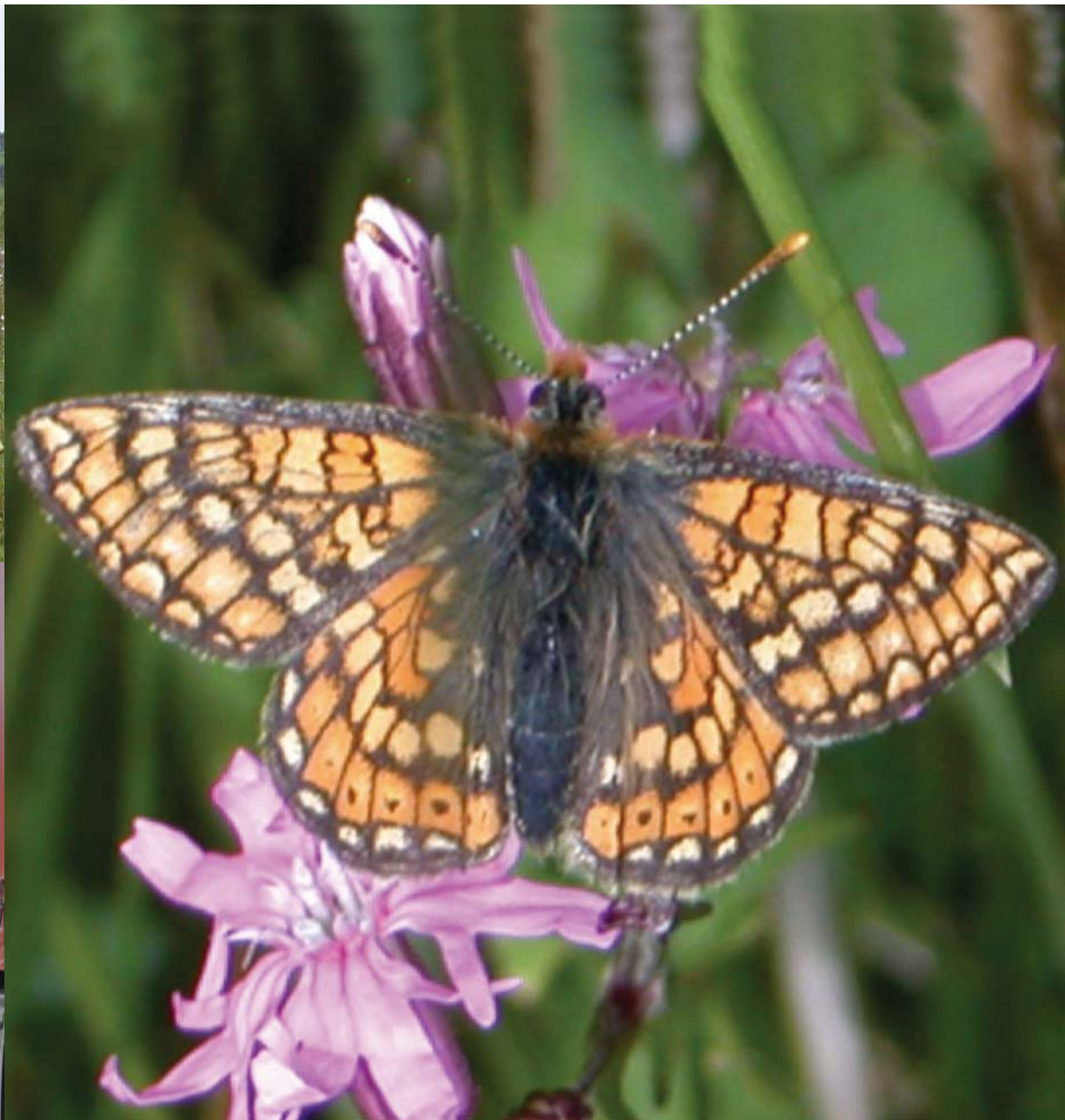
ENGLISH NATURE

The butterfly handbook

General advice note on mitigating the impacts of roads on butterfly populations



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HIGHWAYS AGENCY

The butterfly handbook

General advice note on mitigating the impacts of roads on butterfly populations including a case study on mitigation for the Marsh Fritillary butterfly along the A30 Bodmin to Indian Queens road improvement scheme

Adrian Spalding
Spalding Associates (Environmental) Ltd
Norfolk House
16-17 Lemon Street
Truro
TR1 2LS
www.spaldingassociates.co.uk

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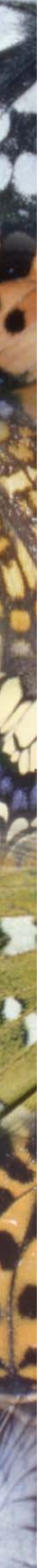


Forward

The second half of the last century saw dramatic changes in the countryside of Britain. Our native wildlife continues to be threatened as habitats are damaged or destroyed. Butterflies have probably never been as endangered as they are today following decades of loss of key semi-natural habitats such as flower-rich grasslands. This report is extremely valuable and timely as it concerns an increasingly important habitat for butterflies and other insects. Road verges can help conserve butterflies and other wildlife as they are an opportunity to provide suitable breeding habitats for many species, and provide crucial links between the patches of habitat that remain.

Butterflies are highly sensitive indicators of the environment and we know that conservation measures for this group will help many other less well-known components of our biodiversity. Road verges already provide valuable habitats for a wide range of species but this report shows how they can be made even better and contribute an ever more important role in the future. This report contains a large number of practical suggestions that I hope are adopted widely in road verge design and maintenance to maximise their potential in conserving our rich wildlife heritage.

Dr Martin Warren
Chief Executive
Butterfly Conservation

Butterfly Conservation
Saving butterflies, moths and their habitats

1 Introduction: butterflies and roads

1.1 Butterflies – their habitats and ecology

Small Tortoiseshell. L Slaughter

> 56 resident butterflies
>
> 26 Priority species
>
> The number of different breeding habitats for larvae is the key factor affecting diversity in butterflies

There are about 56 permanently resident species in Britain and 2-3 regular migrants (Thomas 1991a). They occupy a range of habitats including grassland, scrub (especially bracken scrub), heathland, wetland, boundary features, woodland, woodland rides and woodland edge (Annex 1). Some species feed as larvae on one particular plant, others feed on a variety of different foodplants. Some of the more widespread species such as Small White and Small Tortoiseshell can be found in a variety of habitats whereas other (often rarer) species are restricted to one or two habitat types. Some species (e.g. High Brown Fritillary) appear to be declining in abundance and range, others (e.g. Speckled Wood) are expanding their range. The UK Biodiversity Action Plan lists 11 species as conservation 'Priority', and a further 14 as Species of Conservation Concern. Further, this list has been updated in the light of the new butterfly atlas published in 2001 (Asher et al) and 4 potential BAP species added (Fox et al 2001) (Box 1). Regional priorities have also been developed for butterflies (and moths); these priorities can be ascertained by reference to the Regional Action Plans prepared by Butterfly Conservation (Box 2).

The presence of a butterfly species at a particular site depends on a range of factors, especially the abundance of foodplants suitable for egg-laying, the abundance and quality of flowers for adult feeding, the abundance of predators and parasitoids (Pollard & Yates 1993) and the structure of the habitat (Warren & Stephens 1989). In fact, rare butterflies are generally restricted to narrow ecological niches defined by the variation in the larval host-plant resource (Thomas 1991b), not the presence of nectar plants. The larval foodplants must grow in abundance in a particular growth form, microclimate or microhabitat (Thomas 1991b). Butterflies thrive on habitat mosaics and structural diversity (BUTT 1986) and the number of different breeding habitats for immature stages is the most important determinant of the diversity and abundance of butterflies in semi-natural habitats (Thomas, Snazell & Ward 2002).

Box 1: UK Biodiversity Action Plan, Species of Conservation Concern and Candidate BAP Butterfly species in Britain

BAP Priority Species	**BAP Species of Conservation Concern**	**Candidate Species**
Chequered Skipper	Lulworth Skipper	Dingy Skipper
Silver-spotted Skipper	Swallowtail	Grizzled Skipper
Large Copper	Wood White	Dark Green Fritillary
Silver-studded Blue	Brown Hairstreak	Grayling
Northern Brown Argus	Black Hairstreak	
Adonis Blue	Small Blue	
Large Blue	Chalkhill Blue	
Pearl-bordered Fritillary	Duke of Burgundy	
High Brown Fritillary	Purple Emperor	
Marsh Fritillary	Small Pearl-bordered Fritillary	
Heath Fritillary	Silver-washed Fritillary	
	Glanville Fritillary	
	Mountain Ringlet	
	Large Heath	

Source: Fox, R. et al. (2001) *The State of Britain's Butterflies*. Butterfly Conservation, CEH and JNCC, Wareham.

Key habitat features include:

- A varied topography with warm or sheltered microhabitats
- Larval foodplants in the particular condition required by the species
- A varied vegetation structure (e.g. a range of turf heights)
- Shelter
- Nectar sources
- The presence of ants as required by some species (these ants may occupy particular habitats with high temperature levels)
- Continuous suitable management

Box 2: Regional Action Plans prepared by Butterfly Conservation

Region	Year
Anglia	2000
East Midlands	2000
East Scotland	2000
Highlands and Western Isles	2000
North East England	2000
Northern Ireland	1998
North West England	2000
South Central England	2000
South East England	2000
South West England	2000
Thames	2000
Wales (National Action Plan)	1998
West Midlands	1997

It is important when planning for a particular species that its ecology is understood, especially concerning egg-laying behaviour and larval habitats (see Box 3 for Marsh Fritillary). There is no single habitat requirement that suits all butterfly species. It should be noted that habitat requirements for adults and larvae may be different for the same species. For the more mobile species, the resources used by the adult and larval stages of a single individual may be kilometres apart (Cowley et al 2000). In the case of Chequered Skipper, the habitat required by males (areas of sparse vegetation on drier ground on woodland edge) is different from the habitat required by females (areas with abundant nectar plants) (Ravenscroft 1994).

Box 3: Understanding species ecology. Marsh Fritillary as a case study

The key factors in determining whether Marsh Fritillary occurs on a site appear to be:

- The presence of devil's-bit scabious - Marsh Fritillaries require large leaves on which to lay their eggs
- The height of the sward (12-25 cm in damp grasslands; 6-7cm on calcicolous grasslands)
- The management regime - grazing by cattle or ponies; rapid burning is suitable if early in the spring whilst the larvae are in hibernacula
- The colony size – the importance of habitat size is not known, but many colonies are small, occupying less than 2 hectares
- The distance from other colonies - distances of up to 3km are well within the range of female Marsh Fritillaries
- Habitat size - over 70 hectares of suitable habitat within a network of sites need to be in favourable management to ensure that a Marsh Fritillary metapopulation has a 95% probability of persistence for 100 years

1.2 Metapopulations

Metapopulation - a number of connected colonies

c. 75% of resident butterflies live in metapopulations

c. 25% of resident butterflies live in open populations

Minimum viable populations range from 0.5 – 70 hectares

Habitat fragmentation is one of the key challenges for conservation

Conservation for butterflies should be at the regional or landscape scale

Many butterfly species are highly mobile and form open populations, with wide-ranging females laying eggs in a number of areas; this group includes the migrant butterflies such as Red Admiral, Painted Lady and Clouded Yellow. However, about three quarters of our butterfly species occupy closed populations (Annex 2), where local birth and death processes are the major determinants of local abundance (Thomas 1995). Sometimes these populations are very small and isolated from other colonies of the same species, but more commonly these populations are connected to each other and dispersal is now recognised as one of the key elements in the maintenance of butterfly populations (Morris et al 1994). Most of the butterflies living in closed local populations exist as metapopulations (Box 4).

