were carried out at each stations for 10 minutes recording birds both seen and heard (Bibby, 1998). All surveys were undertaken between 7am and 9am in late April, May and June. This allowed for detecting early and late breeders.



**Figure 5.** The Main Estate: the yellow dots represent the transect walked for the bird survey

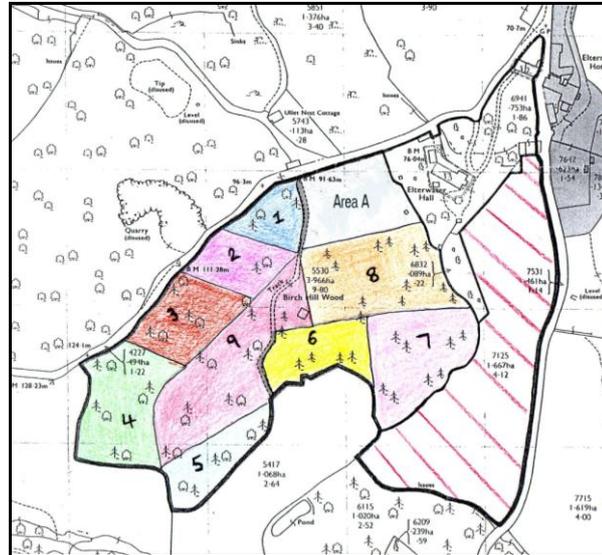


**Figure 6.** The 9 count stations within Birch Hill Wood, represented by black dots. Area A has been cleared for a proposed wood store.

### *Vegetation Survey*

The present study undertook the National Vegetation Classification (NVC) method. The woodland was divided into 9 areas (Figure 7), decided upon according to areas of similar vegetation. Within these areas, quadrats of 50 meters by 50 meters were laid out (Rodwell, 1991). Within each 50m x 50m quadrat all species of trees and shrubs were identified and abundance of percentage cover (Appendix C) stated in order to assess the canopy of the wood. Next the homogenous stands of the field flora within each area were distinguished and 6 quadrats, 4 meters by 4 meters were then set out (Rodwell, 1991). Within each quadrat all species of field and ground flora were identified along with abundance cover. For Elterwater grassland, smaller quadrats of 2 x 2 meters were carried out in accordance with NVC guidelines (Rodwell, 1992).

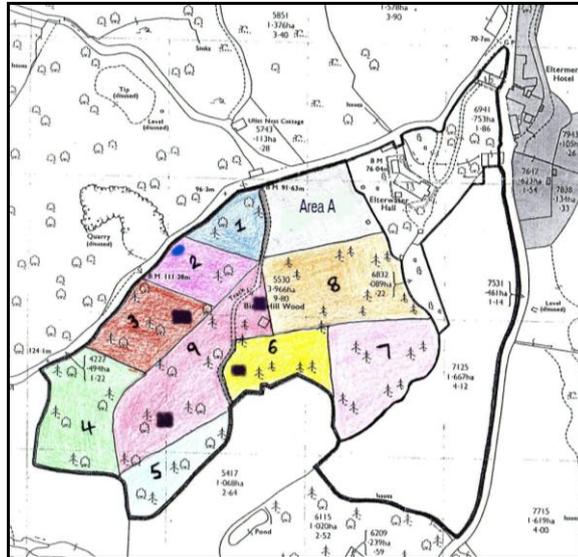
On completion of the data collection, results were tabulated and the frequency (number of quadrat occurrences) (Appendix C), of each plant was calculated. The results were compared against the NVC guide and the community identified.



**Figure 7.** Birch Hill Wood and the identified 9 areas. Elterwater meadow is shown in pink hatching. Area A has been cleared for a proposed wood store.

### *Reptiles and Amphibians*

In order to survey reptiles, squares of black roofing felt, 1 meter by 1 meter were placed in open areas of the woodland<sup>4</sup> as seen on Figure. 8. The objective being, to provide a warm resting place as the dark rectangles will absorb the warmth from the sun and provide a favourable space. For the amphibian survey, the pond situated in the woodland in area 2 (Figure 8) was surveyed once during June. The perimeter of the pond was walked while undertaking a visual survey of the water looking for adults, spawns and tadpoles<sup>4</sup>.

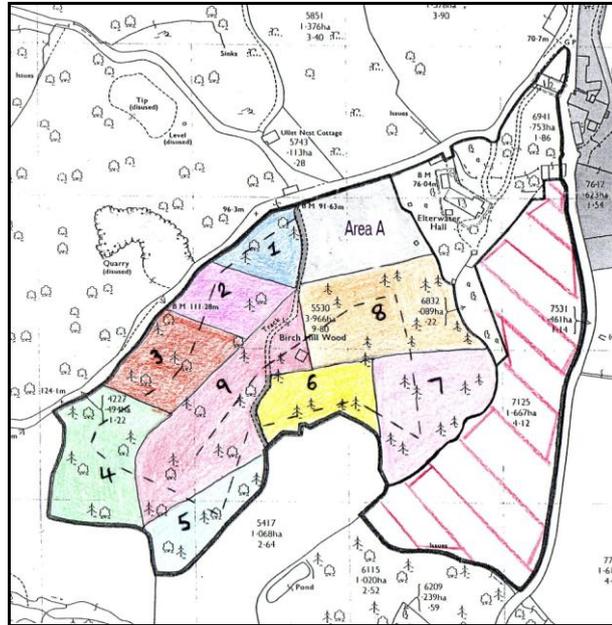


**Figure 8.** The location of 4 heat mats (black squares) placed in Birch Hill Wood for the reptile survey. The blue dot represents the pond in area 2.

### *Butterflies and Bumblebees*

Birch Hill Wood and Elterwater Hall were surveyed for butterflies and bumblebees. A set transect was determined linking all nine areas together as shown in Figure 9. This transect was walked during the warmest part of the day 11 am to 3 pm, once in May and again in June (Pollard & Yates, 1993). All observations of both butterflies and bumblebees were recorded; any species without positive identification were captured for closer identification and released safely into the natural environment.

The result of this work will generate a species list with density estimates for both butterflies and bumblebees.



**Figure 9.** Transects walked for the Butterfly and Bumblebee survey. The Black dotted line represents the transect walked in Birch Hill Wood and the pink line is the transect walked in Elterwater grassland.

## *Mammals*

### *Small Mammal Surveys*

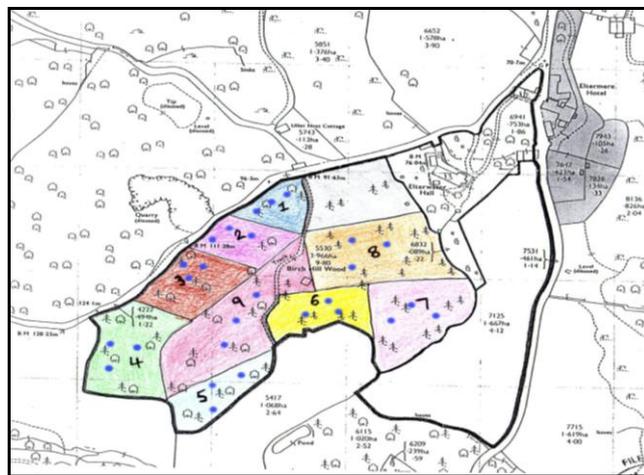
As small mammal populations are unpredictable (Alibhai and Gibbs, 1985) the scope of this section will be primarily to collate a species list. The survey was carried out within a small area of the main estate (Figure 11) and Birch Hill Woodland (Figure 10).

Three traps were located in each areas depicted on Figure 8 and for the main estate and six traps were located in the scrub land at the side of the estate. Longworth traps were set out 24 hours prior to the actual survey for pre-baiting where the traps are set on a pre-bait setting which allows the mammal to enter and exit the trap without being caught (Gurnell and Flowerdew, 2006). The traps were set with dry straw as bedding material and dry dog food as bait with a scent enhancer in the form of peanut butter to improve the chances of attracting rodents; meal worms are also added to attract insectivores (Ian Hartley. pers.comm.).

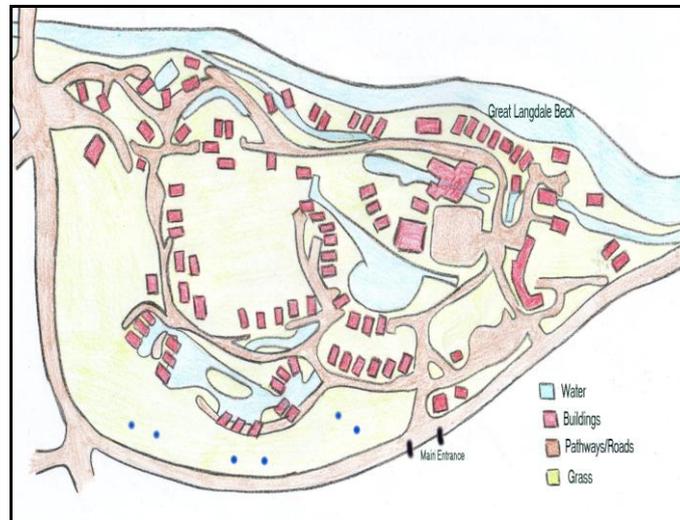
After the 24 hours of pre-baiting the traps were checked, additional food added and taken off pre-bait. The pre baiting period was set between 7pm and 7pm the following day,

this 24 hour period allowed for the attraction of both nocturnal and diurnal species. Trapping started at 7pm and was completed at 7am. At the end of the trapping session traps were checked with any caught mammals identified and released. At 8.30 am the traps were reset with food and bedding and left until 2 pm to capture the diurnal species.

At 2pm the traps were checked, any caught mammals were identified and released and this time all equipment was gathered up.



**Figure 10.** The location of Longworth traps within Birch Hill Wood shown as blue dots.



**Figure 11.** The location of Longworth traps on the main estate shown as blue dots.

### *Large Mammal Survey*

Birch Hill Wood was surveyed for large mammals. As with the butterfly and bumblebee survey a transect was determined linking all nine areas together as shown in Figure 10. This survey was slightly different to the others depicted in this report as the presence of large mammals is being determined by inference rather than actual counting of numbers. Visual indications were used to indicate large mammal activity such as vegetation disturbance and animal faecal droppings.

### *Bat Survey*

Within the roof of the main building a bat colony has established itself, the scope of this project would include the determination of species and number of bats within the colony.

In order to survey this roost, a Magenta Heterodyne bat detector was used. Bats fly at night just after dusk and early in the morning at dawn<sup>8</sup>. The survey began at 9.15pm, which is

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<sup>8</sup>Data obtained from [www.bats.org.uk/pages/nbmp](http://www.bats.org.uk/pages/nbmp) on 25/06/08

the start of dusk in southern Cumbria, and carried through till 11pm when the sky is completely dark. The survey involved positioning the bat detector outside of the roost in order that all the bats exiting the roost space were counted and the species identified (J Martin. pers.comm.)

Once the main roost had been surveyed the main estate, Elterwater Village and Birch Hill Wood was walked for 90 minutes in a transect to detect other bat species flying around the area<sup>8</sup>.

