Butterfly Conservation

Landscape-scale conservation for butterflies and moths

Lessons from the UK

Landscape-scale conservation for butterflies and moths: lessons from the UK

by Sam Ellis, Nigel Bourn and Caroline Bulman

This report would not have been possible without the significant support of the national Government Agencies:

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Foreword

Sir John Lawton

Sir John Lawton

Chairing the panel that produced *Making Space for Nature* between 2009 and September 2010 (the 'Lawton Report') was one of the most interesting things I have done in the voluntary conservation sector.

It was also one of the most depressing, because despite huge efforts by both the statutory and voluntary sectors, particularly since the end of the Second World War, *Making Space* concluded that England's protected area network was still not preventing the continuing declines of many species of plants and animals, some of them truly alarming. This is absolutely not to say that conservation efforts have been a waste of time; I shudder to think how much worse things would have been without those efforts! And of course there have been some real successes. It isn't all bad news. Red Kites are back in force, and Large Blue butterflies flourish, to name but two. Butterflies, by the way, feature prominently in the evidence base summarised in *Making Space*, both the successes, and the ongoing declines of many once widespread species. The declines fall disproportionately on the habitat specialists that require coppiced woodland, grazed chalk grasslands, and so on. I don't need to spell the issues out for this audience.

What is driving the ongoing declines of so many species? *Making Space* concluded that there are four main reasons. First, many protected sites are simply too small; 77% of SSSIs and 98% of Local Wildlife Sites in England are less than 100 ha, too small to prevent random fluctuations driving local populations to extinction. Only a tiny remnant of some habitats remain, and many surviving patches of semi-natural habitat are poorly managed, or not managed at all. And finally many surviving sites are isolated in a sea of inhospitable agricultural or urban landscapes. Butterflies have played a vital role in developing and testing the science of metapopulation dynamics that shows so clearly why this combination of four factors can have such devastating consequences for species unable to easily disperse and that require specialised habitats. Although *Making Space* dealt only with England, much the same arguments apply to the Devolved Administrations.

The solution? The 'executive summary' of *Making Space* was blindingly simple. We need "more, bigger, better managed and joined up" sites in a landscape level approach to wildlife conservation. It wasn't a new insight. Butterfly Conservation has used metapopulation science to build landscape projects that are species led, but which necessitate conserving whole landscapes, and habitats within those landscapes. These projects are designed exactly to create "more, bigger, better and joined" for Lepidoptera, primarily butterflies, but also (as is clear from this report) for moths.

The report summarizes over 10 years of experience in delivering "more, bigger, better and joined" at sites across the UK. It is also timely. The lessons learned come at a time when the landscape approach is a central plank of the Government's new *Biodiversity 2020* strategy and is being rolled out on a wider scale, for example in the 12 *Nature Improvement Areas* that came out of the 2011 Natural Environment White Paper *The Natural Choice*, part of Government's response to *Making Space*. And last, but absolutely not least, the report shows what can be achieved through a highly focused species-led approach. Very simply "more bigger, better and joined" works, and needs to be rolled out far more widely, because, of course, recreating, restoring and joining up habitats benefits not just butterflies and moths, but a host of other creatures with which they share their habitat.

For all these reasons I commend this excellent and timely report and thank the funders for their vision and support.

Sir John Lawton
York, July 2012

Executive summary

1. Butterflies remain one of the UK's most threatened wildlife groups, with three-quarters of species declining in either distribution or population during the 10-year period 1995-99 to 2005-09 (Fox *et al.*, 2011).

2. The science of metapopulation biology has increased our understanding of how butterfly populations persist within landscapes. In response Butterfly Conservation has shifted the majority of its conservation work during the last decade from a focus on single sites to targeting networks of sites across a landscape.

3. Butterfly Conservation defines landscape-scale conservation as *the coordinated conservation and management of habitats for a range of species across a large natural area, often made up of a network of sites* (Bourn and Bulman, 2005).

4. Area and isolation of habitat patches are vital factors in ensuring species survival across a landscape (Hanski, 1999). However, research suggests that because rare species are restricted to very specific habitats or niches, it is just as important to maintain high quality habitat within individual sites, as to maintain the site network (Thomas *et al.*, 2001).

5. The publication of this report is timely as recent government initiatives such as *Making Space for Nature* (Lawton, 2010), have called for widespread use of landscape-scale conservation. The principles are embedded in the UK Government's recent white paper, *The natural choice: securing the value of nature* and Defra's updated biodiversity strategy *Biodiversity 2020: A strategy for England's wildlife and ecosystem services* (Defra, 2011).

6. This report describes 12 evidence-based case studies from around the UK of landscape-scale conservation targeted at threatened butterflies and moths. For each case study we describe the landscape, the habitat requirements of the target species, the project delivery mechanisms, funding sources, land management outcomes and species responses.

7. Some common themes emerge from our experiences delivering landscape-scale conservation. We believe the key wider lessons relevant to the conservation of wildlife at the landscape-scale are:

I. Species conservation can be very effective at the landscape-scale, but careful targeting of management, both across the site network and within each site, is essential to maximise the chances of success.

II. Extinction of species on small, isolated sites need not be inevitable if they are properly managed and the principles of landscape-scale conservation can be applied at relatively small spatial scales.

III. Skilled project officers are an essential component of effective landscape-scale conservation, providing the link between landowners and managers, partner organisations, grant schemes and other funding sources, contractors and volunteers.

IV. Landscape-scale projects must be underpinned by sound ecological research, their design supported by good quality spatial data and their effectiveness measured by a suitable monitoring system.

V. Butterflies and moths respond very rapidly to landscape-scale conservation and projects focused on a single butterfly or moth can and do benefit a suite of other species which have broadly similar habitat requirements.

VI. Short-term funding (e.g. Landfill Communities Fund) is invaluable for the restoration phase of landscape-scale projects, but well designed agri-environment and woodland grant schemes are not only a key delivery mechanism but a very effective means of sustaining project outcomes.

VII. The maintenance of existing high quality habitat is more cost effective in the long run than restoration management.

VIII. Landscape-scale conservation always involves partnership working, but must be developed through a shared vision and action on the ground.

Introduction: Butterfly Conservation and landscape-scale conservation

Neil Hulme

High Brown Fritillary, the UK's fastest declining butterfly

Butterflies are still in serious decline and remain one of the UK's most threatened wildlife groups. The results from Butterfly Conservation's most recent analysis (Fox *et al.,* 2011) show that between 1995-99 and 2005-09, 72% of species declined in abundance (38 of 53 species assessed) at monitored sites and the distributions of 54% of species also declined during the same period (32 of 59 species assessed). Overall three-quarters of butterfly species declined in either distribution or population during this 10-year period (Figures 1 and 2).

During the last century extensive studies have been made on the biology and ecology of butterflies (and to a lesser extent moth species), making Lepidoptera one of the most widely understood insect groups. With increasing destruction, modification and fragmentation of our natural and semi-natural habitats research has frequently focused on the way that populations persist within these dynamic landscapes. The science of metapopulation biology has subsequently developed understanding of how individuals move between habitat patches within a landscape; as well as the effect of increasing isolation, changes in patch size and quality and the incidence of extinction and colonisation (Hanski 1998). Butterfly populations became the main study system for this influential research and Butterfly Conservation responded by shifting the majority of its conservation work from a focus on single sites, to targeting networks of sites across a landscape. This report describes case studies of such projects and identifies wider lessons that are relevant to the implementation of landscape-scale conservation.

The metapopulation concept can be thought of as a 'population of populations', occupying islands of habitat within a 'sea' of unsuitable habitat. This clearly describes the countryside we see in Britain today, where areas of remnant habitat, such as chalk grassland, woodlands, wet meadows etc, are surrounded by an agriculturally improved and developed landscape. The butterflies which inhabit these remnants tend to be the more specialist species that are rapidly declining – they are more prone to local extinction due to low population size, natural fluctuations and deteriorating habitat suitability. If extinction occurs there is the potential for recolonisation by individuals from a nearby population. However, as further habitat destruction and change takes place, these sites become increasingly isolated, recolonisation becomes less likely and the metapopulation will be at greater risk of extinction.

Butterfly Conservation defines **landscape-scale conservation** as *the coordinated conservation and management of habitats for a range of species across a large natural area, often made up of a network of sites* (Bourn and Bulman, 2005). Metapopulation theory has re-orientated conservation priorities to the landscape-scale by emphasising the importance of area and isolation (Hanski, 1999). However, research suggests that because rare species are restricted to very specific habitats or niches, it is just as important to maintain high quality habitat within individual sites, as to maintain the site network (Thomas *et al.*, 2001). This principle is central to Butterfly Conservation's approach to landscape-scale conservation delivery. Moreover, in the context of climate change, a landscape-scale approach appears to be the best option for creating the habitat heterogeneity likely to be needed for species with changing ecological requirements as well as providing the opportunities for them to move through the landscape.

The publication of this report is very timely as recent government initiatives such as *Making Space for Nature: A Review of England's Wildlife Sites and Ecological Network* by Sir John Lawton (2010), have called for widespread use of landscape-scale conservation. The principles are embedded in the UK Government's recent white paper, *The natural choice: securing the value of nature* (TSO, 2011) and the recent updated biodiversity strategy from DEFRA (2011) *Biodiversity 2020: A strategy for England's wildlife and ecosystem services.*

Landscape-scale conservation for Lepidoptera in practice has two main objectives. Firstly, to maximize habitat quality within individual sites by targeted management. This is no different to managing a single site, but at the landscape-scale more cognisance is taken of the spatial context of the individual sites. For

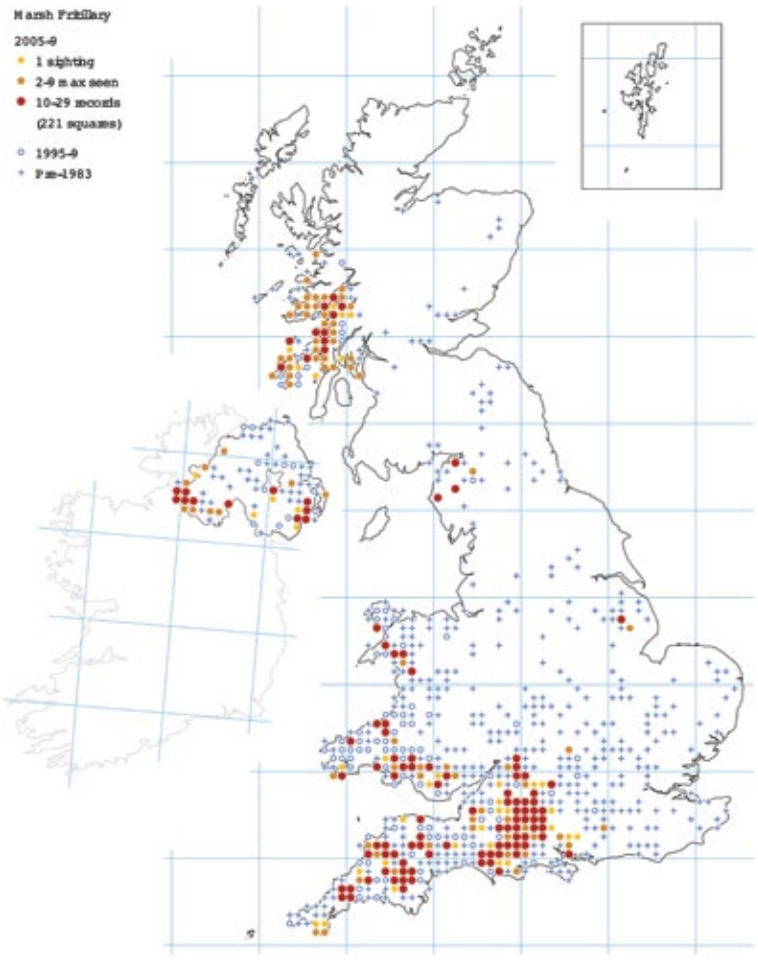


Figure 1 Like many UK butterflies, the Marsh Fritillary has declined in distribution and been lost from large parts of the country. During the most recent recording period, this decline has slowed and even been reversed in some regions thanks to landscape-scale conservation initiatives

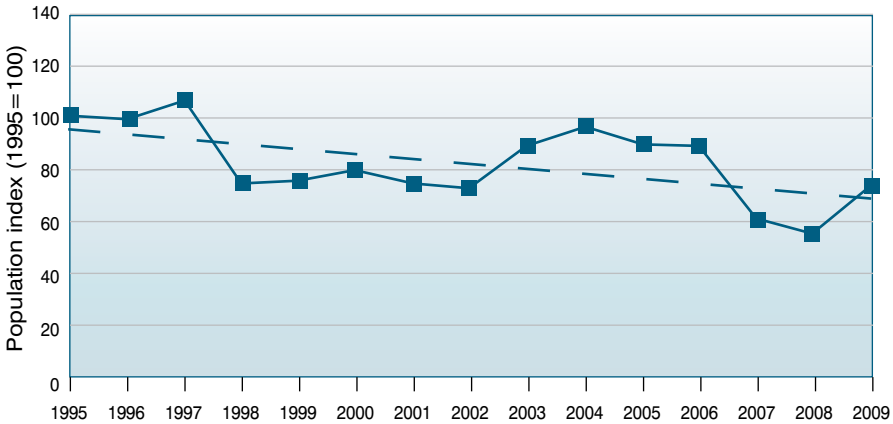


Figure 2 Evidence from the UK Butterfly Monitoring Scheme shows that butterfly populations across the UK have undergone a significant decline of 29% since 1995

Martin Warren

Butterflies and moths have precise ecological requirements that need to be provided for in any landscape; such as for this High Brown Fritillary larva that requires violets growing within moderately dense Bracken litter to provide a warm microclimate

example, sites at the centre of a network may well be given higher priority for management than would a small, isolated site on the network's periphery.

The second major objective is to improve connectivity both within and between sites, improving the ability of butterflies and other organisms to move around a landscape, thus increasing the rate of colonisation. Managing to improve connectivity involves the removal of barriers to dispersal (e.g. felling strategically located plantations or planting flower-rich margins). It can also include management that improves habitat availability within the landscape (e.g. ride-widening).

Since the turn of the millennium, Butterfly Conservation has been involved to a greater or lesser extent with 73 landscape-scale projects across the UK (Figure 3). These projects have targeted key areas for some of the UK's most threatened species, nearly all have received some external funding, directly or indirectly, to enable delivery and all involve partnerships with government agencies, other conservation organisations and landowners.

Broadly we utilise two approaches to landscape-scale conservation, firstly to provide advice to landowners and encourage or assist with the uptake of agri-environment or woodland grant schemes; and secondly to secure funding to directly undertake habitat management under the guidance of Butterfly Conservation project officers.

These are not mutually exclusive with most projects having elements of both approaches.

The need for evidence-based as opposed to experience-based conservation is now well recognised (Pullin and Knight, 2001). We describe here 12 case studies from around the UK which provide quantitative evidence of the lessons learnt from delivering landscape-scale conservation over the last 15 years. For all our landscape-scale projects we try where resources allow, to monitor the impact on not just the target species, but on other wildlife and on habitat condition. For Lepidoptera we adopt standard monitoring methods appropriate to the target species, such as species occupancy (presence/absence within a habitat patch or site), butterfly transects (full species weekly transects or single species transect counts), adult timed counts, larval or egg counts. Further details of these methods are available on the UK Butterfly Monitoring Scheme website (www.ukbms.org).

The main foci of these case studies are UK Biodiversity Action Plan (UK BAP) Priority Species butterflies and their habitats: Small Blue *Cupido minimus*, Duke of Burgundy *Hamearis lucina*, Small Pearl-bordered Fritillary *Boloria selene*, Pearl-bordered Fritillary *Boloria euphrosyne*, High Brown Fritillary *Argynnis adippe*, Marsh Fritillary *Euphydryas aurinia* and Heath Fritillary *Melitaea athalia*. A group of Breckland moths are the focus of one case study, comprising the Grey Carpet *Lithostege griseata*, Basil Thyme Case-bearer *Coleophora tricolor*, Lunar Yellow Underwing *Noctua orbona*, Forester *Adscita statices*, Tawny Wave *Scopula rubiginata* and Marbled Clover *Heliothis viriplaca*. With the exception of Tawny Wave and Marbled Clover, these moths are also UK BAP Priority Species. In England, all the BAP Priority Species are also listed under section 41 of the Natural Environment and Rural Communities Act (2006). In Wales, the High Brown Fritillary is a section 42 species of the Natural Environment and Rural Communities Act (2006) and in Scotland, the

Martin Warren

Britain's landscapes consist of isolated fragments of semi-natural habitat surrounded by intensively managed land, as illustrated by this photograph of downland in the south of England

Marsh Fritillary is a section 2.4 species of the Nature Conservation (Scotland) Act (2004). The High Brown Fritillary, Marsh Fritillary and Heath Fritillary are fully protected by the Wildlife & Countryside Act (1981). The Marsh Fritillary is also protected under Annex II of the European Commission's Habitats and Species Directive.

For each case study we describe the landscape, the target species and a summary of its autecology and habitat requirements. The project delivery mechanisms and funding sources are outlined, together with the land management outcomes achieved to date. Species responses to management are described: either changes in site or habitat patch occupancy, or population trends. Responses of non-target Lepidoptera are also reported where data are available.

Community involvement in each project (e.g. public events, training and recruitment of volunteers) is a crucial component of every landscape project and we describe the contributions made to project delivery by volunteers. Finally we summarise the key successes and lessons learnt from each project and where relevant, plans to sustain the project outcomes in the future.

Some common themes emerge from our experiences of delivering landscape-scale conservation for threatened Lepidoptera across the UK. We believe that sharing this evidence has never been more important, and the final chapter brings this together to help provide lessons for conserving wildlife at a landscape-scale.

Butterfly Conservation landscape target areas

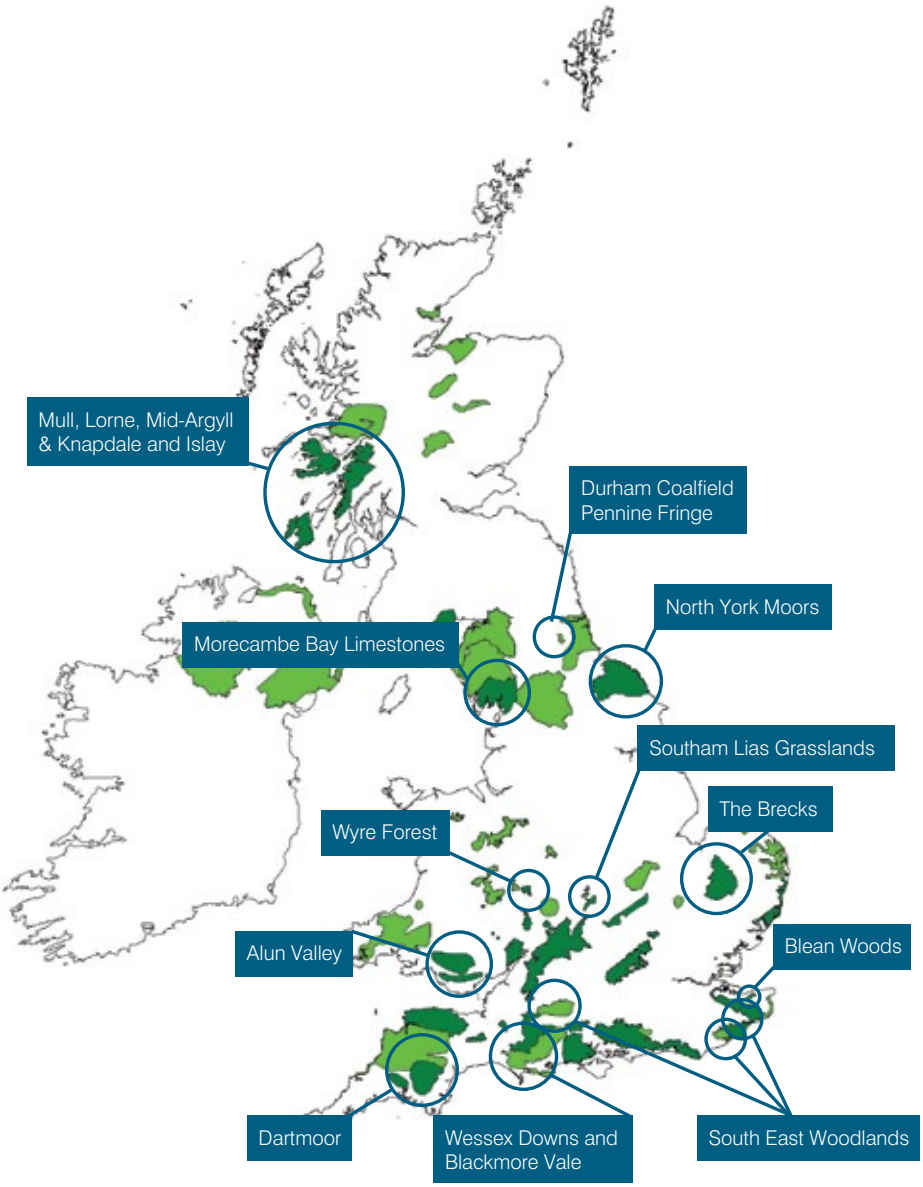


Figure 3 Location of Butterfly Conservation's 73 landscape target areas in the UK. Landscapes with current or recently completed projects are highlighted dark green and those with currently limited engagement or in a project development phase light green. The locations of the 12 landscape-scale case studies are circled

Restoring Marsh Fritillary metapopulations on Dartmoor

Jenny Plackett, Nigel Bourn and Caroline Bulman

Steve Doyle

Marsh Fritillary

Introduction

As the Marsh Fritillary *Euphydryas aurinia* is a species closely linked to extensive pastoral farming, the main mechanism for its conservation across the landscape is agri-environmental schemes. These are designed to help farmers farm in a more environmentally sensitive way. Through the Two Moors Threatened Butterfly project, Butterfly Conservation has worked closely with Natural England, the National Park Authorities and the farming communities of Dartmoor and Exmoor to maximise biodiversity delivery. The project demonstrates the huge added value a targeted scheme, backed with a strong supportive presence on the ground, can bring to our agri-environment schemes. By working closely with the local farmers whole landscapes can be brought into a range of favourable management options.

The Marsh Fritillary is distributed widely throughout Europe as far eastwards as Korea in Asia, but its range has declined seriously in most European countries over the last century (Swaay and Warren, 1999). The butterfly has declined substantially in the UK and its distribution in Britain declined by 46% between 1970-82 and 1995-2004 (Asher *et al.*, 2006). A more detailed survey showed that 66% of colonies in England were lost between 1990 and 2000 (Hobson *et al.*, 2001). On the positive side, many previously unknown colonies have been discovered over the last 20 years (Fox *et al.*, 2006) and during the last ten years the distribution decline has lessened to 9% (Fox *et al.*, 2011). Current strongholds for the butterfly are the Culm grasslands of Devon and Cornwall, the Rhôs pastures of South Wales and Dartmoor, damp grasslands of Argyll, and the chalk downland of Dorset and Wiltshire.

The Marsh Fritillary breeds in

Jenny Plackett

The Marsh Fritillary larval foodplant, Devil's-bit Scabious, is responding well to management

open grassy habitats, especially damp grassland dominated by tussock-forming grasses; calcareous grassland (usually on west or south-facing slopes) and heath and mire vegetation with Devil's-bit Scabious *Succisa pratensis* the larval foodplant (Asher *et al.*, 2001). The females have a preference for laying egg batches on foodplants growing within a vegetation range of between 5 and 25 cm depending on the habitat type – shorter swards on calcareous sites and towards the upper range on damp grasslands (Barnett and Warren, 1995; Bulman, 2001).

Causes of the species decline over the last century include the dramatic loss of unimproved grassland (e.g. 92% of South West England's damp pasture and 60% of chalk downland) following agricultural improvement and changes in the management of remaining habitat fragments, principally abandonment of grazing and over-grazing (Hobson *et al.*, 2001). The Marsh Fritillary is typically associated with extensive grazing by cattle or ponies, which create the varied turf required for breeding. Sheep grazing is generally unsuitable, as these animals tend to graze the foodplant too tightly and create a more uniform sward (Warren, 1994). Sheep grazing also heavily impacts on seed set (lack of flowers) and tends not to create the necessary small bare patches through moderate poaching to allow new plants to colonise.

Marsh Fritillary populations function on a landscape-scale. They are often highly cyclical with large fluctuations in population size, making them prone to local extinction, but this characteristic also allows the butterfly to colonise new sites in good years as well as patches of less suitable habitat. The butterfly persists in areas where large networks of suitable habitat exist, with groups of local populations being connected by occasional

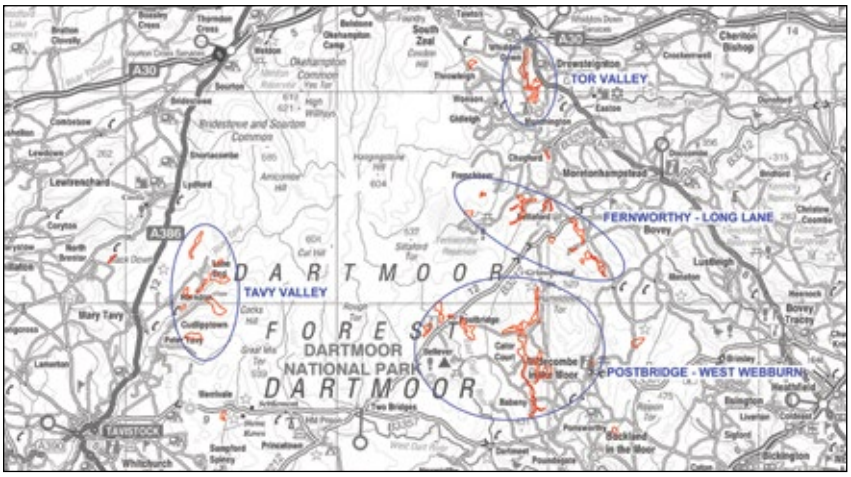


Figure 1 Location of the four habitat networks on Dartmoor which support Marsh Fritillary colonies

dispersal, known as metapopulations (Warren, 1994; Bulman, 2001; Bulman *et al.*, 2007)

On Dartmoor, lack of grazing is a common problem on Rhôs pasture because the habitat offers low quality grazing, which makes grazing of these marginal sites uneconomic. Under-grazed, neglected or abandoned habitat patches quickly become unsuitable for the butterfly, as Western Gorse *Ulex galli* and willow *Salix* spp. scrub dominate and the grass sward becomes rank and overgrown, shading out foodplants. As habitat loses condition through lack of management, connectivity within the landscape is reduced, leaving the remaining patches isolated and their Marsh Fritillary colonies vulnerable.

The Two Moors partnership project was initiated in 2005 to reverse the declines of the Marsh Fritillary, the High Brown Fritillary *Argynnis adippe* and the Heath Fritillary *Melitaea athalia* across Dartmoor and Exmoor. Habitat networks for targeting resources at these species were identified, and project staff work closely with landowners to encourage sensitive management and increase connectivity between sites. Support

Jenny Plackett

Marsh Fritillary larval web in late summer

and advice is offered in habitat management, accessing funding to pay for required works and help given liaising with contractors and graziers.

The project supports Natural England staff by assisting in agri-environment applications and by ensuring appropriate management prescriptions are included in the agreement terms. Training events are organised for conservation professionals, landowners and contractors, and project staff work closely with volunteers to undertake practical management and species monitoring. Guided walks and other public events are organised to increase understanding and appreciation of butterflies.

Jenny Plackett

Volunteers clear scrub to restore Marsh Fritillary habitat condition

The Marsh Fritillary is present at only one Exmoor site, where the butterfly has responded to Bracken *Pteridium aquilinum* management, rank grassland cutting and the reintroduction of sympathetic grazing. Dartmoor National Park is a national stronghold for the species, where it is found in four separate networks, across the moor (Figure 1), including the Fernworthy-Long Lane valley described here as a case study.

The Fernworthy-Long Lane network supports one of the most extensive area of potential habitat within the National Park, with 100 ha of Rhôs pasture, spread over 20 habitat patches on 15 different farm holdings (Figure 2). The system was defined as a Prime Valley System by Dartmoor National Park Authority as part of their Rhôs pasture survey undertaken during 1994-1996. These Prime Valley Systems were the most important wildlife areas within the scope of the study and are a priority for conservation action. The extensive area of Rhôs pasture habitat in this system makes it a key target for landscape-scale restoration.

Project methods

Effort in the four Dartmoor habitat networks has focused on encouraging landowners to enter into agri-environment agreements, securing appropriate longer-term management. Management works have been funded through landowners' agreements where possible, or undertaken by volunteer parties if funding was unavailable. In the Fernworthy-Long Lane valley system six of 20 habitat patches were known to be occupied by the butterfly in 2005; 15 were ungrazed or inappropriately grazed (with unsuitable animals or at the wrong time of year), and in 16 habitat patches the open grassland habitat was being invaded by willow and Gorse scrub. The average distance from any habitat patch (regardless of its occupancy state) to the nearest occupied patch was 542 m.

Working with landowners and Natural England staff, the project has helped to secure Higher Level Stewardship (HLS) agreements at eight of the 15 farm holdings (on which the 20 habitat patches are located), supporting appropriate management over the 10-year agreement period. Capital Works payments secured through this scheme, or the older Environmentally Sensitive Areas (ESA) scheme, supported scrub control works at a number of occupied habitat patches, and fencing/boundary works were undertaken to enable grazing by hardy cattle or ponies to be reintroduced. Management of other invading vegetation (Soft Rush *Juncus effusus*, Greater Tussock-sedge *Carex paniculata*) was also carried out, and small areas of woodland were felled and hedges cut to create clear flight paths and improve connectivity between habitat patches. On one patch with low frequency of the larval foodplant, young Devil's-bit Scabious plant plugs were transplanted from a nearby donor site by volunteers. On another patch, the landowner collected the seed from flower heads and scattered it in another patch undergoing habitat restoration elsewhere on the farm, to improve the quality of breeding habitat. Management of unoccupied as well as occupied habitat was undertaken, to increase the area of potential breeding habitat and improve connectivity between patches. On some habitat patches, no vegetation management was required other than the introduction of an appropriate grazing regime. Grazing was re-introduced, or the grazing regime modified, on 15 patches grazed too heavily or by unsuitable animals.

Over £100k in funding was secured through agri-environment scheme agreements and other sources. This supported capital expenditure on fencing and scrub control and provided landowners with area-based payments to graze their land with low numbers of hardy animals suited to this type of rough grassland at the appropriate time of year.

Land management results

Table 1 summarises the project's achievements in terms of overall advice provision and management undertaken for nine habitat networks across the two moors. Following advice from the project, 71% of sites within Dartmoor's four habitat networks have been managed for the Marsh Fritillary.

In the Fernworthy-Long Lane network, habitat improvement work carried out between 2005 and 2010 resulted in management of just over 10 ha of land, including over 8 ha of scrub control. Nearly 5 km of fencing was erected or boundary improvements undertaken across eight holdings in order to implement an appropriate grazing regime (Table 2). This management has both increased the area and improved the quality of breeding habitat within the valley system, as well as improving connectivity between patches. Between 2005 and 2010 the area of confirmed occupied habitat rose from 32.9 ha to 85.6 ha.

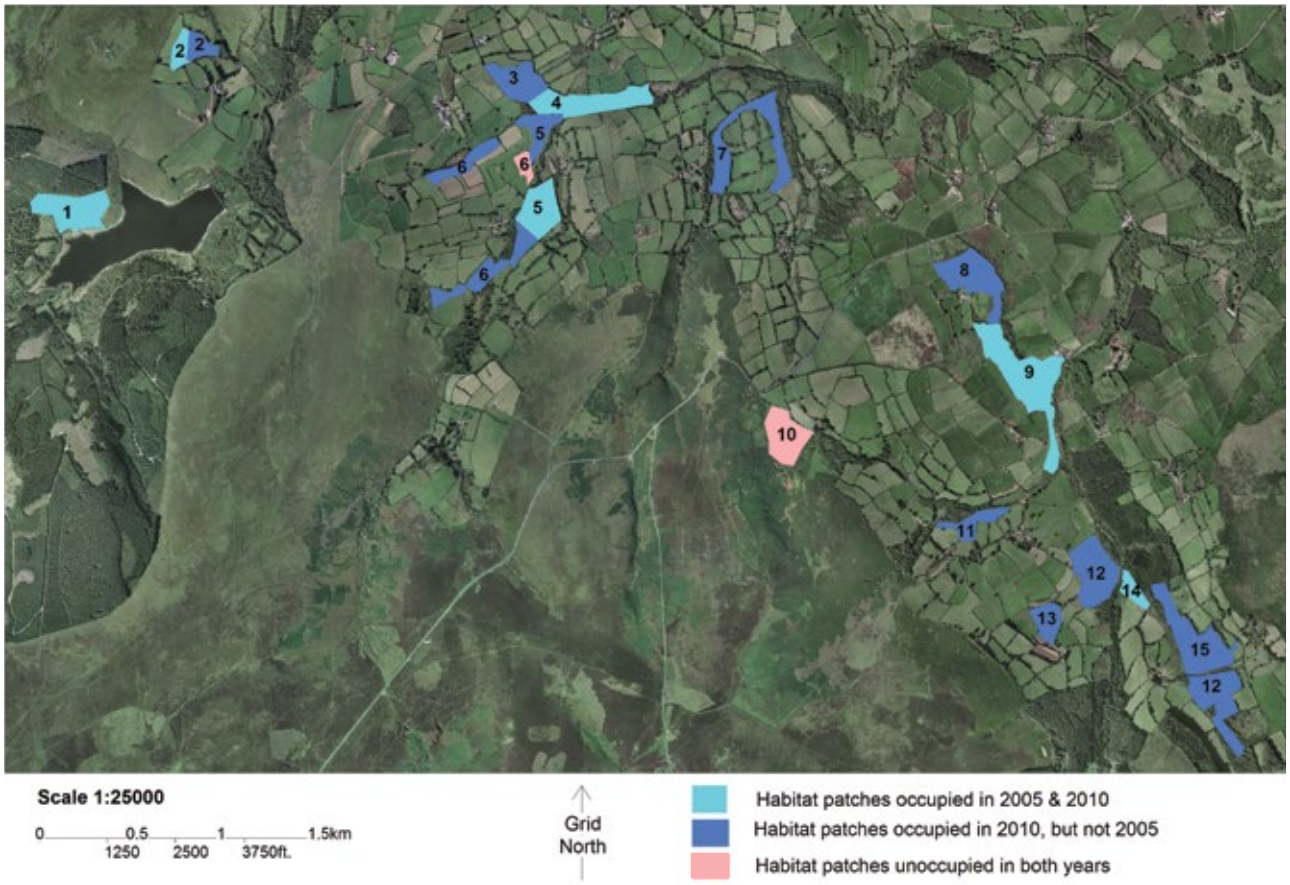


Figure 2 Map showing location of 15 farm holdings and changes in Marsh Fritillary patch occupancy 2005-10 in the Fernworthy-Long Lane habitat network

Species response

Marsh Fritillary populations were monitored at a subset of sites in all the habitat networks and at all sites within the Fernworthy-Long Lane valley during the adult flight period using timed counts and autumn larval web counts. Both sets of raw data were adjusted to give number recorded per person per hour. Within the Fernworthy-Long Lane network the number of occupied habitat patches increased three-fold from six confirmed in 2005 to 18 in 2010. Connectivity has improved with halving of the mean distance from each patch to the nearest occupied patch falling from 542 m to 260 m over the same period. This may be in part due to the increase in recording effort over the project period and newly discovered colonies, with eight habitat patches confirmed as occupied during 2010 monitoring, which were not surveyed in 2005. Overall there was a significant increase of 1,082% ($P<0.01$) in the abundance of larval webs between 2005 and 2010 in the network (Figure 3), with the largest increases in 2009 and 2010, following on from two particularly poor years in 2007 and 2008, when wet and cool weather prevailed during the flight period.