Box 4: Metapopulations

Metapopulations are formed from a number of connected colonies. They are characterised by occasional movement between local colonies, with colonisations and extinctions. There can be frequent local extinctions, but the population survives in the wider area and can re-colonize available habitat (Gilpin & Hanski 1991). Only one or two females from each generation are required for gene flow to be maintained between isolated colonies (Nei et al 1975). The two extreme models put forward are:

- The permanently populated mainland habitat patch surrounded by temporary satellites (Boorman & Levitt 1973)
- Habitat patches of equal importance, each with a finite occupancy (Levins 1969).

One of the best known examples of a metapopulation is that of the Marsh Fritillary, considered by Warren (1994) as falling between these two extremes. Studies of the genetics of Marsh Fritillary in Britain (Joyce & Pullin 2003) indicate that at the national scale there are threshold distances at which populations start to substructure and at which random mating between all individuals does not occur; in contrast, examination of genetic diversity at the local scale indicates that many scattered and seemingly isolated populations should be considered as single units.

Metapopulation dynamics mean that we need to consider butterflies at the regional or landscape scale, not just at site level. Management decisions for key species should be considered in relation both to the distribution of existing colonies in the area and to the distribution of unoccupied but suitable habitat available for future colonisation. Desk-top studies supported by survey work will allow ecologists to construct maps of the current populations and available habitat. If the distance a particular butterfly can travel is known, then gaps greater than this distance indicate the boundaries of the metapopulation area. As an example, the lack of suitable habitat patches in an area over 10km wide is likely to prevent the spread of the Silver-spotted Skipper from occupied regions into more distant areas where all the suitable habitat patches are vacant (Thomas & Jones 1993). Meadow Browns will return to familiar habitat patches rather than non-familiar ones if given the choice, so that dispersal to new sites is less common than might otherwise be predicted, although they will also find new habitat by using a systematic search strategy (Conradt et al 2000). The effective long-term conservation of these and most other butterflies requires the protection of metapopulations in a viable closely-linked network of habitat patches. Knowledge of the transient dynamics of the metapopulation structure of each species is critical to understanding its conservation needs.

Meadow Brown. A Spalding

These results can be confirmed by genetic analysis of specimens from populations within the area, e.g. by Joyce & Pullin (2003) for the Marsh Fritillary. It follows therefore that it is important that populations remain connected to allow re-colonisation of suitable habitat and for the maintenance of genetic diversity. Genetic analysis is increasingly used as a research tool to inform our understanding of the distributions of butterflies and information may be already available for key species in the vicinity of road developments.

1.3 Colonisations and extinctions

A further refinement of this method is to predict the probability of an occupied habitat patch being colonised over a set period by a particular butterfly based on patch size and the distance from the nearest population patch (Thomas 1995). This can be done by first surveying all the local populations and unoccupied habitat within the area and then measuring the distance from the nearest local population and calculating the probability based on a graph of patch size/distance from the nearest populated patch for each species. The nearer the colony, the higher the probability of colonisation.

The quality of the available habitat affects the probability of a butterfly staying on the site. Poor quality habitats can become 'sinks' where butterflies can feed as adults but which cannot support breeding populations; these habitat areas can be a drain on metapopulations and prevent the colonisation of more suitable sites. In fact, habitat quality probably contributes more to species persistence in a locality than habitat area or isolation (Thomas et al 2001), so that extinction rates in a typical landscape could be reduced if the quality of habitat on these sites was increased from normal to optimum. Once a species becomes locally extinct, the probability of recolonisation depends on the spatial relationships of feeding habitat within the landscape, the dispersal characteristics of the species and any changes in the landscape structure e.g. habitat removal (Fahrig & Merriam 1994).

1.4 Minimum breeding areas

Minimum breeding areas have been calculated for a range of butterflies ranging from 0.5 hectare (e.g. Marbled White) to over 50 hectares for Purple Emperor, but these areas have to be considered in relation to other nearby habitat within the metapopulation structure. For example, recent experimental modelling suggests that over 70 hectares of suitable habitat within a network of sites need to be in favourable management to ensure that a Marsh Fritillary metapopulation has a 95% probability of persistence for 100 years (Bulman 2001).

The Goss Moor NNR divided by the A30 . English Nature

1.5 Habitat fragmentation and corridors in the wider landscape

Habitat links:	Wildlife corridors Stepping stones Areas of high quality feeding habitat

Habitat fragmentation may be one of the most challenging issues facing conservationists (Dobson et al 1999). It is possible that we vastly under-estimate the rates of movement necessary to maintain optimal densities of migrants (not just of butterflies but for all wildlife species) for ecological interactions and the maintenance of ecosystem diversity and function. For example, Warren (1993) found that key butterfly species have been disappearing even from protected areas and concluded that, if site protection alone is not enough to maintain butterfly populations in the longer term, more emphasis should be placed on creating and maintaining habitat links at a landscape scale.

In the absence of functioning habitat links, habitat fragmentation leads to:

- Isolation of populations
- Local extinctions
- Reductions in biological diversity
- Loss of genetic heterozygosity within populations
- Reduced fitness of individuals and populations
- Disruptions to metapopulations
- Reduced probability of re-colonisation

The more the landscape becomes fragmented, the more important links become. These can work on different levels:

- The local scale (e.g. connecting small, close habitat patches)
- The landscape scale (connecting major landscape features e.g. wetlands)
- The regional scale (at this scale corridors need to be large and wide).

The local and landscape scales are probably the most important for butterflies. Habitat links such as wildlife corridors work especially well when the surrounding countryside is poor in habitat quality e.g. in intensively farmed land. In addition to providing connectivity between sites, some habitat links can function as breeding areas and act as source patches, which provide surplus individuals to unoccupied patches of lower habitat quality in the nearby area.

1.6 Biodiversity objectives at the landscape scale

Biodiversity is just one of the issues that need to be considered when designing a new road and it is important to aim for a balance between nature conservation and other priorities such as landscape integration, road safety and pollution control (Highways Agency 2001). However, one of the key objectives of any road design should be to ensure that road schemes seek to enhance biodiversity wherever possible (Byron 2000); this is particularly important if UK BAP habitats and/or species are present (UK Biodiversity Group 1995). It is important to take a broad view at the landscape scale, especially with regard to habitat fragmentation and butterfly metapopulation structure; the impacts of a road scheme on biodiversity should be considered in the context of the wider local and regional ecosystems (Byron 2000). Mitigation should be targeted at key indicator species (e.g. priority species, Box 1) as the loss of these may affect a large number of other species (Byron 2000).

Marsh Fritillary. A Spalding

2 The impact of roads on butterflies

2.1 Introduction – are roads beneficial or harmful?


Brown Hairstreak. A Spalding

Roads have positive and negative affects

Road corridors through poor habitat may enhance wildlife

Road corridors through high quality habitat may harm biodiversity

Road corridors are important for butterflies associated with grassland

Road corridors can act as barriers or as wildlife corridors and stepping stones

It has been recognised for over thirty years that roads can be important for wildlife including butterflies, with 25 of the 60 British butterfly species recorded on roadside verges (Way 1977). Most of these species occupy the grassland habitat present along the roadside verges or central reservations (Box 5), especially where the verge has been undisturbed for many years. In some cases, particularly in intensively farmed landscapes, roadside habitats may provide the best chance of seeing butterflies in the area, usually the more mobile species such as Red Admiral and Small White (Munguira & Thomas 1992), but rare species such as Brown Hairstreak can also be found (Box 6). A pioneer study (Feltwell & Philp, 1980), in what was claimed to be the first general study of the natural history of an entire motorway in Britain, found that the M20 motorway verges (the central reservation was not studied in the interest of safety) were important for butterflies, with 16 species recorded including large colonies of Essex Skipper, Marbled White and Ringlet. Roads are known to be especially important for butterflies associated with early successional habitat, e.g. short-turf grassland with abundant bare ground (Morris et al 1994) and it is often these species (e.g. Silver-spotted Skipper) which are most threatened. Additional habitat suitable for butterflies and associated with roads includes woodland, bracken scrub, heathland and boundary features. It is worth remembering that many of the most important wildlife sites in the post-industrial landscape are man-made (e.g. Box, 1993; Spalding & Haes 1995) and Warren (1993) found that many of the most important sites for calcareous grassland butterflies are ancient artefacts (e.g. hill forts).

Box 5: Typical roadside verge species

Species	Foodplant
Brown Argus	common rock-rose and crane's-bills
Common Blue	trefoils *Lotus* sp etc
Essex Skipper	grasses
Gatekeeper	grasses
Large Skipper	grasses
Marbled White	grasses
Meadow Brown	grasses
Orange Tip	crucifers
Red Admiral	nettles
Ringlet	grasses
Small Blue	kidney vetch *Anthyllis vulneraria*
Small Copper	sorrels and docks
Small Heath	grasses
Small Skipper	grasses
Speckled Wood	grasses
Wall ?	grasses

Box 6: Rare or local butterflies utilising habitat alongside roads in Britain

Adonis Blue
Black Hairstreak
Brown Hairstreak
Chalkhill Blue
Chequered Skipper
Dingy Skipper
Grizzled Skipper
Lulworth Skipper

taken from Thomas, Snazell & Ward (2002)

However, on the broader landscape scale, roads are often considered harmful to wildlife, reducing connectivity and limiting wide-ranging species. Mader (1984) considered that the two main factors leading to the increased isolation of habitats are intensive agriculture and linear constructions, including roads and railways; in his view roads represented a significant barrier to the movement of wildlife species within landscapes (see Section 2.3.2). Roads running through areas of high wildlife value are likely to be more harmful to biodiversity than roads running through areas of low wildlife value, where some of the best wildlife habitat may lie alongside the roads. This is true of new as well as existing roads, with the exception that the construction of new roads provides an opportunity for habitat design to enhance the nature conservation value of the area. Routes built through intensive farmland, urban areas and other poor biotopes are likely to result in a net gain for insect diversity (Thomas, Snazell & Ward 2002) and studies in France along new motorways have shown that three species of Burnet moth (*Zygaena* species) have significantly expanded their range due to natural colonisation of new roadside embankments (Faillie & Nicolle 2003). However, although new roads create new opportunities for habitat creation for butterflies, this should not be used to justify road building on high quality wildlife habitat.

The effect of roads on butterflies may be divided into positive and negative affects (Box 7).

Box 7: Possible effects of roads on butterfly populations

Positive effects

- Provision of additional wildlife habitat in an intensively farmed agricultural landscape
- Provision of corridors in fragmented landscapes
- Provision of stepping stone habitat
- Increased area of early-successional stage habitat
- Protection from predators in the central reservation

Negative effects

- Loss or decrease in quality of habitat
- Increased habitat fragmentation and barriers to movement e.g. from increased turbulence
- Increased road kills
- Increased pollution, including increased salinity
- Changes in microclimate near the road
- Increased disturbance to vegetation e.g. by cutting or spraying
- Different composition of plants and animals on roadside verges
- Increased light pollution at night (leading to increased feeding times for birds)
- Indirect effects associated with construction, e.g. storage sites

6-Spot Burnet Moth. A Spalding

2.2 Positive effects

2.2.1 The provision of additional wildlife habitat

Where roads run through intensively farmed or urban land, the roadside verges and central reservations may be of higher nature conservation value than the surrounding landscape. The greatest abundance of butterflies in these landscapes may be found besides these roads (Munguira & Thomas 1992) where the verges act as wildlife refuges. Meadow Browns in particular can have large populations on roadside verges. New roads may be designed in such a way that the wildlife value of the area can be enhanced. Butterflies can spread from road edge habitat onto adjacent land if the management regime changes to one more appropriate for butterfly populations.

