Queen's University Belfast

ENVIRONMENTALLY SENSITIVE AREAS IN NORTHERN IRELAND

Monitoring of
Antrim Coast, Glens and Rathlin ESA
Sperrins ESA
Slieve Gullion ESA

Biological evaluation of the ESA scheme between 1994 and 2004

Report to the Department of Agriculture and Rural Development

by

Agri-environment Monitoring Unit

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Agri-environment Monitoring Unit

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CONTENTS

1. INTRODUCTION

1.1 The ESA scheme

The Environmentally Sensitive Area (ESA) Scheme was introduced by the then Department of Agriculture for Northern Ireland (now DARD) to help safeguard areas of the countryside where the landscape, wildlife or historic interest is of particular importance and where that interest would benefit through farmers continuing with or engaging in environmentally sensitive farming practices. The scheme was introduced in 1988 and was expanded to the present level of 20% of the land area of Northern Ireland. The five designated areas are:

Mournes and Slieve Croob ESA
Antrim Coast, Glens and Rathlin ESA
West Fermanagh and Erne Lakeland ESA
Sperrins ESA
Slieve Gullion ESA

Each of the ESAs had a main reason for designation in terms of landscape character, habitat diversity and/or heritage. For example, the Sperrins and Slieve Gullion were designated in 1994 primarily for heather moorland. The Antrim Coast, Glens and Rathlin ESA was designated to its present extent in 1993, for its traditional farming landscape and semi-natural woodland.

Participation within the scheme is voluntary. Farmers enter into a ten-year agreement and receive annual area-based payments in return for carrying out specific habitat-based management prescriptions. For example, heather moorland (i.e. land with more than 25% heather) has a maximum stocking rate that must be adhered to and no grazing is permitted over the winter period. Under existing ESA management agreement woodlands are required to be fenced and no livestock grazing is allowed.

Agri-environment schemes now reside under the Northern Ireland Rural Development Plan (NIRDP) 2000-2006, which includes the ESA scheme, the

Countryside Management Scheme (CMS) and the Organic Farming Scheme (OFS). The present ESA scheme closed to new applicants at the end of 1999. The new ESA scheme was introduced in 2001 in compliance with the Rural Development Regulation (EU) No. 1257/99 and has more options than the previous scheme and also certain minimum environmental standards. It has the same range of habitats and payments as the CMS, which was introduced in 2000 and covers the remaining 80% of Northern Ireland. Most existing ESA farmers are expected to transfer to the new ESA scheme when their agreements come to an end.

The target for ESA (old and new) in the Rural Development Plan is for 5000 agreements by 2006. In May 2004 there were 4199 farmers/landowners participating in the old scheme and 555 under the new ESA scheme. Approximately 143,000ha of land is under agreement. The area of each habitat under ESA and NESA management is given in Appendix 1.

1.2 Monitoring programme

A long-term monitoring programme was established in 1992 by DANI (now DARD) to determine the effectiveness of the ESA scheme in fulfilling its objectives of maintaining and enhancing biodiversity, landscape and heritage features. Biological and landscape monitoring programmes have been established in all ESAs. A baseline biological survey in the West Fermanagh and Erne Lakeland ESA was completed in 1993 (Hegarty *et al*. 1994) and baseline surveys in the other four ESAs were carried out in 1994 (Hegarty *et al*. 1995). These surveys provided baseline data on the wildlife value of a range of sites from target habitats within the ESAs. Plant species and certain invertebrate groups (i.e. ground beetles and spiders) have been monitored.

Monitoring plant species is the most widely used method of assessing ecological changes in the environment. Vegetation is the key to the entire ecosystem and plant diversity may often be correlated with animal diversity. Therefore monitoring plant diversity is indicative of the wildlife value of the habitat. Recording detailed changes at the plant species level is widely used to examine long-term ecological changes, such as the relationship between plant composition and agricultural management (Hopkins & Wainwright, 1989).

Ground beetles and spiders were monitored as they are habitat specific, easily trapped in pitfall traps and are good indicators of biological change (Kirby, 1992). Pitfall traps are the most efficient method of collecting invertebrate samples and produce more species than any other method (Coulson & Butterfield 1985). They also collect animals throughout the time they are in place and so are less labour intensive for the number of species trapped. The wealth of information on the ecological requirements of individual ground beetle species has proven useful in environmental quality assessment (e.g. Eyre & Rushton 1989; Luff, 1996). Spiders are sensitive to vegetation structure and as such are good indicator species (Gibson *et al.*, 1992). Information on spider distribution, their habitats and ecology has become available more recently with the publication of the provisional atlas of British spiders (Harvey *et al*, 2002) and the species inventory for Northern Ireland spiders (McFerran, 1997).

Invertebrate monitoring in association with plant species monitoring provides an indication of the biodiversity of a habitat. Species lists of ground beetles and spiders have been compiled for each target habitat. Rare and threatened species have been found within the ESAs and their status and distribution documented (Hegarty *et al.,* 1994, 1995). These species act as indicator species in assessing the effectiveness of the ESA scheme in maintaining habitat quality.

A complete resurvey of monitoring sites within all ESAs was carried out in 1999 and 2000 on participant and non-participant farms (Cameron *et al.,* 2000, 2001). The present 10-year resurvey in 2004 compares data from habitats under agreement on ESA participant farms with baseline data. This permits a more precise evaluation of the scheme over a longer time period during which the effects of management prescriptions have had a greater opportunity to become apparent. This report compares plant and invertebrate species composition over time as indicators of biodiversity and habitat condition on heather moorland in the Sperrins ESA, the Slieve Gullion ESA, and heather moorland and woodland in the Antrim Coast, Glens and Rathlin ESA. Although the Antrim Coast, Glens and Rathlin form one ESA, Rathlin Island has been considered separately due to the distinct composition and character of the flora and fauna. Heather moorland within the Mournes and Slieve Croob ESA was not monitored in 2004 due to the very small sample of agreement sites. Biological monitoring results for the 10-year resurvey of the West Fermanagh and Erne Lakeland ESA are discussed in a separate report (Cameron et al, 2004).

The main policy driver for biodiversity is currently the UK Biodiversity Action Plan (BAP). Agri-environment schemes are one of the main vehicles by which BAP objectives and targets for many habitats and species are expected to be met and delivered. Therefore monitored habitats within the ESAs are discussed in terms of their contributions to delivering targets for particular BAP priority habitats in Northern Ireland (Northern Ireland Biodiversity Group, 2000).

1.3 Heather regeneration study

Moorland has been traditionally managed by rotational burning of small patches of older heather to create a mosaic of uneven aged stands. A combination of mature heather and young developing heather has been shown to be the most desirable combination for production and for species conservation (Gimingham 1985). Older stands provide shelter for sheep and cover for grouse and other ground nesting birds whilst young shoots are the most palatable and nutritious. Uneven phased stands have been shown to have greater invertebrate species diversity due to the greater range of structure and ages (Coulson 1992).

More recently, flailing has been used as a management tool with the same objectives as burning. There is little history of controlled heather management in Northern Ireland. In 1997 botanical monitoring was carried out on a number of heather moorland sites that had recently been either burned or flailed.

These sites were monitored in 1998, 2000 and again in 2004. The resulting plant species data provides the basis for a comparative study.

The study aims to provide information on the suitability and effectiveness of these practices for heather regeneration in Northern Ireland. Management of heather moorland under ESA agreement by burning or flailing is permitted if part of an agreed heather management plan.

2. METHODS

2.1 Sampling programme

A total of 108 heather moorland and 28 woodland sites were surveyed in 1994, including participant and non-participant farms. In 2004 only sites under ESA agreement were surveyed giving a total of 89 sites for botanical monitoring (Table 1). Invertebrates were monitored on a sub-sample of these sites.

Table 1. Number of sample sites monitored in 2004 on heather moorland and woodland in each of the ESAs.

ESA	Habitat	Number of sites	
		Plants	**Invertebrates**
Antrim Coast & Glens	Heather moorland	8	4
Antrim Coast & Glens	Woodland	19	13
Rathlin	Heather moorland	6	3
Slieve Gullion	Heather moorland	13	9
Sperrins	Heather moorland	43	34

2.2 Botanical monitoring

Plant monitoring was carried out between April and September 2004, with sites being visited once during this period. Permanent quadrats initially recorded in 1994 were resurveyed. Surveys were carried out at the same time of year as the baseline monitoring. Woodlands were surveyed during May and heather moorland in July, August and September. Plant nomenclature follows Stace (1997) mosses and liverworts follow Watson (1981).

Details of specific habitat monitoring techniques are listed below. All ESA and heather management sites were plotted using a Garmin 12 XL Global Positioning System in 2000 to aid future relocation.

Heather moorland

At baseline monitoring in 1994, a 60m transect was measured across the site from a randomly placed 1m metal stake and four permanent quadrats were marked out at 15m intervals (MAFF, 1987). These quadrats were relocated in 2004 with the aid of a detailed field map and GPS. All plant species (including bryophytes) within a 1m x 1m quadrat were recorded, along with estimates of percentage cover for each species. The presence of additional species in the surrounding 2m x 2m quadrat was recorded. Records were also made of the mean heather height, dead heather, bare ground and dung.