## RESULTS

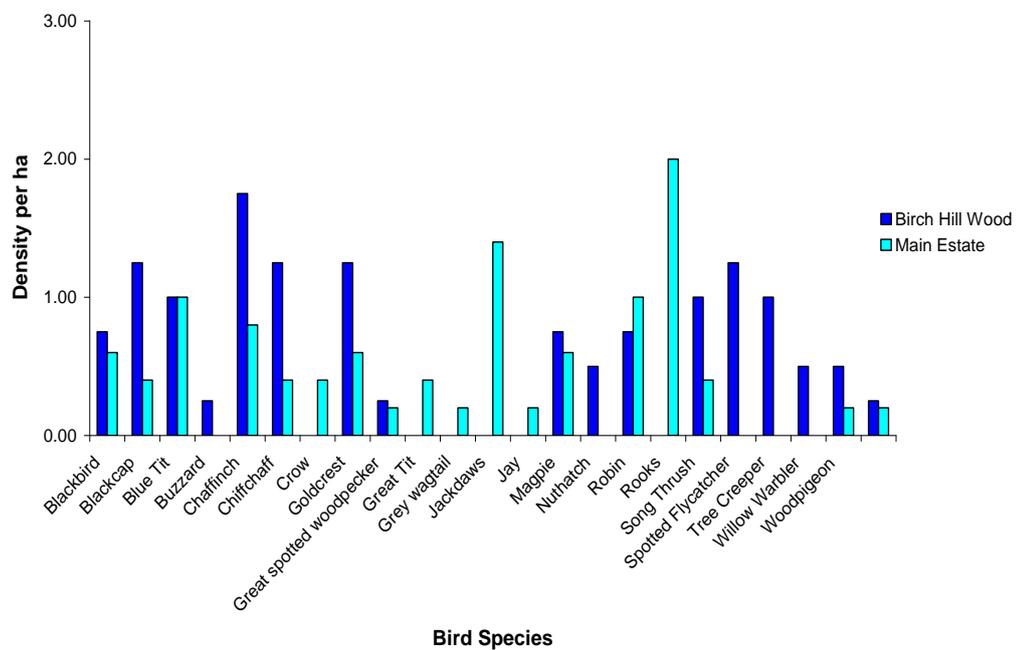
### *Birds*

From the survey taken 27 species of bird were identified (Table 4) including tawny owl *Strix aluco*, sparrow hawk *Accipiter nisus* and swift *Apus apus* which were seen overhead. The data were collected and integrated so that the results with the highest number of individuals and species were used. The number of birds on site has been converted into SI units of densities per hectare (Table 4) in order to be comparable to other available population data and to form a base density for future studies. Birch Hill Wood is 4 hectares and therefore the data collected is divided by 4 and the Main Estate is 5 hectares and therefore the main estate data is divided by 5.

**Table 4.** Shows number of individuals encountered per area during the bird survey and calculated bird densities per area (individuals encountered divided by area size).

Species	Birch Hill Wood/ individuals encountered	Birch Hill Wood/ Density per hectare	Main Complex/ Individuals encountered	Main Complex/ density per hectare
Blackbird	3	0.75	3	0.60
Blackcap	5	1.25	2	0.40
Blue Tit	4	1.00	5	1.00
Buzzard	1	0.25	0	0.00
Chaffinch	7	1.75	4	0.80
Chiffchaff	5	1.25	2	0.40
Crow	0	0.00	2	0.40
Goldcrest	5	1.25	3	0.60
Great spotted woodpecker	1	0.25	1	0.20
Great tit	0	0.00	2	0.40
Grey wagtail	0	0.00	1	0.20
Jackdaws	0	0.00	7	1.40
Jay	0	0.00	1	0.20

Magpie	3	0.75	3	0.60
Nuthatch	2	0.50	0	0.00
Robin	3	0.75	5	1.00
Rooks	0	0.00	10	2.00
Song thrush	4	1.00	2	0.40
Spotted flycatcher	5	1.25	0	0.00
Treecreeper	4	1.00	0	0.00
Willow warbler	2	0.50	0	0.00
Woodpigeon	2	0.50	1	0.20
Wren	1	0.25	1	0.20



**Figure 12.** Density per hectare of all birds found in each area of the site, Birch Hill Wood and the main estate.

From the bird densities calculated it can be seen that chaffinch *Fringilla coelebs*, blue tit *Cyanistes caeruleus*, blackbird *Turdus merula*, chiffchaff *Phylloscopus collybita*, goldcrest *Regulus regulus*, jackdaw *Corvus monedula*, magpie *Pica pica*, robin *Erithacus rubecula*, rook *Corvus frugilegus* and song thrush *Turdus philomelos* demonstrate the highest densities

within the study site (Table 4). A comparison of the bird densities found in each area within the study site can be made (Figure 12). Both areas have a similar number of species with Birch Hill Wood containing 17 species and the main estate containing 16. However each area holds a slightly different bird community, which is probably due to habitat differences between the sites. Table 5 demonstrates this community difference showing the 4 birds with the highest densities within each area. Those found within the main estate, robin, blue tit and jackdaw, have adapted more to utilise the nest boxes provided and the artificial holes provided by the slate buildings when nesting. The high density of rooks may be due to the availability of tall open canopy trees within the main estate (Stott, 2002). The commonest birds found within Birch Hill Wood, chaffinch, chiffchaff, goldcrest and spotted flycatcher typically nest in deciduous trees and hedgerows, provided by the wood.

**Table 5.** The top 4 birds within Birch Hill Wood and the main estate in terms of highest density per hectare

Birch Hill Wood		Main Estate	
Species	density per ha	Species	density per ha
Chaffinch	1.75	Rooks	2.00
Chiffchaff	1.25	Jackdaws	1.40
Goldcrest	1.25	Robins	1.25
Spotted flycatcher	1.25	Blue Tits	1.25

During the study another bird survey has been carried out by an independent hotel client. The data only states bird species identified and does not state densities and therefore will only be used for the species list of the study site. In addition coal tit *Periparus ater*, long tailed tit *Aegithalos caudatus*, greenfinch *Carduelis chloris*, marsh tit *Poecile palustris*, dunnock *Prunella modularis*, house sparrow *Passer domesticus*, swallow *Hirundo rustica*, house martin *Delichon urbica*, goldfinch *Carduelis carduelis*, pied wagtail *Motacilla alba*, grey heron *Ardea cinerea*, and black headed gull *Larus ridibundus* will be added to the species list.

From the data collected a diversity index (H) was calculated, for the whole study site, using the Shannon Weaver index  $H = - \sum_{i=1}^s p_i \ln p_i$  (Fowler et al, 1998).

This gave a value of  $H = 2.97$ . This will be useful for any future studies that want to measure whether diversity of the site has increased or decreased.

### *Reptiles and Amphibians*

From the heat mats placed around Birch Hill Wood no reptiles were found. When surveying the pond, again nothing was found, however during the study casually 2 common frogs were observed, 1 within Birch Hill Wood and 1 on the main estate. This does not mean reptiles and amphibians are not present on site. The current study did not have sufficient time resources to undertake a more detailed survey which may have influenced the results.

### *Butterflies and Bumblebees*

From the several surveys carried out only 4 species of butterfly were identified. Within Birch Hill Wood: orange tip *Anthocharis cardamines*, red admiral *Vanessa atalanta* and green veined white *Pieris napi*, and within Elterwater grassland: green veined white and meadow brown *Maniola jurtina*. The meadow brown and green veined white were found in the highest abundance with the red admiral and orange tip only being sighted once (Table 6).

The Shannon-Weaver index  $H = - \sum_{i=1}^S p_i \ln p_i$  produces a value of  $H = 0.84$ .

**Table 6.** Densities per hectare (individuals encountered divided by area size ) for butterflies recorded within Birch Hill Wood and Elterwater Grassland.

Species	Birch Hill Wood/ individuals encountered	Birch Hill Wood/ density per hectare	Elterwater Grassland/ individuals encountered	Elterwater Grassland/ density per hectare
Orange tip	1	0.25	0	0
Red admiral	1	0.25	0	0
Green veined white	8	2	4	2.35
Meadow brown	2	0.50	12	7.06

The Bumblebee surveys identified 3 species of bumblebee: Buff tailed bumblebee, white-tailed bumblebee, and the early bumblebee. Birch Hill Wood presented the highest density of bumblebees with the buff-tailed bumblebee being sighted the most (Table 7). Overall the buff tailed bumblebee shows the most abundance within the 2 sites with the white tailed being the least abundant.

The Shannon- Weaver index  $H = - \sum_{i=1}^S p_i \ln p_i$  equates to a value of  $H = 0.86$  for the bumblebees.

**Table 7.** Densities per hectare (individuals encountered divided by area size) for bumblebees recorded within Birch Hill Wood and Elterwater Grassland.

	<b>Birch Hill Wood/ individuals encountered</b>	<b>Birch Hill Wood/ density per hectare</b>	<b>Elterwater Grassland/ individuals encountered</b>	<b>Elterwater Grassland/ density per hectare</b>
Buff tailed bumblebee	15	3.75	5	2.94
White tailed bumblebee	4	1	0	0
Early bumblebee	6	1.50	0	0

### *Mammals*

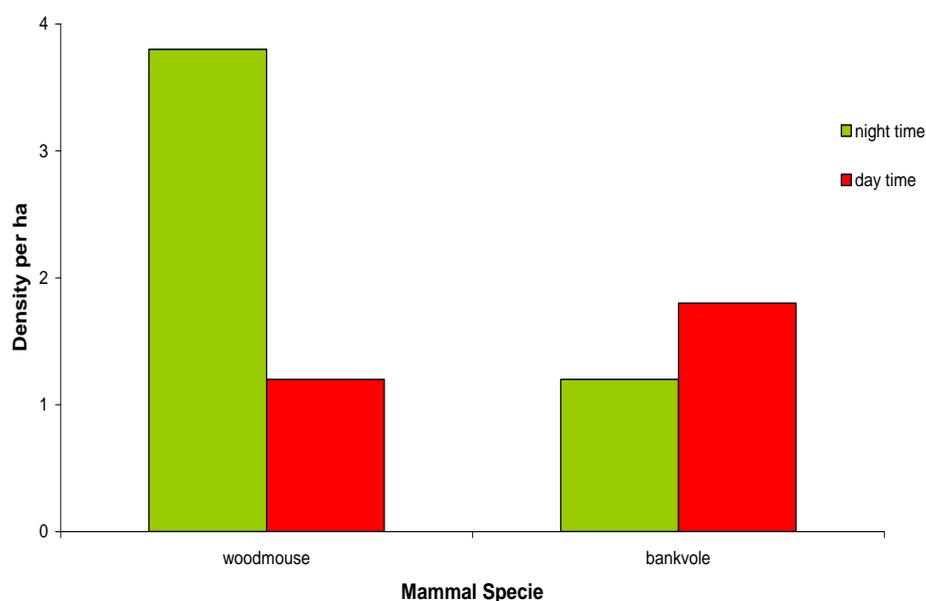
The small mammal survey showed that wood mice *Apodemus sylvaticus* and bank voles *Clethrionomys glareolus* are present within Birch Hill Wood and the main estate in high densities (Figure 13). Casual observations within Birch Hill Wood indicate that Roe Deer *Capreolus capreolus*, grey squirrels *Sciurus carolinensis*, rabbits *Oryctolagus cuniculus* and sheep are present within the woodland but no signs of badger *meles meles*, red squirrel *Sciurus vulgaris* or any other mammals were found.

As for the bird results a Shannon Weaver index has been calculated for the mammal population present within the study site.

$$H = - \sum_{i=1}^S p_i \ln p_i, H = 0.66.$$

This value can now be used for future biodiversity

studies within the study site.



**Figure 13.** Overall abundance, density per hectare, of small mammals caught during the 24 hour survey carried out within the main estate and Birch Hill Wood.

### *Bats*

From previous surveys of the site carried out by the Westermorland and Furness Bat Group, common pipistrelle and soprano pipistrelle have both been identified. The roost within the sports complex is comprised of an estimated 150 common pipistrelles (S Martin pers. Comm.). From the survey carried out for the roost, the bat species was identified as common pipistrelle. The number of bats counted from the roost was very low, only 2 were seen emerging from the roost. From the walk through survey bats were found throughout the main site after dark and the area surrounding the estate especially the Langdale Beck. From the high volume of bats picked up by the bat detector it was hard to count accurately, however estimates of individuals encountered have been made (Table 8). No bats were found at Birch Hill Wood. The bats that were identified were common pipistrelle and soprano pipistrelle.

