

European Co-operation in the Field of Scientific and  
Technical Research



**COST 341**

**Habitat Fragmentation due to Transportation  
Infrastructure**

United Kingdom National State of  
the Art Report



European Commission  
Directorate General Transport



The Highways Agency (HA) is the primary author of this report, which forms the UK contribution to the COST 341 Action. Tony Sangwine, as head of the Horticulture and Nature Conservation team within the Traffic, Safety and Environment Division of the HA has overseen its production as Project Manager. The document reports the State of the Art in the UK regarding Habitat Fragmentation due to Transport Infrastructure. It has been compiled following consultation with a wide range of statutory and non-governmental organisations, and written by Claire Hicks (HA Environmental Advisor and COST 341 Project Officer). As an Executive agency of the Department of the Environment, Transport and the Regions (DETR), the HA is the UK lead participant in the COST 341 project, and is assisted by its research partner Penny Angold of the Department of Geography at The University of Birmingham. HA is responsible for the management, maintenance and improvement of the motorway and trunk road network in England. Accordingly, much of this report has been based upon the HAs specialist knowledge of the roads sector, and cites best practice and case studies predominantly relating to roads in England. However, during the research process, every effort has been made to obtain relevant information and examples from colleagues working in Scotland, Wales and Northern Ireland, and from the railway and inland waterway sectors.

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## Table of Contents

Chapter 1. Introduction.....	7
Chapter 2. Key Ecological Concepts.....	8
Chapter 3. Effects of Infrastructure on Nature .....	9
Chapter 4. National context/European context .....	10
<b>4.1. Introduction</b>	<b>10</b>
<b>4.2. Biogeographical description</b>	<b>16</b>
<b>4.3. Overview of fragmentation</b>	<b>19</b>
<b>4.4. Administrative and legislative framework</b>	<b>22</b>
<b>4.5. Land-use planning in relation to nature and landscape conservation and transport infrastructure</b>	<b>31</b>
<b>4.6. Summary</b>	<b>35</b>
Chapter 5. Habitat Fragmentation due to Existing Transportation Infrastructure.....	37
<b>5.1. Introduction</b>	<b>37</b>
<b>5.2. European transportation networks</b>	<b>38</b>
<b>5.3. Transportation networks</b>	<b>41</b>
5.3.1. Highways/motorways	41
5.3.2. Secondary road infrastructure	43
5.3.3. Railways	44
5.3.4. Waterways	47
<b>5.4. Effects of the existing transportation network on nature</b>	<b>50</b>
5.4.1. Habitat loss	55
5.4.2. Corridor function	58
5.4.3. Disturbance	61
5.4.4. Fauna casualties	63
5.4.5. Barrier effect	67
5.4.6. Effects on populations	69
5.4.7. Overview of environmental bottlenecks	74
<b>5.5. Secondary effects of transport infrastructure</b>	<b>75</b>
<b>5.6. On-going research and review of relevant studies</b>	<b>76</b>
<b>5.7. Summary</b>	<b>80</b>

Chapter 6. Traffic Safety in Relation to Fauna Casualties .....	83
<b>6.1. Introduction</b>	<b>83</b>
<b>6.2. General guidance for reducing deer road traffic accidents</b>	<b>83</b>
Chapter 7. Avoidance, Mitigation, Compensation and Maintenance.....	85
<b>7.1. Introduction</b>	<b>85</b>
<b>7.2. Avoidance of habitat fragmentation</b>	<b>85</b>
<b>7.3. Overview of mitigation measures</b>	<b>90</b>
7.3.1. Fauna passages	107
<b>7.4. Overview of compensation measures</b>	<b>114</b>
7.4.1. Habitat Creation	114
7.4.2. Habitat Translocation	115
7.4.3. Translocation of Protected Species	118
7.4.4. Habitat Enhancement	119
<b>7.5. Existing quality standards for measures; justification, minimum requirements</b>	<b>121</b>
7.5.1. Design Manual for Roads and Bridges	122
7.5.2. Standardising Design Measures	123
7.5.3. Technical Guidance	126
7.5.4. Government Guidance	127
<b>7.6. Maintenance aspects</b>	<b>127</b>
7.6.1. Verge management	132
7.6.2. Management of other surfaces	134
7.6.3. Coordinating land-use in adjacent areas	135
<b>7.7. Evaluation and monitoring of the effectivity of measures</b>	<b>137</b>
7.7.1. Developing Best Practice	138
7.7.2. National Monitoring	140
<b>7.8. Summary</b>	<b>140</b>
Chapter 8. Habitat Fragmentation and Future Infrastructure Development.....	143
<b>8.1. Introduction</b>	<b>143</b>
<b>8.2. Policies and strategies/trends</b>	<b>144</b>
<b>8.3. Indicators/indexes of fragmentation</b>	<b>147</b>
<b>8.4. Models to predict fragmentation by new infrastructures</b>	<b>154</b>
<b>8.5. Data on transportation networks development</b>	<b>159</b>
<b>8.6. On-going research and review of relevant studies</b>	<b>164</b>

<b>8.7. Summary</b>	<b>177</b>
Chapter 9. Economic Aspects .....	179
<b>9.1. Introduction</b>	<b>179</b>
<b>9.2. Environmental Accounting</b>	<b>179</b>
<b>9.3. Prioritising Mitigation</b>	<b>180</b>
Chapter 10. General Conclusions and Recommendations .....	181
<b>10.1. Overview</b>	<b>181</b>
<b>10.2. Basic Principles for Better Management of the Fragmentation Effect</b>	<b>183</b>
<b>10.3. Potential for Further Investigation</b>	<b>183</b>
Chapter 11. References.....	185
Annex I. Mapping.....	200
Annex II. Directory of Organisations and Competent Authorities .....	201
Annex III. Bibliography .....	202
Annex IV. Members of the COST 341 Management Committee .....	203
Annex V. COST 341 Memorandum of Understanding.....	204
Annex VI. Technical Annex.....	205
Annex VII. COST Transport Overview.....	211



## **Chapter 1. Introduction**

## **Chapter 2. Key Ecological Concepts**



## **Chapter 3. Effects of Infrastructure on Nature**

## Chapter 4. National context/European context

### 4.1. INTRODUCTION

The United Kingdom (UK) of Great Britain and Northern Ireland covers an area of 244,100 km<sup>2</sup> and consists of the four countries England, Scotland, Wales and Northern Ireland, each of which has a varying degree of autonomy. An island nation, the UK is situated in Northwest Europe, separated from the European Continent by the English Channel and the North Sea. The UK has a rolling landscape which is increasingly mountainous towards the north, with the Grampian Mountains in Scotland, Pennines in Northern England, and Cambrian Mountains in Wales (see Map 1: Topography (England and Wales) and Map 2: Topography (Northern Ireland)). The main natural inland waterways include the River Thames, Severn and Spey. Approximately 75% of the total UK land area is under agricultural uses, although the actual area fell by almost 300,000 hectares between 1985 and 1995. This decline has been mirrored by a similar increase in land used for non-arable purposes (see Map 3: Land Use (England and Wales) and Map 4: Land Use (Scotland)).

#### 4.1.1 Demography

Between 1971 and 1991 the UK population increased by 3% to 56.9 million (with increases of nearly 4% in England, 6% in Wales and 4% in Northern Ireland, and a decline in Scotland by 2%). By 1996 the estimated population of the UK was 58.8 million, accounting for 15.8%, or almost one sixth, of the population of the European Union. According to 1996 projections, the future trend is towards stabilised growth rates at around 0.22% per year, which equates to an increase by a further 5% between 1996 and 2031. Population is projected to increase in all the UK countries, except Scotland (Office for National Statistics, 1998).

Despite the UK having one of the highest population densities in the world, its population is very unevenly distributed and only a quite small proportion of its land surface is heavily settled. Population density varies from over 3500 per km<sup>2</sup> in London to less than 15 per km<sup>2</sup> in the remotest parts of Scotland (see Map 5: Population Density (England and Wales), Map 6: Population Density (Scotland) and Map 7: Population Density (Northern Ireland)). This concentration of population in certain areas is a legacy of the industrial era and the associated rapid growth of large factory-based settlements, and of strict land-use planning policies designed to limit the outward spread of population from the largest built-up areas. Recent decades have seen some important changes in population distribution, reflecting changing residential preferences. The principal feature of regional population change has been the drift of population from North to South, and this has been accompanied by a shift from urban to rural regions.

While the UK's population is growing in overall size and continues to redistribute itself geographically, the most remarkable changes of the past few decades have been those relating to demographic structure. In particular, the population has been ageing, it has been

getting more diverse in ethnic terms and it has been dividing itself up into smaller and more varied types of household.

### 4.1.2 Economy

The UK joined the European Community in 1973, exporting products such as cereals, rape, sugar beet, potatoes, meat and meat products, poultry, dairy products, electronic and telecommunications equipment, engineering equipment, oil and gas, petrochemicals, and pharmaceuticals. Total GDP increased by 38% between 1980 and 1995. The manufacturing sector now accounts for around a fifth of GDP, whilst the service sector has grown steadily over recent years and now accounts for two thirds of GDP. Around 2.5% of GDP is estimated to be spent on environmental protection (Office for National Statistics, 1997).

### 4.1.3 Transport

Transport systems are highly developed to serve even the most remote regions of the UK, via the modes of road, railway and waterway (see Map 8: Transport Infrastructure (England and Wales), Map 9: Transport Infrastructure (Scotland) and Map 10: Transport Infrastructure (Northern Ireland)). Table 4.1 shows the extent of the existing linear transport infrastructure network across the UK.

Table 4.1: Extent of Linear Transport Infrastructure by Mode

COUNTRY	ROADS (KM)	RAILWAY (KM)	WATERWAYS (KM)
TOTAL UK	369,867	16,656	3218

Source: DETR, 1998

These UK figures hide regional variations between the density of each network in each country, and the density of traffic using the network within the four countries (Figure.4.1). Southeast England is the most developed of the regions, with an intensive transport network, compared with the Highlands and Islands of Scotland where the transport network is very sparse. These variations represent the result of historical and environmental considerations (e.g. topography, climate) which have affected the way the networks have developed.

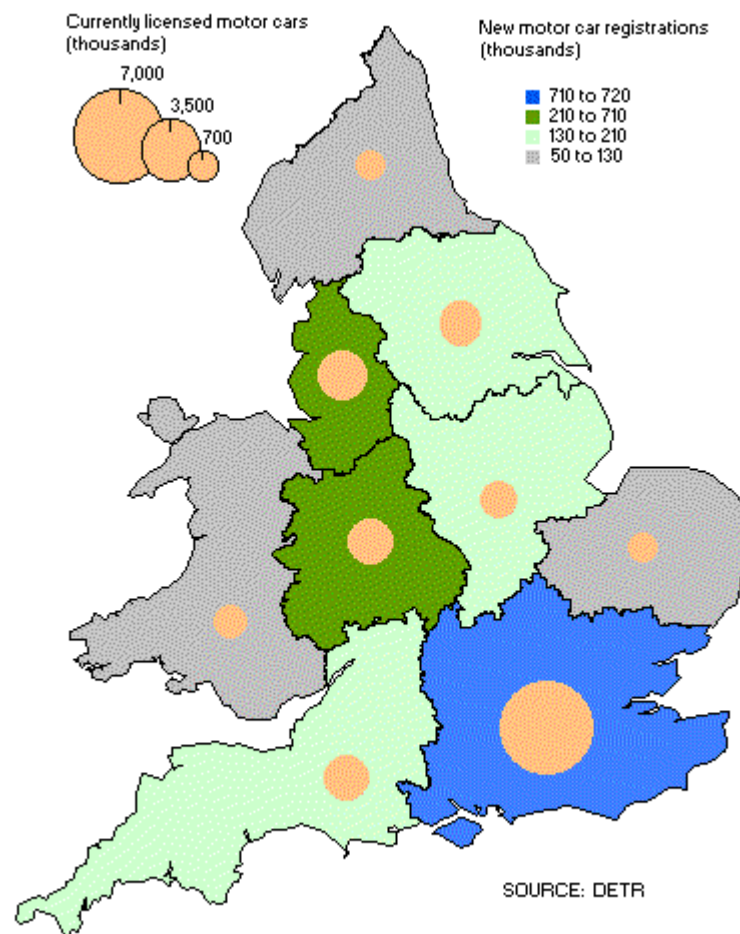


Figure 4.1: Motor car licences and registrations (1996)

During the 1990s the main developments in transport have been concerned with policy (in particular privatisation of large sectors of the industry), with attempts to stem car ownership and to promote public transport, and with an acceptance of the need to take the environmental impact of transport activities more fully into account. Additions and improvements to the national road and rail networks were largely completed with the opening in 1991 of the last section of the M40 motorway between Oxford and Birmingham and the electrification of the final section of the London to Edinburgh trunk railway in 1994. The most significant development of the 1990s, however, was the Channel Tunnel Rail Link, opened in 1994 between Folkestone and Calais to provide through rail facilities between the UK and the Continent.

Between 1945 and the late 1970s much of the transport sector was in public ownership, but since 1980 components of this state-owned system have been progressively dismantled and transferred to the private sector. This process was largely completed in the mid 1990s with the break-up of British Rail. Privatisation and deregulation of major transport enterprises were two of the principal objectives in the former Conservative administration's free market policy initiated in 1980, and although the present Labour Government has retained some of its predecessor's privatisation plans it has also

introduced a new transport policy which is directed much more towards the integration and co-ordination of the various inland modes (DETR, 1998). Both Conservative and Labour Governments have attempted to stem the ever-growing tide of private car ownership, and the increasing use of road transport in general (see section 4.1.1), but attempting to create a more attractive public transport system coupled with restraint upon car drivers. However, despite massive investment in inter- and intra-urban public transport the imbalance between road and rail traffic remains (Tables 4.2 and 4.3).

Table 4.2: Passenger traffic in the UK by mode of transport (percentage distribution of total passenger km by mode)

YEAR	PASSENGERS	
	ROAD	RAILWAY
1965	89	11
1975	92	8
1985	92	7
1996	94	5

Source: HMSO, 1996 and 1997

Table 4.3: Freight traffic in the UK by mode of transport (percentage distribution of total freight tonne km by mode)

YEAR	FREIGHT	
	ROAD	RAILWAY
1965	57	21
1975	66	15
1985	56	9
1996	66	6

Source: HMSO, 1996 and 1997

Serious congestion on many sections of the principal road network indicates that the demands of road transport for additional capacity have still to be adequately satisfied, but the policy of continual road construction has been recognised as one that will not achieve the desired objective of providing a sustainable transport system.

#### *4.1.3.1. Roads and Road Traffic*

During the 1990s road traffic has continued to increase, with a consequent rise in levels of congestion on the road network. In 1970 there were 44,933 km of major roads in the UK, of which 1,057 km (2.4%) were motorways. By 1996 the length of major roads had increased by 6.8% to 48,215 km, of which 3,226 km (6.7%) were motorways. The total length of roads has increased from 322,484 km in 1970 to 368,820 km in 1996.

There was a 58% increase in motor vehicle traffic between 1980 and 1995. Almost all of this was increased car traffic, which accounted for nearly 82% of all motor vehicle traffic in 1995 (HMSO, 1996). Figure 4.2 shows the continual growth in the numbers of licensed vehicles on the roads of the UK. In 1970 there were just under 10 million licensed private cars, increasing to 21.17 million in 1996. From 1970 to 1996 the number of licensed public transport vehicles has increased only slightly, from 93,000 to 107,000. Conversely, the numbers of licensed ‘goods’ vehicles, agricultural tractors and motorcycles has actually fallen over this same period.

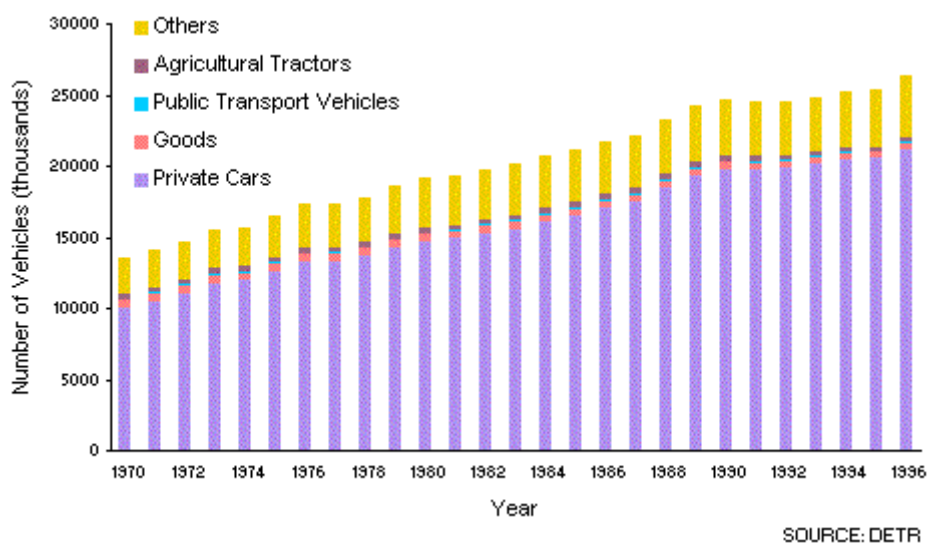


Figure 4.2: Motor vehicles currently licensed in Great Britain (1970-1996)

In terms of passenger transport, the use of cars and vans has increased the most, as illustrated in Figure 4.3, which is expressed in terms of billion passenger kilometres per year.

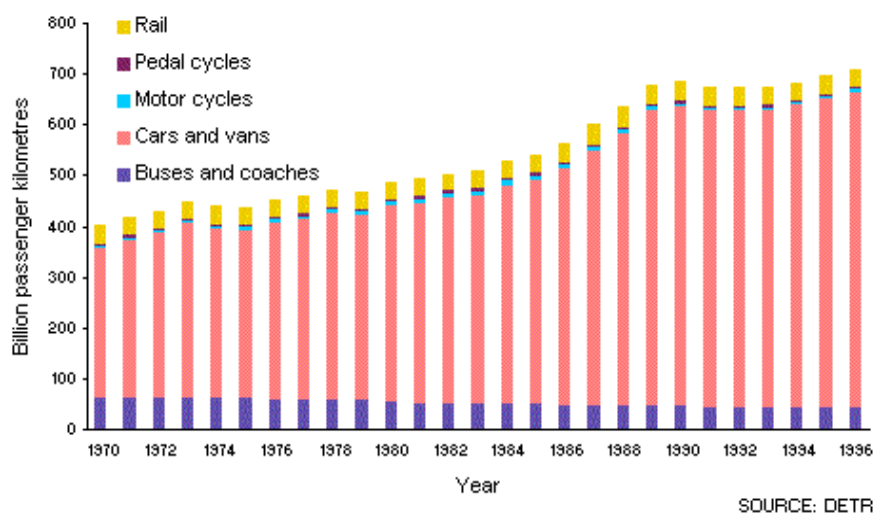


Figure 4.3: Passenger transport in Great Britain (1970-1996)

In 1970 cars and vans accounted for 74% of transport, but by 1996 they represented some 87% of transport. In contrast, rail transport has remained relatively unchanged in absolute amount, with the percentage travelled by rail falling from 9% in 1970 to 5% in 1996. The relative amount of freight carried by road has increased steadily in recent years, whilst the proportion of freight carried by rail has steadily declined.

These increased flows of traffic are carried on an infrastructure which has been progressively improved in terms of new and upgraded trunk and principal roads, but congestion remains a serious problem on the national highways. The rate of motorway construction has gradually declined since the ambitious building programmes of the 1960s and 1970s, and in the 1986-1996 decade only 306 km were added. A demand-led approach to new road construction is no longer seen as the most appropriate or effective solution to congestion, and where road schemes have been agreed the Government is actively encouraging Private Finance Initiatives (PFIs) to contribute to the considerable costs involved. Two significant examples of the results of private investment are the Queen Elizabeth II bridge, which carries the M25 over the Thames to supplement the capacity of the earlier tunnel, and the second bridge over the River Severn in the Southwest which links with the M4 and M5 motorways. The privately funded Birmingham Northern Relief Road (a 43 km long three-lane toll motorway) once completed will represent the longest privately financed road in the UK. Proposals for the introduction of tolls across the national motorway system have also been considered, similar to those which have operated successfully for many years in Continental Europe (e.g. France, Spain and Italy).

#### *4.1.3.2. The Railway System*

Although the proportions of national passenger and freight traffic carried by rail have continued to decline in the 1990s (Table 4.3), a distinction can be drawn between the passenger sector, where the amount of traffic has increased, and freight haulage, which is still falling in both absolute and relative terms. Passenger traffic has been the leading source of railway revenue since 1975. The length of route open to passenger train services has increased steadily since 1969 to 15,034 km in 1996 (representing a growth of 5%), and 110 new or reopened stations have been added since 1986. In 1998 31% of the network was electrified, although some of the older electrified sections are in urgent need of upgrading. Despite these improvements in passenger services and the absolute increases in the numbers carried, in 1996 the railways still accounted for only 5% of all passenger travel (Table 4.2). Changes since 1986 in the freight traffic situation have been less promising, with a decline of 31% in the length of routes open to freight trains and a fall of 27% in the amount of goods hauled. Only 5% of all freight by tonnage is now carried by rail. The opening of the Channel Tunnel to through rail passenger and freight trains in 1994 has had, to date, only a limited impact upon the UK system, as the high-speed rail link between London and Folkestone remains under construction.

In early 1993 the Government decided to transfer the railways to the private sector, and the Railways Act passed in December 1993 enabled the process of dismantling British Rail and awarding franchises for specific areas of passenger and freight operations to a group of private sector companies. By 1998 services had been franchised to 25 principal train operating companies (TOCs). A separate company, Railtrack, was given the responsibility for the track, supporting infrastructure, rolling stock provision and maintenance. The

current status of the UK's railway system as a complex mosaic in which train services, rolling stock, track and maintenance facilities are all owned by different undertakings is in marked contrast to systems in Europe, where state ownership with large subsidies from the Government is still the most common situation.

Investment in urban light rail systems has been seen as a means of relieving congestion on the road and traditional railway network. Examples of such systems are the Metro (Tyne and Wear, 1984), the Docklands Light Railway (London, 1987), the Metrolink (Manchester, 1992) and the Sheffield Supertram (1994). Plans for light rail transit also exist for Edinburgh, Nottingham, and Bristol, but funding is dependent on the success of the existing systems. Both the Manchester and Sheffield systems recorded substantial increases in traffic during their first few years of operation, but a longer time period is required before more informed judgements on their success in promoting public transport usage can be made.

## 4.2. BIOGEOGRAPHICAL DESCRIPTION

The UK has an oceanic climate with cool summers and warm wet winters. There are few natural ecosystems remaining, found only in inaccessible areas such as cliffs and mountaintops. There are no significant natural barriers (e.g. extensive mountain ranges or river systems) within the UK, compared with other countries in mainland Europe. The English Channel and the Irish Sea represent the most obvious natural barriers, separating the UK from continental Europe and Ireland respectively. In Northern Ireland, and throughout the numerous coastal and offshore islands, this barrier effect is reflected in the differing range of ecosystems and species present in comparison with mainland Britain (e.g. there are no native snakes in Ireland, and no native rats on many islands off Scotland). The isolation imposed by the island character of the UK has resulted in a reduced flora and fauna. The 'natural capital' of the UK, consists of an estimated 30,000 animal species (excluding marine, microscopic and less known groups such as mites and roundworms, of which there are many thousands), about 2,300 higher plants, 1,000 liverworts and mosses, 1,700 lichens, 20,000 fungi, and about 15,000 algae. Around 170 species of plants and animals in the UK are thought to have become extinct in the past 100 years. Because of the oceanic climate and historical circumstances the UK has a number of endemic habitats and species e.g. Scottish crossbill (*Loxia scotica*) and relict indigenous Scots Pine (*Pinus sylvestris* var. *scotica*), and many sub-species on the limit of their range.

### 4.2.1 Habitats

The main ecosystem types are semi-natural, formed as a result of historic land use and agricultural practices. Habitats of national importance include: reedbeds; fens; ancient and/or species-rich hedgerows; lowland heath; purple moor grass and rush pastures; upland oakwood; native pine woodlands; lowland meadows; upland hay meadows; lowland dry acid grassland; lowland calcareous grassland; lowland wood-pasture and parkland; wet woodland and lowland beech and yew woodland; peatlands; and open water habitats. All of these are, to a great extent, remnants of previously larger areas which have been eroded by intensification of land use, especially in the 20<sup>th</sup> Century. Many of the



remnant patches have a small total area, and critically small population sizes of species are dependent on these for survival.

### 4.2.2 Species

There are no large carnivores remaining in the UK, most being hunted to extinction before the 19<sup>th</sup> Century, consequently no migratory movements of large mammals occur. The largest remaining mammal is the Red Deer (*Cervus capreolus*), and the largest carnivores are the otter (*Lutra lutra*), badger (*Meles meles*) and fox (*Vulpes vulpes*). Of the 13 native species of amphibians and reptiles found in the UK, the natterjack toad (*Bufo calamita*), adder (*Vipera berus*), sand lizard (*Lacerta agilis*), smooth snake (*Coronella austriaca*) and leathery turtle (*Dermochelys coriacea*) are classified as 'rare'. Other important wild species include the wildcat (*Felis sylvestris*), red kite (*Milvus milvus*), adonis blue butterfly (*Lysandra bellargus*), black poplar (*Populus nigra*) and harbour porpoise (*Phocoena phocoena*).

### 4.2.3 Habitat and Species Protection

Habitats and species of special international and national importance have been identified following the implementation of the EC Habitats and Species Directive (1992). This and other legislative provisions (Section 4.4) have led the UK to develop a comprehensive system of site protection, enforced by statutory designation (Table 4.4).

Table 4.4: UK Statutory Site Designations

SITE TYPE	ESTABLISHED BY	NO. IN UK	TOTAL AREA (HA)	IMPLICATIONS FOR INFRASTRUCTURE PROJECTS
<b>INTERNATIONAL</b>				
World Heritage Site	UK Government	2	923	Any impacts should be considered significant. Adverse impacts will not be permitted.
Biosphere Reserve	UK Government	13	44,256	Any adverse impacts should be considered as significant. Impacts will not be permitted by planning authorities/SOS unless in urgent national interest.
Biogenetic Reserve	UK Government	18	8,000	Any adverse impacts should be considered as significant. Developments are very unlikely to be permitted by planning authorities/SOS unless in urgent national interest.
Ramsar Site	UK Government	122	462,125	Any adverse impacts should be considered as significant. EA will be required. Impacts on Ramsars are unlikely to be permitted by planning authorities/SOS unless in urgent national interest.
Special Protection Area (SPA)	UK Government	177	743,859	Protected via the SOS/planning process. Any adverse impacts should be considered significant. EA will be required. Any adverse impacts are unlikely to be permitted unless development is in overriding public interest.