2.2.2 The provision of corridors in fragmented landscape

Many butterfly species are reluctant to cross intensive farmland (Box 8; Box 9); for example Gatekeeper and Meadow Brown showed limited movement across intensively farmed agricultural landscape (4.7% and 16% respectively) in a study by Dover (1991). Butterflies may instead move along roads if suitable habitat is available throughout the road corridor. In this way, roads can act as wildlife corridors linking isolated areas of nature conservation value.

Box 8: Butterflies which are reluctant to cross inhospitable habitat (e.g. agricultural land and roads)

Adonis Blue (Thomas 1983)
Black Hairstreak (Thomas 1984)
Gatekeeper (Dover 1991)
Heath Fritillary (Warren 1987)
Meadow Brown (Dover 1991)
Silver-studded Blue (Thomas 1985)
Small Pearl-bordered Fritillary (Thomas & Snazell 1989)

Box 9: The proportion of butterfly populations measured crossing comparable (3-50 m) distances of continuous habitat (taken from Thomas, Snazell & Ward, 2002)

	continuous	roads	arable
Meadow Brown	46-47%	17-21%	16%
Marbled White	45-50%	10-32%	?
Adonis/ Chalkhill Blue	2-7%	1-2%	0%
Gatekeeper	?	?	5%

New roads can be used to link wildlife areas. They can be especially beneficial to butterflies if they touch the edges of these areas rather than cutting through them; in this way the dispersal of species which are reluctant to cross intensive farmland is enhanced (Thomas, Snazell & Ward 2002).

A well-known example is the M40 (Box 10) which was designed so that a link was created to allow invertebrates to move along the roadside verges between woodland at Shabbington Wood SSSI and Whitecross Green SSSI (Bickmore 1992); the existing habitat between these woodlands was agricultural land unsuitable for invertebrates to cross. In particular, blackthorn was planted for the Black Hairstreak butterfly. Although it may be 50 years or more before the full benefits of habitat connectivity are realised, added benefits such as the screening effect provided make an important contribution to the landscape.

M40. English Nature

2.2.3 The provision of stepping stone habitat

In addition to providing habitat links for butterflies for moving along the road corridor, the provision of suitable habitat allows butterflies to use road verges as stepping stone habitat when moving across the road.

Black Hairstreak. L Slaughter

Box 10: The M40, Oxfordshire

The route of the proposed Waterstock – Wendlebury motorway extension to the M40 was altered mainly because of the predicted impact it would have to a population of Black Hairstreak. The following mitigation measures were carried out:

- A link was created to allow invertebrates to move along the roadside verges between woodland at Shabbington Wood SSSI and Whitecross Green SSSI (the existing habitat between these woodlands was agricultural land unsuitable for invertebrates to cross).
- A special wildflower seed mix was used over a shallow depth (50mm) of topsoil within the motorway fence line.
- Blackthorn was planted in severed fields adjacent to an existing site for the Black Hairstreak butterfly, including blackthorn bushes with Black Hairstreak pupae attached.
- The compensation area was planted with blackthorn and currently supports a major population of the Brown Hairstreak.
- The compensation area (once intensive farmland) now supports 25 species of butterfly which colonised the site in 1991-1994, including Brown Argus, Marbled White and Essex Skipper.
- Wildflower glades were created by removing topsoil and seeding with wildflower seed from a hay crop from local flower-rich hay meadows.
- The attenuation reservoirs were rounded off and flattened to produce a more irregular natural looking profile and were built on clay, not lined with concrete.

Although it may be 50 years or more before the full benefits of habitat connectivity are realised, there are added benefits such as the screening effect provided.

Bickmore, C.J. 1992. M40 Waterstock – Wendlebury: planning, protection and provision for wildlife. *Proceedings - Institution of Civil Engineers Municipal Engineer.* **93**: *75-83*

This is particularly important for those butterflies which occupy a metapopulation structure.

In general terms, the smaller the gap between habitat patches the quicker the vacant patch can be colonized (Thomas, Thomas, & Warren 1992); in this context stepping-stone habitat patches can speed up the re-colonization of vacant sites. The more isolated a patch, the less likely it is to be occupied, and the greater the gap between habitat patches the longer it takes for the vacant patch to be colonized. The maximum natural single-step colonization distances are different for each species; they have been calculated for some of the rarer butterflies, e.g. 0.6-1km for Silver-studded Blue and 1.4km for Black Hairstreak (Thomas, Thomas, & Warren 1992). Conservation decisions in road design should therefore be made in relation to vacant habitat patches as well as occupied ones within the vicinity of the road.


Chalkhill Blue. A Spalding

Box 11: Grassland species found in different sward heights

long sward (>20cm)	**medium sward (5-20cm)**	**short sward (<5cm)**
Dark Green Fritillary	Brown Argus	Adonis Blue
Duke of Burgundy	Chalkhill Blue	Grayling *
Essex Skipper	Common Blue	Silver-spotted Skipper
Gatekeeper	Dingy Skipper	
Large Skipper	Grizzled Skipper	
Lulworth Skipper	Small Copper	
Marbled White		
Marsh Fritillary		
Meadow Brown		
Ringlet		
Small Blue		
Small Heath		
Small Skipper		
Wall*		

* requires bare ground
(adapted from Butt, 1986)

2.2.4 An increased area of early-successional stage habitat

Many of the most threatened butterflies in Britain are dependent on the early stages in ecological succession (Morris et al 1994). These include species associated with coppice woodland such as Pearl-bordered Fritillary, grassland species such as Adonis Blue and heathland species such as Silver-studded Blue. Roads can make an important contribution to the amount of this early successional stage habitat, especially for grassland species associated with short and medium turf heights with abundant bare ground (Box 11). In some areas, roadside verges may also be suitable for heathland species.

2.2.5 Protection from predators in central reservations

The central reservation may provide an important refuge for invertebrates where they are safe from those predators which are unable to cross the road (Port & Thompson 1980). Butterflies may be protected in this way from bird predation.

2.3 Negative effects

2.3.1 Loss or decrease in quality of habitat

The building of new roads in areas of high wildlife value can lead to the permanent loss of butterfly habitat and the irreversible reduction of the critical nature conservation capital (English Nature 1994). The creation of new habitat cannot fully compensate for the loss of habitat of high value for butterflies. There may be a decline in core species and an increase in edge species, leading to significant changes in community composition. However, it is important to be realistic in the assessment of potential habitat loss for butterflies. The example of Twyford Down (Box 12), where the numbers of Chalkhill Blues increased in the first 3 years following the opening of the M3 (Thomas, Snazell & Ward 2002), shows that creative road design can increase the wildlife value of some sites for butterflies, at least in the short term.

One major effect of road building may be to change the hydrology of an area. This may be especially damaging where fragile wet areas occur that may be supporting important BAP species such as the Marsh Fritillary and Large Heath. It is important to be aware that this type of damage is difficult to mitigate for because of the complex interaction of hydrology and ecology in these areas; as a result, road routes should avoid wet grassland wherever possible.

Box 12: Twyford Down

Twyford Down has come to symbolise the destruction of high quality wildlife habitat by new roads; in fact, the true picture is one of biodiversity enhancement, particularly for butterflies. The route was fixed but it was proposed in mitigation to recreate downland in places, e.g. on the restored route of the existing Winchester bypass. The key stages in habitat assessment and creation were as follows:

- Appointment of scientific advisers (in this case from ITE)
- Surveys of animal and plant communities along the route (1991 –1992)
- Surveys of adjacent areas to ensure that reconstructed downland would contain appropriate plant and animal communities
- Identification of key habitats and species
- Design of the habitat restoration programme
- Preparation of the restoration sites
- Introduction of relevant plants in suitable proportions by turf translocation, seeding and plug plants
- Manipulation of management techniques to drive the development of the plant and animal communities, e.g. by mowing and grazing
- Monitoring the botanical and invertebrate communities for ten years after habitat restoration and translocation, e.g. by fixed botanical quadrats, pitfall traps and suction samples for invertebrates, butterfly transects, and mark-release-recapture experiments.

The habitat restoration has been shown to be successful for butterflies, and many of those species of butterfly that inhabit the area now have additional populations on the restoration area, many at higher densities than on the rest of the site. In particular, the numbers of Chalkhill Blues increased here in the first 3 years following the opening of the M3, with a few individuals flying across the road which indicates that the metapopulation structure in this area has been improved as a result of mitigation for butterflies (Thomas, Snazell & Ward, 2002).

Snazell, R.G. 1998. *Ecology and Twyford Down*. Institute of Terrestrial Ecology. Wareham.

2.3.2 Increased habitat fragmentation and barriers to movement

Habitat fragmentation is one of the main conservation issues arising from the modern intensively farmed landscape and roads add to this effect by creating barriers to the movement of butterflies. The main barrier effect is created by the nature of bare, un-vegetated road surfaces which butterflies are reluctant to fly over, although it is possible that arable land presents a greater barrier to butterfly movement than roads (Box 9).

Box 13: Examples of butterflies likely to cross roads

Likelihood of crossing roads		
Unlikely	**Fairly likely**	**Likely**
Chalkhill Blue	Common Blue	Brimstone
Orange Tip	Essex Skipper	Large White
	Gatekeeper	Peacock
	Green-veined White	Red Admiral
	Large Skipper	Small Tortoiseshell
	Marbled White	Small White
	Meadow Brown	
	Small Heath	
	Small Skipper	
	Wall	

adapted from Munguira & Thomas (1992), Thomas, Snazell & Ward (2002), Dennis (1986)

The effect on butterflies appears to depend on the species concerned (Box 13). Roads are probably no barrier to the movements of those butterflies such as Large White, Small White, Red Admiral and Small Tortoiseshell which live in open populations (Annex 2), but may impede species with closed populations (Munguira & Thomas 1992). In a detailed study of butterflies and roads (Munguira & Thomas 1992), 10-30% of Meadow Browns, Marbled Whites and Common Blues (all species living in closed populations) were found to cross the road during their adult flight period and males were more likely to cross than females e.g. the proportion of Meadow Browns found crossing a road was in the ratio 1.5 males : 1 female. Importantly, butterflies are known to cross narrow roads with broad open verges more easily than wide roads with no adjacent suitable habitat. In a wide motorway such as the M3 at Twyford Down (Box 12), marking experiments indicated that only 2-7% of the local Chalkhill Blue population crossed the road (Thomas, Snazell & Ward 2002), while the M56 presents a substantial barrier to male Orange Tips, reducing movement across the motorway by around 90% when compared to movement between other patches in the surrounding area (Dennis 1986).

Orange-tip. R Hoddinott

The barrier effect of roads may be increased or decreased by design factors, e.g. increased shading may create apparent barriers (Dennis 1986). Turbulence may also prevent butterflies crossing. Dennis (1986) found that Green-veined Whites were heavily buffeted by traffic and either carried across, after being lifted high in the air, or returned to same side of the road. The number of vehicles per minute is an important factor, although Thomas, Snazell & Ward (2002) suggest that the aerodynamics of modern vehicles allow butterflies to be swept up and over speeding cars (in contrast to the more upright, less streamlined vehicles of previous years).