Woodland

Permanent 14m x 14m quadrats were located within each woodland site. Plant species were recorded in the central 2m x 2m quadrat, along with their estimated percentage cover. Additional species in the outer quadrat were listed. The presence of any tree or shrub regeneration was noted, together with any management information.

2.3 Invertebrate monitoring

Ground beetles and spiders were sampled during three, four-week periods between April and October in 1994, and subsequently in 2004. This was achieved at each site using five pitfall traps (i.e. polythene containers 9cm wide and 20cm deep) part filled with ethylene glycol to prevent the escape and deterioration of specimens before collection. Traps were placed 20 m apart in a line through the centre of each site. At the end of each sampling period traps were emptied and removed. At the beginning of the next sampling period traps were replaced and refilled with a fresh ethylene glycol solution. The contents from all 5 traps were pooled for each sampling site and frozen at -5^{o}C until sorting. All adult ground beetles taken in the traps were identified to species using Lindroth (1974). Species identifications were confirmed by Dr. Roy Anderson, (Agriculture and Environmental Science, Department of Agriculture and Rural Development). All adult spiders were identified to species using Roberts (1985). Species identifications were confirmed by Dr. Peter Merrett (British Arachnological Society).

2.4 Heather regeneration study

Surveys were carried out in 1997 at eleven sites where management by burning or flailing had been carried out the previous winter. These were in Cos. Antrim, Tyrone and Londonderry, on land under ESA agreement, with the exception of one non-ESA site and also a demonstration site at Glenwherry Hill Farm. Botanical surveys were carried out in August and September. Four quadrats were recorded along each 60m transect line. Plant species cover (including bryophytes) was recorded within a 1m x 1m quadrat and any additional species in the surrounding 2m x 2m quadrat were listed. Unmanaged controls were surveyed on adjacent heather areas in each case. The mean heather height in each quadrat was also recorded, together with bare ground, dead heather and dung.

Burned and flailed heather sites were resurveyed in 2004. Transects were relocated at each site using marker poles placed at baseline monitoring, together with GPS.

2.5 Data storage

Plant and invertebrate records were stored on MS Access databases and MS Excel was used for manipulation and statistical analysis of data.

All invertebrate records were also stored on the relational database Recorder 2002 and have been transferred to the Centre for Environmental Data and Recording (CEDaR) at the Ulster Museum. Recorder facilitates this transfer and provides summary lists and tables compatible with multivariate analysis packages.

2.6 Data analysis

Species diversity

In order to monitor the success of the ESA scheme in maintaining or enhancing the biological diversity of a habitat, plant and invertebrate species numbers, frequency and abundance were determined. Species richness, i.e.

the number of species found on a habitat, is the most widely adopted measure of diversity (Magurran, 1988). Frequency was determined by the percentage of sites for each habitat that a species occurred on. Abundance refers to the mean percentage cover of a plant species within a specified quadrat size.

Changes in species richness over time on habitats under ESA agreement were determined by statistical comparison using paired t-tests of the mean number of species per site in 1994 with the mean number of species in 2004. The mean number of higher plant species, i.e. excluding mosses, liverworts and lichens, was also compared.

The Shannon-Weiner diversity index (Kent and Coker, 1992) was calculated for higher plant species for each woodland site. This index combines the number of species and the relative proportion of individuals of each species. A paired t-test was used to compare average diversity indices between baseline and resurvey.

Alpha diversity indices were calculated for carabid beetles and spiders for each site. Alpha (α) was estimated by maximum likelihood in:

$$S = \alpha \ln (1 + N/\alpha)$$

Where:- S is the species total and N is the total individuals of all species at each site (Southwood 1978).

Plant strategy theory

Plant strategy theory (Grime *et al.,* 1988) defines plant species in terms of ruderals (R), competitors (C), stress-tolerators (S), or intermediates. Each type occurs under different environmental conditions. Ruderals are typically annual weeds, found on disturbed, productive habitats. Competitors are typically fast growing species, found on conditions of high productivity and low disturbance. Stress-tolerators are found where an environmental factor is limiting productivity, e.g. on low nutrient soils or soils liable to waterlogging. Many stress-tolerator species are vulnerable to intensive agricultural practices, such as fertiliser application and drainage. By examining the frequency and composition of indicator species and plant species with known ecological requirements and C-S-R plant strategies, indications on the effect of the management practices may be inferred. For example, an increase in stress-tolerator species on a habitat may indicate improved vegetation quality due to reduced disturbance or reduced fertiliser inputs.

The vegetation of each monitored habitat can be described in terms of the relative proportions of species in each of the CSR groups. These proportions were compared between 1994 and 2004 for ESA participant farms.

Vegetation condition assessment

Sward composition and structure were used to characterise vegetation and to determine the effects of management on the condition of heather moorland. The mean cover of heather (*Calluna vulgaris*), dwarf-shrubs (i.e. *Calluna, Erica* spp*., Vaccinium* spp*., Empetrum nigrum* and *Ulex gallii*), bare ground, bryophytes including *Sphagnum* mosses, and graminoids (i.e. grasses, sedges and rushes) were attributes used to assess vegetation. These are easy to measure but are good indicators of habitat condition.

Vegetation classification

The TABLEFIT program (Hill, 1996) was used to classify each site into the closest National Vegetation Classification (NVC) type. This also helped to assign sites to particular BAP priority habitats and so determine the appropriate targets for vegetation condition.

Two-way indicator species analysis or TWINSPAN (Hill, 1979) was used to classify the monitored woodland sites into vegetation types on the basis of plant species abundance in 1m^2 quadrats. TWINSPAN can be useful for detecting vegetation change as species assemblages may shift between classes over time.

3. HEATHER MOORLAND

3.1 Antrim Coast, Glens and Rathlin

3.1.1 Vegetation description

There are currently around 1600ha of heather moorland under agreement in the Antrim Coast, Glens and Rathlin ESA. The majority of this is likely to be upland heath or blanket bog. The monitoring sites could be described as either wet or grassy dry heath, on deep or shallow peat. The vegetation was variable, with NVC type generally classified by TABLEFIT as H10 *Calluna vulgaris- Erica cinerea* heath or M15 *Erica tetralix-Scirpus cespitosus* heath.

Heather was generally in a mature state, with an average height of 31 cm. Grazing levels varied from none or light grazing, to fairly heavy grazing by cattle or sheep.

3.1.2 Plant species diversity and composition

There were no significant changes in mean plant species diversity between 1994 and 2004 (Table 2). The total number of species recorded overall increased from 82 to 95. This increase was mainly due to an increase in the number of bryophytes recorded in 2004, possibly due to recorder differences.

Table 2. Mean number (±SE) of plant species per transect for heather moorland in the Antrim Glens in 1994 and 2004, with statistical comparison (n=8).

	1994	**2004**	p
Mean number of plant species	23.9 (±3.8)	26.9 (±2.8)	NS
Mean number of higher plant species	15.1 (±3.7)	15.1 (±3.1)	NS

The most frequent species (i.e. occurring on >80% of sites) recorded in 2004 were heather (*Calluna vulgaris*), tormentil (*Potentilla erecta*), and mosses *Hypnum cupressiforme* and *Hylocomnium splendens* (see Appendix 2).

The mean percentage cover of heather was 42% in 1994 and 2004, i.e. there was no significant change in the abundance between years (Appendix 3). Overall dwarf-shrub cover had not significantly changed However heather cover remained very low at two sites, which appeared to be heavily grazed. There was no significant change in graminoid cover and no increase in the cover of bare ground.

3.1.3 Plant species proportions in the CSR strategy groups

There was a small increase in the proportion of stress-tolerator species from 46% to 51%.

3.1.4 Invertebrate diversity

Carabid beetle species

The mean number of carabid beetle individuals and species, and alpha diversity index showed no significant changes between 1994 and 2004 (Table 3).

Frequency lists for carabid species are given in Appendix 4. *Carabus nitens,* identified as an indicator species in baseline monitoring, was found on two sites in 2004 This uncommon species is primarily found on upland peat in Northern Ireland. It is declining throughout Europe and listed in the British Red Data Book (Shirt, 1987) as nationally scarce.

Table 3. Carabid beetle species richness and diversity on heather moorland in the Antrim Glens in 1994 and 2004, with statistical comparision (n=4).

	1994	**2004**	p
Mean number of carabid individuals per site	72.5 (±23.7)	168 (±62.5)	NS
Mean number of carabid species per site	10 (±1.1)	11.5 (±0.7)	NS
Mean alpha diversity per site	4.0 (±0.4)	3.3(±0.3)	NS

3.2 Rathlin Island

3.2.1 Vegetation description

Rathlin Island has 235ha of lowland heathland under ESA agreement. The monitored sites were grassy dry heath or wet heath on shallow peat of around 10cm. They were best classified as NVC communities H10 *Calluna vulgaris-Erica cinerea* heath or M15 *Erica tetralix-Scirpus cespitosus* heath.