Special Area of Conservation (SAC)	UK Government	301	1,568,060	As for SPAs above.
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**NATIONAL**

Environmentally Sensitive Area (ESA)	UK Government	43	3,377,000	Introduced under section 18 of the 1986 Agriculture Act to help safeguard areas where the landscape, wildlife or historic interest is of national importance. An ESA has no planning status and cannot therefore be used as a reason for refusing planning permission.
Areas of Special Protection (AoSP)	UK Government	n/a	n/a	
National Nature Reserve (NNR)	EN/CCW/ SNH/EHS	362	206,710	Protected via the SOS/planning process. Any adverse impacts should be considered significant. Any adverse impacts unlikely to be permitted in any circumstances.
National Park	Countryside Agency/CCW	10	1,376,000	
Marine Nature Reserve (MNR)	EN/SNH/CCW	3	19,390	Protected via SOS.
Site of Special Scientific Interest (SSSI) (England, Scotland and Wales)	EN/SNH/CCW	6,382	2,109,450	Protected via SOS/planning process. Any adverse impacts should be considered significant. EN/SNH/CCW must be consulted. Any adverse impacts may not be permitted or may be subject to condition. EA may be required if impacts are significant.
Areas of Special Scientific Interest (ASSSI) (Northern Ireland)	EHS	117	78,968	As for SSSIs above, except EHS must be consulted.
Areas of Outstanding Natural Beauty (AONB) (England and Wales)	Countryside Agency (England) and CCW (Wales)	41	2,123,700	
National Scenic Areas (NSA) (Scotland only)	SNH	40	1,001,800	

**LOCAL**

Local Nature Reserve (LNR) (England, Scotland and Wales) and Local Authority Nature Reserve (LANR) (Northern Ireland)	Local Government Authorities (LGAs)	629	33,00	Protected under local bylaws and through the planning system.
Country Parks	LGAs	281	35,150	
Limestone Pavements	LGAs	n/a	n/a	

Source: JNCC, 1998.

However, this extensive system of site protection provides no guarantees that wild species and natural habitats will be strictly protected. Observations on damage to SSSIs have been widely documented in the late 1990s. Causes of damage include agricultural and recreational activities, unauthorised tipping and the actions of statutory undertakers (e.g. infrastructure developers). In 1995/6 some 2,000 hectares (0.1% of the total SSSI area) were affected by long-term damage, and nearly 3,000 hectares were affected by short-term damage (EN, CCW, SNH, JNCC).

### 4.3. OVERVIEW OF FRAGMENTATION

The UK has a long history of land use and land management. There has been a gradual intensification of land use, particularly over the last 50 years, which has resulted in a highly fragmented landscape, especially in England where the population is generally most dense (375 per km<sup>2</sup>) (see Map 5: Population Density (England and Wales)) and land use most intensive (see Map 3: Land Use (England and Wales)). Most habitats are now greatly fragmented. In Wales, Scotland and Northern Ireland, with population densities of 140, 66 and 122 per km<sup>2</sup> respectively (see Maps 5, 6, and 7: Population Density (England and Wales) (Scotland) (Northern Ireland)), there are more extensive areas of semi-natural habitat which may be considered as unfragmented. However, even in areas that appear to be fairly continuous such as upland moors, disruption of species movement and behaviour may still be occurring through creation of new tracks, new fencing, conifer plantations and conversion of heather moor to grassland.

Landscape and habitat fragmentation have been widely recognised as issues of concern in the UK, however, the extent of the problem is not fully documented or researched. Broad estimates of the scale of fragmentation can be derived from surveys which have attempted to measure land use change as a whole e.g. the Countryside Survey 1984, and 1990. Comparison of data collected as part of the Countryside Survey in 1984 and 1990 shows that there have been small reductions in the area of arable land, improved grassland and heath/moorland cover in lowland landscapes, partly because of increased urbanisation and afforestation. Comparable changes in upland landscapes have been negligible. Other semi-natural land cover increased by 10% in lowland landscapes with gains in unmanaged rough grassland habitats, but fell by 3% in upland landscapes. Woodland increased by 3% in lowland and upland landscapes. The total stock of managed hedges in England and Wales decreased by 186,000 km (33%) between 1984 and 1993. The rate of decline of hedgerows slowed however, from 22,000 km per year between 1984 and 1990 to 18,000 km between 1990 and 1993. About a third of the decrease in length of managed hedges between 1984 and 1990 was caused by total removal and the other two thirds by management neglect and by the conversion to other boundary types e.g. walls and fences (ITE). Figures such as these represent the balance between losses and gains, however it is important to recognise that in some land cover types the creation of new habitats does not compensate for the losses of high quality older habitats.

It is widely accepted that many species and habitats in the UK have declined in number or area since 1945. Heathland loss for in England, for example, is very well documented, as is change in ancient woodland habitat. Around a quarter of native species of fish, invertebrates, plants, and mosses are threatened or nationally scarce. However, many species will always be rare simply because the extent of their habitat is naturally very small

or because the UK is at the geographical limit of their natural range. Over the last twenty years there have been substantial changes in the population sizes and geographical distributions of many British breeding birds (Table 4.5). In woodland, coastal and wetland habitats more species experienced an increase in numbers than a loss. However, this trend was reversed for farmland birds where 22 species experienced a decline in population size and 10 a decline in geographical distribution. There has been a significant loss of plant diversity in hedgerows in lowland pastoral landscapes and in semi-natural grasslands in lowland landscapes in the UK between 1978 and 1990. The area of chalk grassland has substantially decreased in England over the last thirty years, particularly in Wiltshire. Around 30% of lakes and ponds, which are important havens for some species, have been lost since 1945. The geographical distributions of just over a half of the UK species of dragonflies and butterflies have reduced since the 1970s. Over a third of British species of mammals are believed to have declined in population size over the last thirty years (most of these being species of rodents or bats) and about a quarter are believed to have increased (most of these being carnivores or deer, and half being non-native species).

Table 4.5: Estimates of percentage change in breeding birds between 1971 and 1995

BIRD SPECIES	MILLIONS OF PAIRS	PRINCIPAL BREEDING SEASON HABITAT	PERCENTAGE CHANGE IN BREEDING NUMBERS (1971–1995)
Wren	7.1	Woodland	5
Chaffinch	5.4	Woodland	28
Blackbird	4.4	Woodland	-21
Robin	4.2	Woodland	3
House sparrow	3.6	Urban	unknown
Blue tit	3.3	Woodland	27
Willow warbler	2.3	Woodland	-39
Wood pigeon	2.4	Woodland	258
Skylark	2.0	Woodland	-61
Dunnock	2.0	Woodland	-50
Meadow pipit	1.9	Upland	unknown
Great tit	1.6	Woodland	34
Pheasant	1.6	Farmland	67
Yellowhammer	1.2	Farmland	-24
Starling	1.1	Farmland	-30
Song thrush	1.0	Woodland	-45

Source: British Trust for Ornithology, 1997

The effect of land use change on native species has proved difficult to measure accurately, with population estimates providing the only indication of the extent of increase/decline. For most species of mammal in the UK it is only possible to make broad estimates of numbers, either by estimating abundance relative to other species or by multiplying the estimated population density of a species in a particular habitat by the amount of suitable habitat in the country. Monitoring of bird numbers is carried out by volunteers contributing to schemes run by organisations such as the British Trust for Ornithology (BTO), Wildlife Trusts, Royal Society for the Protection of Birds (RSPB) and the Joint Nature

Conservation Committee (JNCC). Changes in bird numbers have been estimated from long-term monitoring of species in plots in particular habitats.

Most information on habitat fragmentation stems from work that has been done in agricultural landscapes, in particular relating the impacts of agricultural intensification to changes in bird populations (see Section 8.4). The Institute of Terrestrial Ecology (ITE) has led research in this area and therefore holds a significant amount of information on the state of fragmentation in the UK. One major problem they have encountered during the course of their work has been the lack of suitable mapping available for measuring the extent of habitat fragmentation. Currently sources of mapped information are limited to:

- English Nature's (EN) Natural Areas Initiative (1998d): EN has mapped and described the natural resources of every characteristic ecosystem and its associated species and land uses by geographic units (Natural Areas) in England. Each has a unique and distinctive combination of geology, landforms, land uses and wildlife.
- Countryside Agency (Commission as was) Character Map: Produced jointly with EN (1997a) and in association with English Heritage. The map identifies distinctive areas with their own characteristic landscapes, wildlife, natural and cultural features.
- Countryside Council for Wales (CCW) LANDMAP Initiative: A system for landscape assessment and decision-making, which aims to guide the development of policies and programmes for the conservation of the Welsh landscape and its wildlife, including features that contribute to local distinctiveness.
- Scottish Natural Heritage (SNH) Natural Heritage Zonation Programme: Aims to describe the natural heritage, assess its current state and analyse the pressures upon it. Like EN's Natural Areas approach it provides the framework for action to preserve local and national biodiversity. Using biogeographical and landscape information Scotland has been divided into 21 areas – Natural Heritage Zones (NHZs) – each containing a distinctive combination of landscape, recreational opportunity and wildlife. The zones provide a strategic framework for setting objectives and priorities at a local level. The information contributing to defining the NHZs is the most comprehensive baseline available from which to measure change in the future. The output of the programme include the following publications: national assessments, describing the natural heritage nationally and within each zone; and national and local prospectuses, exploring the policy issues and priorities/opportunities in each zone (Mitchell, 1999).
- The National Countryside Monitoring Scheme (NCMS): A retrospective study of land cover change throughout Scotland from the late 1940s, initiated by the Nature Conservancy Council in 1983 and fully implemented in 1986 as a national survey of land cover change. It has mapped 7.5% of the land area of Scotland for three time periods (SNH, 1996). In terms of infrastructure, the NCMS findings show that the transport corridor (the area occupied by road and railways) increased by a fifth over the study period (1940-1980).

Biodiversity Action Plans (BAPs) which have been drawn up by the UK Government as part of its Sustainable Development Strategy (DoE, 1994; and DETR, 1999), represent the first real attempts to systematically catalogue habitat fragmentation and habitat loss. The UK Biodiversity Steering Group report has identified targets and costed Action Plans for 116 priority species and 14 key habitats of ‘conservation importance’. The habitat plans cover about 2 per cent of the UK land area. Of these priority species and habitats, fragmentation is recognised as the main threat causing the loss or decline of 6 species of mammal (water vole (*Agricola terrestris*); red squirrel (*Sciurus vulgaris*); barbastelle bat (*Barbastella barbastellus*); Bechstein’s bat (*Myotis bechsteinii*); lesser horseshoe bat, (*Rhinolophus hipposideros*); sand lizard (*Lacerta agilis*)), and 3 bird species (nightjar (*Caprimulgus europaeus*); woodlark (*Lullula arborea*); and ciril bunting (*Emberiza cirius*)). In addition to the priority species and habitats, the UK BAP lists a further 234 species and 10 habitats of ‘conservation concern’ for which Action Plans have been drawn up. Fragmentation is an issue of equal concern for those trying to implement these plans.

#### 4.4. ADMINISTRATIVE AND LEGISLATIVE FRAMEWORK

In the UK, the need to protect and enhance the natural resource of habitats, species, natural features and characteristic environments has been recognised in legislation since the mid 19th Century, when the first laws were introduced to protect wild birds. Since then nature conservation in the UK has become based on an extensive framework of international and national legislation and policy. This is implemented via a number of statutory, non-governmental, charitable and private organisations and agencies.

##### 4.4.1. Administration

The government department with overall responsibility for environmental matters in England, Scotland and Wales is the Department of the Environment, Transport and the Regions (DETR); whilst in Northern Ireland it is the Department of the Environment (DoE) (Northern Ireland). Within each country the terminology used for authorities responsible for the environment varies as follows:

- Department of Environment, Transport and the Regions (DETR) (England)
- The Scottish Executive
- National Assembly for Wales
- Northern Ireland Assembly

Each of these bodies has a wide range of environmental protection responsibilities including areas such as planning and development control, countryside and wildlife issues, and air, noise and water pollution. They each have Statutory Advisors dealing with environmental and nature conservation issues (Table 4.6).

Table 4.6: Statutory Nature Conservation Advisors

AGENCY	STATUTORY ROLE	RESPONSIBLE GOVERNMENT DEPARTMENT
English Nature (EN)	Nature conservation in England	DETR
The Environment Agency	Environmental protection (pollution) in England and Wales	DETR and The National Assembly for Wales
Countryside Agency	Countryside conservation and rural development in England	DETR
Countryside Council for Wales (CCW)	Nature and countryside conservation in Wales	The National Assembly for Wales
Scottish Natural Heritage (SNH)	Nature and countryside conservation in Scotland	The Scottish Executive
Scottish Environmental Protection Agency (SEPA)	Environmental protection (pollution) in Scotland	The Scottish Executive
Environment and Heritage Service (EHS)	Conservation of nature, the countryside and the architectural heritage of Northern Ireland	Department of the Environment (Northern Ireland)
Environmental Protection Agency (EPA)	Environmental protection (pollution) in Northern Ireland	Department of the Environment (Northern Ireland)
Joint Nature Conservation Committee (JNCC)	Advice and information on nature conservation in the UK and internationally (a committee of the above agencies).	DETR

Source: JNCC, 1998.

The mechanisms available to the statutory agencies to conserve wildlife and the countryside include the establishment of statutory protected sites (Section 4.2, Table 4.4); controlling certain activities through licensing schemes; the provision of education; and the encouragement of wildlife-friendly management practices through a combination of advice, support, compensation and initiatives. The broad differences between the statutory agencies are highlighted below.

#### *English Nature:*

Established by Parliament in 1991, EN is responsible in England for advising central and local government on nature conservation and for monitoring, research and promotion of natural features. EN's roles include:

- Designation and management of, and consultation on SACs, SPAs, NNRs and SSSIs;
- provision of advice and information to promote nature conservation;
- advice on and issue of protected species licences;
- acting as a statutory consultant authority in development plans; and
- work on UK and international nature conservation with the JNCC.

#### *Countryside Council for Wales:*

Created by Parliament in 1991, CCW is the Welsh Government agency responsible for advising central and local government on nature conservation and for monitoring, research and promotion of natural features. CCW's roles include:

- acting as statutory advisor and consultee on wildlife and countryside conservation matters;
- working with, and provision of, grant aid to partner organisations, including local authorities, non-governmental organisations and voluntary groups on countryside and conservation projects;
- promotion of landscape and wildlife protection, countryside recreation and support for rural communities and countryside managers; and
- work on UK and international conservation issues with the JNCC.

*Scottish Natural Heritage:*

SNH is a government-funded body established by Parliament in 1992, responsible to the Secretary of State for Scotland. SNH has a broader role than that of EN, and is responsible for conservation and enhancement of wildlife and landscape and other natural heritage matters. It advises government on Scottish landscapes and recreation issues. SNH's role includes:

- acting as statutory advisor and consultee on wildlife and countryside conservation measures in Scotland;
- advising government;
- informing, researching and promoting nature conservation; and
- ensuring any impacts on any aspects of Scotland's natural heritage reflect the government's commitment to sustainability.

*Environment and Heritage Service:*

EHS was launched as an agency of the Department of the Environment (Northern Ireland) in 1996. EHS and the Department for Agriculture for Northern Ireland (DANI) share a joint responsibility to maintain biodiversity and the rural environment throughout the province. EHS's role includes:

- acting as regulatory authority for the prevention of air, land and water in Northern Ireland; and
- fulfilling statutory responsibility for the conservation of wildlife and natural habitats.

*Joint Nature Conservation Committee:*

JNCC is the forum through which the three UK nature conservation agencies (EN, CCW, SNH) deliver their statutory responsibilities for the UK as a whole, and internationally. JNCC's special functions are principally:

- to advise ministers on the development of policies for, or affecting, nature conservation in Great Britain and internationally;
- to provide advice and knowledge to anyone on nature conservation issues affecting Great Britain and internationally;
- to establish common standards throughout Great Britain for the monitoring of nature conservation and for research into nature conservation and the analysis of the results; and
- to commission or support research which the Committee deems relevant to the special functions.



*The Countryside Agency:*

The Countryside Agency was formed in 1999, following the merger of the Rural Development Commission and the Countryside Commission. It has statutory responsibilities for countryside, rural socio-economic and recreational matters in England, including advising the public and central government on countryside conservation and rural development issues.

*The Environment Agency (EA) (England and Wales) and Scottish Environmental Protection Agency (SEPA) (Scotland):*

The EA and SEPA were established in 1995. EA took the functions of the National Rivers Authority (NRA) and the waste regulation authorities (WRAs) and its main role is environmental protection and enhancement. It also has an important role in promotion and implementation of the government's sustainable development policy. It provides a first point of enquiry on all pollution and environment related issues. SEPA is responsible for similar functions in Scotland. Like the EA, SEPA offers a one-stop approach to pollution prevention and environmental protection.

*Environmental Protection Agency (EPA) (Northern Ireland):*

The EPA was set up in 1993. It has a wide range of environmental protection functions including licensing and control of activities that may cause pollution and environmental monitoring for both air and water. The EPA works with local authorities and private companies on a variety of environmental issues. The EPA is also committed to the concept of sustainable development.

*Others:*

In addition to these statutory conservation authorities there are a host of local government, independent non-governmental organisations, and registered activist charities who have an interest in nature conservation issues, and who work within the administrative and legislative framework. They include:

- Local Government/Authorities: County Councils and unitary authorities are involved in strategic and planning issues, whilst District and Parish Councils are involved at a local level.
- The Forestry Commission: responsible for forestry issues in England and Wales. It is divided into two units: Forest Enterprise that manages land and timber production, and the Forestry Authority that is responsible for wildlife and countryside issues.
- Non-Government Organisations: play an important role in the development, management and implementation of nature conservation legislation and policy. As well as acting as a source of expert advice they promote and support environmental issues, and may lobby government and attempt to influence public opinion. The following list of NGOs gives an indication of the range of organisations that are established in the UK:
  - The National Trust: A large independent charity committed to the preservation of places of historic interest and natural beauty in England, Wales and Northern Ireland. It is also a major landowner in the UK.

- Royal Society for the Protection of Birds: A charitable organisation committed to the conservation of birds and their environment. It is a source of expert advice and information on ornithological and environmental issues, carries out and publishes research and lobbies government. It is a major landowner in the UK.
- The Wildlife Trusts Partnership: A network of British Wildlife Trusts and urban wildlife groups. They provide specialist information and advice on all aspects of nature conservation and are involved in managing over 2000 nature reserves throughout the UK.
- WWF-UK

#### 4.4.2 Legislation

Nature conservation in the UK is founded on domestic and international legislation, and international treaties and conventions to which the UK is a signatory. The main elements of this legal framework are outlined in Table 4.7.

Table 4.7: Legislation relating to Nature Conservation

DATE	TITLE	MAIN PROVISIONS
1949	National Parks and Access to the Countryside Act	Established protection (in Great Britain) for National Parks, Areas of Outstanding Natural Beauty (AONBs), National Nature Reserves (NNRs), Local Nature Reserves (LNRs) and Sites of Special Scientific Interest (SSSIs).
1965	Amenity Lands Act (Northern Ireland)	Established statutory Nature Reserves in Northern Ireland.
1970	UNESCO's Man and the Biosphere (MAB) ecological programme (Project No.8)	Established Biosphere Reserves.
1971	Convention on Wetlands of International Importance especially as Waterfowl Habitat	Established 'Ramsar sites' - Wetlands of International Importance especially as Waterfowl Habitat. Sites which are considered internationally important for waterfowl can be designated by governments as Ramsar Sites (in the UK via EN or a similar statutory body, but sites must be existing SSSIs).
1972	UNESCO Convention concerning the protection of the world's cultural and natural heritage (World Heritage Convention)	Established World Heritage Sites.
1973	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Regulates trade in endangered species by instituting a system of prior permits and certificates for trade in endangered species listed on Appendices of the Convention.
1979	EC Directive on the Conservation of Wild Birds	Established Special Protection Areas (SPAs) for Birds and emphasised the need for wider countryside measures to protect habitats and species.
1979	Council of Europe Convention on the Conservation of European Wildlife and Natural Habitats (The Berne Convention)	Aims to conserve wild fauna and flora and their natural habitats and to promote co-operation between countries in their conservation efforts. Nations must reflect wildlife and habitat conservation in planning and development policies and especially with respect to threatened species.

1979	Bonn Convention on Migratory Species of Wild Animals	Recognised the need for countries to co-operate to conserve animals that migrate across national boundaries/between areas of national jurisdiction and the high seas.
1981	The Wildlife and Countryside Act	Strengthened protection for SSSIs and certain species; established Marine Nature Reserves.
1985	Wildlife (Northern Ireland) Order	The principal legislation for wildlife protection in Northern Ireland.
1985	Nature Conservation and Amenity Lands (Northern Ireland) Order	Allowed for the designation of National Nature Reserves in Northern Ireland.
1990	Environmental Protection Act	Created English Nature, the Nature Conservancy Council for Scotland (now Scottish Natural Heritage), the Countryside Council for Wales and the Joint Nature Conservation Committee, all with effect from April 1991.
1991	Agreement on the Conservation of Bats in Europe	Signatory states to undertake to implement an Action Plan for species and habitat conservation, and species management for bats.
1991	The Rio Convention on Biological Diversity	The basis for the UK Biodiversity Action Plan.
1992	EC Habitats and Species Directive	Establishes Special Areas of Conservation (SACs) to protect habitats and (non-bird) species, to complement SPAs in a suite of sites known as Natura 2000 sites. Each Nation is required to draw up national plans (Agenda 21) to achieve the commitment to sustainable development.
1992	The Protection of Badgers Act	Protects badgers and their setts and imposes restriction on works carried out within certain distances of badger setts. Licences are granted by EN to allow action to be undertaken which would normally be prohibited under the Act.
1993	ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas) - an international agreement between countries bordering the North and Baltic Seas	Promotes the conservation of small cetaceans. Participating states agree to co-operate on issues including national legislation and research into, for example, cetacean population sizes and the effects of fishing.
1994	The Conservation (Natural Habitats etc) Regulations	Implements the EC Habitats and Species Directive in the UK (through the provisions of the Wildlife and Countryside Act 1981).
1995	The Environment Act	Established the EA (England) and SEPA (Scotland), and further developed National Park management, financing and designation.
1995	African Eurasian Waterbird Agreement	Signatory states undertake to implement an Action Plan for species and habitat conservation, and species management for specified group of water birds.
1996	Wild Mammals Protection Act	Aims to prevent violent, injurious or otherwise cruel acts against any wild mammal (except mercy killing or lawful hunting). The Act does not apply in Northern Ireland.
1997	The Hedgerow Regulations	Made under Section 97 of the 1995 Environment Act, providing a facility for protection of important hedgerows in the countryside by controlling hedgerow removal through a system of notification. The regulations apply to most hedgerows except residential or garden hedges and those less than 30 years old.

Source: JNCC, 1998.

#### 4.4.2.1. International

The main pieces of international legislation of importance are the Ramsar Convention 1971 (designating Ramsar Sites (Table 4.8)), the EEC Directive on the Conservation of Wild Birds, 1979 (designating SPAs (Table 4.9)), and the Habitats and Species Directive, 1992 (designating SACs (Table 4.10)).

Table 4.8: Designated Ramsar sites in the UK as at 31 August 1999

COUNTRY	NUMBER OF SITES	SITE AREA (HA)
England	68	281832.6
England/Scotland	1	30706.26
England/Wales	3	39374
Northern Ireland	12	84481.08
Scotland	48	201639.73
Wales	7	11366.49
United Kingdom	139	649400.16

Source: English Nature, 2000

Table 4.9: Candidate Special Areas of Conservation in the UK as at 31 August 1999

COUNTRY	NUMBER OF SITES	SITE AREA (HA)
England	141	540513.89
England/Scotland	3	111598.71
England/Wales	4	3605.16
Northern Ireland	21	47136.35
Scotland	131	686553.35
Wales	40	376547.61
United Kingdom	340	1765955.07

Source: English Nature, 2000.

Table 4.10: Classified Special Protection Areas in the UK as at 31 August 1999

COUNTRY	NUMBER OF SITES	SITE AREA (HA)
England	73	388375.29
England/Scotland	1	30706.26
England/Wales	2	37785.76
Northern Ireland	11	70659.86
Scotland	103	340217.25
Wales	11	66830.31
United Kingdom	201	934574.73

Source: English Nature, 2000.

Together the Birds and Habitats Directives commit the UK to avoidance of significant deterioration of natural habitats within SACs (Table 4.9) and SPAs (Table 4.10), and prevents disturbance of species for which the site has been designated. SACs together with classified SPAs form the Natura 2000 network of sites (Figure 4.4).

The Habitats Directive requires the establishment of a European network of important sites to contribute to the conservation of 169 habitat types and 623 species identified in Annexes I and II of the Directive. The listed habitat types and species are those considered to be most in need of conservation at a European level. In the UK 83 Annex I habitats are known to occur. Of these a selection are identified as priority habitat types because they are considered to be vulnerable and are mainly, or exclusively, found within the European Community. Of the 83 habitat types that occur in the UK, 23 are priority habitat types for which sites have been selected (Table 4.9). JNCC's report 270, 'The Habitats Directive: selection of Special Areas of Conservation in the UK' provides more information on priority habitat types. Annex II of the Directive lists 623 species, of which 51 have been recorded in the UK in recent times. A number of species listed in Annex II are considered to be particularly rare or endangered and are classified as priority species. Only one of these, the liverwort, Western rustwort (*Marsipella profunda*), occurs in the UK. It is currently known from only two localities, both of which are in England. Of the 51 species recorded in the UK in the last century eleven have not had specific sites selected. JNCC's report 270, also provides details of the Annex II species found in the UK. The Habitats Directive is implemented in the UK through: The Conservation (Natural Habitats, & c.) Regulations 1994 and The Conservation (Natural Habitats, & c.) (Northern Ireland) Regulations 1995.

#### 4.4.2.2. National

The main domestic legislation of relevance is the Wildlife and Countryside Act 1981 (as amended 1985) which strengthened SSSI protection to many species of wildlife by restricting killing, taking from the wild and disturbance of various listed flora and fauna. In addition the Environmental Protection Act 1990, provided further protection for SSSIs and established the three statutory nature conservation councils (EN, CCW, SNH) and the JNCC. There is also legislation related to individual sectors of economic activity, such as transport, town and country planning and resource use, which include relevant legislation on environmental protection e.g.:

- Highways Act 1980 and Roads (Scotland) Act 1984: Section 105A and 20A of these Acts respectively require that for any scheme passing through or within 100m of a SSSI the statutory bodies must be given the opportunity to express an opinion.
- Land Drainage Improvement Works Regulations (SI 1217) 1988: Applying to any improvement or other works to any existing watercourse including ditches, streams, drains and culverts.
- Town and Country Planning Act 1990: Includes management agreements relating to granting planning permission.
- EIA Directive 85/337/EEC as amended by 97/11/EC (see section 4.5) implemented through the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999, SI No. 293.