**Table 8.** Number of bats encountered during the evening bat survey of the main estate, Birch Hill Wood and surrounding village.

Species	Main Estate /individuals	Elterwater Village/ individuals	Birch Hill Wood/ Individuals
Common pipistrelle	10	12	0
Soprano pipistrelle	0	1	0

The Shannon-Weaver index,  $H = - \sum_{i=1}^s p_i \ln p_i$  produces a value of  $H = 0.17$ .

Density per hectare can only be worked out for the main estate as the area size of Elterwater village is unknown. The density for the common pipistrelle on the main estate is 2 per ha.

#### Vegetation

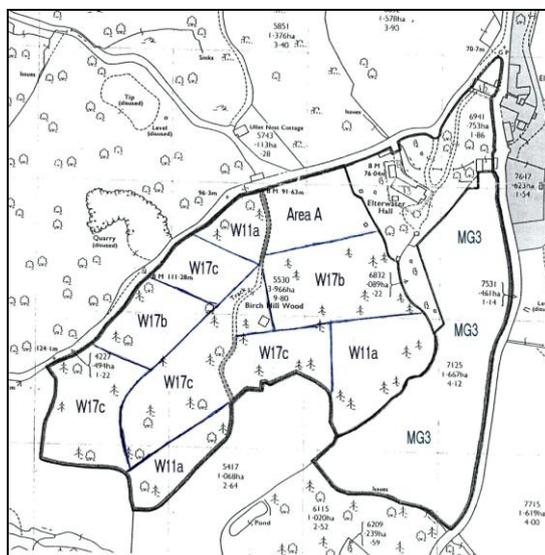
The Birch Hill Wood canopy is dominated by sessile oak *Quercus petraea*, downy birch *Betula pubescens* and sycamore maple *Acer pseudoplatanus* which are present in every area. Other species that can be found in low abundance (<10%) and low frequency (3 or 4 areas out of the 9) are field maple *Acer campestre*, horse chestnut *Aesculus hippocastanum*, beech *Fagus sylvatica*, ash *Fraxinus excelsior*, rowan *Sorbus acuparia* and hazel *Corylus avellana* (Table 9). The shrub layer of the woodland is dominated by non native rhododendrons *Rhododendron spp* which can be found in 8 of the 9 areas. Wood Sorrel *Oxalis acetosella* is found within the field layer in high abundance and frequency, being found within 8 of the 9 areas sampled as was bluebell *Hyacinthoides non-scripta*, although the whole woodland is dominated by bracken *Pteridium aquilinum* which is present in 6 of the 9 areas between 3% and 90%. The wood presents some grasses such as creeping soft grass *Holcus mollis* and sweet vernal grass *Anthoxanthum odorata* although these are found in low abundance <30% and frequencies, being found in only 3 of the 9 areas. Other pteridophytes of the wood are broad buckler fern *Dryopteris dilatata* and golden male fern *Dryopteris affinis* which in some areas can be found in high abundance such as area 1 where they cover up to 90% of the ground, in area 2 the occasional hard fern *Blechnum spicant* can be found. The ground layer is similar throughout the wood, with the wetter areas displaying higher abundance of bryophytes such as common hair cap moss *Polytrichum commune* and bog moss *Sphagnum recurvum* (Table 9).

**Table 9.** Abundance (percentage cover) of each plant present within each area and frequency (number of encounters across all samples) of each plant measured in Birch Hill Wood (Rodwell 1991).

Birch Hill Wood		Area / Abundance									
Species		1	2	3	4	5	6	7	8	9	Frequency
<i>Canopy Layer</i>											
Sycamore maple	<i>Acer pseudoplatanus</i>	2	5	5	5	5	5	6	3-5	4	V
Sessile oak	<i>Quercus petraea</i>	4	5	5	8	7	6	4	2	5	V
Downy birch	<i>Betula pubescens</i>	4	-	4	6	4	5	7	7	4	V
Ash	<i>Fraxinus excelsior</i>	-	-	2	-	-	-	4	4	4	III
Rowan	<i>Sorbus aucuparia</i>	1	-	-	3	-	-	-	4	-	II
Horse chestnut	<i>Aesculus hippocastanum</i>	-	-	-	-	-	5	5	5	-	II
Field maple	<i>Acer campestre</i>	4	4	-	-	-	-	-	-	-	II
Beech	<i>Fagus sylvatica</i>	-	-	-	-	-	-	-	4	-	I
<i>Shrub Layer</i>											
Rhododendrons	<i>Rhododendron spp</i>	-	4-6	8	7-8	2-5	5	4-6	4-6	4-6	V
Hazel	<i>Corylus avellana</i>	-	-	-	-	-	5	-	-	-	I
<i>Field Layer</i>											
Bluebell	<i>Hyacinthoides non-scripta</i>	3-5	-	3-5	2-6	3-4	3-6	5-8	5-6	6-8	V
Bracken	<i>Pteridium aquilinum</i>	5-9	3-8	2-7	-	3-5	4-5	-	-	6-9	IV
Fox glove	<i>Digitalis purpurea</i>	1-3	-	-	-	1	1	-	-	1-4	III
Golden male Fern	<i>Dryopteris affinis</i>	4-8	-	1-7	-	2-4	2-4	2-6	-	-	III
Common bent grass	<i>Agrostis capillaris</i>	2-3	3-5	-	-	-	2-3	3-4	-	1-3	III
Creeping soft grass	<i>Holcus mollis</i>	3-5	-	-	1-4	3-5	-	-	-	-	II
Common sorrel	<i>Rumex acetosa</i>	1-3	-	-	-	1	-	-	-	1	II
Sweet vernal Grass	<i>Anthoxanthum odoratum</i>	-	1-6	-	-	-	1-2	3-4	-	-	II
Broad buckler Fern	<i>Dryopteris dilatata</i>	-	1-6	-	-	-	3-5	2-5	-	-	II
Creeping buttercup	<i>Ranunculus repens</i>	2-4	2	-	-	1	-	-	-	-	II
Honeysuckle	<i>Lonicera periclymenum</i>	-	-	-	-	3-5	-	-	4-6	-	II
Pignut	<i>Conopodium majus</i>	-	-	-	-	1-3	-	3	-	-	II
Cock's foot	<i>Dactylis</i>	-	-	-	2-4	-	-	3-4	-	-	II

Pale sedge	<i>glomerata</i> <i>Carex pallescens</i>	-	-	-	-	1-3	1-4	3-4	-	-	II
Marsh bedstraw	<i>Galium palustre</i>	-	1-2	-	-	-	-	-	-	2-4	II
Goose grass	<i>Galium aparine</i>	2-4	-	-	-	2-3	-	-	-	-	II
Wood crane's bill	<i>Geranium</i> <i>sylvaticum</i>	1-3	-	-	-	1-2	-	-	-	-	II
White sedge	<i>Carex curta</i>	-	1	1	-	-	-	-	-	-	II
Crested dogs tail	<i>Cynosurus</i> <i>cristatus</i>	-	-	-	-	2-5	-	-	-	-	I
Bramble	<i>Rubus fruticosus</i>	4-5	-	-	-	-	-	-	-	-	I
Tufted hair grass	<i>Deschampsia</i> <i>cespitosa</i>	-	-	-	-	6-8	-	-	-	-	I
Hard Fern	<i>Blechnum</i> <i>spicant</i>	-	1	-	-	-	-	-	-	-	I
Fiddle dock	<i>Rumex pulcher</i>	-	-	-	-	1-2	-	-	-	-	I
Wavy hair grass	<i>Deschampsia</i> <i>flexuosa</i>	-	-	-	-	4	-	-	-	-	I
Nettles	<i>Urtica dioica</i>	1-4	-	-	-	-	-	-	-	-	I
Bugle	<i>Ajuga reptans</i>	-	-	-	-	1	-	-	-	-	I
<b>Ground Layer</b>											
Wood Sorrel	<i>Oxalis</i> <i>acetosella</i>	-	3-7	2-4	3-5	4-5	3-5	3-4	1-5	3-4	V
Common hair Cap Moss	<i>Polytrichum</i> <i>commune</i>	-	1-6	-	2-4	-	3-4	-	2-5	2-4	III
Yellow Pimpernel	<i>Lysimachia</i> <i>nemorum</i>	-	-	-	-	2-3	1-3	3-4	-	-	II
Bog Moss	<i>Sphagnum</i> <i>recurvum</i>	-	1	-	-	-	1	-	-	-	II
Moss	<i>Rhytidiadelphus</i> <i>squarrosus</i>	-	I	-	-	-	-	1	-	-	II

Following the analysis guidelines of the National Vegetation Classification (NVC) several woodland communities within Birch Hill Wood were identified; the first W11 Sessile Oak – Downy Birch – Wood Sorrel woodland and the second W17 Sessile Oak – Downy Birch – Dicranum moss woodland (Rodwell, 1991). Using the detailed plant data collected during the survey the identified woodland types can be categorised further into sub communities. Altogether there were 3 sub-communities found (Appendix D). W11 Sessile Oak – Downy Birch – Wood Sorrel woodland with a *Dryopteris dilatata* sub community. W17b Sessile Oak – Downy Birch – Dicranum moss typical woodland and W17c Oak, Birch, Moss woodland with an *Anthoxanthum Odoratum/Agrostis capillaris* sub community (Figure 14). The differing woodland communities found correspond with the areas dictated earlier (Figure 7).



**Figure 14.** Birch Hill Wood and Elterwater grassland displaying the location of each NVC classification.

The two types of woodland found are very similar and are only distinguished by the presence/absence of a few plant species or the abundance/frequencies of some species across the samples taken (Table 10). Both woodlands are typical oak birch woodlands found within cool/wet areas of North-western England (Rodwell, 1991). However W11 is more typically found in areas with low base soils whereas W17 is found in poor nutrient lacking soils. The outcome of the NVC survey shows that some areas of the woodland contain more nutrients within the soil than others.

**Table 10.** Displays all vegetation found in Birch Hill Wood and their abundance and frequencies compared to possible woodland communities W11 *Quercus petraea-Betula pubescens-Oxalis acetosella* and W17 *Quercus petraea-Betula pubescens-Dicranum majus*. Frequency expressing number of times a species occurs across the samples, is stated in roman numerals and abundance expressing percentage cover is in parentheses.