Heather was generally short and wind-clipped with an average height of 15cm, and in building or mature phase. Sites were generally subject to moderate grazing by cattle.

3.2.2 Plant species diversity and composition

Sites on Rathlin continued to have greater species diversity in terms of mean numbers of plant species than heather moorland sites on any of the other ESAs. This is because the heath vegetation occurs in a mosaic with species-rich grassland or flush. There were no significant changes in mean numbers of plant species or higher plants per site between 1994 and 2004 (Table 4). The total number of recorded species decreased slightly from 91 to 86.

Table 4. Mean number (±SE) of plant species per transect for heather moorland on Rathlin Island in 1994 and 2004, with statistical comparison (n=6).

	1994	**2004**	p
Mean number of plant species	38.0 (±3.2)	40.0 (±3.1)	NS
Mean number of higher plant species	29.7 (±2.9)	28.3 (±3.7)	NS

The most frequent species recorded on all heath sites on Rathlin in 2004 were heather (*Calluna vulgaris*), western gorse (*Ulex gallii*), carnation sedge (*Carex panicea*), lousewort (*Pedicularis sylvatica*), tormentil (*Potentilla erecta*), and the moss *Hypnum cupressiforme* (see Appendix 2).

There was no change in mean heather cover (Appendix 3). However there was an increase in total dwarf-shrub cover from 44% to 54%, although not significant. There had been a general increase in western gorse (4 to 7%). Bare ground cover was very low (2%), showing no change between years. There was an increase in mean graminoid cover ($p<0.05$) from 24% to 32%.

3.2.3 Plant species proportions in the CSR strategy groups

There was a small increase in the proportion of stress-tolerator species from 48% to 52%, together with small decreases in ruderals and competitors.

3.3.4 Invertebrate diversity

Carabid beetle species

Rathlin Island had a higher mean number of carabid beetle species and individuals per site than in any other ESA. The carabid community present included typical dry grassland species as well as specialised heathland species. Frequency lists for carabid species are given in Appendix 4. The number of carabid individuals, species and species diversity showed no significant changes between 1994 and 2004 (Table 5).

Cymindis vaporariorum was found on one site on Rathlin at baseline and identified as a potential indicator species. However this scarce species was not recorded again in 2000 or 2004.

Table 5. Carabid beetle species richness and diversity on heather moorland on Rathlin Island in 1994 and 2004, with statistical comparison (n=3).

	1994	**2004**	p
Mean number of carabid individuals per site	469 (±105)	211(±27)	NS
Mean number of carabid species per site	19.0 (±1.1)	15.3 (±1.3)	NS
Mean alpha diversity per site	4.0 (±0.2)	3.9 (±0.6)	NS

3.3 Slieve Gullion

3.3.1 Vegetation description

Slieve Gullion ESA has around 150ha of heather moorland under agreement, the lowest of any ESA. The monitoring sites were dry heath on shallow peat of 5-15cm depth, and usually on steep rocky land. These were classified as NVC types H8 *Calluna - Ulex galli* heath or H10 *Calluna - Erica cinerea* heath.

In 2004 half of the sites were ungrazed with the rest generally subject to light grazing by cattle or sheep. Two sites had been recently burned. With the exception of these, heather was in a mature state with a mean heather height of 44cm. Many sites appeared to becoming encroached by gorse (*Ulex europaeus*) and bracken (*Pteridium aquilinum*).

3.3.2 Plant species diversity and composition

There was a significant decrease in the mean number of plant species and higher plants recorded between 1994 and 2004 (Table 6). N.B. There was also a very similar decrease if the two burnt sites were excluded from the analysis. There was a large decrease in the total number of plant species recorded between years, from 127 to 91 species.

Table 6. Mean number (±SE) of plant species per transect for heather moorland on Slieve Gullion ESA in 1994 and 2004 with statistical comparison (n=13).

	1994	**2004**	p
Mean number of plant species	33.2 (±1.9)	22.0 (±2.6)	<0.05
Mean number of higher plant species	21.9 (±1.6)	15.1 (±3.1)	<0.01

The most frequent species recorded on heather moorland in Slieve Gullion were heather (*Calluna vulgaris*), bell heather (*Erica cinerea*), velvet bent (*Agrostis canina*) and tormentil (*Potentilla erecta*). Western gorse (*Ulex gallii*) was also a characteristic species. Plant frequency species lists for 1994 and 2004 are given in Appendix 2.

Data from the two burnt sites was not used in analysis of species abundance, as they had a significant cover of bare ground and dead material. The mean cover of heather had increased from 23% to 33%. There was a significant increase in dwarf-shrub cover from 49% to 64% ($p<0.05$). It had increased or remained the same on all but one of these sites. There was no change in graminoid cover between years (27% to 26%). Bare ground cover was very low, except for the two burnt sites.

3.3.3 Plant species proportions in the CSR strategy groups

The proportion of stress-tolerator species remained stable at 47%. There was an increase in the proportion of competitive ruderal species (6 to 11%) and a decrease in ruderal species (8 to 4 %).

3.3.4 Invertebrate diversity

Carabid beetle species

Slieve Gullion had the lowest mean number of carabid beetle species and individuals recorded compared to the other ESAs. A significant decrease was observed in both the mean number of carabid individuals and the mean number of species per site on ESA joiner heather sites (Table 7). However there was no significant decrease observed in the mean diversity index between years. Frequency lists for carabid species are given in Appendix 4. A number of species had decreased in frequency, notably *Nebria salina*, which prefers open ground in peatlands (Anderson *et al*., 2000).

Table 7. Carabid beetle species richness and diversity on heather moorland in the Slieve Gullion ESA in 1994 and 2004, with statistical comparison (n=9).

	1994	**2004**	p
Mean number of carabid individuals per site	95.0 (±16.7)	39.0 (±8.5)	<0.05
Mean number of carabid species per site	13.6 (±1.6)	8.4 (±1.1)	<0.01
Mean alpha diversity per site	4.5 (±0.5)	4.0 (±0.7)	NS

3.4 Sperrins

3.4.1 Vegetation description

The Sperrins ESA has the largest area of heather moorland under agreement, around 21,000ha. Over half of the monitored sites could be described as blanket bog vegetation, NVC types M17 *Scirpus cespitosus- Eriophorum vaginatum* mire or M19 *Calluna vulgaris – Eriophorum vaginatum* mire. Around a quarter of sites were wet heath vegetation M15 *Scirpus cespitosus – Erica tetralix* heath. There was also some lowland raised bog M18 *Erica tetralix-Sphagnum papillosum* mire, dry heath H21 *Calluna vulgaris-Vaccinium myrtillis* heath and grassy/degraded heath. Peat depth on blanket and raised bog was generally greater than 1m, whereas on heath varied from 20cm to 50cm.

In 2004 around half of monitored sites had moderate to light sheep grazing, with cattle grazing occurring on only seven sites. Five sites (12%) showed impacts of heavy sheep grazing. A further 10 sites (23%), half of which were lowland raised bog, showed no signs of recent grazing.

3.4.2 Plant species diversity and composition

There were no significant differences in plant species or higher plant species diversity between 1994 and 2000 (Table 8). The total number of species recorded on all sites had decreased from 111 to 99.

Table 8. Mean number (±SE) of plant species per transect for heather moorland in the Sperrins ESA in 1994 and 2004, with statistical comparison (n=43).

	1994	**2004**	p
Mean number of plant species	27.6 (±1.0)	29.1(±1.1)	NS
Mean number of higher plant species	13.8 (±0.8)	13.3 (±0.7)	NS

The most frequent species recorded on heather moorland in the Sperrins ESA were heather (*Calluna vulgaris*), cotton grasses (*Eriophorum* spp.), cross-leaved heath (*Erica tetralix*), the mosses *Hypnum cupressiforme, Sphagnum capillifolium, Sphagnum papillosum* and *Rhytidiadelphus loreus.* Plant frequency species lists for 1994 and 2004 are given in Appendix 2.

The mean cover of heather had not changed between 1994 and 2004 (Appendix 3). Although mean cover of dwarf-shrubs was 41%, on sites where cover was low in 1994, this was generally still the case. Dwarf-shrub cover below 25%, as measured along the transect, was found on eight sites in 1994, which increased to fourteen sites in 2004. There was less dead heather recorded in 2004 than in 1994. The mean cover of bare ground had decreased from 6% to 2% ($p<0.05$). Mean graminoid cover had significantly increased from 39% to 51% ($p<0.001$).

3.4.3 Plant species proportions in the CSR strategy groups

The proportion of stress-tolerator species remained stable at 51%. There was an increase in the proportion of stress-tolerant competitors (15 to 20%) and a decrease in ruderal species (10 to 7%) and generalists (11 to 5%).

3.4.4 Invertebrate diversity

Carabid beetle species

The number of carabid beetle individuals, species and species diversity showed no significant changes between 1994 and 2004 on heather sites in the Sperrins ESA (Table 9).

Frequency lists for carabid species are given in Appendix 4. The frequency and abundance of *Carabus nitens* appeared to have decreased, with only two individuals caught on two sites in 2004 as compared to 20 individuals at five sites in 1994. The declining species *Carabus clathratus* was newly recorded on one site in 2004.