## Natura 2000 sites in the UK as at July 1999

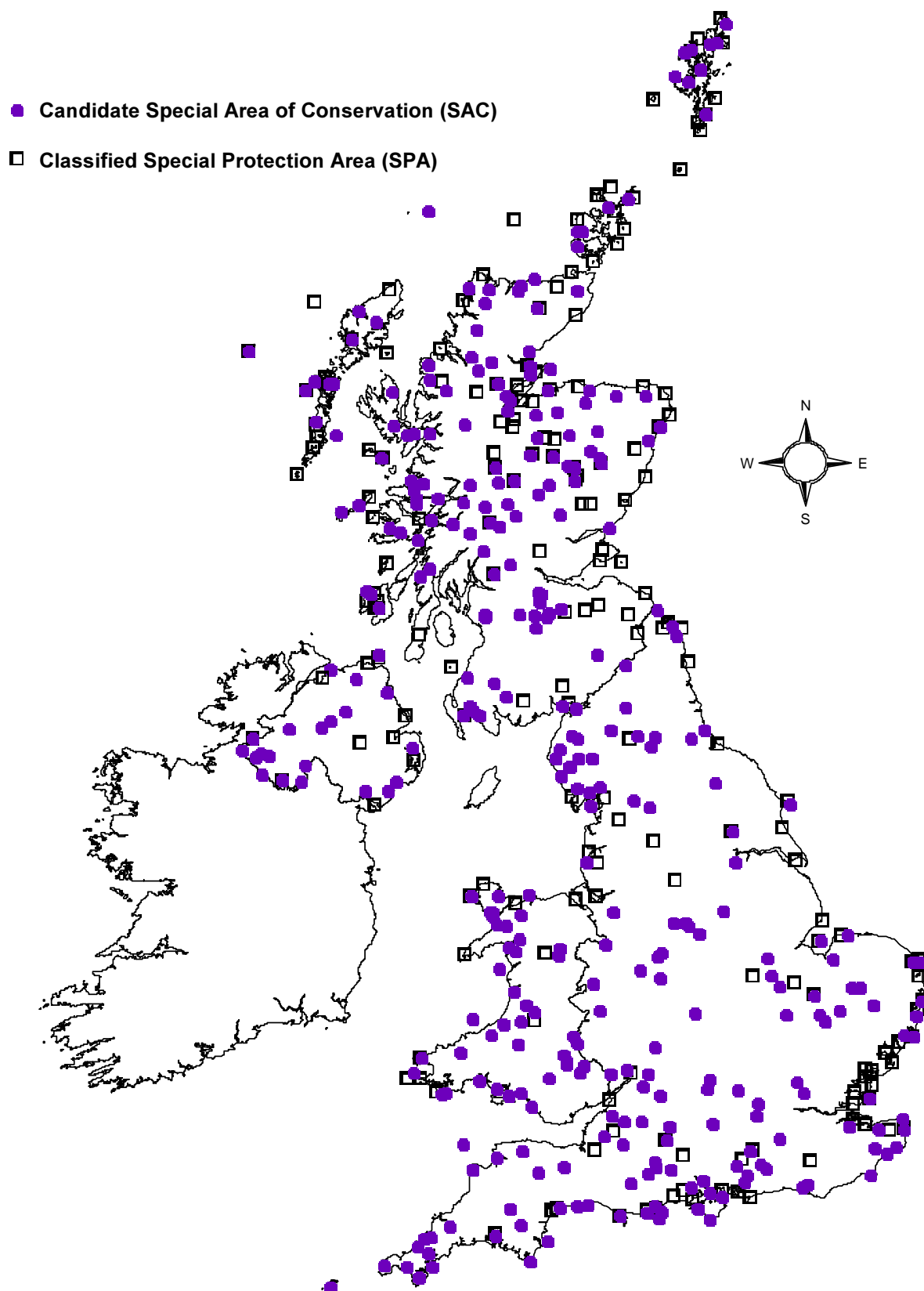


Figure 4.4: SACs and SPAs

#### 4.4.2.3. Biodiversity and sustainability

'Sustainable development' is a phrase that has become widely used in recent years, particularly during and since the Earth Summit in Rio de Janeiro in 1992. Following the Rio Convention on Biological Diversity, the UK was one of the first countries in the world to prepare a national Sustainable Development Strategy, published in 1994. This included action plans for biodiversity, forestry and climate change and had implications for a number of sectors including roads. In 1998, the UK Sustainable Development Strategy was reviewed and revised, to reflect changes that have taken place since 1994, and on 17 May 1999 the UK Government published 'A Better Quality Of Life': a strategy for Sustainable Development in the United Kingdom. The strategy has four main aims: social progress which recognises the needs of everyone; effective protection of the environment; prudent use of natural resources; and maintenance of high and stable levels of economic growth and employment.

Implementation of the biodiversity principles contained within 'A Better Quality of Life' should, in theory, strengthen existing wildlife policy and legislation. Implementation of the 1994 Sustainable Development Strategy has thus far focused on the requirement to produce and implement a national Biodiversity Action Plan (BAP). The UK BAP was published in 1994 and set 59 objectives for conserving and enhancing wild species and wildlife habitats. To achieve these objectives, the UK Biodiversity Group has produced a list of species of conservation concern, of which some are classed as priority species. Progress to date has resulted in the production and costing of 350 Species Action Plans (SAPs), 24 Habitats Action Plans (HAPs) and 37 Habitat Statements (HSs). These national targets are to be met at a local level via local biodiversity action plans (LBAPs), which are currently in production.

### 4.5 LAND-USE PLANNING IN RELATION TO NATURE AND LANDSCAPE CONSERVATION AND TRANSPORT INFRASTRUCTURE

The Government set out its policy for the future of transport in 'A New Deal for Transport: Better for Everyone' (1998). This policy aims to support sustainable development through the delivery of an integrated transport policy, where 'integration' means:

- within and between different types of transport;
- with the environment;
- with land use planning; and
- with policies for education, health and wealth creation.

Land use planning has a key role in delivering the Government's integrated transport strategy. By influencing the location, scale, density, design and mix of land uses, planning can help to reduce the need to travel, reduce the length of journeys and make it safer and easier for people to walk, cycle or use public transport. (Draft) PPG11 on Regional Planning provides guidance on the preparation of regional transport strategies (RTS), as an integral part of regional planning guidance (RPG). These provide the long-term strategic framework which informs development plans, local transport plans and transport operators in developing their plans and programmes. (Draft) PPG12 on Development Plans provides advice about maintaining consistency between local transport plans and development

plans. Local transport plans (for authorities outside London) have a central role in co-ordinating and improving local transport provision. National planning policy is filtered down to regional and local levels through Regional Planning Policy Guidance Notes (RPGs) and County Council and Unitary Authority Structure Plans, and Local Plans.

#### **4.5.1. Mitigating the impact of new transport infrastructure**

Great care must be taken to avoid or minimise the environmental impact of any new transport infrastructure projects, or improvements to existing infrastructure. Wherever possible, appropriate measures should be implemented to mitigate the impacts of transport infrastructure. A range of site designations has been developed to promote nature conservation and to protect landscapes and the national heritage (section 4.4.2.2). Such sites are designated by, inter alia, Government Circulars and Planning Policy Guidance Notes (PPGs) (e.g. PPG1 General Policy and Principles, PPG2 Green Belts, PPG7 The Countryside: environmental quality and economic and social development, PPG9 Nature Conservation, PPG15 Historic Buildings and Conservation Areas, PPG16 Archaeology and Planning and MPG6 Guidelines for Aggregates Provision). An updated programme of PPG development is currently underway.

Nature conservation is achieved in the UK via statutory legislation (as described in section 4.4) and policy guidance in the form of Planning Policy Guidance Notes (PPGs). Although advisory in nature, PPGs can be enforced via legislation where necessary. The two main PPGs of relevance to nature conservation and transport infrastructure are PPG 9 on Nature Conservation (1994) and PPG 13 on Transport (1994). PPG 9 sets out the main statutory obligations under both domestic and international law and government policy as it relates to nature conservation including:

- Government nature conservation objectives and legal framework for achieving these;
- the roles of local planning authorities and EN;
- designated sites;
- development control, development plans, SSSIs and important sites, minerals and species protection; and
- aids the implementation of the EC Habitats Directive (1992) via the Habitats Regulations (1994).

The PPG notes that development in or near SSSIs must be very strictly controlled. A planning authority is expected to pay particular regard to the national or international importance of a site when weighing the case for proposed development against nature conservation interests. In the case of a Special Protection Area (SPA) or Special Area of Conservation (SAC), the statutory nature conservation authority will advise whether, in their opinion, a proposed development would significantly affect the ecological objectives for which the site was designated, and will suggest measures they consider appropriate to apply in such circumstances. It is important to note that for sites under international designation, there must be 'imperative reasons of overriding public interest' for development to take place. This will include reasons of human health and safety, or wider environmental consequences.



PPG 13 on Transport (1994) provides advice for planning authorities on how to integrate transport and land-use planning. It advises that formal Environmental Assessment (EA) is required for all major road transport proposals, and for all other road proposals if the development is likely to have significant environmental effects.

#### *4.5.1.1. Environmental Assessment (EA)*

EA is a method and a process by which information about environmental effects is collected, assessed and used to inform decision making (Glasson *et al.*, 1999). Formal EA requirements were introduced in the UK in 1988 when regulations were issued to comply with the European Community Directive on the Assessment of Certain Public and Private Projects on the Environment (85/337/EEC) (1985) (as amended by Directive 97/11/EC, 1999). Under this Directive there is a requirement for certain types of project to be subject to EA before development consent is granted. The projects that should be assessed are listed in Annex 1 and 2 of the Directive. For major transport proposals, such as motorways and long-distance rail lines EA is required in every case. For other transport proposals, EA is required if the particular development would be likely to have significant environmental effects. In the case of projects that require planning permission, the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 (SI 1999 No 293) apply.

#### *4.5.1.2 Planning for roads*

Following implementation of the Directive 85/337, guidance on how EA was to be carried out for road developments came in the form of Standard HD 18/88 (DoT 1989), and the Design Manual for Roads and Bridges (DMRB) vol. II: Environmental Assessment (DoT 1993). In 1999 'A New Deal for Trunk Roads in England: Guidance on the New Approach to Appraisal (NATA)' was added to DMRB Volume 5. The purposes of the NATA are to assist choosing between different options for solving the same problem and prioritising between options. The output is an Appraisal Summary Table (AST) considering five criteria: environment; safety; economy; accessibility; and integration. Road schemes affect ecology and nature conservation through impacts on SSSIs, NNRs, SACs, SPAs and Protected Species. Section 105A of the Highways Act 1980 stipulates that the relevant statutory body (i.e. EN, SNH, CCW) must be given the opportunity to express an opinion on any road scheme passing through or within 100 metres of an SSSI. The assessment technique for considering ecological and nature conservation issues associated with a road scheme involves a three-stage assessment:

- Stage 1: Sufficient assessment is undertaken to identify the nature conservation constraints associated with broadly defined routes or corridors. Details of the location and nature of any designated sites are obtained from the statutory body and LPA. Information is also gathered on existing surveys of the area. The results of the stage 1 assessment consists of a map of the overall study area showing ecological constraints, such as designated sites or other areas of ecological importance, and a statement setting out the nature conservation interest of the study area. The statement also indicates, provisionally, whether further surveys are required.

- Stage 2: A more detailed assessment is made of the impact of the route options. The information gathered at stage 1 is updated and where it is agreed with the statutory body that further work is required, a detailed desk study and a preliminary walkover survey are carried out. The results of the Stage 2 assessment includes an updated version of the Stage 1 map, and a statement describing the nature conservation value of the study area and the significance of possible impacts, taking account of any proposed mitigation measures. The statement sets out the criteria used to define levels of significance, indicate areas which should be regarded as a constraint, states whether the impacts identified should be regarded as temporary or permanent, or of local, regional or national importance, and describes any survey techniques employed.
- Stage 3: Identifies any significant nature conservation impacts likely to arise from the construction of the preferred route. It identifies the location, type and importance of all areas of nature conservation interest that may be affected and states their relative value, taking account of any agreed mitigation measures. In some cases, the desk study carried out at Stage 2 is supplemented by further field survey. Specialist surveys may also be carried out on sensitive or important areas or where it is known that protected or endangered species are present. Detailed maps are produced and the results of any surveys are reported together with the views of the statutory bodies.

#### **4.5.2. Planning permission for local authority development**

Under the Town and Country Planning General Regulations 1992 (SI 1992 No 1492) (as amended) local authorities must apply for planning permission for their own development proposals, such as local road schemes (see also DOE Circular 19/92, Annex 1). Such applications must follow the same publicity procedures as would apply to any planning application, and where they affect existing or proposed highways, they should be notified to the Secretary of State. By virtue of the Town and Country Planning (Development Plans and Consultation) Directions 1992 (DOE Circular 19/92, Annex 3) any local road proposal which is a departure from the development plan must be notified to the Secretary of State.

#### **4.5.3. Planning for new railways, tramways and inland waterways**

The construction of railway, tramway, other guided transport systems, inland waterway schemes, and works across rivers or in the sea which interfere with navigation rights are normally approved by means of Ministerial Orders made under sections 1 and 3 of the Transport and Works Act 1992. Orders may provide for the carrying out of works, the compulsory land acquisition required in connection with the works, and any other ancillary matters. Applications for orders are made to the Secretary of State, or alternatively, applicants can seek planning permission separately from the local planning authority. For transport schemes, the proposed route should be shown (at least indicatively) in the development plan, which should address any land-use opportunities and pressures created by the route. Most schemes will be considered at a public inquiry, at which the planning

aspects can be fully considered before any Order is made. For schemes which the Secretary of State considers to be of national significance, the Act provides for Parliament to vote on the proposals in principle. If approved by both Houses (Commons and Lords) the application will proceed to an inquiry for more detailed consideration.

#### 4.6 SUMMARY

The UK is a country with a long history of land use and land management, and a well developed planning and environmental assessment system. UK policy has dramatically shifted in the last eight years. In 1989 the announcement of an expanded roads policy caused great concern for the environment, and growing evidence that such a programme was likely to result in increased traffic levels, increased road use and increased pollution and environmental damage led to a statement from English Nature in 1992. This statement emphasised the direct negative impacts during construction arising from land take, changes in topography, surface and sub surface water drainage, stream and river diversion and constraint, earthworks and associated site damage. Evidence such as this, together with the expense of extensive road building programmes, led to a radical change in transport policy, focusing on integrated transport and a fundamental appraisal of the type and quality of evidence on which Ministers take road and planning decisions. It is now recognised that much of the required transport infrastructure is already in place, and emphasis has changed to be on maintenance and monitoring priorities rather than new construction.

Within the EC, the value of wildlife corridors at the strategic level is recognised and embodied in Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna (the Habitats Directive), under which the network of Natura 2000 sites are designated. Article 10 of the Directive requires Member States to:

*“...endeavour, where they consider it necessary, in their land use planning and development policies, and in particular, with a view to improving the ecological coherence of Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild flora and fauna. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for migration, dispersal and genetic exchange of wild species.”*

Although the requirements of Article 10 have been incorporated in a draft National Planning Policy Guideline on Natural Heritage in Scotland (The Scottish Office, 1998) and are endorsed in a Scottish Office Circular (The Scottish Office, 1995), as yet there is little tangible evidence of implementation in the UK. However, ecological networks similar to the Dutch ‘National Ecological Network’ are being planned and implemented at the regional and local level in the UK. In Cheshire, the UK’s first county ecological network is being planned within the context of the Cheshire 2011 Structure Plan, under a pilot project developed jointly by Cheshire County Council, Salford University, Liverpool John Moores University and English Nature (‘Econet’: Cheshire County Ecological Network). If successful, similar plans could be developed for other regions and counties. The network will incorporate the following elements:

- core areas, comprising clusters of nationally and internationally important sites (e.g. SSSI, SPA, SAC), in addition to sites of 'critical natural capital' (e.g. ancient woodland and peatland habitats);
- nature restoration areas, which will adjoin or be in close proximity to core areas;
- corridors and stepping stones, to allow species to disperse and migrate between core areas and nature restoration areas; and
- buffer zones, to protect the network from potentially damaging external influences such as pollution and land drainage.

The project, initiated in 1996, uses a geographical information system (GIS) as an analytical tool. Data collection, analysis and the development of a rule-based system to guide habitat restoration and creation are expected to be complete in 2000. Realisation of the network on the ground is anticipated by the year 2020. The scale and status of the 'Econet' project have recently been increased with Cheshire County council's success in a multi-national bid for funding from the LIFE-Environment programme - the European Union's fund for supporting projects that demonstrate practical, innovative solutions to environmental problems. The £3.16 million 'Life ECONet Project' is a joint initiative between the County Council and local authorities, private industry and research centres from the UK, Italy and the Netherlands. Thanks to £1.55 million from the European Commission (EC) and a range of partnership agencies, Cheshire County Council can now forge ahead with an ambitious four-year international project to develop ecological networks. The project will run for 4 years from September 1999 until September 2003 and aims to integrate environmental considerations in land use planning through the use of ecological networks. Further information on this project is given in section 8.6.6.

As yet the idea of ecological networks are not embodied in national legislation. However, interest in the concept of ecological networks reflects a significant move away from the more traditional approach to nature conservation, pre-occupied with designated areas such as SSSIs. The move towards ecological networks provides an opportunity to integrate nature conservation and other land-uses through land use policy and spatial planning. Ecological corridors and buffer zones are becoming key elements in nature conservation strategy, reflecting a wider appreciation of the problems posed by habitat fragmentation and the need to make landscapes more permeable to wildlife. However, the realisation of the networks can only be possible with political and public support and co-operation. Extensive discussions will need to be held, therefore, with a wide range of stakeholders to raise awareness of the concept of ecological networks, and to seek their integration into other policy sectors such as land-use planning, regional development, and transport.

Transport policy needs to strike a balance between three key issues: the environment, the economy and personal choice. The Government believes that a change in emphasis is needed to recognise the long-term consequences of high road-traffic growth. This is set out in the Transport Green Paper: The Way Forward (1996). Transport policies cannot be viewed in isolation. They must take account of other Government initiatives – especially financial and environmental policies. The latter includes the Planning Policy Guidance Notes, particularly PPG 13 (which deals with transport and land-use planning policy) and recent government publications on sustainability and biodiversity. National and European environmental legislation (e.g. the Environment Act 1995, and Community Directives on environmental assessment, habitats, birds and air quality) must also be taken into account.

## **Chapter 5. Habitat Fragmentation due to Existing Transport Infrastructure**

### **5.1 INTRODUCTION**

Habitat fragmentation describes both the process and spatial pattern resulting from the disruption of once relatively extensive habitats into smaller, more isolated patches (Reynolds, 1999). It is an issue that has been widely recognised as having significant consequences for nature conservation. In the UK, farming practices, built development, woodland management, land drainage and water abstraction have all caused, or are currently resulting in, direct loss or fragmentation of habitat. (UK BAP Vol.1, 1995). There are many examples of habitat loss including: 95% loss of neutral grassland including hay meadows since 1930, 80% loss of calcareous grassland since 1940, 40% loss of lowland heath since 1950 (84% since 1800), and 50% loss of fens and mires since 1950 (EN, 1996(1)). The UK BAP states that “The fragmentation or isolation of key habitats is to be avoided and wherever practicable past fragmentation to be reversed” (Vol.1, 1995).

Fragmentation due to existing transportation infrastructure is substantial in the UK. This is set against a background of relatively intensive land use and extensive habitat fragmentation and isolation in general. Development of transport infrastructure, in the form of roads, railways and canals, contributes towards the process of habitat fragmentation as a consequence of:

- direct loss of habitat;
- disturbance and avoidance due to noise, pollution and visual stimuli; and
- mortality.

Changed verge management, replacement of roadside ditches by buried drains, road construction and the upgrading of existing roads can cause loss of, and damage to, wildlife habitats. There are also impacts through increased demands for aggregates, increased pressure for adjacent development, and through the substantial contribution transport makes to greenhouse gas emissions and acid rain. Together these factors conspire to create species metapopulations, i.e. formerly large continuous populations of plants or animals divided into smaller, partially isolated local populations (subpopulations). Being smaller, these are likely to fluctuate more widely over time and to have a higher probability of extinction. The probability of recolonisation is also likely to be reduced due to the resistance to animal dispersal posed by structures such as roads. By their linear nature, roads, railways and waterways have considerable potential to fragment and isolate nature conservation resources (in addition to the more direct effects of habitat destruction and modification), and a wide range of mitigation measures have been instigated across the country in recent years in an attempt to reduce such negative effects on wildlife, as well as to maximise any enhancement opportunities.

For many years UK researchers have been attempting to determine the significance of transport infrastructure development for habitat fragmentation. A great deal of valuable information was gained from participation in the International Conference on Habitat Fragmentation, Infrastructure and the Role of Ecological Engineering, hosted by the

Ministry of Transport, Public Works and Water Management in Maastricht, The Netherlands (18-21 September 1995). The eight UK representatives were: Penny Angold (the University of Birmingham); Mrs Olivia Bina (RSPB); D.S. Gibbons (the University of Derby); Keith Kirby (English Nature); P. James (University College, Salford); I. Marshall (Cheshire County Council); and Mrs R. J. Patel (the University of Wales, Cardiff).

English Nature, in particular, has been active in researching habitat fragmentation, producing a series of inter-related reviews as part of its Commissioned Research Programme. The outputs of the Habitat Fragmentation Programme include:

- ENRR 60 (1993) Linear features: linear habitats and wildlife corridors
- ENRR 89 (1994) Habitat Fragmentation: species at risk
- ENRR 94 (1994) Are habitat corridors conduits for animals and plants in a fragmented landscape? A review of the scientific evidence
- ENRR 95 (1994) Habitat fragmentation and heathland species
- ENRR 139 (1995) Habitat fragmentation pilot study: insect mobility
- ENRR 178 (1996) The significance of secondary effects from roads and road transport on nature conservation
- EN Science no.10 (1995) Rebuilding the English Countryside: habitat fragmentation and wildlife corridors as issues in practical conservation
- EN (1994) Roads and nature conservation: Guidance on impacts, mitigation and enhancement

Evidence from Wales, indicates that although no direct information is available, fragmentation of habitats and populations is a major concern. There are a number of road schemes which are currently passing through the planning and assessment stages which include the examination of fragmentation and severance effects e.g. the Heads of the Valleys Dualling (Abergavenny to Hirwaun) scheme has undertaken extensive surveys and assessment to determine the severance and fragmentation effects on bats, otter, migratory fish and marsh fritillary (*Eurodryas aurinia*). The Marsh Fritillary surveys have also included an assessment of fragmentation effects on metapopulations.

Such existing research has indicated that the fragmentation effect takes the form of a barrier whose permeability varies according to the scale and characteristics of the infrastructure (i.e. road, rail or waterway, total land requirement and geometric characteristics) leading to landscape and habitat fragmentation. This effect acts on landscape structure and affects both animal and plant diversity. Biologically, population interchange may be jeopardised and habitat sizes may be reduced below the necessary threshold.

## 5.2 EUROPEAN TRANSPORTATION NETWORKS

There are a number of designated TENS (Trans European Network transport links) in the UK that are a part of the core trunk road network, and several UK rail routes also form part of the wider European transportation network. The routes are shown in Figures 5.1 to 5.4 below.



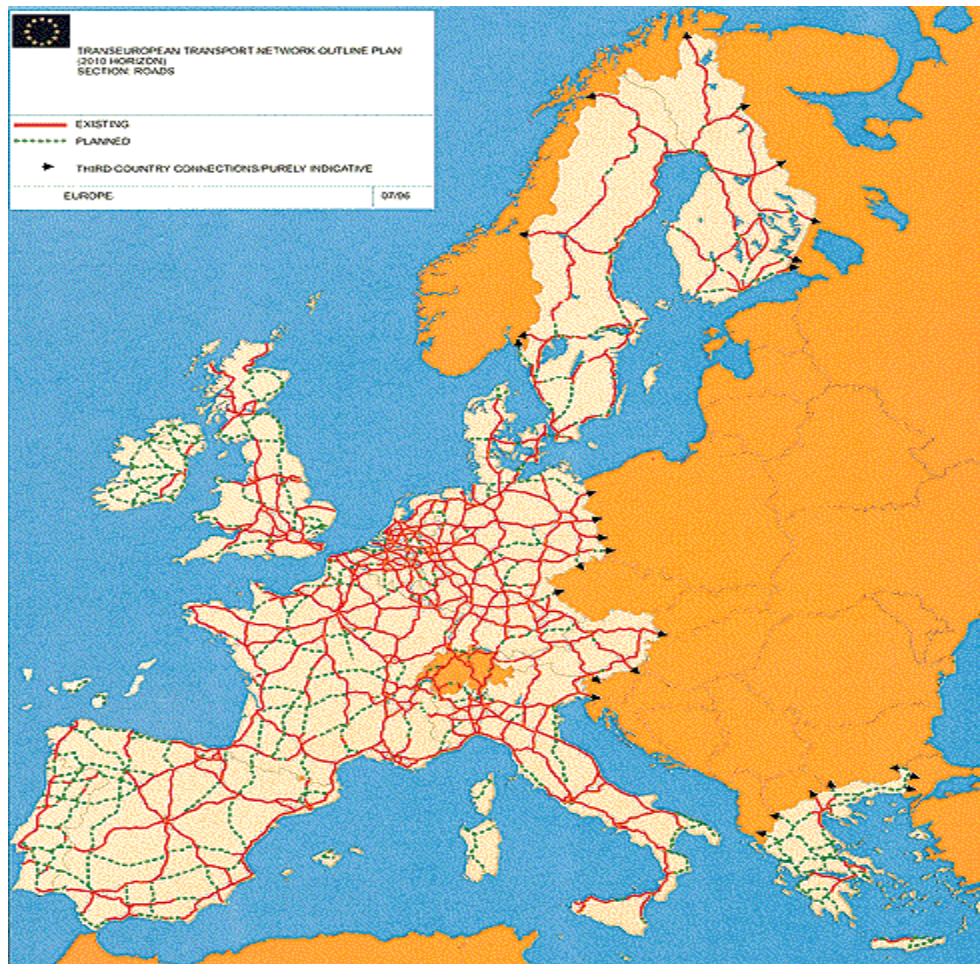


Figure 5.1: Trans-European Road Network (EC overview)



Figure 5.2: Trans-European Road Network (UK overview)

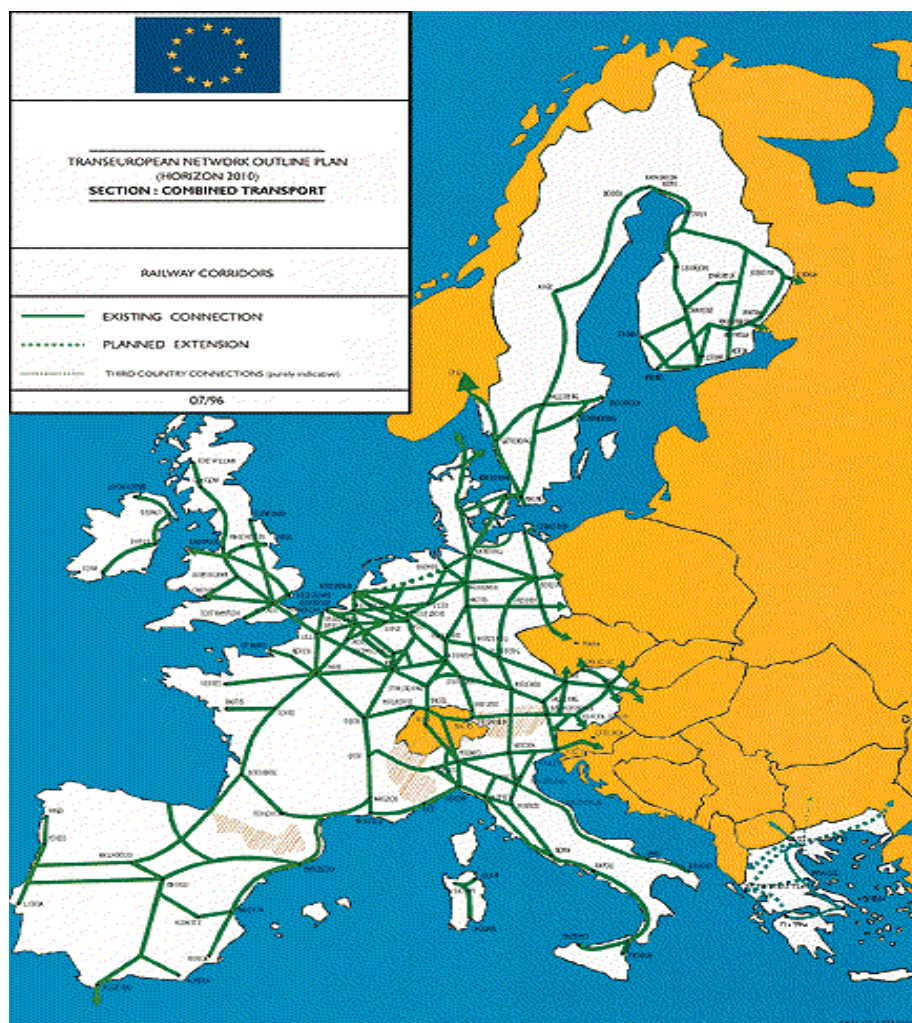


Figure 5.3: Trans-European Rail Network (EC overview)

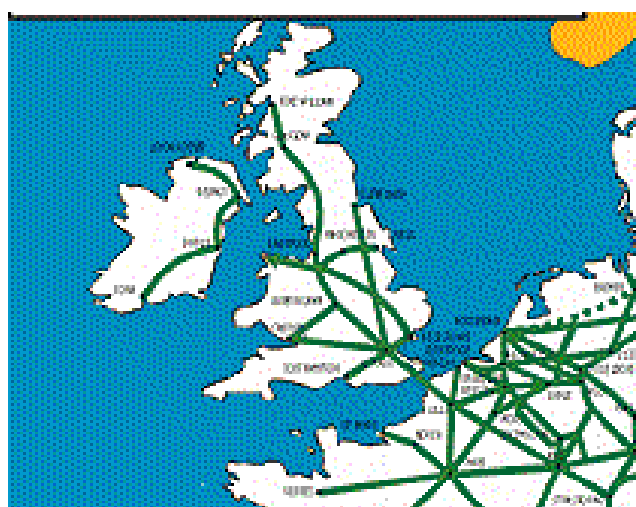


Figure 5.4: Trans-European Rail Network (UK overview)



Completion of the Channel Tunnel link to France has resulted in the development of a high-speed rail link to London (see 4.5 above), which is currently under construction. This new rail line has been nominated as a TEN.