2.3.3 Road kills

It appears that the amount of traffic on the roads has no apparent effect on the abundance and diversity of butterflies on the roadside verges (Munguira & Thomas 1992) and butterflies can be seen feeding undisturbed on flowers swaying in turbulence (Feltwell and Philp 1980). However, butterflies can be killed when crossing roads and recent studies in Illinois (Mckenna et al 2001) indicate that butterfly mortality can be extremely high, especially for migrant species such as the Monarch (with an estimated death rate of up to 500,000 Monarchs in a single week) (Box 14). In Britain, mobile species such as the Pieridae (whites and yellows) may be the worst affected; for example, Munguira & Thomas (1992) found that 7% of Large Whites were killed by vehicles along a road at Bere Regis in Dorset, compared to only 0.6 – 1.9% of sedentary species such as Marbled White and Common Blue.

Road kills depend to some extent on the number of vehicles using the road, but Mckenna et al. (2001) found that butterfly mortality peaked at a rate of 13,500 vehicles per day, after which mortality declined. It is possible that butterflies become more reluctant to cross roads when there is a constant stream of traffic, perhaps because increased turbulence knocks them down at the side of the road before they attempt to cross. In tourist areas such as Cornwall and Devon, increased holiday traffic coincides with peak summer populations for some butterflies, so that butterfly road kills are likely to be comparatively high unless traffic is almost continuous throughout the hottest parts of the day.

Box 14: Butterfly mortality along roads in Illinois, U.S.A.

Summary of road and butterfly data from Illinois:

Illinois has
- 138,000 miles of road network
- Estimated 20 million butterfly kills including:
  - 80% Pieridae
  - Nymphalidae
  - Hesperidae
  - Papilionidae
  - Lycaenidae
- Up to 500,000 Monarchs killed in a single week
- Mortality peaked at a rate of 13,500 vehicles per day
- Mortality declined as vehicle movement increased to 26,000 vehicles per day

Mckenna, D.D., Mckenna, K.M., Malcom, S.B. & Berenbaum, M.R. 2001. Mortality of Lepidoptera along roadways in Central Illinois. *Journal of the Lepidopterists' Society*. **55(2)**:63-68.

2.3.4 Pollution

Muskett & Jones (1980) found no general detrimental effect on roadside macro-invertebrates from road traffic pollution (species diversity did not vary with increasing distance from road) and increased pollution caused by high traffic volumes along roads appears to have no apparent direct effect on the abundance and diversity of butterflies on the verges (Munguira & Thomas 1992). However, biological responses to increased pollution may take several years to become apparent, perhaps only when pollutants have reached specific threshold concentrations (Ashmore 2002).

There may also be indirect effects on butterfly populations that are less easy to quantify. For example, soil and vegetation near roads may contain high concentrations of lead (now reduced with the introduction of catalytic converters) and zinc (due to tyre dust and lubricating oil) (Wade et al 1980). In fact, the elevated nitrogen concentrations found in plants on roadside verges may be beneficial for some invertebrates, e.g. moth species (Port & Thompson 1980), because nitrogen is important in the diet of insects for growth and reproduction; on the other hand, added nitrogen can result in the increased dominance of particular grasses on chalk downland and the replacement of heathland by vigorous grasses (English Nature 1994), which can affect key butterfly communities. Grassland communities can also be changed by the prolonged application of de-icing salts which can raise soil pH values and be toxic to trees, shrubs and various grass species (English Nature 1994).

Common Blue. A Spalding

Additional causes of pollution include dust pollution (Farmer 1993) and the formation of low level ozone, both of which can affect plant growth and therefore larval feeding. Carbon monoxide and sulphur dioxide appear to have little effect on the ecology of roadside habitat (Ashmore 2002).

3 The statutory agencies and the legal framework

3.1 The Highways Agency and biodiversity

> **The Highways Agency is responsible for biodiversity on 30,000 hectares**
>
> **The Highways Agency has an Action Plan for Adonis Blue**
>
> **Roads which affect SSSIs or SACs are covered by the Habitats Directive 1992 and Statutory Instrument No 1241 Highways**
>
> **23 butterfly species are protected by law, 6 species with full protection**

The Highways Agency is responsible for encouraging and managing for biodiversity on its land, totalling around 30,000 hectares of so-called "soft estate" (i.e. the land defined as within the highway boundaries but not part of the carriageway). The Highways Agency has published a Biodiversity Action Plan which explains how the Agency will enhance the nature conservation value of its landholdings over the next ten years (Highways Agency, 2002). The Action Plan includes plans for the following habitats: boundaries, grasslands, heathlands, water and woodland. Two butterfly species are mentioned; Adonis Blue (with a full action plan) within the grassland habitat plan (Box 15) and High Brown Fritillary (with a short species statement) within the woodland habitat plan. The single action for High Brown Fritillary is to record suitable habitat on Highways Agency land and highlight it in the Environmental Database. The Highways Agency records ecological and environmental information on its own database.

3.2 SSSIs and SACs

Roads which will affect SSSIs or SACs are covered by the following legal framework.

3.2.1 SSSIs

Statutory Instrument No 1241 Highways requires nature conservation matters to be addressed if the proposed route is within 100 metres of an SSSI or national nature reserve (Highways (environmental assessment effects) Regulations Statutory Instrument No 1241. HMSO. London 1988).

Adonis Blue. A Spalding

> **Box 15: Highways Agency Biodiversity Action Plan: Adonis Blue**
>
> Although not yet recorded on Highways Agency land, suitable habitat for Adonis Blue occurs at a range of sites on the trunk road and motorway network including the A303 near Yarnbury in Wiltshire. The BAP lead partner for Adonis Blue is Butterfly Conservation.
>
> The following actions by the Highways Agency are listed:
>
> - Inform local area managers in network areas 3, 4 and 5 on appropriate management of verges for the Adonis Blue
> - Survey verge habitat for Adonis Blue and its larval foodplant of Horseshoe Vetch and record results on the HA Environmental Database
> - For all new road schemes and road improvements in network areas 3, 4 and 5 search for records in the initial desk study and survey at stage 2. Avoid habitat loss for Adonis Blue wherever possible
> - Where impact is unavoidable, consider options for compensatory habitat enhancement, linkage and removal of barriers to dispersal
> - Ensure existing sites are managed appropriately; draw up management plans where sites are within or adjacent to nationally or internationally designated sites
> - Consider creating specific Adonis Blue habitat adjacent or near to existing populations at five sites in the south
>
> Information on Adonis Blue should be included in environmental training for HA staff and Managing Agents

3.2.2 Natura 2000 sites

Article 6(3) of the Habitats Directive 1992

Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment

of its implications for the site in view of the site's conservation objectives. In light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public.

If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. (Natura 2000 aims to establish a network of protected areas as a coherent European ecological network of SPAs and SACs under Article 3(1) of the Habitats Directive).

Article 6(4) of the Habitats Directive 1992

Where the site concerned hosts a priority natural habitat type and/or a priority species, the only considerations which may be raised are those relating to human health or public safety, to beneficial consequences of primary importance for the environment or, further to an opinion from the Commission, to other imperative reasons of overriding public interest.

Site integrity has been defined in the following way in PPG9 (DoE, 1994):

The integrity of a site is the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or levels of populations for which it was classified (Paragraph C10. PPG9).

Byron (2000) suggests that this principle can be applied at all levels of sites in the conservation hierarchy and also to sites outside the designated areas, not just to SSSIs and SACs.

3.3 Legally protected butterflies

23 butterfly species are protected by law, of which 6 species have full protection (Annex 3). Legislation for butterflies is largely designed to protect butterflies from collectors and does little to protect the habitats in which butterflies live (Asher et al 2001). The only British butterflies listed under the Habitats Directive (1992) are the Large Blue (protected as a species) and the Marsh Fritillary (listed as a qualifying interest feature for SACs where the habitat is protected). Detail on the Marsh Fritillary is provided in Box 16.


Hiigh Brown Fritillary. L Slaughter


Heath Fritillary. A Spalding


Swallowtail. A Spalding


Large Copper. A Spalding


Marsh Fritillary. A Spalding


Large Blue. A Spalding

Box 16: Marsh Fritillary

The Marsh Fritillary is listed in the EC Habitats Directive and Appendix II of the Bern Convention. Since 1998, it has been fully protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended). Section 9 of the Act prohibits the intentional killing, injuring or taking of, the possession of and the trade in Marsh Fitillaries. In addition, places used for shelter and protection are safeguarded against intentional damage, destruction and obstruction and Marsh Fitillaries must not be intentionally disturbed whilst occupying those places. Section 16 of the Act provides a mechanism for licensing actions which would otherwise be unlawful. Under this Section, English Nature are the licensing authority for actions and developments that would affect Marsh Fitillaries. Section 10 identifies certain exceptions to Section 9, including provision to cover incidental actions that are an unavoidable result of an otherwise lawful activity.

The Marsh Fritillary is a qualifying interest feature for Special Areas of Conservation (SAC) as required by the Habitats and Species Directive (92/43/EEC). If its status on a SAC will be affected by proposed road development, an appropriate assessment of the implications of the new road for the site should be made under the Habitats Directive 1992.

4 Site evaluation and mitigation

Butterfly-rich verge on the A303. A Spalding

4.1 Evaluating impacts

Biodiversity should be enhanced wherever possible

Ecologists should have early input

Surveys should cover the whole metapopulation of key species

Vacant habitat should be mapped

Mitigation is centred on provision of wildlife corridor and stepping stone habitat

Introductions should be considered where appropriate

The key consideration in evaluating the impact of road developments on biodiversity is that there is no significant reduction in overall biodiversity; the biodiversity of the area should be enhanced wherever possible (Byron 2000). The impact of any road scheme should be considered at the local and landscape level; this is especially important for those butterflies which live in metapopulations. Suggested stages in impact assessment are shown in Box 17. It is important that ecologists have early input into proposals for new road schemes because the route chosen may have important positive effects for butterflies (e.g. linkages between habitats) or negative effects (e.g. barriers to movement within metapopulations). Surveys should be undertaken at suitable times of year to ensure that the current position of butterfly populations within the area is fully understood, including mapping suitable but vacant habitat that could be naturally colonised.

Assessment of the area to be surveyed should be based on the pattern of existing butterfly populations and the known distance over which key species can colonise new areas. Vacant but potential habitat should be mapped over a wide enough area to encompass the entire metpopulation. The impact of the road on the viability of the populations of key species can then be assessed. It is essential that the survey is designed and managed by butterfly experts who understand the ecology of the key species present. The ability to identify butterfly species is not in itself a sufficient qualification for this assessment work.

Box 17: Suggested site evaluation of new roads for their impact on butterfly populations

Stage One: Impact assessment

- Carry out a desk study to determine key species resident or previously resident in the area
- Assess area to be surveyed including metapopulations of key species
- Assess the nature conservation status of the route e.g. SACs, SSSIs, CWS etc
- Assess the route in the context of Natural Areas, national and local BAPs, Butterfly Conservation's Regional Action Plans
- Carry out surveys to establish the presence of priority species and suitable habitat within the area agreed
- Assess the effect of the road on the viability of populations of key species within the surrounding landscape at the metapopulation scale
- Assess the barrier effect of the road on butterfly populations

Stage Two: Mitigation assessment

- Assess the potential of the road as a wildlife corridor and stepping-stone habitat
- Assess the route alignment: north, south, west or east-facing slopes will benefit different butterfly species
- Assess the soil suitability for wildflower mixes and identify appropriate plant species to support butterfly populations
- Identify seed/plant sources from the local area
- Identify management and monitoring programmes

It is possible to predict butterfly distributions based on habitat types and foodplant distribution, especially for sedentary species such as Common Blue and Silver-studded Blue, but survey work is more reliable. Detailed surveys for all High Priority species (Box 1) should be carried out where these are known to occur (or have recently occurred) within the survey area; surveys for Medium Priority species should be carried out where they are fully protected (e.g. Swallowtail) or where the regional populations are of national importance.