Table 9. Carabid beetle species richness and diversity on heather moorland in the Sperrins ESA in 1994 and 2004, with statistical comparison (n=33).

	1994	**2004**	p
Mean number of carabid individuals per site	129 (±14.3)	146 (±15.8)	NS
Mean number of carabid species per site	11.9 (±0.7)	10.6 (±0.4)	NS
Mean carabid diversity per site	3.6 (±0.2)	3.1 (±0.2)	NS

4. WOODLAND

4.1 Plant species diversity and composition

No significant difference was observed in the mean number of higher plant species recorded per $4m^2$ quadrat between the 1994 and 2004 in monitored woodlands in the Antrim Coast, Glens and Rathlin ESA (Table 10). However there was a significant decrease in mean species number from 44 to 38 in the $200m^2$ quadrat. A highly significant decrease in the mean Shannon-Weiner diversity index was also observed between 1994 and 2004 ($p<0.001$).

Table 10. Mean number (±SE) of higher plant species per quadrat in woods in the Antrim Coast, Glens and Rathlin ESA in 1994 and 2004 (n=19).

	1994	**2004**	p
Mean number of higher plant sp. per $4m^2$	16.0 (±1.5)	15.8 (±1.3)	NS
Mean number of higher plant sp. per $200m^2$	43.9 (±2.7)	37.9 (±1.7)	<0.05

The proportion of bare ground decreased significantly between baseline and resurvey (Table 11). However there were no significant differences observed between average ground cover of other dominant woodland ground cover types including bluebell (*Hyacinthoides non-scripta*), grasses and bryophytes. No significant change was recorded in the cover of bramble (*Rubus fruticosus* agg.), although cover had almost doubled from 2.7% to 5.4%.

Table 11. Mean percentage ground cover (±SE) of key components of the woodland vegetation in 1994 and 2004 with significance levels (n=19).

	1994	**2004**	p
Bare ground	9.2 (±2.1)	0.3 (±0.2)	<0.001
Bramble	2.7 (±1.6)	5.4 (±2.3)	NS
Grasses	13.4 (±3.3)	17.4 (±5.3)	NS
Bryophytes	14.3 (±4.5)	13.9 (±3.3)	NS
Primrose	2.8 (±1.3)	1.2 (±1.1)	NS
Bluebell	9.4 (±2.3)	13.9 (±4.2)	NS

4.2 Plant species proportions in the CSR strategy groups

Comparison of CSR strategy species (Grime, 1988) showed little difference between most strategy types between 1994 and 2004 (Figure 1). However there was an increase in stress-tolerant competitor (CS) species from 20% to 28% . This grouping includes many of the woody shrub species characteristic of overgrown woodland and scrub e.g. bramble (*Rubus fruticosus*), hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), holly (*Ilex aquifolium*) and ivy (*Hedera helix*).

Desirable woodland ground flora species are generally classified as 'stress-tolerators'. No change was observed in the proportion of stress-tolerator (S) species between surveys.

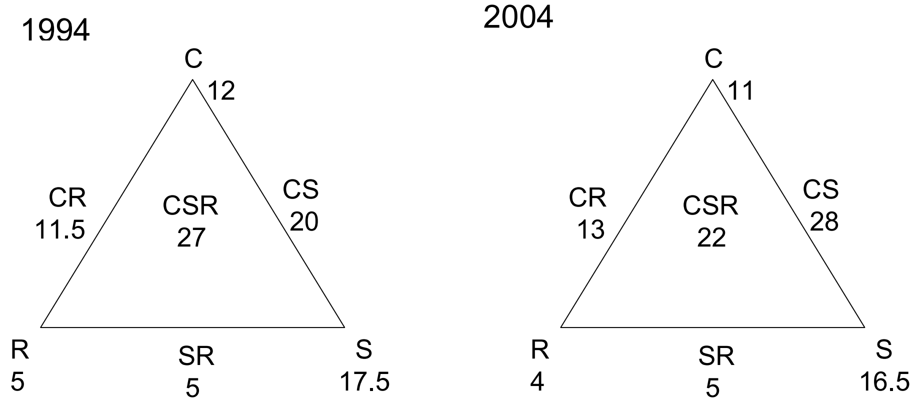

Figure 1. Proportion of plant species in C-S-R categories for baseline (1994) and resurvey (2004) of ESA woods.

4.3 Grazing of woods

The proportion of the sample woodlands that were assessed as being grazed fell from 37% to 26% between baseline and ten-year remonitoring. ESA policy requires total exclusion of livestock from woodland areas under agreement. Many woodland areas were not fenced. However, fencing was not always required, due to the inaccessibility or location of the woodland. Grazed woods were generally fenced with evidence of infrequent sheep trespass, highlighting the difficulty in ensuring the exclusion of livestock from woodland areas.

4.4 Regeneration of woody species

Regeneration of seedlings and saplings was shown to be in decline since baseline survey, with 63% of woods having seedling regeneration and 32% having sapling regeneration, compared to 79% and 53% respectively, at baseline. Ash (*Fraxinus excelsior*) and sycamore (*Acer pseudoplatanus*) were the most common regenerating species in both surveys. Other regenerating species include beech (*Fagus sylvatica*), holly (*Ilex aquifolium*), hazel (*Corylus avellana*) and rowan (*Sorbus aucuparia*).

Oak (*Quercus* sp.) was not recorded as a seedling or sapling in any of the woods at baseline and only one sapling was recorded during resurvey.

4.5 TWINSPAN classification

TWINSPAN (Hill, 1979) was used to identify woods of similar types (Figure 2). Woods were split into two broad groupings. Group 1 woods appear to be species-poor and overgrown in comparison to Group 2 woods. Indicator species of Group 1 include bramble (*Rubus fruticosus* agg.) and creeping buttercup (*Ranunculus repens*), whilst indicator species for Group 2 include wood sorrel (*Oxalis acetosella*), bluebell (*Hyacinthoides non-scripta*) and hazel (*Corylus avellana*).

In the recent 2004 resurvey only 10% of woods classified in Group 1 were identified as being grazed, whilst 44% of woods in Group 2 were identified as being grazed.

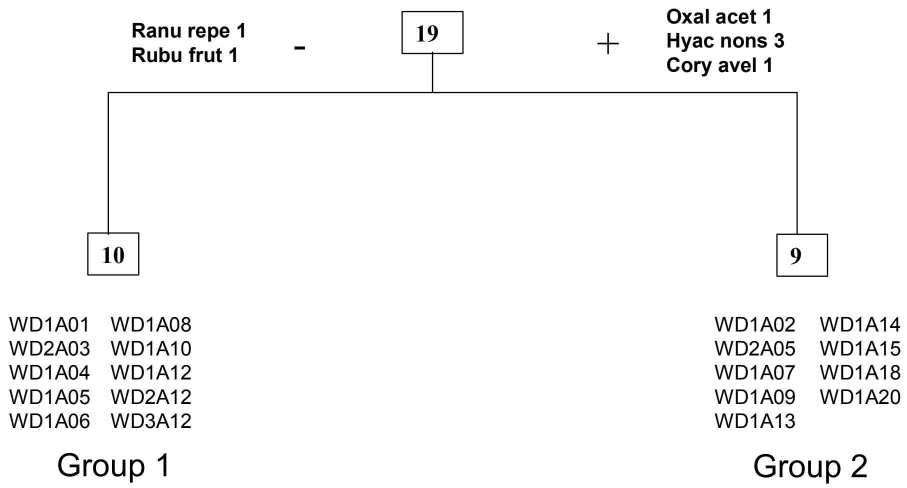

Figure 2. TWINSPAN dendrogram displaying first dichotomous split of 19 ESA woodland samples with indicator species.

4.6 Invertebrate diversity

Carabid beetle species

The number of carabid beetle individuals and species captured in ESA woodlands showed no significant change between baseline and resurvey after ten years (Table 13).

Frequency lists for carabid species are given in Appendix 4. *Pterostichus oblongopunctatus,* a carabid species not found elsewhere in Northern Ireland (Anderson *et al*., 2000), was recorded from ESA participant woods in the Antrim Glens but at fewer sites in 2004. Newly recorded species in 2004 included *Amara similata, Bradycellus sharpi* and *Stomis pumicatus*, all of which are uncommon in Northern Ireland.

Table 13. Carabid species richness and diversity in woodlands in the Antrim Coast, Glens and Rathlin ESA in 1994 and 2004, with statistical comparison (n=13).