### 5.3 TRANSPORTATION NETWORKS

#### 5.3.1 Highways/motorways

The National road network in the UK consists of motorways (2-5 lanes of traffic in each direction), trunk roads, A, B, and C-class roads and unclassified roads. Motorways and trunk roads are under the jurisdiction of the Highways Agency (England), Scottish Executive (Scotland), National Assembly for Wales (Wales), and the Department of the Environment for Northern Ireland (Northern Ireland). All other roads are controlled and managed by local highway authorities (County and District Councils, and Unitary and Metropolitan Authorities) or private companies. Traffic density across the network is extremely variable, ranging from nearly 200,000 vehicles per day on the M25 (a motorway in the Southeast of England) to less than 5, 000 vehicles per day on some rural Scottish and Welsh all purpose trunk roads.

##### 5.3.1.1. *The Highways Agency*

The Highways Agency (HA) was established as an executive agency of the Department of Transport in April 1994. It is responsible for managing on behalf of the Secretary of State for Transport an efficient, reliable, safe and environmentally acceptable trunk road network throughout England. The Agency currently manages and maintains a network of some 6,500 miles of motorways and trunk roads in England, valued at around £55 billion. It works closely with local authorities, rail, coach, bus, and water and air operators to integrate the network with the rest of England's roads and other forms of transport. The Roads Review of 1998 gave the Highways Agency the strategic aim to: 'contribute to sustainable development by maintaining, operating and improving the motorway and trunk road network in support of the Government's integrated transport and land use planning policies'. Two of the key objectives associated with this strategic aim are:

- to minimise the impact of the network on both the natural and built environment; and
- to work in partnership with road users, transport providers and operators, local authorities and others affected by its operations, to promote choice and information for travellers, monitoring and publishing information about the performance and reliability of the network.

The Roads Review also changed the emphasis from investing in extending the trunk road network to maintaining the existing stock as the first priority, making more efficient use of existing road space and tackling some of the most serious problems through a carefully targeted programme of improvements (Chapter 8, section 8.5). The Review also identified strategically important routes, which will remain under the direct responsibility of the Agency (the core network). About 70% of motorways and trunk roads fall into this category. The remaining 30% of the network will be 'de-trunked' with responsibility for management transferred to local authorities. Under the White Paper 'A Mayor and

Assembly for London' the Greater London Authority (GLA) will be responsible for all motorways and trunk roads within Greater London, except for the M1, M4, M11 and M25 which can be more efficiently managed as part of a national network.

#### 5.3.1.2. Environment

The Highways Agency is always looking to explore different ways of conserving wildlife, the landscape and natural habitats. It respects obligations towards Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), attempting to avoid incursions into these areas (unless there are imperative reasons of overriding public interest and there are no alternative solutions). The same approach is taken to sites which are candidates for these designations, as well as to important wetland sites which have been classified under the Ramsar Convention (RAMSARs). There is similarly a strong presumption against going ahead with works that might affect sites such as Sites of Special Scientific Interest or Areas of Outstanding Natural Beauty, ensuring that all realistic options are examined carefully before road schemes likely to affect them are taken forward. Where sites such as these cannot be avoided, suitable measures to reduce or offset adverse impacts are provided. HA employs specialist consultants to identify the presence of protected species and takes measures to protect or relocate them. It also installs measures such as fencing to stop animals crossing busy trunk roads at surface level, instead directing them towards purpose-built or specially adapted crossings. This reduces road accidents and animal casualties. Guidance on the methods developers should employ during road design and construction are contained in Volumes 10 and 11 of the Design Manual for Roads and Bridges. This includes details on best practice for avoiding, reducing and compensating for nature conservation impacts associated with road development. It is constantly being revised and updated as new techniques become tried and tested.

A recent example of where nature conservation interests were given high priority was the Newbury Bypass. Fifteen protected species, including the now famous Desmoulin's whorl snail, otters (*Lutra lutra*), dormice (*Muscardinus avellanarius*), water voles (*Arvicola terrestris*), badgers (*Meles meles*), and several different species of bats, snakes, lizards, and deer have been relocated or protected. Nine environmental balancing ponds were also created to ensure that pollutants are not discharged into nearby rivers and streams. New appraisal methods (the New Approach to Appraisal - NATA) mean that environmental considerations relating to road investment projects are considered on the same level as economic ones.

The Highways Agency is the leading planter of broadleaf woodland and native trees in England. All new road schemes automatically include extensive landscaping as part of the project. HA have joined forces with the National Urban Forestry Unit (NUFU) to create more woodlands by the motorway. Highway verges and other planted areas near to roads can provide valuable habitats for wildlife, indeed some are even designated as Sites of Special Scientific Interest (SSSIs). HA aims to manage and maintain the network in a way which minimises impacts on species and habitats. For instance, surveys in Cornwall on the trunk road network have shown that at 19 locations protected plant species have become established because they have been provided with the prime habitat in which to flourish (Cornwall Wildlife Trust, 1997).

### 5.3.1.3 Biodiversity

The Government has committed itself to conserving biological diversity within the UK and to contributing towards conserving global biodiversity through all appropriate means (Section 4.4.2.3). As a Government agency, HA is obliged to participate fully in the process set out in Biodiversity, the UK Action Plan, and is currently producing its own Biodiversity Action Plan. An important part of the HA's business is its research and development programme, a proportion of which is directed towards promoting the conservation and enhancement of biodiversity. The following projects relating to nature conservation are either under way or proposed for the next 5 years:

- Research into how breeding birds make use of roadside verges and other highway land. This will help to determine what effect road traffic has on birds.
- Research into reptile habitats on roadside verges to identify indicators for establishing the need for surveys in advance of road-improvement work.
- Continued research into barn owls living close to trunk roads.
- Production of more comprehensive advice on dealing with a wide range of species commonly affected by road improvements. These include newts, otters, bats, owls, deer and badgers.
- Research into wildlife casualty-reduction methods, as well as the effects those casualties have on wildlife populations.
- Research into the long-term effects that water from our drainage systems has on the ecology of lakes, rivers and other watercourses.

### 5.3.1.4. National Roads Directorate, Scotland

The National Roads Directorate of the Scottish Office Development Department (SODD-NRD) is responsible for the development and management of the Trunk Road Network in Scotland. The network currently comprises over 3,200 km of road and associated verges, covering a total area of over 6,000 hectares. SODD NRD endorses all the procedures, guidance and good practice described in the DMRB (Vols. 10 and 11), and supplements these with further guidance and procedure for Scotland in the form of 'Cost Effective Landscape: Learning from Nature' (1998). This policy aims to promote nature conservation through the provision of greater diversity of habitats, flora and fauna along the road corridor and greater integration with adjacent habitats. It advocates that designs for new landscapes should use natural characteristics, explore alternatives and use resources wisely. It advises that opportunities for addressing habitat and species fragmentation be considered as a fundamental part of understanding the site at the outset of the design process. The policy is having an immediate impact on trunk road landscape design and management. The Scottish Executive has also recently published a draft of its Trunk Road Biodiversity Action Plan (TRBAP), which is based around the Cost-Effective Landscaping methodology (Scottish Executive, 2000).

## 5.3.2 Secondary road infrastructure

Trunk roads and motorways represent a mere 4% of the total road network in the UK. The remaining 'secondary road infrastructure' is under the jurisdiction of the local government

authority for each area i.e. County Council or Unitary Authority. This includes roads from classes A to U, but generally does not include larger dual carriageways (twinning roads). Typical traffic densities range from 700 vehicles per day on a single-track road (U-class road in Hampshire, 1991) to 2000 per day on a C class road, 4000 per day on a B road and 15,000 per day on a single carriageway A road.

### 5.3.3 Railways

The railway infrastructure, including track, signalling, bridges, tunnels and stations, is almost entirely owned by Railtrack Plc., and extends to 18,000 km of route. Despite the decline of the rail network over the past 40 years, there is currently a desire to revive rail travel. Railways are seen as the only mode of land transport which can satisfy the environmental and economic challenges of the ever-increasing demand for transport. Rail transport is energy efficient, producing significantly less carbon dioxide emissions per passenger kilometre or freight tonne kilometre than road transport. Indeed, the external costs of air and noise pollution, congestion, accidents and infrastructure damage are all less for rail than for road. Rail infrastructure also requires less space than the road network, reducing the impact of the transport sector on use of land and on biodiversity. Railtrack's Environmental Policy (Railtrack, 1999) details some of their aims and objectives, and how they plan to achieve them. In pursuing the best practicable environmental option the company aims to:

- comply fully with and keep abreast of all legal obligations covering operations past, present and future, requiring employees and contractors to act in accordance with the environmental policy;
- ensure that new projects, maintenance and renewals are managed professionally in a way which incorporates assessment of environmental impact and takes appropriate action to keep any adverse impacts to a minimum;
- seek to minimise emissions and reduce waste; and
- be sensitive in the management of natural and heritage features.

Railtrack provides access to the tracks and stations, manages timetabling and operates signalling and has responsibility for maintaining, renewing and upgrading the rail infrastructure. The national railway assets are as follows:

- 2,500 stations owned by Railtrack and mainly leased to train operators ;
- 14 major stations owned and operated by Railtrack ;
- 90 depots (leased to train operators and contractors);
- 32,000 km of track;
- all the signalling and electrical control equipment needed to operate this track along a total route length of 16,000 kilometres;
- 40,000 bridges, tunnels and viaducts;
- 9,000 level crossings; and
- connections to over 1,000 freight terminals.

The network is comprised of 32,000 km of track, representing 16,000 route km, running through some of the UK's most industrialised urban areas and through some of the most

remote national parks (Figure 5.5). Railtrack's first responsibility is to ensure the efficiency of the national rail network by maintaining the tracks, and that includes keeping it free of vegetation. Overhead vegetation must be kept clear of the tracks, as fallen leaves reduce the adhesion between train wheels and rails, causing serious operating problems; they must also ensure that vegetation does not obscure signals, obstruct overhead cables, or interfere with train movements.



Figure 5.5: The UK Railway Asset

Trackside vegetation can provide important habitats for flora and fauna, maintaining biodiversity and acting as a 'wildlife corridor', often linking isolated habitats (ITE, 1984). These corridors are especially important in urban areas. The overriding responsibility to provide an efficient railway infrastructure must be balanced by a responsibility to safeguard wildlife and the wildlife corridor, by managing vegetation in an informed and sensitive manner. For instance, five species of tree have been identified that cause most problems and these are selectively felled, taking care not to damage birds' nests. Another key area of vegetation management concerns the use of herbicides. As unchecked growth can reduce the operational safety of the line, most of the open track is sprayed annually with weed killer to facilitate maintenance. Railtrack needs to ensure that contractors use the correct type and quantity of herbicide necessary, and that sensitive sites are protected. If not already vegetated, the planting of trees, shrubs and hedges along linesides actually

stabilises the soil. Foxes, stoats and weasels like this type of habitat. Grass, heathland and scrubby areas do need management so they do not encroach onto the lines, but with due consideration this can be carried out without harming wildlife.

Railtrack works in consultation with many external authorities. For instance they are currently working with the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), English Nature, Scottish Natural Heritage, Countryside Council for Wales and the water companies to agree a list of sites where the types of herbicides used by contractors should be restricted e.g. near watercourses, near abstraction sites for drinking water, or where the ecology needs special protection. Last year (1999) 251 such sites were agreed with these parties, a list which is due to increase to 728 in 2000.

### 5.3.3.1 *The 'wildlife corridor'*

There are several thousand protected sites on or adjacent to Railtrack land, including Sites of Special Scientific Interest (SSSIs), Areas of Outstanding Natural Beauty (AONBs) and Natura 2000 sites. Many are also important heritage sites, and Railtrack has a responsibility to protect and conserve them. The Railtrack Asset Register is an initiative designed to catalogue all the trackside assets. It is planned to include information on the location of protected nature conservation and heritage areas and on land ownership. This information is vital to contractors, enabling them to take appropriate measures to conserve the areas during routine maintenance, construction or herbicide spraying. Railtrack are currently confirming ownership of all SSSIs previously owned by British Rail with English Nature. They have agreed to jointly develop management statements for these sites, to ensure they are managed sensitively and their conservation value is protected.

### 5.3.3.2 *The London Underground*

Over half the London Underground (LU) network is actually above ground and around 220 km of trackside property is available as a potential wildlife corridor or refuge. As such, LU is playing a major part in protecting wildlife and rare plants. This year (2000), London Transport has undertaken a survey, with the support of the London Ecology Unit, to assess the biodiversity of the Underground system. The survey identifies the habitats and many of the species present, their significance nationally, regionally or locally, and how the assets may be better managed or enhanced in the future to promote nature conservation. The London Ecology Unit report confirms that the embankments are teeming with protected species, undisturbed by human trespassers. Tracksides are home to deer, badgers (*Meles meles*), shrews, frogs, lizards, water vole (*Arvicola terrestris*), newts, toads and slow worms. Hedgehogs, grass snakes, squirrels, butterflies, kestrels (*Falco tinnunculus*) and urban foxes are also now common sights. Remarkably, the Tube is also providing a home for colonies of some of Britain's rarest bats. The long-eared (*Plecotus auritus*) and natterer's (*Myotis nattereri*) varieties were discovered in a disused tunnel at Highgate. Pipistrelle bats (*Pipistrellus pipistrellus*) have also been spotted roosting in other disused tunnels. In the last 30 years, pipistrelles have declined by 70 per cent. At Highgate they are planning to put up boards for hibernation and winter roosting. The survey also identifies 350 plant species on the linesides, including the bristly Oxtongue (*Picris echioides*), Cat's-ear (*Hypochaeris*), Mugwort (*Artemisia*) and Bluebell (*Hyacinthoides non-scripta*). By

leaving rough grassland and mature oak woodland undisturbed the Underground system nurtures rare plants and preserves animal habitats. More than 50,000 trees and shrubs and 60 different species of wild flowers have been planted per year along the lineside for the last 10 years. Many tracksides have now been designated as Sites of Importance for Nature Conservation' in their own right.

### 5.3.4 Waterways

There was an extensive canal network linking the ports and major rivers over much of England in the 19<sup>th</sup> Century, serving particularly industrial towns and areas of heavy industry. During the 20<sup>th</sup> Century, much of this network fell into disuse and became overgrown. The British Waterways Board is responsible for the management of 3,200 km of navigable waterways and canals in England, Scotland and Wales (see Map11: Waterways (England and Wales), Map 12: Waterways (Scotland) and Map 13: Waterways (Northern Ireland)) and is engaged in restoring many lengths of the old canal system, largely for recreational use. Scotland, Wales and Northern Ireland have historically had fewer canals, although navigable waterways still exist for trade and pleasure craft such as the Caledonian Canal through the Great Glen in Scotland connecting the Atlantic Ocean with the North Sea.

The waterway network includes 3,200 km of canals, 4,763 bridges, 397 aqueducts, 60 tunnels, 1,549 locks, 89 reservoirs, nearly 3,000 listed structures and ancient monuments, and 66 Sites of Special Scientific Interest. This resource is used extensively for walking, angling, cycling, wildlife pursuits and visiting heritage buildings and structures (Figure 5.6). British Waterways is required, under the Transport Act of 1968, to maintain its canals and rivers in a safe and satisfactory condition in accordance with standards defined in the Act. To help it achieve this, British Waterways receives grant from the Government.



Figure 5.6: Typical inland waterway

In 1988 two evaluation surveys were initiated by British Waterways Environment Services team to assess the nature conservation value, and water quality of the waterways resource (Waterway Environment Services, 1996). The output of the surveys included a 'Wildlife Sites Register' which identifies statutory and non-statutory sites of ecological and wildlife value. The Wildlife Sites Register lists and describes all statutory wildlife sites on or adjoining waterways, including Sites of Special Scientific Interest (SSSIs), Special Protection Areas (SPAs) and Special Areas for Conservation (SACs). The Register also lists and describes designated, but non-statutory wildlife sites on or adjoining waterways e.g. the County Wildlife Sites. The Wildlife Register is currently being revised and will be re-issued alongside the completed British Waterways Biodiversity Action Plan.

The work of British Waterways is guided by an environmental policy which is focused on maintaining a high quality waterway environment. The objective is to build on the maturity and diversity of the waterways and to ensure that all management actions enhance their environmental quality and long term viability. Environmental practice is guided specifically by an Environmental Code of Practice (ECP), produced as a response to the British Waterways Act 1995. It reviews all environmental legislation that affects waterway management and sets out schedules describing environmental impacts and assessments of waterway management. The ECP is gradually being introduced into all work planning and implementation. The specifications give guidance on good environmental practice for routine works, such as towpath mowing and hedgerow management. They are due to be extended to cover issues such as bank protection techniques and channel design.

Although canals are man-made they support a huge variety of wildlife. Consistency of management over their 200 years of existence has enabled many species and habitats to become well established. Many canals now support species and habitats that are rare elsewhere, making them an important conservation resource.

#### *5.3.4.1. Habitats*

Though the canal corridor is limited to a relatively narrow strip of land it manages to contain a surprisingly wide range of habitats, each supporting a different community of plants and animals. These habitats include hedgerows, towpath verges and the water channel itself. This combination of habitat strips in a narrow corridor gives canals a unique 'biodiversity', further enhanced in places by cuttings, embankments and water supply reservoirs. The hedgerows have now become home to a wide range of plants and animals, but they are very different from the hawthorn strips originally planted. Many other shrubs and wildflowers now occur, along with a wide range of insects and birds. Next to the hedgerow are the towpath verges. Depending on how the path is used and managed it can provide habitat for numerous species. On many canals three distinct zones can be seen: a wildflower and insect-rich tall grass next to the hedge; a mown or surfaced central section dominated by trample resistant plants; and a marshy strip at the edge of the canal channel. The last of these is particularly valuable for insects such as dragonflies, which spend part of their life cycles underwater but use this habitat to emerge and feed as adults. The water channel is usually the most important habitat of the three. At the margins there may be reedy fringes which merge with the marshy strip of the towpath. These fringes are important for aquatic insects and as breeding and spawning grounds for fish and birds, particularly on the opposite side of the canal to the towpath. The open water habitat



supports different species, with a range of pondweeds, aquatic insects and fish. Reservoirs, often remote from the waterways, supply water along 600 miles of feeder channels to the canal system and provide an additional habitat. Managing the flow of water to the canal system can limit the extent to which the reservoir can be used for ecological value, with draw-down in summer leaving little more than extensive mud flats. Many reservoirs are protected for their nature conservation value, but this is often in conflict with leisure activities such as sailing, windsurfing, and angling.

#### 5.3.4.2. Wildlife Species

The variety of canal habitats means that many different birds live along canals. In the hedgerow and along the towpath there are species such as sparrows (*Passeridae*), finches (*Fringillidae*), wrens (*Troglodytidae*), thrushes (*Turdidae*) and warblers (*Sylviidae*). At the water's edge there may be herons or kingfishers, whilst in the open channel there will be waterbirds such as Mute Swans (*Cygnus olor*), Moorhens (*Gallinula chloropus*) and Coot (*Fulica atra*). The towpath vegetation can include many types of wildflower. A study of one wildlife-rich canal revealed over 400 different species along its towpath. Characteristic species include Skullcap (*Scutellaria*), Meadowsweet (*Filipendula*) and Willowherb (*Epilobium*). In the margins of the canal reeds and tall grasses dominate, though they are usually mingled with a variety of shorter flowering plants. Typical flowering plants of the margins include Yellow Iris (*Irises pseudacorus*), Arrowhead (*Sagittaria*) and Branched Bur-reed (*Sparganium erectum*). In the canal channel live the true aquatic plants. They range from the floating Duckweeds (*Lemna*) to the submerged Pondweeds (*Potamogeton*) and Water-starworts (*Callitriche*). These species are essential food and habitat for aquatic invertebrates. Scores of different invertebrates live amongst the towpath grasses and flowers. Many are hidden in the undergrowth but some such as bees, hoverflies and butterflies are easy to spot. Butterflies include the distinctive Gatekeeper (*Pyronia tithonus*), so-called because it patrols up and down the hedgerow. Insects that spend their larval stages underwater often spend their adult life flying amongst the flowers of the towpath. These include the mayflies, caddisflies and alderflies as well as the larger and more familiar damselflies and dragonflies. In the water itself there is a different world of aquatic larvae, beetles and bugs. Common species include the water boatmen (*Sigara scotti*), water scorpions (*Ranatra linearis*) and pond skaters (*Gerris families*). The towpath, cuttings and embankments are home to many mammal species. Some, like wood mice (*Apodemus sylvaticus*) and bank voles (*Clethrionomys glareolus*) live in the hedgerow, whilst others such as water voles (*Arvicola terrestris*) live in the waterside margin. Larger animals, like badgers (*Meles meles*) and foxes (*Vulpes vulpes*), burrow into the embankment slopes. Canalside buildings, bridges and tunnels provide roosting sites for bats. Amphibians and reptiles including frogs, toads newts and grass snakes can also be found. Beneath the water the dominant animals are the fish. Large numbers of small roach (*Rutilus rutilus*), bream (*Abramis brama*) and gudgeon (*Gobio gobio*) dominate, though there are many other species, including the predatory pike (*Esox lucius*).

#### 5.3.4.3. Rare and Uncommon Species

Much of the nature conservation value of canals lies in their wildlife diversity, rather than the presence of particularly rare species. However many nationally rare and protected species can be found. Familiar examples include bats and badgers (*Meles meles*) but other

species such as crayfish (*Austropotamobios pallipes*) and Floating Water-plantain (*Luronium natans*) also occur. Some canals support locally rare species, or those restricted to particular sorts of canal habitat. Reed Warblers (*Acrocephalus scirpaceus*), for example are limited to those sections of canal that have Common Reed growing in the margins. British Waterways has special responsibility for many rare species. Water voles (*Arvicola terrestris*) have become very rare in recent years and British Waterways are now closely involved in numerous schemes to conserve and enhance their populations.

#### 5.3.4.4. Colonists and Invaders

Canals are home to many species that have used them to colonise new areas over the years. Some of these species are natives that have found the canal environment particularly suitable. These include the rare Floating Water Plantain (*Luronium natans*), which spread from Welsh lakes into canals in the 1860s. Other colonisers are less desirable. These are the alien species, i.e. colonists from abroad which use the canals to spread around the country. Aliens include Canadian Pondweed (*Potamogeton epihydrus*), which spread rapidly through the canal system in the 19th Century to become a common pondweed today. More recent examples include zander (*Stizostedion lucioperca*), a predatory fish from Europe that is changing the ecosystem of Midland canals, and most recently, red-eared terrapins (*Mauremys caspia*), released as unwanted pets.

#### 5.3.4.5. Biodiversity Action Plan

Biodiversity is an important issue in waterway management and British Waterways are currently developing a Biodiversity Action Plan (BAP) to help maximise this biodiversity for the future. The draft BAP, released in spring 1999, is based on Government guidelines and covers every habitat and species of importance on the waterway network. British Waterways are lead partners in the Governments UK Plan for some of the rarities.

## 5.4 EFFECTS OF THE EXISTING TRANSPORTATION NETWORK ON NATURE

Effects of the transportation network on nature are either direct or indirect (Table 5.1).

Table 5.1: Direct and indirect effects of infrastructure on habitats

EFFECTS	CONSEQUENCES
Total area of habitat is reduced	<ul style="list-style-type: none"> <li>▪ Population size is reduced</li> <li>▪ Higher risk of extinction due to chance events (e.g. weather, disease, predation) or direct human intervention (e.g. agricultural development, deforestation)</li> <li>▪ Higher risk of extinction due to inbreeding</li> </ul>
Remaining habitat is broken up into isolated remnants	<ul style="list-style-type: none"> <li>▪ Reduced connectivity between fragments i.e. increased isolation</li> <li>▪ Reduced immigration rate</li> <li>▪ Reduced chance of re-colonisation following local extinction</li> </ul>
Ratio of the edge to interior habitat increases	<ul style="list-style-type: none"> <li>▪ Increased predation</li> <li>▪ Reduction in 'core' habitat due to changes in species composition at the patch edge</li> </ul>

Source: Reynolds, 1999

Direct effects relate to the barrier that is created in the existing landscape, which causes a subsequent loss of land and/or existing habitat. The barrier effect leads to a change in the composition of the surrounding habitat, and the proportion of edge habitat increases. Indirect effects include the likely increase in wildlife road casualties, particularly amongst territorial animals such as badgers, breeding amphibians and aerial species such as birds and bats. Other indirect impacts include a change in surrounding land use and an overall negative impact on species dispersal and breeding. Local populations may become more vulnerable to extinction due to insufficient habitat area, low population numbers and increased effects from natural population fluctuations. Overall there is often a localised loss of biodiversity, especially in habitats which are more vulnerable to fragmentation e.g. ancient woodlands, with subsequent detrimental effects on wildlife and habitat of designated and protected sites (e.g. SSSIs, SACs, SPAs). Associated indirect impacts include pollution, noise and hydrological changes which may in turn cause habitat degradation, and disturbance.