Species		Birch Hill Wood	W11	W17
<i>Canopy Layer</i>				
Sycamore maple	<i>Acer pseudoplatanus</i>	V (2-6)	-	I (1-5)
Sessile oak	<i>Quercus petraea</i>	V (2-7)	II (1-9)	IV (1-10)
Downy birch	<i>Betula pubescens</i>	V (4-7)	II (1-10)	III (1-9)
Ash	<i>Fraxinus excelsior</i>	III (2-4)	I (1-7)	I (1-7)

Horse chestnut	<i>Aesculus hippocastanum</i>	II (5)	-	-
Rowan	<i>Sorbus aucuparia</i>	II (1-4)	II (1-7)	II (1-5)
Field maple	<i>Acer campestre</i>	II (4)	-	-
Beech	<i>Fagus sylvatica</i>	I (4)	-	I (1-5)
<b>Shrub Layer</b>				
Rhododendrons	<i>Rhododendron spp</i>	V (2-8)	-	I (1-4)
Hazel	<i>Corylus avellana</i>	I (5)	II(1-8)	II (1-7)
<b>Field Layer</b>				
Bluebell	<i>Hyacinthoides non-scripta</i>	V (2-8)	III(1-10)	I (1-5)
Bracken	<i>Pteridium aquilinum</i>	IV (2-9)	IV (1-9)	III (1-8)
Fox glove	<i>Digitalis purpurea</i>	III (1-4)	I (1-7)	I (1-5)
Golden male fern	<i>Dryopteris affinis</i>	III (1-8)	-	-
Common bent grass	<i>Agrostis capillaris</i>	III (2-5)	IV (1-9)	II (1-7)
Creeping soft grass	<i>Holcus mollis</i>	II (1-5)	IV (1-8)	II (1-8)
Common sorrel	<i>Rumex acetosa</i>	II (1-3)	I (1-2)	I (1-3)
Sweet vernal grass	<i>Anthoxanthum odoratum</i>	II (1-6)	V (1-8)	II (1-8)
Broad buckler fern	<i>Dryopteris dilatata</i>	II (1-6)	I (1-9)	I (1-6)
Creeping buttercup	<i>Ranunculus repens</i>	II (1-4)	I (1-2)	-
Honeysuckle	<i>Lonicera periclymenum</i>	II (3-6)	II (1-6)	I (1-6)
Pignut	<i>Conopodium majus</i>	II (1-3)	II (1-4)	-
Cock's foot	<i>Dactylis glomerata</i>	II (2-4)	-	I (2-3)
Pale sedge	<i>Carex pallescens</i>	II (1-4)	-	-
Marsh bedstraw	<i>Galium palustre</i>	II (1-4)	-	-
Goose grass	<i>Galium aparine</i>	II (2-4)	I (1-2)	-
Wood crane's bill	<i>Geranium sylvaticum</i>	II (1-3)	-	-
White sedge	<i>Carex curta</i>	II (1)	-	-
Bramble	<i>Rubus fruticosus</i>	I (4-5)	I (1-8)	I (1-9)
Crested dogs tail	<i>Cynosurus cristatus</i>	I (2-5)	-	-
Tufted hair grass	<i>Deschampsia cespitosa</i>	I (6-8)	I (1-6)	I (1-5)
Hard fern	<i>Blechnum spicant</i>	I (1)	-	II (1-5)
Fiddle dock	<i>Rumex pulcher</i>	I (1-2)	-	-
Wavy hair grass	<i>Deschampsia flexuosa</i>	I (4)	IV (1-8)	V (1-9)
Nettles	<i>Urtica dioica</i>	I (1-4)	-	-
Bugle	<i>Ajuga reptans</i>	I (1)	I (1-4)	-
<b>Ground Layer</b>				
Wood sorrel	<i>Oxalis acetosella</i>	V (1-7)	V (1-9)	III (1-7)
Common hair cap moss	<i>Polytrichum commune</i>	III (1-6)	I (1-2)	I (1-8)
Yellow Pimpernel	<i>Lysimachia nemorum</i>	II (1-4)	I (1-4)	I (1-4)
Bog moss	<i>Sphagnum recurvum</i>	II (1)	-	-
Moss	<i>Rhytidiadelphus squarrosus</i>	II (1)	IV (1-8)	II (1-7)

The Elterwater grassland is dominated by velvet bent grass *Agrostis canina* and yorkshire fog *Holcus lanatus*, both of which presented abundances of between 26-75% and were found within all samples taken (Table 11). Sweet vernal grass is frequent across the field but not within high abundance. As well as members from the poaece family there are also flowering plants present such as oxeye daisy *Leucanthemum vulgare*, foxglove *Digitalis purpurea* and herbs such as common sorrel *Rumex acetosa* although these are found in low

frequency and abundance. From the NVC analysis this grassland can be classified as MG3 Sweet Vernal Grass – Wood crane’s bill (*Anthoxanthum odoratum* – *Geranium sylvaticum*) grassland MG3 is typical of mesotrophic soils with neutral to mildly acid levels that are found in northern upland valleys (Rodwell, 1992). Other possible grasslands were MG9 *Holcus lanatus-Deschampsia cespitosa* grassland, U1 *Festuca ovina* – *Agrostis capillaris* – *Rumex acetosella* grassland and U4 *Festuca ovina* – *Agrostis capillaris* – *Galium saxatile* grassland (Appendix E). However these are not as compatible with the vegetation found within Elterwater grassland as MG3.

**Table 11.** Frequency and abundance of all plants found on Elterwater grassland. Frequency expressing number of times a species occurs across the samples, is stated in roman numerals and abundance expressing percentage cover is in parentheses.

Species	Frequency and Abundance
Velvet bent grass <i>Agrostis canina</i>	IV (6-7)
Cock’s foot <i>Dactylis glomerata</i>	IV (4-5)
Creeping buttercup <i>Ranunculus repens</i>	V (1-4)
Yorkshire fog <i>Holcus lanatus</i>	V (7-8)
Common sorrel <i>Rumex acetosa</i>	V (3-5)
Oxeye daisy <i>Leucanthmun vulgare</i>	III (1-2)
Sheep’s fescue <i>Festuca ovina</i>	IV (2-5)
Fox glove <i>Digitalis purpurea</i>	III (1)
Sweet vernal grass <i>Anthoxanthum odoratum</i>	V (4-6)
Meadow foxtail <i>Alopecurus pratensis</i>	IV (1-4)
Soft rush <i>Juncus effusus</i>	I (3)
Pignut <i>Conopodium majus</i>	IV (1-3)
Fen bedstraw <i>Galium uliginosum</i>	III (1-4)
Common bent grass <i>Agrostis capillaries</i>	V (5-6)
Wood crane’s bill <i>Geranium sylvaticum</i>	III (1-2)

## DISCUSSION

### *Birds*

The data collected from Langdale Estate is evident that there is a strong bird community present within the grounds. Although a Shannon-weaver index was carried out, currently this is not useful as there have been no previous studies on the site and therefore is not comparable. The index could be used in comparison to other woodlands within Cumbria however no studies exist.

After comparing the densities obtained on Langdale Estate with national densities (Table 12), 12 of the Langdale species show a higher density which is very encouraging.

These twelve species are blackcap, carrion crow, chiffchaff, chaffinch, goldcrest, great spotted woodpecker, jackdaw, jay, magpie, nuthatch, song thrush and spotted flycatcher (Table 12). The other 7 species (blackbird, blackcap, blue tit, great tit, robin, willow warbler, woodpigeon, and wren) present a lower population density on Langdale Estate than the average national densities per hectare of British Woodlands. From these 7 species blackbird, great tit, robin and wren have significantly lower densities, >50% (Table 12) lower than the national average, although blackbird, robin and wren all have high and currently increasing populations within Cumbria (Risley et al., 2008). The low numbers could be due to a lack of suitable habitat or food within Langdale Estate or high competition with other species for nesting sites.

**Table 12.** Compares the the density (territories per hectare) of bird species found within Langdale Estate and the national average density (territories per hectare) of birds found within woodlands in 1991 (Gibbons, 1993). The % change is provided by BTO (Risley et al., 2008) apart from those with an asterisk which have been provided by Hewson et al 2007).

Species Name	Main Estate density	Birch Hill Wood density	National woodland density average 1991	% change over past 1994 - 2007
Blackbird	0.43	0.43	0.67	56
Blackcap	0.29	0.71	0.27	158
Blue tit	0.71	0.57	0.82	17
Carrion crow	0.29	0.00	0.07	58
Chaffinch	0.57	1.00	0.25	24
Chiffchaff	0.29	0.71	0.23	144
Goldcrest	0.43	0.71	0.22	141
Great spotted woodpecker	0.15	0.15	0.07	179
Great tit	0.29	0.00	0.49	58
Jackdaw	1.00	0.00	0.05	100
Jay	0.15	0.00	0.09	22
Magpie	0.43	0.43	0.09	-9
Nuthatch	0.00	0.29	0.09	78*
Robin	0.71	0.43	1.04	46
Song thrush	0.29	0.57	0.25	116
Spotted flycatcher	0.00	0.71	0.03	-70*
Tree creeper	0.00	0.57	0.09	n/a
Willow warbler	0.00	0.29	0.47	30
Wood pigeon	0.15	0.29	0.39	37
Wren	0.15	0.15	1.34	70

From the list of species found within Langdale Estate, 11 have been identified by Birds of Conservation Concern (BTO, 2007). House sparrow, marsh tit, song thrush and spotted flycatcher are listed on the red list which indicates they are globally threatened with breeding populations showing rapid declines of > 50% over the last 25 years. Black-headed gull,

dunnock, grey wagtail, house martin, swallow and willow warbler are listed on the amber list which indicates breeding populations declining by 25-49% over the last 25 years. As well as being identified as species in need of conservation concern, song thrush, spotted flycatcher, house sparrow and marsh tit are listed within the National Biodiversity Action Plan<sup>2</sup>. However, only the Song Thrush is listed on the Cumbrian Biodiversity Action Plan (Cumbria Biodiversity Partnership, 2001).

### *Management Plan*

It would be ideal for the current density of birds found on Langdale Estate to remain constant. However special interest should be given to song thrush, spotted flycatcher and marsh tit. As these birds are under conservation concern, maintaining and perhaps improving their populations within the study site would be beneficial.

The following strategies will benefit all species present but will also contribute mainly to those of special interest. Most birds feed upon berries and seeds during autumn and therefore by increasing the number of fruit producing shrubs such as holly within Birch Hill Wood will be ideal. All year round birds will feed upon insects especially the spotted flycatcher and therefore the use of insecticides and other chemicals that may damage insect populations within the study site should be prohibited. To encourage more birds onto the main site and perhaps as supplements in Birch Hill Wood feeders could be put out in quieter areas of the complex. Also bird boxes could be placed on trees to increase potential breeding sites. These need to be fully enclosed boxes presenting a small hole in the front for excess (Appendix F). The size of the hole will dictate the bird species willing to utilise the box. Smaller holes of 25 mm are ideal for blue tits, coal tits and marsh tits, medium holes of 28 mm for great tits, tree sparrows and pied flycatchers and larger holes of 32 mm for house sparrows and nuthatches<sup>9</sup>.

### *Reptiles and Amphibians*

The results for reptiles and amphibians were disappointing however this does not mean to say the site is absent of them. These species are very shy and illusive and finding them can be very challenging. However the results could be indicative of the study site not being an ideal habitat for them. Great crested newt and natterjack toad are both listed within the Cumbrian BAP (Cumbria Biodiversity Partnership, 2001). However Birch Hill Wood isn't an ideal location for either species, although the main estate with its interconnecting waterways and areas of grass are, however the wildfowl and human presence render these areas unsuitable for colonisation.

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<sup>9</sup> Information obtained from [www.rspb.org.uk](http://www.rspb.org.uk) on 13/08/08.

### *Management Plan*

As data from the 1995 reptile and amphibian atlas shows certain species can be found within southern Cumbria, strategies can be put in place attempting to encourage them and increase the diversity of the site. Within area 2 (Figure 8) of the site is a small pond which has been encroached by weeds and moss. If this site was to be developed, it could provide a suitable habitat for frogs and toads. This pond is unsuitable for great-crested newts as it is not located closely to other ponds nor is it within a grassland area, although the 1995 atlas suggests they can be found in southern Cumbria (Cumbria Biodiversity Partnership, 2001). To encourage reptiles into the woodland, areas of short vegetation could be created for basking; also log piles and rockeries situated near dense vegetation will provide suitable hiding areas and will also provide warmth for when the weather isn't warm and dry<sup>10</sup>.