	1994	**2004**	p
Mean no. of carabid individuals per site	101 (±14.9)	275 (±75.8)	NS
Mean no. of carabid species per site	13.1 (±0.7)	14 (±0.9)	NS
Mean alpha diversity per site	4.4 (±0.4)	3.7 (±0.3)	NS

5. HEATHER REGENERATION STUDY

5.1 Plant species diversity

The mean number of plant species and higher plants per site were recorded on burned and flailed sites in 1997 and 2004 (Table 14). Control sites adjacent to the managed areas were also monitored. (NB. There were two transects recorded at two of the burned sites, with the same control used for both). The mean number of species recorded per site between 1997 and 2000 for the burned, flailed and control sites were significantly higher, with more bryophytes and lichens being recorded (Cameron *et al*., 2001). However in 2004 there were no significant differences although there was still a higher number of species on the burnt and flailed than in 1997. There were also no significant differences in the mean number of higher plant species between 1997 and 2004, although the species diversity on flail control sites appeared to have decreased. The total number of higher plants recorded overall for burned and flailed sites increased (by three and six species respectively) whereas the controls remained stable.

Table 14. Mean number of plant and higher plant species (±SE) on burned, flailed and control sites in 1997 and 2004 with statistical comparison.

Management	**n**	**Mean no. species per site**			**Mean no. higher plants per site**		
		1997	2004	p	1997	2004	p
Burned	8	22.4 (±2.2)	27.8 (±2.3)	NS	12.1 (±1.0)	13.0 (±1.1)	NS
Burn Control	8	22.3 (±1.6)	23.8 (±1.9)	NS	13.5 (±1.7)	13.7 (±1.6)	NS
Flailed	6	23.2 (±1.5)	25.5 (±1.5)	NS	11.2 (±1.4)	12.3 (±1.7)	NS
Flail Control	6	22.5 (±1.7)	19.7 (±1.7)	NS	11.3 (±2.5)	9.8 (±1.2)	NS

In 1997 there was no significant differences between the mean number of plant species or higher plants in recently burned or flailed sites and their respective controls. In 2000 there were significantly more species recorded on the burned sites than on adjacent controls ($p<0.05$) with a greater number of bryophytes recorded. Species diversity was still greater on burned sites in

2004, although not significantly higher. For flailed sites in 2004 there was a significantly higher species diversity when compared to the controls, partly due to a decrease in plants recorded on control sites.

5.2 Plant species frequency and abundance

Burned heather

A total of 65 species were observed on burned heather sites in 2004 compared with 62 species in 1997. New species recorded on burned sites since 1997 include hard fern (*Blechnum spicant*) and sundew (*Drosera rotundifolia*). Species not recorded in 2004 were bracken (*Pteridium aquilinum*) and mouse-eared chickweed (*Cerastium fontanum*).

Species that increased in frequency between years on burned sites include heath rush (*Juncus squarrosus*), deer grass (*Trichophorum cespitosum*), wavy hair grass (*Deschampsia flexuosa*) and *Sphagnum* species. The frequency of the moss *Campylopus introflexus* increased from 25% to 75% of burned sites, whereas it did not occur on any of the control sites.

The mean cover of heather (*Calluna vulgaris*) on burned sites had increased from 10% to 41% ($p<0.05$) since 1997 (Figure 3). By 2004 there was no significant difference in mean heather cover between burned sites and controls. Actual increase in heather cover on burned sites varied between 20% and 50%, with the exception of one site that only had a slight increase of 3%. There was no significant decrease in mean heather cover on control sites, although there was a large decrease on three of the controls where heather was becoming degenerate and dying. There was a significant increase in total dwarf-shrub cover from 16% to 58% ($p<0.001$) between 1997 and 2004. However there was no change in the mean abundance of cross-leaved heath (*Erica tetralix*). Bell heather (*Erica cinerea*) occurred at only one burned site (dry heath) at which it had increased from 5% to 30%.

The mean cover of graminoids increased from 33% to 49% between 1997 and 2004 ($p<0.05$). In particular hare's tail cotton grass (*Eriophorum vaginatum*) increased in mean cover from 8% to 19% on the burned sites ($p<0.05$). Graminoid cover significantly increased on control sites, presumably due to loss of heather cover.

The mean percentage of bare ground on burned sites was significantly lower in 2000 than in 1997 ($p<0.05$). By 2004 only one of the sites had any bare ground and this was low (2%). There was no longer any significant difference in bare ground cover between burned and control sites (Figure 4).

The abundance of bryophytes on burned sites increased from 14% to 38% between 1997 and 2004 ($p<0.001$). There was no significant difference in bryophyte cover between the burned and control sites in 2000 although the species composition showed some variation. However in 2004 bryophyte cover was significantly higher on previously burned sites than controls.

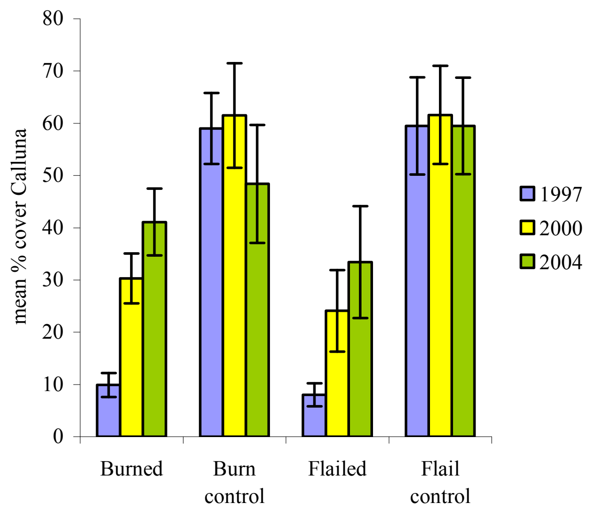

Figure 3. Mean percentage cover (±SE) of *Calluna vulgaris* per 1m^2 quadrat on burned, flailed and control sites in 1997, 2000 and 2004.

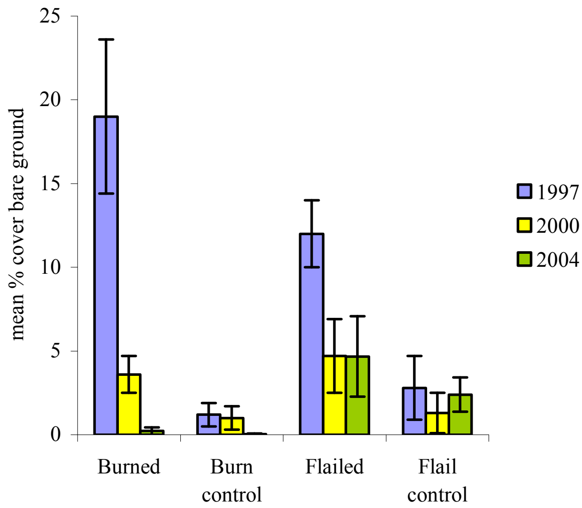

Figure 4. Mean percentage cover (±SE) of bare ground per $1m^2$ quadrat on burned, flailed and control sites in 1997, 2000 and 2004

Flailed heather

Sixty-one species were observed on flailed sites in 2004 compared with 55 species in 1997. Species that increased in frequency included velvet bent (*Agrostis canina*), mat grass (*Nardus stricta*), deer grass (*Trichophorum cespitosum*), sweet vernal grass (*Anthoxanthum odoratum*) and bog asphodel (*Narthecium ossifragum*).

Mean heather cover on flailed sites increased from 8% to 33% between 1997 and 2004 (Figure 3a). With the exception of one site there had been increases in heather cover but this varied from 10% to 60%. This suggests that heather regeneration following flailing has been more successful at some sites than others. The proportion of *Calluna vulgaris* was still significantly higher on control sites ($p<0.05$).

The occurrence of bare ground decreased from all sites in 1997 to two-thirds of sites in 2004. The proportion of bare ground was no longer significantly higher on flailed sites than on control sites as was the case in 1997 (Figure 3b).

The mean cover of graminoids increased from 27% to 52% between 1997 and 2004 ($p<0.05$). In particular at all four flailed sites where hare's tail cotton–grass (*Eriophorum vaginatum*) occurred it increased in mean cover from 13% to 37% ($p<0.05$). The abundance of bryophytes on burned sites increased from 21% to 38% between 1997 and 2004. There was no significant difference in bryophyte cover between flailed and control sites in 1997 or 2004.

5.3 Comparison of heather regeneration on burned and flailed sites

Heather cover was predicted from the 2000 data to reach the value prior to management (i.e. control level) by 2005 for burned sites and 2006/7 for flailed sites, assuming that growth was constant (Cameron *et al.,* 2001). However in 2004 although there had been increases on burnt and flailed sites these had started to level off (Figure 5). The mean cover of *Calluna* remained slightly higher (41% and 33% respectively) on burned sites than flailed .

The mean height of *Calluna vulgaris* was compared for burned and flailed sites (Figure 6). Increase in heather height appeared to be fairly constant for both treatments over the time period of the study. Heather height was slightly greater on the flailed sites in 2000, possibly because burning had removed the heather down to ground level. However by 2004 height was very similar between burned and flailed sites.