The net outcome of transportation network development is that populations of plants and animals living in small isolated patches of habitat are more likely to become extinct than those living in larger, well-connected patches. The demise of many plant and animal populations is likely to reflect the adverse effects of habitat fragmentation. Table 5.2 outlines the species and habitats that have been identified during the Biodiversity Action Plan process (see section 4.4.2.3) as being affected either directly, or indirectly by habitat fragmentation.

Table 5.2: BAP species and habitats affected by habitat fragmentation

SPECIES	CURRENT FACTORS CAUSING LOSS OR DECLINE
Natterjack toad ( <i>Bufo calamita</i> )	<ul style="list-style-type: none"> <li>Loss of habitat due to housing and industrial development, agriculture and reduced grazing on heathlands</li> <li>Fixation of dune systems and prevention of tidal inundation through the creation of sea defence mechanisms.</li> <li>Habitat fragmentation, leading to genetic isolation of populations.</li> <li>Acidification and loss of breeding pools.</li> </ul>
Hornet robberfly ( <i>Asilus crabroniformis</i> )	<ul style="list-style-type: none"> <li>Loss of unimproved grassland and heath leading to habitat fragmentation.</li> <li>Use of persistent parasite treatments for stock (e.g. ivermectins) which kill dung beetle hosts.</li> <li>Changes in stock management.</li> </ul>
Dormouse ( <i>Muscardinus avellanarius</i> )	<ul style="list-style-type: none"> <li>Changes in woodland management practice, notably cessation of hazel coppicing and stock incursion into woodland.</li> <li>Fragmentation of woodland, leaving isolated, non-viable populations. (Short distances, possibly as little as 100m, form absolute barriers to dispersal, unless arboreal routes are available).</li> </ul>
Violet click beetle ( <i>Limoniscus violaceus</i> )	<ul style="list-style-type: none"> <li>Lack of suitable ancient trees at the current sites leading to habitat fragmentation due to the age-structure of the tree population.</li> </ul>
Water vole ( <i>Arvicola terrestris</i> )	<ul style="list-style-type: none"> <li>Loss and fragmentation of habitats.</li> <li>Disturbance of riparian habitats.</li> <li>Predation by mink.</li> <li>Pollution of watercourses and poisoning by rodenticides.</li> </ul>
Silver spotted skipper butterfly ( <i>Hesperia comma</i> )	<ul style="list-style-type: none"> <li>Insufficient grazing by stock and rabbits.</li> <li>Loss of unimproved calcareous grasslands and fragmentation of remaining habitats.</li> </ul>

Narrow-headed ant ( <i>Formica exsecta</i> )	<ul style="list-style-type: none"> <li>▪ The loss of suitable heathland due to destruction and inappropriate management, for example through agriculture and urban development, inappropriate afforestation, untimely and extensive fires, and encroachment by scrub, trees and bracken leading to shading out of nests and subsequent encouragement of competitive species of ant at sites in England.</li> <li>▪ Loss of natural and semi-natural habitats in Scotland, e.g. Caledonian Pine Forest, and the intensive management of moorland for game birds and red deer.</li> <li>▪ Motorcycle scrambling at Bovey Heathfield in England</li> <li>▪ Excessive grazing and inadequate browsing by inappropriate species of ponies in the New Forest, and the production of dense, single age heather (<i>Calluna vulgaris</i>) monoculture with reduced marginal scrub between heath and woodland.</li> <li>▪ Nutrient enrichment of soils and development of grass swath.</li> <li>▪ Habitat fragmentation leading to potential inbreeding and loss of genetic fitness in isolated populations.</li> </ul>
Marsh fritillary ( <i>Eurodryas aurinia</i> )	<ul style="list-style-type: none"> <li>▪ Agricultural improvement of marshy and chalk/limestone grasslands.</li> <li>▪ Afforestation and development of habitats.</li> <li>▪ Changes in grazing stock and practice.</li> <li>▪ Increasing fragmentation and isolation of habitats.</li> </ul>
Red squirrel ( <i>Sciurus vulgaris</i> )	<ul style="list-style-type: none"> <li>▪ Spread of grey squirrels.</li> <li>▪ Habitat fragmentation making some areas less suitable for red squirrels, increasing their vulnerability to displacement by grey squirrels.</li> <li>▪ Disease.</li> </ul>

HABITAT	CURRENT FACTORS CAUSING LOSS OR DECLINE
Upland hay meadows	<ul style="list-style-type: none"> <li>▪ The factors currently affecting upland hay meadows reduce the quality and decrease the quantity of the habitat, and its fragmentation brings increased risk of species extinctions in the small remnant areas. The main factors are:</li> <li>▪ Agricultural improvement through ploughing, drainage, re-seeding, inorganic fertiliser treatment and slurry application.</li> <li>▪ A general shift from hay-making to silage production, with more frequent and often earlier annual cutting, as a result of a decline in the perceived value of hay in intensive modern farming regimes and the reduced reliance on good weather.</li> <li>▪ Changes in management from hay meadow to grazing pasture, particularly on the less accessible sites.</li> <li>▪ Increased grazing intensity and duration, particularly in spring.</li> <li>▪ Increased supplementary stock feeding associated with higher grazing levels leading to enhanced nutrient loadings and localised poaching.</li> <li>▪ Increased eutrophication as a result of too frequent application of farmyard manure.</li> <li>▪ Agricultural and other management neglect leading to rank over-growth.</li> <li>▪ Application of herbicides and other pesticides.</li> <li>▪ Atmospheric pollution and climate change, the influence of which is not fully assessed.</li> </ul>
Lowland calcareous grassland	<ul style="list-style-type: none"> <li>▪ The factors currently affecting calcareous grassland reduce the quality and quantity of the habitat, and its fragmentation brings increased risk of species extinctions in the small remnant areas. For example a survey of the Lincolnshire Wolds found that 66% of sites were less than 1 ha in size and none was more than 10 ha in size. The factors include:</li> <li>▪ Agricultural intensification by use of fertilisers, herbicides and other pesticides, re-seeding or ploughing for arable crops.</li> <li>▪ Farm specialisation towards arable cropping has reduced the availability of livestock in many lowland areas. The result is the increasing dominance of coarse grasses such as tor grass <i>Brachypodium pinnatum</i> and false oat grass <i>Arrhenatherum elatius</i> and invasion by scrub and woodland, leading to losses of calcareous grassland flora and fauna.</li> <li>▪ Over-grazing is a less widespread problem, and is sometimes associated with supplementary feeding, which can also cause localised sward damage, due to trampling and long-term nutrient enrichment.</li> <li>▪ Development activities such as mineral and rock extraction, road building, housing and landfill.</li> </ul>

Lowland calcareous grassland cont'd	<ul style="list-style-type: none"> <li>▪ Localised afforestation with hardwoods and softwoods.</li> <li>▪ Recreational pressure bringing about floristic changes associated with soil compaction at some key sites.</li> <li>▪ Invasion by non-native plants, including bird-sown <i>Cotoneaster</i> species, causes problems by smothering calcareous grassland communities at some sites.</li> <li>▪ Atmospheric pollution and climate change, the influence of which is not fully assessed.</li> </ul>
Lowland meadows	<ul style="list-style-type: none"> <li>▪ The factors currently affecting lowland meadows reduce the quality and decrease the quantity of the habitat, and its fragmentation brings increased risk of species extinctions in the small remnant areas.</li> <li>▪ Agricultural improvement through, drainage, ploughing, re-seeding, fertiliser treatment, slurry application, conversion to arable and a shift from haymaking to silage production.</li> <li>▪ Decline in the perceived agricultural value of species-rich pasture and hay in farming regimes.</li> <li>▪ Abandonment leading to rank over-growth, and bracken (<i>Pteridium aquilinum</i>) and scrub encroachment.</li> <li>▪ Supplementary stock feeding, associated with increased stocking levels, which can lead to eutrophication as well as localised poaching.</li> <li>▪ Application of herbicides and other pesticides.</li> <li>▪ Atmospheric pollution and climate change, the influence of which is not fully assessed.</li> <li>▪ Reduced inundation frequency and duration, in water-meadows and floodplain grasslands associated with abandoned irrigation schemes, and lowered water tables as a result of land drainage, flood alleviation engineering, surface and ground water abstraction, floodplain gravel extraction and other activities.</li> <li>▪ Floristic impoverishment due to heavy grazing pressure and changes in stock species and breeds.</li> </ul>
Lowland dry acid grassland	<ul style="list-style-type: none"> <li>▪ The factors currently affecting acid grassland reduce the quality and quantity of acid grassland. The fragmentation of the habitat brings increased risk of species extinctions in the small remnant areas. The factors include:</li> <li>▪ Agricultural intensification by use of fertilisers, herbicides and other pesticide, liming, re-seeding or ploughing for arable crops.</li> <li>▪ Agricultural and other management neglect leading to rank over-growth, and bracken <i>Pteridium aquilinum</i> and scrub encroachment.</li> <li>▪ Over-grazing is a more localised problem, and is sometimes associated with supplementary feeding which can cause localised sward damage.</li> <li>▪ Afforestation particularly with softwoods on light sandy soils.</li> <li>▪ Development activities such as mineral and rock extraction, road building, housing and landfill.</li> <li>▪ Atmospheric pollution and climate change, the influence of which is not fully assessed.</li> </ul>

Source: UK Biodiversity Group Action Plans

In terms of road development, the Design Manual for Roads and Bridges recognises the following possible effects on nature conservation:

- Direct loss of habitat.
- Opportunities for creating wildlife habitats on former areas of low nature conservation interest, such as intensive arable.
- Drainage impact on adjacent land.
- Pollution and leachate from road construction materials affecting adjacent land.
- Severance and fragmentation of habitats, animal populations and animal territories.
- Changes in the management of vegetation, as a result of severance and access difficulties.

- Disturbance of wildlife during construction.
- Changes in the microclimate of adjacent areas, as a result of viaduct or embankment construction, for example.

The significance of severance or disturbance caused by any one road is dependent on the alignment of the road, the particular plant and animal populations affected and the indirect effects that it causes, resulting in habitat change (Sowler, 1999, pers.comm). Effects can be magnified where a number of roads exist in close proximity.

In 1990 the Wildlife Trusts (RSNC as was) produced a series of reports (Head-on-Collision Reports) looking into the impact of the road building programme on wildlife habitats. The reports carried out an appraisal of all the road schemes that threatened the valuable landscapes and wildlife habitats of the UK. Specifically the studies recorded the linear distance of planned roads which would impact on known areas of natural or semi-natural habitat. Although this approach represented one of the first attempts at quantifying the area of habitat affected by road developments, the criteria used were somewhat limited and the methodology has not been approved by the independent roads review board. The Head-on-Collision Report for Southeast England (RSNC, 1990) provided the first indication of the potentially serious impact of the roads programme on wildlife resources. The report identified 372 important wildlife sites threatened by road building in nine counties (Berkshire, Buckinghamshire, East Sussex, Essex, Hampshire, Hertfordshire, Kent, Surrey and West Sussex). Of the 372 sites, 50 were designated SSSIs, and more than 140 were ancient woodlands. Since this first report, the Wildlife Trusts have set about extending their study to produce similar statistics for the rest of the UK. Reports have subsequently been produced for every region of the UK. The report for Scotland (Scottish Wildlife Trust, 1996) showed that 92 schemes would have a direct impact on wildlife habitats, with 254 km of these roads dissecting natural and semi-natural areas. The schemes were also calculated to have an impact on 101 designated areas.

Together, roads, railways and waterways and the land either side of them may provide corridors for biological interchange between different types of environment and may help to interlink landscapes. They may contribute to either a reduction or improvement in diversity depending on the following factors:

- characteristics of structures;
- types of landscape and biotope in which they occur;
- nature of living species or communities affected;
- geometric characteristics (natural ground level, cutting or embankment affecting light, humidity and wind conditions);
- geological and soil characteristics of sites;
- layout and maintenance of verge areas;
- level of complexity of landscapes crossed (small or large grid, mosaic of sub-units, open or closed); and
- type of ecosystems involved and groups inhabiting them.

### 5.4.1 Habitat loss

In the UK, as in many of the heavily modified landscapes of European countries, there is widespread acceptance that natural and semi-natural habitats (and their associated species) have declined considerably in the last fifty years (NCC, 1984) (see section 4.3 on the results of the Countryside Survey). In 1984 the former Nature Conservancy Council estimated the loss of British habitats since 1945 as follows:

- Ancient Woodland: 30 - 50% loss
- Flower-rich meadows: 95% loss
- Lowland grassland on chalk and limestone: 80% loss or significant damage
- Limestone pavements in Northern England: 45% badly damaged or destroyed
- Fens and coastal marshes: 50% loss or significant damage
- Lowland raised bogs: only 6% now left in original state
- Upland grasslands, heaths and blanket bogs: 30% loss or significant damage

In lowland Britain, deforestation, originally largely connected with land clearance for agriculture, was extensive as long ago as the 14th Century. By 1350, woodland was thought to have covered only about 10% of the area of England (Rackham, 1986). In Cambridgeshire, with the exception of conifer plantations, approximately 50% of woodland exists in patches of 10 ha or less; woodlands larger than 100 ha comprise only about 10% of the county's tree cover. Thus much of the avifauna of Britain's broadleaved woodlands now lives in a network of scattered, and often small, habitat patches. Lowland heath is a scarce habitat which supports a wide range of rare plants and animals. In England only one sixth of the heathland present in 1800 now remains. Fragmentation and disturbance from developments such as housing and road construction are some of the factors affecting the habitat at present.

Kirby and Thomas (1994) recognise the change in the extent of valued habitats has been caused primarily by changes in agricultural and forestry practices, but that other types of development including new roads and railways have played a part. Infrastructure developments may be a relatively minor (although not insignificant) cause of direct habitat loss but their linear nature makes them a more serious problem in terms of habitat fragmentation. Natural landscapes are a mosaic of patches of different types and sizes. Few species can use all the patches in a landscape so their survival depends on an ability to move from one patch to another. The heavily modified cultural landscapes that characterise the UK are similarly patchy, but the contrasts between one patch and its neighbour are generally greater than in natural systems. Different species use landscapes at different scales. As well as the reduction in the total extent of different habitats, the size of the surviving patches may be less and the intervening land may present potential problems or dangers to species movement (Dawson, 1994). Such habitat fragmentation can effect species survival over and above the impact of direct habitat loss.

Concerns over habitat loss are most frequently raised where statutory protected sites are involved. The Government's wildlife agencies say that over 300 SSSIs are damaged each year, most of them according to the National Audit Office, quite legally (NAO, 1994). Between 1991 and 1996 one in five SSSIs in England and Wales were damaged and 45% of English SSSIs were found to be in an 'unfavourable condition'. However, the contribution of transport infrastructure development to this decline is unclear. Very few

studies have specifically sought to quantify the areas of habitat that are lost directly to infrastructure development. This is largely due to the problems involved in obtaining consistent historical data. An exception to this is a project recently initiated by Scottish Natural Heritage, which aims to examine the potential fragmentation effect of roads and railways on peatlands, one of the country's most sensitive habitats. Scotland's peatlands are mostly bogs (blanket and raised) which have highly specialised plant and animal communities. Scotland contains 70% of Great Britain's peat bogs. As well as being unique geological features, peat bogs also provide important records of environmental change and act as valuable sinks for atmospheric carbon dioxide. Both blanket and raised bogs are noted to be priorities for nature conservation under the 1992 EC Habitats Directive, and Scotland's peat bogs are of international importance due to their rarity elsewhere in Europe. Of 27,840 hectares of raised bog which once existed, only 8.4% still remains in a near-natural state, following agricultural drainage, afforestation, peat extraction and other development. It is accepted that road building can upset the balance of peatland species by altering the bog's water regime or increasing the nutrients entering the system. Although still in a very early stage, the study has produced some interesting results, shown by the summary statistics in Table 5.3 and in Figure 5.7.

Table 5.3: Loss of peatlands in Scotland due to transport infrastructure

LAND COVER CLASS		UNADJUSTED AREA OF PATCHES DISSECTED BY ROADS AND RAIL (KM <sup>2</sup> )	POSSIBLE EXTENT OF LAND COVER OF INTEREST DISSECTED	LENGTH OF ROAD AND RAIL DISSECTING LAND COVER FEATURE (KM)
Blanket bog and other peatland	Core	2,485	2,485	574
	Primary	988	592.8	393
	Secondary	4,209	1683.6	1,430
	TOTAL	7,682	4761.4	2397
Wetlands	Core	43	43	84
	Primary	2	1.2	5
	Secondary	52	20.8	77
	TOTAL	97	65	166
Saltmarsh	Core	19	19	17
	Primary	0.3	0.18	0.7
	Secondary	0.4	0.16	0.6
	TOTAL	20	19.34	18.3
<b>TOTAL (All Classes)</b>			<b>4845.74</b>	<b>2581.3</b>

Source: Scottish Natural Heritage (2000)

The SNH work proves that given a suitable database of information, it is possible to make estimates of habitat loss attributable to specific development types.



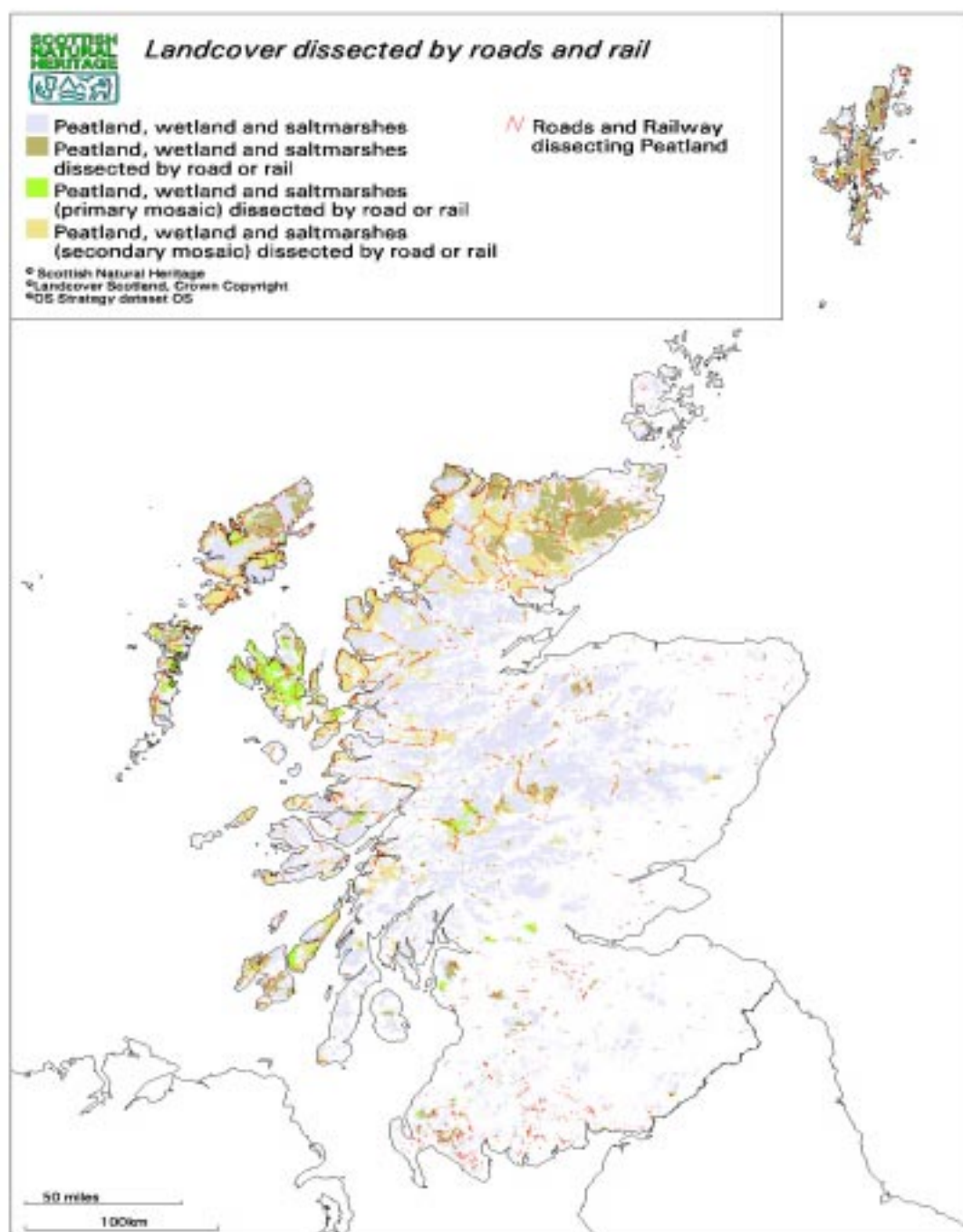


Figure 5.7: Peatlands affected by road and rail infrastructure

Note: The analysis was based on: Land cover of Scotland 1:25, 000 and Ordnance Survey Strategic Dataset 1:25, 000.

Core = patches of land cover that do not occur as a mosaic

Primary = patches in which the land cover class of interest is the dominant component

Secondary = patches in which the land cover class of interest is the secondary component

Source: Scottish Natural Heritage, 2000.

### 5.4.2 Corridor function

The corridors debate has stimulated considerable coverage in the nature conservation literature (e.g. Simberloff and Cox, 1987; Harris and Gallagher, 1989). Despite this, a striking feature is the paucity of literature on the management of road corridors for conservation purposes. Best practice in terms of management techniques for corridors is open to much discussion due to the diversity of ideas which exist on their value, and the great variety of communities from which they are formed. Corridor management it seems is reliant on experience rather than science (Loney and Hobbs, 1991). A report by Saunders and Hobbs (1991), on a conference organised by the Australian Roadside Conservation Committee (RCC) (1989), provides a wealth of information on the management of roadside verges as corridors. Although the roadside verge environment in Australia is certainly very different to that in the UK, the advanced status of research there provides a valuable insight into the principles that need to be considered for road verge management elsewhere.

The primary value of corridors is that they have the potential to maintain and enhance connectivity between habitats and species, thus facilitating the maintenance of biological diversity. This value stems from the variety of different roles that verges have in the landscape including (Loney and Hobbs, 1991):

- their use by wildlife (animals and plants) for movement;
- their use by wildlife for habitat;
- as functional landscape units which reduce wind and water erosion and provide shelter; and
- for aesthetic purposes to provide interest to the traveller.

As well as these benefits, the negative aspects of corridors have also been highlighted. In this respect they act as barriers and sinks, they channel species so as to increase the risk of mortality, and they serve as conduits for exotic species (weeds, animal pests and disease) (Loney and Hobbs, 1991). Existing research in the UK, outlines the following criteria as being most important to corridor function:

- the wildlife corridor should be as continuous as possible to ensure the survival of those species with little ability to cross inhospitable areas;
- a corridor needs to be as wide as possible to maximise habitat area and to minimise the risk of being degraded by events such as fire and predation;
- a corridor will have the most benefit for the widest range of wildlife if it is predominantly composed of semi-natural habitats;
- a corridor should be as diverse in vegetation composition and age structure as possible, so that there is a wide range of potential users; and
- a corridor should act as a conduit for colonisation or recolonisation of sites, linking areas which are reservoirs of species.

Although there is a paucity of scientific information to support the corridor theory, the value of transportation corridors for wildlife is becoming more widely accepted. A commonly accepted ecological axiom is that isolated sites tend to support a smaller number of species than those with access to other sources of wildlife. The so-called 'island effect' is most readily visible in the urban environment in the form of unconnected areas of

greenspace. It is believed, however, that by linking green areas within cities to the surrounding countryside, thereby creating wildlife corridors, it is possible to reduce the 'island effect' since wildlife will be able to move along these channels and perhaps colonise new sites. Foxes, hedgehogs and kestrels are known to have already ventured into the urban environment. A greater variety of species will only be encouraged by increasing the number of green sites within the built-up areas, and by improving their quality and the degree of linkage between them. Developing an effective corridor network is of crucial importance in this respect.

In, particular the value of waterways as nature conservation corridors has been taken on board by many local planning authorities, who have developed comprehensive 'corridor' studies. The development of the Corridor Study concept has been born out of a real need to find a framework within which the competing interests of engineering management, tourism development, heritage, environment and commercial development can co-exist and thrive. It has been recognised that canal Corridor Studies can act as catalysts bringing positive change, benefiting business and employment, leisure and recreation, conservation and landscape management, often in partnership with local authorities and the private sector. Some examples of such studies are outlined below.

#### *5.4.2.1. Milton Keynes Wildlife Corridor Project*

Initiated in 1994 after the concept of wildlife corridors was included in the Milton Keynes Borough Council Local Plan, the aims of the project were to:

- Identify and map a network of wildlife corridors which link sites of importance for nature conservation. The wildlife corridors were classified as 'local' (of a single habitat type e.g. hedgerow, path verges) and 'major/regional' (larger corridors containing a variety of semi-natural habitats e.g. disused railways, canals, rivers etc); and
- Produce management guidelines for the wildlife corridors identified and develop planning guidelines to help protect and conserve the most important habitats and corridors.

In total 18 Wildlife Corridors were selected for designation by Milton Keynes Borough Council (Milton Keynes Borough Council, 1996). These included major railway and motorway corridors, local roads, the Grand Union Canal, the River Ouse and green lanes and disused railways. Each site was subjected to a detailed survey, the results of which were mapped and analysed using GIS technology. Priorities for the project included the development of specific management plans for each corridor, habitat enhancement/creation schemes to close corridor 'gaps', community involvement and more detailed wildlife surveying and monitoring. The outcomes were visual profiles of each corridor which proved to be useful planning and management tools.

#### *5.4.2.2. Tyne and Wear nature conservation strategy*

The Tyne and Wear nature conservation strategy is based on a countywide strategy map which identifies important wildlife sites, and the network of wildlife corridors which connect urban areas to the surrounding countryside. It is intended that by providing a clear

strategic map, decisions on land-use affecting individual sites can be easily related to the wildlife corridor framework. The map recognises three types of wildlife corridor:

- Strategic wildlife corridor: open-space corridors of particular interest on a countywide basis. They are the longest of the wildlife corridors and they indicate the major open passageways between and into the urban areas.
- Local wildlife corridor: a more localised network linking rural and urban areas within and between each district. They consist mainly of urban greenspace together with important wildlife sites.
- Wildlife links: these are narrower than local wildlife corridors but in many cases longer as they include many man-made linear features such as railway embankments, disused waggonways, road verges, pathways, and natural features such as streams. These help form an intricate web for the movement of wildlife and people throughout the county.

Though varying in length and size, the three types of corridor nevertheless carry out the same function, namely providing food and shelter for wildlife and enabling plants and animals to move along them, and throughout the county as a whole. Since the introduction of the UK BAP process, the Tyne and Wear nature conservation strategy (NCC, 1988) has been strengthened through the production of a Local BAP entitled 'The Gosforth Park to Cramlington Wildlife Corridor'. This provides specific species and habitat targets which aim to enhance the overall nature conservation value of this important wildlife corridor.

#### *5.4.2.3. Coventry Canal Corridor Study*

The Coventry Canal Corridor Study was carried out in partnership with Coventry City Council. It looked at all aspects of this predominantly urban waterway and identified opportunities for landscape improvement, urban regeneration, community benefit and leisure and tourism. The study was adopted as Supplementary Planning Guidance as part of the City's Urban Development Plan. A number of successful initiatives have followed, attracting funding from central government and the European Community. These include the creation of a Groundwork Trust in Coventry, initially with a canal focus, a successful Arts Lottery bid for a major canal-side public art project, and a series of boundary improvements and 'pocket parks' within the canal corridor implemented by Groundwork.