### *Butterflies and Bumblebees*

The number of butterfly species recorded was low compared to the possible species likely to be found in southern Cumbria (Table 2). Only 4 species had been identified compared to a possibility of 13 species likely to be found within the Langdale area (Asher et al., 2001). Elterwater grassland provided the highest number of species found during the survey (Table 6) which suggests that the vegetation is more suitable than the vegetation within Birch Hill Wood. Looking at similar data obtained by the UK Butterfly Monitoring Scheme (UKBMS) (Table 13) it can be seen that the meadow brown population within Cumbria compared to other species is very high. Orange tip and red admiral seem only to occur in sparse numbers and the green-veined white is either present in high numbers >90 or low numbers <30. From this it can be said that the abundance of individuals found within Langdale Estate for all 4 species are low, of the four species only meadow brown and green-veined white have experienced national declines over the past 50 years of less than 20%. (Asher et al., 2001). A possible cause of the low number of sightings in both species and abundance could be due to the unsuitability of the habitats present within the estate. The data from UKBMS also showed that other sites of similar habitats were presenting many more species such as painted lady *Vanessa cardui* and peacock *Inachis io*. Within the woodland at Roudsea in Ulveston, 22 species of butterfly were recorded in 2006<sup>11</sup>, although this site is further south than Langdale, the Langdale site should be able to attract more species with some site management.

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<sup>10</sup> Information obtained from [www.herpconstrust.org.uk](http://www.herpconstrust.org.uk) on 18/08/08

**Table 13.** Other sightings of the 4 butterfly species found within Langdale Estate at similar sites within Cumbria<sup>11</sup>. NR = not recorded.

Site name and location	Habitat type	Species	Mean annual sighting	Sightings within 3rd week of July 2006
Beetham Fell, South Cumbria,	Deciduous Woodland	orange tip	NR	NR
		meadow brown	150	18
		red admiral	13	4
		green-veined white	8	0
Flash Bank Wood Nature Trail, Sedgewick, Cumbria	Dry semi/unimproved grassland	orange tip	1.2	1
		meadow brown	190	18
		red admiral	13	2
		Green-veined White	12	2
Heathwaite Nature Trail, Arnside, Cumbria	Dry semi/unimproved grassland	orange tip	1.2	NR
		meadow brown	650	94
		red admiral	4	6
		Green-veined White	6	NR
Smarsdale Gill, South Cumbria	Dry semi/unimproved grassland	orange tip	7	NR
		meadow brown	360	35
		red admiral	66	11
		Green-veined White	180	15
Brigsteer Park Wood, Kendal, Cumbria	Mature Broadleaved Woodland	orange tip	19	NR
		meadow brown	140	21
		green-veined white	210	8
		red admiral	6	4
Roudsea Wood, Ulveston, Cumbria	Mature Broadleaved Woodland	orange tip	12	9
		meadow brown	140	27
		red admiral	18	2
		green-veined white	91	4
Whitbarrow, Howe Riding, Cumbria	Mature Broadleaved Woodland	orange tip	29	NR
		meadow brown	260	29
		red admiral	8.5	4
		green-veined white	NR	NR
Witherslack Woods, Local Nature Reserve, Cumbria	Mature Broadleaved Woodland	orange tip	5	2
		meadow brown	56	4
		red admiral	3	NR
		green-veined white	14	2

<sup>11</sup>Data obtained from [www.ukbms.org.uk/sites](http://www.ukbms.org.uk/sites) on 14/08/08

Of the bumblebees there is currently no accessible published work stating bumblebee abundance within Cumbria or collating a national density and therefore the data cannot be compared, however the data can be beneficial for any future studies.

#### *Management plan*

Initially this plan should concentrate on the species already identified within the study site. As the current populations are low an ideal strategy would be to improve the existing habitat, demonstrating the need for vegetation management. The orange tip feeds upon cuckooflower *Cardamine pratensis* and garlic mustard *Alliaria petiolata* (Asher et al., 2001); these are common plants within Cumbria and survive well within woodlands (Halliday, 1997). Therefore the introduction should be considered within Birch Hill Wood and Elterwater grassland. The cuckooflower thrives alongside soft rush and therefore planting it within the rush rich areas of the grassland would be ideal and would also be appropriate for the green-veined white. The meadow brown feeds upon flowering grasses such as common bent grass which are already present within the wood and the grassland. The red admiral feeds upon nettles *Urtica dioica*. These are present within a few parts of Birch Hill Wood but none exist within Elterwater grassland, therefore it would be ideal to create nettle banks within both areas to encourage a higher diversity of butterflies. Other possible species to encourage into the area would be peacock, painted lady, small heath, large skipper, and small tortoiseshell, which all feed upon food sources already available within both sites such as nettles, thistles and tall grasses (Asher et al., 2001). A rare species for southern Cumbria is the small-pearl bordered fritillary, which feeds upon common dog violets and marsh violets integrated with bracken and thrive in areas of light grazing usually by deer, thereby offering the open areas of Birch Hill Wood as an ideal location for the introduction of marsh violets, in an attempt to encourage small pearl bordered fritillaries to the site. The butterfly management plan should also include the reduction of bracken and rhododendrons within Birch Hill Wood, as this will increase the diversity of the ground flora allowing other species to regenerate, these strategies will be discussed later (see vegetation section).

Management for the bumblebees would be very minimal as all they require are flowering plants which are present in Elterwater by the presence of buttercup and daisy. Within Birch Hill Wood they favour the foxglove and if the bracken and rhododendrons are thinned out, a more flower rich ground flora will regenerate.

#### *Vegetation*

From the vegetation survey, two types of habitat were identified, Birch Hill Wood presenting deciduous woodland and Elterwater grassland developing into a hay meadow. Further analysis using the National Vegetation Classification system, Birch Hill Wood was classified as two particular types of woodland, the first an oak-birch-wood sorrel wood with the second an oak-birch-dicranum moss wood. These are both typical and widely distributed communities within Britain found on moist, free draining, and base poor soils within the

North West where the climate is cooler and wetter (Rodwell, 1991). However the oak, birch, dicranum moss woodland is the more common woodland of the two.

Nationally over the past 60 years oak woodlands in upland areas have experienced 30-40% decline (Cumbria Biodiversity Partnership, 2001). Due to this dramatic loss, upland oak woodlands have been placed on the Cumbria BAP and the UKBAP<sup>2</sup>. Therefore it would be ideal if Birch Hill Wood be restored back to semi natural woodland. This can be done with the removal of the rhododendron species present. All the other plant species that make up the composition of the wood are ideal and characteristic of an oak-birch wood.

Elterwater grassland was identified as a sweet-vernal grass – wood crane’s bill grassland. This type of grassland is typical of upland areas where high intensive grazing has previously been carried out. There are pest species present within this site; however it is an ideal site to manipulate in order to attract fauna species such as butterflies. Hay meadows and lowland pastures are listed within the Cumbria BAP (Cumbria Biodiversity Partnership, 2001) and the UKBAP<sup>3</sup> due to a 97% decline over the past 50 years making Elterwater grassland an ideal habitat to restore.

#### *Management Plan*

Birch Hill Wood contains a high density of the rhododendron plant species, found in 8 of the 9 areas surveyed. This plant is a non native species introduced from Portugal in the 1700’s (Sheppard et al., 2006). The rhododendron is fast spreading wherever it colonises due to its reproductive nature, each plant produces more than 1 million light weight seeds per season making dispersal quick and easy. Due to the plants thick dense cover it prevents the colonisation of any ground flora under or around it posing a threat to other native plants (Tyler et al., 2006). The plant also changes the ph of the soil increasing the acidity, preventing others from growing. Due to the hostile environment this plant creates the best management strategy would be to remove it. There are several methods for the removal of rhododendrons all with positive and negative issues. Such methods include herbicide application and cutting. Herbicides can be applied by either spraying the plant or injecting the chemical into the base stem. Herbicide injection would be the more efficient of the two as the whole plant gets treated and possible negative effects on other flora and fauna species are limited. Cutting and digging up of the plant is a more environmentally sound method however the cost of manual labour and the time scale are greater than that of the herbicide method (Tyler et al., 2006). Also this does not guarantee the killing of the plant which will most likely grow back. With the rhododendron removed there will be a lot of bare ground left within the woodland.

Over time ground flora similar to that already present within the wood will re-colonise the newly bare ground as well as saplings of the larger trees, oak and birch being able to re-colonise. Other management strategies could be to re-plant some of the bare ground with shrubs. The rhododendron did provide cover for the bird community and therefore this cover needs to be replaced. An ideal shrub for the woodland would be hazel since it is already present within some areas of the woodland (Rodwell, 1991). Hazel will provide adequate cover and more food for both birds and mammals. By creating a hazel coppice within the

newly created space, the timber can be harvested on a 7-10 year rotation providing some economic gain which can then be put back into conserving the woodland (Harmer, 2004). Harvesting the hazel prevents the shrubs from over growing and provides more diverse habitats for other wildlife within the wood. To help the hazel establish and to prevent unwanted grazing, it may be ideal to surround them with a protective casing.

Along with rhododendron removal, another species which needs containing is bracken. The bracken present within the wood although is a valuable feature of the field flora could be cut down a little due to its very dominant nature. It is this dominant nature that inevitably limits the richness of the surrounding flora creating unwanted shade and deep litter, out-competing other species (Rodwell, 1991). Methods of thinning out the bracken involve manual cutting, herbicide or stock grazing. Studies have proven that manual cutting annually produces the best effect at keeping the abundance of bracken low. However light sheep grazing (0.5 sheep per hectare) will also keep abundance low and increase species richness of the area (Le Duc et al., 2007). Therefore a combination of the two methods will produce the best results. Annual cutting in June and winter grazing should keep the bracken cover to a minimal and manageable level.

The level of work involved with these plans if completed outside of breeding season for birds, butterflies and small mammals will not effect the current populations within the study site.

Management on Elterwater grassland will be very minimal. In order to keep the diversity richness of the community, light grazing in the winter months will be beneficial, preventing any one grass specie becoming dominant. Another strategy of maintaining and increasing the richness of the flora is using a traditional method of lightly spreading farmyard manure after grazing by sheep (Rodwell, 1992). A common place practice currently is spreading chemical fertilizers on hay meadows; however this will have adverse effects and decrease the quality and richness of the field. Other planting strategies are those mentioned within the butterfly and bumblebee section and will help increase plant diversity along with attracting new fauna to the site. With this light management plan, Elterwater grassland should increase in floral richness and eventually attract some species of interest such as orchids of which there are 27 species present within Cumbria (Halliday, 1997).

## *Mammals*

### *Small mammals*

The small mammals found within Langdale Estate, wood mice and bank vole, are typical species of woodland habitats (Flowerdew, 1985; Alibhai & Gipps, 1985). Overall within the whole site wood mice presented a larger population than bank vole. This reflects national populations as wood mice are in abundance of 38 million compared to 23 million bank voles (Harris and Yalden, 2008) Although densities of both species were calculated, due to the unpredictable and cyclic populations small rodents display comparing the densities to

other work will hold no relevance. However during the 1980 and 90's a lot of work was carried within this area and the data recorded displays the erratic fluctuations of these species. For example, Gorman and Zab (1993) studied the wood mice population of deciduous woodland in Scotland, the first year density per hectare was 30 with the second year density falling to 5 individuals per hectare. Alibhai & Gibbs (1985) put together a summary of several years data for bank voles and from results obtained from July; surveys would follow a pattern of being low the first year (less than 5) with the repeat survey the following year producing higher results (greater than 30). Obviously demonstrating cyclic patterns, however without further studies within Langdale Estate it isn't known which part of the cycle the population is currently within.

#### *Management Plan*

Further studies into the yearly densities of small mammals within the site are needed along with a more in depth study of the species present before any strategy plans can be put together. Planting of hazel will help provide more food for the population. Since no rare species were detected, no specialized management is needed.