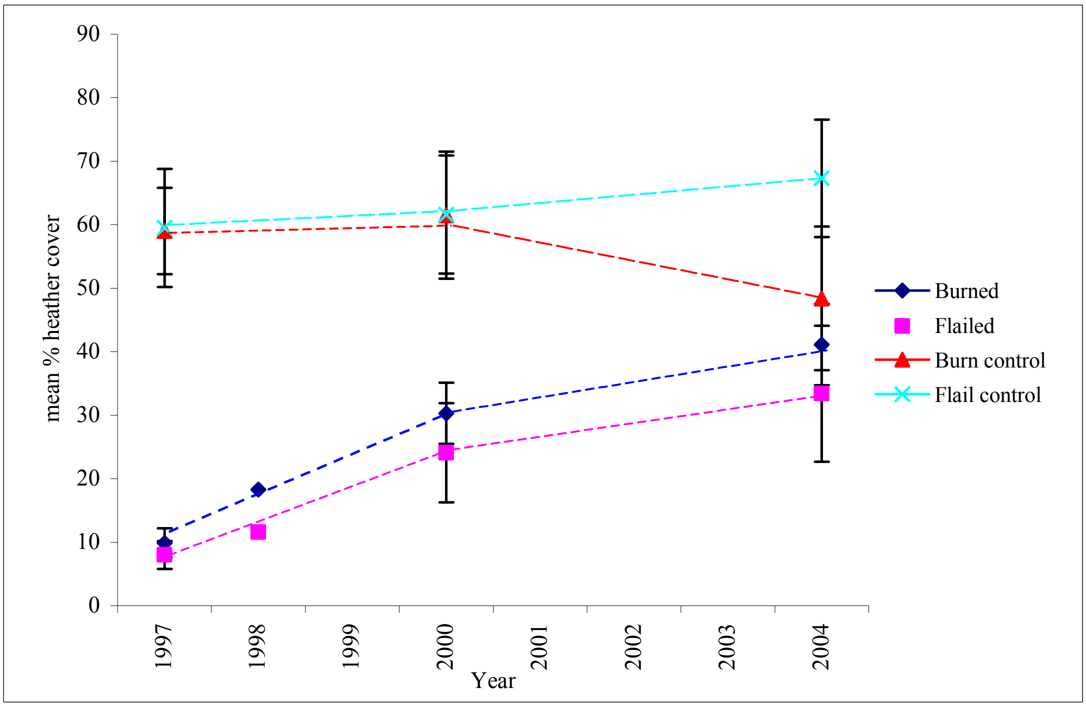

Figure 5. Mean percentage cover of *Calluna vulgaris* between 1997 and 2004 on burned, flailed and control sites.

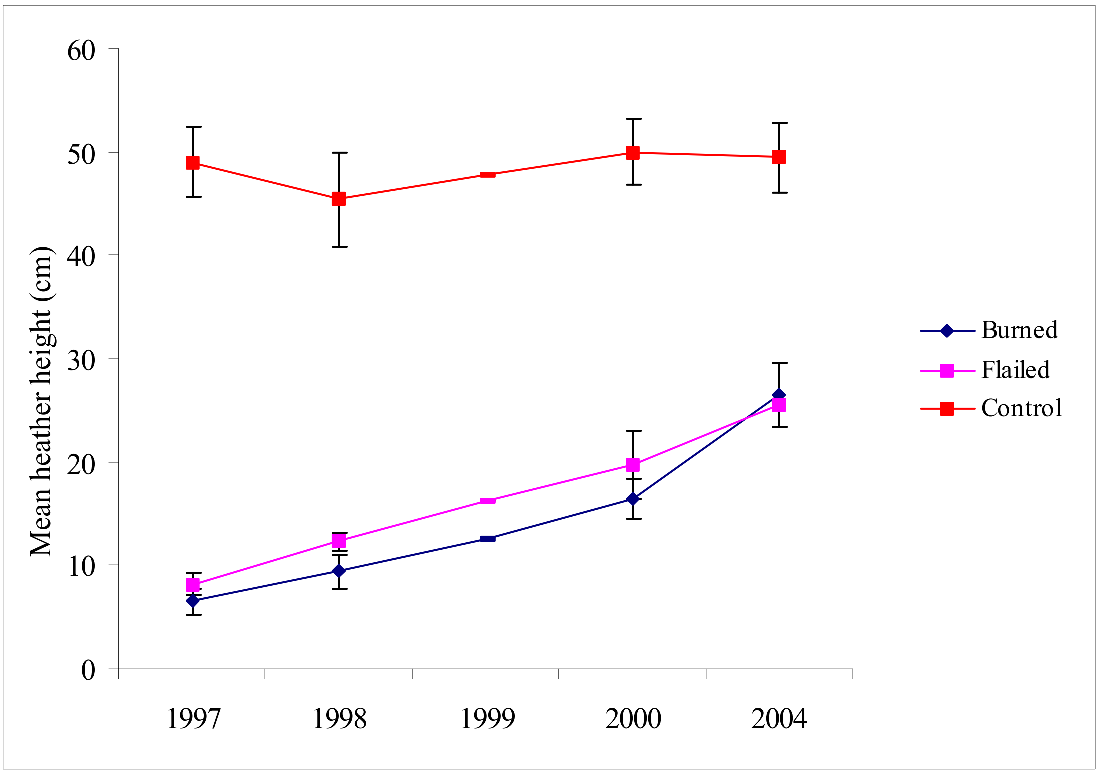

Figure 6. Mean height of *Calluna vulgaris* between 1997 and 2004 on burned, flailed and control sites.

5.4 Plant species in CSR strategy groups

The proportion of stress-tolerators on burned and flailed sites had increased between 1997 and 2004. The proportion of stress-tolerating species on these sites was higher in 2004 than on adjacent control sites (Table 15), possibly indicating vegetation condition had been improved by burning or flailing.

Table 15. Relative proportions of each CSR category for each of the management types in 2004.

Management	**Total no. of CSR species**	**Proportion of plant species in each CSR strategy group (%)**						
		C	R	S	CR	SC	SR	CSR
Burned	29	3	1	66	-	14	2	7
Burn control	26	-	4	58	-	19	4	15
Flailed	28	3	-	68	-	11	7	11
Flail control	20	-	-	65	-	20	-	15

6. DISCUSSION

6.1 Heather moorland

Antrim Coast, Glens and Rathlin ESA

There were no significant changes in plant or carabid species diversity on heather moorland sites under ESA agreement in the Antrim Glens between 1994 and 2004. Sample size was small with a mixture of wet and dry heath sites subjected to variable grazing. There was no significant change in mean dwarf-shrub cover. However there was low heather cover on two sites where grazing levels were high, resulting in poor vegetation condition at baseline and resurvey. Therefore wetter sites in particular may need further reduction in stocking rates in order to improve condition.

Rathlin Island

The lowland heathland sites under ESA agreement on Rathlin had greater plant and carabid beetle species diversity than those sampled in the other ESAs. Species diversity had been maintained between 1994 and 2004. The small sample of sites included both wet and dry heath. High species diversity may be due to the fact that the heath tends to occur in mosaic with species-rich grassland or flush. This means increased structural diversity of the vegetation and the presence of different plant communities.

There was moderate grazing by cattle and sheep. Heather was very short due to suppression by climatic factors, so effects of grazing are difficult to determine. There had been an increase (non-significant) in mean dwarf-shrub cover.

Slieve Gullion ESA

There had been a significant loss of plant species richness on monitored heather moorland sites under ESA agreement in Slieve Gullion between 1994 and 2004. Most of the sites were areas of dry heath on steep slopes. Half of the sites were ungrazed with the rest subject to light grazing. The abandonment or low intensity farming on this rocky, inaccessible land appears to have led to increase of heather, gorse and bracken. Heathland is dependant on management by grazing to prevent succession to scrub or woodland.

There had been a significant increase in heather and total dwarf-shrub cover on the unburnt sites. Mean dwarf-shrub cover was 64% and dry heath in favourable condition generally has over 75% cover of dwarf-shrubs (Jerram & Drewitt, 1998). Reduced grazing levels under ESA management may be improving habitat condition although this appears to have lead to loss of species diversity. Heathlands in general have low botanical diversity so this is not necessarily a negative effect.

Two of the sites that had been recently burnt were not included in the analysis due to the lack of vegetation at time of survey. Burning of dry heath is permitted under ESA management in order to regenerate heather where it has become overmature. The burning of some of the sites may have been deliberate or accidental. However this should lead to heather regeneration as long as the areas are not subjected to high grazing levels.

There appeared to be a significant loss of carabid beetle diversity. This may be explained by the decreased structural diversity of the vegetation and the lack of open areas, for which some species have a preference. A number of species had decreased in frequency, notably *Nebria salina*, for which grazing or other management to reduce the canopy in dwarf-shrub heaths appears to be important for survival (Anderson *et al*, 2000).

Sperrins ESA

The monitored sites in the Sperrins ESA were generally blanket bog and wet heath, although lowland raised bog and dry heath were represented. There were no significant changes in plant species diversity between 1994 and 2004. The sites were usually grazed by sheep, with 12% showing impacts of heavy grazing at resurvey. There was no increase in mean heather cover and on most sites where cover was low at baseline it had remained so. The proportion of sites with degraded heath, i.e. <25% heather cover, had increased from 19% to 32% since 1994. The decrease of heather on certain sites is probably due to continued grazing pressure and also burning on one site. Wet heath and blanket bog vegetation with less than 25% dwarf-shrub cover is considered to be in unfavourable condition (Jerram & Drewitt, 1998). Therefore present grazing levels have not been low enough to improve vegetation condition since the baseline survey. The significant increase in mean graminoid (i.e. grasses, sedges and rushes) cover may be a further indication of heavy grazing. However there was a decrease in the amount of bare ground suggesting less poaching damage since 1994.