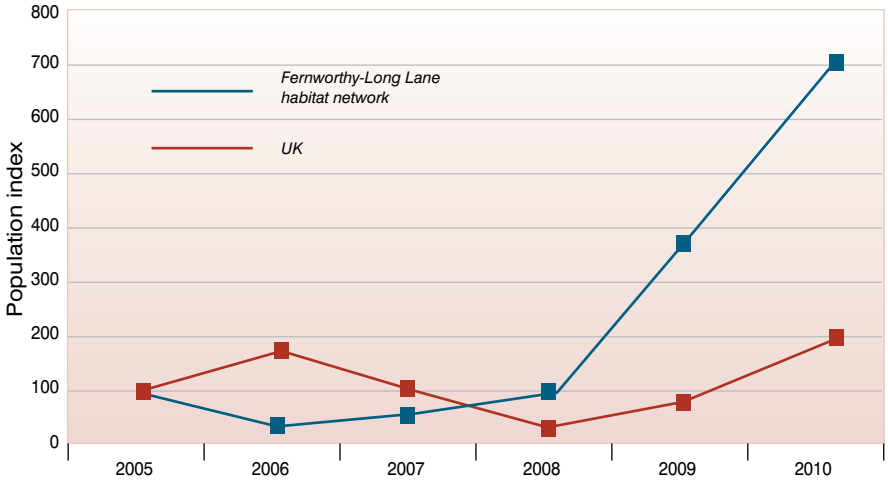


Figure 3 Marsh Fritillary larval web population trends in the Fernworthy-Long Lane habitat network 2005-10. Data analysed by TRIM; UK national trend included for comparison

Building local partnerships

Volunteer effort has been increasingly important in achieving appropriate management in Rhôs pasture habitat, particularly during 2010. Cuts in agri-environment scheme support by Natural England have made it

		Target species	No. sites	Total area (ha)	No. habitat patches advice provided	Area advice provided (ha)	No. habitat patches managed for fritillaries	Area managed for fritillaries (ha)	No. habitat patches where scrub managed	Area of scrub managed (ha)	% habitat network advice provided	% habitat network managed for fritillaries
Exmoor	Heddon Valley	HBF	15	68	15	68	14	66	12	15.1	100	97
Exmoor	Exe Valley	HBF	7	59	7	59	5	57	5	14	100	90
Exmoor	Codsend Moor	MF	3	79	3	79	3	79	0	0	100	100
Dartmoor	Dart Valley	HBF	10	138	9	108	9	108	6	8.2	78	78
Dartmoor	Walkham Valley	HBF	3	181	3	181	3	181	3	4.5	100	100
Dartmoor	Tor Valley	MF	7	58	6	47	6	47	3	2.6	81	81
Dartmoor	Postbridge-West Webburn	MF	20	218	17	183	14	173	6	4.9	84	79
Dartmoor	Fernworthy-Long Lane	MF	20	103	19	101	20	103	14	8.2	98	100
Dartmoor	Tavy Valley	MF	8	68	7	63	4	16.5	3	0.7	92	24
Dartmoor & Exmoor	Other areas	HBF, MF, HF			74	894	19	499.5	11	6.4		56
Total					**160**	**1,783**	**97**	**1,330**	**63**	**72.3**		

Table 1 Summary of advice provision and management achievements across nine Exmoor and Dartmoor habitat networks 2005-11
MF = Marsh Fritillary; HBF = High Brown Fritillary; HF = Heath Fritillary

Jenny Plackett

Volunteers plant out young Devil's-bit Scabious plants to improve breeding habitat quality

more difficult to access funding to pay for important management works, so there has been a heavy reliance on volunteers to carry out practical habitat management. In particular, BTCV volunteers have been invaluable, and volunteers from local community conservation groups (e.g. Chagford Conservation Group, the Wildlife Hit Squad from East Dartmoor Woods and Heaths NNR, South West Lakes Trust, Groundwork and students from Duchy College in Cornwall) have also given considerable help in surveying and practical management. During 2010, for example, volunteers contributed 192 volunteer days on Marsh Fritillary sites. Eight training events and workshops in identification and monitoring were attended by a total of 87 people in 2010.

Key lessons

Agri-environmental schemes are a key mechanism for the delivery of targeted habitat management across whole landscapes. They enable significant levels of financial support to farmers and landowners who are often farming in economically marginal areas. It allows them to go the extra mile that conservation land management often requires to maximise the public benefits that these schemes can offer. However, it is often the case that the full potential of the scheme goes unrealised due to insufficient support to the landowner, both in terms of further advice and delivery of what are often complex solutions to problems that have been developing in these marginal areas for several decades.

Jenny Plackett

Invading scrub and tall hedges have been cut back to improve connectivity between sites

Regular 'care and maintenance' visits have been crucial to the success of the project, and of the Environmental Stewardship Scheme, in achieving biodiversity gain. Most sites require several visits per year, when the habitat is inspected and support and encouragement are offered to maintain appropriate management.

Partnership working with Natural England and the National Park, along with volunteer organisations and contractors, has helped to improve habitat quality and connectivity, and secure the appropriate management of Rhôs pasture in the Fernworthy-Long Lane valley for the benefit of the Marsh Fritillary and other wildlife. Maintaining these partnerships and continuing to work with landowners across Dartmoor over the coming years, offering advice and support, is crucial to ensure that the successes gained so far can be sustained in the long-term.

Managing the habitat for the Marsh Fritillary has helped to maintain and restore habitat on a landscape-scale for other declining Lepidoptera, such as the Narrow-bordered Bee Hawk-moth *Hemaris tityus* and Small Pearl-bordered Fritillary *Boloria selene*, as well as a wide range of other flora and fauna found in wet pastures.

	Holding 1	Holding 2	Holding 3	Holding 4	Holding 5	Holding 6	Holding 7	Holding 8	Holding 9	Holding 10	Holding 11	Holding 12	Holding 12	Holding 13	Holding 14	Holding 15	**Total**
No. of habitat patches	1	2	1	1	2	3	1	1	1	1	1	2		1	1	1	**20**
Habitat management advice given	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	No	Yes	**14 holdings**
Support with entry to agri-environment scheme (HLS)	No agreement	Yes	No (in ESA)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No (in ESA)		No (in ESA)	No (in DNPA agreement)	No (in ESA)	**8 holdings**
Vegetation management																	
Total area of vegetation managed	1.1	0.3	0.5	3	0.35	0.8	1.31	0.1	0.4	0.3	0.21	0.35	0.8	0.1		0.4	**10.02ha**
Scrub control	1.1		0.5	3	0.3	0.4	0.4	0.1	0.4	0.3	0.16	0.35	0.7	0.1		0.4	**8.21ha**
Soft Rush mowing/Bracken control		0.3				0.3	0.66				0.01						**1.27ha**
Woodland felling					0.05	0.1	0.25				0.04		0.1				**0.54ha**
Grazing																	
Fencing/ boundary restoration	633m (350m planned)		450m	510m	226m	1292m	560m				202m		1010m				**4883m**
Total area managed by grazing (ha)	6.6 (1.3 planned)	2.3	4.8	7	3.4	7.6	7.1	7	12	5.3	2.7	7	6	2.6	1.6	8.4	**91.4ha**
Planting/sowing																	
Devil's-bit Scabious (ha)	0.2					0.2											**0.4ha**
Changes in patch occupancy																	
Occupied in 2005 (adults or webs)	Yes	Yes	No	Yes	Yes	NS	No	NS	Yes	NS	NS	NS	NS	NS	Yes	NS	**6 patches**
Occupied in 2010 (adults or webs)	Yes	Yes 2 sites	Yes	Yes	Yes 2 sites	Yes 2 sites	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	**18 patches**
Increase in habitat resource (ha)			4.8			7.6	7.1	7			2.7	7	6	2.6		8.4	**53.2ha**

Table 2 Summary of habitat management and changes in patch occupancy of Marsh Fritillary in the Fernworthy-Long Lane system 2005-10
NS = Not surveyed; DPNA = Dartmoor National Park Authority

Conserving the High Brown Fritillary on the Morecambe Bay Limestones

Sam Ellis, Dave Wainwright and Martin Wain

Mike Hunter

High Brown Fritillary

Introduction

Most of our threatened butterflies have very demanding ecological requirements. For these species, land management operates at a comparatively coarse scale and even with careful targeting the required habitat conditions may only be met within a subset of habitat patches or within a small proportion of a given patch. We describe here the impact of a woodland management programme aimed at reversing the decline of Britain's most threatened butterfly the High Brown Fritillary *Argynnis adippe*, in its national stronghold the Morecambe Bay Limestones.

The High Brown Fritillary is Britain's most threatened butterfly, having undergone recent major declines in both distribution (79% between 1970-82 and 1995-2004) and abundance (85% 1995-2004) (Fox *et al.*, 2006). This decline is ongoing, with distribution losses of 49% and population declines of 69% between 1995-99 and 2005-09 (Fox *et al.,* 2011). Several colonies still occur on Dartmoor and Exmoor and one in the Alun Valley in South Wales, but the Morecambe Bay Limestones and to a lesser extent, the South Cumbria Low Fells to the north, are the UK's national stronghold supporting two-thirds of the remaining populations.

Formerly the butterfly occurred widely in woodland clearings, probably where Bracken *Pteridium aquilinum* was also present, but breeding is now restricted to either 1) Bracken-dominated habitats or grass/Bracken mosaics or 2) limestone rock outcrops, usually where scrub or woodland has recently been cleared or coppiced. Only on the Morecambe Bay Limestones are rock outcrops used, with all other British sites now confined to Bracken habitats. Most Morecambe Bay Limestones sites support a mosaic of habitats, with limestone or acid grassland, pavement, Bracken, scrub and woodland predominant.

Common Dog-violet *Viola riviniana* is the main larval foodplant. The High Brown Fritillary over-winters as eggs, which are laid singly on leaf litter (often dead Bracken), or amongst moss growing on limestone outcrops. The larvae hatch in early spring and spend long periods basking on dead Bracken where there is little grass cover or in short, sparse vegetation. Temperatures in these microhabitats can be 15–20 °C higher than in surrounding grassy vegetation,

Sam Ellis

Sam Ellis

Both coppiced woodland and Bracken mosaics are used by breeding High Brown Fritillaries

allowing the larvae to develop quickly in otherwise cool spring weather.

The High Brown Fritillary has been recorded with a presumed breeding presence (i.e. suitable breeding habitat present) on 65 Morecambe Bay Limestones (and South Cumbria Low Fells) sites. In 2007, when a new site dossier was produced (Ellis and Wainwright, 2008), 50 sites still supported populations in eight separate networks (Figure 1); but the butterfly had become extinct on 15 sites (23% loss).

On the Morecambe Bay Limestones the High Brown Fritillary appears to be threatened more by changes in habitat quality caused by succession rather than direct habitat loss. Many sites are large (median area = 27.7 ha), but suitable breeding habitat within them is probably quite localised. Within networks most sites are either contiguous or close to one another and isolation is unlikely to be a significant factor. Nevertheless extinctions on smaller, more isolated sites suggests a metapopulation structure and therefore loss of connectivity may be important for smaller outlying sites and networks (Ellis and Wainwright, 2008).

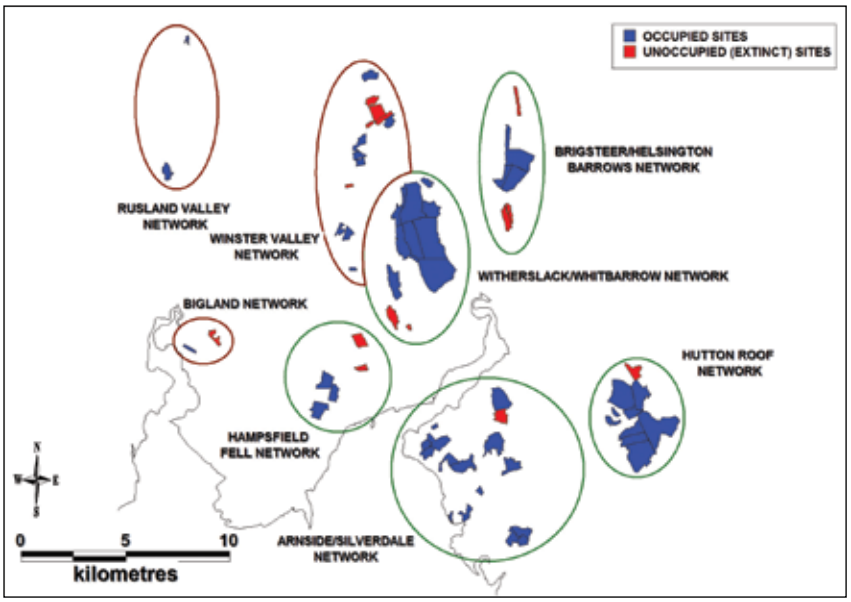


Figure 1 Location and extent of High Brown Fritillary sites in eight networks on the Morecambe Bay Limestones (green ellipses) and South Cumbria Low Fells (brown ellipses) in 2007

Nearly half the sites are owned or leased by conservation organisations and on many the conservation of the High Brown Fritillary is a key objective. Efforts to conserve the butterfly began as long ago as the mid-1980s and have continued to the present day under the auspices of the High Brown Fritillary Action Group which comprises 11 partner organisations. In 2007 nearly 80% of sites were in some form of management which could benefit the butterfly, although its scale on many was unknown (Ellis and Wainwright, 2008).

By 2007 about half the Morecambe Bay Limestones

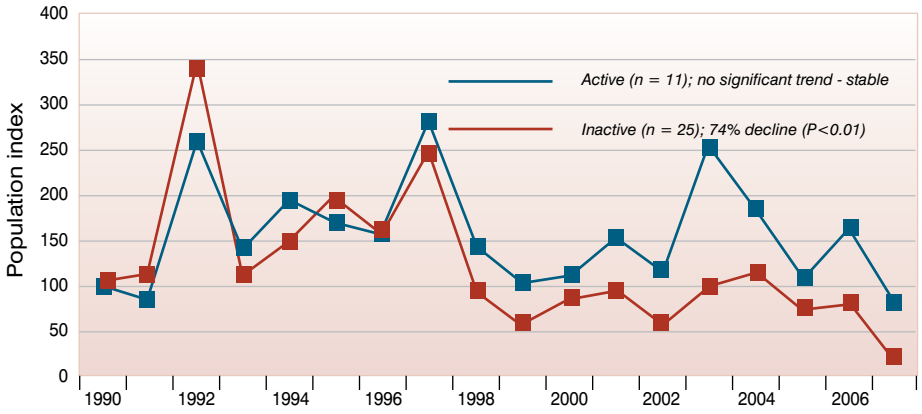


Figure 2 The impact of active woodland management (e.g. coppicing, ride management, scrub cutting over limestone outcrops) on High Brown Fritillary populations in the Morecambe Bay Limestones and South Cumbria Low Fells 1990-2007

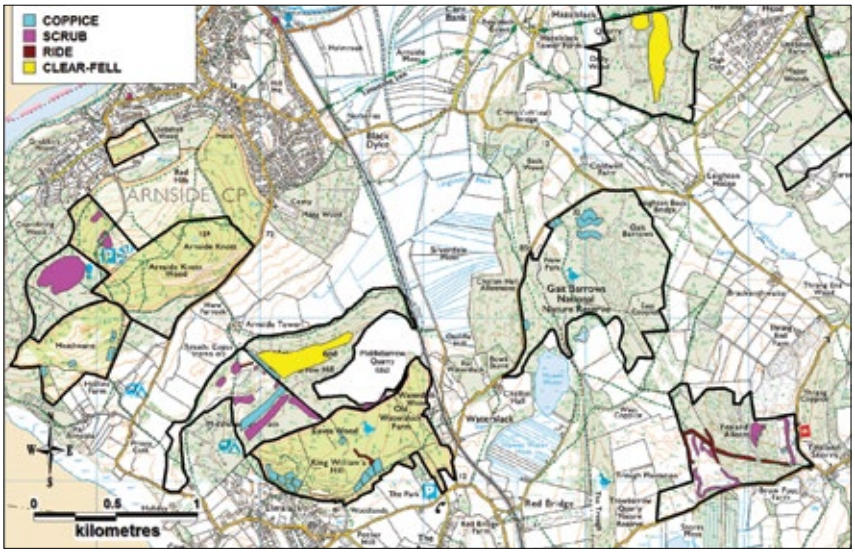


Figure 3 Location of clearings and rides established 2008-11 in the Arnside/Silverdale network. Black lines indicate boundaries of current, former and potential High Brown Fritillary sites

sites were monitored by butterfly transects. Trend analyses showed the High Brown Fritillary had declined in this landscape by 40% since 1990, but site trends were very variable with some declining and others increasing. More detailed analyses of transect population trends showed there were no clear differences between SSSIs and non-SSSIs, between primarily woodland and primarily grassland sites, nor between sites in agri-environment schemes compared with those not in a scheme. However, on sites where some form of active woodland management (e.g. coppicing and ride management in woodland and scrub cutting over limestone outcrops on grassland sites) was regularly undertaken, populations were stable in comparison to a 74% decline on sites with no 'woodland' management (Figure 2). These data suggest that High Brown Fritillary populations on the Morecambe Bay Limestones are most effectively maintained by a regular supply of new clearings, irrespective of the predominant habitat type.

Project methods

In 2008 a four-year programme of coordinated and targeted management commenced to reverse the regional decline, principally funded by GrantScape through the Landfill Communities Fund. Whilst the main focus was the creation of potential breeding habitat through clearings, the project also aimed to improve within site connectivity through ride management to aid dispersal and increase opportunities for natural colonisation of former sites. Project officers liaised with partner organisations, landowners and contractors to ensure management was undertaken at agreed locations and within agreed constraints.

Since the project's inception Forestry Commission England (FCE) agreed to target the landscape with Woodland Improvement Grants (WIGs), part of the English Woodland Grant Scheme (eWGS). Landowners were able to claim grants for coppicing, thinning and ride management and project officers assisted FCE staff to target the most appropriate sites. Over £250k was committed, significantly increasing both the number of sites and management originally envisaged. FCE also undertook clearance of conifers on four sites to restore Ancient Semi-Natural Woodland (i.e. PAWS).

Habitat condition within each of these habitat patches was assessed in May 2011, when suitable fritillary habitat was easily identified. We recorded 12 different features, reflecting both positive and negative condition using standard Butterfly Conservation methodology (Brereton *et al.,* 2005). The response of the High Brown Fritillary to management was assessed through a programme of late June/July timed counts in 112 of the 114 clearings and rides. Other threatened species were also recorded and timed counts undertaken where possible in May to coincide with the flight period of spring Lepidoptera.

Land management results

After the first three years, at least 114 clearings and rides had been managed, potentially restoring 60 ha habitat on 23 sites (Table 1, Figure 3). This is a conservative estimate because not all sites managed through WIGs were accessible to survey. Most management was undertaken in the core Arnside/Silverdale and Witherslack/Whitbarrow networks, with much of the remainder in the Brigsteer/Helsington Barrows network (Table 2). Management was funded more or less equally between GrantScape and WIGs, with FCE responsible for all the conifer clearance undertaken. The total cost of the GrantScape management was £81k. There were significant differences in clearing size but this is largely attributable to the conifer clear-fells, with two exceeding 5 ha. Most other clearings were relatively small, with coppice coupes half the size of scrub clearances. There was also considerable variation in ride length with about a third less than 200 m but a fifth exceeding 600 m.

Ellis and Wainwright (2008) collated woodland management data from nine key sites for the preceding 23 year period (1984-2006), when a total of 46.4 ha of habitat was restored. Whilst no doubt an underestimate for the whole landscape, the average of 3.8 ha per year for the seven year period 2000-06 supports the notion that there is now more woodland management ongoing in the Morecambe Bay Limestones than for many decades. Despite the scale of the current project, management was only implemented on 28% of current or former High Brown Fritillary sites. Approximately 6% of the total area of the project sites has been managed to date, equating to about 7% of the woodland, 5.5% of ancient woodland, 10% of PAWS and 7.5% of the calcareous grassland resource.

Both GrantScape and WIG clearings and rides produced equally good fritillary habitat, on average around 5% cover (Figure 4), despite the fact that the individual features which comprise good habitat quality (violets, exposed rock, Bracken or leaf litter) occurred at much higher frequency or abundance. Some suitable fritillary habitat was produced in 97% of clearings and rides, but at less than 2% cover in a third of these, and exceeding 10% cover in only 5%. We believe the significant differences in violets, Bracken litter, grass cover and scrub/coppice regrowth size (the latter two negative indicators for suitable habitat) reflect the greater number of scrub clearances undertaken through GrantScape. Although the locations of coppice coupes were selected on the advice of project officers, based on the presence of features such as rocks and/or shallow soil, it is less easy to predict the vegetation composition following clearance. On the other hand, violets and Bracken litter are more likely to be still present under scrub patches, key factors in their selection for clearance.

	No. of clearings or rides	Mean area of clearing or ride (ha)	Area (ha) managed under different funding sources					
			GrantScape	WIGs	Forestry Commission England	Natural England	Private Landowner	**Total**
Coppicing	56	0.24	5.50	7.58	0	0.27	0	**13.35**
Scrub management	25	0.58	7.27	7.15	0	0	0	**14.42**
Ride management	25	0.59	8.24	5.92	0	0	0.49	**14.65**
Ride management length (m)	25	402	4,570	4,930	0	0	540	**10,040**
Conifer clear-fell	8	2.20	0	0	17.61	0	0	**17.61**
Total	**114**		**21.01**	**20.65**	**17.61**	**0.27**	**0.49**	**60.03**

Table 1 Management classified by management type and funding source implemented on High Brown Fritillary sites on the Morecambe Bay Limestones 2008-11

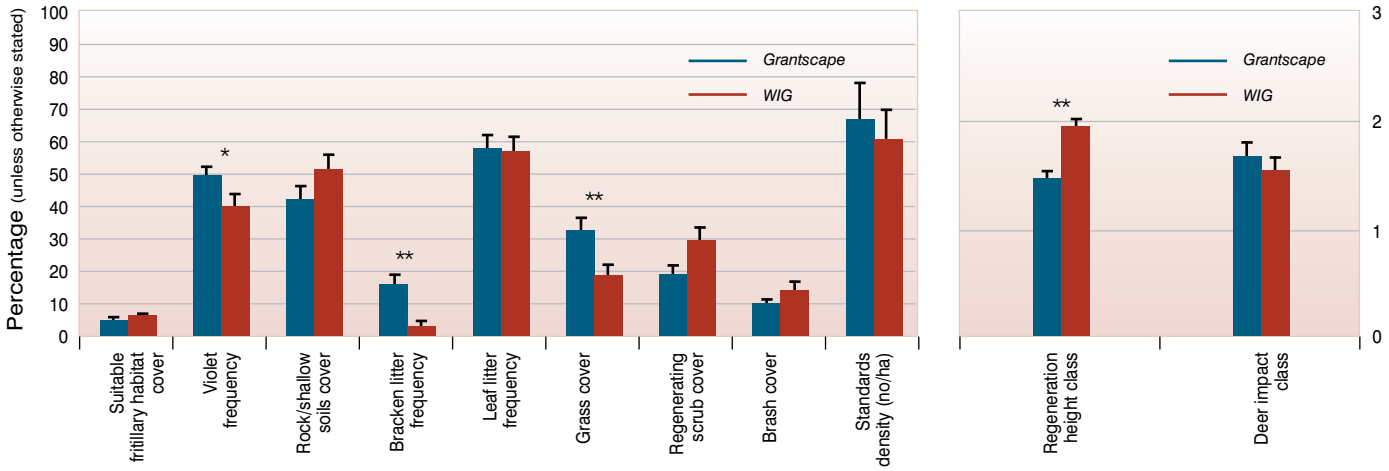


*Figure 4 Mean habitat condition responses under the GrantScape (53 clearings/rides) and WIG (49 clearings/rides) funding programmes in 23 Morecambe Bay Limestones sites in 2011(significant differences indicated by * P <0.05; ** P< 0.01)*

Dave Wainwright

Dave Wainwright

Impact of management on a shady ride at Halecat Woods

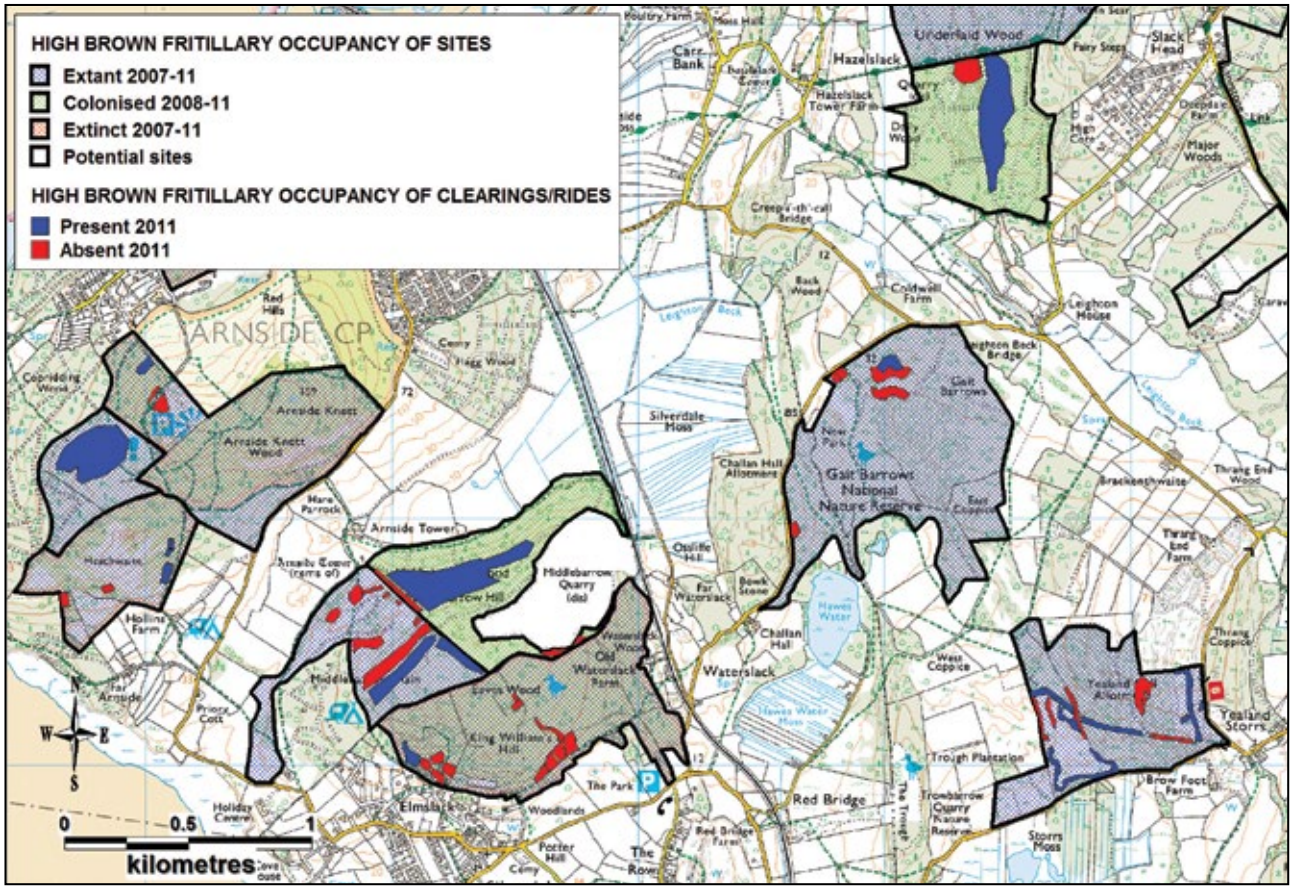
Species response

Prior to the project commencing, the High Brown Fritillary regional population trend had declined by 2007 to its lowest index in 18 years monitoring. Thereafter the population increased each year until 2011, which produced the lowest ever index. Undoubtedly the wet summer of 2011 was a key factor, but it is unclear how much of the previous increase could be attributed to improved management, because only 48% of project sites were monitored by transects. In some cases management was undertaken along transect routes, especially on existing rides, but in other clearings and new rides they had not been previously monitored, demonstrating the need for targeted survey by timed counts in each clearing and ride.

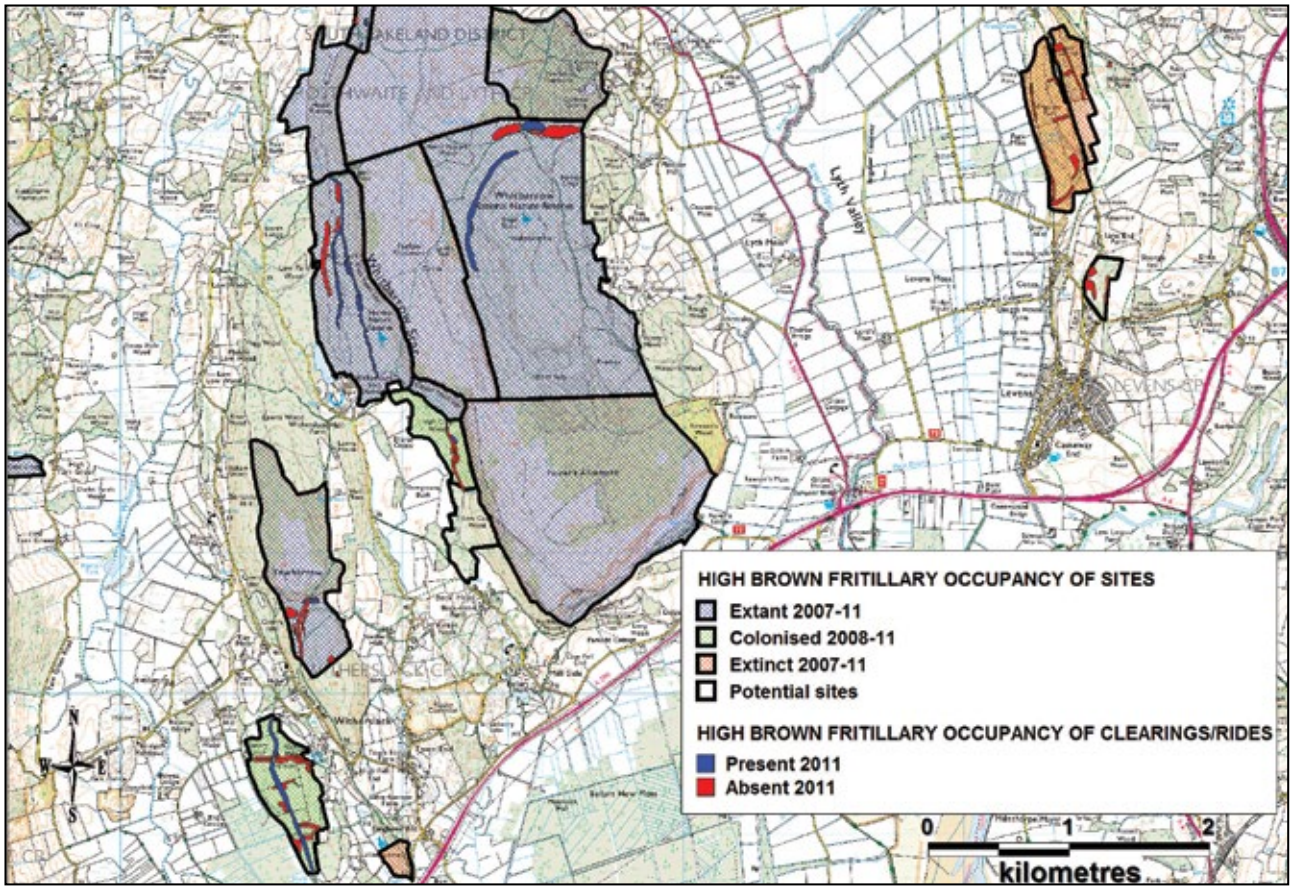
The High Brown Fritillary was recorded from 23% of the monitored clearings and rides (Figure 5, Table 2). However, it is likely this is an underestimate of occupancy for several reasons. Firstly surveys were nearly all undertaken in the wet summer of 2011, when the regional population index was at its lowest. Secondly, the median survey time was only eight minutes and the butterfly may have been present but missed in some clearings and rides. Thirdly, only confirmed identifications were recorded, with unidentified large fritillaries seen in 37% of the unoccupied clearings and rides. Confusion arises only between the High Brown and Dark Green Fritillary *Argynnis aglaja*, but not with the Silver-washed Fritillary *Argynnis paphia*. The ratio of High Brown Fritillary to Dark Green Fritillary was approximately 1: 2.4, suggesting 124 of the 429 unidentified large fritillaries could be the former. It is therefore reasonable to assume the target species was present in some of the apparently unoccupied clearings/rides.

	Network					
	Arnside/ Silverdale	Hutton Roof	Hampsfield Fell	Witherslack/ Whitbarrow	Brigsteer/ Helsington Barrows	**Total**
No. sites managed	9	1	1	7	5	**23**
No. clearings/rides	48	1	4	41	20	**114**
No. occupied sites 2007	7	1	0	5	1	**14**
No. occupied sites 2011	9	1	0	7	1	**18**
Change in occupancy	29%	0%	0%	40%	0%	**29%**
No. extinct sites 2007	1	0	0	1	2	**4**
No. extinct sites 2011	0	0	0	0	2	**2**
No. potential sites 2007	1	0	1	1	2	**5**
No. potential sites 2011	0	0	1	0	2	**3**
No. occupied clearings/rides 2011	16	0	0	10	0	**26**
Proportion occupied 2011	34%	0%	0%	25%	0%	**23%**
No. unoccupied clearings/rides 2011	31	1	4	30	20	**86**
No. unoccupied clearings/rides with unidentified large fritillaries 2011	15	0	2	11	13	**41**

Table 2 Changes in High Brown Fritillary occupancy in response to management in five Morecambe Bay Limestones networks 2008-11



a) Northern end of the Arnside/Silverdale network



b) Southern end of the Witherslack/Whitbarrow network

Figure 5 High Brown Fritillary occupancy in 2011 of clearings and rides established 2008-11 in relation to overall site occupancy in parts of the two main Morecambe Bay Limestones networks

Sarah Bradley

Volunteers managing a ride in Witherslack Woods

Occupied clearings and rides were significantly larger than unoccupied ones (Figure 6). Whilst this partly reflects the butterfly's colonisation of some large clear-fells, these data do emphasize the importance of creating habitat of sufficient size within a site to maximize the chances of colonisation. Unsurprisingly occupied clearings and rides were also characterised by more abundant or frequent fritillary habitat, violets, rock/shallow soils, Bracken litter and by lower standard densities. Brash cover was also significantly greater but this is explained by the occupancy of some clear-fells.

An increase in High Brown Fritillary occupancy of 29% was recorded on project sites (Figure 5, Table 2). Between 2009 and 2011 the butterfly recolonised two former sites, including one where it had not been recorded since 1983, and colonised two with no previous records. Colonisations were confined to the core Arnside/Silverdale and Witherslack/Whitbarrow networks, where most work was undertaken, but also where there is least evidence of fragmentation and isolation. All known sites are now occupied in both networks, bar one small isolated site. However, there were no re/colonisations of the 20 clearings and rides in the Brigsteer/Helsington Barrows network. Former sites here are more isolated than in the two core networks but were still less than 1 km from a potential source population, and large unidentified fritillaries were recorded in 65% of clearings and rides.

The project has been beneficial for a number of other UK BAP Priority Species butterflies and moths utilising similar habitat. Despite less intensive sampling (only 21% of timed counts undertaken during their flight period), the spring-flying Pearl-bordered Fritillary *Boloria euphrosyne* was known to have re/colonised two sites (increasing the regional resource from 14 to 16 sites), the Duke of Burgundy *Hamearis lucina* colonised one new site and the pyralid moth *Anania funebris* re/colonised two sites. The early summer species, Northern Brown Argus *Aricia artaxerxes* and Small Pearl-bordered Fritillary *Boloria selene* were respectively recorded from 24 and 28% of clearings/rides.

Building local partnerships

Promoting a sustainable future is critical to the project's success and central to this is recruitment of new volunteers who can contribute to both practical management (e.g. coppicing, scrub burning) and the survey and monitoring of both butterflies and habitats. During the first three years over 40 work parties were held, working with both existing partner organisations and new ones such as a local Further Education college.

Several local partnerships have been developed including a management group bringing together seven landowners to coordinate management proposed for c.100 ha of land in part of the Arnside/Silverdale network. Close working relationships with several large estates and businesses have been established enabling Butterfly Conservation to work alongside tourism and rural enterprises (e.g. commercial shooting), as well as contributing to the employment of many local contractors.

Key lessons

This project provides evidence of the rapid response of a threatened butterfly to targeted management, with colonisation of new habitat patches within already occupied sites, as well as of nearby former and potential sites. The presence of the butterfly on several rides/linear scrub clearings, and the site re/colonisations suggests the High Brown Fritillary has also utilised improvements in connectivity. However, more isolated sites, do not as yet, seem to have been re/colonised, but this may simply reflect the relatively short timescale and some may well be occupied in the next few years should habitat remain suitable. Occupancy of some of the former/potential sites is particularly important in that once populations become established these may act as stepping stones to the more isolated sites in the future. There are also a large number of potential sites in this landscape many of which are in close proximity to occupied patches and sites and which can now reasonably expect to be colonised once management is implemented.

We believe the patch occupancy rate of 23% reflects the localised nature of suitable habitat (around 5% on average) for this most demanding of species but is very probably an underestimate and further monitoring

is likely to increase this proportion. This occupancy rate demonstrates the value of managing enough clearings and rides across the landscape because some may never produce any habitat of sufficient quality and others only a small proportion. However, less than 6% of the ancient woodland was managed over three years, and only a fraction of the entire landscape resource. Our data show that only a small proportion of the woodland resource is managed during a project and therefore the impact on high forest flora and fauna is likely to be minimal.