4.2 Designing for mitigation

It is important to avoid high quality wildlife habitat where Priority butterfly species are known to occur, or have recently occurred. The design of three proposed motorway extensions have been significantly altered on the basis of the potential harm they would cause to butterflies, two for the Black Hairstreak (M1, M40) and one for the Chalkhill Blue (M3) (Thomas, Snazell & Ward 2002).

Once the route of the new road development has been decided, the key mitigation for alleviating damage to butterfly populations will be the potential of the road to provide habitat links connecting existing and potential butterfly habitat in the area (Box 17). Detailed mitigation will be dependent on the route alignment as different aspects are suitable for different butterflies (Box 18), depending largely on requirements for warmth. Temperature analysis (e.g. with laser thermometers) can show whether it is advantageous to modify an area topographically (Morris et al 1994) to provide the warmest microclimates appropriate for key species. The optimum sites for butterflies have a diversity of habitat to cope with varying climatic conditions, so that in hot dry summers butterflies can move to cooler areas with thicker soil less prone to drought, and in cool wet summers butterflies can move onto areas with thin dry soils that heat up quickly in the sun; a varied topography (as provided in road cuttings and on embankments) is especially important with anticipated climate change.

Box 18: Butterflies suitable for different aspects of road cuttings and embankments

All aspects	south-facing
Dark Green Fritillary	Adonis Blue
Duke of Burgundy	Brown Argus
Gatekeeper	Chalkhill Blue
Marbled White ?	Grayling
Meadow Brown ?	Green Hairstreak
Ringlet	Northern Brown Argus
Small Heath	Silver-spotted Skipper
	Small Blue
	Small Copper
	Wall

Partly taken from Morris et al 1994.

5 Road design

5.1 Introduction

Ecological engineering must be incorporated at the beginning

Nature conservation issues must be incorporated from the earliest stages of project development (Highways Agency 2001) and it is important that designs for new roads are approached from an ecological engineering standpoint; they should be the result of a partnership between planners, engineers, landscape architects, archaeologists, amenity groups and ecologists (Morris et al 1994). As engineers and landscape designers may have little knowledge of biodiversity and less knowledge of invertebrates, it is important to include insect habitats in the very earliest designs (Thomas, Snazell & Ward 2002).

The key design features of the new road include the following:

- Roadside verges
- The central reservation
- Cuttings and embankments
- Swales
- Attenuation reservoirs
- Compensation land

Setting the timetable for habitat restoration at the start of the operation is critical; it is essential to do things in season e.g. planting plugs, seeding etc. It is important to time activities according to the main construction contract, i.e. when habitat becomes available for translocation, when cuttings and swales are built etc.

Habitat creation for butterflies follows key stages (Box 19). It is important to identify the minimum viable habitat required by each target species and design a network of habitat patches along the road corridor in association with adjacent suitable habitat (occupied or vacant); each habitat patch should be within flight reach of the adjacent habitat for the target species, e.g. 0.6-1 km for Silver-studded Blue (Thomas et al 1992). Where possible, road design should retain or create natural habitat links to assist butterfly movement, e.g. appropriate landscaping of the road corridor which create opportunities for natural species migration (Highways Agency 2001). The possibility of linking habitat patches in an intensive agricultural landscape should be investigated as an environmental mitigation measure of new roads, as occurred with the design of the M40 (Box 10). The use of verges along road bridges to link both sides of a new road should be considered in some cases; bridges have been used in this way to enable wildlife to cross over the high speed railway line on the Channel Tunnel Rail Link and in the Netherlands Ecoduct bridges have been used to link wildlife habitat to compensate for habitat fragmentation (Box 20).

Silver-studded Blues. L Slaughter

Box 19: Key steps in roadside habitat design and creation for butterflies

- Identify target species
- Identify other butterfly species occupying the same habitat as target species for habitat integrity
- Identify habitat requirements e.g.:
  - Minimum viable habitat
  - Larval foodplants in correct position
  - Short or long sward
  - Bare ground
  - Shelter
  - Presence of ants
  - Nectar sources
- Identify key areas for butterfly colonisation and movement, e.g. south or north-facing banks; marshy areas
- Design network of habitat patches along the road corridor in association with adjacent suitable habitat (occupied or vacant)
- Design and create suitable topography
- Establish suitable sub-soil or top soils
- Translocate ant nests as appropriate (e.g. for Lycaenid butterflies)
- Sow seed mix or plant potted plants or shrubs
- Translocate turves with plants and invertebrates
- Establish shelter belts as appropriate
- Introduce key species as appropriate in accordance with the relevant BAP and following discussions with English Nature, Butterfly Conservation (local and national) and other appropriate conservation organisations.

> **Box 20: The use of Ecoducts to mitigate for habitat fragmentation**
>
> - Ecoducts are one of the most suitable measures available to counteract habitat fragmentation for butterflies
> - Ecoducts have been used in the Netherlands for mammals to cross a 4 lane motorway which dissects a large nature reserve
> - They can be walled at the edges to reduce traffic disturbance
> - Trees and shrubs can be planted at the edges with open grassland in the middle
> - A width of 30 metres should be ample for butterflies
> - The building cost in the Netherlands in 2002 was about 3 million Euros (= about £1.8 million)

Brief notes on habitat creation for butterflies are provided in Boxes 21a and 21b; additional information on habitat creation for roads is provided in *Roads and nature conservation. Guidance on impacts, mitigation and enhancement* (English Nature 1994).

5.2 General elements of habitat design for butterflies

5.2.1 Soils

> **Many butterflies prefer small scale habitats with varied micro-climates**
>
> **Shelter is important**
>
> **Translocation of turf can be successful for invertebrates**
>
> **Ant nests are keystone species and can be used as innocula**

The target butterfly species should be appropriate for adjacent populations and the soil types along the road corridor; there may be different soil types in different road sections in areas of complex geology. Soil analysis (e.g. pH values, soil structure and nutrient status) may provide important information. It is important to avoid damage to the structure and chemical composition of the soil. The total soil nitrogen and the rate of mineralisation is critical in determining plant growth and wild flower mixes generally do best where soil nutrients are low (Wells & Bayfield 1990; Department of Transport 1993).

Any soil used should be appropriate to the location and the habitat (Highways Agency 2001) and sub-soil is particularly useful in habitat creation because it has lower nutrient status and may contain fewer weed species. In contrast, top soils may contain annual and perennial weeds (e.g. *Rumex* species) which can be difficult to control except by spot treatment with herbicides. No fertilisers should be applied to soils used in landscaping schemes so that the nutrient load can be reduced over time (Munguira & Thomas 1992). The removal of fertile topsoil can lead to the creation of a low-productivity minimum management sward suitable for early successional stage butterflies (Morris et al 1994).

> **Box 21a: Brief notes on habitat creation (woodland and scrub) for butterflies**
>
> The following are some of the key points when considering habitat creation:
>
> **Shelter belt woodland**
>
> - Woodland butterflies (e.g. Purple Emperor, Purple Hairstreak and White-letter Hairstreak) require particular species of tree as larval foodplants.
> - Woodland clearing butterflies (e.g. Wood White, Pearl-bordered Fritillary, Speckled Wood) feed as larvae on low-growing plants.
> - Woodland edge butterflies (e.g. Ringlet) feed as larvae on low-growing plants and require light shade.
> - The suitability of woodland clearings will depend on the vegetation structure, vegetation composition and amount of shade (Warren & Stephens 1989).
> - Different butterflies prefer different amounts of shade (Thomas 1991a) – it is important to design the ride width and orientation and the ultimate tree height to provide appropriate shade for target species.
> - Wildflower glades were created in the M40 Waterstock – Wendlebury corridor by removing topsoil and seeding with wildflower seed from a hay crop from local flower-rich hay meadow (Bickmore 1992).
> - The full nature conservation benefits may take around 50 years to achieve (Bickmore 1992).
>
> **Scrub**
>
> - Scrub is an essential element of butterfly habitat, providing shelter even on grassland habitat (e.g. for Duke of Burgundy).
> - Scrub provides larval foodplant for a range of species, e.g. Holly Blue (holly, ivy and European gorse), Green Hairstreak (e.g. European gorse, broom, bramble, buckthorn), Brown Hairstreak (blackthorn), Black Hairstreak (blackthorn), Brimstone (buckthorn, alder buckthorn).
> - Suitable scrub species (e.g. European gorse) can be planted as individual plants within tree guards.
> - In the creation of new butterfly habitat at Ryewater Meadows in Dorset, alder buckthorn was planted for Brimstone, European gorse for Green Hairstreak and holly for Holly Blues (Warren & Stephens 1989).
> - The planting of hedgerows to create sheltered habitats can also be beneficial for Brown Hairstreak which feeds on blackthorn (Warren & Stephens 1989).

Box 21b: Brief notes on habitat creation (heath and grassland) for butterflies

Heathland

- Heathland butterflies include Grayling and Silver-studded Blue.
- Heathland habitat is especially vulnerable to fragmentation and degradation and road corridors present excellent opportunities for linking heathland fragments.
- Heathland is suitable for establishment on both south and north-facing slopes of cuttings and embankments.
- Sparse heathland with abundant bare ground is especially suitable for butterflies.
- Wet heathland is suitable for establishment in the attenuation areas and swales.
- Grasses such as *Festuca ovina* sheep's fescue can add to the heathland mix (Wells & Bayfield 1990); sheep's fescue and *Agrostis setacea* bristle bent are foodplant for Grayling.

Grassland

- The sward structure is important for butterflies so it is important to create a grassland mosaic with a range of turf heights (Butt 1986).
- Some species prefer short turf, medium turf and long turf (Box 11).
- A low-productivity minimum management sward can be created by changing the topography and removing much of fertile topsoil (Morris et al 1994).
- Shelter can be provided by variations in topography, e.g. by building steep banks (Warren & Stephens 1989).
- The addition of nectar plants to the seed mix is important as there is a significant correlation between the abundance of nectar sources and abundance and diversity of butterflies (Munguira & Thomas 1992).
- Wild flower mixes generally do best where soil nutrients are low (Wells & Bayfield 1990).
- All seed should be locally sourced and donor sites for seed need to be identified. *Flora locale* promotes good practice among those involved in native plant and seed collection, propagation and habitat restoration and creation.
- Seeding with bird's-foot trefoil may be beneficial because it provides additional nitrogen to the soil and is the larval foodplant of many butterflies including Dingy Skipper and Common Blue.

5.2.2 Topography

Many invertebrates (including butterflies and ants) prefer small scale habitats with a variety of micro-climates. Temperature readings taken across areas with humps and hollows will show a greater range in temperatures than temperature readings across flat land; for example, Morris et al. (1994) found a 90C variation in temperature across an anthill 23cm

Silver-spotted Skipper nectaring on clover. L Slaughter

high, which shows the difference minor adjustments to topography can make. Some species will lay their eggs in the hottest and driest habitat, others will lay their eggs on the longer vegetation in more shady areas. Varied topography will give different amounts of shelter from the wind, especially important in linear features where the wind can follow the road corridor.