#### *5.4.2.4. Selby Canal Landscape and Environmental Enhancement Project*

The scheme, completed in 1998, has transformed a featureless stretch of urban waterside into an attractive linear landscape. It was just one of a number of similar initiatives on the Selby Canal which were originally identified in the Selby Canal Corridor Study (1994). These proposals have attracted grant funding and Landfill Tax contributions.

Many other similar corridor studies have been implemented by local authorities throughout the UK. A common conclusion drawn by all is that co-operation on the creation, improvement and management of sites which run through areas of land under different ownership is essential if the corridor network is to be continuous and effective. This is also true of corridors which cross district and county boundaries since wildlife have no concept of map boundaries on the ground. In all cases co-operation between the various

landowners and local authorities is crucial to avoid disjointed corridors and to ensure that the corridor network is effective.

### 5.4.3 Disturbance

Disturbance and avoidance zones manifest themselves in several ways and can extend outward from a road for hundreds of metres. The work on breeding birds in the Netherlands, correlating traffic density and bird density, guides thinking on the subject. Vehicle generated noise is considered to be the main factor leading to the disturbance effect (Reijnen and Veenbaas, 1997; Reijnen *et al.*, 1995). Despite the paucity of data in the UK, birds remain the best studied group of species with regards to disturbance effects and impacts. It is important to distinguish between ‘effect’ and ‘impact’ because the two terms are often used interchangeably (Ecoscope, 1999). An effect occurs where birds are displaced for a period of time or permanently to another habitat. An impact can only be said to occur where it causes a direct reduction (or increase) in the population of a species. Because the latter is very difficult to study, disturbance ‘effect’ is normally the feature considered. Gradients of response by birds to disturbance can be identified, depending on the intensity, frequency and duration of the disturbance. In general birds appear to habituate to continual noises so long as there is no large amplitude ‘startling’ component. Vehicles and vehicle-movements are tolerated much better than people at the source of disturbance. Studies have shown that disturbance caused by the presence of people can have a considerable negative effect on breeding success, mainly due to nest abandonment and increased predation of eggs and young. Disturbance may also prevent pairs from breeding and effect the choice of future nest-sites. It is particularly interesting to note that in the UK many of the SSSIs controlled by the Ministry of Defence and used as training areas and artillery ranges, support diverse breeding bird populations, suggesting the disturbance effect is not significant.

Disturbance caused by development (whether during construction or operation) varies considerably depending on the construction programme, use of heavy plant, presence of site operators and irregularity in the generation of dust and noise. Disturbance caused by roads is related to traffic volume, layout of the road, carriageway size and hence scale, and adjacent habitat types (which will attract different species). In general larger bird species, those higher up the food chain, or those which feed in flocks in the open, tend to be more vulnerable to disturbance than small birds living in structurally complex or ‘closed’ habitats such as woodland. However, it is difficult to generalise. In estimating the severity and likely impact of disturbance to birds, the following factors should be taken into account:

- intensity of disturbance;
- duration and frequency (continuous, infrequent, regular, variable);
- proximity of source;
- seasonal variation in sensitivity of affected species;
- presence of people associated with source;
- whether birds move away, but return after disturbance ceases;
- whether regional numbers are affected;
- whether there are alternative habitats available nearby; and
- whether rare, scarce or especially shy species are affected.

It is especially difficult to determine whether disturbance is causing temporary displacement of birds, or having impacts on populations which are of importance for conservation. Although no strategic research has been conducted regarding the disturbance thresholds of birds in relation to road building and operation, Ecoscope (1999) make some generalisations about those species or groups of species most likely to be affected. In general it is those species (not only restricted to birds) with the following attributes that are most vulnerable to disturbance and development impacts (Hill *et al.*, 1997):

- large species;
- long-lived species;
- species with relatively low reproductive rates;
- habitat specialists;
- species living in open (e.g. wetland) rather than closed (e.g. forest) habitats;
- rare species;
- species using traditional sites; and
- species whose populations are concentrated in a few key areas.

Few studies have specifically investigated the biological basis for disturbance impacts of roads and any wildlife group. However, understanding how roads and other infrastructure networks affect the ecology of a species, and the extent of the effect in terms of distance from the source of the disturbance, is vitally important. This holds true for both site-specific and strategic environmental impact assessment.

In the UK over the past few years there have also been a number of studies which have either reported impacts of lighting on birds or which have reviewed the types of impacts that might occur. Most of the evidence has focused on seabirds being disoriented by bright moon-lit skies on migration. In parallel there has been an increased interest in the impacts of road lighting on terrestrial and wetland birds, especially where roads pass through important habitat or are adjacent to sites of conservation importance on the basis of their bird populations. Notable species which are impacted upon include the nightjar (*Caprimulgus europaeus*) and the owl families (i.e. nocturnal species). However, there has been little strategic or site-specific research into the issue. Road lighting reduces night time traffic accidents, but it can have a substantial impact on wildlife. The extent of knowledge concerning the effects of road lighting on flora and fauna is limited and consequentially the extent of mitigation measures proposed for road schemes is also minimal (Markham, 1996). Artificial lighting has conflicting effects on different species of fauna and flora. On one hand it can provide a valuable deterrent to deer and a readily accessible insect food supply to bats, but on the other hand it can disrupt growth regulation in plants (Campbell, 1990), breeding and behaviour patterns in birds (Lofts and Merton, 1968) and cause declines in moth populations (Frank, 1990). It is therefore possible that mitigation measures will also have conflicting effects on different species. From the studies that have been carried out, the following basic principles for reducing the impact of road lighting are suggested:

- avoid lighting on roads crossing natural areas; and
- use methods of lighting which are less alluring, especially for insects.

The Design Manual for Roads and Bridges recognises that roads illuminated by some types of street lights are frequently used as feeding sites by several species of bats. White

(mercury vapour) street lamps apparently attract more insects, and therefore more bats, than orange, low- pressure sodium lamps, since they emit ultra- violet light. High- pressure sodium lamps include some mercury vapour and emit some UV, and are thus intermediate in their attractiveness to bats. Street lights generating ultra- violet light attract insects and hence provide a valuable and predictable food source for aerial-hawking species, such as pipistrelles (*Pipistrellus pipistrellus*). Furthermore, lit roads can constitute linear landscape elements which bats may use to navigate in open areas.

#### 5.4.4 Fauna casualties

For animals that are able to cross road and railway lines, the traffic encountered may lead to their deaths and overall, the diminution of their populations (Thomas *et al.*, 2000, Slater, 1996; and Hopkinson *et al.*, 1990). For particularly busy roads or railway lines then this toll will in effect have similar consequences to that of the barrier effect (see Section 5.4.5). There have been varying estimates of the number of animals killed by motor vehicles in the UK, although there seems little, if any, data for railways. As wildlife casualties are rarely reported, such estimates must constitute only a percentage of the quantifiable damage inflicted on British wildlife. Hopkinson *et al.*, (1990) state ‘the impact of these fatalities is under-researched although in certain areas the impact on a population could be significant’. The clearest observations relate to birds, large mammals and amphibians, which are discussed in turn below.

##### 5.4.4.1. Birds

In 1985, 600 miles of road were monitored for birds killed by traffic. These results were added to earlier surveys, which included one carried out by the British Trust for Ornithology in 1960. It was estimated that between 30 and 70 million birds are killed each year on British roads (Harwood, Hilbourne, *et al.*, 1992). The very wide range is a consequence of the small percentage of the road network, some 0.3%, analysed (Orton, 1986). Other studies have suggested that bird carcass counts may underestimate the actual number of deaths by a factor of twelve, as many birds are thrown into hedges, nearby fields or preyed on by scavengers. The house sparrow (*Passer domesticus*) suffered losses of between 9 and 21 million deaths which is equivalent to three times the total population at the beginning of each year. Some 8.4 to 17.7 million blackbird (*Turdus merula*) were also estimated as lost annually, with collisions with vehicles being cited as one of the most frequent causes of death amongst house sparrow and blackbird fledgelings (Orton, 1986). Birds of prey suffer too. It has been estimated that 5,000 barn owls (*Tyto alba*) are killed on British roads each year (Doar, 1992) with the percentage of this species killed by motor vehicles increasing from 6% between 1910 and 1954 to 15% between 1955 and 1969 and to 52% by 1987 (Shawyer, 1987). The opening of new motorways and bypasses has been cited as a cause of higher levels of fatalities, although within 10 years overall fatalities are reported to drop markedly as local population are depleted (Shawyer, 1987). In a study undertaken of wildlife road casualties along a 25 mile section of the A303 in Somerset, undertaken by The Hawk and Owl Trust, 110 barn owl mortalities were recorded in an 18 month period (Shawyers, pers. Comm.) With the UK population estimated to consist of only 4,000 breeding pairs (Mead, 1999), the barn owl is of particular conservation concern. Interestingly, the type of road and even the volume of traffic does not appear to influence the number of birds killed. Instead the type of habitat adjacent to the road is the controlling

factor. Thus roads with hedgerows have a high number of bird deaths on them, followed by roads bordered by gardens. Wooded and tree-lined roads also have high bird death rates (Orton, 1986).

#### 5.4.4.2. Badgers (*Meles meles*)

Adult badgers have no natural predators in Britain. Although the UK badger population can be described as ‘approximately stable’ there is evidence that in certain areas numbers have declined through a combination of habitat change and loss, illegal persecution and road traffic mortality. Neal and Cheeseman (1996) suggest that at least 37,500 badgers are killed on the roads each year, while Clarke *et al.*, (1998) contend that this figure might be as high as 50,000, which is the equivalent of one badger from each family group (Harris, 1989). In addition, for every lactating sow killed there may be further mortalities of dependent cubs underground. This potentially poses a serious threat to the badgers breeding population (Secrett and Cliff Hodges, 1986). However, the badger population is currently increasing in many parts of the UK, particularly the south-west (Philip Clarke *et al.*, (1998), and the number of casualties appears to be a sustainable loss. However, it is likely that road traffic mortality may be important at both the local and metapopulation level in determining badger population viability in areas where badgers are at moderate to low density. Seasonal patterns of road mortality have also been identified, with peaks occurring as a result of variations in badger activity, during spring, mid-summer and autumn. The most obvious peak, during spring, is due to a general increase in activity and range expansion by sexually active males. The majority of badger casualties occur on the older road network, but unprotected new roads (especially widened existing roads) which sever badger territories can however be devastating to a social group. There is no research on the isolation of badger populations by larger roads, or whether there are any genetic implications.

#### 5.4.4.3. Otters (*Lutra lutra*)

The recent increase in the size of the otter population has led to a sharp rise in otter casualties. New road schemes and improvements to existing roads and railways which do not take the needs of otters into account in their design and construction could seriously affect the successful re-colonisation of some areas, as well as adversely affecting existing populations. The problem of casualties amongst otter populations has been targeted in both the Biodiversity Steering Group’s Action Plans (Biodiversity: The UK Steering Group Report, 1995) and the Joint Nature Conservation Committee’s document ‘A Framework for Otter Conservation in the UK: 1995-2000’ (JNCC, 1996) as requiring immediate attention. As a result of these reports, Government policy is to reduce and, where possible, eliminate possible threats to otter populations. Careful design of road, railway and waterway schemes can assist in the implementation of this policy.

An adult otter, like the badger, has no natural predators in Britain. Although capable of living in excess of 10 years in captivity, the average life expectancy of a wild otter is thought to be just over 3 years (Kruuk and Conroy, 1987). A large percentage of otters die as a result, directly or indirectly, of man’s activities. Of these, an average of 60% of recorded deaths in the UK are road casualties, although this varies geographically e.g. increasing to 86% in Scotland (Green and Green, 1987). Over 180 animals have been



killed in South West England alone since 1986. It is important to note that this may only be the tip of the iceberg, for many casualties are never recorded and some carcasses may never be found. This number may seem small but should be considered in light of an estimated population of 350 otters in England in the 1980s (Harris *et al.*, 1995). The otter is currently expanding to re-colonise parts of the country where it has not been seen in the last 30 years. It is in these areas that a single road casualty has the most impact, because the population has yet to become established and it may take many years for new animals to arrive. Seasonal peaks in mortality have also been identified, with the majority of animals being killed during November/December and March/April (Philcox *et al.*, 1999). These correspond with periods of high rainfall, when the rivers are in flood, and with the main period of otter activity coinciding with rush hour traffic.

#### 5.4.4.4. *Bats*

Bats are occasionally found dead on roadside verges, having apparently been swept into the path of traffic. A limited amount of work on this has been undertaken in Germany but no systematic records of bat road casualties are maintained in the UK. The numbers concerned are likely to be relatively small, and in general it would be expected that narrow country lanes (particularly with high hedges) would cause more bat mortality (per vehicle movement) than major roads, since a bat is more likely to be attracted there and is less likely to be able to escape from the path of traffic.

#### 5.4.4.5. *Amphibians*

Amphibian mortality is most obvious during breeding migrations in March when hundreds of individuals may be killed on a single night within a short stretch of road (Cooke, 1995). Up to 40% of breeding amphibians may be killed each Spring on roads, with the male population usually suffering higher casualties (Langton, 1989). There are thus particular implications for the construction of new roads close to the edges of breeding waters and where a large proportion of the population may attempt to cross or move along roads (Langton, 2000). Mitigation for amphibian mortality includes the use of a standard road warning sign depicting the silhouette of a common toad (approved for use on England and Wales in 1985). There are hundreds of locations in England and Wales that are registered as suitable for signs warning of seasonal amphibian mortality. These are placed as locations where hundreds or thousands of adult toads (and other amphibian species) may be killed each year. A register of these sites is maintained for the DETR by Froglife (a non-governmental conservation organisation).

#### 5.4.4.6. *Others*

Statistics for deer killed are not accurately collected, but estimates range from 20,000 to 42,000 per year, with accidents involving deer accounting for approximately 3 human casualties per year. Roads also account for the loss of 100,000 foxes (*Vulpes vulpes*) each year, which is the equivalent to the total number of mortalities from shooting and fox hunting (Pye-Smith, 1997). There are no data on smaller animal casualties, although hedgehogs and squirrels are also known to suffer large losses to road traffic (Ratcliffe, 1984). These estimates, coupled with the many fatalities that are unrecorded for many more species, suggest that animal mortality could run in to millions in the UK.

There is extremely little information concerning animal fatalities caused by railways. It can however, be assumed that lower casualty rates exist on railways for a number of reasons. First, the UK railway network has been established for much longer than the road network, with very little new rail infrastructure built recently. Thus a more mobile animal population have had time to adapt by changing, for example, foraging trails and territories. Second, the UK rail network is not as comprehensive as the road network and will therefore not affect as many animal communities. Finally, railways may be simply less threatening to wildlife because they are generally as narrow, or narrower, than roads and are therefore quicker to get across. Railway traffic on the busiest routes is also of a more intermittent frequency than on equivalent roads, thus reducing the chance of an animal being struck. However, a key problem with rail is that of rail electrification, especially when the electricity supply is through a ground level third rail. Thus when the Tonbridge to Hastings line was electrified in Kent in 1986, over 100 badgers were killed at their traditional crossing points within the first three months of operation. New rail infrastructure inevitably threatens wildlife, especially where the line is totally fenced.

Wildlife mortality as a result of vehicle collisions can contribute to the barrier effect of roads and railways (Reynolds, 1999). The risk of animal mortality due to collisions will depend on infrastructure characteristics, traffic density, habitat type, and time of the day. Assuming an animal gets as far as venturing onto the road surface the probability of successfully crossing to the other side is a function of animal crossing speed, road width and traffic density (Table 5.4).

Table 5.4: Risks involved for animals in crossing a road

ANIMAL GROUP	AVERAGE CROSSING SPEED (CM/SECOND)	RISK OF DEATH @ 500 VEHICLES/HOUR	RISK OF DEATH @ 1500 VEHICLES/HOUR
Spiders	12	c. 40%	c.100%
Beetles	18	c. 25%	c.75%
Amphibians	30	c.18%	c.45%
Mouse/vole	42	c.10%	c.35%

Source: Kaule and Reck, 1993 (Straben and Lebensraume, Institute for Land-Use Planning, University of Stuttgart)

To put the above traffic density figures in context, traffic flows of between 500 and 1000 vehicles per hour are typical for rural A-roads in the UK. From current knowledge, the basic principles for reducing animal mortality on roads are to:

- avoid crossing habitats which shelter large or sensitive populations;
- avoid intersecting migration routes;
- avoid deliberate or accidental creation of attractive areas forming part of the road corridor;
- prevent the crossing of the road by means of suitable fencing (noting that although fencing can provide some protection against casualties it needs to be combined with tunnels and bridges to allow animal movements); and
- create a layout which keeps animals away from vehicles.

The inclusion of mitigation measures on new and improved roads and the provision of mitigation on existing roads, wherever the opportunity or need arises, could make a major contribution to reducing the number of fauna casualties and the impact on populations as a whole. One priority though, is the need for more extensive and accurate data on the extent of the problem that is being mitigated against.

#### 5.4.4.7. *National Survey of Wildlife Road Casualties*

The impact of vehicles on wildlife is most conspicuous to the general public in the form of road casualties. The scale of the problem is illustrated by considering the case of foxes, where an estimated 100,000 become road casualties each year. This is the equivalent to the total number of mortalities from shooting and fox hunting combined. It is recognised that for rare and vulnerable species, such as the barn owl (*Tyto alba*), road casualties might have a significant impact on populations (The Mammal Society). In response to increasing concerns over the significance of fauna casualties for wider populations, the Mammal Society and The Hawk and Owl Trust are jointly co-ordinating a national survey of wildlife road casualties, which will run from June 2000 until May 2001. The aim is to identify factors which cause wildlife to fall victim to vehicles in high numbers along certain sections of road. The findings from this study will be used for designing appropriate road verge management prescriptions to minimise wildlife road casualties.

On the secondary road network, volunteers will be asked to record wildlife road casualties observed during everyday journeys. At each casualty, basic site information will be recorded including species, road cross-section, adjacent wildlife corridors (e.g. treelines, water courses, headlands, etc.), blind bends, road verge habitat, adjacent landuse, highway boundary features (e.g. hedge, fence, ditch) and road category. Due to safety concerns volunteers cannot be asked to record wildlife road casualties on motorways or major trunk roads. This responsibility will be delegated through the involvement of the Highways Agency and their route Managing Agents. It is proposed that fortnightly surveys of the HA network in three managing agent areas will be carried out by the agents over a period of a year.

#### 5.4.5 **Barrier effect**

All roads act as barriers or filters to the free movement of animals (Forman and Alexander, 1998) and can affect the dispersal of plants. They can stop the movement of some invertebrates altogether and, depending on the width, may stop the dispersal of mammals which closely follow lines of vegetation in the landscape. They can affect the movements of larger animals, such as badgers and otters within their territories and between areas of different habitats. Physical severance can also affect wildlife behaviour such as the movement pattern and feeding of waders and wildfowl on marshlands and in coastal areas (Sowler, per.comm.).

Road severance inhibits the movement of small mammals (Secrett and Cliff Hodges, 1986). For example small forest mammals are reluctant to venture on to road surfaces where the distance between the forest margins due to road severance exceeds 20 metres (Mader, 1984). This distance or barrier effect is more important than either traffic flows or

type of road surface (Secrett and Cliff Hodges, 1986). Mader (1984) suggested that the road barrier effect was due to a combination of five factors:

1. micro-climatic conditions at the edge of the road;
2. local emissions, noise, and increased salinity from salt application;
3. due to road verges being areas of environmental instability if they are periodically cut;
4. a different characteristic fauna and flora on the road verge as compared to local habitats; and
5. the danger of accidents and death from moving traffic.

Thus a four lane highway was found to be as effective a barrier to small mammal dispersal as a body of fresh water twice as wide (Secrett and Cliff Hodges, 1986). Studies of highly mobile forest dwelling species such as beetles and mice that resided within 50m of a road have shown that beetles rarely enter the road verge and hardly ever cross the road. For mice, even unused forest roads seem to constitute an unbreachable divide (Mader, 1984). Richardson *et al.*, (1997) appear to have undertaken the most recent detailed survey of the effects of roads on the movement of small mammals in the UK. They compared sites along a busy dual carriageway in Cambridgeshire with sites along a quiet paved test track in Bedfordshire. The dual carriageway was between 20-30m wide, while the test track was 25m wide. The research found that roads did appear to be significant barriers to field voles (*Microtus agrestis*), bank voles (*Clethrionomys glareolus*) and wood mice (*Apodemus sylvaticus*). Both road width and traffic density contributed to the barrier effect. Field and bank voles were recorded crossing the roads but crossings were infrequent. Interestingly, they found no evidence that roads were selective filters of rodents.

Studies such as Richardson *et al.*, (1997) and Mader (1984) show that for very sedentary species such as dormice (*Muscardinus avellanarius*), bank voles (*Clethrionomys glareolus*) and yellow-necked mice (*Apodemus flavicollis*), any alien habitat including a road is a barrier. Very mobile species can generally cross roads with little difficulty other than casualties from vehicle collision. The range of species in between these extremes will suffer maximum effects of fragmentation caused by roads, and are more likely to exist as metapopulations (continuous populations divided into smaller isolated local populations). These smaller fragmented populations fluctuate to greater extremes over time and are more vulnerable to extinction than a single large population. Populations cut off by roads can also suffer genetic isolation with consequent increased levels of physical deformities. Populations become more vulnerable to change in their abiotic and biotic environment and are subject to both greater extinction and selection pressures (Mader, 1984). Species diversity will be especially threatened if a species is site specific or if its habitat is so severely reduced or damaged that the population can no longer support itself. This may lead to local extinctions. In the UK as a whole however, national extinctions are unlikely to occur from the cumulative loss of habitat or habitat modification (Hopkinson *et al.*, 1990).

Differences in barrier effect have been noted between the different infrastructure types. Railways often form more of a barrier to larger mammals in the UK, because they are more likely to be extensively fenced. For example, the main rail link through the New Forest in Hampshire (linking the ports of Southampton with London) for a long time formed the northern boundary of the distribution of introduced Sika Deer (*Cervus nippon*). This

population had rapidly spread through the Southern part of the New Forest with no check at the two fenced roads which cross the area. In addition to the effects of fencing, the track bed, consisting of large granular material, and the tracks themselves are a very significant barrier to amphibians, in a way that roads are not. Canals on the other hand tend to be slow flowing waterways with pollution problems and low oxygen levels, creating significant barriers for animals. Many aquatic animals also require facilities to be provided in order that they may gain entry to and exit from the canal.

#### 5.4.6 Effects on populations

The interruption or hindrance to small animals caused by a new road has raised concerns about reduced genetic interchange or the increased risk of chance extinctions of species from the fragmented system. Risks through in-breeding in small populations may be overstated. Red kite (*Milvus milvus*) populations in Wales have recovered from a low point of less than ten individuals in the 1930s and most of the current population is descended from one matrilineal line. Red squirrel (*Sciurus vulgaris*) populations are similarly thought to be threatened more by unfavourable conditions than genetic bottlenecks arising from small population size (Wauters *et al.*, 1994).

##### 5.4.6.1. Dormice (*Muscardinus avellanarius*)

The demise of many plant and animal populations is likely to reflect the adverse effects of habitat fragmentation (Reynolds, 1999). In the UK the dormouse is a case in point. The dormouse has disappeared from approximately 50% of its former range in the UK over the last 100 years, with progressive local extinction taking place, especially in the northern counties. There is good circumstantial evidence to suggest that the demise of this species is due in part to the process of loss and fragmentation of the woodland habitats upon which the species depends (Bright and Morris, 1996). The history of woodland loss in the county of Warwickshire is typical. In prehistoric times around 80% of the county was under continuous woodland. By 1887 woodland covered only 2.9% of the county, in more than 50 fragments. In 1970 woodland habitat (including regenerated and replanted woodland) covered 2.6% of the area in 60 fragments, some isolated by more than 10km from their nearest neighbours (Thorpe, 1978).

Normal behaviour confines dormice to small areas of suitable habitat. They travel only short distances (no more than a few hundred metres) (Bright and Morris, 1996) and are reluctant to cross open ground. Populations of dormice in patches of remnant woodland surrounded by intensively managed farmland or urban infrastructure are effectively isolated and vulnerable to local extinction. Once this occurs it is likely to be permanent. Re-colonisation of vacant woodland patches is very unlikely due to the barriers to dispersal posed by the surrounding hostile landscape. Evidence for such fragmentation-induced isolation and local extinction is provided by the results of field studies undertaken in Hertfordshire. For a given size of woodland area it was shown that there was a higher incidence of dormice in woods that have more woodland in the immediate surroundings. In addition, the incidence of dormice in recently established woodlands decreased with increasing distance from the nearest ancient woodland (Bright and Morris, 1996). Dormouse dispersal is clearly inhibited by increasing distance between woodland fragments, and these results support the view that populations of dormice in less isolated

woods probably have a lower risk of local extinction due to successful dispersal between sites.

#### 5.4.6.2. Bats

Habitat fragmentation is also bad news for many bat species, populations of which have declined in both numbers and range in north west Europe (Stebbing, 1988). Many species avoid open areas and commute from roost sites to feeding areas using linear landscape features such as tree-lines, hedgerows and river/stream corridors. Such 'flyways' are invariably used for example by brown long-eared bats (*Plecotus auritus*) and by *Myotis* species such as Daubenton's (*M. daubentonii*) and Natterer's (*M. nattereri*) (Swift, 1997). Loss and fragmentation of these landscape features is likely to be detrimental to such species. For example, Brandt's bat (*M. brandtii*) has been found to avoid flying in open habitats and is prevented from reaching fragmented and isolated foraging habitats by the lack of suitable connecting vegetated corridors between roosts and feeding sites. There is some evidence that many bat species, through their ability to echolocate, use linear landscape features as acoustical landmarks by which they navigate. Gaps in commuting routes or 'flyways' of less than twice the maximum sonar range may not be a problem, but gaps between flyway fragments larger than this may constitute barriers to movement. Given that the maximum sonar ranges may range from 13 to 60 metres (depending on species) even gaps in hedgerow and treeline flyways as small as 30 metres may constitute barriers to movement for bats and contribute to the fragmentation and isolation of bat foraging habitats.

The Advice Note on bats in the DMRB recognises that the loss of a single roost site can have implications for the bat population over a wide area. It is not only the loss of large nursery roosts with obvious congregations of bats which is important. A traditional mating roost or lek may consist of a single tree, (which at the time of a summer bat survey could be occupied by a single bat) but its loss could have serious implications for that population. Activity studies have shown that some species will make large detours to avoid gaps in otherwise continuous corridors. Severance of such features may disrupt feeding activity and place an energetic burden on commuting bats. Horseshoe bats (*Rhinolophus ferrumequinum* and *Rhinolophus hipposideros*), in particular, rarely travel far from cover and could become isolated from feeding sites if their traditional commuting routes are severed. It has also been suggested that lit motorways form a barrier to movement by horseshoe bats. Since bats may travel several kilometres in the course of a night's foraging, severance could affect bats in roosts some distance from the transport infrastructure in question. The potential significance of severance of a habitat feature depends entirely on its level of use, the species of bats involved and the availability of alternative habitats and features. This can only be determined by detailed activity surveys.