Bracken litter was significantly more frequent in occupied than unoccupied clearings. Bracken was present in 75% of occupied scrub managed clearings, but was also present in 53% of the occupied coppice coupes and rides. Asher *et al.* (2001) suggest that the High Brown Fritillary formerly occurred in woodland clearings where Bracken was probably present. The role of Bracken in grass/Bracken mosaics is well understood, but our data suggest it could also be a key habitat component in woodlands too. Presence of nectar plants was not recorded as part of the habitat condition survey but casual observation suggested that they were most abundant in places where the openness of the woodland structure had allowed Bracken to persist and it is possible that availability of nectar encouraged colonisations by the target species.

Butterfly Conservation recommends that for open space butterflies the number of large standards should not exceed 15 per ha (Clarke *et al.,* 2011). Unoccupied clearings and rides had higher (but not significantly) densities of standard trees (c. 65 per ha) than occupied clearings (c. 40 per ha), but as no distinction was made between standard size during the habitat condition survey, these data should be treated with a degree of caution. The High Brown Fritillary is a species which does not tolerate shading of its breeding habitat and therefore clearings and rides with higher numbers of large standards are less likely to be occupied. Clearings and rides of this nature arose during this project either because WIGs funded only thinning or because landowners were reluctant to sacrifice commercially and aesthetically valuable trees. In these instances it is likely that the quality of habitat produced, while perhaps suitable for High Brown Fritillaries, would have been further enhanced had more standard trees been felled. As a general rule however areas with large standards were less likely to be selected in the first place for clearance because of difficulties with timber extraction and disposal of large volumes of branch wood.

Regenerating scrub and coppice and standard density data indicate some clearings are already becoming unsuitable for the butterfly which emphasises the importance of continuity of management. Some may require early intervention where the intention is to establish permanent open space, others allowed to revert to canopy closure before re-coppicing, and in order to maintain connectivity, rides will need to be managed on rotation. Unlike grasslands, where a less intensive management regime (usually grazing) follows restoration, longer-term management of woodlands, whilst less intensive than the restoration phase, will still require a significant and ongoing input.

This project also demonstrates the real value of partnership working. Volunteers from a whole range of organisations have and will continue to play an important role in this landscape, not only in survey and monitoring, but in maintaining woodland open space, especially on smaller or more difficult sites. There is no doubt that without the FCE and the eWGS programme, the impact of this project would have been considerably less. Our data demonstrate that there was very little difference in habitat quality between clearings and rides produced under GrantScape or WIGs, but we believe this is almost certainly the result of the close working relationship developed between our project officers, FCE staff and the woodland landowners and their agents. As eWGS has the potential to enter into longer-term agreements with landowners, we believe its continued availability and targeting at key sites on the Morecambe Bay Limestones is crucial to the long-term future of this butterfly in the UK.

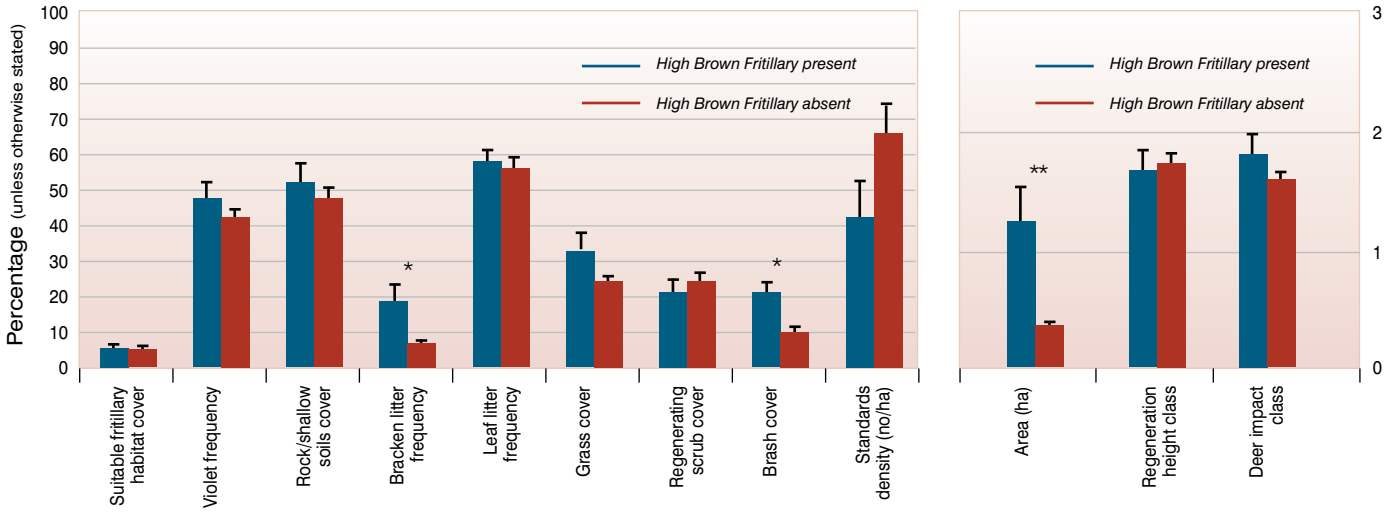


*Figure 6 Differences in mean habitat condition between clearings and rides occupied (n = 26) and unoccupied (n = 86) by the High Brown Fritillary on 23 Morecambe Bay Limestones sites in 2011(significant differences indicated by: * P <0.05; ** P< 0.01)*

Conserving the Marsh Fritillary in Dorset: lessons from over 15 years of landscape-scale conservation

Caroline Bulman, Nigel Bourn, Richard Belding, Ian Middlebrook, Sarah Brook, Bill Shreeves and Martin Warren

Martin Warren

Marsh Fritillary on chalk grassland in Dorset

Introduction

This case study presents one of the few examples of a threatened species responding positively at a landscape-scale to targeted agri-environment schemes. Crucial elements to success have been the targeted advice and support to landowners by Natural England and Butterfly Conservation staff.

In England current strongholds for the Marsh Fritillary are the Culm grasslands of Devon and Cornwall, Rhôs pastures on Dartmoor and the chalk downland of Wiltshire, principally across Salisbury Plain and both chalk and wet grasslands in Dorset.

In Dorset the host plant, Devil's-bit Scabious *Succisa pratensis* grows in two contrasting habitats, damp meadows on heavy soils (mainly in the north and west of the county) and on dry chalk downland (mainly north and central Dorset) (Figure 1). The Marsh Fritillary breeds in both habitats but the occurrence of the species on the chalk downland is probably a more recent event. Historically colonies were generally found in the wet grasslands that give this butterfly its common name. Many of these sites have disappeared through drainage and agricultural improvement. The Marsh Fritillary was able to colonise the downland sites due to a general reduction in grazing pressure, which allowed the host plant to grow in a more favourable sward height range for the species. The first known downland colony was at Hod Hill, which established itself during the early 1900s (Thomas and Webb, 1984) and still supports a large population of the butterfly. The number of downland colonies now outnumbers those on traditional wet grassland sites. Despite the utilisation of downland sites at the turn of the 20th century the abundance and distribution of the species has been in decline in the county due to habitat loss and fragmentation.

To achieve long-term population stability, the butterfly requires an extensive network of well connected habitat patches where Devil's-bit Scabious is abundant. Research has shown that an area of between 80 ha and 142 ha per 1,600 ha (i.e. 5-9% of a landscape) is required to achieve persistence for 100 years, depending on the spatial location of the habitat (Bulman *et al.*, 2007). We describe the results from 25 years of monitoring the coordinated conservation efforts to save this species across the two distinct Dorset landscapes.

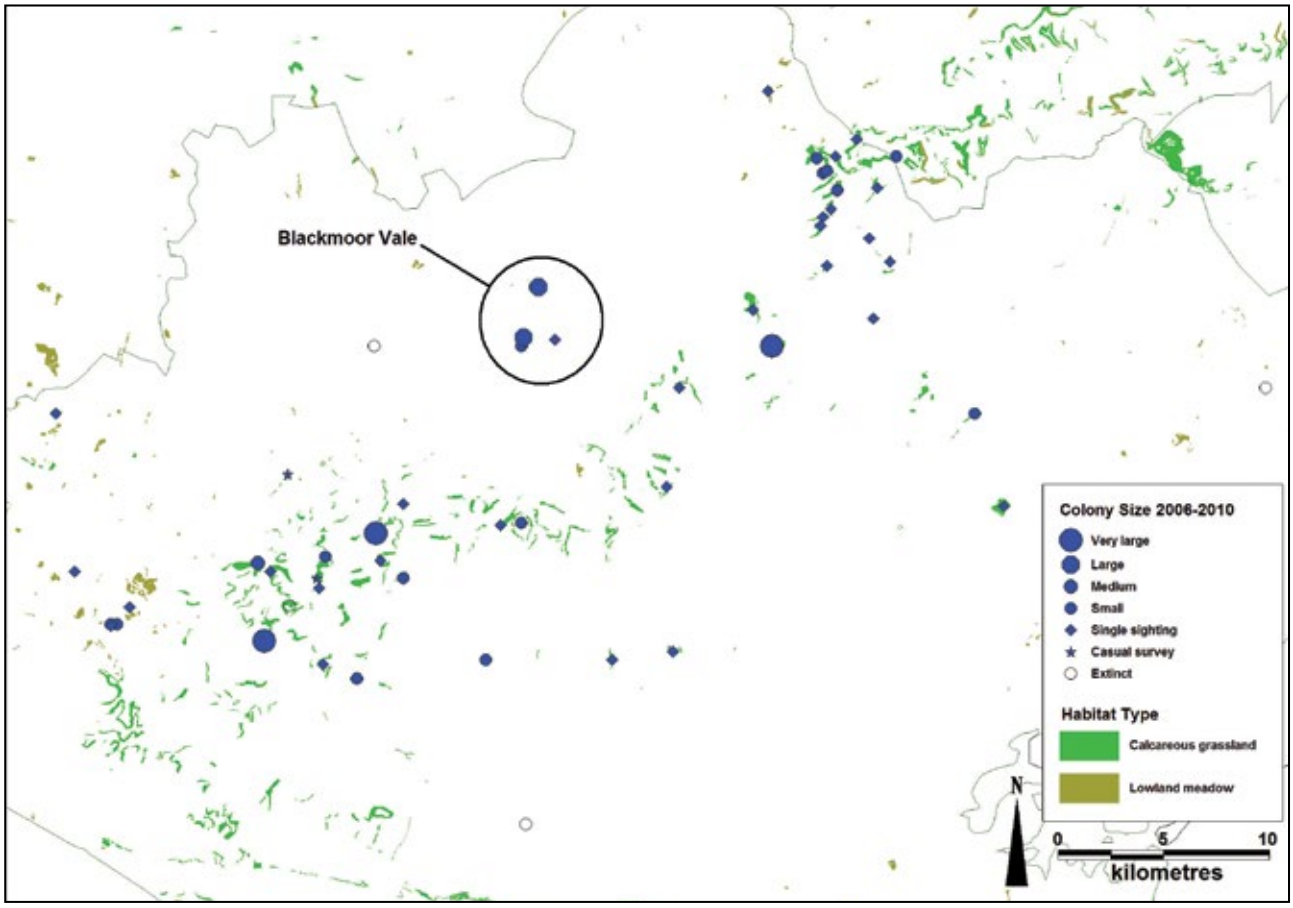


Figure 1 The current distribution and status of Marsh Fritillary in Dorset (2006 to 2010). Wet grassland sites in the Blackmoor Vale are shown, most other sites occur on chalk grassland

Project methods

Butterfly Conservation has worked closely with Natural England (and its predecessors) since the early 1980s, undertaking training and land manager advisory visits to explain the ecology and management requirements of the Marsh Fritillary within its grassland habitats across most of the key landscape areas. Since the early 1990s we worked to help improve the conservation delivery under the South Wessex Downs Environmentally Sensitive Area (ESA), helping to develop a supplementary grazing payment for the lower levels of cattle grazing required by the butterfly.

In Dorset, the status and distribution of the Marsh Fritillary has been monitored and studied in great detail (Figure 1). Monitoring by the transect method has taken place since 1980 by volunteers on 27 sites. At a number of key and potential sites (32 in total since 1983), larval web counts have also been carried out to monitor annual abundance and counts converted to total numbers according to the area of breeding habitat searched (after Thomas and Simcox, 1982). Distributional changes over the

Caroline Bulman

A Marsh Fritillary larval web in late summer

Martin Warren

Chalk grassland in Dorset, showing the variation in sward structure required by the Marsh Fritillary

period were studied using a variety of methods, including targeted surveys by staff and volunteers.
Data on management and agri-environmental scheme status were collected for each site following face to face interviews with a senior Natural England advisor.

Land management results

In 1993 a significant new tool to help the introduction of sympathetic grazing management on many downland sites in Dorset occurred through the creation of the South Wessex Downs Environmentally Sensitive Area. This included a special extensive grazing supplement within the scheme. The supplement was introduced in 1998 following advice from Butterfly Conservation to help conserve the Marsh Fritillary and other invertebrates known to benefit from extensive cattle grazing, rather than sheep grazing. Since the introduction of such agri-environment schemes, we have worked closely with Natural England staff to ensure that the key sites are entered into an agreement which either maintains or restores the grassland into suitable habitat for the Marsh Fritillary. This can be best achieved through extensive summer grazing of sites which produces a varied sward, where abundant Devil's-bit Scabious occurs between 5 and 12 cm on chalk sites with a preference for a longer sward height of between 12 and 25 cm on damp grassland sites (Bulman, 2001). Suitable stocking densities range from 0.2 to 0.3 livestock units per ha per year.

Of 34 sites occupied between 2001 and 2010 (Table 1), 30 were in a current agri-environment scheme (either Wildlife Enhancement Scheme (WES), Countryside Stewardship Scheme (CSS) or Higher Level Environmental Stewardship (HLS)). The supplementary extensive grazing allowance was available on 12 sites and entered into on four of these; grazing reductions were negotiated on a further two without the extra payment being required.

Species response

Throughout Dorset, the Marsh Fritillary has been recorded at 119 sites in 30 years, including single sightings, and from 52 sites between 2000 and 2011. Of the 52 post-2000 sites, the butterfly had not been previously recorded from 25 and new, mostly small, colonies were established at 15 sites. With one exception, most of the colonies were only occupied for a few years. Pre-

Caroline Kelly

Larval web monitoring on a Dorset chalk grassland site

	In agri-environment scheme	Not in agri-environment scheme	Total
Number extant sites 2001-10	30	4	34
Management improved for Marsh Fritillary			
Yes			33
No			1
Marsh Fritillary response			
Positive	20	2	22
Negative	1	0	1
No change	7	2	9
Unknown	2	0	2
Agri-environment scheme influenced management			
Yes			21
No			2
Not applicable			11
Extensive grazing supplement			
Yes			4
No			8
Ineligible or unavailable			22

Table 1 Marsh Fritillary sites in Dorset 2001-10 and responses to agri-environment agreement status

Colony size	1985-1990	1991-1995	1996-2000	2001-2005	2006-2010
Very large	0	0	0	2	3
Large	3	3	3	3	2
Medium	3	2	4	2	1
Small	12	6	8	11	14
Total colonies	**18**	**11**	**15**	**18**	**20**
Single sightings	18	8	15	34	29
Extinct colonies*	15	17	2	3	4

* Refers to number of colonies that became extinct that were extant during previous recording period

Table 2 Number and size of Marsh Fritillary colonies in Dorset 1985-2010

1990 extinctions occurred on 15 sites and post-1990 extinctions on 17 sites, most of which supported small colonies or were only single sightings (1-9 adults).

The patterns of distribution over five date periods indicates that Marsh Fritillary populations have fluctuated in size over time, with some colonies becoming extinct while some new sites have been colonised, particularly in southern and eastern Dorset within the last 10 years. Such fluctuations are characteristic of Marsh Fritillary and clearly demonstrate this species' metapopulation structure (Table 2). Although there were more colonies present in Dorset during the 1980s many of these were small. Many local extinctions occurred during this period when recording effort increased, suggesting a high turnover of small sites or that a number of sites supported transient colonies. Since a low point of 1991-95 and when the ESA was designated, the total number of colonies has risen steadily to the largest number for 30 years, with the proportion of larger and more stable colonies present also increasing. Several colonies persisted throughout the period, highlighting the importance of key sites for the persistence of the Dorset Marsh Fritillary metapopulation.

Annual counts of adult abundance have been monitored regularly throughout the UK as part of the UK Butterfly Monitoring Scheme. Abundance trends from butterfly transects show that Marsh Fritillary populations have fluctuated substantially over the last two decades, with a non-significant increase of 40%. When the trend for Dorset is separated from and compared to the national trend it is

clear that the species is increasing in comparison to the rest of the UK, especially over the last 10 years (Figure 2). The trend for Dorset represents a 278% increase during 20 years in comparison to a 52% decline over the same time period for monitored sites in the rest of the UK ($P<0.001$).

When the two grassland types are compared, Marsh Fritillary abundance on chalk grassland sites increased significantly by 750% ($P<0.01$) over 14 years in comparison to a slight, but non-significant downward trend on damp grassland sites (Figure 3). The timing of this increase in number of colonies and abundance coincided with the introduction of sympathetic grazing management on many downland sites through the ESA. The majority of sites were cattle grazed and Marsh Fritillary habitat was improved on 97% of sites. A positive species response, either a colonisation or an increase in abundance at established sites, was demonstrated on 65% of sites. Most holdings under the ESA have now been transferred to HLS, thus ensuring that appropriate cattle grazing has continued. We know that several appropriately managed new sites on the chalk have been colonised in the last decade (e.g. Butterfly Conservation's reserve at Lankham Bottom and sites within the Sydling Valley) from established neighbouring colonies.

Conversely, the mixed fortunes on damp grassland sites are due

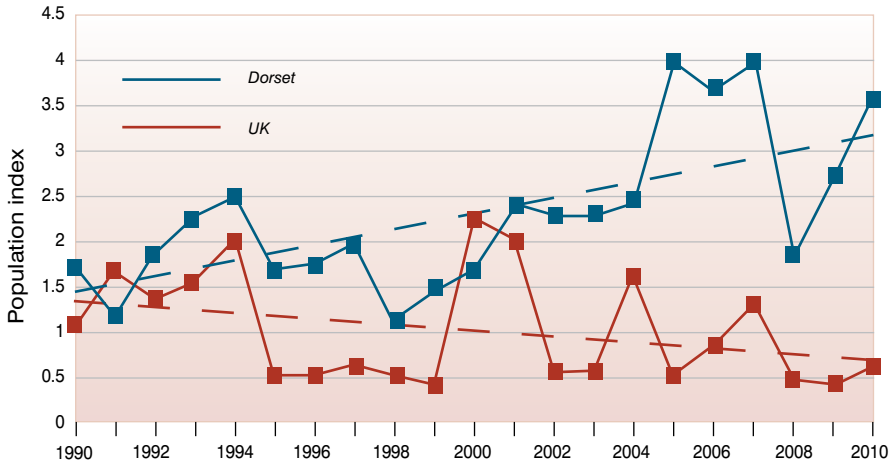


Figure 2 Adult Marsh Fritillary abundance trends on transect monitored sites in Dorset compared to elsewhere in the UK 1990-2010 (dashed lines = linear trends)

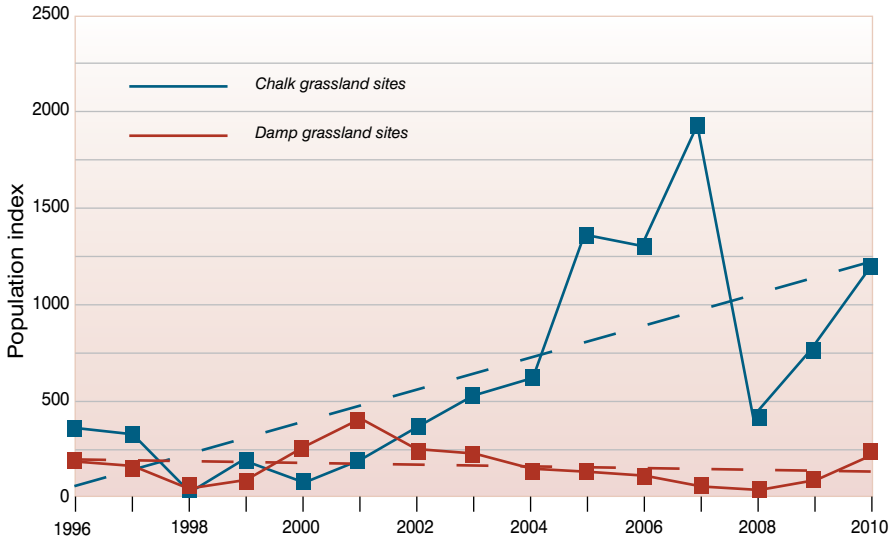


Figure 3 Adult Marsh Fritillary abundance trends on transect monitored sites at Dorset chalk grassland (n = 5) and damp grassland (n = 7) sites 1996-2010 (dashed lines = linear trends)

Sean Cooch

Cattle grazing introduced during 2010 at Lydlinch Common, Dorset, for the first time in 50 years

to difficulties in arranging suitable grazing regimes (e.g. on common land) and few have been entered into schemes. The majority of damp grassland sites have been either unmanaged or managed by periodic cutting, which, though not ideal, has maintained the populations on some sites and controlled scrub encroachment. Fortunately some damp grassland sites are now being grazed for the first time in many years. At Lydlinch Common, following major scrub management, special approval for permanent fencing was granted by the Secretary of State and cattle grazing began in 2010, the first time the majority of the common had been grazed in 50 years. These changes mean that in the last 15 years the importance of the chalk grassland sites to the conservation of Marsh Fritillary has increased hugely.

Management for the maintenance and restoration of sites for the Marsh Fritillary is suitable for a wide range of other threatened species utilising the same habitat. For example, the Narrow-bordered Bee Hawk-moth *Hemaris tityus* co-occurred with Marsh Fritillary on 77% of 23 chalk downland sites (Hedges, 2011). The same study found that management for Lepidoptera also benefited other invertebrates, with species richness of Devil's-bit Scabious feeding Arthropods, including the Jewel Beetle *Trachys troglodytes*, significantly increasing with the size of Marsh Fritillary populations.

Key lessons

The crucial element to the successful conservation of the Marsh Fritillary across Dorset has been the targeted advice and long-term support to landowners by Natural England and Butterfly Conservation staff and an agri-environment scheme that allows sites to be managed appropriately.

The distribution and abundance of the species is well documented in Dorset which allows the targeted management of as much habitat as possible for the species, both within the central chalk downland and within remaining damp grassland. In practice, this means encouraging extensive cattle grazing on sites where the species occurs and on sites with potentially suitable habitat close by for colonisation to occur (potentially up to 1 or 2 km away).

On damp grassland sites in Dorset, greater efforts are needed to introduce extensive cattle grazing regimes in order to stabilise the habitat for the species. Maintaining consistent management is also important as the negative effects of intense grazing pressure on Marsh Fritillary can take place in a very short period, whereas following the positive effects of management intervention, it can take several years for populations to recover to viable levels (Betzholtz *et al.*, 2007).

The highly dynamic nature of Marsh Fritillary populations means that its long-term conservation requires landscape-scale management of the entire network of existing and potential sites. Although crucial to optimise habitat quality on the core sites, small sites in the network may be critical as reservoirs should populations at core sites catastrophically decline, as well as acting as stepping stones that ensure the long-term viability of the network (Bulman, 2001; Bulman *et al.*, 2007; Anthes *et al.*, 2003). Habitat restoration should be targeted in areas with potential habitat close to existing populations and in areas where connectivity between populations could be improved. Our data demonstrate that management aimed at maintaining and restoring sites for the Marsh Fritillary is also suitable for a wide range of other threatened species utilising the same habitat and foodplant.

The impact of management on Pearl-bordered Fritillary populations in the Wyre Forest

Jenny Joy and Sam Ellis

Sam Ellis

Pearl-bordered Fritillary

Introduction

Landscape-scale conservation can only really be delivered in partnership with other organisations, landowners and volunteers. In the Wyre Forest, Butterfly Conservation has worked closely with Forestry Commission England (FCE), Natural England (NE) and others to restore a Pearl-bordered Fritillary *Boloria euphrosyne* metapopulation through a programme of targeted woodland management.

The Pearl-bordered Fritillary is one of the fastest declining butterflies in the UK, having suffered a 61% distribution loss between 1970-82 and 1995-2004 and a 66% decline in abundance between 1977 and 2004 (Fox *et al.*, 2006). These losses are ongoing, with the most recent analysis showing a distribution loss of 43% (the second greatest in the UK) and a 42% decline in abundance between 1995-1999 and 2005-09 (Fox *et al.*, 2011). A third of English colonies became extinct between 1997 and 2004, leaving an estimated 170 populations. Since 1997 the species has become extinct in Dorset, Kent, Somerset, Surrey and reduced to a single site in Gloucestershire.

Conversely, the butterfly continues to do well in parts of the West Midlands region (Joy and Williams, 2008), surviving in scattered colonies in the Oswestry Uplands and responding well to management on a few Herefordshire sites. Undoubtedly the Wyre Forest though, is the regional stronghold as well as being the third of the English strongholds (Dartmoor and the Morecambe Bay Limestones are the other two). The Wyre Forest consists of 2,634 ha of ancient woodland and is one of the most ecologically diverse in England. Over 60% is designated SSSI and nearly 550 ha is a National Nature Reserve (NNR). In 1997, the Pearl-bordered Fritillary was recorded on 41 Wyre Forest sites (Joy, 2002). By 2002, a comprehensive survey recorded the butterfly on 32 sites, but on a number of these, abundance had already declined from 1997 levels with most (76%) only supporting small colonies.

In England the Pearl-bordered Fritillary uses either 1) woodland rides and clearings, such as recently coppiced or clear-felled woodland, and pylon lines or 2) well-drained habitats on lower hill land and commons with mosaics of Bracken *Pteridium aquilinum,* grass, and often patchy scrub. In both habitats it requires abundant violets, usually Common Dog-violet *Viola riviniana*, growing in short, sparse vegetation, where there is abundant dead/brown plant material (e.g. leaf litter or dead Bracken). In the Wyre Forest, the butterfly was thought to occur principally in woodland clearings, conditions being created by either

coppicing or clear-fells, but was also known to occur on some Bracken/grass/scrub mosaics as well as other open space habitat such as deer lawns, disused railway lines, water pipelines and wildlife corridors maintained for their conservation interest.

Project methods

Between 2003 and 2012, Butterfly Conservation worked closely, through a series of funded projects, with partner organisations in the Wyre, coordinating survey and monitoring as well as providing management advice, principally to NE and FCE who manage the main central forest block. A Wyre Forest Lepidoptera Liaison Group was established and has met biannually to share knowledge and coordinate action.

From 2008 to 2012, FCE coordinated the Grow With Wyre Landscape Partnership Scheme, funded by the Heritage Lottery Fund, including the Back to Orange project targeted at conserving the fritillaries of the Wyre Forest. Land management was funded by SITA Trust (£74k) with contributions from the larger scheme (£9k) to develop volunteer and community aspects. From 2008 to 2012, Butterfly Conservation staff were supported through the Midlands Fritillary project funded by Countdown 2010 and the Tubney Charitable Trust. Additional funds were secured to support the production of management plans for specific sites and specialist contractor site surveys. Efforts to conserve the Pearl-bordered Fritillary were focused on maintaining and expanding existing breeding habitat through the forest and by identifying new sites that might offer scope for occupancy. This largely involved providing management advice and occasionally letting habitat management contracts. Identification workshops were also held to support potential survey and monitoring volunteers and winter work parties organized to contribute to the management programme.

Since 2002, the Pearl-bordered Fritillary monitoring programme has comprised butterfly transects on two sites plus timed counts on at least 10 others. Timed counts are particularly suitable in a dynamic landscape where occupancy of a single clearing may only last a few years. Counts were classified as small, medium or large population sizes following Oates (2003): large = peak season counts of 50 or more, medium = 21-49, small = 20 or less. Note a site is defined as a single clearing or ride supporting a local population. These sites can be adjacent, as in the case of coppice coupes or clear-fell areas created at different times, or some distance apart (e.g. wildlife corridors). In 2011 an assessment was made of the coppice and ride-widening programmes being implemented by NE in three areas of the NNR by timed counts in the coppice coupes and counts along individual rides.

Jenny Joy

This coppice coupe on a south-facing slope provides ideal breeding habitat and has been continuously occupied by the Pearl-bordered Fritillary for seven years

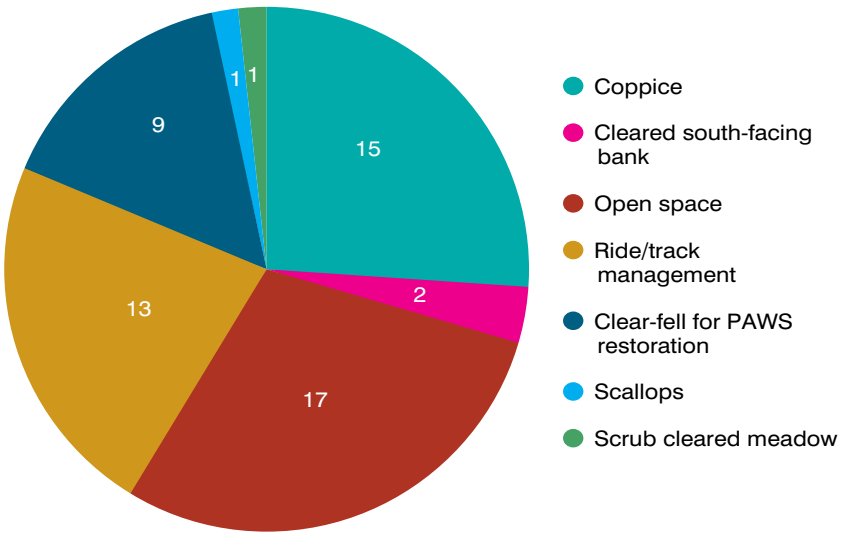


Figure 1 Predominant management type recorded at well known Pearl-bordered Fritillary sites in the Wyre Forest 2002-2011 (n = 58)
PAWS = Plantation on Ancient Woodland Site

Land management

The Pearl-bordered Fritillary has occupied or continued to occupy at least 68 sites in the Wyre Forest from 2002 to 2011. The predominant management type implemented on each of 58 well known sites was identified (Figures 1 and 2). While coppice and clear-fell would be expected to feature highly (41% of occupied sites), the number of sites managed as permanent open space (29%) or maintained by ride/track work (22%) was much higher

Jenny Joy

Jenny Joy

This ride has been widened to improve connectivity. Bracken management and scarification ensures breeding and nectaring habitat is also provided along the open ride

than expected. These data clearly demonstrate that the butterfly can benefit from a variety of management regimes and is being successfully maintained in the long-term through open space management such as random mowing of paths in Bracken, Bracken rolling in July, annual cut and collect programmes (to encourage nectar sources and prevent scrub encroachment), grazing and site enlargement (frequently done as part of ongoing thinning operations so at minimum cost).

A total of 21 sites were directly managed through the Back to Orange project, including opening up south-facing slopes, damp areas and a powerline, improving linkage, scallop creation, successful liming trials, and the fencing of one site to enable grazing. A collector flail was also purchased to help increase the level of ride management and enable arisings to be easily removed. Stump removal was also undertaken on certain sites (e.g. scalloped areas) so they could be more easily managed in the long-term.

In addition to Back to Orange, FCE has continued to widen rides, create scallops and links and to use volunteer work parties to ensure brash is removed from sites that are clear-felled/cut in the most important areas. NE has recently extended their ride-widening programme to two further areas and are managing coppice rotations in three different areas of the forest. They also cattle graze most of the flower-rich meadows along the main river corridor.

Species response

Overall the population index for the Wyre Forest between 2002 and 2011 increased by 113% in comparison to a non-significant trend across the whole UK during the same period (Figure 3). 2010 and 2011 were exceptional years for the Pearl-

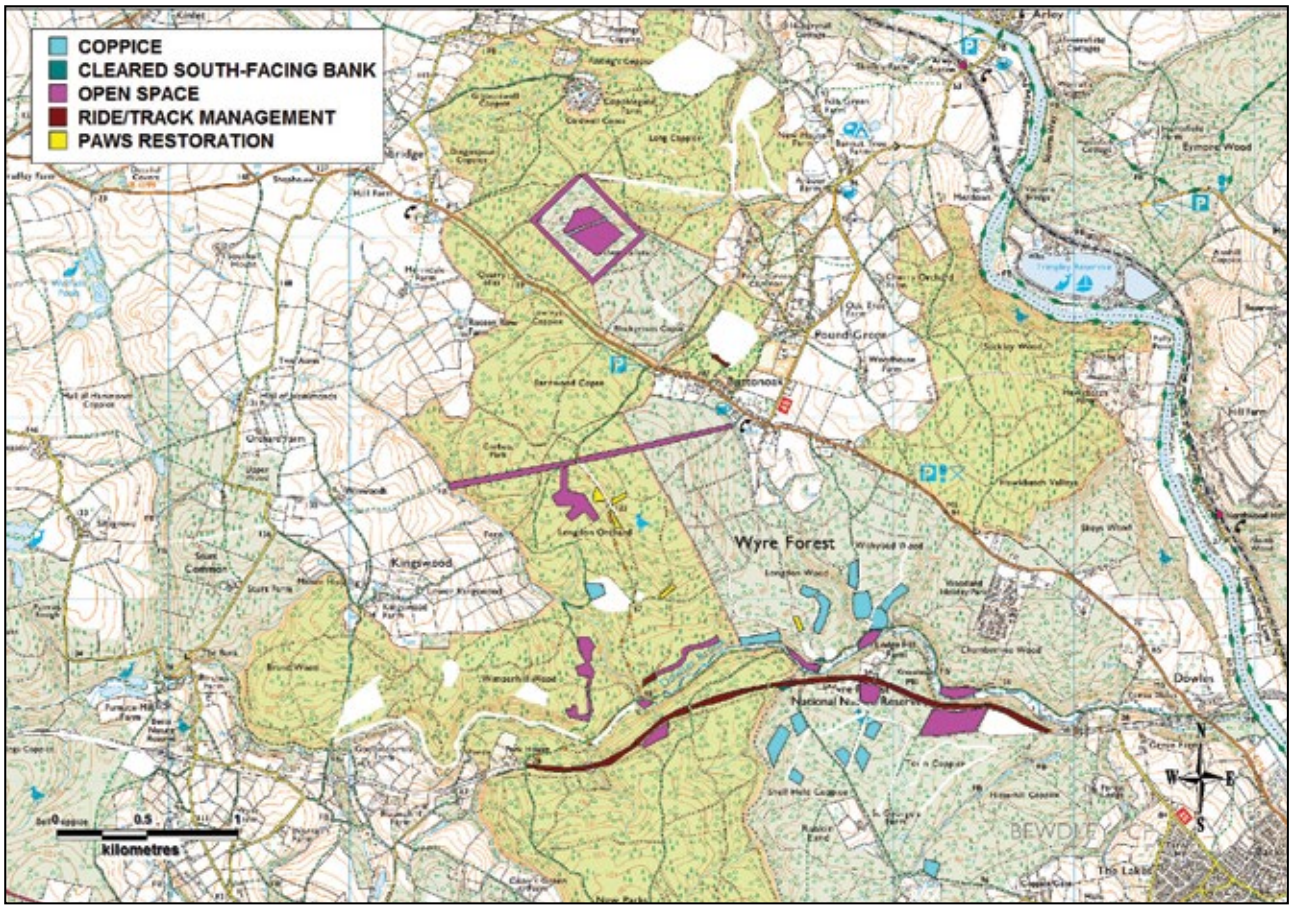


Figure 2 Predominant management type recorded at timed count monitored Pearl-bordered Fritillary sites in the Wyre Forest 2002-2011 (n = 41)

bordered Fritillary in the Wyre Forest with 2011 recording the highest numbers over the entire recording period. In 2011, 11 large, three medium and 16 small colonies were identified by timed counts (Table 1). These exceptional years follow on from generally poor results in 2008 and 2009, themselves probably a consequence of the prolonged poor summer of 2007. These data illustrate just how quickly populations can respond under ideal weather conditions once the required habitat is present. Timed count population increases data were mirrored on transects, with annual indices from both the Wyre Forest East and Wyre Forest West routes increasing both in 2010 (to 43 and 28 respectively) and in 2011 (to 186 and 318).

The size of many sites monitored by timed counts tends to be small with 15% being <0.25 ha in size and only 39% being >1 ha. Nevertheless, small sites can support high population densities if the habitat conditions are optimal (e.g. 159 adults recorded on a 0.27 ha site in 2011). Good numbers can also be maintained on small sites for some years (e.g. one site has only increased in size from 0.5 to 0.75 ha over the past 10 years but has regularly recorded more than 10 adults).