Diversity of habitat can be achieved through small scale engineering with mini-diggers, using the following design procedures (e.g. Morris et al 1994; Munguira & Thomas 1992):

- Scrape soil to sides
- Excavate ditches
- Spread topsoil back over excavation
- Dribble soil down each bank
- Excavate sheltered inundations in cuttings
- Create steps with steep thin-soil risers

5.2.3 Seeds and plants

Wild flowers are important as nectar plants and as larval foodplants. Different butterflies seek out different nectar plants so it is important to know which are the key nectar sources (e.g. Marsh Fritillary nectars on hawkweeds *Hieracium* species, thistles *Cirsium* species and knapweeds *Centaurea* species). The provision of flowering plants is important within the sward and the number and abundance of butterfly species is correlated with the abundance of nectar sources (Munguira & Thomas 1992).

Many of the landscaping schemes incorporating the creation of wildflower grassland in recent years have failed due to lack of consideration of the special requirements of the wild flowers chosen (Landlife 1997). Two of the key problems are the use of fertile topsoils which contain problematic weed seed banks and the use of competitive grass species. One of the simplest methods of promoting success is to sow wildflowers direct into nutrient poor soils (Landlife 1997). Tall herbs can be seeded in gaps of deeper soil between areas of low nutrient status (Morris et al 1994). A special wildflower seed mix was used on the M40 over a shallow depth (50mm) of topsoil within the motorway fence line (Bickmore 1992). Many plants can be pot-grown and planted as mature plants as happened successfully at Twyford Down, but whether sown as seed or planted out, all plants should be locally sourced. *Flora locale* aims to promote good practice in the use and sourcing of native flora for all projects that have wildlife in mind (Flora locale 2005) and publish a code of practice for collectors, growers and suppliers of native flora as well as a list of native flora suppliers (www.floralocale.org). Landlife (1997) publish a wildflower index for 48 wildflowers, with notes on germination rates, light and moisture requirements, number of seeds per gramme, soil type and pH preferred, flowering season and life cycle.

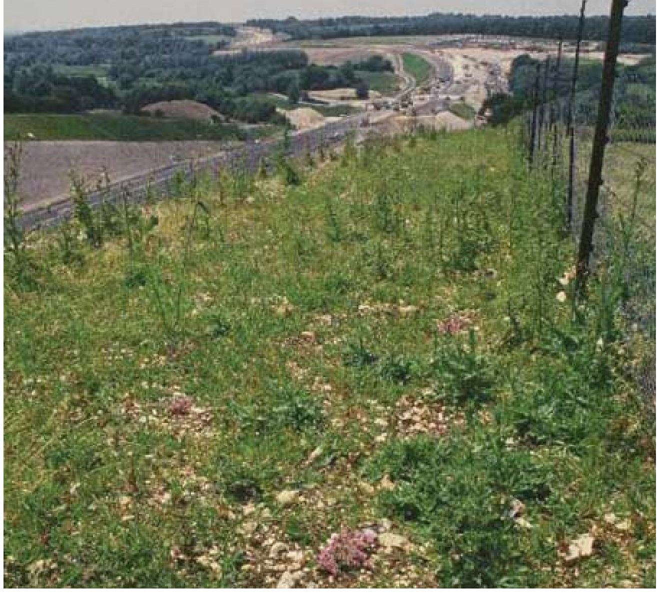
5.2.4 Translocation

It is generally considered that habitat creation does not compensate for valuable habitats lost for the following reasons (English Nature 1994):

- The lack of historical continuity
- The inability to provide complex topography and drainage
- The disturbance to soils
- The loss of plant diversity and richness
- The establishment of simple, less diverse ecosystems in place of complex relationships between species

However, despite these general reservations, the translocation of turf (complete with ant nests and seed banks) has been shown to be successful for invertebrate communities (e.g. at Twyford Down- Snazell 1998) and the translocation of blackthorn bushes (with Black Hairstreak pupae attached) was successful on the M40 (Bickmore 1992). Translocation is especially useful for dry grassland

Turf transplants at Twyford Down. English Nature



Pots of wild thyme by the M3 at Twyford Down. English Nature

and heathland. It is important to move as large turves as possible; at Twyford Down turves 2.4m by 1.2m and up to 30cm thick were moved by a macroturfing technique (Snazell 1998). This method disrupts the soil less and takes more plants, more soil and more invertebrates including ants. Ant nests can be used as innocula. They are keystone species that create micro-habitats for many other species within their biotopes and management for ants will enhance the biodiversity value of these sites. The general principles of turf translocation are shown in Box 22.

5.3 The key design features

Verges should contain a wide variety of butterfly habitat

Central reservations can provide expensive but important habitat

Deep cuttings can provide the maximum potential for butterflies

Slopes can be stepped to provide varied topography

Swales and attenuation reservoirs can be used for wetland species such as Marsh Fritillary

Severed land can be managed for butterflies

5.3.1 Verges

For new roads, the most important single factor is to ensure that the verges contain a wide variety of the specific larval habitats of the butterfly species characteristic of the region (Thomas, Snazell & Ward 2002). Verges should have the following features:

- Be as wide as possible (Munguira & Thomas (1992) found that density of butterflies was correlated with the width of the verge)

Flower-rich verge. A Spalding

- Include an abundance of larval foodplants
- Have broken or undulating terrain with a mix of unfertilised soils and deeper soils
- Have a mixture of native scrub and/or hedgerows
- Have maximum shelter
- Be unfertilized

The current practice of flattening out roadside verges after construction, coating with topsoil and then seeding with cultivars or agricultural ley grasses reduces the capacity of the verge to support butterflies (Thomas, Snazell & Ward 2002). It is possible to create microhabitat and shelter on flat ground by micro-landscaping small humps and hollows in order to create additional habitats for butterflies. Planting scrub and hedges will create additional shelter and suitable habitat for species.

Box 22: General principles of turf translocation are:

- Translocation should take place in winter
- Cut turves should be as large and thick as possible
- Turves should not be laid on top of each other
- The time from cutting to re-laying should be as brief as possible (say 1.5 hours)
- Translocated turves can be flattened by using the low-impact tracks of an excavator
- The turfed area should be surrounded with rabbit-proof fencing to protect the turf and invertebrate populations; rabbits should be allowed on when the turf develops

(taken from Snazell 1998)

5.3.2 The central reservation

The Highways Agency prefer narrow central reservations (2.5 metres wide) because each additional metre width increases the construction costs. However, wide central reservations can be valuable for wildlife if suitable habitat is present and can form stepping stone areas for mobile species. The central reservation can be treated as a verge (section 5.3.1) and planted with grassland or scrub as appropriate.

However, the cost of widening the reservation is very high in relation to the wildlife gain, since it broadens the total land take considerably. It may be more cost-effective to look for mitigation and habitat creation on the cuttings and embankments, the swales and the attenuation reservoirs. In addition, the safety barriers erected on each side of the central reservation may limit colonization, especially where the reservations are narrow.

5.3.3 Cuttings and embankments

Deep cuttings provide the maximum potential for butterflies and should be given priority for habitat creation (Thomas, Snazell & Ward 2002). South and west-facing slopes which heat up quickly in the sun are highly valuable for butterflies; north-facing slopes are less favoured but will be used by species that require damper conditions such as the Duke of Burgundy or by many other species in very hot drought years. Even on warm slopes it is important to create shelter from the wind, especially along roads where the wind will funnel through cuttings, so scrub (e.g. European gorse) should be planted in places to act as wind breaks. Butterflies do best in areas with a varied topography, so the creation of sheltered hollows or indentations is beneficial (Thomas 1991b). The temptation to grade out slopes should be resisted as far as possible. Slopes could ascend in a series of steps such as occur at Maiden Castle in Dorset, which is an area of high quality butterfly habitat with steep thin-soiled risers and flatter deep-soiled areas (Munguira & Thomas 1992). Embankments offer similar habitat potential for butterflies although they provide less sheltered habitat.

Wide central reservation at the junction of the A303 and A3057, of potential value for wildlife. A Spalding

5.3.4 Swales

Swales have only recently been used in Britain but have been extensively used in North America (Environment Agency 1997). They consist of shallow grass-lined depressions which run alongside the road and which are used for the conveyance, storage and infiltration of runoff with the minimum of erosion (English Nature 1996). Their use can result in the improvement of water quality by reducing suspended

Blocks of gorse scrub providing windbreaks on the A39. A Spalding

solid loads and encouraging bio-filtration; planting with species such as willow or purple moor-grass will further enhance bio-filtration by increasing the water contact time and may have the by-product of enhancing the wildlife value of the swales. These swales can act as wildlife corridors linking the attenuation areas where wetland habitat will be created (section 5.3.5). Their use for butterflies should be targeted at species such as Green-veined White and Orange Tip (utilising the plants such as garlic mustard and ladies smock which will grow in such conditions) and Marsh Fritillary where adjacent habitat supports this butterfly.

5.3.5 Attenuation reservoirs

Attenuation reservoirs are used in conjunction with swales for the storage of storm water. These basins may be vegetated, usually with plants such as reeds and rushes which are known to survive in nutrient rich conditions and are generally pollutant tolerant (Environment Agency 1997). Where there are a series of ponds, the first pond can be lined and impermeable, facilitating the collection of silts and pollutants. Subsequent ponds may be of softer engineering, with large areas of wet grassland to hold occasional flood water. Engineering costs can be minimised in this way but a larger land take may be necessary. On the M40, the geometric engineering design of reservoirs was rounded off and flattened to produce a more irregular natural looking profile and they were lined with clay not concrete (Bickmore 1992). The south and south-west facing slopes of these features could be managed to provide ideal habitat for butterflies. These areas can be made more suitable for wetland butterflies by the following measures:

- Planting pot-grown larval foodplants
- Planting with a suitable seed mix to encourage appropriate habitat formation
- De-nutrification, e.g. by cutting and removal of vegetation
- Landscaping gentle slopes to increase the south and south-west-facing areas
- Creating shallow basins
- Planting scrub to increase shelter

5.3.6 Compensation and severed land

Compensation and severed land can be managed for butterflies and may provide important new habitats, including for non-roadside verge species such as woodland butterflies. Compensation land adjacent to the M40 currently supports a major population of the Brown Hairstreak as well as a colony of the White-letter Hairstreak and the grassland area on compensation land supports 25 species of butterfly which colonised the site between 1991-1994 (Thomas, Snazell & Ward 2002). These areas can provide some of the major mitigation for butterflies.

Wetland habitat along the A39. A Spalding

5.4 Butterfly introductions

The design of a new road may provide an opportunity to re-introduce butterflies to an area where they once occurred. Opportunities for species introduction should be encouraged where possible (Highways Agency 2001) but only for butterflies previously resident in the area, for which the BAP includes re-introduction proposals and for which re-introduction is mentioned in the key actions in the relevant Regional Action Plan published by Butterfly Conservation (Box 2). Re-introductions should then only be attempted if the area available is about 5 times larger than the minimum viable population area and a metapopulation can be established (Thomas 1995). If these criteria are met, then donor sites should be identified and, as lead partner, Butterfly Conservation should be consulted at an early stage to discuss the suitability of the site and advise on procedures.