The frequency and abundance of the indicator species *Carabus nitens* appeared to have decreased between 1994 and 2004. It is difficult to say whether this is an actual decline or due to natural fluctuations in the population, or simply trapping efficiency in any particular year. The species *Carabus clathratus* was recorded on one site in 2004. This declining species is very local in Northern Ireland and has been found where there are very wet ground conditions (Anderson *et al*, 2000), on peatlands or lakeshores.

The possibility of areas of *Calluna* dying in the Sperrins due to the heather beetle (*Lochmaea suturalis*) was discussed in a previous monitoring report (Cameron *et al,* 2001). The larvae of this species cause damage to heather shoots and heavy outbreaks may cause plants to die. It was noted that there high numbers trapped at some sites in 2000 and an apparent increase in the amount of dead heather. Only a low number of adult beetles were recorded at few sites in 2004. There was also less dead heather recorded in 2004 than in 1994. These factors suggest that outbreaks of heather beetle are cyclical and heather may recover without any specific management.

6.2 Woodland

There was a significant decline in plant species richness in the larger quadrat in the monitored ESA participant woods in the Antrim Coast, Glens and

Rathlin ESA between 1994 and 2004. This may be linked to changes in woodland management, primarily the exclusion of livestock since the baseline survey.

The fact that there were no significant changes in the abundance of many typical woodland species, such as bluebell (*Hyacinthoides non-scripta*) and primrose (*Primula vulgaris*), together with little change in general bryophyte and graminoid cover, would suggest that there are few short-term observable changes in dominant vegetation composition. Longer time-periods may yield more significant trends in vegetation change.

Despite the general trend of the cover of many desirable woodland species being maintained, Shannon-Weiner diversity index has significantly decreased since the initial survey. This may reinforce the theory that woody shrubs are becoming more dominant following reduction in grazing and so outshading less competitive species. Although statistically non-significant, the doubling in the mean cover of bramble (*Rubus fruticosus*) may be due to reduced grazing pressure since the inception of the ESA scheme. McEvoy (2004) found bramble to have a significantly higher cover in ungrazed woodlands. It is a species known to significantly reduce botanical diversity (McEvoy and McAdam, 2002), a factor which could be partly responsible for the loss in species diversity in monitored woods. However bramble can also increase the survival of certain species of tree saplings via 'facilitation' or 'associational resistance' (Olff et al., 1999) where individuals of a browse-resistant species have a positive effect on the growth of another species by protecting it under conditions of high browsing pressure.

An increase in stress-tolerant competitor species may also be an indicator of the reduction in grazing pressure, corresponding with the increase in bramble. No change in the proportion of stress-tolerator species was observed suggesting that the proportion of desirable woodland indicator species has been maintained since the start of the scheme. McEvoy (2004) found higher levels of ruderal species in grazed woods. This was explained by the combined effects of soil disturbance created by poaching, and the introduction of seeds from outside the woodland area via dunging and on the hooves and fleece of animals. The proportion of ruderal species was also unchanged from the baseline survey suggesting that either i) before exclosure, grazing was never significant enough to increase the proportion of ruderal species, or ii) enough grazing still occurs to maintain the level of ruderal species in the wood.

The proportion of bare ground has been shown to be higher in grazed woods, through the effects of vegetation removal through grazing and the mechanical effects of poaching and trampling (McEvoy, 2004). The significant reduction in bare ground cover in monitored woods is likely to be a result of the reduced grazing pressure brought about by livestock exclusion under ESA agreements. This reduction in bare ground could have an impact on seedling germination and sapling survival, as the formation of bare patches, or openings in the ground-layer vegetation by livestock can encourage regeneration of woodland flora and tree seedlings (Scott *et al* 2000; Putman, 1996).

Indications of recent tree regeneration are evident, but noticeably less than at baseline survey. This could be due to the mechanisms described above, i.e. loss of regeneration niches created by trampling and the cessation of grazing/browsing of competing vegetation by large herbivores. However, it would be unwise to extrapolate such results as a future trend as many tree species produce an abundant 'mast' crop of seeds on a cyclical basis, producing irregular regeneration patterns from year to year. Studies on regeneration in broad-leaved woodland in Scottish ESAs have shown that seedling and sapling numbers may be more strongly influenced by natural variations of climate and seed production than by stock exclosure (Henderson *et al*, 1997).

Despite ten years in the ESA scheme many woodland areas were still not fenced and five of the nineteen monitored sites still showed signs of some type of recent use by sheep. A higher proportion of the sites classified as species-rich using TWINSPAN analysis were grazed than those classified as species-poor. This could infer that grazing maintains species diversity, or could simply indicate that the location of these woodland types makes them more susceptible to stock trespass. Many of the more species-rich woodland areas occur away from habitation in steep or inaccessible locations where fencing is difficult and episodes of stock trespass, or fence breaches are difficult to monitor.

In terms of BAP priority habitats, most of the monitored sites could be described as 'mixed ashwoods', although some of these were old plantations rather than semi-natural woodlands.

6.3 Heather regeneration study

Monitoring of vegetation was carried out on a range of sites to assess the suitability of burning and flailing as management techniques for regeneration of heather moorland in Northern Ireland. Plant species diversity and composition were compared on burned and flailed sites, and respective controls, between 1997 and 2004. There were increases in the mean number of species recorded on the burned and flailed sites between 1997 and 2004, although these were not significant. Species diversity was greater on than the respective controls in 2004. In particular there had been a loss of diversity on flail controls. Controls generally had high cover of mature and degenerate heather, with a mean height of 50cm. Plant diversity was low under the dense canopy of heather due to the shading effect.

The effects of burning and flailing on the regeneration of *Calluna vulgaris* were examined. There was a significant increase in *Calluna* cover on burned sites, and by 2004 there was no difference in mean cover between these sites and adjacent controls. Most sites had good regeneration of heather with bushes generally in the building growth phase and a mean height of 25cm. The heather condition appeared better than on controls, where *Calluna* was becoming degenerate and dying, leading to decreases in cover on some sites (and increase in graminoids).

There was a significant increase in mean *Calluna vulgaris* cover on flailed sites. However this was variable, with increases between 10 and 60% on all but one site. Therefore regeneration appeared to be more successful at some sites than others. Heather cover was still significantly lower than on adjacent control sites. An initial comparison in 1998, two years following management, found that regeneration was occurring more rapidly on burned than flailed sites. This trend appears have continued as a slightly higher cover of *Calluna* was found on burned sites in 2004. Other experimental studies comparing the effectiveness of cutting to burning have found that flailed sites had a time lag of one year in achieving a particular cover value (Cotton and Hale, 1994).

Increases in *Calluna* cover appear to be slowing down on both burned and flailed sites since 2000, when levels were predicted to be to around 60% by 2005. This may be due to interaction of other factors particularly grazing. However *Calluna* height was still showing a linear increase over time.

Several factors play a part in the regeneration of heather, which has led to management being more successful at some sites than others. The heather management sites included dry heath, wet heath and blanket bog vegetation. The effects of burning or flailing are likely to be different depending on the vegetation type and soils. The age of stand before burning or cutting will affect the regeneration of heather. In this study all sites had mature heather, in some cases degenerate. Old bushes are less likely to regenerate from stem base (MacDonald, 1990). The flailing process left behind some mature bushes and lower stems. Heather stands also have the capacity to recover from damage by regeneration from seed. For seed germination to be successful the underlying peat surface needs to be exposed. This may be an explanation for the higher regeneration of heather by burning rather than flailing, as burning removes more litter and the ground layer of mosses.

Burning initially creates a new, open habitat with less shade and a greater proportion of bare ground. Therefore there was a high cover of bare ground recorded in 1997. By 2004 there was virtually no bare ground present, indicating good vegetation recovery.

There was a significant increase in graminoids on burned and flailed sites since 1997, as expected due to regrowth following management. In particular the hare's tail cotton-grass (*Eriophorum vaginatum*) had become more abundant on the wetter sites (blanket bog/wet heath). Burning of blanket mire is known to increase graminoids and frequent burning can lead to dominance by *E.vaginatum*, purple-moor grass or deer-grass over heather (Jerram & Drewitt, 1998). These species may be encouraged by burning as their growing points are underground or protected by the tussocky growth form. In general this was the case for the sites in this study, although sample size was limited. Burning or flailing of the drier sites led to an increase in bent grasses and sedges.

There had been a significant increase in bryophyte cover on burned and flailed sites between 1997 and 2004. For example the mean abundance of the moss species *Campylopus introflexus* increased, mainly due to large increase on one burnt site. This moss, a non-native species, is one of the first colonisers of bare peat following burning. Bryophyte flora associated with pioneer heather is different from that of degenerate stands (Gimingham, 1992).