There is no doubt that the targeted Back to Orange management was extremely successful in its main aim of helping conserve the Wyre Forest fritillaries. The Pearl-bordered Fritillary occupied 13 of 21 new sites established through the project (62% occupancy) and there were large increases in numbers on at least five other existing sites. The Wood White *Leptidea sinapis* butterfly is now much more

Jenny Joy

Jenny Joy

Forestry Commission England and Butterfly Conservation volunteers open up a clearing where 157 Pearl-bordered Fritillaries were subsequently recorded

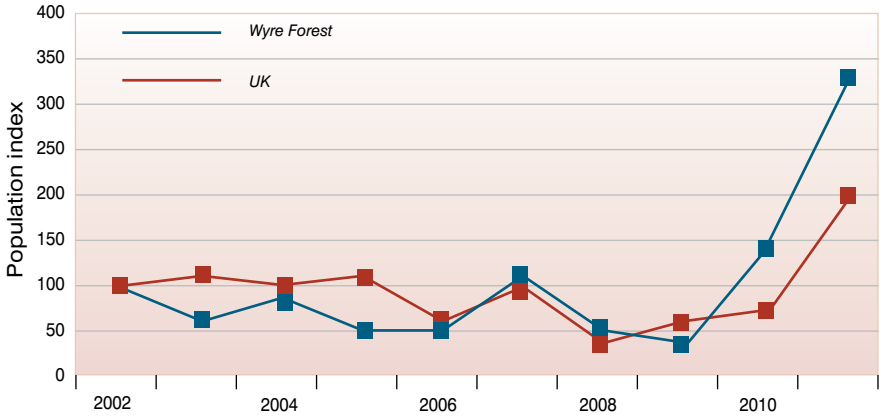


Figure 3 Pearl-bordered Fritillary population trend in the Wyre Forest landscape 2002-11. Data analysed by TRIM; UK national trend included for comparison

Year	Total no. occupied sites	No. small colonies	No. medium colonies	No. large colonies	Total area occupied (ha)
2002	15	11	4	0	27.07
2003	14	13	1	0	27.12
2004	14	11	3	0	25.86
2005	18	17	1	0	31.65
2006	13	11	2	0	22.82
2007	16	10	6	0	27.79
2008	18	15	3	0	34.73
2009	13	11	2	0	39.66
2010	23	16	4	3	46.25
2011	30	16	3	11	52.11

Table 1 Population size of Pearl-bordered Fritillary colonies on sites in the Wyre Forest monitored by timed counts from 2002-2011 where L = large (peak season counts of 50 or more), M = medium (21-49), and S = small (20 or less)

secure in the forest with numbers significantly higher on its main remaining site and one new site now possibly established after dispersal in 2010. Grizzled Skipper *Pyrgus malvae* numbers are finally starting to increase from an all time low in 2009, and other butterflies and moths such as Silver-washed Fritillary *Argynnis paphia* and Drab Looper *Minoa murinata* have moved into the more open areas. Corridors created have already been effective both in terms of encouraging colonisation of new sites and in terms of improved habitat condition.

During the 2011 NNR survey, Pearl-bordered Fritillaries were seen along most of the rides (total of 179 seen) and the butterfly was present on 11 out of 14 coppice coupes (79% occupancy).

More than three-quarters of colonisations occurred between 2009 and 2011 (Figure 4 and 5) coinciding with the Back to Orange project. Assessments of the distance between the 41 sites occupied since 2002 and the nearest extant colony (Figure 6) revealed that over half the colonisations (66%) were adjacent to or within 0.25 km of an existing population. This demonstrates the importance of targeted woodland management close to occupied sites to maximize colonisation events for this largely sedentary butterfly. Three longer distance colonisation events occurred (> 0.5 km), suggesting that under suitable conditions, the butterfly is able to capitalise on a network of well connected habitat patches.

Building local partnerships

As a result of running butterfly identification courses in the forest for two years, a Wyre Forest Butterfly Recorders Group was established in 2010. Between 2009 and 2010, the number of people involved in the survey and monitoring programme quadrupled. This increased survey effort has enabled colony size estimates to be made for a larger range of sites in 2011. Butterfly Conservation now leads at least four volunteer work parties in the Forest annually with many others being led by FCE or NE. Butterfly Conservation's West Midlands Branch volunteers take a leading role in many of these activities.

Key lessons

The Wyre Forest currently supports a thriving Pearl-bordered Fritillary metapopulation which has occupied or continued to occupy at least 68 sites since 2002. The butterfly has benefited from a variety of targeted management regimes with open space and ride/track management being just as important as coppice and clear-fell. The amount of occupied habitat has nearly doubled over the past 10 years with the targeted management near existing occupied sites within the main forest block being a key factor in the level of success.

Close partnership working over at least the last decade has also been instrumental in the successful conservation of the Pearl-bordered Fritillary and other butterflies and moths in the Wyre Forest. This has resulted in regional FCE and NE fully supporting subsequent project work and taking the lead in identifying

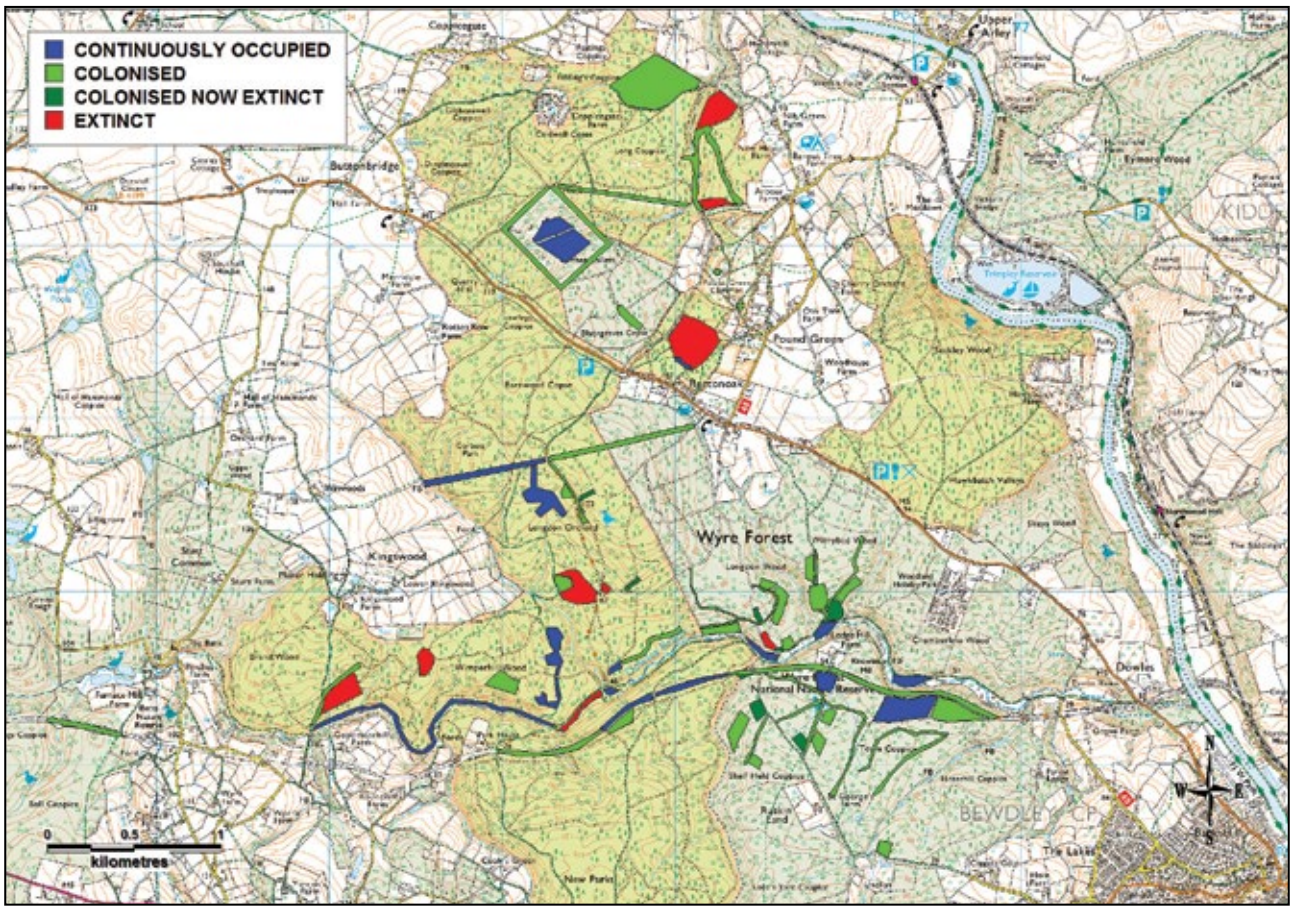


Figure 4 Change in status of Pearl-bordered Fritillary at sites in the main Wyre Forest block 2002-2011 (n = 68)

further opportunities to extend breeding habitat.

There is no doubt that the emphasis on volunteer development through the Grow with Wyre and the Midlands Fritillary projects and the consequent increase in volunteers, has been hugely successful in terms of increasing our knowledge of the current status of the rarer Wyre Forest Lepidoptera. Additional volunteers have also enabled Butterfly Conservation to support more management through a combination of volunteer work parties and closer liaison with key partners.

Providing more long-term sustainable coppice, involving local coppice workers and further improvements to connectivity will be the focus of the Re-connecting the Wyre project, a follow-up to Back to Orange commencing in 2012. This new project will also focus on volunteer development to ensure survey and monitoring is sustained, as this is the key to assessing the success of the woodland management programme.

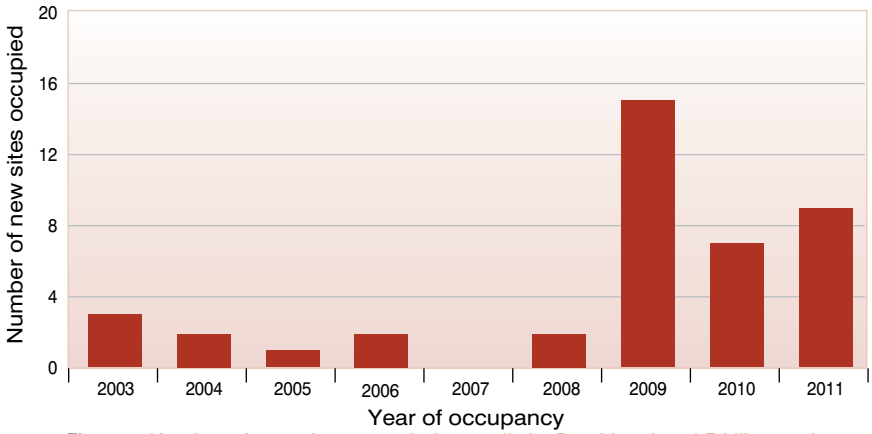


Figure 5 Number of new sites occupied annually by Pearl-bordered Fritillary at the Wyre Forest 2003-2011 (n = 41)

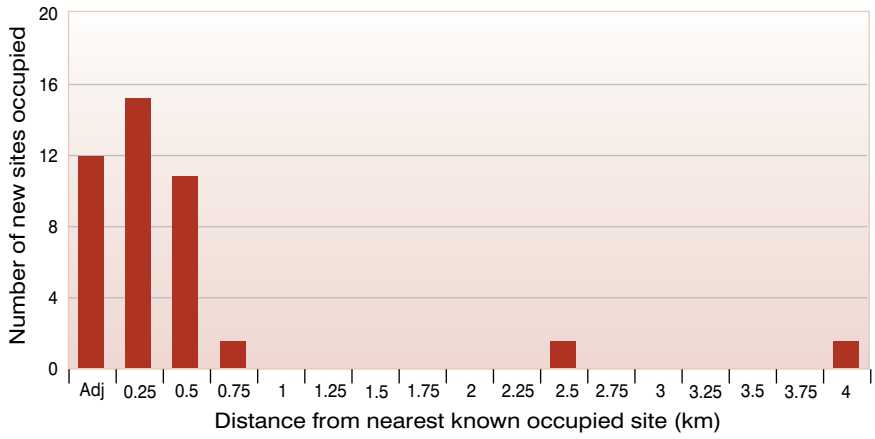


Figure 6 Proximity of new Pearl-bordered Fritillary sites to nearest occupied site in the Wyre Forest 2003-2011 (n = 41)

Specialist moths in Breckland: creating bare ground habitat on a landscape-scale

Sharon Hearle and Sam Ellis

Sharon Hearle

Grey Carpet

Introduction

Ground disturbance is a key tool for creating early successional habitat. In the Brecklands of eastern England we demonstrate how a range of ground disturbance techniques have been utilised to create suitable habitat for a suite of threatened moths across the landscape.

Breckland is a unique area of open heathland, forestry and agricultural land that straddles the western borders of Suffolk and Norfolk. A Breck was a temporary field cultivated for a few years and then abandoned to enable fertility to recover. The mosaic nature of the resulting grass-heath vegetation is a consequence of local variation in soil conditions and land management history. The presence of bare ground and early successional habitats is an important feature of Breck heathlands and dry grasslands and provides habitat for many scarce insects and plants. In recent years management by sheep grazing and mowing combined with some very wet summers has contributed to a decline in bare and disturbed ground on Breckland grass-heath sites and forest rides.

The Grey Carpet *Lithostege griseata* and the micro-moth Basil Thyme Case-bearer *Coleophora tricolor* are confined as breeding species in the British Isles to Breckland. The Brecks are also an important landscape for several other Lepidoptera species, including a number of nationally rare species of moth, such as Lunar Yellow Underwing *Noctua orbona*, Forester *Adscita statices*, Tawny Wave *Scopula rubiginata* and Marbled Clover *Heliothis viriplaca*.

For all these species disturbed ground is known to be an important factor in their occurrence. The Grey Carpet is associated with disturbed ground and early successional stages; Breckland is also the main centre of distribution of Flixweed *Descurainia sophia*, the larval foodplant. The larvae of Basil Thyme Case-bearer feed on Basil Thyme *Clinopodium acinos* by sealing the flowerhead with silk forming a protective case before moving on to grasses on which they overwinter and feed on in the spring. Basil Thyme grows in open, regularly disturbed calcareous grass heaths. The Brecks is one of three UK strongholds for the Lunar Yellow Underwing; the larvae feed on a variety of grasses on dry open heaths where tufts of grass grow with bare soil. The Brecks is also a stronghold for the Forester moth; the larvae feed on Sheep's Sorrel *Rumex acetosella* and Common Sorrel *Rumex acetosa*. The

Tawny Wave frequents rides and is largely confined to the Brecks and the Marbled Clover is often seen at flowers by day and frequents the tall ruderal vegetation that emerges after bare ground cultivation on some site.

Project methods

In 2008-09 Butterfly Conservation created 59 bare ground plots using five different treatments across 15 sites in Suffolk and Norfolk, with the objective of creating bare ground suitable for the target moth species across the landscape (Figure 1). The project was funded largely by SITA Trust through the Landfill Communities Fund. The total cost of bare ground creation by contractors was £15k.

At all sites the existing vegetation was a tall grass sward with no evidence of recent disturbance. Most of the plots were 150 m long and 3 m wide although some were much larger. 46 plots were created between November 2008 and March 2009 and a further 13 plots were created in November/December 2009.

As creation of bare ground is a relatively rare, untested technique, a great deal of liaison was needed to identify locations for the various treatments. It was necessary to check that work would not impede public access, damage archaeology, destroy known wildlife interest or impact on other research. On Forestry Commission England (FCE) land this project is part of larger partnership with Plantlife and the University of East Anglia, enabling a longer-term study of their impact on other invertebrate groups (e.g. spiders) and plants.

Sharon Hearle

Rotovation of a ground disturbance plot at Maidscross Hill

Sharon Hearle

Turf stripping at Cavenham Heath NNR

The five treatment types were:

Rotovating: Standard agricultural equipment was used to create 29 plots at 13 different sites. Rotovation is rapid and straightforward; rotovator depth can be adjusted and the number of passes varied to break up the grass turf and create a fine tilth. All existing vegetation is removed and the grass sward completely broken up.

Forest ploughing: The same equipment is used to create the conditions for planting forest crops and is therefore readily available on FCE managed sites. Two plough ridges are created either side of an undisturbed central sward. The objective of the ridge and furrow is to create a variable microtopography for invertebrates. This treatment was used to create 9 plots at 5 different sites.

Agricultural ploughing: Standard agricultural equipment was used to create 6 plots at 2 different sites. The objective of the ridge and furrow is to create a variable microtopography for invertebrates.

Disc harrowing: Standard agricultural equipment was used to create 4 plots at 3 different sites. The disc harrow cuts through the existing vegetation creating bare ground but without completely destroying the sward. This treatment has been successfully used before to create ideal conditions for Basil Thyme and consequently Basil Thyme Case-bearer.

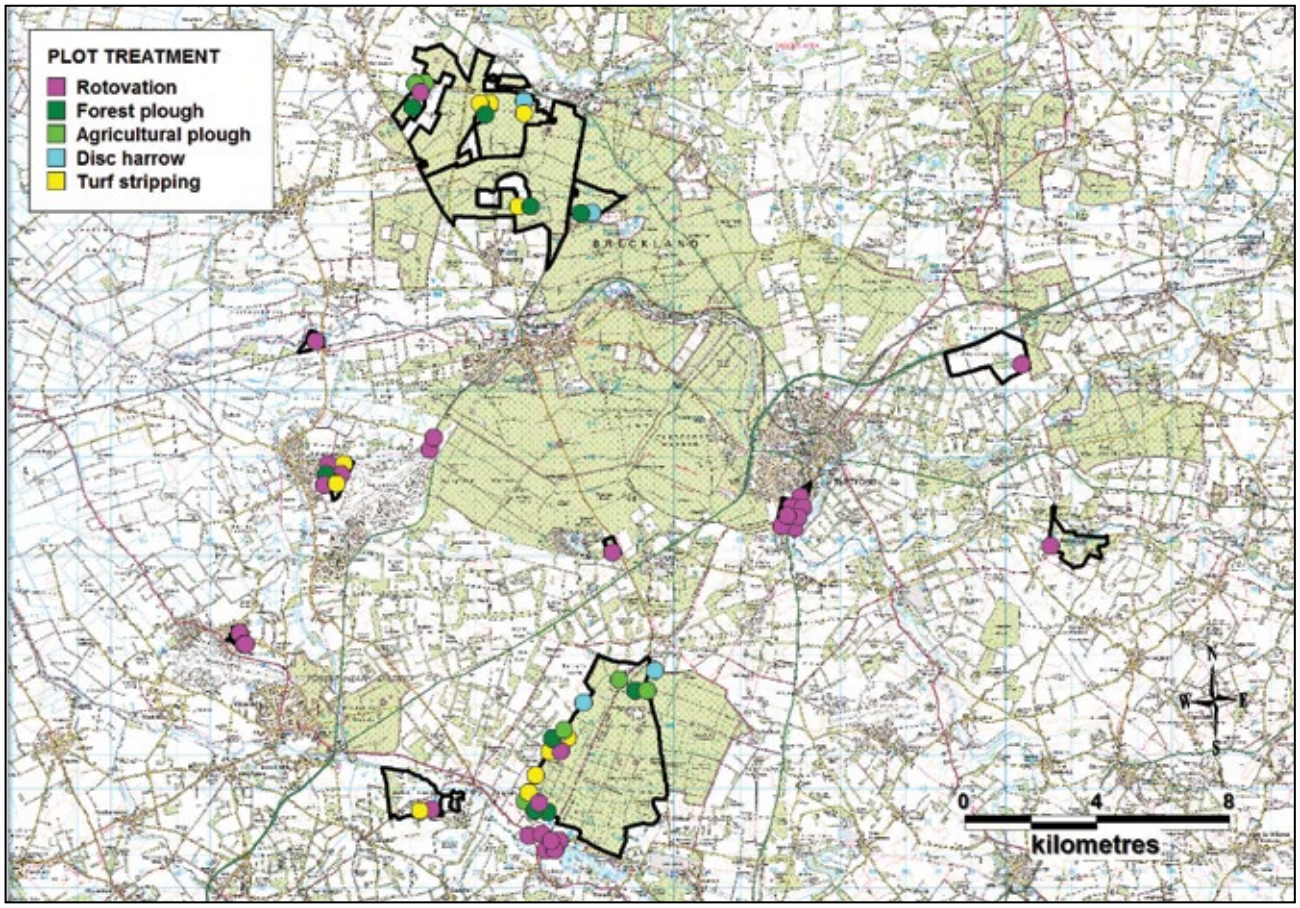


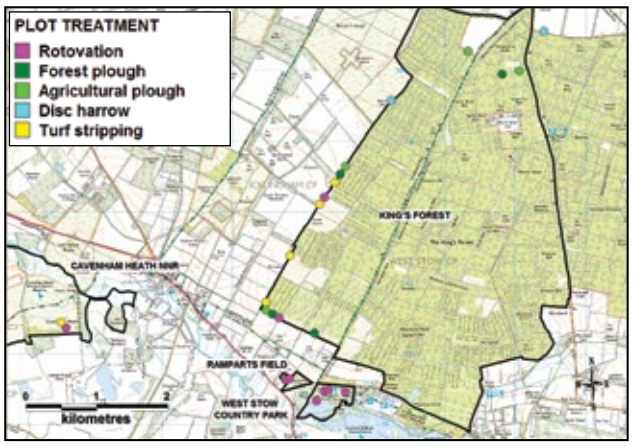
Figure 1 Location of 59 bare ground plots established on 15 sites across the Brecks landscape during 2008-09

Sharon Hearle

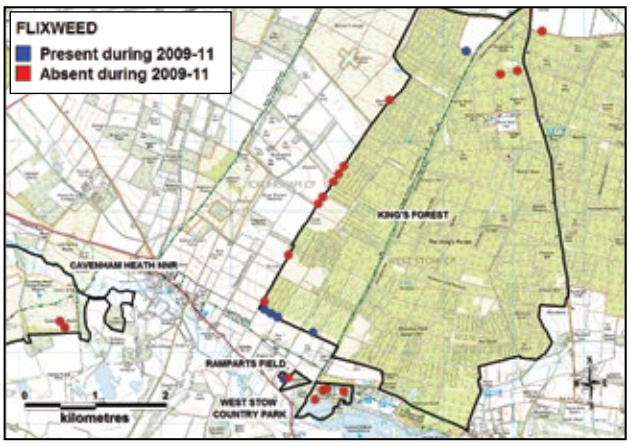
King's Forest rotovated plot with abundant Flixweed

Turf stripping: A bulldozer was used to scrape turf and top soil into a bank along the boundary of the strip to create 11 plots at 4 different sites. This was the most expensive treatment because of haulage costs to the different sites. At Cavenham Heath NNR further expense was incurred where the arisings had to be moved further afield to avoid obscuring World War 2 archaeology.

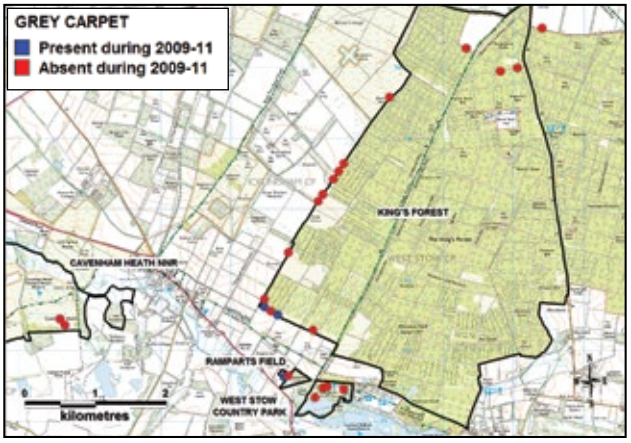
Figure 2 illustrates the location and management treatment of the 24 most southerly plots across four sites in the Brecks. All the plots were visited at least twice in 2009 and 2010 with visits between April and June and again between July and September, to survey four of the target moths and two of the larval foodplants. About half the plots were also surveyed again in 2011. Plots were walked during the day in fine, dry weather to record day-flying moths such as the Grey Carpet and Forester that can be easily disturbed during the day by walking through the vegetation. Grey Carpet larvae can also be readily found during the day on Flixweed. The presence of Lunar Yellow Underwing was confirmed by night-time torchlight searches for larvae feeding on grass between November and March. Basil Thyme Case-bearer monitoring required collection and storage of Basil Thyme seed-heads before the larvae emerge.



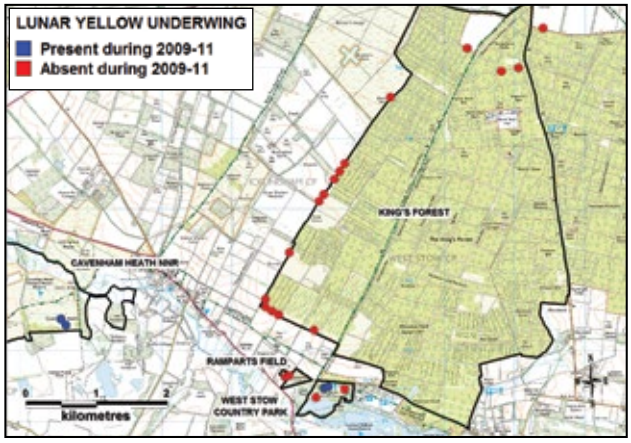
a) Plot treatments



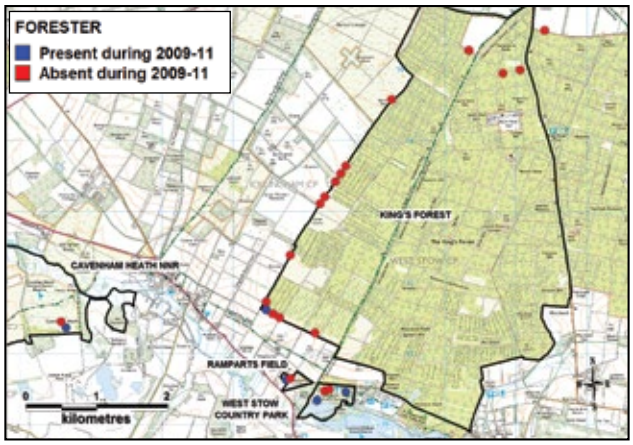
b) Flixweed (Grey Carpet larval foodplant)



c) Grey Carpet



d) Lunar Yellow Underwing



e) Forester

Figure 2 Location of 24 of the bare ground plots established in the southern half of the Brecks landscape during 2008-09 together with responses of target moths and their larval foodplants in the period 2009-11

Flixweed (Figure 2b) and subsequently Grey Carpet (Figure 2c) appeared on plots close to arable margins along the southern edge of King's Forest. In contrast Lunar Yellow Underwing larvae were recorded on new grass tufts surrounded by bare soil on plots on long established heathlands at Cavenham Heath NNR and West Stow Country Park (Figure 2d). The Forester was attracted to abundant nectar sources, such as Viper's-bugloss, which appeared on some plots (Figure 2e).

Since not all plots were surveyed in 2011, the results presented here may well underestimate both the occurrence of the target habitats and the occupancy of the target moth species.

Land management results

Tables 1 and 2 summarise the results of plot surveys undertaken in 2009, 2010 and 2011 and respectively show the proportion of plots which produced suitable habitat features for the target moths and the proportion actually occupied by those species. Successional changes were observed on the plots with plant cover gradually increasing, but also changes in plant composition occurred, producing potential habitat for the target moth species at different stages. An abundance of nectar from a variety of ruderals was present throughout spring and summer, a major factor in attracting moths such as Forester and Grey Carpet during the day and many butterflies and other nectaring insects.

Species response

1. Grey Carpet: Flixweed, an arable weed and the foodplant for Grey Carpet appeared on 34% of plots and was the dominant species on some (Figure 2b). Grey Carpet (adults or larvae) were found on 13% of plots (Figure 2c) including one with only two plants present. Bare ground plot treatments produced only temporary

Sharon Hearle

Sharon Hearle

Cranwich Heath plot with abundant nectar from Viper's-bugloss utilised by the Forester moth

habitat and Flixweed did not appear on the same plots in 2010 and 2011, so further annual disturbance would be needed to ensure habitat continuity. Plots created directly next to arable margins, particularly those with a cultivated margin next to the arable crop, were especially successful in Flixweed colonisation such as those along the southern edge of King's Forest (Figure 2b). Flixweed grows in abundance in cultivated arable margins and amongst crops especially root crops such as Sugar Beet. Plots along forest rides which had been formerly cultivated fields also tended to support Flixweed. At Cavenham Heath NNR Flixweed did not appear on either rotovated or turf stripped plots even though it was frequent in the margin of the nearby arable field, probably due to the fact that this site has not been cultivated before.

Dave Green

Lunar Yellow Underwing

2. Basil Thyme Case-bearer: Basil Thyme, the foodplant for Basil Thyme Case-bearer appeared on one plot but only as occasional plants until 2011, when over a dozen appeared.

3. Lunar Yellow Underwing: Many of the plots provided suitable grass tufts for Lunar Yellow Underwing larvae but heavy sheep, rabbit or even deer grazing can reduce the suitability of grass tufts for the moth as the season progresses. Although only 12 plots were surveyed, Lunar Yellow Underwing larvae were found on eight of these (Figure 2d). The turf stripped plots initially remained very bare over a couple of seasons but are now beginning to develop grass tufts and may provide habitat in the future.

4. Forester: The Forester moth was attracted to the abundant nectar that appeared on many plots and was found on 20% of plots created (Figure 2e). At four plots previously dominated by Sand Sedge *Carex arenaria*, Sheep's Sorrel appeared in abundance after disturbance which may support breeding Forester in the future.

Building local partnerships

Volunteer involvement in survey and monitoring was vital to the project's success; nearly 70 volunteer days were contributed to this task in 2009 and 2010. Without this input it would have been very difficult for the project officer to undertake multiple site visits to widely dispersed plots and survey a suite of target moths with different adult flight periods. Day-flying moths such as Grey Carpet, Forester and Marbled Clover can be monitored

relatively easily with minimal training. However survey and monitoring the Lunar Yellow Underwing requires more specific training and dedication, whilst surveying for Basil Thyme Case-bearer is a highly skilled specialist undertaking less suitable for volunteers.

Key lessons

Mechanical soil disturbance created highly suitable conditions for a range of Breckland moths on some of the plots. Bare ground creation can be an imprecise tool that only occasionally produces the early successional habitat required by the target species. It is difficult to predict the plant species composition on a newly established bare ground plot, as this depends on a range of factors including soil type, vegetation and land management history of the plot prior to disturbance, grazing impacts and weather. However, the most threatened moths and their larval foodplants occur in relatively low numbers across the landscape, so such work is required at a very low level to maintain and increase populations of the target species.

In the Brecks a mosaic of vegetation types from calcareous to acid grassland can occur within a small area, making it difficult to select the most suitable plots for disturbance for a particular species. However, as further ecological knowledge is acquired, we anticipate being able to target ground disturbance even more successfully in the future.

The presence of invasive plants in the sward prior to ground disturbance can also influence the composition of the vegetation following management. For example, where Bracken *Pteridium aquilinum*, Sand Sedge or Wood Small-reed *Calamagrostis epigejos* were present before disturbance, these species reappeared very quickly following treatment.

Larval foodplant	Treatment type					
	Rotovation	Forest Ploughing	Agricultural Ploughing	Disc Harrowing	Turf Stripping	**Total**
Flixweed	11 (38%)	4 (44%)	2 (33%)	0	3 (27%)	**20 (34%)**
Basil Thyme	0	0	0	0	1 (9%)	**1 (2%)**
Total number of plots	**29**	**9**	**6**	**4**	**11**	**59**

Table 1 Number of plots (% of total for each treatment) producing suitable habitat for target species 2-3 years after plot creation

Target species	Treatment type					
	Rotovation	Forest Ploughing	Agricultural Ploughing	Disc Harrowing	Turf Stripping	**Total**
Grey Carpet adult or larvae	6 (21%)	0	1 (16%)	0	1 (9%)	**8 (13%)**
Basil Thyme Case-bearer larvae	0	0	0	0	0	**0**
Lunar Yellow Underwing larvae*	6 (21%)	0	0	1 (25%)	1 (9%)	**8 (13%)**
Forester adult	10 (34%)	3 (33%)	1 (16%)	0	2 (22%)	**16 (27%)**
Marbled Clover adult	3 (10%)	0	0	0	1 (9%)	**4 (7%)**
No. plots with records	8 (28%)	6 (66%)	5 (83%)	3 (75%)	8 (73%)	**30 (51%)**
Total number of plots	**29**	**9**	**6**	**4**	**11**	**59**

* Only 12 plots surveyed

Table 2 Number of plots (% of total for each treatment) with records of target species 2-3 years after plot creation

Almost all the different treatment plots created an abundance of nectar from a variety of flowering plants throughout spring, summer and autumn, a major factor in attracting moths such as Forester and Grey Carpet, many butterflies and other nectaring insects.

The early successional vegetation on the plots is dynamic, changing year by year. Rotovated plots with abundant Flixweed in year one, were reduced to just a few plants by year two. Conversely turf stripped plots remained very bare in year one, but were beginning to develop a more complex open sward of grass tussocks amongst bare ground by year two and three. To ensure the presence of some suitable conditions each year, plots should be managed on rotation and management should include a range of treatments.

Sharon Hearle

Grass tufts utilised by Lunar Yellow Underwing on turf stripped plot at Cavenham Heath NNR

The Heath Fritillary in the Blean Woods: a low input large output landscape project

Nigel Bourn, Tom Brereton, Caroline Bulman and Caroline Kelly

Caroline Bulman

Heath Fritillary

Introduction

Not all landscape-scale projects require large resources for Butterfly Conservation to make a difference. One such project involves an active partnership to conserve the Heath Fritillary *Melitaea athalia* in the Blean Woods, north of Canterbury in Kent, a major stronghold for the species now containing approximately 60% of all UK colonies. The woodlands are principally owned and managed by several conservation bodies including RSPB, Kent Wildlife Trust, Natural England, The Woodland Trust and Forestry Commission England.

In the UK the Heath Fritillary is restricted to just four small areas; the Blean Woods in Kent, Exmoor in Somerset, the Tamar & Lydford Valleys in Cornwall and Devon and introduced populations in a few woodlands in south Essex. The majority of sites are owned or managed by conservation organisations or public bodies with a duty to maintain the biodiversity interest, and nearly all are now actively managed, in part, for the Heath Fritillary.