#### *Large mammals*

From the observational studies carried out there was no species of interest within Birch Hill Wood. The deer and occasional sheep provide light grazing within the woodland with the deer grazing on the bluebell flora. As grey squirrels are present it is unlikely that red squirrels will move into the woodland. Both squirrels utilise the same resources within deciduous and coniferous woodland. Where both species exist competition will occur between the two with the grey squirrel being the stronger competitor when resources are limited. Studies have shown that the red squirrel prefers coniferous woodlands whereas the grey prefers deciduous leading to a conclusion that attracting red squirrels to Birch Hill Wood probably will not be viable (Bryce et al., 2005).

#### *Management Plan*

Roe deer within the woodland provides a small implication for management. The effects of deer grazing leads to the grazing of young trees, shrubs and herbs and encouraging the more dominant flora, bracken and grasses to flourish (Gill, 2000). However the small population present within Birch Hill Wood wouldn't pose a threat to the species richness of the wood and the light grazing level they do provide will be beneficial keeping the diversity high. Preventing the deer from grazing on unwanted parts of the woodland can be done with temporary fences or barriers (Gill, 2000).

### *Bats*

Although the survey on the bat roost didn't detect as many bats as had been previously recorded it can still be said the roost within the sports centre contains approximately 150 common pipistrelle bats. This roost, due to its unusual location has been monitored for 15 years due to bats getting lost within the building. The walk through survey of the surrounding area provided evidence of more bat presence. Reports by the tracking mammal partnership organisation estimate the average common pipistrelle colony in England to be 60, with a national population of over 2 million (Battersby, 2005). Therefore the Langdale roost can be said to contain a stable population, and therefore raising no cause for concern.

### *Management Plan*

The site contains common pipistrelles which are listed on the Cumbrian BAP and therefore the continual monitoring of the resident roost should be upheld. Although with the population of the roost being strong compared to other roost sizes, no management strategies need to be undertaken unless further problems occur with individuals getting lost within the complex.

### *Promotion of Biodiversity within the Study Site*

From all the surveys undertaken the Langdale Estate contains a high number of different species and therefore should use this knowledge into transforming the estate into an area of interest for the public.

The existing nature trail within Birch Hill Wood should be utilised. Currently it is overgrown and unmanaged. By cutting back the vegetation and laying down a formal path with natural materials, it can be useable once again and enjoyed by the public. Also along the nature trail within each of the 9 areas (Figure 7) there are numbered posts. At each of these posts, it would be ideal to put up information boards with facts about the likely wildlife to be found. The same management ideas can be applied to Elterwater grassland, an information board displaying butterflies species, along with the management strategies of the grassland to inform the public. Creating a walkway through the grassland to allow people to wander through without disturbing the vegetation and wildlife such as the one present at Ranworth Nature Reserve, Norfolk (Appendix G) would be ideal. Both areas boost fantastic views over the valley which also should be utilized, perhaps install benches at appropriate points within both areas. More information boards erected around the main estate could be utilised to display information regarding possible bat and bird species likely to be seen, as well as informing people of proposed management plans for the biodiversity project, as this could bring in public interest and perhaps repeat customers to the site.

## CONCLUSION

Langdale Estate presents a moderate level of biodiversity across the groups of species surveyed. From the species found on site, marsh tit, spotted flycatcher, song thrush and house sparrow have been listed in the National Biodiversity Action Plan, with song thrush also being listed in the Cumbria Biodiversity Action Plan. Birch Hill Wood and Elterwater grassland also contain habitats that are listed in both Cumbria and National Biodiversity Action Plans. The Biodiversity Action Plan for Langdale Estate should incorporate all these species and habitats along with the 4 species of butterflies due to their populations being locally low. The management strategies that have been suggested will maintain the established species and increase those that lack diversity. Carrying out some vegetation management within both sites will develop diversity richness and in some cases may attract species of special interest such as orchids and butterflies. Where species listed on the Langdale BAP currently reside, effort should be taken to maintain their populations.

This work has introduced new data and knowledge relating to Langdale Estate which can be used for future site management and future ecology work within the surrounding area.

### *Further Work*

Where surveys didn't produce favourable results, more detailed investigations should be carried out to receive better outcomes. The ongoing annual monitoring of all populations within the site will be beneficial as this will monitor diversity and assess whether it decreases or increases throughout the years, especially after management of the site takes place.

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## REFERENCE

- Alford, D.V. (1975) *Bumblebees*, Davis-Poynter, London.
- Alibhai, S.K. and Gipps, J.H.W. (1985) The Population Dynamics of Bank Voles, *Symp.Zool.Soc. London.*, 55, 277- 313.
- Arnold, H.R (1973), Provisional atlas of the amphibians and reptiles of the British Isles, Biological Records Centre, Huntingdon
- Arnold, H.R. (1995) *Atlas of amphibians and reptiles in Britain*, ITE research publication no. 10, Biological Records Centre, Huntingdon.
- Arnold, H.R. (1995a) *Atlas of mammals in Britain*, ITE research publication no. 6, Biological Records Centre, Huntingdon.
- Asher, J., Warren, R., Fox, R., Harding, P., Jeffcoate, G. and Jeffcoate, S. (2001) *The Millennium Atlas of Butterflies in Britain and Ireland*, Oxford University Press, Oxford
- Battersby, J. (2005) *UK Mammals: Species Status and Population Trends*, Tracking Mammals Partnership and JNCC, Peterborough.
- Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S.H. (2000) *Bird Census Techniques*, 2nd ed., Academic Press, London.
- Bibby, C.J., Jones, M. and Marsden, S. (1998) *Bird Surveys: Expedition Field Techniques*, Royal Geographical Society, Expedition Advisory Centre, London.
- British Trust for Ornithology (2007) The Population Status of Birds in the UK: Birds of Conservation Concern 2002-2007, British Trust for Ornithology, Thetford.
- Bryce, J., Cartmel, S. and Quine, C.P. (2005) *Habitat Use by Red and Grey Squirrels: Results of Two Recent Studies and Implications for Management*, Forestry Commission, Edinburgh.
- Cumbria Biodiversity Partnership (2001) *The Cumbria Biodiversity Action Plan*, Cumbria Wildlife Trust, Cumbria.
- Flowerdew, J.R. (1985) The population dynamics of wood mice and yellow necked mice, *symp.zool.soc.london*, 55, 315-338
- Fowler, J., Cohen, L. and Jarvis, P. (1998) *Practical Statistics for Field Biology*, 2nd ed, Wiley, Chichester.
- Fox, R., Warren, M.S., Asher, J., Breeton, T.M. and Roy, D.B. (2007) *The state of Britain's butterflies 2007*, Butterfly Conservation and the Centre for Ecology and Hydrology, Dorset.
- Gibbons, D.V. (1993) *The new atlas of Breeding Birds in Britain and Ireland 1988-1991*, Poyser, London
- Gill, R.M., and Fuller, R.J. (2007) The effects of deer browsing on woodland structure and songbirds in lowland Britain, *ibis*, 149 (Suppl.2) 119-127.
- Gourman, M.L. and Zab, A. (1993) A comparative study of the ecology of woodmice *Apodemus sylvaticus* in 2 contrasting habitats, deciduous woodland and maritime sand dunes. *Journal of Zoology*, 229 (3), 385-396.
- Gurnell, J. and Flowerdew, J.R. (2006) *Live Trapping Small Mammals: A Practical Guide*, The Mammal Society, London
- Halliday, G. (1997) *A Flora of Cumbria*, Univ. of Lancaster, Centre for North-West Regional Studies, Lancaster.
- Harmer, R. (2004) Restoration of neglected hazel coppice, Forestry Commission, Edinburgh

- Harris, S., Morris, P., Wray, S. and Yalden, D. (1995) *A review of British mammals: Population estimates and conservation status of British mammals other than cetaceans*, Joint Nature Conservation Committee, Devon.
- Harris, S. and Yalden, D.W. (2008) *Mammals of the British Isles: handbook*, Mammal Society, Southampton.
- Hewson, C.M., Amar, A., Lindsell, J.A., Thewlis, R.M., Butler, S., Smith, K. and Fuller, R.J. (2007) *Recent changes in bird populations in British broadleaved woodland*, *ibis*, 149 (Suppl.2), 14-28.
- Jeacock, M., Lax, A. and Dunn, C. (2003) *Elterwater Gunpowder Works, Cumbria: An archaeological and History Survey*, English Heritage, Swindon.
- Le Duc, M.G., Pakeman, R.J. and Marrs, R.H. (2007) A restoration experiment on morrland infested by *Pteridium aquilinum*: Plant species responses. *Agriculture Ecosystems and Environment*, 119 (1-2), 53-59.
- Nature Conservancy Council (1987) *The conservation of endangered amphibians and reptiles*, Nature Conservancy Council, Peterborough.
- Pollard, E. and Yates, T.J. (1993) *Monitoring Butterflies for Ecology and Conservation: the British butterfly monitoring scheme*, Chapman and Hall, London.
- Riseley, K., Noble, D.G and Baille, S.R. (2008) The Breeding Bird Survey 2007, BTO Research Report 508, British Trust for Ornithology, Thetford.
- Rodwell, J.S. (1991) *British Plant Communities Volume 1: Woodlands and scrub*, Cambridge University Press, Cambridge.
- Rodwell, J.S. (1991) *British Plant Communities Volume 3: Grasslands and montane communities*, University Press, Cambridge.
- Sheppard, A.W., Shaw, R.H. and Sforza, R. (2006) Top 20 environmental weeds for classical biological control in Europe: a review of opportunities, regulations and other barriers to adoption. *Weed Research*, 46, 93-117.
- Stott, M. (2002) *The Breeding Birds of Cumbria: a tetrad atlas 1997-2001*, Cumbria Bird Club, Cumbria
- Tyler, C., Pullin, A. and Stewart, G. (2006) Effectiveness of management interventions to control invasion by *Rhododendron ponticum*, *Environmental Management*, 37 (4), 513-522.
- Williams, P. (2005) Does specialization explain rarity and decline among British bumblebees? A response to Goulson et al. *Biological Conservation*, 122, 33-43

## APPENDICES

*Appendix A*

Reptiles and Amphibians listed within the National Biodiversity Action Plan<sup>2</sup>.

Common Name	Scientific Name	Common Name	Scientific Name
Adder	<i>Vipera berus</i>	Natterjack toad	<i>Epidalea calamita</i>
Common lizard	<i>Lacerta vivipara</i>	Pool frog	<i>Pelophylax lessonae</i>
Common oad	<i>Bufo Bufo</i>	Sand lizard	<i>Lacerta agilis</i>
Great crested newt	<i>Triturus cristatus</i>	Slow worm	<i>Anguis fragilis</i>
Grass snake	<i>Natrix natrix</i>	Smooth snake	<i>Coronella austriaca</i>

*Appendix B*

Mammals listed within the National Biodiversity Action Plan<sup>2</sup>.

Common Name	Scientific Name	Common Name	Scientific Name
Barbastelle bat	<i>Barbastella barbastellus</i>	Noctule	<i>Nyctalus noctula</i>
Bechstein`s bat	<i>Myotis bechsteinii</i>	Otter	<i>Lutra lutra</i>
Brown hare	<i>Lepus europaeus</i>	Pine marten	<i>Martes martes</i>
Brown long-eared bat	<i>Plecotus auritus</i>	Polecat	<i>Mustela putorius</i>
Dormouse	<i>Muscardinus avellanarius</i>	Red squirrel	<i>Sciurus vulgaris</i>
Greater horseshoe bat	<i>Rhinolophus ferrumequinum</i>	Soprano pipistrelle	<i>Pipistrellus pygmaeus</i>
Harvest mouse	<i>Micromys minutus</i>	Water vole	<i>Arvicola terrestris</i>
Lesser horseshoe bat	<i>Rhinolophus hipposideros</i>	West european hedgehog	<i>Erinaceus europaeus</i>
Mountain hare	<i>Lepus timidus</i>	Wildcat	<i>Felis silvestris</i>

*Appendix C*

The domain scale used for recording abundance during the NVC survey (Rodwell 1992). Abundance is recorded as percentage cover within a quadrat.