A major factor in determining the effects of management on heather is the interaction with grazing. Most sites were under ESA agreement and therefore should have been subject to relatively low levels of grazing, with winter exclusion of livestock. However levels of grazing within the study varied considerably. Sheep will preferentially graze areas that have been recently burned or flailed where heather is shorter than surrounding mature bushes (Grant, 1968). Heather regeneration was less successful at sites where high grazing pressure was apparent due to sheep being attracted to these areas. In this study only fairly small individual patches of heather were burnt or flailed leading to overgrazing on some sites. A planned programme of heather management where a proportion of the area is burned every year should alleviate this problem and create the desired mosaic of differing ages of heather stand.

7. CONCLUSIONS

With the exception of sites in Slieve Gullion, plant species diversity of heather moorland had been maintained under ESA management. High numbers of species do not necessarily indicate higher quality vegetation. It should be noted that heathland and bog habitats have inherently low botanical diversity. Habitat-specific species found are those that can tolerate some environmental stress such as low nutrient availability or waterlogged soils. The proportion of stress-tolerant species was stable or had increased slightly in heather moorland in all the ESAs. This indicates that habitat quality is being maintained or enhanced due to management under ESA agreement.

The increase in dwarf-shrub cover on dry heath sites in Slieve Gullion, due to reduced grazing under ESA management, may have led to the loss of plant and carabid species diversity. This is in comparison to heath sites on Rathlin where moderate levels of cattle and sheep grazing result in a mosaic of vegetation structure and plant communities. Invertebrate communities are more diverse where there is high structural diversity. Therefore there should be a balance between high grazing intensity and lack of grazing, both which can lead to loss of biological diversity on heathland.

On wetter sites (i.e. blanket bog or wet heath) where heather cover was low at baseline due to overgrazing prior to management under ESA agreement, vegetation often remained in poor condition with low heather cover and a lot of bare ground. In particular many sites in the Sperrins ESA had heather cover less than 25%. This suggests that stocking levels are too high for the habitat to recover to favourable condition after 10 years. However with the introduction of the new ESA scheme, stocking rates on these habitats should be reduced. Under the new scheme, heather moorland has to be classified as blanket bog, wet heath, dry heath or degraded heather. Each of these has specific management prescriptions and maximum grazing levels. Lowland raised bog is also classified separately, with no grazing allowed on intact sites at any time.

Blanket bog, upland heathland, lowland heathland and lowland raised bog are all BAP priority habitats in Northern Ireland (NIBG, 2000). High stocking levels currently have a significant impact on blanket bog and heathland vegetation. Positive management of these habitats under ESA agreement should contribute to the delivery of BAP targets. In particular reduction of stocking rates should help to improve the condition of these habitats, which are vulnerable to damage from overgrazing.

Examination of the effects of burning and flailing for heather moorland management indicated that heather regenerated more rapidly after burning but both methods gave satisfactory results and could be used depending on prevailing circumstances. A rotational system of burning part of the moor each year should be adopted to maintain the desired mosaic of uneven heather stands and prevent congregation and overgrazing by sheep on recently burned patches.

Despite entry into ESA agreements many of the monitored woodland areas in the Antrim Coast, Glens and Rathlin ESA remain unfenced, or have episodes of unmanaged stock trespass. Reduction in grazing has reduced the effects of poaching. Indications are that there is an increase in woody shrubs, such as bramble. Despite this no changes in the dominant components of the woodland ground flora have been observed, however plant species number and diversity have been significantly reduced. Regeneration of tree seedlings and saplings is evident, but at decreased levels from baseline survey. Not enough data is present to link this effect with the reduction in herbivore numbers.

Studies on the effects of livestock exclusion on broad-leaved woodlands have generally shown that permanent complete exclusion is not necessary to ensure regeneration. Low levels of grazing may also provide greater diversity of vegetation structure and species composition than either overgrazing or the absence of grazing in fenced woods. An option for light grazing (i.e. 0.5LU/ha) of woods has been introduced into the new ESA/CMS management prescriptions. This option can be used if the woodland is >1ha, has been closed off to livestock for a considerable time, ground flora has become dominated by bramble, and if there is evidence of natural regeneration of trees and shrubs.

The variability between woodland sites in the Antrim Coast, Glens and Rathlin ESA means that ideally site-specific management plans should be implemented for successful enhancement of biodiversity and regeneration. Under new ESA /CMS agreements, woods are now classified as either oak, mixed ash or wet woodland. These correspond to the BAP priority habitats for broad-leaved woodland in Northern Ireland (NIBG, 2000) and so management should contribute to delivery of appropriate targets.

The ten-year biological monitoring programme of the ESA scheme has found evidence that the scheme has met its objective of maintaining and enhancing biodiversity on land under agreement. Monitoring has also determined that on some habitats such as degraded heath and woodland, modifications to management prescriptions may prove beneficial. These have since been addressed with the introduction of the new ESA scheme. Management should therefore now be more tailored to the maintenance and improvement of vulnerable or declining habitats in Northern Ireland.

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9. APPENDICES

1. **Area of habitats under ESA agreement in 2004**
   a) Area of each habitat and feature under old ESA agreement
   b) Area of each habitat and feature under new ESA agreement

2. **Frequency of plant species recorded on habitats under ESA agreement for each ESA in 1994 and 2004.**

3. **Mean percentage cover of vegetation attributes in 1994 and 2004 for heather moorland in each ESA.**

4 **Frequency of carabid beetle species captured on habitats under ESA agreement for each ESA in 1994 and 2004.**

Appendix 1. Area of habitats under ESA agreement in 2004

a) Area of each habitat and feature under old ESA agreement (*West Fermanagh and Erne Lakeland ESA only, ** Antrim Coast, Glens and Rathlin ESA only)

HABITAT CODE	HABITAT	AREA (HA)
I	Improved grassland	47984.48
U	Unimproved grassland	30659.7
R	Rough grazing	16914.65
W	Woodland / scrub	2490.54
M	Heather moorland	26162.66
SRD	Species-rich dry grassland	170.48
SRW	Species-rich wet grassland	81.47
SRH	Species-rich hay meadow	5.11
WP	Wet pasture*	986.44
H	Hay meadow *	1034.23
L	Limestone grassland*	985.01
OW	Over-wintering sites*	32.87
CHO	Chough Option**	265.27
ARS	Ancient monument	209.04
WCI	Wildlife corridor improved	28.63
WCR	Wildlife corridor rough	21.57
WCU	Wildlife corridor unimproved	88.9
TOTAL	**Total area under scheme**	**128121.1**

b) Area of each habitat and feature under new ESA agreement in 2004.

HABITAT CODE	HABITAT	AREA (HA)
I	Improved grassland	5349.01
U	Unimproved grassland	2956.55
SRD	Species-rich dry grassland	96.41
SRW	Species-rich wet grassland	716.05
SRC	Species-rich calcareous grassland	79.16
SRF	Species-rich fen meadow	0
SRH	Species-rich hay meadow	89.26
SRA	Species-rich acid grassland	0.5
UBR	Upland breeding wader site - restricted	186.39
UBN	Upland breeding wader site - closed grazing	78.56
LWG	Wetlands - lowland wet grassland	179.65
FEN	Wetlands - fen	0
SWA	Wetlands - swamp	2.33
CAR	Wetlands - carr	2.13
REE	Wetlands- reed bed	0.68
EBW	Wetland - enhanced breeding wader	35.78
HMD	Heather moorland - dry heath	319.57
HMW	Heather moorland - wet heath	2341.3
HMB	Heather moorland - blanket bog	108.93
DHM	Degraded heath	410.74
RMG	Rough moorland grazing	1376.11
LRB	Lowland raised bog	54.52
FWS	Farm woodland	99.42
FSC	Farm scrub	174.51
AFI	Land adjacent to lakes - fields - improved	2.57
AFU	Land adjacent to lakes - fields - unimproved	2.55
BLI	Land adjacent lakes - buffers - improved	0.3
BLU	Land adjacent lakes - buffers - unimproved	0.2
GCT	Coastal farmland - cliff tops	0
GCF	Coastal farmland - cliff faces	0
SAS	Coastal farmland - sand dunes	0
GSM	Coastal farmland -grazed salt marsh	0
PRK	Parkland	42.18
ARC	Archaeological feature	27.75
RWS	Arable - Retention of winter stubble	6
CGC	Arable - Improved grassland to spring	0
CGW	Arable - Wild bird cover on improved	3.16

AFW	Arable - Wild bird cover as arable margin	0
RGF	Arable - Rough grass field margin	0
CCM	Arable - Conservation crop margin	0
WFI	Winter feeding sites for swans and geese -	29.04
WFA	Winter feeding sites for swans and geese –	0
LBI	Lapwing breeding site - improved grassland	0
LBU	Lapwing breeding site - unimproved	63.03
BUI	Buffers - improved grassland	1.38
BUU	Buffers - unimproved grassland	8.82
ORE	Restoration of traditional orchards	0.7
ORT	Recreation of traditional orchards	0.16
PNT	Provision of native trees	10.19
TOTAL	**Total area under scheme**	**14855.59**