In the Blean woodland complex the butterfly uses rides (50% of colonies) and coppice (45%) or recently clear-felled woodland (5%) where its larval foodplant, Common Cow-wheat *Melampyrum pratense*, is abundant. Here the Heath Fritillary occupies woodland clearings or coupes that remain suitable for only short periods of time. Colonies tend to reach maximum size in the first two or three years after felling/coppicing, and then begin to decline as conditions become too shady. If a clearing is not colonised within the first two years after its creation then it will remain uncolonised and not

Caroline Bulman

Heath Fritillary on Common Cow-wheat

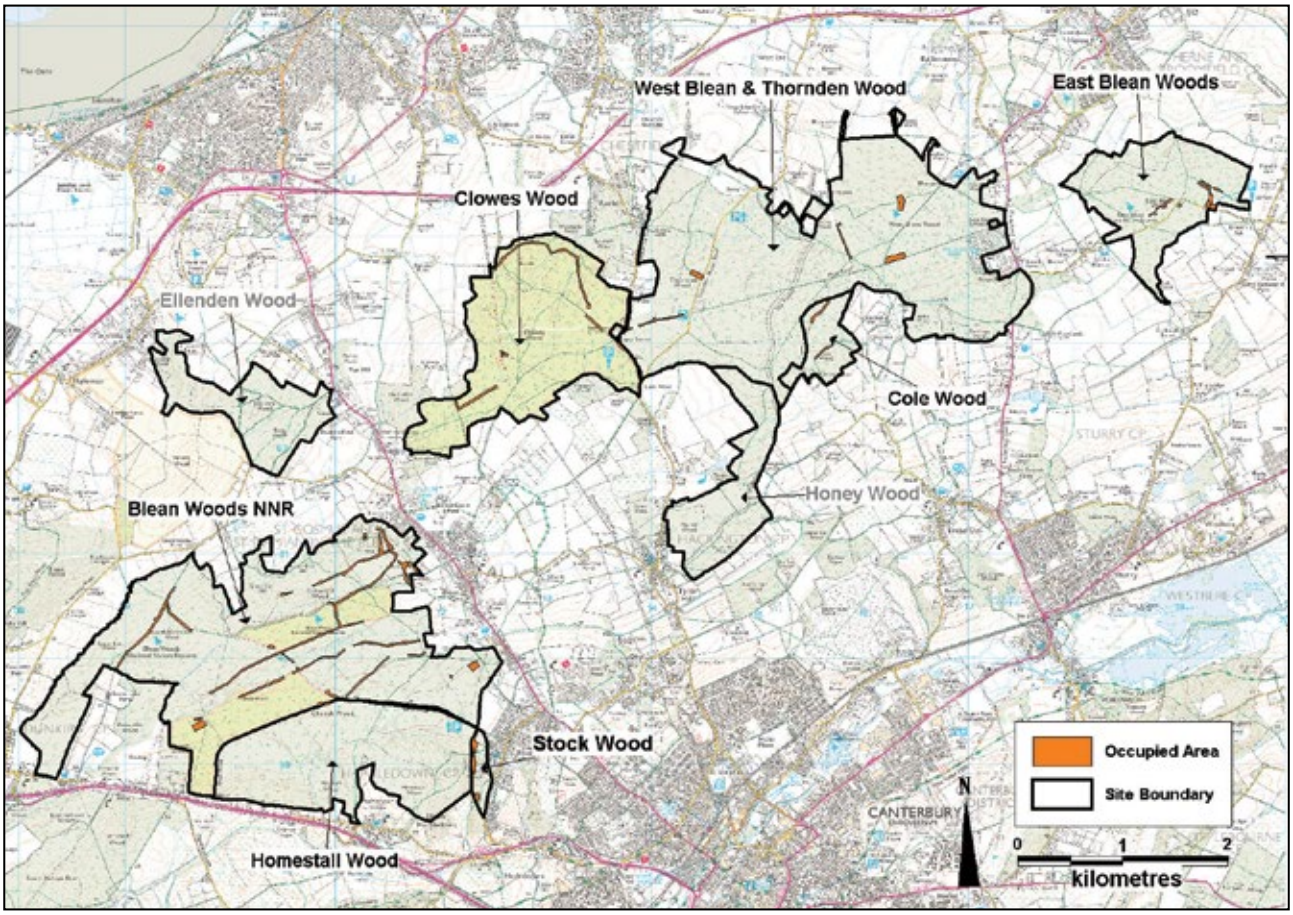


Figure 1 Location of Heath Fritillary colonies in the Blean Woods complex in 2011. Currently unoccupied sites named in grey

be utilised by the butterfly until the coppice cycle starts again. A cleared patch of woodland is generally suitable for between three and six years depending on tree species and growth rate. Warren (1987) found that in the Sweet Chestnut *Castanea sativa* coppice, a large component of the Blean Woods, the vigorous growth and the absence of deer meant colonies could be lost in as little as six years without regular cutting. During the 2000s colonies in coppice coupes went extinct after only two to four years, possibly due to more vigorous regrowth.

In order to maintain the Heath Fritillary population in the long-term in such a dynamic landscape, suitable clearings must be created (and colonised) at the same rate at which extant colonies are being lost. Thirty years of monitoring the Heath Fritillary in the Blean Woods has shown that, on average, only about one in three cleared areas provide suitable breeding habitat, although this proportion is increased because areas are often cut for other target species such as the Common Nightingale *Luscinia megarhynchos*. These woodlands therefore require sustained active management to conserve this butterfly.

The Heath Fritillary is one of Britain's most threatened species of butterfly, having undergone a 25% decline in distribution between 1970-82 and 1995-2004 and an even steeper population decline of 73% between 1984 and 2004 (Fox *et al.*, 2006). Fortunately, thanks to the targeted management in the Blean and elsewhere, these declines have been halted and even reversed in the last decade (Fox *et al.*, 2011). In the Blean Woods, following a rapid loss of colonies in the 1990s numbers have now recovered to pre-1980 levels (Table 2).

Mike Enfield

Sweet Chestnut coppice coupe with abundant Common Cow-wheat in the foreground

Site	Management type	2008-2009	2009-2010	2010-2011
East Blean Wood	Coppice coupes and ride-widening/scallops	1.2	1.3	0.7
West Blean & Thornden Wood (incl. Cole Wood)	Clear-fell	7.8	27.5	26.1
	Coppice/other	6.4	7.4	1.9
Clowes Wood	Ride edges, wide ride cuttings, way-leaves	3.4	2.9	3.0
Blean Woods NNR (incl. Stock Wood)	Coppice coupes and ride management	12.7	13.2	14.6
Homestall Wood		2.5	2.3	2.0
Total		**34.0**	**54.5**	**48.2**

Table 1 Woodland management within the Blean Woods and areas managed during each winter management period

Project methods

Butterfly Conservation has been monitoring all known sites for the Heath Fritillary in the Blean Woods since 1980, using the timed-count method, with six comprehensive surveys being carried out at between four and eight year intervals. Since 2002 Butterfly Conservation has coordinated all the survey results across the complex annually and each year the occupied habitat is mapped (Figure 1). Each year repeat surveys are undertaken of all the extant colonies from the previous year, of all the new management blocks carried out during the past winter, and of any unoccupied management blocks from the previous two years as the butterfly generally only colonise habitat within two years of creation (Warren, 1987 and Figure 2). An estimate of habitat suitability is made by recording the presence of Common Cow-wheat using an abundance scale (0-5, where 0 represents absence), and notes made on the general habitat condition and any management requirements.

Habitat management data from the previous winter management period is now obtained from the relevant partner organisations enabling tracking of the species across the landscape as it responds to the annual management. This data is also used to determine the area of management achieved across the

	1980	1984	1989	1996	2004	2008	2009	2010	2011
Total number of colonies	25	21	14	14	25	37	30	31	23
Total area of occupied habitat (ha)	28	22	19	23	20	18	30	27	28

Table 2 Total number of Heath Fritillary colonies and total colony flight areas for the Blean Woods 1980-2011. Only data for years with comprehensive surveys included

landscape as a whole each year by the partnership. Monitoring results and management assessments are summarised in an annual report which is circulated to all partners and meetings between the managers and Butterfly Conservation are held to inform management priorities for the winter. Such detailed and long-term data sets are attractive for academics resulting in collaboration with the University of York to carry out population dynamic modelling for a successional species (Hodgson *et al.,* 2009).

Land management results

The butterfly has historically been linked with the traditional practice of woodland coppicing, giving it the local name of the 'Woodman's Follower' and management aims to ensure a succession of sunny clearings with abundant hostplant in otherwise sparse vegetation. Coppicing produces such clearings, but continuity of management is essential. Wide sunny rides are needed for the species to move to new, freshly cleared areas where conditions are suitable for breeding. All the management work within the Blean is undertaken by the woodland owners, principally the RSPB, Forestry Commission and Kent Wildlife Trust (Table 1).

Butterfly Conservation has been involved with the Heath Fritillary in the Blean woodland complex from the 1980s and during this time we have built up a comprehensive understanding of the ecological needs of the species and its distribution in relation to areas of suitable habitat including coppice, rides and permanent open space within the Blean landscape. This in-depth knowledge has demonstrated the reliance of the species on new open habitat within the woodland in close proximity to extant sites. This has allowed the management to be targeted at existing occupied sites and nearby open space. Levels of management have not generally increased across the landscape, only the area occupied (Table 2).

Species response

Figure 1 shows the overall distribution of Heath Fritillary across the landscape in 2011. The Heath Fritillary occupies small recently cut coupes of size greater than 0.2 ha and the open ride network where Common Cow-wheat is abundant. This equates to less than 2% of the area in any one year and has been considerably less than that in the recent past.

Table 2 shows the overall number of colonies and colony flight areas for the Blean Woods, for those years where a comprehensive survey was undertaken. The UK BAP target for the Blean Woods complex to maintain 25 colonies has been exceeded every year since 2004 (31 colonies in 2010), while in many ways the more challenging and ecologically more robust target of achieving 30 ha of suitable occupied habitat each year was finally achieved in 2009 following several years where the amount of breeding habitat was decreasing, reaching its lowest ever level in 2008. Delivering the second target is a better measure of success because the increase in colony numbers since 2004 is at least partly explained by the fragmentation of several colonies in East Blean and Thornden and West Blean Woods, following less management. An increase in colony numbers due to fragmentation results in smaller colonies occupying smaller areas, such colonies are at increased risk of extinction.

The increase in Heath Fritillaries in the late 1990s coincided with improved targeting of coppicing close to existing colonies, which significantly increased the level of occupancy of coppice coupes. Between 1990 and 1992, 18% (2 of 11) of cut coppice coupes were colonised by Heath Fritillaries, compared with 75% (9 of 12) between 1998 and 2000. In 1996 and 1997 (prior to regular monitoring and targeting), there were no Heath Fritillary colonies located in commercially managed coppice coupes, even though there were 18 scattered through the wood which had been cut over the previous four years.

Figure 2 shows the distribution of created patches in terms of age and distance to the next nearest occupied patch and the colonisation events between 2005 and 2009. Within

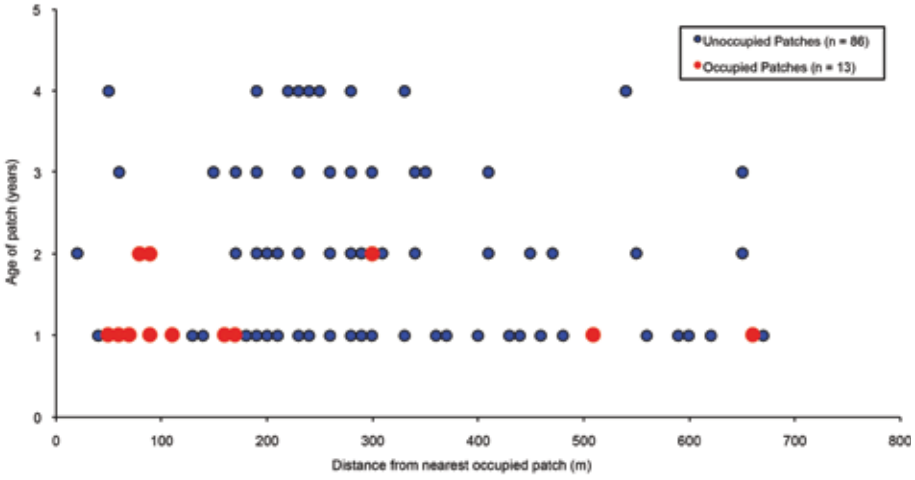


Figure 2 Heath Fritillary colonisation in the Blean Woods relation to age of year after patch creation and distance from nearest colony between 2005 and 2009 (13 colonised)

1 Summer 2004, area occupied

A small colony is found in the north of the wood in a Sweet Chestnut coppice coupe cut the previous year. All other known colonies in the wood are checked and confirmed as extinct as the habitat has become unsuitable.

4 Management 2006-2007, area occupied in 2007

Two small coupes cut in 2006-07 adjacent to existing colonies. Both these areas are colonised, and the previously occupied areas become unsuitable. Without the annual management these two colonies would have been lost from the woodland.

7 Management 2009-2010, area occupied in 2010

Extensive forestry operations to the south of the colonies as shown. The rides opened five years previously are re-cut, another ride similarly opened up and one new coppice coupe cut. The colony in the north fails to respond and the one in the south contracts to area occupied in 2009.

2 Management 2004-2005, area occupied in 2005

In the winter of 2004/05 a new coupe cut just to the west of the occupied area and extensive ride side cutting undertaken south to the junction. The area occupied by the colony expands slightly and the new adjacent coupe is partially occupied. A second colony is established in the south in a new area 600 m down the widened ride.

5 Management 2007-2008, area occupied in 2008

Three further coupes cut adjacent or near the two existing colonies. The coupe in the north is colonised while the previous years occupied area goes extinct (after a years occupancy). The southern colony expands slightly into newly cut areas.

8 Management 2010-2011, area occupied in 2011

A coupe is cut at the end of the east/west ride and an area coppiced to connect the two rides. Two colonies stable and a third colonisation along the edge of an old ride that is now more open due to adjacent forestry being removed. The latter area has had occasional sightings for several years but has now become a third established colony in the wood. The two original colonies in the wood have occupied the same area for four or five years and need to colonise the newly created areas or are likely to be lost.

3 Management 2005-2006, area occupied in 2006

Further increase in the coupe cut in the north of the wood and to the small coupe cut in the south. The butterfly fails to respond significantly with no change in the area occupied by the first colony and only a very slight expansion into the new cut area by the second colony.

6 Management 2008-2009, area occupied in 2009

No Sweet Chestnut coppice cut as extensive plantation forestry operations occur to the west of the occupied areas as shown. In the north the colony re-occupies an area cut two winters previously, while in the south the areas cut two winters previously are occupied for the first time.

Figure 3 Tracking a colony through West Blean Wood, 2004-2011 demonstrates the short occupancy time of colonies (2-5 years) and the need for targeted annual management

this five year period there were 13 colonisations, 10 (77%) occurring less than 170 m from the nearest existing colony and all 13 occurred within two years of the patch being created. This figure demonstrates the highly dynamic nature of the Heath Fritillary, as it follows the management through the woodland and the need to plan and target future management carefully (Hodgson *et al.*, 2009).

Figure 3 illustrates the response of the butterfly to management in one part of the woodland complex between 2004 and 2011. The original small colony in 2004 expanded in response to targeted management during the winter of 2004/05, which created new patches. Note the widening of the rides appears to have helped the one 600 m colonisation event to have occurred. The original colony went extinct after three years as the patch became shaded and unsuitable. Further extinctions follow in the created patches after only two to four years of occupancy, before finally occupying areas several hundred metres away from the original colony.

Key lessons

Monitoring data has shown that the Heath Fritillary responds well to positive conservation management work. Thanks to the efforts of a considerable number of organisations and individuals, the number of Heath Fritillary colonies in Blean Woods has increased since the 1980 baseline.

This project has demonstrated the key role that monitoring data can play in helping to successfully target habitat management, with clear efficiency gains. At Thornden and West Blean Woods, the change in occupancy of cut coppice from 18% in the early 1990s (without targeting) to 75% by the late 1990s (by targeting with monitoring data) is testimony to this.

This case study has highlighted the importance of annual monitoring for highly dynamic species like the Heath Fritillary. Monitoring data keeps managers and landowners informed and focused on the priorities for management and avoids complacency as the habitat condition status can soon change as clearings are often only suitable two to four years after they have been created.

The cost of adding a species element to the conservation of the woodlands in the Blean is miniscule at about £3k per annum. This includes surveys, report writing and management review meetings. The maintenance and management of the woodlands runs at approximately £100k per annum. By adding the species element (at a cost of about 3% of the overall budget) this enables the management to be targeted across the landscape to a far greater degree and is effectively adding huge value to the overall conservation effort.

Restoring very small fragmented landscapes for the Small Pearl-bordered Fritillary in the Durham Coalfield Pennine Fringe

Sam Ellis and Dave Wainwright

Sam Ellis

Small Pearl-bordered Fritillary

Introduction

Most landscape-scale projects operate over hundreds or thousands of hectares. In County Durham we demonstrate that restoration of a relatively small fragmented landscape for the Small Pearl-bordered Fritillary *Boloria selene*, is not only achievable, but essential to enable the dynamic changes in habitat quality to occur and still maintain the species in the area.

The Small Pearl-bordered Fritillary has undergone major declines in both distribution (34% between 1970-82 and 1995-2004) and abundance (70% 1976-2004) in Britain in recent years but especially in central and eastern England (Fox *et al.*, 2006). In the Durham Coalfield Pennine Fringe it was reduced to four known colonies in 2000 (Ellis, 2000), all located along the mid-western boundary of this rolling upland, mainly pastoral, County Durham landscape (Figure 1).

In northern and western Britain, the butterfly is found in two main habitats, 1) damp grassland/ moorland, especially around wet flushes, and 2) grassland with Bracken *Pteridium aquilinum* and/ or scrub. Breeding occurs in grassy vegetation, where one or both of the two main larval foodplants, Marsh Violet *Viola palustris* and Common Dog-violet *Viola riviniana* are abundant. Research on the remaining sites discovered they supported small, relatively isolated populations and that medium height swards were the most suitable for breeding as they provided a more suitable microclimate as well as encouraging violet regeneration (Ellis *et al.,* 2011). In order to restore this small fragmented landscape, efforts to improve habitat on occupied patches would need to be matched by restoring currently unoccupied patches as well as improving connectivity between them.

Project methods

In 2002 three of the four remaining populations were located along roadside verges or paths and were ungrazed with the fourth only very lightly grazed. Succession to rank vegetation, dense Bracken and scrub was evident on all four sites and needed to be reversed to restore suitable habitat. Conversely, unoccupied potential habitat patches were mainly located within pastures overgrazed by sheep and characterised by short swards with relatively few violets. Unoccupied sites were all relatively close to or between occupied patches and mostly located along existing watercourses. Restoration of the former would therefore not only increase the overall habitat resource but also improve connectivity between them, enabling more rapid colonisation by the butterfly.

From 2002, scrub control, Bracken management and mowing rank vegetation were undertaken on occupied and some potential sites (Table 1). On both occupied and potential patches we established small grazing compartments (on average 1.20 ha) by fencing actual or potential breeding habitat and on the more exposed sites we also established small shelterbelts. On two patches where there were few or no larval foodplants we planted both species of violet, grown by local authority horticulturists from locally sourced seed, to create potential breeding habitat. We investigated the potential to restore breeding habitat and provide connectivity along plantation watercourses by

creating streamside rides, but were unsuccessful in purchasing the woodland to implement this strategy. Much of the practical management was undertaken by volunteers but over £40k of funding was secured from a range of sources and paid for the fencing.

The preferred grazing regime proposed for the grazing compartments was light cattle grazing as some poaching encourages violet regeneration in grassland and trampling of Bracken habitats helps break up dense standing trash. However, farming beef cattle in the upland fringe is increasingly uneconomic and only one site was cattle grazed. The new grazing compartments either remained ungrazed or were lightly sheep grazed for several years. However, from 2009 the compartments have been grazed on rotation by three fell ponies.

Land management results

Between 2002 and 2009 the habitat resource in this network increased from 1 to 6 ha occupied habitat, six times the 2002 resource (Table 1).

Dave Liddle

Impact of establishing exclosures to control the level of livestock grazing. Marsh Thistle is a favourite nectar plant of the Small Pearl-bordered Fritillary

Dave Liddle

Volunteers clear scrub to restore Small Pearl-bordered Fritillary habitat

This increase was partly attributable (3 ha) to the discovery of previously unrecorded patches on existing sites and two new sites. Nevertheless, the landscape restoration project has already resulted in an additional 2 ha occupied habitat, tripling the 2002 resource and this figure is likely to increase further as more potential sites come into suitable condition.

Species response

All sites were monitored annually from 2003 either by single transect counts (Thomas, 1983), or in the case of Waskerley Way and Greenfield Farm from 2004, by a weekly transect (Pollard, 1977) encompassing both populations. All restored and created patches were separated from occupied patches by a maximum of 0.1 km and all those supporting appropriate breeding habitat have been recolonised by the Small Pearl-bordered Fritillary (Figure 2). Some patches now support larger populations than the original occupied patches. Annual indices on the Waskerley Way and Greenfield Farm sites have increased (Figure 3a), despite the impact of the weather in 2007-08 and in contrast to the significant 59% national UK decline between 1976-2010 (Botham *et al.*, 2010). These two populations are now distributed over more patches (2002: 4 patches; 2009: 11 patches), but numbers have declined on the original occupied patches, where habitat quality remains below optimum. Connectivity has been increased with minimum distances between sites reduced from 0.81 km to 0.34 km.

At Greenfield Farm a grazing compartment was established in 2002 to enclose an unoccupied heavily sheep grazed mire. The butterfly colonised the patch in 2003 with an overall positive transect trend thereafter (Figure 3b). At Waskerley Way a grazing compartment was established on a large area of heavily sheep grazed mire in 2005. The Small Pearl-bordered Fritillary colonised this patch later that year and the trend thereafter on the transect has also been positive (Figure 3c). Likewise colonisation of a grazing compartment planted with about 800 violets occurred the year after (Figure 3d), although numbers remained low until 2008-09 when a breeding population appears to have finally established. In 2009 this small patch accounted for 25% of the transect records for the butterfly, although declining thereafter.

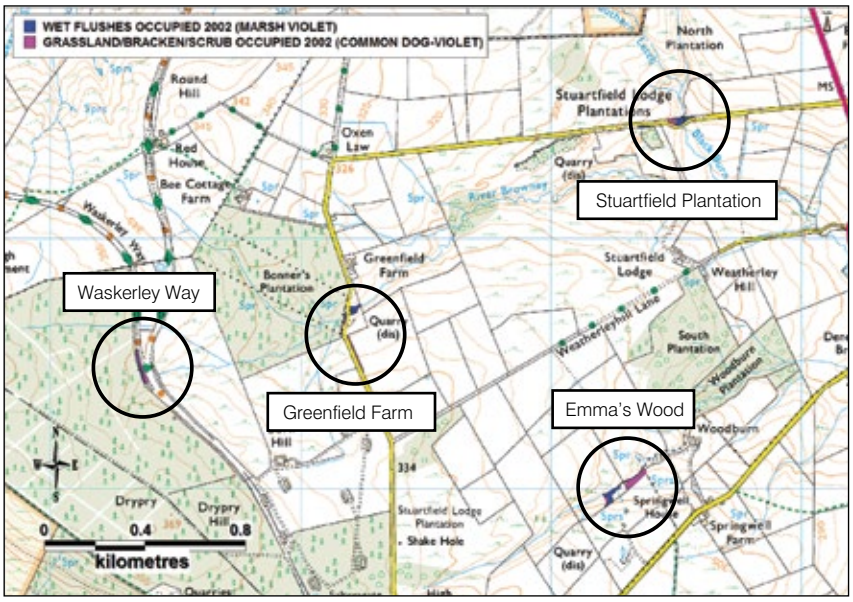


Figure 1 Location of wet flush and grassland/Bracken/scrub habitat patches (plus main larval foodplant) on four Small Pearl-bordered Fritillary sites in the Durham Coalfield Pennine Fringe in 2002 prior to management

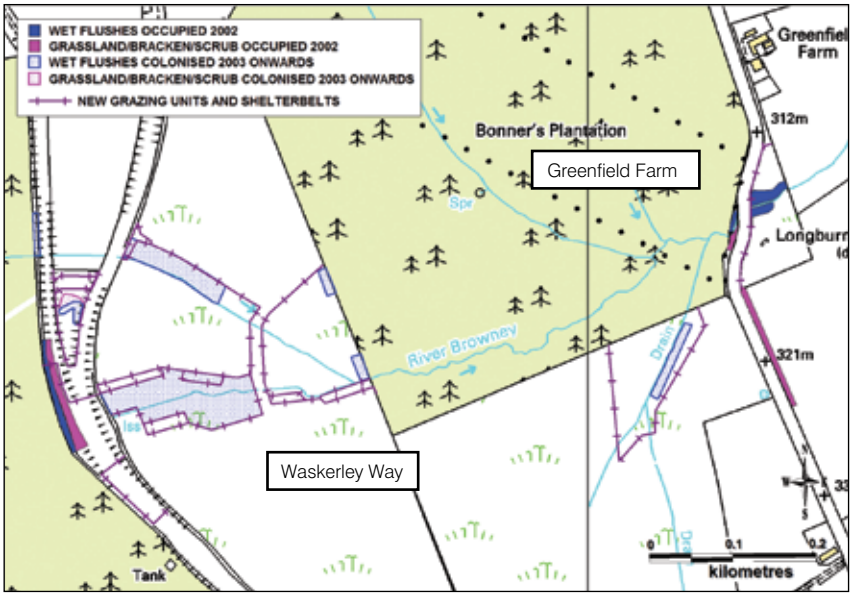


Figure 2 Changes in Small Pearl-bordered Fritillary patch occupancy at the Waskerley Way and Greenfield Farm sites in the Durham Coalfield Pennine Fringe following landscape-scale management 2003-08

Building local partnerships

This project could not have been implemented without the assistance of volunteers from a variety of partner organisations, including Durham County Council voluntary rangers, Durham Wildlife Trust, BTCV and Butterfly Conservation North East England Branch. The University of Sunderland undertook a significant proportion of the research and Durham County Council rangers led nearly all the volunteer work parties, as well as established the butterfly transect. More recently one of the landowners has been so enthused by the project that he has entered Natural England's Higher Level Stewardship scheme, building an education centre and encouraging children from local schools to assist with practical tasks such as planting shelterbelts and violets.

Key lessons

This project provides evidence that the principles of landscape-scale conservation are applicable regardless of landscape area. In this case we successfully restored a small landscape for the Small Pearl-bordered Fritillary where the population survived on a few habitat fragments.

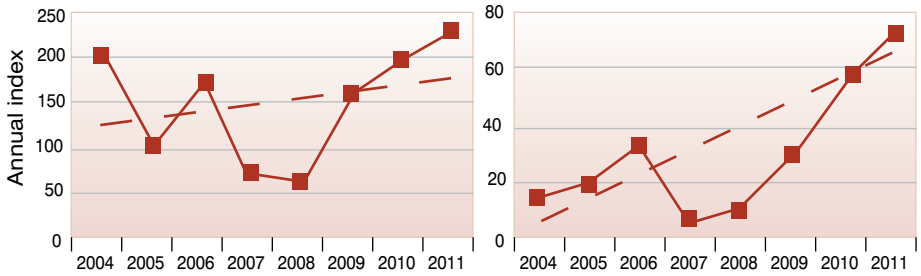
Species on the verge of local extinction often survive on suboptimal habitat patches. The main driver of decline in this landscape was identified as overgrazing and the butterfly survived on three of the four original sites because they were ungrazed verges. The continued decline on these verges despite management effort, suggests habitat quality was and remains, suboptimal. Without intervention on both occupied and unoccupied patches further local extinctions may well have occurred in this landscape. Restoration across the landscape was not only achievable, but essential to enable the dynamic changes in habitat quality to occur and still maintain the species in the area.

However, this only represents the first project phase, much more extensive habitat restoration both within, between and beyond the existing sites is planned to secure the long-term future of this metapopulation.

Whilst there has been investment in grazing infrastructure (average of £5-6k per annum for seven years) to enable long-term management, nearly all the habitat restoration was undertaken by volunteers. This partly reflects the scale of the management, but also the enthusiasm and dedication of the local authority ranger who worked so closely with Butterfly Conservation to enable the project to progress.

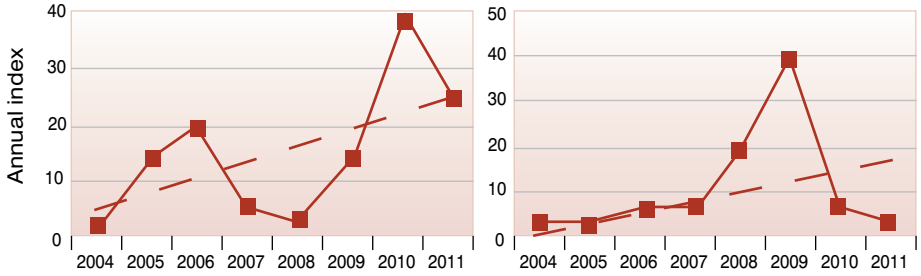
	Cat Back	Waskerley Way	Greenfield Farm	High Plantation	Emma's Wood	Stuartfield Plantation	**Total**
Vegetation management							
Total area managed (ha)		0.24	0.39		1.35	0.23	**2.21**
Scrub control (ha)		0.13	0.01		1.35	0.23	**1.72**
Bracken management (ha)			0.19			0.20	**0.39**
Grassland mowing and raking (ha)		0.24	0.20			0.20	**0.64**
Controlled grazing							
Fencing installed (km)		2.03	0.56	0.48	3.03	0.56	**6.66**
Grazing compartments (ha)		5.42	1.89	0.55	8.30	0.66	**16.82**
Grazing compartments (no.)		5	2	1	4	2	**14**
Mean compartment size (ha)		1.08	0.95	0.55	2.08	0.33	**1.20**
Planting							
Shelterbelts (ha)		0.31					**0.31**
Shelterbelts (no.)		6					**6**
Mean shelterbelt size (ha)		0.05					**0.05**
Violet planting (area)		0.06	0.09				**0.15**
Changes in patch occupancy							
Occupied patch area in 2000 (ha)		0.21	0.22		0.45	0.22	**1.10**
Occupied patch area in 2009 (ha)	1.47	1.61	0.32	1.15	0.45	0.99	**5.99**
Previously unrecorded patches (ha)	1.47	0	0	0.71	0	0.77	**2.95**
Previously unoccupied patches (ha)	0	1.40	0.10	0.44	0	0	**1.94**

Table 1 Management implemented and changes in patch occupancy on Small Pearl-bordered Fritillary sites in the Durham Coalfield Pennine Fringe 2002-09



a) Annual indices for transect encompassing Waskerley Way and Greenfield Farm populations

b) Annual indices for Greenfield Farm grazing compartment established 2002



c) Annual indices for Waskerley Way grazing compartment established 2005

d) Annual indices for Waskerley Way grazing compartment planted with violets 2003

Figure 3 Small Pearl-bordered Fritillary weekly transect counts on two Durham Coalfield Pennine Fringe sites 2004-11 following habitat restoration. Dotted lines indicate trends

High Brown Fritillary in the Vale of Glamorgan: saving the last site in Wales

Russel Hobson and Richard Smith

Paul Dunn

High Brown Fritillary

Introduction

Habitat loss and fragmentation has occurred on such a scale and so rapidly in some landscapes that the first stage of landscape-scale conservation is to secure the population of the threatened species at its remaining site(s). Only then can then the process of rebuilding the network of habitat patches across the entire landscape begin.

In Wales the High Brown Fritillary *Argynnis adippe* has declined in range by 81% (Fox *et al.,* 2006). Up until 2003 there was a small population in Montgomeryshire (Spencer and Kelsall, 2004) and others at the southern end of the South Wales Valleys, but it is now restricted to one locality, centred on the Alun Valley on the western side of the Vale of Glamorgan, south of Bridgend. The butterfly currently occupies just five 1km squares, with the next nearest population across the Bristol Channel at Heddon Valley on Exmoor.

The Alun Valley comprises a landscape of about 254 ha of unimproved habitat (Figures 1 and 2). Part of the site (Old Castle Down and Ogmore Down) is common land and an SSSI, primarily for its very unusual mix of humid heath, calcareous heath and limestone grassland. Across this whole landscape, there are also significant areas of ancient woodland, neutral and acid grassland, with Hazel *Corylus avellana* and Gorse *Ulex europaeus* scrub and Bracken *Pteridium aquilinum.* Land use is also mixed. Part of Ogmore Common is a golf course and there are three active quarries. Sheep grazing is largely confined to the common with much of the non common land ungrazed. The surrounding farmland has a significant proportion of arable with pasture for sheep, cattle and horses.

In the Alun Valley, as in much of its British range, the High Brown Fritillary utilises Bracken-dominated habitats or grass/Bracken mosaics. Common Dog-violet *Viola riviniana* is the main larval foodplant, but breeding only occurs in short, sparse vegetation with little grass cover. A shallow layer of Bracken litter and standing trash (or other leaf litter) produces the warm microclimate enabling rapid larval development in cool spring weather.

Project methods

Standardised adults counts began in 1995 and showed continued declines in abundance in the

Alun Valley, coinciding with the disappearance of the species from other South Wales Valleys sites. A baseline habitat assessment in 2002 showed that while 69 ha of the Alun Valley landscape had potential for High Brown Fritillary, only 15 ha was identified as having suitable breeding habitat and that the quality of what remained was thought to be declining.

In 2002 it was noted that adult High Brown Fritillary had been using trial coppice plots, begun in 1999. A management plan (Smith and Hobson, 2004) was funded by a Species Challenge Fund grant from Countryside Council for Wales (CCW), which enabled a successful application for funding from Aggregates Levy Sustainability Fund.

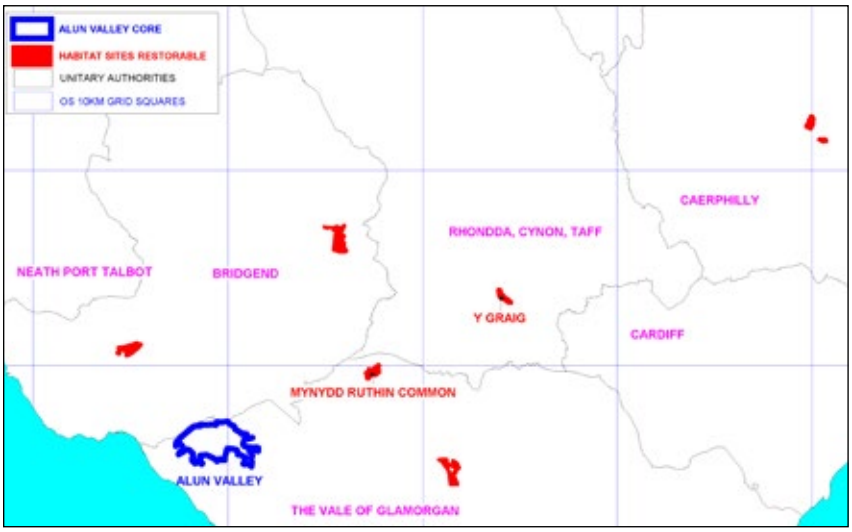


Figure 1 Location of the Alun Valley and former/potential High Brown Fritillary sites in South Wales

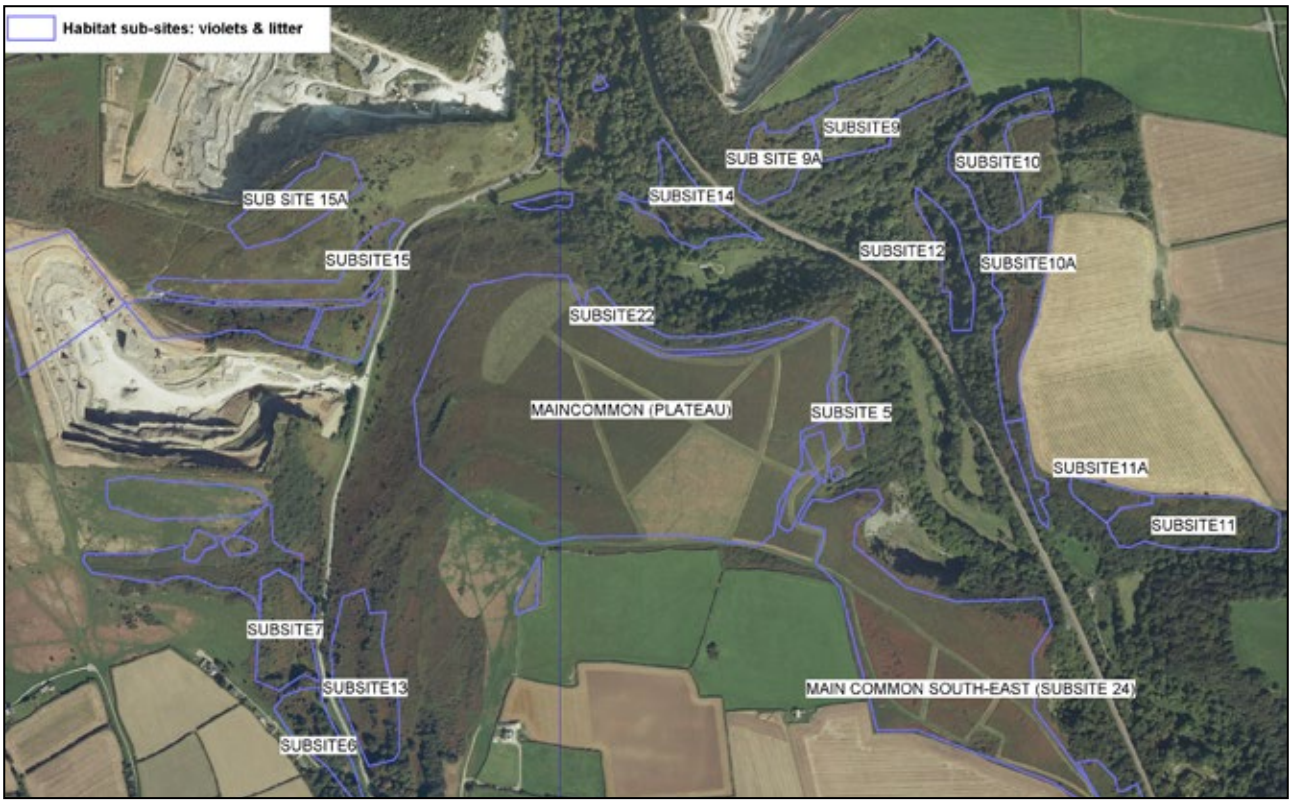


Figure 2 Location of High Brown Fritillary habitat patches in the Alun Valley

Paul Dunn

A view of the Alun Valley looking west

With the management plan support was gained from the commoners, landowners and one of the quarries and work started on an initial three-year project in 2003. The funding enabled a part-time project officer (10 days/year 2003-06, then six days/year 2007 onwards) to be employed to coordinate the management and monitoring work. The project officer was separately employed to produce the newsletter, reports and undertake vegetation monitoring.