<b>Domin Scale</b>	<b>% cover</b>
10	91-100
9	75-90
8	51-74
7	34-50
6	26-33
5	11-25
4	4-10
3	<4 and many individuals
2	<4 and several individuals
1	<4 and few individuals

The frequency scale used for recording species frequency encounters across several samples of vegetation (Rodwell 1992).

<b>Roman Numeral Code</b>	<b>% of samples presenting species</b>	<b>abundance description</b>
I	1-20%	Scarce
II	21-40%	Occasional
III	41-60%	Frequent
IV	61-80%	Constant
V	81-100%	Constant

## Appendix D

Birch Hill Wood vegetation related to possible woodland communities identified within the National Vegetation Classification. Frequency expressing number of times a species occurs across the samples, is stated in roman numerals and abundance expressing percentage cover is in parentheses. Highlighted communities indicate the most compatible to Birch Hill Wood.

Species	Birch Hill Wood	W11a	W11b	W11c	W17a	W17b	W17c
<i>Area 1</i>							
<i>Betula pubescens</i>	V (4)	<b>III(1-9)</b>	IV(1-9)	III(1-9)	III(1-9)	III(1-7)	III(3-7)
<i>Quercus petraea</i>	V (4)	<b>V (5-10)</b>	II (2-9)	I (4-8)	V (1-10)	V (3-10)	V (4-10)
<i>Sorbus acuparia</i>	V (1)	<b>II (1-3)</b>	IV (1-7)	I (1)	II (1-5)	I (1-2)	II (1-5)
<i>Acer campestre</i>	V (4)	-	-	-	-	-	-
<i>Acer pseudoplatanus</i>	V (2)	-	-	-	I (1-4)	I (1-2)	I (2-5)
<i>Pteridium aquilinum</i>	V (5-9)	<b>III (1-9)</b>	IV (1-5)	IV (1-9)	III (1-7)	III (1-7)	IV (1-8)
<i>Dryopteris affinis</i>	V (4-8)	-	-	-	-	-	-
<i>Agrostis capillaris</i>	V (2-3)	<b>IV (1-9)</b>	IV (1-6)	IV (1-9)	II (1-6)	I (1-5)	IV (1-7)
<i>Rubus fruticosus</i>	V (4-5)	<b>III (1-8)</b>	I (1)	I (1-2)	I (1-5)	I (1-7)	II (1-9)
<i>Holcus mollis</i>	V (3-5)	<b>III (1-8)</b>	III (1-7)	IV (1-8)	II (1-6)	I (1-5)	III (2-8)
<i>Digitalis purpurea</i>	IV (1-3)	<b>II (1-7)</b>	-	I (1-7)	-	I (1)	II (1-5)
<i>Hyacinthoides non-scripta</i>	V (3-5)	<b>III (1-10)</b>	IV (2-5)	I (1-4)	I (1-5)	I (1-2)	I (2-5)
<i>Galium aparine</i>	IV (2-4)	<b>I (2)</b>	-	I (1-2)	-	-	-
<i>Ranunculus repens</i>	III (2-4)	<b>I (1)</b>	-	I (2)	-	-	-
<i>Rumex acetosa</i>	III (1-3)	<b>I (1-2)</b>	-	I (1-2)	-	-	I (1-3)
<i>Geranium sylvaticum</i>	I (1-3)	-	-	-	-	-	-
<i>Urtica Dioica</i>	III (1-4)	-	-	-	-	-	-
<i>Area 2</i>							
<i>Quercus robur</i>	V (5)	V (5-10)	II (2-9)	I (4-8)	V (1-10)	V (1-10)	<b>V (4-10)</b>
<i>Acer campestre</i>	V (4)	-	-	-	-	-	-
<i>Acer pseudoplatanus</i>	V (5)	-	-	-	I (1-4)	I (1-2)	<b>I (2-5)</b>
<i>Rhododendron spp</i>	V (4-6)	-	-	-	I (1)	I (1-4)	<b>I (1)</b>
<i>Pteridium aquilinum</i>	V (3-8)	III (1-9)	IV (1-5)	IV (1-9)	III (1-7)	III (1-7)	<b>IV (1-8)</b>
<i>Anthoxanthum odorata</i>	V (1-6)	IV (1-7)	V (3-8)	V (1-8)	II (1-6)	II (1-4)	<b>IV (1-8)</b>
<i>Polytrichum commune</i>	IV (1-6)	-	-	-	I (2-4)	I (1-6)	-
<i>Oxalis acetosella</i>	V (3-7)	IV (1-9)	V (2-7)	IV (1-8)	III (1-5)	I (1-4)	<b>IV (1-7)</b>
<i>Agrostis capillaris</i>	IV (3-5)	IV (1-9)	IV (1-6)	IV (1-9)	II (1-6)	I (1-5)	<b>IV (1-7)</b>
<i>Sphagnum recurvum</i>	III (1)	-	-	-	-	-	-
<i>Galium palustre</i>	III (1-2)	-	-	-	-	-	-
<i>Carex curta</i>	II (1)	-	-	-	-	-	-
<i>Blechnum spicant</i>	I (1)	I (1-5)	V (1-7)	II (1-8)	III (1-5)	II (1-5)	<b>I (1-2)</b>
<i>Rhytidadelphus squarrosus</i>	I (1)	III (1-5)	IV (1-4)	III (1-5)	I (1-4)	I (1-4)	<b>II (1-7)</b>
<i>Area 3</i>							
<i>Quercus petraea</i>	V (5)	V (5-10)	II (2-9)	I (4-8)	V (3-10)	<b>V (3-10)</b>	V (4-10)
<i>Acer pseudoplatanus</i>	V (5)	-	-	-	I (1-4)	<b>I (1-2)</b>	I (2-5)
<i>Betula pubescens</i>	V (4)	III (1-9)	IV (1-9)	III (1-9)	III (1-9)	<b>III (1-7)</b>	III (3-7)

<i>Fraxinus excelsior</i>	V (2)	II (1-7)	I (3-6)	-	I (2-6)	<b>I (1-3)</b>	I (1-7)
<i>Rhododendron spp</i>	V (8)	-	-	-	I (1)	<b>I (1-4)</b>	I (1)
<i>Pteridium aquilinum</i>	V (2-7)	III (1-9)	IV (1-5)	IV (1-9)	III (1-7)	<b>III (1-7)</b>	IV (1-8)
<i>Hyacinthoides non-scripta</i>	III (3-5)	III (1-10)	IV (2-5)	I (1-4)	I (1-3)	<b>I (1-2)</b>	I (2-5)
<i>Dryopteris dilatata</i>	III (1-6)	III (1-9)	I (1)	I (1-5)	I (1-6)	<b>II (1-4)</b>	I (1-4)
<i>Ranunculus repens</i>	II (2)	I (1)	-	I (2)	-	-	-
<i>Oxalis acetosella</i>	II (2-4)	IV (1-9)	V (2-7)	IV (1-8)	III (1-5)	<b>I (1-4)</b>	IV (1-7)
<i>Dryopteris affinis</i>	II (1-7)	-	-	-	-	-	-
<i>Carex curta</i>	I (1)	-	-	-	-	-	-
<b>Area 4</b>							
<i>Quercus petraea</i>	V (8)	V(5-10)	II (2-9)	I (4-8)	V(1-10)	V(3-10)	<b>V(4-10)</b>
<i>Acer pseudoplatanus</i>	V (5)	-	-	-	I (1-4)	I (1-2)	<b>I (2-5)</b>
<i>Betula pubescens</i>	V (6)	III (1-9)	IV (1-9)	III (1-9)	III (1-9)	III (1-7)	<b>III (3-7)</b>
<i>Rhododendron spp</i>	V (7-8)	-	-	-	I (1)	I (1-4)	<b>I (1)</b>
<i>Sorbus aucuparia</i>	V (3)	II (1-3)	IV (1-7)	I (1)	II (1-5)	I (1-2)	<b>II (1-5)</b>
<i>Oxalis acetosella</i>	V (3-5)	IV (1-9)	V (2-7)	IV (1-8)	III (1-5)	I (1-4)	<b>IV (1-7)</b>
<i>Hyacinthoides non-scripta</i>	IV (2-6)	III (1-10)	IV (2-5)	I (1-4)	I (1-5)	I (1-2)	<b>I (2-5)</b>
<i>Holcus mollis</i>	IV (1-4)	III (1-8)	III (1-7)	IV(1-8)	II (1-6)	I (1-5)	<b>III (2-8)</b>
<i>Dactylis glomerata</i>	III (2-4)	-	-	-	-	I (2-3)	-
<i>Polytrichum commune</i>	II (2-4)	-	-	-	I (2-4)	I (1-6)	-
<b>Area 5</b>							
<i>Quercus petraea</i>	V (7)	<b>V (5-10)</b>	II (2-9)	I (4-8)	V (1-10)	V(3-10)	V(4-10)
<i>Acer pseudoplatanus</i>	V (5)	-	-	-	I (1-4)	I (1-2)	I (2-5)
<i>Betula pubescens</i>	V (4)	<b>III (1-9)</b>	IV (1-9)	III(1-9)	III (1-9)	III (1-7)	III (3-7)
<i>Rhododendron spp</i>	V (2-5)	-	-	-	I (1)	I (1-4)	I (1)
<i>Hyacinthoides non-scripta</i>	V (3-4)	<b>III (1-10)</b>	IV (2-5)	I (1-4)	I (1-5)	I (1-2)	I (2-5)
<i>Dryopteris affinis</i>	V (2-4)	-	-	-	-	-	-
<i>Holcus mollis</i>	V (3-5)	<b>III (1-8)</b>	III (1-7)	IV (1-8)	II (1-6)	I (1-5)	III (2-8)
<i>Oxalis acetosella</i>	V (4-5)	<b>IV (1-9)</b>	V (2-7)	IV (1-8)	III (1-5)	I (1-4)	IV (1-7)
<i>Lysimachia nemorum</i>	V (2-3)	<b>I (1-3)</b>	I (1-3)	I (1-3)	I (1-3)	-	I (3)
<i>Deschampsia cespitosa</i>	V (6-8)	<b>II (1-3)</b>	I (1-5)	I (1-6)	I (5)	I (4)	I (1-5)
<i>Pteridium aquilinum</i>	V (3-5)	<b>III (1-9)</b>	IV (1-5)	IV(1-9)	III (1-7)	III (1-7)	IV (1-8)
<i>Lonicera periclymenum</i>	V (3-5)	<b>III (1-6)</b>	II (1-4)	II (1-6)	II (1-6)	I (1-3)	I (1-4)
<i>Cynosurus cristatus</i>	V (2-5)	-	-	-	-	-	-
<i>Conopodium majus</i>	III (1-3)	<b>I (1-3)</b>	II (1-4)	II (1-4)	-	-	-
<i>Galium aparine</i>	II (2-3)	<b>I (2)</b>	-	I (1-2)	-	-	-
<i>Rumex pulcher</i>	II(1-2)	-	-	-	-	-	-
<i>Ranunculus repens</i>	I (1)	<b>I (1)</b>	-	I (2)	-	-	-
<i>Digitalis purpurea</i>	I (1)	<b>II (1-7)</b>	-	I (1-7)	-	I (1)	II (1-5)
<i>Deschampsia flexuosa</i>	I (4)	<b>IV (1-7)</b>	IV (2-8)	V (1-8)	IV (2-7)	V (1-8)	III (1-8)
<i>Carex pallescens</i>	I (1-3)	-	-	-	-	-	-
<i>Ajuga reptans</i>	I (1)	<b>I (1-2)</b>	-	II (1-4)	-	-	-
<i>Rumex acetosa</i>	I (1)	<b>I (1-2)</b>	-	I (1-2)	-	-	I (1-3)
<b>Area 6</b>							
<i>Quercus petraea</i>	V (6)	V(5-10)	II (2-9)	I (4-8)	V (1-10)	V(3-10)	<b>V(4-10)</b>
<i>Acer pseudoplatamus</i>	V (5)	-	-	-	I (1-4)	I (1-2)	<b>I (2-5)</b>
<i>Aesculus hippocastanum</i>	V (5)	-	-	-	-	-	-
<i>Corylus avellana</i>	V (5)	III (1-7)	II (1-7)	II (1-5)	II (1-7)	III (1-7)	<b>III (1-6)</b>
<i>Betula pubescens</i>	V (5)	III (1-9)	IV (1-9)	III(1-9)	III (1-9)	III (1-7)	<b>III (3-7)</b>
<i>Rhododendron spp</i>	V (5)	-	-	-	I (1)	I (1-4)	<b>I (1)</b>
<i>Hyacinthoides non-</i>	V (3-6)	III(1-10)	IV (2-5)	I (1-4)	I (1-5)	I (1-2)	<b>I (2-5)</b>