6 Managing roads for butterflies

6.1 General management principles

> **There are a number of key principles for management for butterflies**
>
> **Management works best when it is targeted at key species**
>
> **There are different management regimes for woodland, hedgerows, scrub, heath and grassland**

- Decide whether management is necessary – the use of thin soils during landscaping combined with rabbit grazing may reduce the need for management
- Larvae and adult butterflies may have different requirements
- Suitable egg-laying sites are essential. These are dependant on the height of vegetation, the structural setting of the hostplant and the timing of flowering
- It is essential for the site to contain suitable nectar flowers, shelter, resting places and perches for male territories
- If possible manage for a range of habitat mosaics
- Some species are choosy about which part of the site suits them; they may not want to move around with rotation management and it may be necessary to manage small parts of the site separately (BUTT 1986)
- Egg-laying and larval sites can be marked and avoided when the site is mown, especially for species which over-winter as larvae such as Marsh Fritillary and many of the skipper butterflies
- The right conditions must be available every year; one year without suitable management may lead to the local extinction of a species
- Monitoring the effect of management on the site is essential
- Different management regimes will be necessary for different habitats in different locations within the road corridor
- Management for wildlife works best when it is targeted at key species and habitats with clear objectives

6.2 Woodland shelterbelt management

- Maintain sheltered open clearings for woodland edge/clearing butterflies
- Maintain open coppice as necessary for coppice species such as Pearl-bordered Fritillary
- Maintain a strip of open habitat along the shelter belt edge, with preference given to the woodland edge furthest away from the road
- Thin trees as necessary to prevent the wood becoming too dense and shady
- Maintain connecting corridors between glades and clearings
- Clearings can be mown every 2-4 years with short turf in the centre and longer turf at the edges (Warren & Stephens 1989)
- The longer marginal scrub zone at the edge of clearings can be mown on a longer rotation every 5-20 years

6.3 Hedgerows

- Encourage the establishment of mixed broadleaved hedgerows
- Maintain areas of longer grass in suitable areas for hedgerow species such as Ringlet and Gatekeeper
- Maintain nectar sources, e.g. bramble
- In appropriate areas cut blackthorn hedges one side per year to prevent local extinctions of Brown Hairstreak (which lays its eggs on one year old wood)
- In appropriate areas maintain sucker growth of elm for White-letter Hairstreak

6.4 Scrub

- Control invasive scrub by cutting and/or burning. The exact rotation will depend on a range of factors including the scrub species and its habitat (including soil structure); for example, rotation of European gorse may be 5-8 years
- Scrub in swales may require cutting back for public safety and in order to maintain the drainage function
- Consider burning of gorse between November and March in some areas because it promotes the growth of finer grasses by removing rank litter

6.5 Heath

- Maintain open areas with bare ground suitable for warmth-loving species such as Silver-studded Blue and Grayling
- Rotationally cut/burn heathland areas

6.6 Grassland

- Management of sward heights depend on the target butterfly species (see Box 11)
- Grassland management of level areas, cuttings and embankments should be by cutting or mowing
- If possible, mow between late September and early May (Munguira & Thomas 1992); it may be necessary to mow a narrow strip near the road more often than this for safety reasons
- Cuttings can either be raked into piles adjacent to any scrub areas and left to rot or removed completely (e.g. by baling); if it is possible that eggs have been laid, cuttings should be left on site
- Only part of the site should be cut in any one year
- Maintain a mosaic of mown and unmown areas (Munguira & Thomas 1992)
- Grazing is not possible within the road corridor for reasons of safety but may be possible on compensation land. Appropriate grazing regimes (e.g. with sheep, cattle and/or horses) will depend on the particular butterfly species to be managed for
- Rabbit grazing may be a key part of the management process
- Damage to ant hills should be avoided when mowing
- Avoid the use of flails which will do damage to the invertebrate fauna (BUTT 1986); rotary cutters are preferable
- Consider mowing corridors through long grassland to provide shorter grass areas (BUTT 1986)

7 Monitoring success

Monitoring butterflies at roadside. A Spalding

Monitoring will inform good practice in the future

Monitoring should follow established methodologies:

- Butterfly transects
- Larval counts
- Mark-recapture programmes

Monitoring should be considered for all nature conservation projects, especially for protected species or habitats or where the knowledge obtained could inform future good practice (Highways Agency 2001). It will take some time for habitats to become established so that detailed monitoring should extend beyond 2-3 years after construction (Highways Agency 2001), since butterfly populations may fluctuate between extremes of abundance and scarcity in the first few years (Thomas, Snazell & Ward 2002).

Monitoring should follow established methodologies, e.g. butterfly transects for adults (Pollard 1977; Pollard, Hall & Bibby 1986). The assessment of trends can be difficult in natural dynamic systems which change in response to environmental factors. As a result, transect results should be correlated with national trends via the national Butterfly Monitoring Scheme run by I.T.E. in order to see whether local trends are showing real responses to habitat change. In addition, transects should be continued for as long as possible (e.g. 5-10 years for grasslands) since short term fluctuations in butterfly numbers can disguise real long term trends. If possible, permanent transects could be established on the roadside (especially on south-facing banks) and the adjacent areas if restored and monitored once a week (e.g. by volunteers from local branches of Butterfly Conservation in agreement with the Highways Agency).

Monitoring can also take place for larvae. This is one of the preferred methods for monitoring Marsh Fritillary populations and other species that are conspicuous at this life stage. Butterfly Conservation have established a standard survey methodology for this butterfly. According to this method, a 2 metre transect is walked on a zig-zag path to cover the site evenly and the number of occupied webs counted, from which a population estimate can be made.

The barrier affect of the road could be assessed by carrying out a mark-recapture programme on target species occupying populations on both sides of the road. As an example, mark-recapture experiments at Twyford Down showed that a small number of Chalkhill Blues flew across the M3 indicating that, due to mitigation measures, movement between populations was not negatively affected (Thomas, Snazell & Ward 2002).

More detailed advice on the methodologies for monitoring butterfly populations is available from Butterfly Conservation and English Nature.

Useful addresses

English Nature
Northminster House
Peterborough
PE1 1UA

Tel: 01733 340345

Butterfly Conservation
Manor Yard
East Lulworth
Wareham
Dorset
BH20 5QP

Tel: 01929 400209

Royal Society for Wildlife Trusts
The Kiln
Waterside, Mather Road
Newark
Nottinghamshire
NG24 1WT

Tel: 0870 0367711

Annex 1: Butterfly species and their associated habitats highlighting (in bold) those species likely to be associated with roads

Grassland	Bracken Scrub	Heathland	General	Scrub	Woodland	Woodland Ride/edge	Boundary Features	Wetland
Adonis Blue	Pearl-bordered Fritillary	Grayling	Clouded Yellow	Green Hairstreak	Comma	**Brimstone**	Brown Hairstreak	**Green-veined White**
Brown Argus	High Brown Fritillary	Silver-studded Blue	Holly Blue		Pearl-bordered Fritillary	Brown Hairstreak	Black Hairstreak	Large Heath
Chalkhill Blue			**Large White**		Purple Hairstreak	Chequered Skipper	Brimstone	**Orange Tip**
Chequered Skipper			**Painted Lady**		Purple Emperor	Comma	**Gatekeeper**	Marsh Fritillary
Common Blue			**Peacock**		Silver-washed Fritillary	Grizzled Skipper	Green-veined White	Small Pearl-bordered Fritillary
Dark Green Fritillary			**Red Admiral**		White Admiral	Duke of Burgundy	Holly Blue	Swallowtail
Dingy Skipper			**Small Copper**			Heath Fritillary	**Orange Tip**	
Duke of Burgundy			**Small White**			High Brown Fritillary	Peacock	
Essex Skipper			**Small Tortoiseshell**			Pearl-bordered Fritillary	**Ringlet**	
Glanville Fritillary						Small Pearl-bordered Fritillary	Speckled Wood	
Grayling						Speckled Wood	White-letter Hairstreak	
Green-veined White						White-letter Hairstreak		
Grizzled Skipper						Wood White		
Large Blue								
Large Skipper								
Lulworth Skipper								
Marbled White								
Marsh Fritillary								
Meadow Brown								
Mountain Ringlet								
Northern Brown Argus								
Scotch Argus								
Silver-spotted Skipper								
Small Blue								
Small Heath								
Small Pearl-bordered Fritillary								
Small Skipper								
Wall								

Taken from habitat descriptions in *The Millennium Atlas of Butterflies in Britain and Ireland*. This table gives the broad habitat types only as some butterfly species occur in smaller numbers in other habitats.

Annex 2: Population structure of British butterflies (from Thomas (1984) and Warren (1992))

Open	Closed
Brimstone	Adonis Blue
Clouded Yellow *	Black Hairstreak
Comma	Brown Argus
Green-veined White	Brown Hairstreak
Holly Blue	Chalkhill Blue
Large Tortoiseshell [1]	Chequered Skipper
Large White	Common Blue
Orange Tip	Dark Green Fritillary
Painted Lady *	Dingy Skipper
Peacock	Duke of Burgundy
Red Admiral	Essex Skipper
Small Tortoiseshell	Gatekeeper
Small White	Glanville Fritillary
	Grayling
	Green Hairstreak
	Grizzled Skipper
	Heath Fritillary
	High Brown Fritillary
	Large Blue
	Large Copper
	Large Heath
	Large Skipper
	Lulworth Skipper
	Marbled White
	Marsh Fritillary
	Meadow Brown
	Mountain Ringlet
	Northern Brown Argus
	Pearl-bordered Fritillary
	Purple Emperor
	Purple Hairstreak
	Ringlet
	Scotch Argus
	Silver-spotted Skipper
	Silver-studded Blue
	Silver-washed Fritillary
	Small Copper
	Small Blue
	Small Heath
	Small Pearl-bordered Fritillary
	Small Skipper
	Speckled Wood
	Swallowtail
	Wall
	White Admiral
	White-letter Hairstreak
	Wood White

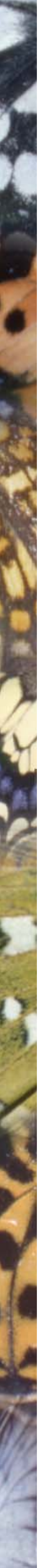
1 probably extinct

* common migrant

Annex 3: Butterfly species protected by law

Species	Legislation/Convention	Protection
Adonis Blue	WCA 1981	Schedule 5 - in respect of sale only
Black Hairstreak	WCA 1981	Schedule 5 - in respect of sale only
Brown Hairstreak	WCA 1981	Schedule 5 - in respect of sale only
Chalkhill Blue	WCA 1981	Schedule 5 - in respect of sale only
Chequered Skipper	WCA 1981	Schedule 5 - in respect of sale only
Duke of Burgundy	WCA 1981	Schedule 5 - in respect of sale only
Glanville Fritillary	WCA 1981	Schedule 5 - in respect of sale only
Heath Fritillary	WCA 1981	Full protection
High Brown Fritillary	WCA 1981	Full protection
Large Blue	WCA 1981 Conservation (Natural Habitats, etc) Regulations EC Habitats Directive - Annex IV Bern Convention - Appendix II	Full protection
Large Copper	WCA 1981	Full protection
Lulworth Skipper	WCA 1981	Schedule 5 - in respect of sale only
Marsh Fritillary	WCA 1981 EC Habitats Directive - Annex II Bern Convention - Appendix II	Full protection
Mountain Ringlet	WCA 1981	Schedule 5 - in respect of sale only
Northern Brown Argus	WCA 1981	Schedule 5 - in respect of sale only
Pearl-bordered Fritillary	WCA 1981	Schedule 5 – in respect of sale only
Purple Emperor	WCA 1981	Schedule 5 - in respect of sale only
Silver-spotted Skipper	WCA 1981	Schedule 5 – in respect of sale only
Silver-studded Blue	WCA 1981	Schedule 5 - in respect of sale only
Small Blue	WCA 1981	Schedule 5 - in respect of sale only
Swallowtail	WCA 1981	Full protection
White-letter Hairstreak	WCA 1981	Schedule 5 - in respect of sale only
Wood White	WCA 1981	Schedule 5 - in respect of sale only