The work focused on cutting back the dense Bracken litter, where Bramble *Rubus fruticosus* agg., Honeysuckle *Lonicera periclymenum* and saplings were establishing in winter. The woody material was stacked in adjacent woodland. This resulted in a disturbed litter layer ranging from bare ground to denser piles of cut litter. Adjacent to these areas taller Hazel and Gorse scrub was coppiced and larger trees felled to create 'flightways' between open bracken patches. The Glamorgan Heritage Coast acted as the main 'contractor' undertaking heavier work with chainsaws and an Allen scythe. This was supplemented by up to nine annual winter work parties with volunteers focussing on areas which machinery could not access. The work has continued from 2007 with further funding from CCW and Vale of Glamorgan County Borough Council

Further grants from CCW and PONT (Wales Grazing Animals Project) were used to fence two blocks (2.4 ha and 13.6 ha respectively) of private land and in 2010 a livestock corral was erected. The smaller block was grazed by horses in 2007 as a one-off trial and poaching created large areas of bare ground that were subsequently colonised by a mixed woodland/limestone grassland flora. The aim of re-introducing rough grazing by ponies and possibly cattle to both blocks has subsequently stalled, as issues of tenure have not been resolved.

With just the Alun Valley landscape occupied but adult numbers increasing dramatically, the previous South Wales Valleys sites were assessed for restoration. With funding from Welsh Assembly Government, former (late 1990s) and other possibly suitable sites within 15 km were assessed. The study not only looked at the quantity of potential habitat but also the willingness of owner/commoners to enter into management and other influences, particularly impact of arson. Eleven sites were visited and work was recommended on eight (Figure 1). However, the area

Richard Smith

Fence and pony corral at subsite 9

of suitable or potentially suitable habitat on these sites was only 8.8 ha (just 3% of the unimproved habitat) compared with the 69 ha in the Alun valley landscape (27% of the unimproved habitat) (Smith, 2007). This proved that the focus of the work needed to remain in the Alun Valley, as there was still much more potential for restoration in this landscape than on other sites.

Even so a further Species Challenge Fund grant helped two other commoners associations begin restoration work during 2008-10. At Y Graig, above Llantrisant in Rhondda Cynon Taf (15 km north-east of Alun Valley), contractors and local authority staff cut back dense Bracken and opened rides to allow the commoners to re-introduce grazing. This prominent site was regularly subject to large scale arson but thanks to the work the scale of burns has been reduced and suitable habitat is being created. At Mynydd Ruthin (7 km north-east of Alun Valley), where grazing restoration is much more difficult, the work mainly involved trialling the cutting of scattered thorn bushes but arson has remained a significant problem.

Land management results

In the first three years of the Aggregates Levy Sustainability Fund project approximately 12 ha had been managed with on-going manual restoration since 2007 of about 2.5 ha per year (Table 1, Figure 2). Some habitat patches have been re-cut up to three times during this period. In total 17 ha of ungrazed land has been restored with another 18 ha restored on the grazed common, leaving a further 34 ha with potential for restoration. It is estimated that, in the absence of grazing, Hazel scrub or dense Bracken requires re-cutting every three years to maintain suitable breeding conditions.

Species response

The standardised adult counts have been an essential tool to assess the

Richard Smith

Volunteers clearing scrub at subsite 11

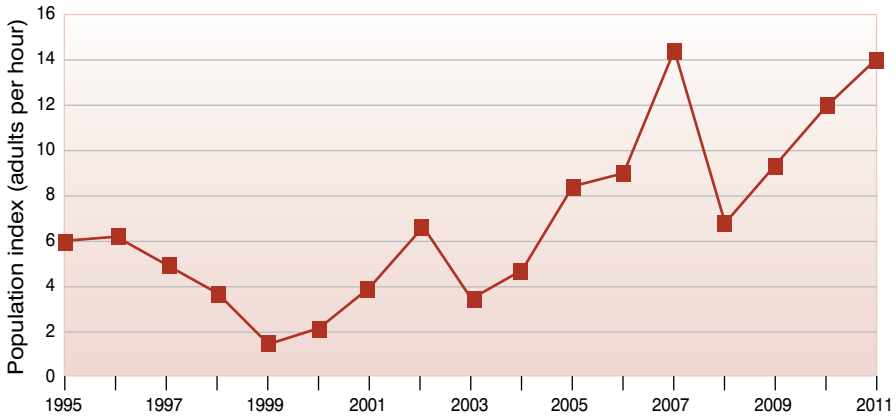


Figure 3 Comparative changes in High Brown Fritillary abundance in the Alun Valley 1995-2011

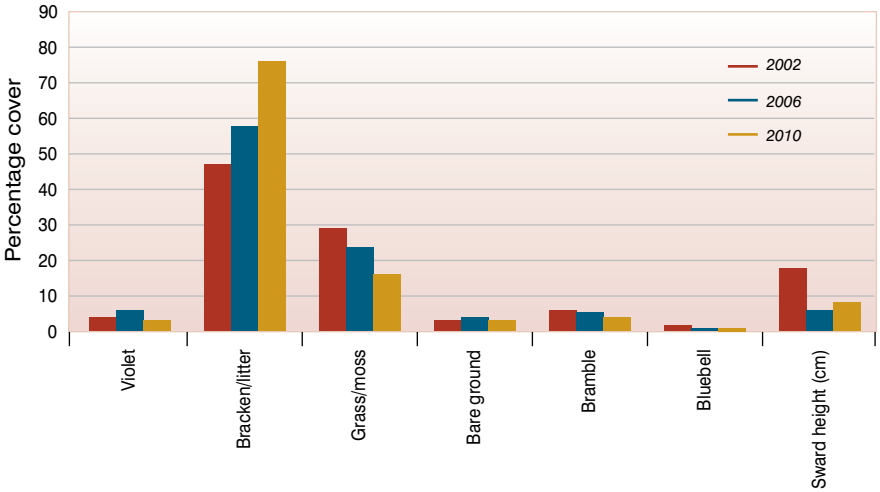


Figure 4 Changes in High Brown Fritillary habitat condition between 2002 and 2008

species response to management (Figure 3) and have been extended over the course of the management work to cover newly restored habitat patches. The baseline vegetation monitoring in 2002 was repeated in 2006 and 2010 (Figure 4) in order to assess habitat change.

Adult numbers rapidly declined from 224 in 1995 to 17 in 1999, when trial coppicing began. Following the start of the Aggregates Levy project the population steadily increased, consistently exceeding 340 since 2007 and, though numbers fluctuate annually, they reached a new high of 588 in 2011.

Vegetation monitoring was undertaken using a standard method of assessing the condition of Bracken slopes for fritillary butterflies (Clarke and Warren, 1997). Line transects down the slopes were sampled at regular intervals and the abundance of positive and negative indicators recorded. When repeated in 2006 the abundance of violets, the larval foodplant, had increased by 112% and the sward height more than halved, compared to the 2002 baseline. These are both positive signs the management is working. Indicators of poor site quality – cover of grass/moss, Bramble and Bluebell *Hyacinthoides non-scripta* – all declined in abundance.

Vegetation monitoring was repeated in 2010. Violet abundance has fallen back but was still above that in 2002, sward height has remained static and grass/moss and Bramble have declined further. Violet abundance was highest on the ungrazed land. This could be because these subsites have been cut more often or the sheep grazing on the common is reducing violet abundance.

Active management of Bracken slopes and scrub has benefited other species. Small Pearl-bordered Fritillary *Boloria selene* has increased in numbers since management work began. Early-purple Orchid *Orchis mascula*, Common Twayblade *Listera ovata* and Parasol mushroom *Macrolepiota procera* all appeared in huge numbers following the horse poaching of the 2.4 ha fenced compartment. Dotted Bee-fly *Bombylius discolor* numbers have also increased with the bare ground and flush of spring flowers that follow winter Bracken management. Hornet Robberfly *Asilus crabroniformis* was recorded for the first time in 100 years in 2006.

Building local partnerships

To raise the profile of the High Brown Fritillary locally, guided walks were organised and advertised in the villages adjoining the Alun Valley. Over 90 people attended five walks and workshops to see the butterfly and the work done between 2004 and 2007. Also the Glamorgan Heritage Coast has been actively promoting the work through its programme of workshops, volunteer days and talks. These activities along with press releases, two newsletters in 2006 and 2007 and a Natur Cymru article in 2010 (Hobson and Smith, 2010) have helped disseminate the message to schools, visitors and further afield.

Key lessons

Significant issues remain to be addressed particularly the need to introduce heavier livestock to graze on both the private land and the commons and more intensive woodland management to maintain an actively coppiced woodland edge.

Richard Smith

The violet-rich habitat created after winter management

However, we believe the High Brown Fritillary population in the Alun Valley has now been secured through this project and there is now a very real chance of successfully restoring the butterfly to other sites in the wider landscape.

This restoration project has been relatively inexpensive, roughly £6k per annum (£58k in nine years) matched with over 35 volunteer days per year (345 volunteer days in total) focussing on the habitat management and adult monitoring.

The project demonstrates excellent partnership working between the voluntary environmental sector, through the local LBAP group, statutory conservation body, local authority and landowners and commoners. This was achieved through a shared understanding of the work needed and sustained by positive results.

Subsite number	Area (ha)	2002/05		2005/06		2006/07		2007/08		2008/09		2009/10		2010/11		2011/14		Total
		Man.	Area (ha)	Man.	Area (ha)	Man.	Area (ha)	Man.	Area (ha)	Man.	Area (ha)	Man.	Area (ha)	Man.	Area (ha)	Man.	Area (ha)	
1	0.70	VSG	0.25	G		G		G		G		G		VCG	0.18	VSPG	0.32	
5	0.34	VSG	0.44	VSG	0.14	G		VSG	0.33	VG	NR	G		VSG	0.09	VSPG	0.34	
6	1.07	VSG	0.36	G		G		G		G		G		G		G		
7	1.56	S	0.79	G		G		G		VG	NR	G		G		G		
8	0.29	VSF	0.51													VS	0.27	
9	2.43	S	1.60	G				V	0.12	V	0.12	VS	0.42	VS	1.16	VCS	1.13	
9a	1.14	VS	0.31	VS	0.12			VS	0.28			VS	0.39	S	0.17	VCS	0.15	
10	1.82		0.30			VSCF	0.29	V	0.14	VG	NR			VS	0.57	VS	0.31	
10a	2.14	S	0.37			VSC				G		V	0.32	S	0.27	S	0.39	
11	2.66	SG	1.52			VSCF	1.13	V	0.34	VG	0.68	V	0.67			VCS	1.52	
11a	0.40	G				VSF		V		G						S	0.08	
12	0.90	S	0.57					V	0.16	V	0.12					VCS	0.71	
13	2.20	SG	1.32	G		G		G		VG	NR	G		G		G		
14	1.33	G		VSG	0.51	G		G		G		G		G		VCSG	0.45	
15&15a	3.21	S	NR													S	1.13	
22	0.99	VSG	0.57	G		G		VSG	0.10	VSG	0.10	G		VSG	0.05	VSG	0.18	
24	9.50											VS	0.10			VSP	0.59	
Main common	22.22	G		G		G		G		G		G		G		G		
Total cut			**12.42**		**0.77**		**1.42**		**1.47**		**2.13**		**1.90**		**2.49**		**9.50**	**32.10**
Total fenced			**2.40**				**13.60**											**16.00**

Table 1 Management implemented for the High Brown Fritillary in the Alun Valley 2003-10 V = hand cutting by volunteers, C = chainsaw, S = power scythe, F = fencing, G = mostly light sheep grazing, P = summer path cutting, NR = not recorded

Restoration of a Small Blue metapopulation on the Southam Lias Grasslands of Warwickshire

Mike Slater and Sam Ellis

Nigel Jarman

Small Blue

Introduction

Landscape-scale projects that are initially focused on a single butterfly can benefit a suite of other species which have broadly similar habitat requirements. Here we describe a project to reverse the decline of the Small Blue *Cupido minimus* on limestone grassland habitat in Warwickshire, where management targeted at this 'umbrella' or 'flagship' species has benefited three other threatened Lepidoptera, as well as other invertebrates.

The Small Blue declined nationally by 38% between 1970-82 and 1995-2004 (Fox *et al.*, 2006), but underwent an even steeper decline in the West Midlands, becoming extinct in Shropshire, Herefordshire, Staffordshire and Worcestershire. By 2009, only three colonies remained in the region, all on lias grasslands around Southam, Warwickshire, where 87% of sites had already been lost. The remaining sites were under further threat from development; either existing consents or new planning applications.

The Small Blue breeds only on flowering Kidney Vetch *Anthyllis vulneraria* in a range of dry, sheltered grassland habitats. In the Southam Lias Grasslands landscape the butterfly occurred on both primary and secondary calcareous grasslands, with the latter including disused quarries, road embankments and disused railways. The most suitable habitat is typically a mosaic of short and tall vegetation with patches of light scrub.

Kidney Vetch is a short-lived perennial which depends on regular recruitment of seedlings to maintain its populations. The plant thrives best in early successional habitats comprising sparse swards and bare ground, conditions best maintained by either light grazing or ground disturbance. In the absence of grazing, Kidney Vetch is outcompeted by vigorous grasses and scrub. Conversely heavy spring and summer grazing, especially by sheep, is detrimental and can remove all Kidney Vetch flowers. Furthermore, Kidney Vetch is a shallow-rooted plant susceptible to desiccation in drought conditions but is also very palatable to slugs in damp conditions, so weather can also impact on foodplant populations.

In the West Midlands it was clear that without intervention at a landscape-scale, regional extinction of the Small Blue was likely. A three-year project was initiated in 2009 with the aim of restoring existing and creating new habitat for the Small

Blue on up to 35 sites. The project encompassed the three extant sites, seven extinct sites which still supported some habitat, as well as 25 potential sites.

Project methods

A programme of works was agreed with each landowner and management was funded principally by SITA Trust through the Landfill Communities Fund.

Habitat restoration of limestone grassland focused on reversing succession from open grassland to dense scrub. Scrub management was undertaken by both contractors and by volunteer work parties, with the latter concentrating on sites where scrub invasion was comparatively light. Cut stumps were treated with herbicide to prevent regrowth and cut material was burnt, dead hedged or chipped on site. Where access allowed, bulldozers were used to remove cut scrub to fire sites. Bulldozing had the advantage of removing cut stumps, reducing the need for herbicide treatment, as well as providing an element of ground disturbance to stimulate the natural regeneration of Kidney Vetch.

On sites currently without the foodplant or where only small numbers of Kidney Vetch plants persisted, direct seeding and/or plug planting, using material of local provenance, was undertaken in early autumn (September/October) or early spring (February/March/early April). Where opportunities arose, bare ground was also seeded with Common Bird's-foot-trefoil *Lotus corniculatus*, an important nectar source, but also the larval foodplant of other rare species such as the Dingy Skipper *Erynnis tages*. Barren Strawberry *Potentilla sterilis* and Wild Strawberry *Fragaria vesca* plug plants were also planted to benefit the Grizzled Skipper *Pyrgus malvae*. Green hay was also used on one site to encourage recolonisation of bare ground.

On unvegetated sites semi-circular or arc-shaped bunds, typically 50 m x 15 m dimensions, were created by bulldozer. These butterfly banks are similar in construction to bee banks and provide topographic diversity, important on wetter sites, as drainage is improved. The bunds also create a range of aspects, so that in drier years when many foodplants become droughted, there will be some on north-facing aspects that remain in

Jane Ellis

Secondary calcareous grasslands, such as this active quarry provide important Small Blue breeding habitat in Warwickshire

Keith Warmington

Keith Warmington

Removal of dense scrub is often the first stage of restoring Small Blue sites

Keith Warmington

Keith Warmington

Butterfly banks and scrapes add topographical diversity as well as create new habitat

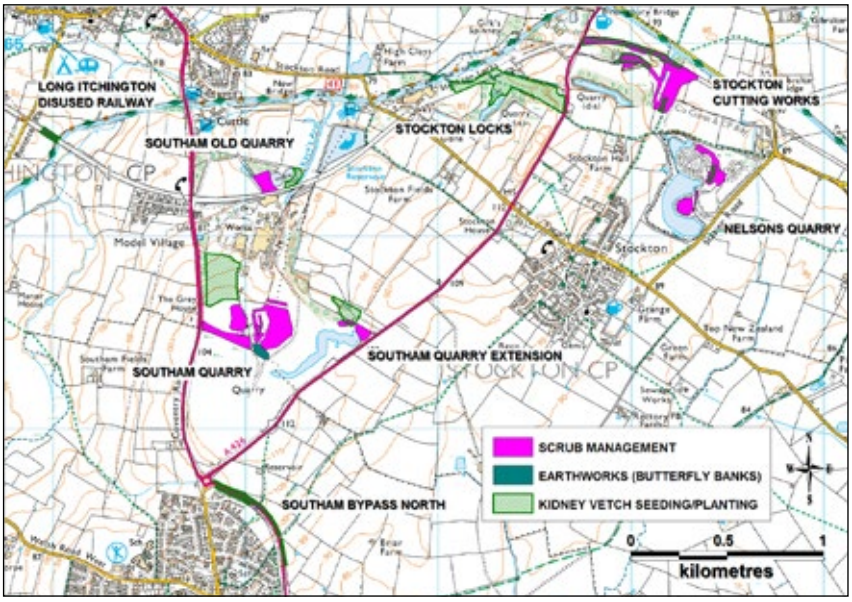


Figure 1 Part of the central Southam Lias Grassland landscape, Warwickshire, showing management undertaken on eight sites in 2009-12 targeted at reversing the decline of the Small Blue. Managing sites along the road verges and disused railways not only produces potential breeding habitat but is also likely to improve connectivity

suitable condition for breeding.

Several different designs were employed to determine which produced the most cost-effective and suitable Small Blue habitat in the shortest time. Banks were created using existing topsoil or underlying subsoil and either left to colonise naturally, or seeded or planted with Kidney Vetch. The Small Blue typically occurs in small populations (<30 individuals at peak in most years) and is normally highly sedentary with adults rarely moving more than 40 m and males being more sedentary than females. As well as providing additional habitat, butterfly banks can potentially act as stepping stones to improve connectivity between fragmented sites, which may be beyond the typical colonising distance of this butterfly.

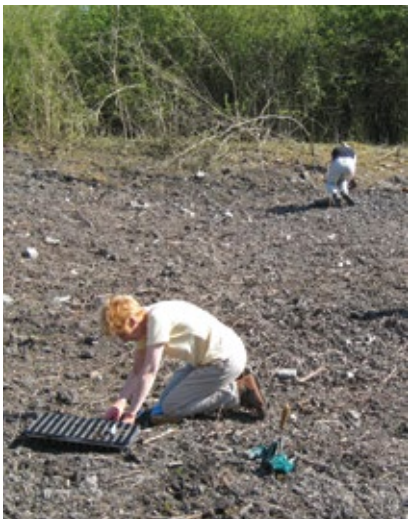
Topographical diversity was also enhanced by removing topsoil and creating 5-7 m long eye-shaped scrapes. Some of the scrapes were seeded with Kidney Vetch whereas others left to colonise naturally. As scrapes tend to be damper than their surrounds, established plants will be less susceptible to drought in drier years.

Land management results

Between February 2009 and February 2012, some management was undertaken on 86% of sites in the landscape (Table 1). Nearly 35 ha scrub was removed on 22 sites (Figure 1). On sites with deep litter layers, scrub management was followed by raking off leaf litter or scraping with a digger. Butterfly banks were created on 14 sites. Two-thirds were created using subsoil and the remaining third with topsoil. As natural colonisation proved to be largely unsuccessful, nearly two-thirds of banks were seeded. Scrapes were dug on just two sites and all were eventually seeded as again no evidence of natural colonisation was detected. Unsuccessful natural colonisation of desirable plants tended to occur on nutrient-rich soils where ruderal species flourished.

Kidney Vetch seeding was undertaken across 25 sites and over 13,000 plug plants were planted on 14 sites (Figure 1). Numbers planted varied from 250 to 3,000 per site. 24 sites were seeded with Common Bird's-foot-trefoil and 1,000 Barren

Keith Warmington



Larval foodplant populations were augmented by seeding or plug planting with Kidney Vetch on many sites

and Wild Strawberry plug plants were planted on two sites. Over 30 ha of potential breeding habitat was established through a combination of seeding and plug planting.

Land management costs for this project were around £68k, comprising £55k scrub control, £3k on earthworks, £2k on seeding and £8k on plug plants. In order to sustain the project benefits landowners were encouraged to enter Environmental Stewardship schemes. To date eight sites have either entered or are pending entry to Entry Level or Higher Level Stewardship schemes.

Species response

For a site to be considered in suitable condition for the Small Blue the target was set of at least 50 flowering Kidney Vetch plants at the peak flight period; anecdotal evidence suggests this is the minimum needed to support a local population. The project set a target of restoring 15 sites to suitable condition and establishing seven viable Small Blue colonies by 2012.

Between 2008 and 2011 the number of sites with some suitable Small Blue habitat present nearly tripled (Table 2). The number of sites with flowering Kidney Vetches doubled between 2009 and 2011 and the number with over 50 flowering plants increased from six to 10. With the exception of two sites where numbers were estimated at 5,000 per site in each year, we estimate the number of flowering Kidney Vetches increased on the rest by around 75% between 2009 and 2011.

The Small Blue has quickly responded to the habitat improvements (Figures 2 and 3). Habitat patches restored on existing sites were quickly colonised and by 2011 the Small Blue had colonised five new sites, a 167% increase in the number of populations. In some cases colonisations of new patches on occupied sites occurred in the same year as management was undertaken, as did two colonisations of previously unoccupied sites. The other three site colonisations occurred between one and four years following restoration. Distances to the

Sites	
No. sites in landscape	35
No. sites managed	30
Scrub management	
No. sites scrub clearance undertaken	22
Area of scrub cleared (ha)	34.2
Butterfly banks	
No. sites with butterfly banks created	14
No. butterfly banks created	27
No. butterfly banks created from topsoil	9
No. butterfly banks created from subsoil	18
No. butterfly banks seeded	17
Scrapes	
No. sites with scrapes dug	2
No. scrapes dug	12
No. scrapes seeded	12
Green hay	
No. sites restored using green hay	1
Kidney Vetch	
No. sites seeded	25
No. sites planted with plug plants	14
No. plug plants planted	13,250
Area seeded or planted (ha)	30.6
Common Bird's-foot-trefoil	
No. sites seeded	24
Wild and Barren Strawberry	
No. sites planted with plug plants	2
No. plug plants planted	1,000
Environmental Stewardship	
No. sites entered into ELS and/or HLS	8

Table 1 Management implemented on 30 current, former and potential Small Blue sites on the Southam Lias Grasslands 2009-12

Habitat or species feature

	2008	2009	2010	2011
Habitat suitability				
No. sites with suitable habitat present	6			17
No. flowering Kidney Vetches present		16,090+	17,926+	20,645+
No. sites with flowering Kidney Vetches present		7	13	15
No. sites with >50 flowering Kidney Vetches present		6	9	10
Connectivity				
Mean distance nearest occupied site (km)	3.78			3.24
Median distance nearest occupied site (km)	2.50			2.25
Small Blue				
No. extant sites	3	3	6	8
No. extinct sites	7	7	6	4
No. potential sites	13			26
No. sites with no potential habitat available	12			1
No. sites with new habitat patches occupied	0	0	2	3
No. habitat patches occupied	6			14
Total area occupied (ha)	3.73			5.51

Table 2 Habitat and species responses to management undertaken on 35 current, former and potential Small Blue sites on the Southam Lias Grasslands 2008-11

Species feature

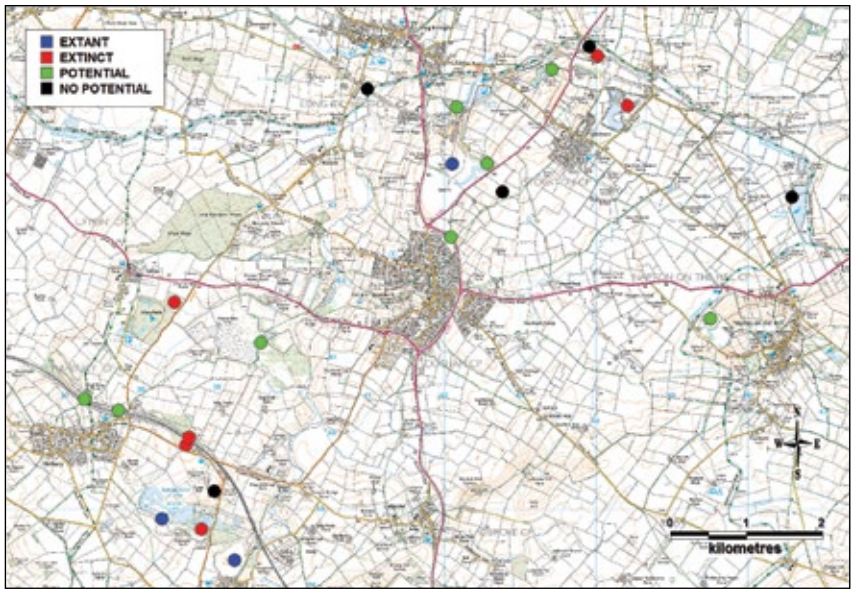
	2008	2009	2010	2011
Dingy Skipper				
No. extant sites	9	10	12	16
No. extinct sites	5	4	3	1
No. potential sites	15			18
No. sites with no potential habitat available	6			1
No. sites with new habitat patches occupied	0	0	2	2
Grizzled Skipper				
No. extant sites	16	16	17	17
No. extinct sites	4	4	3	3
No. potential sites	9			17
No. sites with no potential habitat available	6			1
No. sites with new habitat patches occupied	0	0	6	7
Chalk Carpet				
No. extant sites	2	2	3	4
No. extinct sites	1	1	1	1
No. potential sites	21			26
No. sites with no potential habitat available	11			5
No. sites with new habitat patches occupied	0	0	1	1

Table 3 Changes in status of other early successional Lepidoptera to management undertaken on 35 current, former and potential Small Blue sites on the Southam Lias Grasslands 2008-11

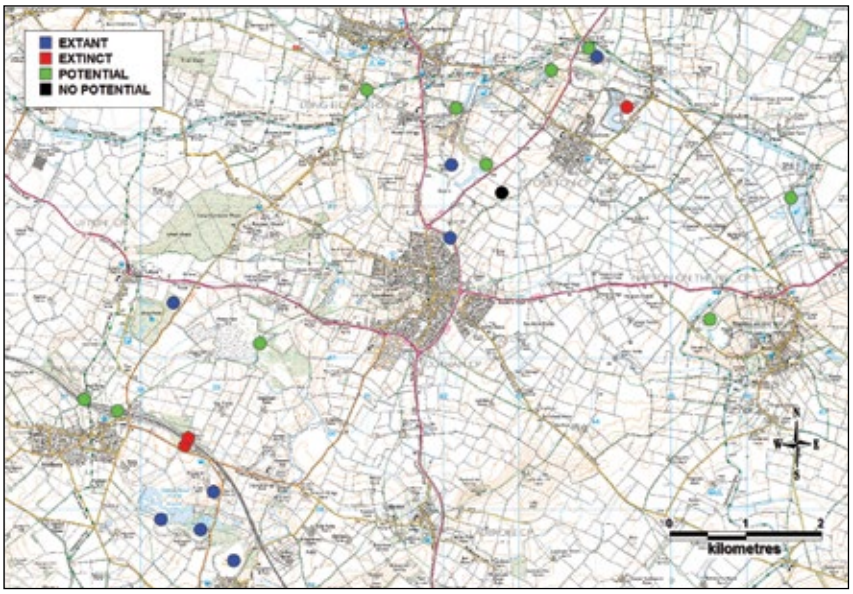
nearest occupied sites were 0.5 km for the two colonisations occurring in the same year as management, and 0.75, 2.25 and 3 km for the other three colonisations. Three of the five colonisations were of former sites. Overall the number of occupied habitat patches in this landscape more than doubled between 2008 and 2011, and the area occupied increased by 2.3 ha to 5.5 ha.

Connectivity within the landscape has improved with a reduction in the mean distance from each of the central 22 sites (see Figure 2) to an occupied site of 30% from 1.9 km to 1.3 km between 2008 and 2011. Corridors in the landscape include two canals, one active railway line, two disused railway lines and the verges along two A roads and one motorway. Two-thirds of sites managed to date are on or adjacent to one of these corridors. Management therefore not only provides potential breeding habitat but contributes to improved connectivity through habitat creation or enhancement schemes or by for example, removing scrub from embankments. Moreover, creation of flower-rich field margins through Environmental Stewardship schemes on some sites, is also likely to further improve connectivity, if not provide breeding habitat. Circumstantial evidence of the importance of corridors is provided by a Small Blue record on the disused railway, equidistant between an established colony and a recently colonised site, about 3 km apart.

Management targeted at the Small Blue has also clearly benefited several other threatened species (Table 3). The Grizzled Skipper has colonised one new site, but has also colonised new patches cleared of scrub on seven existing sites. The Dingy Skipper has also colonised restored patches on two existing sites, and more significantly colonised seven other sites, including four former sites, a 90% increase. The Chalk Carpet *Scotopteryx bipunctaria* moth colonised two new sites, increasing the number of colonies in the West Midlands region from two to four, as well colonising restored patches on an existing site. Other early successional taxa, including bees, beetles and orchids have also benefited. For example, three of Warwickshire's scarcest bumblebees *Bombus ruderarius*, *Bombus ruderatus* and *Bombus humilis* (all currently UK BAP Priority Species) have all been observed foraging on patches of Kidney Vetch created through this project.

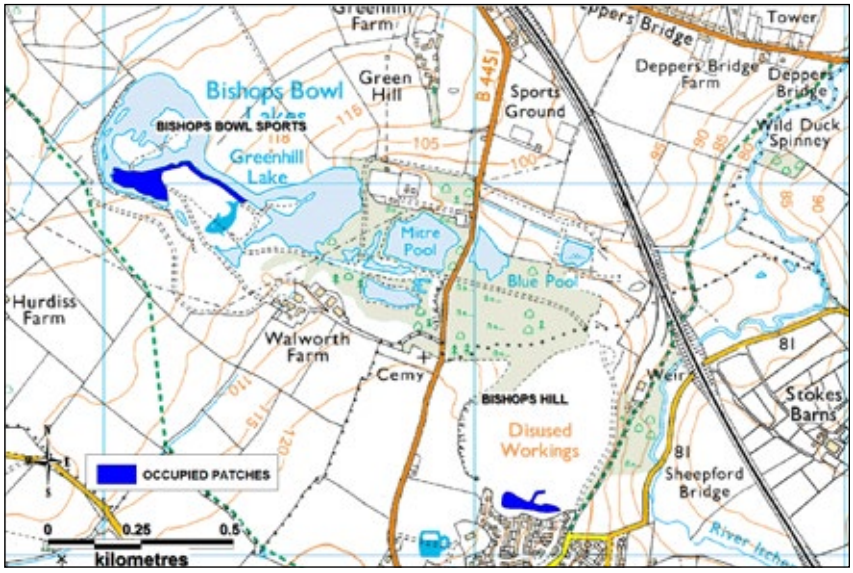


a) 2008 status

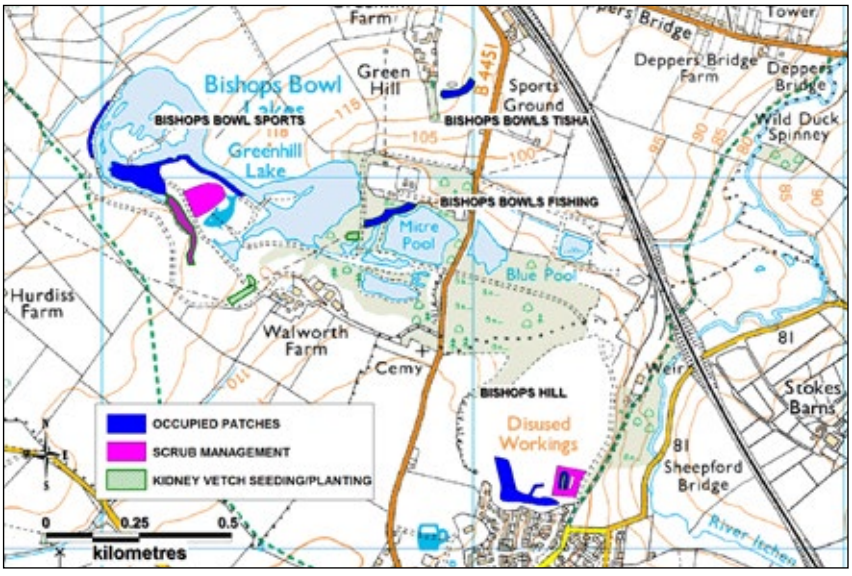


b) 2011 status

Figure 2 Changes in status of the Small Blue on the central 22 sites of the Southam Lias Grassland metapopulation, Warwickshire. The 13 outlying sites (12 potential and one former) to the south and north are omitted for clarity



a) 2008 status



b) 2011 status

Figure 3 Part of the central Southam Lias Grassland landscape, Warwickshire, showing changes in Small Blue patch occupancy between 2008 and 2011 following targeted management during 2009-12. Other potential habitat patches restored following management are also shown in Fig 3b

Building local partnerships

Talks and training days have been held to recruit volunteers to help with scrub management, raising and planting plug plants, seeding and butterfly and moth monitoring. Between October 2009 and February 2012 for example, volunteers contributed nearly 450 volunteer days of practical management. Volunteer community 'friends of' groups have been established at three sites. Several primary schools have taken an active part in the project, not only by undertaking site visits but also growing Kidney Vetch plants which are then planted on site. To bolster the core volunteer team, other volunteer groups have helped with practical tasks, including Warwickshire Wildlife Trust, Sustrans and British Waterways. Two company corporate groups have given practical support and the National Probation Services Community Payback Team has been invaluable. In Bishops Itchington, the local community centre and café has been renamed the Blue Butterfly Café, indicative of the local interest generated by the project. A thriving Small Blue Action Group comprising the partner organisations has also been established to coordinate the project and volunteer efforts.

Key lessons

This project has demonstrated that, with adequate resources, it is relatively easy to restore limestone grassland and brownfield landscapes to provide the early successional habitat required by the Small Blue. Restoration was also relatively quick, partly the result of seeding and plug planting Kidney Vetch. This is perhaps a more acceptable approach

in this landscape because most sites were either badly degraded or had only been recently created. Colonisation by the Small Blue from sites up to 3 km distant also occurred over a much shorter timescale than anticipated, mostly within a year or two of management. No doubt the seeding and plug planting programme contributed to this rapid response.

Some management techniques proved more successful than others. Seeding Kidney Vetch, for example, was more successful than plug planting because the latter are more susceptible to drought and disturbance by animals. The effectiveness of innovative management techniques such as butterfly banks and scrapes may take longer to ascertain but much useful knowledge has already been gained. Three new management factsheets, available as downloads from the Butterfly Conservation website, have been produced based on knowledge gained: *Creating a Butterfly Bank; Creating a Scrape; Seeding and Plug-planting for Butterflies.*

To date an additional 2.3 ha of habitat has been occupied by the Small Blue, yet nearly 30 ha has been seeded or plug planted and over 30 ha scrub removed. Beyond this restoration phase, it is reasonable to assume that many more habitat patches and sites will come into suitable condition and eventually be colonised by the butterfly.

The project also demonstrated that management targeted at a single species can have major benefit for other threatened Lepidoptera using the same early successional habitat. In this case the Small Blue has been an effective 'flagship' or 'umbrella' species for the Dingy Skipper, Grizzled Skipper and the Chalk Carpet moth; there were significant increases in occupancy at both the site and patch level for all these species.

Keith Warmington

The Small Blue colonised this site a few years after Kidney Vetch plug planting and seeding. Restoration and creation of linear sites such as roadside embankments not only provides breeding habitat but improves connectivity

Sam Ellis

The Blue Butterfly Café in Bishops Itchington

Landscape-scale woodland restoration for multiple species in the South East Woodlands

Dan Hoare, Kate Dent, Caroline Kelly, Laura McLellan, Fran Thompson and Steve Wheatley

Neil Hulme

The Duke of Burgundy has thrived in both the Denge and Tytherley Woods, bucking the national trend (down 46% over 10 years)

Introduction

Many of our most threatened woodland butterflies and moths are associated with open habitats such as clearings and rides. We demonstrate the value of targeted management in reversing these declines at the landscape-scale in South East England, one of the UK's most heavily wooded regions. We suggest that economic forestry alone appears unlikely to produce the highest quality habitat for these species, without the targeting incentives included within woodland grant and agri-environment schemes.