#### 5.4.6.3. Birds

In all, out of the 247 species of British breeding birds, 139 are thought to be rapidly or moderately declining and 23 have declined by at least 50% in the past 25 years. While the generally increasing populations of estuarine and marine species are encouraging, the status of a number of farmland and woodland species is deteriorating. The 'Common Birds Census' makes annual counts of birds at 200 to 300 farmland and woodland plots

throughout Great Britain. From these are derived an index of the national population size of each species. Between 1971 and 1996, out of a total of 49 bird species on farmland, the populations of 18 decreased whilst 14 increased. The skylark (*Alauda arvensis*), grey partridge (*Perdix perdix*) and song thrush (*Turdus philomelos*) each declined by over half (Figure 5.8.). Wood pigeons (*Columba palumbus*), pheasants (*Phasianus colchicus*), stock doves (*Columba oenas*) and collared doves (*Streptopelia decaocto*) all showed large increases in numbers on farmland. In woodlands, 12 species increased and 11 decreased, with the song thrush (*Turdus philomelos*) again one of the species in decline. In general these changes are not well understood, but the losses on farmland are related partly to modern agricultural practices, including the clearance of hedgerows, the intensive use of pesticides and the autumn sowing of cereal crops with the resulting absence of winter stubble.

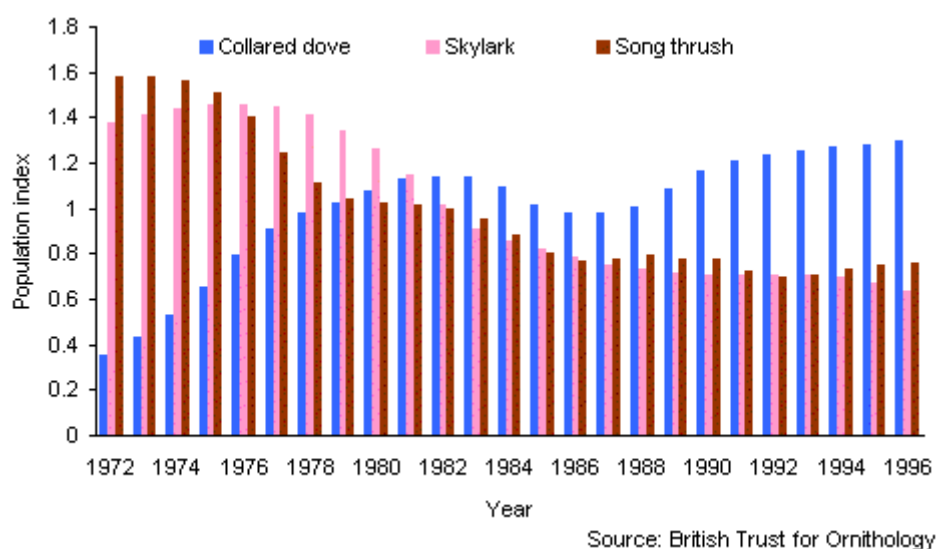


Figure 5.8: Trends in populations of collared dove, skylark and song thrush, 1972 to 1996

Where a habitat becomes so fragmented nationally, as for example heathland in the UK, subpopulations of birds such as black grouse (*Tetrao tetrix*) have become fragmented and become ‘populations’ in their own right with no capacity for dispersal between patches, and have often, therefore, become extinct in recent years in certain regions of the country (Ecoscope Applied Ecologists, February 1999). It is not always possible to determine the links between populations and the state of the environment. Significant natural fluctuations may be related to climate or to interactions between the predators and prey of birds, and between competing species of birds. But it is also apparent that bird populations are being greatly affected by the increasing intensity of rural land use which has removed many habitats and altered others. Modifying human activities to protect these species will also help to maintain the full range of biodiversity upon which they depend. Some 24 species are the subject of action plans being prepared by the UK Biodiversity Steering Group.

#### 5.4.6.4. Water voles (*Arvicola terrestris*)

Water voles excavate extensive burrow systems into the banks of waterways, using them for food storage, nesting, living in and bolt holes. They were once common and conspicuous waterside mammals, but a survey from 1989 to 1990 indicated that they were absent from 52.6% of the sites surveyed in England and Wales (Figure 5.9).

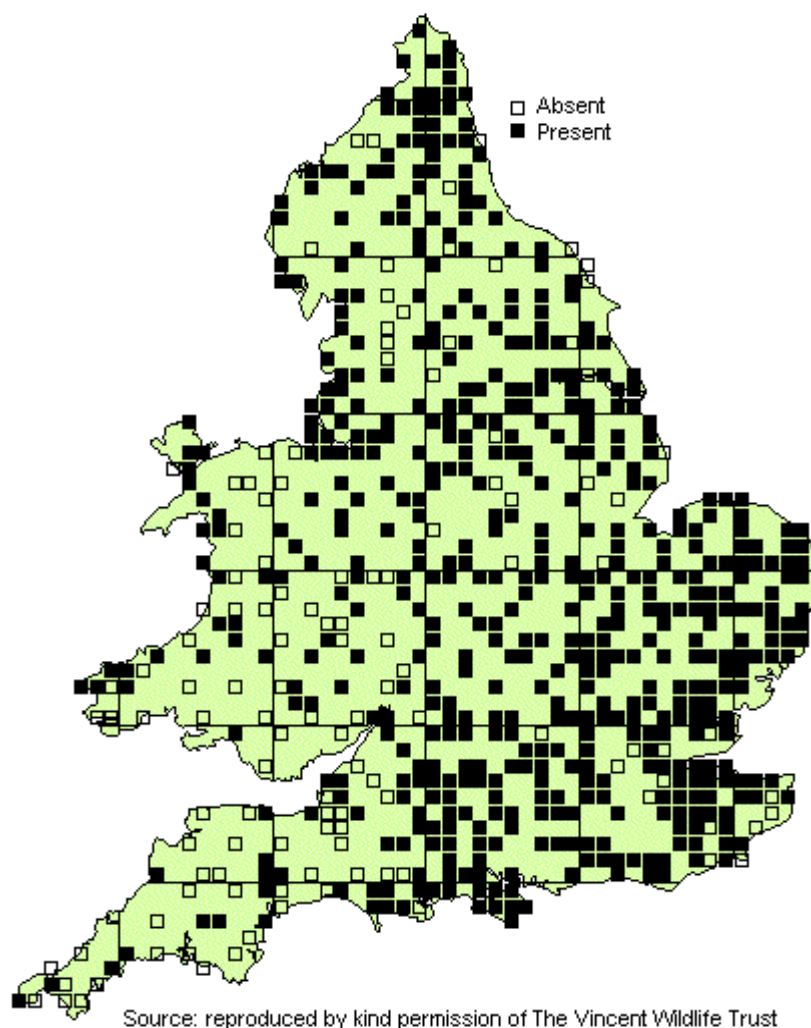


Figure 5.9: The distribution of 10km squares found to be occupied by water voles during 1989/90. The results shown are the combined data from the baseline and historical survey sites.

These sites were chosen from baseline and historical surveys. The baseline survey provided a series of sites over mainland Britain covering various waterways. The historical survey consisted of sites where water voles had been recorded in the past. Water voles were found to be absent from two-thirds of the sites where they had been recorded in the 1930s. A variety of factors are thought to be causing this serious decline. Changes in both land-use and riparian habitat management have resulted in habitat loss and degradation, causing fragmentation and isolation of water vole populations. This has led to an increased vulnerability to predation, especially by American mink (*Mustela vison*), which have coincidentally been spreading and consolidating their range throughout Britain. During the 1980s there was a period of accelerated site loss and this appears to have continued very



steeply through the 1990s. For instance, the results of a re-survey of the River Thames catchment sites during 1995 showed a dramatic regional decline from 72% to 23% site occupancy in a mere five years (from 1990 to 1995). This is believed to be a consequence of population fragmentation and losses of isolated water vole colonies through such factors as droughts, flooding, habitat degradation and the continuing spread of mink.

Restoration and re-creation of extensive areas of riparian vegetation (with perhaps selected periods of trapping for effective mink control) are suggested as the best mechanism for arresting the water vole's decline and allowing recovery over much of its former range. The water vole is included under schedule five of the Wildlife and Countryside Act 1981. This means that it is an offence to damage or destroy, or obstruct access to, any of the habitats which the voles use for shelter, or to disturb the animals while they are occupying such habitats. The Environment Agency has further developed protection for the animal through the production of the water vole Biodiversity Action Plan.

#### *5.4.6.5. Assessing fragmentation effects of populations*

The effects of fragmentation on populations is more widely researched for agricultural land uses than those associated with transport infrastructure. However, some general principles may be drawn from this work. Shelley *et al.*, (1998) provide a valuable insight into the effect of agricultural fragmentation on bird populations, noting that in assessing the consequences of fragmentation for wildlife populations, a knowledge of how the size and isolation of patches interact with species distributions and abundance is vital. For several years, they have been involved in a study of the bird populations of small woods in East Anglia, in a landscape devoted to intensive, arable agriculture. The woods were censused in each of three years (1990-1992) to identify the annual complement of breeding species using a mapping technique based on the methodology of the British Trust for Ornithology's Common Birds Census (Marchant and Balmer, 1993; Marchant and Musty, 1992; and Marchant, 1983). The woods were visited four times each breeding season, between the end of March and the beginning of August.

#### *Breeding and woodland area*

Different species were found to have different probabilities of breeding in relation to woodland area. Widespread species, such as Wren (*Troglodytes troglodytes*) and Blue Tit (*Parus caeruleus*), many of which commonly breed in habitats other than woodland (e.g. gardens and hedgerows), occurred in the majority of the smallest woods. In contrast, for species, such as Marsh Tit (*Parus palustris*) and Treecreeper (*Certhia familiaris*) which could be described as woodland specialists, i.e. species largely dependent on woodland and uncommon or rare in alternative habitats, the probabilities of breeding only approached 100% for woods of 10 ha or larger.

#### *Regional population size*

The relationships between the chance of a species breeding and woodland area may be influenced by regional population sizes, as well as, or instead of, area per se, but the amount of habitat available in a region will also have an influence on regional population sizes. Habitat fragmentation inevitably involves habitat loss, reducing regional carrying capacity.

### *Species distributions*

A number of other factors also influence species distributions in networks of fragmented habitat. Some species, such as Great-spotted Woodpecker (*Dendrocopos major*), move readily between adjacent small woods and thus have an area requirement which may be larger than that apparent from the location of the nest site alone. Other species may have patchy distributions within larger woods depending on the location and extent of their particular habitat (such as dead trees, internal edges or wet areas)(Hinsley *et al.*, 1996, 1995a and 1995b).

### *Benefits*

Habitat fragmentation can also have beneficial effects for some populations by increasing the structural diversity of the landscape matrix and increasing the variability between fragments. Where there is high connectivity between major patches, predators may find the new habitats which provide more feeding and denning opportunities than previously (Ecoscope, 1999). Disused railway lines have also been observed to have a beneficial effect on bird populations. A study by Patel (1995) investigated the differences in bird populations of railway lines passing through wooded and agricultural land in different parts of the UK (SW Scotland, NW England, the Scottish borders, South Wales and East Anglia). Birds were censused using the line transect and point count methods, and territories were defined using standard criteria. Plant communities were recorded and related to bird species and abundance. The study found that scrub-covered lines passing through farmland held significantly more birds than those with little or no vegetation in SW Scotland but not in Wales. A sample of common species were less abundant when there was little vegetation on the line in SW Scotland. Lines with bushy vegetation and farmland on one side and woodland on the other held marginally more birds than those with only farmland or woodland on both sides. Lines through woodland with different amounts of vegetation on the line itself had similar bird populations. Bird populations of identical types of abandoned railways in Scotland and Wales only differed in the case of scrub-covered lines cutting across farmland. In this case the Welsh bird community was more diverse both in terms of species richness and abundance.

### **5.4.7 Overview of environmental bottlenecks**

Environmental bottlenecks are areas of conflict created where ecological corridors and transport infrastructure coincide. At present in the UK there are no widely applied methods for identifying such bottlenecks, although preliminary investigation into the application of Strategic Environmental Assessment (SEA), and the use of existing databases such as the Countryside Information Service (CIS) has been undertaken. Developments with this technology are discussed in more detail in Chapter 8.

One operational initiative worthy of note is that of the Ecological Network. Following the visionary planning initiative to combat habitat fragmentation in Holland (the National Ecological Network), similar ecological networks are being planned and implemented at the regional and local level in the UK. Cheshire County Council is providing the lead in this research through the EU funded Life EConet Project (see section 8.6.6). Using computer generated masterplans and landscape ecology principles for guidance, the scheme aims to create new links between scattered wildlife habitats isolated by progressive land uses, and to integrate ecological networks into the heart of the policies and

programmes of economic and land use decision-makers. Existing wildlife sites will not only be protected but will also be enlarged through the restoration of habitats, and linked through the creation of corridors and stepping stones for the dispersal and migration of species. Ecological networks provide a unifying framework for identifying which areas are important for functioning ecological systems, and for providing guidance on how best to integrate nature conservation into other land uses. The growing interest in the ecological network theory reflects a move away from the traditional approach to nature conservation, with its pre-occupation with core areas such as SSSIs. Ecological networks provide an opportunity to integrate nature conservation and other land-uses through land use policy and spatial planning. Ecological corridors and buffer zones are becoming key elements in nature conservation strategy, reflecting a wider appreciation of the problems posed by habitat fragmentation and the need to make landscapes more permeable to wildlife. The application of GIS to map Ecological Networks enables the location of potential environmental bottlenecks to be identified, and for mitigative actions and policies to be put in place to reduce the impact of the bottlenecks on wildlife.

Environmental bottlenecks are more widely identified on a less formal level, particularly in relation to wildlife mortality. For example in National Parks, blackspots for traffic accidents involving deer are identified, and signs put up to warn motorists of the increased dangers in specific areas. Similarly road warning signs for toads and badgers are a common sight in certain parts of the UK, indicating that accident bottlenecks have been recognised through observation of the past events at that site. Further work is being carried on environmental bottlenecks by HA at present, in relation to barn owls (*Tyto alba*). Experimental plots have been located adjacent to barn owl road casualty hotspots on the A303 in Somerset, in an attempt to determine whether verge management techniques can be used to control the number of casualties and thus reduce the severity of the bottleneck. Technologies such as those mentioned above, certainly have the potential to increase awareness of further bottlenecks and improve the accuracy of the mitigation measures that are currently in place.

## 5.5. SECONDARY EFFECTS OF TRANSPORT INFRASTRUCTURE

The indirect effects of transport infrastructure, including changes in patch size, and increased pollution or disturbance, are very difficult to assess. Markham, (1996) provides the most comprehensive assessment of the secondary effects of transport infrastructure. This reports all highlight the significance of the 'edge effect', which has been studied in detail by Angold (1997), in relation to the impacts of a road upon adjacent heathland habitat fragments.

The 'edge effect' is that which the infrastructure has on the nearby environment owing to the local environmental changes which it causes e.g. microclimatic parameters, illumination, alterations affecting ground, drainage etc. Studies carried out in the vicinity of a main road in the New Forest in Southern England (Angold, 1995) show that edge effects on heathland are principally due to eutrophication linked to nitrogen oxide emissions, leading to an increase in the competitive capacities of the most vigorous herbaceous species, such as Purple Moor-grass (*Molinia caerulea*) and Upright Brome grass (*Bromus erectus*), but an inversely proportional reduction in other less competitive species such as Heather (*Calluna vulgaris*) and Common Rock-rose (*Helianthemum*

*nummularium*). These effects, observed for distances of up to 100m on grassland and 200m on heathland, also depend on the amount of traffic. Generally speaking, long-term studies such as this show that edge effects appear more through a reorganisation of plant groups within a site rather than in the disappearance of species. Angold (1997) concluded that without the use of conservation buffer zones to protect habitats from edge effects, little undisturbed habitat may be left in a fragmented landscape even though the absolute area of the fragments may be relatively large.

Some general principles that the study highlighted were that roads impact on plant species composition, plant performance and soil nutrient levels, due to pollutants and the primary edge effect generated by the road was a nitrogen input. The extent of the edge effect is closely correlated with the amount of traffic the road carries, and therefore with the amount of atmospheric pollution from vehicle exhausts. The implication of this is that the core area of undisturbed habitat in a fragmented landscape may be substantially smaller than it initially appears, demonstrating the importance of buffer zones to absorb edge effects from land use adjacent to protected habitats. Some basic rules for reducing edge effects are to:

- plant sufficiently dense screens to filter pollutants; and
- provide buffer areas of varying widths along the edge of the infrastructure.

In a country with increasing motor traffic, where vehicles are a major source of pollutants, the consequences for plant species in terms of habitat fragmentation could be significant. Habitats and species are not only affected by nitrogen and sulphur dioxides, but by carbon dioxide and carbon monoxide and other volatile organic compounds. Critical loads (i.e. estimates of exposure to pollutants below which significantly harmful effects on sensitive elements of the environment are unlikely to occur) of these pollutants can be used to show the areas potentially at risk from damage. For a particular effect such as acid damage to trees, critical loads are prepared and mapped by the DETR's Critical Loads Advisory Group (CLAG), based at the Institute of Terrestrial Ecology (ITE). There are currently large parts of the UK where terrestrial and freshwater ecosystems are at risk of acidification, eutrophication or ozone damage as a result of air pollution.

Railways produce secondary effects that are quite distinct from road impacts. The main difference between the two modes is that the railway track beds drain freely and quickly, often directly into the surroundings, unlike roads which generally have systems to collect and dispose of runoff. Herbicide is also more readily used on railways than on roads to keep track beds clear, and lime is applied for bacterial cleansing (which in areas of acid soils and water can cause significant changes to areas nearby). Old track ballast is often left on the side of the track or removed elsewhere without treatment, and new ballast requires significant use of primary aggregates in a way that roads do not.

## **5.6. ON-GOING RESEARCH AND REVIEW OF RELEVANT STUDIES**

Growing interest in the topic of habitat fragmentation has led to the development of several strands of research which are currently ongoing. The studies of particular interest are summarised below.

### 5.6.1. Small Mammal Studies

In September 1998 the Highways Agency awarded a research contract to a PhD student, Ms Jackie Underhill, studying at the School of Geography, the University of Birmingham. Under the supervision of Dr Penny Angold (one of the UK's COST representatives), Ms Underhill's ongoing project is concerned with measuring the extent of road avoidance by wildlife, specifically on road verges in deciduous woodland habitat. The practical element of the work involved the setting up and monitoring of sand traps on the highway verge in Warwickshire, West Midlands. These are designed to capture the footprints of fauna that move both along the verge (corridor effect) and across the highway, and allow comparison of roads with differing traffic densities. A range of mammals has been recorded using the sand-trapping methodology including muntjac (*Muntiacus reevesi*) and fallow deer (*Cervus dama*), fox (*Vulpes vulpes*), rabbit (*Oryctolagus cuniculus*), woodmouse (*Apodemus sylvaticus*), shrew (*Sorex araneus*) and field vole (*Microtus agrestis*). During the project it was recognised that sandbeds cannot provide a verifiable method of measuring small mammal movement, so the methodology was expanded to include the use of longworth traps (to monitor small mammals) and CCTV equipment (for larger mammals). The trapping part of the project had commenced (4-17 December 1999) in order to measure the barrier effect and suppression of movement effects of the roads on small mammals. 150 traps were set out on one side of the road and monitored over 24 hours. The traps were then moved to the other side of the road and monitored over the following 24 hours. The process was repeated on three nights, and carried out at two different sites in order to compare the effects of roads with different traffic volumes. Follow-up trapping rounds are planned for March, June and September 2000. An additional aspect to the research is the inspection of disused railway bridges under roads as corridors for small mammal movement.

Another ongoing research project has been commissioned by the Highways Agency to increase the knowledge of small mammal populations on road verge habitat, and specifically, determine which road verge characteristics affect small mammal abundance and diversity. The School of Biological Sciences at the University of Bristol are undertaking the three year project, which was initiated in 1998. During the first year a detailed survey of 20 sites has been implemented along the A303 in Somerset to provide an understanding of small mammal annual population cycles within the road verge grassland habitat. During the course of the study data is also being collected on barn owls (*Tyto alba*), in order to provide an insight into the relationship between small mammal and predator casualties. The next stage of the research will involve an extensive grassland management experiment to examine whether small mammal populations can be manipulated through verge management. The Mammal Society national road verge small mammal survey (section 5.6.2) will provide additional data for the project, as will the results of a barn owl radio-tracking experiment.

### 5.6.2. The Mammal Society National road verge small mammal survey

The Mammal Society's national survey of small mammals on grassland road verges will be repeated during spring 2000. The objective of the research is to identify the relationships between road verge habitat features and small mammal abundance and diversity. To date over 100 road verge survey site recording forms have been returned from previous surveys

in locations ranging from northern Scotland to Cornwall. Preliminary analysis of the data indicates that the wood mouse has been the most frequently recorded species. Common shrews (*Sorex araneus*), bank voles (*Clethrionomys glareolus*) and field voles (*Microtus agrestis*) were also frequently recorded in the survey. A number of volunteers captured less common and more elusive species such as water shrews (*Neomys todians*), harvest mice (*Micromys minutus*) and even yellow necked mice (*Apodemus flavicollis*). The yellow necked mouse is a species usually favouring mature woodlands and hedgerows rather than grassland road verges. These animals are, therefore, most likely to be dispersing to suitable habitat rather than in permanent residence on road verges.

### 5.6.3. Countryside Agency Greenways Project

The Greenways project is an initiative which aims to help the Government deliver its sustainable development strategy. 'Greenway' is a term used to describe a wide range of routes for commuting and recreation, in and around the countryside. Although they are designed for shared use by people on foot, bicycle and horseback, they inevitably provide routes for wildlife too. Greenways may be a single route or a network of routes linking up with each other and with a range of places of interest. Many routes make use of existing corridors in the landscape such as rivers, canals or disused railways. A total length of 17,000km of Greenways are either planned or already in existence. A survey carried out to assess what people want from Greenways indicates they should provide:

- a 'natural' green environment to make it pleasant to use and to encourage wildlife;
- protection from the sound of traffic;
- a continuous off-road route;
- things of interest along the way;
- facilities such as refreshment stops, play areas and toilets;
- ease of access for horses, prams and cycles
- freedom from litter and vandalism; and
- somewhere safe to park cars or good public transport provision to improve accessibility.

The development of Greenways creates an opportunity to provide positive enhancement and improved management for both the route corridor and for the wider environmental setting. It is vitally important to give consideration to the impact these routes have on nature conservation. Linear routes linking areas of open space and countryside provide corridors through which animals, birds and insects can move freely. The majority of multi-user routes constructed in Britain have added significantly to areas under direct management for nature conservation and wildlife protection.

Financial support is needed at all phases of the development of Greenways. The availability of funds to maintain such recreational routes is a major concern for local authorities and hampers the development of new routes. Land ownership is also an issue. One of the objectives of Greenways is to provide routes where people would like to go, rather than where public access is currently available. The costs of acquiring land for new routes are a constraint upon the development of Greenways. There are few funding sources for feasibility studies and maintenance work. Further information on Greenways is given

in Groome (1990), Chester City Council (1996), Bicycle Association/Sustrans, (1994), Stewart (1987), and Fabos and Ahern (editors) (1996).

#### 5.6.4. Institute of Terrestrial Ecology (ITE) Research

The Animal Ecology Section of ITE studies the factors that influence the numbers and distribution of birds and mammals. Currently research topics cover:

- environmental control of annual cycles;
- variation in reproductive success between individuals ;
- population dynamics; and
- effects of landscapes on populations.

These studies include laboratory work, fieldwork and long-term monitoring of a large variety of species. Fundamental research of this kind complements studies of the changes resulting from man-made alterations to the environment, such as pesticides and pollution, habitat fragmentation and climate change. The main areas of interest are described below.

##### 5.6.4.1. *Birds of Prey*

*Sparrowhawk population studies:* Much work has been concerned with birds of prey. Although they live at low densities, such species are ideal subjects for study because they are extremely sensitive to human activities, such as: destruction and degradation of habitats; pesticide use; and game preservation. Long-term research on a sparrowhawk (*Accipiter nisus*) population has provided information on lifetime reproductive rates i.e. the total number of young raised by individuals during their entire lives. This information is important to biologists because it reflects Darwinian fitness i.e. the contributions that individuals make to the genetic make-up of future generations.

##### 5.6.4.2. *Mammals*

*Lowland deer:* Research (carried out for the Ministry of Agriculture, Fisheries and Food) is designed to assess the population dynamics and ranging behaviour (using radio-telemetry) of muntjac deer (*Muntiacus reevesi*) and fallow deer (*Dama dama*) within habitat mosaics of lowland England. Damage caused by these species to crops, trees and natural vegetation is quantified. The overall aim of the project is to allow the prediction of the likely numbers of deer in particular habitats, and to examine ways of reducing their potential detrimental impacts when these species spread to new areas and reach higher population levels.

##### 5.6.4.3 *Ecophysiology*

*Photoperiodism:* Birds in seasonally changing environments undergo annual cycles in behaviour and physiology. They need to reproduce, moult, and, in many cases, migrate. It is vital that these functions occur at the right time of year. Change in daylength is used to time these functions because it is the most reliable and predictable environmental variable. Long-term studies are being carried out on the mechanism by which daylength controls breeding seasons, moult, and puberty.

*Pesticides:* Pesticides and their residues can affect the size of bird populations. The numbers of birds of prey in particular have declined markedly because of the widespread use of organochlorine pesticides. ITE have been monitoring pesticide residues such as DDE and HEOD in the bodies of dead birds for over 30 years. Species studied include birds of prey, herons (*Ardea cinerea*), and kingfishers (*Alcedo althis*). Another potential problem concerns exposure of wildlife to more than one pesticide. Before a pesticide is registered, its toxicity to non-target organisms has to be assessed. In such tests, each pesticide is treated alone. Wildlife is often exposed to combinations of pesticides. It has been shown that pesticides can interact synergistically, i.e. the effect of two pesticides in combination is much greater than the sum of their individual effects. The potential dangers of different combinations in different species are currently being assessed on behalf of the Joint Nature Conservation Committee.

#### 5.6.4.4. *Habitat Fragmentation*

*Relationship between the number of breeding species and woodland area:* It has been found that the area of a woodland is the main factor determining the number of breeding species present, and that numbers decline rapidly when the area is less than 2 ha. There are also changes in species composition from one breeding season to the next, particularly in species represented by small numbers of individuals. Small woods therefore rely on immigrants from elsewhere to replenish their numbers. Habitat fragmentation reduces both population size and stability. Such information is helpful in the selection and maintenance of nature reserves, and in modifying the structure and use of the existing landscape in order to enhance its conservation value. Part of this work is being funded by the British Association for Shooting and Conservation.

#### 5.6.5. **Defragmentation**

Several projects are underway to raise the profile of habitat fragmentation and to begin the defragmentation process. An example of this is the work being undertaken by the Environment Agency (EA) to de-culvert short stretches of river in south London. Work began in February 2000 on restoring almost 400m of the River Ravensbourne, south of Bromley. The project is being funded by the EA and Bromley Council, who have come to realise the environmental and amenity value of uncovering a 350-400m section of the river. When work is finished, the section's bends and fish spawning areas will be restored. Despite the obstacles, the EA would like to de-culvert other rivers where such plans won't interfere with development and won't compromise flood defences. The idea of putting rivers in pipes is not environmentally sound, and if EA have the money, they foresee one de-culverting project a year in South London. Other rivers that may offer de-culverting possibilities include Lewisham's River Quagee and the River Wandle in Croydon. There are no guarantees that uncovering short sections of London's rivers will result in fish spawning, but it is a distinct possibility.