adapted from Asher et al., 2001



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ENGLISH NATURE

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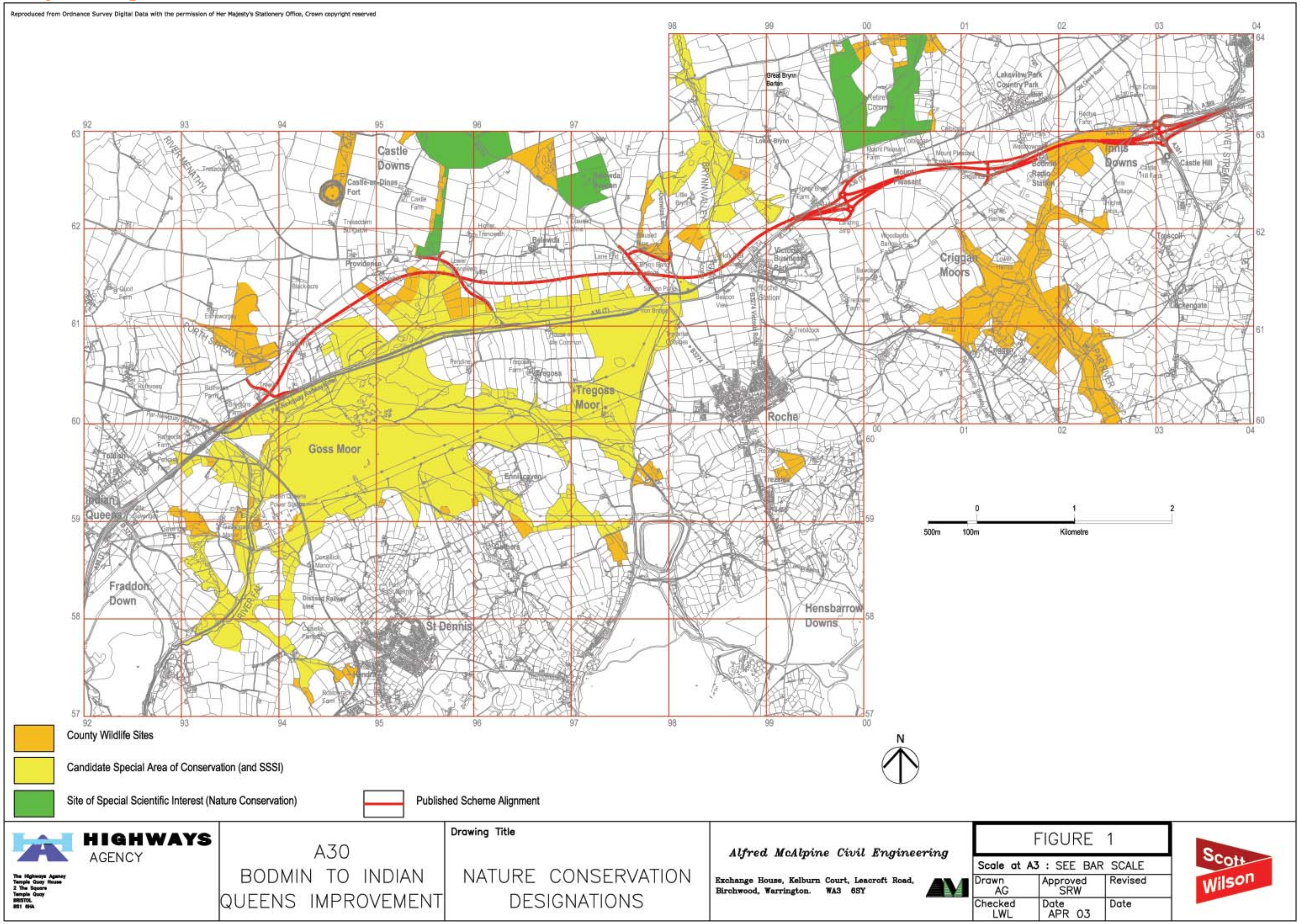
Map 1: The A30 across Goss Moor in Cornwall: the existing and agreed new route within the context of sites of nature conservation value within the surrounding landscape.



A30 Bodmin to Indian Queens road improvement scheme: a case study on mitigation for the Marsh Fritillary butterfly

Introduction

The current route of the A30 trunk road between Bodmin and Indian Queens bisects the Goss Moor component of the Breney Common and Goss and Tregoss Moors Special Area of Conservation (SAC). The SAC area supports four European Features: North Atlantic wet heath; European dry heath; transitional mires and quaking bogs; and the Marsh Fritillary butterfly. The Goss and Tregoss Moors component of the SAC site is a National Nature Reserve managed by English Nature. Currently the reserve is bisected by the A30 trunk road. An approved road improvement scheme promoted by the Highways Agency will reroute the trunk road to the north of the NNR and SAC.

In the main the new road will run across areas of low-grade agricultural land athough it will result in some damage to three County Wildlife Sites and a small loss (1.6ha or 1.32% of the total area) of the SAC. Overall the new road presents a positive opportunity to enhance the nature conservation value of the area. It will improve habitat quality, help link isolated habitat fragments and provide an opportunity to remove a significant barrier to the effective management of a large part of the SAC. To mitigate for the loss of habitat within the SAC, degraded habitat will be restored and new habitat created on former agricultural land. The existing road will be downgraded and in part removed. These mitigation proposals will increase the long-term viability of the Marsh Fritillary metapopulation by increasing the quality and quantity of breeding habitat and enabling colonisation of former sites by reducing isolation.

Marsh Fritillary egg mass. A Spalding

Marsh Fritillary on buttercup. A Spalding

Box 1: Good quality breeding habitat for the Marsh Fritillary

- Abundant devil's-bit scabious, the larval foodplant
- An open, variable sward between 8-25cm by the end of the grazing period

This is best achieved through light cattle or pony grazing (between May-October)

The Marsh Fritillary butterfly

The Marsh Fritillary is declining in most European countries (by >50%) with a 60% decline in Britain during the last 30 years. These declines are due to loss of unimproved grassland habitat and management changes on the fragments that remain. The butterfly is listed under the EC Habitats and Species Directive and the Bern Convention and is a qualifying interest feature for SACs. It is a priority UK Biodiversity Action Plan species and since 1998 has been fully protected under the Wildlife and Countryside Act 1981.

The butterfly has one generation per year and flies during May and June. Females lay large batches of eggs on the host plant devil's-bit scabious (*Succisa pratensis*). The larvae hatch in late July/August and feed as a group on the scabious plants, forming a conspicuous larval web around the plant. The larvae over-winter within hibernacula deep inside grass tussocks and emerge in February/March to bask and feed, pupating in April. Populations of the Marsh Fritillary can be found in damp grasslands such as culm or rhos pasture and also on dry calcareous grasslands. The butterfly is generally sedentary moving only short distances within its home patch. However some individuals will disperse and have been known to move up to 15-20km away; as a result, the butterfly persists in metapopulations within fragmented landscapes.

Within a metapopulation of the Marsh Fritillary, extinction may occur due to changes in habitat quality, reduction in population size (small populations will have a greater chance of extinction) or attack by predators such as larval parasitoids. The chance of colonisation will depend mainly on isolation (the distance an individual has to travel from a neighbouring population).

To ensure the long-term viability of a Marsh Fritillary metapopulation it is important to have:

- Good quality breeding habitat
- A long-term management regime
- A series of sites across the landscape both occupied and unoccupied by the butterfly
- Short distances between these sites (i.e. a low isolation factor)

The A30 improvement scheme and benefits to the Marsh Fritillary

The downgrading of the existing A30 contributes to a European LIFE Nature project focused on the SAC. This is a 5 year partnership project aimed at securing the Marsh Fritillary population of mid Cornwall by removing 6km of trunk road that currently dissects the SAC; the road scheme will help reduce habitat fragmentation and link currently isolated habitat within the Goss and Tregoss Moors SSSI. By contributing to the LIFE Project, the downgrading of the existing trunk road will help fund habitat management work on 9 project sites covering an area of 1050 hectares. On Goss and Tregoss Moors NNR the removal of the road will allow the restoration of habitat management on parts of the reserve previously inaccessible to stock and machinery.

As often happens following the construction of new transport links, small areas of land will become isolated from some agricultural holdings. In the vicinity of Goss Moor these isolated land parcels are characterised by rush pasture vegetation and developing scrub and present an ideal opportunity for habitat re-creation to complement habitats within the SAC. Wildlife gain for the Marsh Fritillary can also be achieved by habitat creation on attenuation ponds and post-construction sites. There is also potential to create good quality Marsh Fritillary breeding habitat within the road corridor using design modifications and habitat creation on roadside verges, swales, cuttings and embankments (central reservations can provide excellent wildlife habitat but in the case of the proposed A30 improvement are likely to be too narrow to support butterflies). The key factor here is planting devil's-bit scabious in grassy swards in these areas, followed by management to ensure the maintenance of an open sward with a height between 6-25cm. Most Marsh Fritillary sites in Britain are grazed by cattle and/or horses, so this is the preferred management on land adjacent to the road. Grazing will not be possible within the road corridor for reasons of safety, so management will be by cutting or mowing, with cuttings raked off into piles or completely removed; these sites may not support permanent colonies of Marsh Fritillary but will provide additional stepping stone habitat. Controlled burning may be possible on some embankments where the smoke will not affect traffic; this management technique has proved to be very successful in some sites, especially on the Devon culm measure grasslands. In addition, the establishment of a flower-rich sward on verges,

Typical Marsh Fritillary habitat. A Spalding

Marsh Fritillary larval web. G Pilkington

Box 2: Re-creating Marsh Fritillary Habitat

Various techniques have been trialled elsewhere. These include:

- Herbicide application followed by re-seeding and grazing
- Application of aluminium sulphate to increase soil acidity and reduce phosphorous availability
- Growing and planting devil's-bit scabious plugs

the central reservation and the sides of cuttings and embankments will benefit more widespread butterflies, in particular Silver-studded Blue, Grizzled Skipper and Dingy Skipper.

If these opportunities can be realised, the size of Marsh Fritillary habitat patches will be increased and the distances between existing breeding sites will be reduced by creating stepping-stones to facilitate colonisation. Suitable breeding habitat can be created through a combination of mowing, grazing, scrub clearance and re-seeding with devil's-bit scabious.

The unique partnership of the road scheme and LIFE Nature project will improve the habitat area and quality across the landscape helping to ensure the long-term viability of the Marsh Fritillary metapopulation within the Mid Cornwall Moors.

Monitoring

The success of any mitigation should be monitored during and after the construction period. It is important that monitoring should take place within the first year although it will take some time for restored or re-created habitat to establish and detailed monitoring should begin two – three years after construction. Monitoring should take place in order to inform future road design elsewhere in Britain and particularly to establish best practice for creating suitable habitat conditions for the Marsh Fritillary.

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Top left: Flower Rich Verge. A Spalding
Bottom left: Heavy Traffic on A30. A Spalding
Main: Marsh Fritillary. A Spalding

Back cover photograph
Main: Marbled White. A Spalding

Case Study cover photograph:
Train over A30 bridge. A Spalding

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