Butterflies such as the Pearl-bordered Fritillary *Boloria euphrosyne* and Duke of Burgundy *Hamearis lucina,* occupying the early succession habitats produced by coppicing and clear-felling, have gone from being widespread species in wooded landscapes to surviving only in a few isolated colonies (population declines of 61% and 28% respectively since the 1970s (Fox *et al.*, 2006)). These losses are the result of large-scale changes in woodland management systems (such as the decline of coppicing), and are indicative of a wider decline in woodland wildlife associated with a loss of structural diversity in woodlands (Thomas and Morris, 1994; Clarke *et al.*, 2011).

Reversing these losses will require not only targeted management on and around remaining sites, but also an increase in woodland management activity at a much wider scale, driven by economic factors and public policy. The South East Woodlands project aimed to reinvigorate woodland management at a landscape-scale, using butterflies and moths as indicators of diverse, well-managed habitats, demonstrating how to engage local communities and land managers in conserving biodiversity through sustainable woodland management. The project included work on many different butterfly and moth species occupying a variety of habitats, but the Pearl-bordered Fritillary and Duke of Burgundy are used as examples in this case study.

Project methods

Between 2007 and 2011, the project focused on three landscape-scale demonstration areas, in Kent, East Sussex and on the Hampshire/ Wiltshire border, covering a total of 83,561 ha (see Figure 1 and Table 1). These project areas all contained significant assemblages of scarce woodland Lepidoptera, but had not previously been the focus of conservation initiatives at a landscape-scale. The landscapes differed in several important factors including the size, type and distribution of woodland, the nature of the intervening non-woodland habitats, and the suite of butterfly and moth species present. This provided an opportunity to examine local differences as well as testing mechanisms that would be effective at promoting increased management across the whole region.

In each landscape a full-time project officer worked for three years to achieve three overall aims: 1) to increase woodland management across the landscape by promoting best practice woodland management for a broad suite of wildlife including butterflies and moths, 2) to target specialised habitat management for key species (such as Pearl-bordered Fritillary and Duke of Burgundy), building networks of suitable habitat and strengthening local populations, 3) to engage communities in conservation action in their local area, providing opportunities for volunteers to take an active role in enhancing woodland biodiversity.

Richard Mearns

The rare Argent & Sable moth has responded well to management in the Tytherley Woods landscape, breeding in coppiced woodland, ride edges and clearings and recolonising sites where it has not been seen for many years

Dan Hoare

Dan Hoare

Habitat restored by clearance of non-native conifers in the Tytherley Woods in 2008 was colonised by the Pearl-bordered Fritillary in 2010

Project officers worked with partner organisations to plan and implement sustainable woodland management appropriate to the landscape. We gave free advice and assistance to woodland managers, agents and owners, providing information on the ecological requirements of butterflies and moths present in the area, explaining how to incorporate these features alongside other management aims such as forestry, game management and recreation. Although the main aim of the project was to promote woodland management, we also provided advice and support on non-woodland sites, which formed a key part of the landscape habitat network.

We used a range of funding mechanisms to support habitat management:

1) Economic forestry is the most sustainable method of funding woodland management, through the sale of timber, firewood, woodchip, charcoal and other coppice products. We encouraged economic forestry where appropriate by helping woodland owners to access markets for their products, providing links to woodland agents and the forestry sector, running workshops on coppice management, harvesting and woodfuel, and producing management plans to assist owners in harvesting their wood sustainably.

2) Grant aid from Forestry Commission England (FCE). FCE were major partners in the project,

Dan Hoare

A close encounter with a hawk-moth at a Rother Woods public event

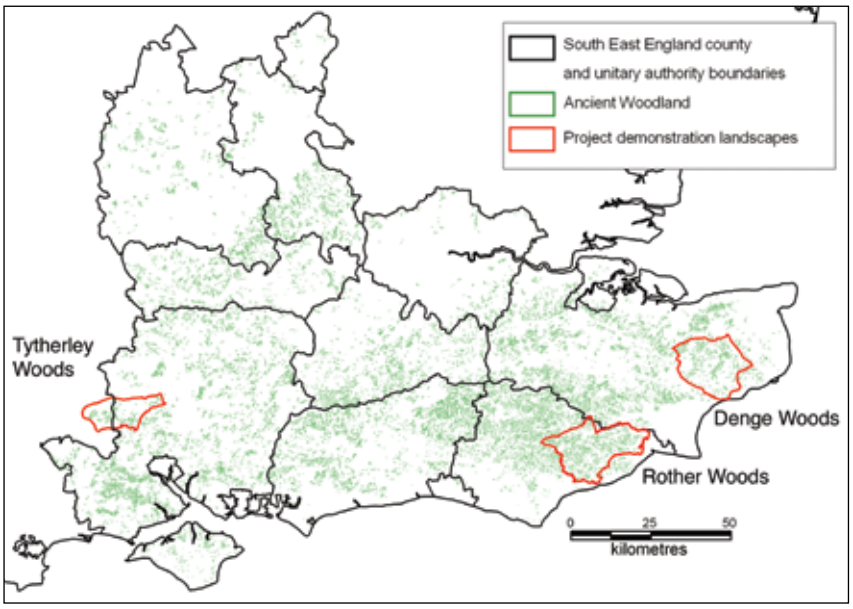


Figure 1 Location of the three South East Woodlands project demonstration landscapes

allocating more than £550k across the three project areas through the English Woodland Grant Scheme (eWGS) between 2007 and 2013. This included a special Woodland Improvement Grant (BIO80 WIG) targeted at the demonstration landscapes, paying 80% of standard costs compared to the 50% rate available across the region. During the course of the project, these grants were increasingly directed towards improving woodland infrastructure, such as tracks, ditches and loading bays, to facilitate long-term woodland management beyond the fixed term of the project.

3) Grant aid from Natural England, through the Entry Level Stewardship and Higher Level Stewardship schemes, was used to support management costs on some non-woodland habitats such as grassland and farmland. This mechanism was particularly effective in the Denge Woods landscape in Kent, where colonies of Duke of Burgundy and Black-veined Moth *Siona lineata* survive on chalk grassland alongside woodland colonies.

4) Funding from the Landfill Communities Fund (SITA Trust, Biffa Award) and from the High Weald AONB Sustainable Development Fund paid for targeted management for butterflies on three sites. A total of £136k was raised from these sources to implement specific management for threatened butterflies in the demonstration landscapes.

5) Direct funding from the landowner. At some sites landowners were able to directly fund woodland management themselves, often because it met multiple aims for them, including improving woodland structure for forestry reasons, game management, recreation and access or conservation benefit.

6) More than 40 conservation work parties by volunteers delivered additional habitat improvements close to existing colonies of the target species.

A variety of management techniques were used across the project areas, but the broad aim was to increase the structural diversity of woodland sites, providing a mix of open, sunny clearings connected by wide rides, alongside mature woodland, scrub of varying ages, regenerating woodland and coppice. The Pearl-bordered Fritillary and Duke of Burgundy both require open habitats in woodland, where their larval foodplants (Common Dog-violet *Viola riviniana* and Primrose *Primula vulgaris* or Cowslip *Primula veris*, respectively) grow in sunny, sheltered conditions. Both species were principally associated with coppice, although there are now relatively few sites where active coppice management has been maintained on a cycle sufficient to support them. Pearl-bordered Fritillary is now strongly associated with Bracken *Pteridium aquilinum* in clearings and rides, and uses conifer clear-fells in the early stages of regeneration, while the Duke of Burgundy tends to be found in permanent, scrub-rich woodland clearings. Management targeting these species included clearing derelict coppice, widening rides, clear-felling non-native conifer plantations to promote natural regeneration of broadleaved woodland, cutting and grazing permanent clearings, managing scrub on open areas and promoting deer management. The Duke of Burgundy is also found on chalk grassland sites in the Tytherley and Denge landscapes, and management of these sites included cutting scrub and modifying grazing regimes to promote tall, Cowslip-rich swards with a high (15-20%) cover of scattered scrub.

Steve Wheatley

Although project funding has now ended, Rother Guardians volunteers continue to help landowners with monitoring and habitat management

In each landscape we assessed woodland management activity and habitat condition for the target species at the start and end of the project for all holdings where access was possible. With the help of volunteers we carried out general butterfly and moth surveys to inform future management and provide landowners with information on the species using their land. We also monitored sites for the target species in each landscape to examine their responses to habitat changes.

Land management results

To monitor management change at such a large scale we divided each landscape into distinct woodland sites, usually reflecting ownership holdings. We classified each site according to whether there was evidence of active management taking place within the last three years (based upon signs of any one of: ride management or creation, coppicing, thinning, clear-felling or selective felling). Between 2007 and 2010, the proportion of monitored woodland (by area) showing evidence of active management increased by 22% (2470 ha) across all three landscapes, and the proportion of monitored sites showing signs of active management increased by 31% (Table 1). At the end of the project, 73% of all woodland sites showed evidence of some management, accounting for 87% of the total woodland area monitored. Ride management was the most frequent form of management, with coppicing and thinning also common, while clear-felling was the least frequently used.

As this analysis took place at quite a coarse scale (woodland sites), we collected additional information for the Tytherley Woods landscape in 2011 to assess management

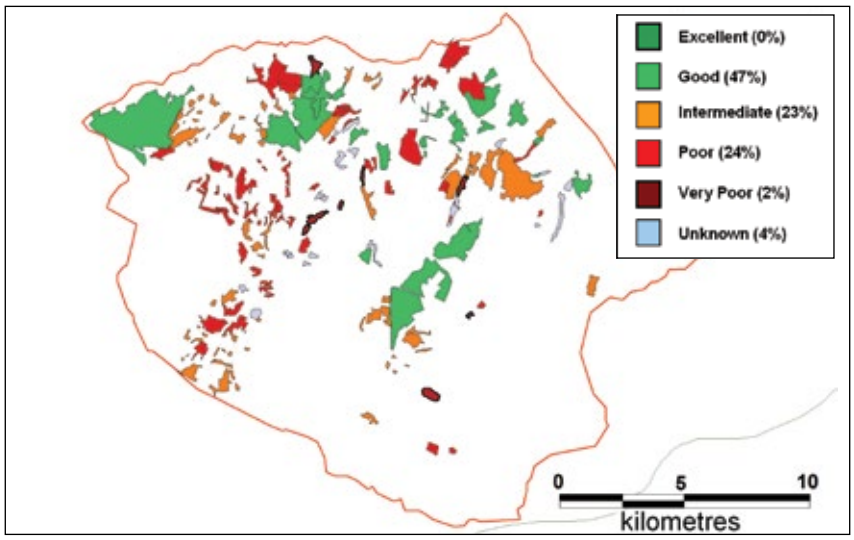
Denge Woods (Kent)	Rother Woods (East Sussex)	Tytherley Woods (Hampshire/Wiltshire)	Total
Landscape description			
Part of the Kent Downs AONB, with mixed conifer and broadleaf woodland on clay plateaus and chalk grassland on the steeper slopes. Coppice species include Sweet Chestnut and Hornbeam.	Part of the High Weald AONB, with very numerous, mostly small woodland fragments, on sandstone ridges separating river valleys. Numerous conifer plantations on ancient woodland sites, and very extensive Sweet Chestnut coppice.	A mosaic of woodland, chalk grassland, arable and livestock farming. Ancient semi-natural woodland includes several areas of high forest dominated by oaks, as well as Hazel coppice with oak standards and extensive conifer plantations on ancient woodland sites.	
Priority species			
Duke of Burgundy, Dingy Skipper, Grizzled Skipper, Black-veined Moth, Drab Looper	Pearl-bordered Fritillary (extinct), Grizzled Skipper, Dingy Skipper, Clay Fan-foot	Pearl-bordered Fritillary, Duke of Burgundy, Small Pearl-bordered Fritillary, Argent & Sable, Drab Looper	
Partner organisations			
Kent Downs AONB, Forestry Commission England, Natural England, Woodland Trust, Kentish Stour Countryside Project	High Weald AONB, Forestry Commission England, Natural England, Woodland Trust	Hampshire County Council, Forestry Commission England, Wiltshire Wildlife Trust, Bentley Wood Trust, National Trust	
Total landscape area			
31,253 ha	34,945 ha	17,363 ha	83,561 ha
Area of woodland monitored			
3,929 ha	4,441 ha	2,521 ha	10,891 ha
Number of woodland sites monitored			
78	108	98	284
Total area managed* 2007 (% of monitored woodland)			
2,777 ha (70)	2,633 ha (59)	1,647 ha (65)	7,057 ha (65)
Total area managed 2010 (% of monitored woodland)			
3,442 ha (87)	3,742 ha (84)	2,343 ha (93)	9,527 ha (87)
Increase in managed area (% increase in proportion of woodland area managed)			
665 ha (17)	1,109 ha (25)	696 ha (28)	2,470 ha (23)
No. of sites coming into management (% increase in proportion of sites managed)			
32 (33)	39 (36)	19 (24)	90 (31)

*The total area of all woodland blocks in which some management took place - note that the actual area of open habitat created is less, see text for details.

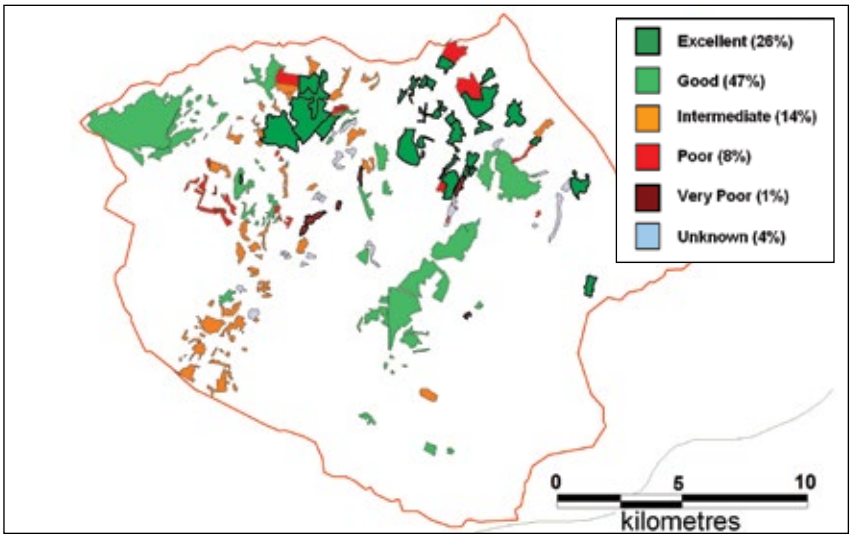
Table 1 The South East Woodlands landscape demonstration areas

activity in more detail. Examining the nine major ownerships within the landscape, totalling 1,231 ha, the total area of the 207 habitat patches managed was 106 ha. So although at the coarse scale, 93% of woodland sites by area were classified as 'managed' in 2010 (i.e. some management was taking place within the site), in fact the area of open habitat created by management was only about 8% of the total woodland area. This emphasises that although the project increased both the amount and the distribution of management, even at the end of the project only a very small proportion of the total woodland area comprised open, early succession habitat – more than 90% of the woodland area was not actively managed during the project.

We also examined woodland habitat condition for Lepidoptera at the start and end of the project, classifying woodland blocks according to the presence of key habitat features such as temporary and permanent open space, and ride condition. Across all three landscapes we improved habitat condition at 160 sites (65% of those monitored). The proportion of woodlands (measured by area at the level of woodland sites) in Good or Excellent condition for Lepidoptera increased by 32% during the project (Table 2). By 2010, 62% of the woodland area was in at least Good condition, demonstrating that this approach can improve habitat conditions for Lepidoptera across a very wide area. Figure 2



a) Woodland condition 2007



b) Woodland condition 2010

Figure 2 Habitat condition assessment in the Denge Woods landscape 2007-2010 (see Table 2 footnote for definitions of categories)

	Denge Woods (Kent)		Rother Woods (East Sussex)		Tytherley Woods (Hampshire/Wiltshire)		Total	
Habitat condition*	% of woodland area in each condition class (based on woodland sites)							
	2007	2010	2007	2010	2007	2010	**2007**	**2010**
Excellent	0	26	0	11	27	27	**6**	**20**
Good	47	47	17	45	0	31	**24**	**42**
Intermediate	23	14	48	36	44	34	**38**	**28**
Poor	24	8	34	8	6	3	**24**	**7**
Very poor	2	1	1	0	0	0	**1**	**0**
Unknown	4	4	0	0	23	5	**7**	**3**

** Project Officers assigned a Habitat Condition to each woodland site on a 1-5 scale from Very Poor (no suitable open habitats of any kind) to Excellent (Containing all five of the following features: wide interconnecting rides; two- or three-zone ride management; temporary open space; permanent open space; a variety of native broadleaf tree species), or scored sites as Unknown.*

Table 2 The impact of management on habitat condition in the South East Woodland demonstration areas

	Denge Woods		Rother Woods		Tytherley Woods		Wider region		Total	
	No. of events	People	No. of events	People	No. of events	People	No. of events	People	No. of events	People
Introductory events	53	1,960	22	849	16	1,113			**91**	**3,922**
Volunteer training	20	315	27	521	34	235	13	340	**94**	**1,411**
Land management workshops	8	95	11	333	6	130	14	353	**39**	**911**
Site advice visits for land managers	92	64	72	60	52	25	45	39	**261**	**188**
National woodland conference							1	395	**1**	**395**
Totals	**173**	**2,434**	**132**	**1,763**	**108**	**1,530**	**73**	**1,127**	**486**	**6,827**

Table 3 Participation in South East Woodlands project events. Note that as some individuals attended multiple events, numbers do not represent the total number of unique participants – we estimate that there were at least 5000 individual participants overall

demonstrates how these changes in habitat condition affect the suitability of the Denge Woods landscape for butterflies and moths. At the start of the project in 2007 a few large sites were in Good condition, including three Forestry Commission sites, but these were isolated from each other by large numbers of smaller, privately owned sites, many of which were in Poor condition (26%), holding little or no open habitat for butterflies.

By 2010, only 8% of the area was in Poor or Very Poor condition, while 26% of the area was in Excellent condition. Many of the smaller private woodlands in the north and central part of the project area had improved in habitat condition by 2010, with 73% of the area in at least Good condition for butterflies and moths.

The mechanisms underlying changes in woodland management were complex and differed across the three landscapes depending on factors such as woodland type and access to local woodland markets. Grants from FCE's English Woodland Grant Scheme were the primary funding mechanism in the project, supporting management across 4,687 ha (44% of the 10,609 ha included in this analysis). In total, more than £550k in eWGS grants has been allocated to the demonstration landscapes from 2007-2013,

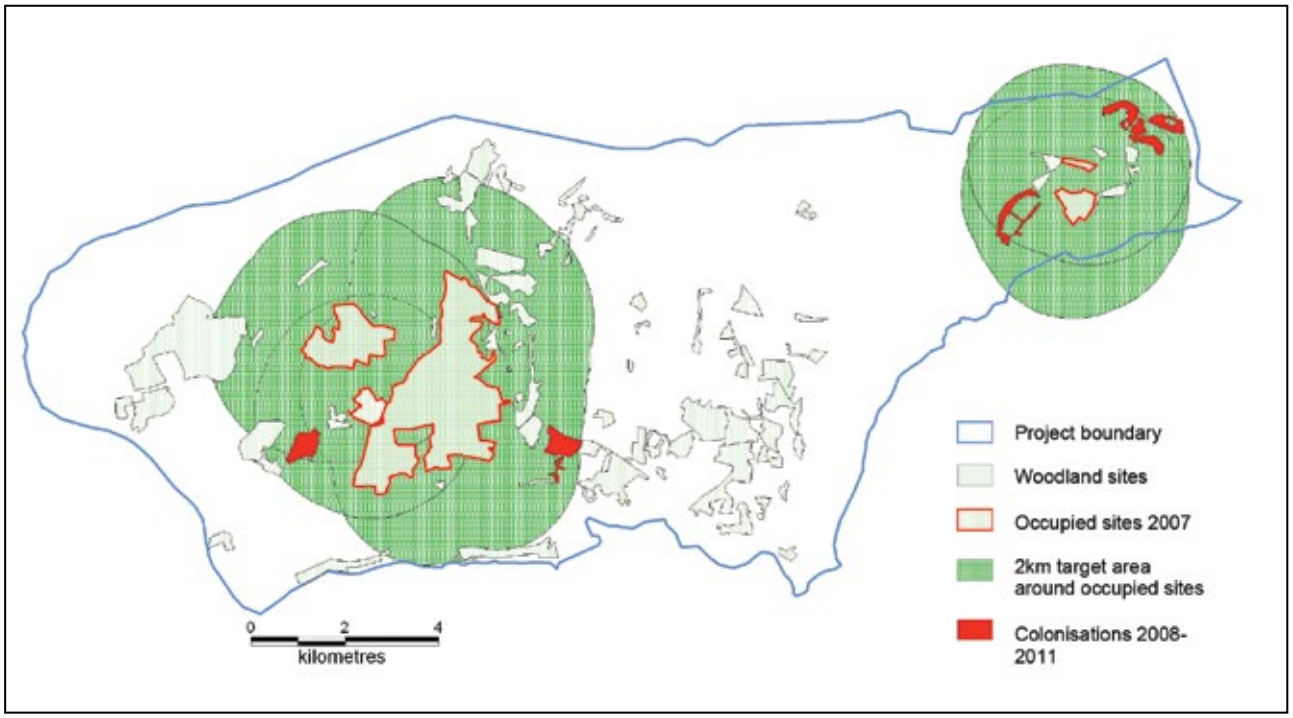


Figure 3 Conservation of Pearl-bordered Fritillary in the Tytherley Woods 2007-2011. In 2007 we prioritised advisory work and conservation management within 2 km of occupied sites, as previous studies suggested the species can readily colonise suitable habitat over this distance. Over the next four years seven woodland sites were colonised following increases in appropriate management, all within the 2 km priority areas. Suitable habitat was also created elsewhere in the landscape but so far remains unoccupied

including support for management planning, habitat management and infrastructure development. Economic management (using the value of timber or other products) supported management across 1,720 ha of woodland (16% of the total). It should be noted that the increase in woodland management recorded is at least partly due to improvements in the market for woodland products, particularly firewood, at a national level during the course of the project, an encouraging sign that sustainable management can be continued. However, eWGS grants were more effective than economic management in delivering the highest quality habitat for Lepidoptera: eWGS was the primary funding source for 77% of all woodland in Excellent condition and 47% of all woodland in Good condition (by area), compared to economic management, which funded 3% of Excellent and 31% of Good woodland. We conclude that while it makes sense to rely on sustainable economic forestry where possible to increase woodland management, the evidence from this study is that targeted grants, which have biodiversity as part of their aims, are far more effective in producing high quality habitat of the sort needed for threatened species such as the Pearl-bordered Fritillary.

Species response

Pearl-bordered Fritillary and Duke of Burgundy were monitored on their known sites and searched for in all suitable habitat between 2007 and 2011. Although in many cases woodland management work did not get underway for one or two years, both species have already started to show strong positive responses to improved habitat condition.

In the Tytherley Woods landscape, 16 habitat patches were created for Pearl-bordered Fritillary through a SITA Trust grant in 2007-08. All of these patches produced suitable breeding habitat within

four years, and 75% of them were colonised by the butterfly over the same period. Other UK BAP Priority species recorded on these patches included Duke of Burgundy, Small Pearl-bordered Fritillary *Boloria selene,* Dingy Skipper *Erynnis tages,* Argent & Sable *Rheumaptera hastata* and Drab Looper *Minoa murinata.* Pearl-bordered Fritillary recolonised seven former sites in the Tytherley landscape during the project, travelling at least 2 km from the nearest extant colony to breed in newly managed clearings and rides. The butterfly now occupies more sites (5 in 2006, 12 in 2011) and is stable or increasing in most of these (Figure 3). In contrast, outside these landscape areas, Pearl-bordered Fritillary has been lost from at least three of the other 10 sites in South East England over the same period (excluding reintroduction sites).

In the Rother Woods landscape, thorough searches confirmed that the Pearl-bordered Fritillary was extinct, and a project was developed to reintroduce the species to a private woodland site at which coppice management had been reinstated as part of a woodfuel business. After careful assessments of habitat suitability and management, Pearl-bordered Fritillaries were released here in 2010 (captive-bred by project volunteers) and their offspring were recorded on the site in 2011.

In 2007, the Duke of Burgundy was in a perilous state in Kent, with a peak count of just 11 butterflies on two sites in the Denge Woods landscape. By 2010 the population had increased to a combined peak count of 173 butterflies across 10 sites. This was in part due to the discovery of at least two previously unrecorded colonies through increased survey work, but also to improved management of existing sites and the colonisation of recently restored habitat, encompassing chalk grassland sites in Environmental Stewardship as well as woodland sites. We also assessed seven new woodland habitat patches totalling 8 ha created with funding from Biffa Award in 2010; in 2011, four had already produced suitable habitat for Duke of Burgundy and two were being used for breeding by the butterfly. In just four years the species has been restored to a network of suitable sites within the Denge landscape, increasing from two occupied 1 km squares to nine.

Building local partnerships

Involving local communities, from landowners to the wider public, was essential to initiate large scale management changes. We focused on showing people the special qualities of their local sites and helping them understand the links between wildlife and woodland management, to enlist their support in increasing management activity in each area. Through a major programme of public events and training we increased the involvement of local people in conserving woodland landscapes. Training was structured in four tiers of activity, from events for the general public through training for volunteers and land management professionals to individual site advice visits for landowners (see Table 3).

These events proved highly effective, with more than 6800 people taking part in a programme of 486 events. The events programme was designed to offer a progression of involvement for participants, so that a member of the public attending a guided walk could subsequently get involved as a volunteer, receive training and then get involved in monitoring and habitat management. 17% of volunteers had never previously volunteered with a conservation organisation, and 69% were not members of Butterfly Conservation, demonstrating that the project successfully reached new audiences as well as supporting existing conservation volunteers. Training ranged from butterfly monitoring and moth identification to use of chainsaws and brushcutters in practical management. Volunteers subsequently contributed more than 1080 days involvement in project activities, equivalent to £87k in labour costs, making an important matched funding contribution to the project and allowing us to achieve far more than we could through staff activity alone.

An important part of the project's legacy was to encourage groups of committed volunteers to continue conservation action in each area after project funding ended. These volunteer groups of 'Woodland Guardians' are still actively involved in all three landscapes, supported by Butterfly Conservation local Branches and partner organisations. Through a combination of conservation work

parties, support and advice for land managers, and closely monitoring the results of management changes, volunteers are helping to ensure long-lasting benefits from the project.

Key lessons

This project has combined broad, landscape-scale increases in woodland management activity with the targeted habitat improvements necessary to reverse the declines of some of our rarest butterflies and moths, developing mechanisms that can be applied much more widely in support of biodiversity (see Hoare *et al.* (2012) for further details). Overall, we have demonstrated that:

1) There is a significant audience of land managers, woodland management professionals and the general public who are keen to get involved in improving woodland biodiversity when given information and support.

2) Woodland management can be increased on a dramatic scale through a combination of information, targeted grant aid and support for economic forestry. But economic forestry alone is unlikely to deliver the highest quality habitats, at least for Lepidoptera, without specific targeting and incentives to include key habitat features of the kind that are included in eWGS BIO80 WIG grants or in Higher Level Stewardship.

3) Populations of threatened species can respond rapidly to appropriate management, where it provides networks of suitable habitat at a sufficient scale. If suitable habitat management is delivered in targeted locations (close to existing colonies) this approach can succeed with relatively modest changes to the overall landscape. In this study, population increases and new colonisations for both Pearl-bordered Fritillary and Duke of Burgundy butterflies were detected when less than 10% of the woodland area was subject to management.

4) Project officer roles can be a very effective way of uniting existing land management mechanisms around a set of focused objectives to deliver results at a landscape-scale. They can act as a hub for a wide range of activities, helping land managers to access public grants, coordinating management across multiple sites, supporting volunteers and connecting them with land managers to encourage accurate monitoring of management impacts. A key factor in this success is the time to build relationships with landowners and project partners, as well as getting to know a landscape in depth.

5) Working in partnership with other organisations can be hugely beneficial, sharing local expertise, avoiding duplicating effort and providing landowners with clear messages and effective support.

6) Volunteer involvement greatly increases what can be achieved with limited resources, if appropriate training and support are provided.

This project provides an effective model for influencing land management at a landscape-scale, delivered by a combination of staff, volunteers and partnership between public bodies, non-governmental organisations and private landowners, with both habitat condition and threatened species serving as indicators of success.

Delivering land management advice for Marsh Fritillary in Scotland

Tom Prescott

Peter Eeles

Adult Marsh Fritillary butterfly

Introduction

The Marsh Fritillary *Euphydryas aurinia* is as closely linked with extensive pastoral farming systems in Scotland as it is in other parts of the UK. The main mechanism for its conservation across the landscape in Scotland is through agri-environment schemes. We describe here the benefits of working in partnership with land managers and their agents to maximise biodiversity gains under the current mechanism. We also highlight the need to establish appropriate monitoring systems and amend the assessment criteria to favour high priority species such as Marsh Fritillary gaining entry into the scheme.

The Marsh Fritillary is a species of the highest conservation concern due to severe declines in its population and range. It is included on the Scottish Biodiversity List and as one of Scottish Natural Heritage's (SNH) Species Action Framework species; the latter being a means of helping to deliver the Scottish Biodiversity Strategy by prioritising 32 species that were the focus of new, targeted management action for five years from 2007. The thrust of the Species Action Framework programme is through the delivery of sympathetic land management rather than via research, survey or monitoring.

The Marsh Fritillary has a very limited distribution in Scotland, predominantly occurring in the western fringes of Argyll and some of the neighbouring islands. However, these colonies represent some of the most important in Europe. The butterfly has become extinct over a large part of its former range in England, Wales and Northern Ireland, whilst even in Scotland it has declined in distribution by around 12% since the mid-1980s with an overall UK distribution decline of 46% between 1970-1982 and 1995-2004 (Fox *et al.*, 2006). Declines in abundance have been even steeper at 73% between 1983 and 2004 (Fox *et al.*, 2006). Despite conservation efforts, the butterfly still declined in distribution by 9% between 1995-99 and 2005-09 (Fox *et al.*, 2011).

The Marsh Fritillary requires abundant patches of Devil's-bit Scabious *Succisa pratensis,* the sole larval foodplant. In order to persist within a landscape, an extensive network of well connected habitat patches is required (Bulman *et al.,* 2007).

In Scotland the Marsh Fritillary occurs in a wide range of different habitats including damp/wet and species-rich grassland, rush pasture,

damp moorland and coastal heath. It also occurs in a variety of settings away from the more traditional unimproved grasslands, including road and trackside verges, woodland and forestry glades/clearings, the margins of hay/silage fields and from upland heaths to coastal grassy swards. Maintenance of suitable habitat is best achieved through light, often seasonal grazing, ideally by cattle or ponies/horses, or even sheep at low densities. The future of the Marsh Fritillary in Scotland, therefore, is inextricably linked to the future of traditional agriculture in a remote corner of the UK. In addition, due to the varied nature of Marsh Fritillary sites in Scotland, their non-uniformity and uniqueness, a standard grazing prescription that fits all sites is not appropriate. This is in stark contrast to the standard management prescriptions that have been applied successfully at sites for other species (e.g. Corn Crake *Crex crex*, Northern Lapwing *Vanellus vanellus* and other breeding waders, Red-billed Chough *Pyrrhocorax pyrrhocorax*). Management advice for Marsh Fritillary in Scotland has to be site specific.

Tom Prescott

Typical Scottish Marsh Fritillary landscape with suitable habitat both on the shore and on the hill ground adjacent to improved fields and woodland/scrub/bracken slopes

Tom Prescott

Good quality Scottish Marsh Fritillary habitat with areas of abundant Devil's-bit Scabious

The vast majority of Scottish Marsh Fritillary colonies do not occur on designated sites (i.e. SSSIs or nature reserves), but occur in field corners or damp pockets of hill ground. Even small areas of habitat, providing they are not too isolated, are important as they contribute to a sustainable metapopulation.

Project methods

Previous contact by Butterfly Conservation Scotland with owners of Marsh Fritillary sites proved problematic. In most cases it was difficult to find out who owned or managed the land. If contact was made few owners/managers had heard of Marsh Fritillary, or Butterfly Conservation Scotland, or knew that the butterfly was present on their land. Furthermore this contact often aroused suspicion and concerns over access. In some cases sites had recently been entered into the Rural Stewardship Scheme, Scotland's former agri-environment scheme, under an unsuitable and even detrimental management regime for five or 10 years and little could be done to modify this management to enhance conditions for the butterfly.

However, in 2008 under the Species Action Framework project Butterfly Conservation Scotland employed a Specialist Advisor to provide site-specific advice to landowners/managers. This was part of a larger project that delivered specialist advice on two other Species Action Framework listed Lepidoptera: Slender Scotch Burnet moth *Zygaena loti* and Pearl-bordered Fritillary *Boloria euphrosyne,* as well as Chequered Skipper *Carterocephalus palaemon*. The appointment coincided with the launch of a new agri-environment scheme, Rural Priorities, funded under the Scottish Rural Development Programme (SRDP). Rural Priorities is a competitive mechanism to ensure that contracts

Clive McKay

Light cattle grazing is ideal at maintaining Marsh Fritillary sites in good condition

are awarded for the proposals best able to deliver agreed regional and national priorities. Previous projects in Argyll had highlighted the significance of Argyll's Marsh Fritillary population and it was thus seen as a high regional priority under Rural Priorities.

In addition, by teaming up with consultants from Scottish Agricultural College and Agrimony (an Argyll based agricultural advisory business) this allowed the Specialist Advisor to input into appropriate farm plans. Importantly, this meant that our input was focused only on suitable/ potential Marsh Fritillary habitat, rather than having to devise a whole farm plan or complete the full on-line application form. In each case a site-specific grazing plan was drawn up by the Specialist Advisor in conjunction with the farmer/ landowner and their agent. This plan took into account the habitat type, availability and type of stock and current condition of the site. This close collaboration also ensured that the resulting plan was practical. A second document outlining the importance and significance of the site for Marsh Fritillary was also produced.

Land management results

By June 2011 Butterfly Conservation Scotland had been involved with around 200 Marsh Fritillary sites and made over 170 site visits, contributing to around 140 Rural Priorities applications. Our input and expertise was looked upon very favourably by the case officers who initially assess the applications and then by the Rural Priorities Assessment Committee that determines which applications are approved, with over 90% being successful and gaining entry into the scheme.

These schemes have been across the species entire Scottish range, resulting in over 3,000 ha being managed specifically for Marsh Fritillary (Figure 1). It has also resulted in many new sites for Marsh Fritillary, and other species (e.g. Forester moth *Adscita statices* and Slender Scotch Burnet moth), being discovered. Some of these were adjacent to known sites highlighting the strength of local metapopulations whilst others were more significant being new 10 km squares, emphasising how under-recorded the butterfly still is in Scotland and/or how its range is increasing. Although the emphasis is on Marsh Fritillary, the butterfly should be seen as a flagship species as the management will also benefit other Lepidoptera including Narrow-bordered Bee Hawk-moth *Hemaris tityus* but also other taxa including Lesser Butterfly Orchid *Platanthera bifolia*, Common Reed Bunting *Emberiza schoeniclus*, Common Snipe *Gallinago gallinago* and Eurasian Curlew *Numenius arquata.*

More importantly this has allowed farmers to claim over £2m thus making the economics of farming in these fragile areas more viable with the added knock-on benefits to the local economy. In some cases new fencing and other infrastructure required to implement the grazing regime, was funded under the scheme; in addition large areas of bracken control was also supported to increase the area of suitable habitat. News soon spread that having Marsh Fritillary or suitable/ potential habitat on your farm was a good hook for getting into the scheme. Scottish Agricultural College in Argyll estimates that around one-third of all their SRDP bids have included positive management specifically targeted at Marsh Fritillary and other key butterflies and moths and that the project's involvement has significantly raised the quality of management for Lepidoptera on the ground. Scottish Agricultural College also believe most of the active land managers in Argyll have now heard of Marsh Fritillary.

This success is due to the partners combined knowledge of the butterfly's distribution and requirements, along with the consultant's local knowledge of sites and their clients, and the willingness to work together. The value of the Specialist Advisor approach has been generally acknowledged with the recent appointment of similar posts for bumblebees and lower plants.

Species response

Disappointingly there is no requirement under Rural Priorities for sites being managed for Marsh Fritillary to be monitored. However, in autumn 2011, with specific funding from SNH, 88 sites within 20 metapopulations entered into SRDP up to 2010, were monitored by contractors. The main aim of this monitoring was to determine the current condition and extent of habitat, as well as determine the

current population of the butterfly at these sites. This survey will act as a baseline so that any changes in habitat condition and butterfly abundance can be monitored in the future and compared with the prescribed management. This will help further our understanding of Marsh Fritillary habitat requirements in Scotland and provide improved management advice in the future.