<i>scripta</i>							
<i>Pteridium aquilinum</i>	V (4-5)	III (1-9)	IV (1-5)	IV(1-9)	III (1-7)	III (1-7)	<b>IV (1-8)</b>
<i>Oxalis acetosella</i>	V (3-5)	IV (1-9)	V (2-7)	IV(1-8)	III (1-5)	I (1-4)	<b>IV (1-7)</b>
<i>Dryopteris affinis</i>	IV (2-4)	-	-	-	-	-	-
<i>Agrostis capillaris</i>	IV (2-3)	IV (1-9)	IV (1-6)	IV(1-9)	II (1-6)	I (1-5)	<b>IV (1-7)</b>
<i>Dryopteris dilatata</i>	III (3-5)	III (1-9)	I (1)	I (1-5)	I (1-6)	II (1-4)	<b>I (1-4)</b>
<i>Anthoxanthum</i>	III (1-2)	IV (1-7)	V (3-8)	V (1-8)	II (1-6)	II (1-4)	<b>IV (1-8)</b>
<i>odoratum</i>							
<i>Lysimachia nemorum</i>	III (1-3)	I (1-3)	I (1-3)	I (1-4)	I (1-3)	-	<b>I (3)</b>
<i>Carex pallescens</i>	II (1-4)	-	-	-	-	-	-
<i>Digitalis purpurea</i>	I (1)	II (1-7)	-	I (1-7)	-	I (1)	<b>II (1-5)</b>
<i>Polytrichum commune</i>	I (3-4)	-	-	-	I (2-4)	I (1-6)	-
<i>Sphagnum recurvum</i>	I (1)	-	-	-	-	-	-
<b>Area 7</b>							
<i>Betula pubescens</i>	V (7)	<b>III (1-9)</b>	IV (1-9)	III(1-9)	III (1-9)	III (1-7)	III (3-7)
<i>Acer pseudoplatamus</i>	V (6)	-	-	-	I (1-4)	I (1-2)	I (2-5)
<i>Aesculus</i>	V (5)	-	-	-	-	-	-
<i>hippocastanum</i>							
<i>Corylus avellana</i>	V (5)	<b>III (1-7)</b>	II (1-7)	II (1-5)	II (1-7)	III (1-7)	III (1-6)
<i>Quercus petraea</i>	V (4)	<b>V(5-10)</b>	II (2-9)	I (4-8)	V (1-10)	V(3-10)	V(4-10)
<i>Fraxinus excelsior</i>	V (4)	<b>II (1-7)</b>	I (3-6)	-	I (2-6)	I (1-3)	I (1-7)
<i>Rhododendron spp</i>	V (4-6)	-	-	-	I (1)	I (1-4)	I (1)
<i>Hyacinthoides non-scripta</i>	V (5-8)	<b>III(1-10)</b>	IV (2-5)	I (1-4)	I (1-5)	I (1-2)	I (2-5)
<i>Oxalis</i>							
<i>Oxalis acetosella</i>	V (3-4)	<b>IV (1-9)</b>	V (2-7)	IV(1-8)	III (1-5)	I (1-4)	IV (1-7)
<i>Dryopteris dilatata</i>	V (2-5)	<b>III (1-9)</b>	I (1)	I (1-5)	I (1-6)	II (1-4)	I (1-4)
<i>Agrostis capillaris</i>	V (3-4)	<b>IV (1-9)</b>	IV (1-6)	IV(1-9)	II (1-6)	I (1-5)	IV (1-7)
<i>Anthoxanthum</i>	IV (3-4)	<b>IV (1-7)</b>	V (3-8)	V (1-8)	II (1-6)	II (1-4)	IV (1-8)
<i>odoratum</i>							
<i>Dactylis glomerata</i>	III (3-4)	-	-	-	-	-	-
<i>Carex pallescens</i>	II (3-4)	-	-	-	-	-	-
<i>Dryopteris affinis</i>	I (2-6)	-	-	-	-	-	-
<i>Lysimachia nemorum</i>	I (3-4)	<b>I (1-3)</b>	I (1-3)	I (1-4)	I (1-3)	-	I (3)
<i>Conopodium majus</i>	I (3)	<b>I (1-3)</b>	II (1-4)	II (1-4)	-	-	-
<i>Rhytidadelphus</i>	I (1)	<b>III (1-5)</b>	IV (1-4)	III (1-5)	I (1-4)	I (1-4)	II (1-7)
<b>squarrosus</b>							
<b>Area 8</b>							
<i>Betula pubescens</i>	V (7)	III (1-9)	IV (1-9)	III (1-9)	III (1-9)	<b>III (1-7)</b>	III (3-7)
<i>Aesculus</i>	V (5)	-	-	-	-	-	-
<i>hippocastanum</i>							
<i>Acer pseudoplatamus</i>	V (3-5)	-	-	-	I (1-4)	<b>I (1-2)</b>	I (2-5)
<i>Fagus sylvatica</i>	V (4)	-	-	-	-	<b>I (1-2)</b>	I (1-5)
<i>Fraxinus excelsior</i>	V (4)	II (1-7)	I (3-6)	-	I (2-6)	<b>I (1-3)</b>	I (1-7)
<i>Quercus petraea</i>	V (2)	V(5-10)	II (2-9)	I (4-8)	V (1-10)	<b>V(3-10)</b>	V(4-10)
<i>Sorbus aucuparia</i>	V (4)	II (1-3)	IV (1-7)	I (1)	II (1-5)	<b>I (1-2)</b>	II (1-5)
<i>Rhododendron spp</i>	IV (4-6)	-	-	-	I (1)	<b>I (1-4)</b>	I (1)
<i>Hyacinthoides non-scripta</i>	IV (5-6)	III (1-10)	IV (2-5)	I (1-4)	I (1-5)	<b>I (1-2)</b>	I (2-5)
<i>Oxalis</i>							
<i>Oxalis acetosella</i>	IV (1-5)	IV (1-9)	V (2-7)	IV (1-8)	III (1-5)	<b>I (1-4)</b>	IV (1-7)
<i>Lonicera spp</i>	II (4-6)	III (1-6)	II (1-4)	II (1-6)	II (1-6)	<b>I (1-3)</b>	I (1-4)
<i>Polytrichum commune</i>	II (2-5)	-	-	-	I (2-4)	<b>I (1-6)</b>	-
<b>Area 9</b>							
<i>Quercus petraea</i>	V (5)	V (5-10)	II (2-9)	I (4-8)	V (1-10)	V (3-10)	<b>V (4-10)</b>
<i>Betula pubescens</i>	V (4)	III (1-9)	IV (1-9)	III (1-9)	III (1-9)	III (1-7)	<b>III (3-7)</b>
<i>Acer pseudoplatamus</i>	V (4)	-	-	-	I (1-4)	I (1-2)	<b>I (2-5)</b>

<i>Fraxinus excelsior</i>	V (4)	II (1-7)	I (3-6)	-	I (2-6)	I (1-3)	<b>I (1-7)</b>
<i>Pteridium aquilinum</i>	V (6-9)	III (1-9)	IV (1-5)	IV (1-9)	III (1-7)	III (1-7)	<b>IV (1-8)</b>
<i>Hyacinthoides non-scripta</i>	V (6-8)	III (1-10)	IV (2-5)	I (1-4)	I (1-5)	I (1-2)	<b>I (2-5)</b>
<i>Oxalis acetosella</i>	V (3-4)	IV (1-9)	V (2-7)	IV (1-8)	III (1-5)	I (1-4)	<b>IV (1-7)</b>
<i>Galium palustre</i>	III (2-4)	-	-	-	-	-	-
<i>Rhododendron spp</i>	III (4-6)	-	-	-	I (1)	I (1-4)	<b>I (1)</b>
<i>Lysimachia nemorum</i>	III (1-3)	I (1-3)	I (1-3)	I (1-4)	I (1-3)	-	<b>I (3)</b>
<i>Digitalis purpurea</i>	III (1-4)	II (1-7)	-	I (1-7)	-	I (1)	<b>II (1-5)</b>
<i>Polytrichum commune</i>	I (2-4)	-	-	-	I (2-4)	I (1-6)	-
<i>Rumex acetosa</i>	I (1)	I (1-2)	-	I (1-2)	-	-	<b>I (1-3)</b>

### Appendix E

Elterwater grassland vegetation related to possible woodland communities identified within the National Vegetation Classification. Frequency expressing number of times a species occurs across the samples, is stated in roman numerals and abundance expressing percentage cover is in parentheses. (Rodwell 1992).

Species	Elterwater	MG3	MG9	U1	U4
<b>Elterwater grassland</b>					
<i>Agrostis canina</i>	IV (6-7)	-	-	I (3)	I (1-8)
<i>Dactylis glomerata</i>	IV (4-5)	<b>IV (1-7)</b>	III (1-7)	I (1-2)	I (1-4)
<i>Ranunculus repens</i>	V (1-4)	<b>I (1-4)</b>	III (1-7)	-	-
<i>Holcus lanatus</i>	V (7-8)	<b>IV (1-6)</b>	IV (2-8)	I (1-6)	-
<i>Rumex acetosa</i>	V (3-5)	<b>V (1-5)</b>	II (1-5)	I (2-5)	II (1-4)
<i>Leucanthmun vulgare</i>	III (1-2)	<b>I (1-3)</b>	I (1-2)	-	-
<i>Festuca ovina</i>	IV (2-5)	-	-	V (1-10)	-
<i>Digitalis purpurea</i>	III (1)	-	-	-	-
<i>Anthoxanthum odoratum</i>	V (4-6)	<b>V (1-6)</b>	II (2-6)	II (1-6)	V (1-8)
<i>Alopecurus pratensis</i>	IV (1-4)	<b>II (1-7)</b>	II (1-8)	-	-
<i>Juncus effusus</i>	I (3)	-	II (1-7)	-	I (1-4)
<i>Conopodium majus</i>	IV (1-3)	<b>V (2-7)</b>	I (1-4)	-	I (1-6)
<i>Galium uliginosum</i>	III (1-4)	-	-	-	-
<i>Agrostis capillaries</i>	V (5-6)	<b>IV (1-7)</b>	-	IV (1-9)	V (1-10)
<i>Geranium sylvaticum</i>	III (1-2)	<b>V (1-9)</b>	-	-	-

## Appendix F

Ideal bird box design



## Appendix G

The protective walkway at Ranworth Nature Reserve