Key lessons

The huge success of this project has highlighted the importance of the Specialist Advisor's role in providing site-specific advice and liaising with the land manager, their agent and the assessors of the scheme. This has increased the quality of applications and enhanced the biodiversity benefits.

Rural Priorities is a competitive scheme that is becoming increasingly difficult to enter as the current assessment procedure does not necessarily favour the best or most suitable Marsh Fritillary sites. Many owners of Marsh Fritillary sites are therefore being discouraged by their agents from applying as they are very unlikely to gain entry into Rural Priorities, but would still have to fund an unsuccessful submission. There is therefore an urgent need to amend the scoring system used to assess applications.

Payment rates for the various management options in Rural Priorities are heavily biased towards in-bye land (enclosed fields used mainly for arable and grassland production), with rates for hill ground being of the order of 100 times lower. Marsh Fritillary colonies on hill ground are therefore rarely entered into the scheme.

2011/12 is the last year of Species Action Framework and consequently this project in its current format. Butterfly Conservation Scotland are currently seeking funding to continue the project but widen its scope by using trained local volunteers to help survey and monitor sites. This will allow regular feedback on the current status of the butterfly and its habitat at selected sites to be provided to the landowner/manager, their agent and Butterfly Conservation Scotland, as well as identifying new sites for delivery of advice.

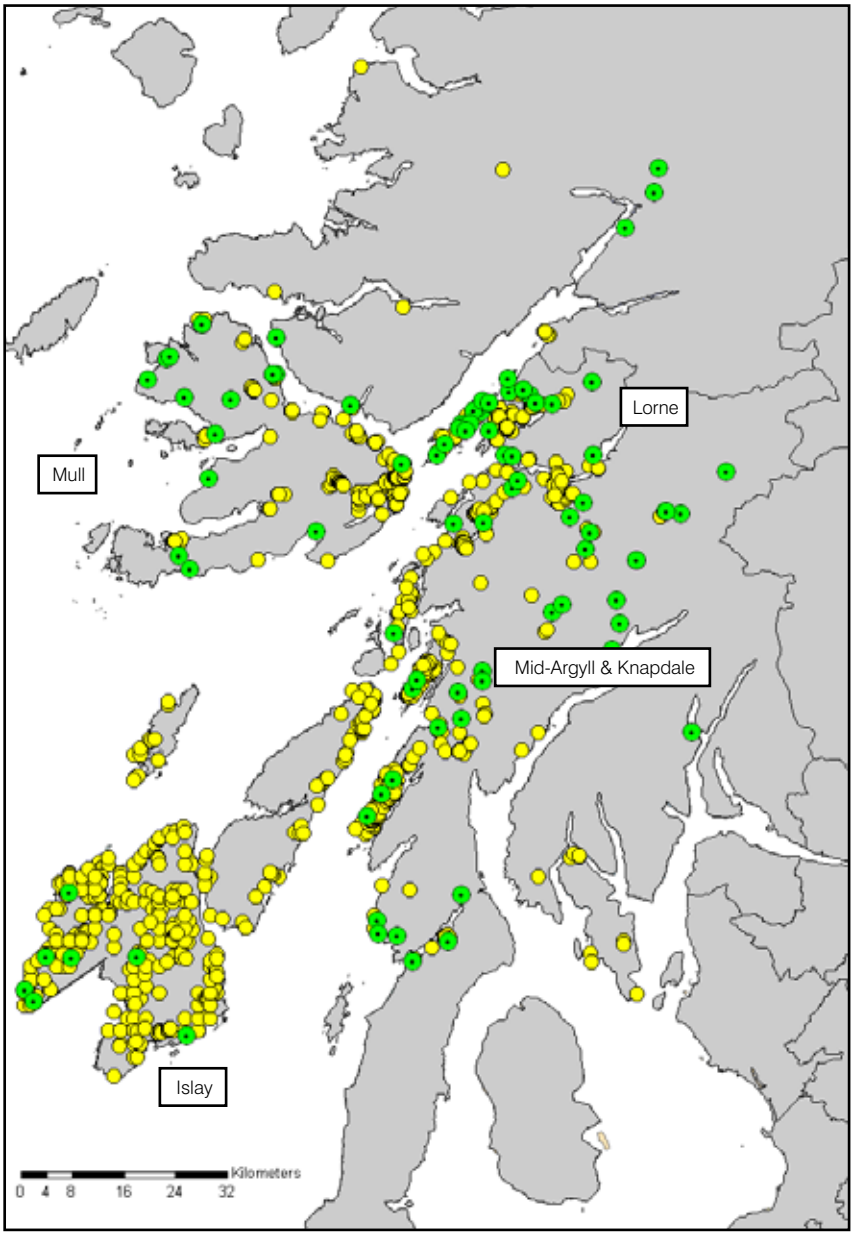


Figure 1 Distribution of Marsh Fritillary 1980-2010 (yellow dots) in relation to the location of sites being managed for the butterfly under the SRDP (green dots) up to 2010 in four Scottish landscapes

Targeting restoration management to stabilise Duke of Burgundy metapopulations on the North York Moors

Sam Ellis and Dave Wainwright

Sam Ellis

Duke of Burgundy

Introduction

In landscapes where intervention is delayed, sites become progressively more unsuitable through lack of appropriate management and butterfly populations continue to decline to the point of extinction. As a consequence the costs of restoration rise because: 1) more sites and/or a greater area of habitat will require restoration; 2) more degraded habitat is often expensive to restore; 3) strategic re/introductions might be required to restore functioning metapopulations. We demonstrate here the cost benefits of early intervention to restore a landscape by comparing the contrasting fortunes of the Duke of Burgundy *Hamearis lucina* in two North York Moors networks.

The Duke of Burgundy has undergone major declines in both distribution (52% between 1970-82 and 1995-2004) and abundance (58% 1995-2004) in Britain in recent years (Fox *et al.*, 2006). This decline is ongoing, with distribution losses of 30% and population declines of 46% between 1995-99 and 2005-09 (Fox, *et al.*, 2011). The butterfly is mainly restricted to the limestone and chalk of southern England but more isolated colonies occur on the Morecambe Bay Limestones and North York Moors of northern England. The butterfly utilises two principal habitats, 1) chalk or limestone grassland with either extensive areas of scrub or topographical shelter and 2) clearings on ancient woodland sites, either regenerating coppice, young plantations, sizeable glades or wide rides. Breeding occurs in tussocky vegetation when one or both of the two main larval foodplants, Cowslip *Primula veris* or Primrose *Primula vulgaris* are abundant. Larger-leaved plants, unlikely to drought during the larval feeding period are preferred (e.g. Turner *et al.*, 2009).

In the North York Moors the Duke of Burgundy is restricted to valleys along its southern edge and occurs in two discrete habitat networks 24 km apart. In the early 1990s, 17 colonies were known from the valleys to the north-west of Helmsley and five colonies to the north-east of Pickering (Ellis and Parks, 2003). All the Helmsley sites comprised limestone grassland habitat and all but two were ungrazed. Three of the Pickering sites also supported limestone grassland, two of which were ungrazed. One Pickering colony

occurred on deciduous woodland rides and another was located on rail verge ballast.

Nearly all sites appeared susceptible to succession to dense scrub and woodland. Consequently limited efforts to reverse population declines on sites were undertaken by volunteers through small-scale scrub management. However, two extinctions occurred in the Helmsley network in the mid-1990s. The metapopulation structure of the Helmsley colonies was studied in 2000 and suggested that occupied sites supported the largest breeding areas in close proximity to other occupied sites whereas unoccupied sites tended to be small and isolated (McAndrew, 2000). The study concluded that this was a non-equilibrium metapopulation and predicted further extinctions. By 2002 only nine Helmsley and four Pickering sites were occupied, with respectively eight and one extinctions since 1993. Given that the remaining populations represented nearly 10% of the UK resource, a landscape-scale conservation programme was instigated in 2003 with the target of preventing further extinctions and stabilising the metapopulation.

Project methods

On calcareous grasslands, the management aim is to maintain a mosaic of open, sunny grassland with abundant *Primula* spp. in medium height swards (5-20 cm), with scrub edges or patches. Taller vegetation is utilised for breeding and shorter vegetation ensures continuity of foodplant supply by provision

Giles Manners

of bare ground for germinating foodplants. In woodlands the aim is to ensure a continuous supply of clearings with abundant *Primula* spp. in open, sunny conditions.

From 2003 both occupied and unoccupied sites in the Helmsley network were targeted to restore suitable breeding habitat. On some sites small-scale scrub management was undertaken by removing small groups of shrubs and trees, but on most sites larger areas of scrub were removed to either create glades within woodland developing over grassland or to restore more extensive areas of grassland. Wherever larger-scale management was implemented, scrub margins were retained but pushed back from the original line, invariably creating bare ground to be recolonised by *Primula* spp.

Ideally intervention in both networks would have begun a decade earlier before extinctions occurred. However, nature conservation often depends on the right opportunities arising. The Helmsley network was not specifically targeted in preference to Pickering, but reflected more established relationships with landowners to enable access for management and the availability of funding to support the work

Dave Wainwright

Contractors clear scrub at a North York Moors site

undertaken by contractors (CAN DO project funding, a partnership between Natural England, the North York Moors National Park Authority and English Heritage, was only available in the Helmsley network).

Land management results

In total, scrub management was implemented over a six-year period on 15 of 18 Helmsley sites (Table 1, Figure 1). Mowing of a very rank sward was also undertaken on one site where grazing was impractical and bruising of dense Bracken *Pteridium aquilinum* followed by Cowslip planting on another. Connectivity between two sites was also improved by creating a ride through dense scrub. No management was undertaken on two Helmsley sites which supported only very small areas of habitat and where little potential to restore was identified. An occupied site which may be a recent colonisation was only discovered in 2008 and management requirements have yet to be determined.

In contrast only two Pickering sites were targeted by positive management (Table 1, Figure 2). Scrub control was undertaken on one and woodland ride-widening on another although not specifically for the butterfly. Unfavourable management for the Duke of Burgundy was implemented on two sites. One site was heavily sheep grazed to maintain suitable habitat condition for the flora; the other site, located on a railway verge, was sprayed with herbicide to control track-side vegetation.

Species response

Monitoring of Duke of Burgundy populations has been undertaken annually since 1993, but not all sites were visited each year. Adult numbers have always been low on most sites and therefore thorough searches of the entire breeding areas were undertaken, recording the total number of adults present. Where several visits were made in the same year the highest recorded count for that season was utilised.

The Pickering network has continued to decline with three further extinctions since 2003 (Figures 2 and 3a) and is now reduced to a single population occupying <1.5 ha habitat (Figure 3b). As a consequence sites have become progressively more isolated, with the remaining colony now >28 km from its nearest occupied site in the Helmsley network, compared to a mean of ~0.4 km in 1993 and 2002 (Figure 3c).

Conversely the decline in the Helmsley network appears to have stabilised (Figures 1, 3a and 3b). Only a single extinction has occurred since management commenced and this on the smallest (0.12 ha) and most isolated site (4 km from nearest occupied site). Another occupied site was discovered in 2008 and is presumed to be a colonisation from a site only 0.15 km distant and a colonisation occurred in 2008 following a 1997 extinction, probably from a site 0.56 km distant. Due to the extinction of small outlying populations, the occupied Helmsley sites are now concentrated in a core area with a mean distance to other occupied sites of 0.46 km in comparison to 1.14 km in 2002 (Figure 3c). However unoccupied sites are now more isolated with a mean distance to an occupied site

	Helmsley network	Pickering network
No. sites in landscape	18	5
No. sites managed	15	2
No. sites managed by scrub control	15	2
No. sites managed by Bracken bruising	1	0
No. sites managed by mowing	1	0
No. sites managed by Primula planting	1	0
No. sites managed by ride-widening	1	1
No. of work parties held by volunteers	16	2
No. days worked by contractors	>116	0
Habitat area managed by contractors (ha)	>6	0
Project funding secured for management	£20,680	£0

Table 1 Management implemented on Duke of Burgundy sites in two North York Moors networks 2003-08

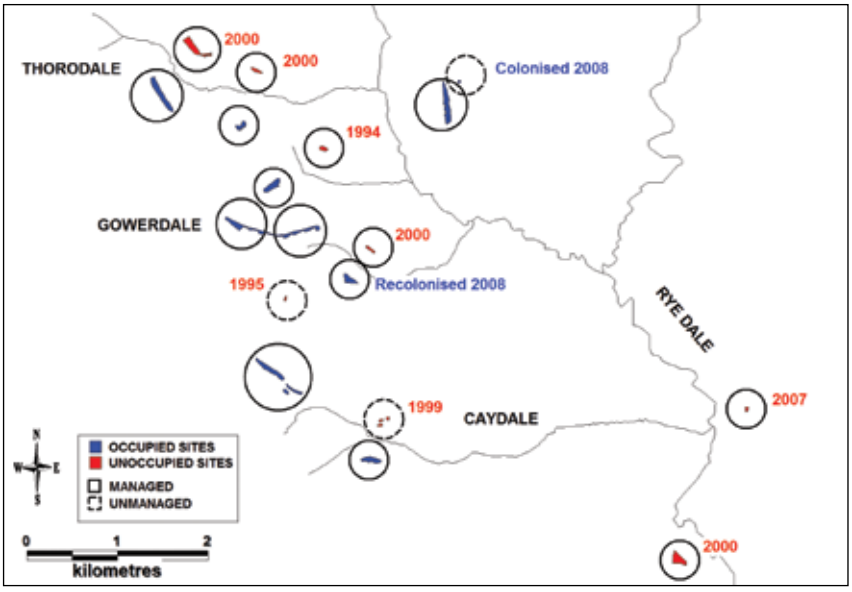


Figure 1 Location and 2009 status of 18 Duke of Burgundy sites in the Hemsley network on the North York Moors in relation to management undertaken 2003-08

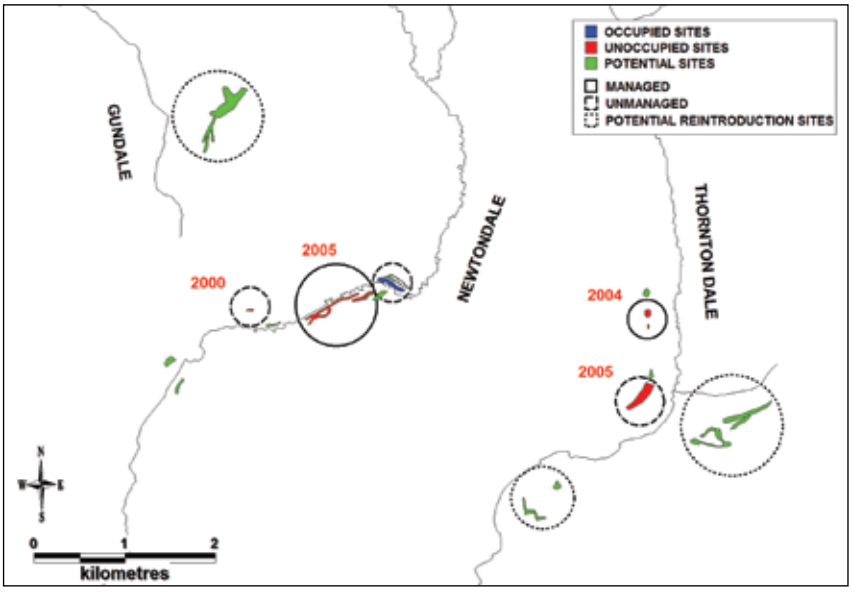
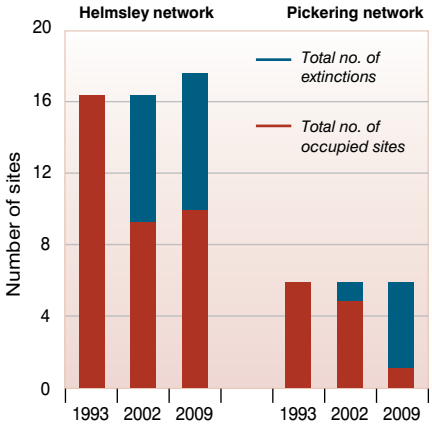
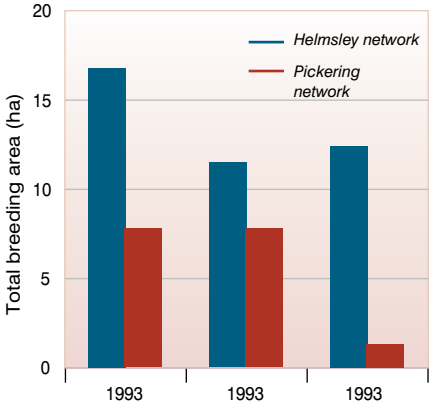


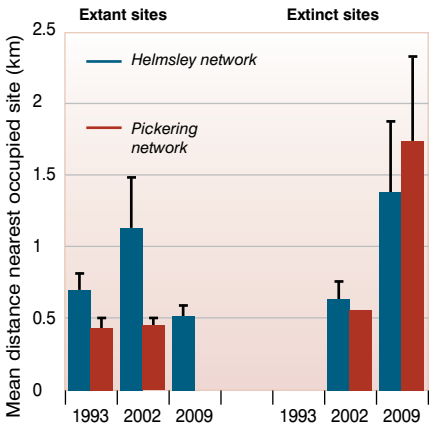
Figure 2 Location and 2009 status of 5 Duke of Burgundy sites in the Pickering network on the North York Moors in relation to management undertaken 2003-08. Potential breeding habitat awaiting restoration and three potential reintroduction sites are also shown



a) Site occupancy



b) Total breeding area



c) Isolation from occupied sites

Figure 3 Impact of habitat restoration on Duke of Burgundy sites in two North York Moors landscapes

Giles Manners

Sam Ellis

Scrub management creates more open grassland with bare ground encouraging germination of Cowslips and Primroses. Suitable breeding habitat is restored in taller vegetation, amongst light scrub or where there is topographical shelter

of 1.29 km compared to 0.68 km in 2002, but still less than that recorded for the Pickering network.

Count data from 1999, when a greater proportion of sites were monitored, show that the population in the Helmsley network has increased by 395% ($P<0.05$) (Figure 4). Conversely the population index for the Pickering network declined by 78% ($P<0.01$) and there was no significant trend across the whole UK during the same period.

Building local partnerships

This project could not have succeeded without the support of the partners comprising the North York Moors Butterfly and Moth Action Group, established in 2001. The support of the North York Moors National Park Authority and Natural England was critical in securing funding to implement the management programme. The North York Moors National Park voluntary rangers were actively involved in managing some of the sites, with the remainder undertaken by contractors. Butterfly Conservation Yorkshire Branch volunteers have assisted with monitoring for many years and helped establish good working relationships with the landowners.

Key lessons

This project demonstrates that with limited resources, careful targeting of habitat restoration at the landscape-scale can stabilise a non-equilibrium metapopulation. In contrast to the Pickering network, the pattern of extinctions and colonisations (with two further colonisations recorded in 2012) does suggest that the

Helmsley landscape now supports a dynamic, but inherently stable, metapopulation. Furthermore, responses have been variable between sites and unpredictable with the greatest increases on sites that appeared least promising. At one site for example, only one adult was recorded in 2002 preceding management in 2003 and none were seen in 2003-05. However counts of between 10 and 24 adults were made in 2006-11 as habitat quality reached an optimum following restoration management. Providing they are not isolated, careful targeting of all potential sites within a network is important, regardless of whether they are currently occupied.

We believe the contrasting fortunes of the two networks do demonstrate the cost benefits of early intervention. The work undertaken in the Helmsley network is the first phase in the restoration of this landscape. We have identified a further 10 sites in the Helmsley network and eight in the Pickering network (Figure 2), including several woodlands, as well as further patches on existing sites which could with appropriate management, support the butterfly. We estimate direct management costs of this second phase to be in the region of £110k in comparison to about £21k for the first phase. A significant proportion of that funding will need to be directed at the smaller Pickering network as these sites have become progressively more unsuitable through lack of appropriate management and the butterfly has declined to the point of extinction. Strategic re/introductions will almost certainly be required to fully restore the Pickering network (Figure 2), adding further to the cost.

Whilst some habitat improvements can be maintained for some time by the slow rate of succession on steep grassland slopes, in the longer-term consideration will need to be given to establishing maintenance regimes. One of the largest sites in the Helmsley network has been fenced with the aim of introducing stock grazing. However grazing to maintain Duke of Burgundy habitat at a later successional stage than the shorter, open swards established under many conservation grazing regimes is a potential conflict that remains to be resolved.

Dave Wainwright

Primroses regenerating following scrub clearance on a North York Moors site

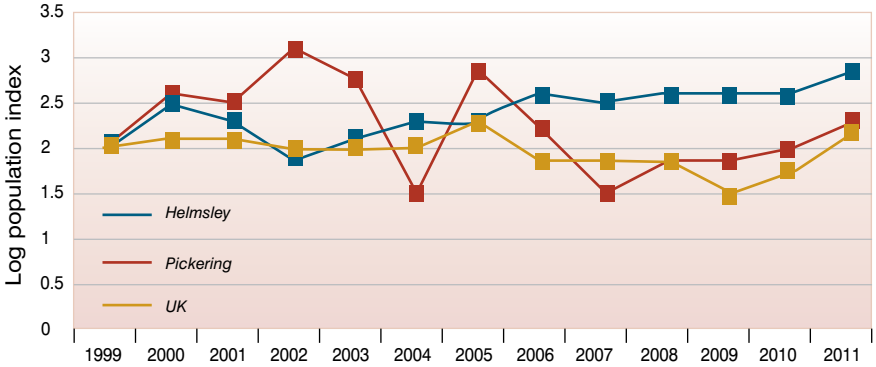


Figure 4 Impact of habitat restoration on Duke of Burgundy population trends in two North York Moors landscapes. Data analysed by TRIM; UK national trend included for comparison

Discussion: lessons from landscape-scale conservation

The 12 case studies described in this publication highlight a number of lessons which can inform current and future landscape-scale projects targeted at conserving threatened Lepidoptera in fragmented habitats. Many of these lessons apply equally to landscape-scale projects targeted at other species groups, as well as to more habitat focused schemes. These lessons fall broadly into five categories:

Approaches to land management at the landscape-scale

1. Our case studies provide evidence that species conservation can be very effective at a landscape-scale.
An understanding of the importance of area, isolation and habitat quality is fundamental to the delivery of landscape-scale conservation for threatened species. Our case studies show that the critical success factor is the improvement of habitat quality across a network of sites, which both raises the carrying capacity of occupied habitat patches and restores the potential of unoccupied patches. Without these improvements, it is unlikely that we could have achieved the increase in numbers of occupied sites, the overall breeding area occupied and improvements in connectivity.

2. Careful targeting is essential to maximise the success of a project across a landscape.
Uniform land management is rarely applied across entire landscapes, nor is it a desirable approach, as a range of management options provides the specialist niches that threatened butterflies and moths require (e.g. variation in turf height within grasslands, or coppicing and ride management within otherwise mature woodland). Targeting of management is therefore required to provide this range of specialist habitats. In practice networks of sites that are in close enough proximity are managed to enable natural colonisation of unoccupied patches (e.g. Wyre Forest Pearl-bordered Fritillary, pages 30-35; Blean Woods Heath Fritillary, pages 42-47, case studies). Improvements in connectivity are achieved along linear features (e.g. woodland rides) or by removing barriers to dispersal (e.g. plantation forestry) but also where there is some prospect of restoring breeding habitat along the feature as well.

For species with the most demanding ecological requirements, careful targeting of management is required even within sites. In the Morecambe Bay Limestones High Brown Fritillary case study (pages 16-23) for example, even with careful targeting of clearings the required habitat conditions were only met within a subset of habitat patches or within a small proportion of a given patch. In the Dartmoor Marsh Fritillary case study (pages 10-15) it has proven very difficult to achieve appropriate grazing levels simultaneously on all sites within the valley system. However, as long as there is sufficient well-grazed habitat across the system as a whole, the metapopulation can be maintained in spite of some habitat being over or undergrazed. Thus by working on a number of sites with different owners and circumstances it is possible to 'fail' on some sites or patches without compromising the overall success of a project to restore a functioning metapopulation. In other words, dynamic changes in habitat quality can occur whilst still maintaining the target species in the landscape.

3. Several of our case studies demonstrate that the extinction of species on small, isolated sites within a landscape need not be inevitable if they are properly managed.
Local extinctions and colonisations occur naturally within metapopulations, but the County Durham Small Pearl-bordered Fritillary (pages 48-51), South Wales High Brown Fritillary (pages 52-57), Warwickshire Small Blue (pages 58-65) and Kent Duke of Burgundy (part of South East Woodlands, pages 66-75) case studies all show that apparently catastrophic regional declines can be reversed.

The first step in this process is to secure the surviving small, isolated populations. Once this is achieved the landscape can be assessed and the metapopulation can be more fully restored by improving the quality and connectivity of unoccupied habitat patches.

4. The principles of landscape-scale conservation can be applied successfully at a relatively small spatial scale and are relevant even at the site level.
Within the Blean Woods (pages 30-35) targeting of management to improve habitat quality and connectivity for the Heath Fritillary is an approach that is as relevant to individual woods as it is to woodland complexes. Similarly, in the South East Woodlands (pages 66-75), within-site targeting of management work resulted in high patch colonisation rates for both Pearl-bordered Fritillary and Duke of Burgundy. While our smaller-scale projects (e.g. County Durham Small Pearl-bordered Fritillary, pages 48-51) have successfully halted and reversed several decades of decline, a second phase project aimed at expanding and restoring the greater landscape is necessary to secure the future of these species and habitats for a longer time period.

5. Larger-scale projects provide the opportunity to support and restore a traditional low intensity or an innovative management system that might otherwise not be commercially viable.
In woodlands the emergence of woodfuel for example, offers opportunities to make the management of small woods in different ownerships economically viable. However careful targeting would be needed to maximise the conservation benefits (e.g. South East Woodlands, pages 66-75). In the Dartmoor (pages 10-15), Dorset (pages 24-29) and Scottish Marsh Fritillary case studies (pages 76-79), the projects play an important role in supporting traditional agricultural management systems. Usually the funding available from agri-environment schemes has made farm businesses more viable in financially fragile areas.

Managing landscape-scale conservation projects

6. Skilled project officers are essential.
Project officers are an essential component of effective landscape-scale conservation. They ensure that management is carefully targeted and that improved habitat quality and connectivity is delivered across the landscape. They achieve this by building up essential long-term relationships with landowners, contractors, volunteers, partner organisations and the local community. Importantly, they can provide the ecological expertise necessary to improve conditions for habitat specialist species which may not be available to other land management advisors with a wider remit. By providing training for volunteers and local partners, and improving the knowledge base within the community, they greatly increase the likelihood of sustaining project outcomes beyond the life of the original project. Unfortunately, our experience is that funding project officers to facilitate the uptake of schemes is currently far more difficult than funding direct management.

Helen Bibby

Expert project officers working closely with the local farming community are an essential partnership for success

7. Land managers have been very receptive to landscape-scale projects.
This is especially true when landowners realise how much help a project officer can offer in terms of land management advice and support. For example in the South East Woodlands (pages 66-75) more than 900 land managers took part in our programme of free workshops. However, it can take time to develop relationships with land managers who can be cautious when dealing with nature conservation organisations. In the North York Moors case study for example (pages 80-85), the Helmsley sites are located on shooting estates and it took many years to persuade estate managers that scrub management for Duke of Burgundy was compatible with management for game birds.

8. Experienced and well supported contractors are essential.
Since both traditional and innovative habitat management techniques may be utilised in landscape-scale projects, experienced and sympathetic contractors with a good knowledge of land management for nature conservation are crucial. Errors by contractors can undermine relationships with landowners built up over many years. It is therefore important that project officers meet contractors or landowners on site when work is underway, to ensure that it is carried out appropriately.

9. Local volunteers can play a significant role in landscape-scale conservation.
Recruitment and training of volunteers is an important component of landscape-scale projects. Volunteers have a vital role in survey and monitoring. They contribute on a scale that could not be achieved by project staff alone. They can also undertake practical conservation, for example where a work party is needed for small-scale sensitive management, a regular feature of many case studies. Where recruitment has been especially successful, management by volunteer work parties matches that achieved through contractors (e.g. Warwickshire Small Blue, pages 58-65). Volunteers also provide ongoing monitoring and support which gives the project some sustainability when project officer funding ceases. Offering a progression of training (e.g. South East Woodlands, pages 66-75) allows individuals who may have little previous experience of conservation to take an active role in shaping the future of their local environment.

Research and monitoring landscape-scale conservation

10. The development and implementation of landscape-scale projects must be underpinned by sound ecological research.
Basic autecological knowledge, which identifies the species' habitat requirements, is invaluable in identifying management prescriptions. In the County Durham Small Pearl-bordered Fritillary case study (pages 48-51) for example, the habitat requirements of the target species were deduced largely from a single season's study of two sites (Ellis *et al.,* 2011). Similarly an understanding of a species' mobility enables connectivity improvements to be factored into management of unoccupied sites isolated from existing populations, (e.g. Blean Woods Heath Fritillary case study, pages 42-47).

11. Good quality spatial data is essential for project design and delivery.
For well targeted and designed landscape-scale conservation projects it is vital to have good data on the distribution and abundance of the target species and the habitats they utilise. The acquisition of such good spatial data often requires considerable preliminary work unless there are active recording schemes to build on, as is the case with butterflies (Fox *et al.*, 2011) and moths (Hill *et al.,* 2010).

12. The establishment of suitable monitoring systems is essential to assess the effectiveness of the project.
Monitoring should include collecting baseline data before management begins as well as through the life of the project. Unfortunately, the short timescales of most funded projects make this difficult to do adequately. In the case of butterflies, the UK Butterfly Monitoring Scheme is incredibly valuable in providing regional and national trends to compare with landscape trends (Botham *et al.,* 2011). The simplest monitoring measures are changes in occupancy at either the site and/or the patch level, but for projects with longer timescales (more than three years), changes in abundance in the landscape or on individual sites can be compared to regional or national trends of the target species. Similarly changes in abundance at the patch level can also be usefully compared with site level trends. In several case studies which can be regarded as first phase projects (e.g. Wyre Forest Pearl-bordered Fritillary, pages 30-35; North York Moors Duke of Burgundy, pages 80-85) demonstrating a response from the target species was critical to the successful development of larger-scale second phase projects.

13. Habitat condition assessments should also be undertaken to analyse changes to habitat quality.
Assessment of habitat condition is the most direct measure of the response of the habitat to management. Habitat monitoring is not susceptible to the vagaries of the British weather which can make assessing the impact on target butterfly and moth species during a short-term project unreliable. Habitat assessment is also particularly useful where the target species may not respond during a three-year funded project.

14. Butterflies and moths respond rapidly to changes in habitat quality.
All our case studies, for example Breckland Moths (pages 36-41) and Warwickshire Small Blue (pages 58-65), demonstrate how quickly Lepidoptera populations can respond, often in the same or subsequent year of management. Lepidoptera can thus be a useful focus when it comes to monitoring landscape-scale projects with short timescales.

15. Landscape-scale projects focused on a single butterfly can benefit a suite of other species which have broadly similar habitat requirements.
For example management of limestone grassland and brownfields targeted at the Small Blue in Warwickshire (pages 58-65), clearly benefited three other threatened Lepidoptera, as well as other invertebrates. In this case the Small Blue proved to be an extremely effective 'umbrella' or 'flagship' species for the fauna of early successional habitats. On Dorset Marsh Fritillary sites (pages 24-29) there is evidence that management for the butterfly has benefited other invertebrates using Devil's-bit Scabious, such as the Narrow-bordered Bee Hawk-moth and the Jewel Beetle.

Funding landscape-scale conservation

16. All our landscape-scale conservation projects could only be delivered with adequate medium to long-term funding.
Most of our landscape-scale conservation projects have taken several years to develop and then to deliver, and there are often ongoing commitments once restoration has occurred. They cannot be effectively delivered within short timescales. As well as the costs of land management, funding is required to pay for staff to provide advice, target project delivery, manage the finances, recruit and train volunteers and report back to funders. For some case studies we provide data on land management costs, but the true project costs are much greater, often double, when staffing and other costs are included. The total cost of a three-year direct funded landscape-scale project is typically in excess of £100k. Unfortunately there are insufficient sources of funding over long enough timescales currently available on this scale in the UK. In some instances Butterfly Conservation costs are only a small proportion of the overall value of the project. For example the advice provided by Butterfly Conservation, at a fraction of the overall projects costs in the Blean Woods (pages 42-47) enables coppicing and ride management to be carefully targeted to benefit the Heath Fritillary.

17. Well designed agri-environment and woodland grant schemes are a key delivery mechanism for landscape-scale conservation.
Agri-environment and woodland grant schemes were an essential tool to enable successful landscape-scale delivery in the South East Woodlands (page 66-75), Dartmoor (pages 10-15), Dorset (pages 24-29) and Scottish Marsh Fritillary (pages 76-79) projects. Schemes are not in themselves landscape-scale conservation initiatives. It is the specific elements of targeting, improving habitat quality and reducing isolation that adds the spatial element to deliver conservation across a landscape. Where habitat restoration is undertaken through a funded project then these schemes provide an opportunity to maintain the project gains, and therefore potentially a very effective exit strategy. Furthermore evidence from both the Morecambe

Rob Wolton

An essential tool for several of our case studies has been the availability of a well designed, targeted agri-environment or woodland grant scheme that encourages and rewards farmers and landowners for good management practice. For landscapes with significant areas of high nature value farmland, this is critical

Bay Limestones High Brown Fritillary (pages 16-23) and South East Woodlands (pages 66-75) case studies suggest that habitat quality produced by woodland grant schemes is as good as that from direct funded projects, because of the support provided by the project officer. Furthermore, results from the South East Woodlands project suggest that commercial forestry alone is unlikely to produce the quality of habitat required by our threatened species, underlining the value of targeted grants which have conserving biodiversity as an explicit aim.

18. The maintenance of existing high quality habitat is more cost effective in the long run than restoration management.
This was clearly demonstrated in the North York Moors Duke of Burgundy case study (pages 80-85), where per capita costs were much greater in the network where habitat quality had deteriorated further because much more restoration management was required.

Working in partnership at the landscape-scale

19. Landscape-scale conservation always involves partnership working.
Butterfly Conservation staff developed and led all these case studies, but none would be delivered effectively without the development of partnerships with a range of organisations and individuals. This is partly because targeted management for Lepidoptera often takes place on land owned by others, but often simply reflects the size and complexity of such projects which would be beyond the means of most conservation organisations to deliver alone. Even in the relatively small landscapes of some case studies, partnership working was essential and these projects would not have progressed as far without the invaluable input of others. For advisory projects, a close working relationship with the government agencies administering agri-environment or woodland grant schemes is essential. Where landscape-scale projects are led by other organisations, Butterfly Conservation can provide huge added value with specialist input ensuring management is targeted appropriately for Lepidoptera (e.g. Blean Woods Heath Fritillary, pages 42-47). These partnerships have often taken years to develop and evolve and are much easier to develop through a shared vision and action on the ground. They then have the potential to be more inclusive as the partnership grows to involve other interested bodies. In our experience broad partnerships for partnerships sake rarely have the vision to develop action on the ground.

20. Publicising landscape-scale projects is important for both partner organisations and funders, but also for local communities.
Some projects may appear to propose or implement significant changes to the landscape. Evidence from the Morecambe Bay Limestones High Brown Fritillary project (pages 16-23) and the Blean Woods Heath Fritillary project (pages 42-47) suggests that only around 1-2% of the land area within the sites is directly affected per year and much less in the context of the overall landscape. Nevertheless engagement with the local community can be critical in allaying any fears. Once they have had projects explained, we have found the local community an invaluable source of new volunteers, many of whom are new to recording and conserving butterflies and moths.

The future of landscape-scale conservation

These case studies demonstrate that large, and not so large, well-funded landscape-scale conservation projects, led by experienced project officers, are the most successful in conserving our threatened species and the ecosystem services they provide. Increases in populations of highly threatened species provide an excellent indicator that broad, landscape-scale initiatives to restore habitats have been successful. For most rare and declining butterflies and moths, Butterfly Conservation will continue to focus resources on landscapes where there is a good chance of restoring networks of occupied and unoccupied habitat as well as improving connectivity between breeding patches. This strategy gives the best chance of populations surviving in the long-term and will build up the most resilience in the ecosystems in which they live. The work will inevitably support the conservation of a wide range of other wildlife living in the same landscapes. It will also continue to raise awareness amongst local communities and act as models for wider landscape-scale initiatives envisaged in recent government biodiversity strategies.

Dave Green

Caroline Bulman

Steve Batt

Landscape-scale conservation for butterflies and moths is essential, both intrinsically and for a range of ecosystem services such as pollination or as food for other species. Here these services are illustrated by a Humming-bird Hawk-moth, an insect predator (a shield bug) feeding on a Marsh Fritillary larva and a Northern Wheatear with an Emperor Moth

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