## 5.7. SUMMARY

From studies undertaken so far it seems that, with the exception of a few species with very low population levels due to general land use change and other sources of habitat destruction, there is little hard evidence of the effect of fauna casualties or barrier effect of transport infrastructure at population level. The otter (*Lutra lutra*) has been absent from most of mainland Britain since the widespread use of organochlorine pesticides and the decline in water quality during the 1960s. Water quality and riparian habitat have since had an ongoing programme of improvement and restoration, and the otter population is now spreading from its remnant area. The expanding population is bringing it into conflict with transport infrastructure, resulting in a high number of road deaths (nearly 400 recorded in last 8 years) which are thought to be a factor that will slow or prevent the recovery of the otter throughout Britain. The direct evidence for transport infrastructure being a barrier and causing fragmentation of populations is far from clear, with it being difficult to isolate the impacts and effects of transport infrastructure from other external influences. The absence of hard evidence of adverse effects at the population level is thought to be due to the cost and problematic nature of research. However, until such time when hard evidence is brought to light, it would be advisable to apply the precautionary principle and assume at least some adverse effects.

The perceived significance of transport development for nature conservation varies according to the group of people and type of development under consideration. The scale of the development, and the landscape context in which it occurs, also alter not just the impact but how it is viewed by people. Undoubtedly, more effort is required on reducing the need for new infrastructure and, in the initial planning stages, more attention should be given to reducing the need for mitigation work during and after construction. Research on ways of assessing the impacts across the different infrastructure modes, across groups of species, across landscapes and across time is also needed.

According to US research, roads overtook hunting as the leading human cause of vertebrate mortality on land sometime during the last three decades (Forman and Alexander, 1998). Estimates of road mortalities based on measurements in short sections of road have been widespread in many countries e.g. Bennett (1991), Forman (1995). A growing literature suggests that roads near wetlands and ponds have the highest mortality rates and factors such as road width, and traffic density and speed affect this rate. The question of concern to many researchers has been whether losses on roads significantly impact populations. Measurements of bird and mammal road mortality in England illustrate the main pattern (Hodson, 1962 and 1966). This work concludes that none of the 100 bird and mammal species recorded had a road mortality rate sufficient to affect population size at the national level. Despite this, mortality rates are apparently significant for a few species listed as nationally endangered or threatened (Bekker and Canters, 1997; Forman *et al.*, 1997). Landscape spatial patterns also help determine mortality locations and rates. Animals linked to specific adjacent land uses include amphibians lost near wetlands (Ashley and Robinson, 1996) and deer impacted between fields in forested landscapes or between wooded areas in open landscapes (Romin and Bissonette, 1996).

All roads serve as barriers or filters to some animal movement, especially for many mammal species, wetland species and carabids (Bennett, 1988; Harris and Scheck, 1991;

Fahrig *et al.*, 1995). Road width and traffic density are major determinants of the barrier effect (Forman, 1995), which tends to create metapopulations (Andrews, 1990; Harris and Scheck, 1991) with a higher probability of extinction (Aanen *et al.*, 1991). The genetics of a population is also altered by a barrier that persists over many generations (Soule, 1997) but little is known specifically of the genetic effects of roads or railways.

The overall ecological effect of avoidance has been shown to be greater than that of direct mortality. Traffic noise, visual disturbance, pollutants, and predators moving along the road corridor, are factors suggested to cause road avoidance by species. Studies of the ecological effects of highways on avian communities in the Netherlands show that species density increases with distance from a road. 'Effect distances' varied according to habitat type and traffic density (Reijnen, 1995; Reijnen *et al.*, 1996). Various large and small mammals, and arthropods have also been found to have lower population densities within 100-200m of roads (Lyon, 1983; Rost and Bailey, 1979; and Ferris, 1979).

Further secondary impacts on populations are related to the exposed soil surfaces created during infrastructure construction. Higher erosion rates and elevated sediment transfer rates impact upon aquatic habitats by inhibiting aquatic plants, macro-invertebrates and fish (Beschta, 1978; and Reid and Dunne, 1984). In addition, stormwater runoff carries increased levels of pollutants which may alter soil chemistry, be absorbed by plants, and affect stream ecosystems over considerable distances (Brown and Gibson, 1994; and Gilson, 1994). Typical water quality responses to runoff include altered levels of heavy metals, salinity, turbidity, and dissolved oxygen (Brown and Gibson, 1994), leading to mortality of fish and other aquatic organisms (Horner *et al.*, 1983). Deicing salt (National Research Council, 1991; and Amrhein *et al.*, 1992) and heavy metals (Dienst Weg- en Waterbouwkunde, 1994; and Getz *et al.*, 1977) are the two main categories of pollutants which impact upon populations. Other chemicals including herbicides, polycyclic aromatic hydrocarbons from petroleum, fertiliser nutrients and nitrogen from vehicle emissions (NOX) have also been shown to affect vergeside vegetation (Angold, 1997; and Cale and Hobs, 1991).

## Chapter 6. Traffic Safety in Relation to Fauna Casualties

### 6.1. INTRODUCTION

There are no central statistics in the UK concerning the number of road traffic accidents involving wild fauna. It is believed that collisions with deer are responsible for around three human fatalities per year, but more minor accidents caused by swerving to avoid animals and birds are likely to be far more common although there is no hard evidence. There are however, isolated reports in the press relating to traffic safety e.g. one person was killed in 1999 and a passenger in the car was severely injured, after swerving to avoid a rabbit on a motorway (The Times, Saturday 21<sup>st</sup> August 1999).

The only detailed piece of research that has been undertaken in relation to traffic safety and fauna casualties is that by SGS Environment (1996) relating to deer (commissioned by the Highways Agency but unpublished to date). This study attempted, for the first time, to draw together national statistics for deer Road Traffic Accidents (RTAs), and to review the techniques used to prevent them. A range of methods were used to extrapolate the available data, and a reasonable estimate of between 30,000 and 50,000 deer RTAs per year in the UK was derived. Additional information for evaluating and assessing deer mitigation measures was also gathered. Based on information available from the European literature on deer RTAs, 40,000 deer RTAs would correlate with around 400 people injured and 10 killed every year. The known figures for the UK confirm between 9 and 19 human fatalities per year. Although these extrapolations must be viewed as very tentative estimates of the true scale of the accident problem, they do highlight the fact that the issue of deer and roads is a serious animal and human welfare issue. It is apparent that the problem of deer RTAs is nationwide, but it is especially serious in the South East.

### 6.2. GENERAL GUIDANCE FOR REDUCING DEER ROAD TRAFFIC ACCIDENTS

Most current thinking agrees that wherever deer accident problems occur, these are most likely to be resolved by applying a range of complimentary mitigation methods, rather than a single method in isolation. The following are best practice guidelines (Putman, 1997):

- deer fencing is the most reliable method of preventing deer straying onto roads; diversionary feeding and deer warning reflectors can also be effective;
- deer underpasses and overbridges are important in allowing safe passage of deer across roads and a regular commitment to long-term maintenance is considered a crucial success in any mitigation; and
- roadside verge maintenance is an important factor in reducing the risks of deer RTAs; short verge vegetation allows drivers to see deer in advance of them crossing the road, however maintaining well cut verges is often in conflict with other nature conservation objectives.

The SGS Environment report strongly recommends that a national scheme for recording animal RTAs is established and that further research is undertaken, particularly into the

effectiveness of deer warning reflectors, deer behaviour, driver behaviour and the national cost implication of deer RTAs. Further work is required in this area specifically addressing:

- *Data Collection*: very little complete data on deer RTAs is available. A minimum of a years nationwide study is needed to provide representative data for a sample of road types and habitats from each region. The foundations of an adequate recording system are already in place as Insurance companies, local authorities and police forces all currently record accidents involving deer. However, extracting the data from their records is at present very difficult. A useful initiative is already under way in Dorset, where approved deer stalkers, managed by the local police, attend all reported deer RTAs and fill in a comprehensive record form after each incident.
- *Deer Warning Reflectors*: these remain one of the most promising methods in reducing deer RTAs, and an investigation into deer mirror effectiveness is considered a priority project.
- *Driver Behaviour*: the question of the ineffectiveness of deer warning signs has been raised and some of the existing literature has investigated ways of improving drivers awareness to deer, but further work on this aspect is still required.
- *Deer Behaviour*: many questions relating to deer behaviour still remain e.g. how do they react to mitigation measures, how do accidents occur, how do deer cross roads, how do deer react to disturbance?
- *Financial implications*: there are a range of cost implications involved in deer RTAs e.g. the loss of income from reduced venison sales, the cost of damage to vehicles, the call-out costs for vets, stalkers and the police to deal with injured or dead deer, the call-out costs for ambulances and any subsequent medical costs, the costs of traffic delays due to a deer RTA. Although not directly related to the design of deer mitigation, an understanding of these costs is important when assessing the 'value for money' of deer mitigation measures and the funds that should be made available for further research.

In the UK deer are probably the only species that pose a significant risk to traffic safety due to their size. However, other species, mainly the larger mammals such as foxes, represent an indirect risk as drivers are inclined to swerve to avoid hitting them. In doing so they may put themselves and other road users at risk. Broadening the research to include other species is also required therefore, in order to fully understand the relationship between fauna casualties and traffic safety.

## **Chapter 7. Avoidance, Mitigation, Compensation and Maintenance**

### **7.1. INTRODUCTION**

The key goals of the 1992 Convention on Biological Diversity are:

- the conservation of biodiversity - species and ecosystems should normally be protected from destruction through in-situ conservation, including nature reserves and policies to save endangered species; and
- sustainable use of the components of biodiversity - the promotion of measures to ensure that future generations will benefit from today's biological resources.

These principles underpin the efforts to avoid, mitigate and compensate for nature conservation impacts associated with transport infrastructure, and are encompassed in the EC Directive on Environmental Assessment 85/337 (as amended). The provisions of Environmental Assessment (EA) encourage infrastructure developers to avoid sites of nature conservation interest wherever possible. Where crossing or passing close (within 100m) to a site is unavoidable, or where the site is on highway/railway land, developers are encouraged to design measures to minimise adverse impact at the earliest possible stage. Best practice advocates that existing links between habitats should be maintained wherever possible so as not to deter animal movement. To prevent animal casualties, a means of crossing the road should be provided wherever the road is fenced and wherever the road system may result in the isolation of previously linked animal populations. Furthermore, and of critical importance, is that these measures need to be carried out, monitored, and where necessary managed in perpetuity.

### **7.2. AVOIDANCE OF HABITAT FRAGMENTATION**

In any development proposal, avoidance of habitat fragmentation is the ideal outcome. However, the very nature of development means that total avoidance of habitat fragmentation is rarely achievable. The main exception to this is where proposed transport schemes are rejected at the planning stage, on environmental, or other grounds. Oxleas Wood SSSI, on the route of the proposed A406 East London River Crossing, is one such example. This became the first major wildlife site to be saved from road development as a result of pressure from more than 7,000 people and organisations. The scheme involved a 9.83 km four-lane trunk road and new bridge over the Thames at a cost of £200 million. The preferred route bisected Oxleas Wood in the London Borough of Greenwich, a SSSI and ancient woodland (one of the last significant tracts of ancient woodland in London), in a 350 ft wide cutting. The scheme was predicted to destroy at least 500 mature trees and thousands of smaller trees and bushes (11.5% of the wood), and endanger some of the 33 breeding bird species. Alternatives for mitigating the impact on Oxleas Wood included 1,200 metre bored tunnels under the wood at an additional cost of £32 million, and a cut and cover tunnel to allow the wood to regenerate, costing £23 million extra. At the planning inquiry (the longest into a trunk road scheme) these options were not

recommended by the Planning Inspector as they were deemed to be too costly, and would have cancelled out the value for money calculated for the new road. Following an intervention by the European Environmental Commission, who began prosecution proceedings against the Government for their lack of sufficient consideration of the effects on wildlife habitats, the scheme was subsequently abandoned. Similar results ensued from inquiries into road schemes proposed to bisect Wytham Wood SSSI in Oxfordshire, and the Bourne Valley SSSI in Dorset. However, such outcomes remain exceptions to the rule: it is still rare for the Secretary of State to refuse planning permission for a proposed road scheme primarily because of its potential impact on nature conservation. Normally, schemes that have reached the inquiry stage are expected to proceed according to the proposed route, or a decision is made to adopt a slightly altered alignment (see section 7.2.1) or revert to one of the alternative route options considered at the scoping stage. Commonly therefore, some degree of fragmentation will result.

Legislation and statutory provisions are designed to ensure that impacts on the environment (e.g. habitat fragmentation) are minimised, as far as is reasonably practicable. The main method for assessing the extent of environmental impact that will ensue is by weighing up scheme options against a ‘do nothing’ scenario (i.e. total avoidance of fragmentation). The New Approach To Appraisal (NATA) for transport projects provides a systematic framework for doing this, and aims to ensure that environmental, economic and social aspects of a proposed scheme are evaluated in a clear and consistent way. It is a tool which ensures the environmental impacts will be taken into account from the very earliest stages of planning and design, and has potential powers to safeguard against unacceptable habitat fragmentation. Once a scheme has been approved on paper, attempts must be made to minimise the severance that will be caused by the development. This may be achieved through:

- selection of a route alignment which avoids the most vulnerable species, habitats and land patterns (based on expert ecological advice);
- the use of tunnels and bridges in sensitive areas; and
- the management and control of construction activities to ensure that impacts on habitats and species are avoided.

### **7.2.1. Route alignment**

The approach taken during the route selection process for the Channel Tunnel Rail Link (CTRL) as described in the Environmental Statement for the scheme, provides an example of how careful route alignment can avoid impacts (in particular to sensitive sites). Throughout the route development and refinement process, a high standard of environmental design was adopted in order to avoid many potentially significant environmental effects. Constructing and operating a 108km high-speed railway through east London, Essex and Kent, together with a new London Terminus and an Intermediate Station, cannot be achieved without affecting the environment along the route. Therefore an aim of the route development process was to keep the effects to a minimum, consistent with meeting the safety, operational, engineering and commercial requirements of the railway. Important elements in this process have been:

- the use of existing transport corridors to minimise severance of and intrusion into the countryside;
- the avoidance of built-up areas wherever possible in order to reduce effects on people and reduce the requirement for demolition of residential and commercial properties and community facilities;
- the avoidance, wherever possible, of areas valued for their agricultural, aquatic, historic, cultural, ecological or landscape resources; and, where landtake could not be avoided, keeping the area affected to a minimum; and
- the inclusion of local mitigation measures such as landscape works and noise barriers to reduce or eliminate adverse effects where they could not be avoided by route selection (CTRL Environmental Statement: Main report, November 1994).

This rationale led to the selection of a route that followed the existing transport corridors of the M2/M20 motorways and the Ashford to Folkestone railway.

Re-routing was an integral part of the planning process associated with the M40 Waterstock to Wendlebury extension, where the initially preferred route severed Otmoor SSSI. In 1984 a decision was taken, following a public inquiry, to abandon the original Otmoor route. This represented a recognition that the impact on the landscape of the moor and the woods of the Bernwood Forest Complex outweighed the cost and economic advantages of the route. The re-routing away from Otmoor cost an additional £2 million (1985 prices) and reduced the economic benefits to road users by £20 million. In this example the primary objective was seen to be the protection of the SSSI and woods for nature conservation, and these considerations were overriding to the economic implications.

Similarly, at Twyford Down SSSI (on the proposed route of the M3), measures to enhance, not merely conserve, wildlife were incorporated from the earliest possible stages of planning. Surveys identified the richest land area under threat (ITE, 1997), and a route was chosen avoiding all but a small fraction of the species-rich grassland. However, Ministers rejected the alternative option of a tunnel under the Down proposed by environmental groups. The extra cost (£90 million) and delay to the scheme was considered to be unacceptable. Although the chosen route was viewed by most to conflict with national and local policies for conservation, and the Government's 'desire' to keep new roads away from protected areas, the planning inspector for the scheme stated that in terms of capital cost and economic assessment, the route 'mainly represented good value for money'. This view is converse to that expressed by the inspector for the M40 as discussed above, indicating the lack of consistency in the planning arena. In cases such as the M40, where there has been closer scrutiny by the European Commission, a clear view has emerged that alternative routes and designs must be seriously assessed. In the future therefore it is likely that there will be a reluctance to accept significant impacts unless it can be demonstrated that there are no practicable alternatives. This raises the issue of what is an acceptable extra cost for such alternatives. One can envisage circumstances in which the need for a project and the lack of alternatives means that a scheme will be approved almost no matter what the environmental effect, in contravention to nature conservation priorities.

### 7.2.2. Route Design

One classic method of avoidance, involves the crossing of valleys using embankments or viaducts. Although designs for such structures are not primarily intended to address fragmentation issues (rather to solve engineering problems) they indirectly constitute an avoidance measure. In addition they inevitably aid protection of particularly sensitive riparian habitats. Their great benefit is that they are multi-modal, equally applicable to roads, railways, and waterways.

#### 7.2.2.1. Viaducts

The main advantages of using viaducts is that they retain views down the valley, can be design contributions to the landscape, minimise visual intrusion, landtake and impact on property, and benefit heritage and nature conservation. Conversely their disadvantages are that they are expensive; and offer fewer opportunities for planting. In general it is accepted that viaducts are best suited to narrow and deep crossing points. Good examples include the A30, Okehampton Bypass and the A69, Cumbria (Figure 7.1).



Figure 7.1 : Viaduct as an example of an avoidance measure, A69 Cumbria

Viaducts are considered especially valuable where otter (*Lutra lutra*) populations are at risk, and the DMRB (Vol. 11 (Otters)) provides guidance on specific bridge design to minimise the impact on this species. It recognises that where a road crosses a river valley the use of a viaduct will provide the least disruption to the habitat and a safe environment for otters will be retained. The viaducts need not be tall, but the principle of using stilts to carry the road (rather than an embankment) allow the habitat below to remain relatively



intact. Viaducts allow free passage of all species through the habitat and reduce the need for fencing to guide animals to safe crossing points. Figure 7.2 shows a wide span bridge with space between the river banks and abutments allowing continuation of the river corridor, and enabling otters to pass at times of high water flow.



Figure 7.2: Good viaduct design for otter mitigation, A685 Cumbria

Bridge design should allow the abutments to be set back far enough to allow the natural riverbank and riverbed to be retained. The bank should be softened using bio-engineering techniques such as log piling, willow hurdles or hazel faggots. If hard protection is necessary, this could be softened with gabions and boulders in preference to concrete and softer treatments above the waterline, for easy access in and out of the river. These materials will also provide sprainting sites for otters, so encouraging the animals to use the safe passage provided. The base of the embankments should then be fenced to guide the otters to this passage.

#### 7.2.2.2 Embankments

The advantages of embankments are that they can be integrated with the adjacent landform, incorporating false cutting for screening and they offer more scope for screen planting. The perceived disadvantages are that they block views down the valley; and can require a large landtake.

#### 7.2.2.3 Tunnelling

It appears to be generally accepted that environmental considerations increasingly lead to tunnelling being considered as an option late in the design of a scheme. Umney and Miller (1991) have addressed this issue in a report that can be used by planners to make a reliable

assessment of economic and environmental considerations. Their review notes that cut-and-cover is being considered as the most viable solution for conserving land for other uses (i.e. preserving nature conservation value) and for reducing traffic noise. A recent example of this type of mitigation measure is found on the A12 Hackney to M11 link, which was put in a tunnel to mitigate the impact on the communities of Wanstead and Waltham Forest. This design measure represented a late addition to the scheme, following recommendation by the Inspector on environmental grounds.

### **7.2.3 Avoiding fragmentation effects during construction**

Fragmentation will initially occur during the construction stage of any development, before appropriate mitigation can be implemented. These effects can be minimised through the timing of operations e.g. avoiding sensitive periods such as bird nesting or the badger close period, when animals are breeding or nursing young. National legislation places penalties on the disturbance of certain species during defined sensitive periods. A phased work plan incorporating codes of practice for operators is therefore essential. Contractors should be made aware of any sensitive areas of the site and of any temporary protection measures required e.g. gates or fences. A code of practice would also set out any requirement for specific terrestrial searches by authorised personnel before earth disturbance, which may be necessary for less conspicuous species such as great crested newts.

## **7.3. OVERVIEW OF MITIGATION MEASURES**

Although it is preferable in nature conservation terms to avoid the severance of habitats, where this is not possible, severance impacts may be mitigated through:

- restoration of derelict habitat links such as wildlife links or road tunnels;
- creation of habitat 'stepping stones' to reduce distances for colonisation and dispersal (e.g. planting to link severed habitats);
- provision of additional or alternative habitats;
- enhancement of the remaining habitat features to benefit wildlife;
- translocation of important or protected species or areas of vegetation (where there is no alternative);
- control of associated impacts (e.g. pollution); and
- timing of operations to ensure works cause least impact on rare and protected species, and vulnerable/valuable habitats (e.g. vegetation removal in winter to avoid impacts on nesting birds).

Two pieces of comprehensive guidance on ecological mitigation measures that have been produced for road developments are English Nature's 'Roads and Nature Conservation' (1994) and the Highways Agency DMRB Vols. 10 and 11 (1994). Collectively they offer the following principles for best practice in the design and application of mitigation measures:

- Design for nature conservation should be considered in all aspects of landscape works and the opportunity taken for creating species and structural diversity in all types of vegetation, rather than concentrating on small nature reserves.
- All mitigation must be based on a thorough ecological survey to provide a full knowledge of the significance of the site and the anticipated impacts. Consultation with English Nature and the voluntary conservation bodies is essential.
- During construction, significant features close to the site can be safeguarded through clearly-stated conditions of contract, good contract management and good site supervision. The assistance of a landscape clerk of works can be a great help.
- Minimising pollution from the road requires engineering-led design solutions with the guidance of an ecologist. Translocation of vegetation should only be attempted after a scientifically-based feasibility study has been completed and evaluated.

An important approach to minimising fragmentation is through the maintenance and creation of habitat links between areas of fragmented or severed habitat. This is also regarded as essential for the conservation of ecosystems and biodiversity (as reflected in UK legislation and government policy e.g. PPG9, Habitats Directive, as discussed in Chapter 4). Maintenance of links can significantly reduce the number of species that incur high mortality rates as road casualties e.g. badgers, otters, birds, deer, bats, hedgehogs and other small mammals. Habitat links can be provided through the conservation and management of existing features such as hedgerows, linear woodlands, roadside verges or watercourses, or can be created via new planting and landscape design (Sowler, 2000). Guidance on species-specific mitigation measures is given for road planners and engineers in DMRB Vol. 10. A summary of the current knowledge is given below for the species thought to be most affected by infrastructure development.

### **Badgers (*Meles meles*)**

Badgers, protected under the Protection of Badgers Act 1992, are creatures of habit and will use the same paths within their territories for many years. When the line of a new or improved road crosses some part of the badger territory they will attempt to cross it. The only proven method for deterring badgers from crossing a road is the use of badger fencing, although no fencing used for this purpose may ever be described as badger-proof. In the past, a variety of fencing specifications have been used on road schemes, but experience has shown the most effective specification is for chain link or welded mesh fencing, attached to wooden post and rail fences using heavy duty staples. As a minimum this should be at least 1m tall above ground, with 600mm buried below ground (300mm down into the soil and a further 300mm turned away from the fence in the direction from which badgers will approach). Any gap or weak spot in the fencing may negate the entire package of protective measures. A combination of fencing, tunnels, underpasses and overbridges can be incorporated into the road design at an early stage, but the siting of these measures is fundamental to their success. Vol. 10 DMRB, Section 2, Part 5 (Badgers) sets out a good and bad practice for the design and location of these measures (Figures 7.3 and 7.4). It is known that tunnels placed only a few yards from the normal route will often be ignored, so

their accurate location is essential. As with other forms of crossings, rapid establishment of vegetation, creating a soft approach to the tunnel will encourage use. The issue of moving badgers is governed by the Wildlife and Countryside Act (1981) and the badger legislation (1992). Early consultation with English Nature is essential, as the process of identifying receptor sites and moving at the right time can be lengthy. In general, creating the right habitat conditions will allow animals to move in by natural colonisation, although soil transfer will bring in a large soil fauna.

*Badger mitigation case study:*

Wainhomes housing development scheme at Connahs Quay in North Wales was proposed in an area of known badger activity. An assessment was made of the foraging area that would be lost through development. As part of the mitigation package an area left undeveloped as a Greenway was recommended, which would be managed to provide foraging area for badgers adjacent to the site and as a general wildlife corridor. The Greenway would also link the two main setts adjacent to the site, ensuring that breeding could continue between the two populations. The housing development was surrounded by badger proof fencing with a new underpass under the main access road where badgers were known to cross. During implementation of the underpass, appropriate landscaping and fencing around the entrance to the tunnel was carried out, in addition to feeding to encourage its use. The perimeter fence is regularly checked and reinforced wherever badgers have been attempting to dig. The effectiveness of the underpass and Greenway is monitored by night watching using volunteers from the local badger group.



**Figure 7.3:** Ideal underpass design for badgers and otters using fencing to guide animals to the entrance



Figure 7.4: Badger tunnel and fencing, A35 Yellowham Hill

### Otters (*Lutra lutra*)

Otters, protected by the Wildlife and Countryside Act (1981) and The Conservation (Natural Habitats etc.) Regulations 1994, are most at risk from traffic when new or improved roads cross their home range, their dispersion routes, or their commuting routes between sea and freshwater. Early survey work should result in road designs which prevent severance. The most effective mitigation is to maintain an undisturbed river corridor by using a series of low bridges to cross the valleys (DMRB Vol.10, section1, Part 5 (Otters), allowing the otters to pass under the road when following the river.

Mitigation to reduce the impacts of roads on otters starts with a thorough and rigorous survey. (DMRB Volume 11 Section 3, Chapter 7). It is essential that an expert in otter ecology be employed in order to confirm the presence or absence of otters in an area of likely otter habitat, and to advise on and design mitigation at each site. Care must be taken that space is always retained between the road and river where they run parallel through a valley (50m is a suitable width to allow). Different areas of potential habitat should not be bisected without allowing safe passage for otters. Where possible, the road should be kept on one side of the river, reducing the number of crossing points. River realignment should be avoided where this will reduce the available habitat. If realignment is unavoidable, hardened margins should be kept to a minimum and a dry passage for otters should be provided. As many natural habitat features as possible should be retained, e.g. mature vegetation, and any habitat which is lost should be restored or recreated along the banks of the new channel. Wherever possible, sections of the redundant channel should be retained in a natural state and managed for otters, with safe passage provided between these areas and the new channel. The New Rivers and Wildlife Handbook (RSPB *et al.*, 1994) gives a list of considerations for such work, as well as more information on channel improvements and habitat restoration. River crossings should be treated with care so the river corridor is

not compromised. The identification of holts or couches, or other potential shelters, at the earliest stages of the design process can prevent their destruction by selecting a route that avoids these areas. The destruction of holts should always be considered as a last resort, as such sites may be rare in that locality. It is essential therefore, that the location of such sites is determined before final route is chosen, in order that alternative alignments can be considered. If destruction is unavoidable, confirmation must be obtained from the otter consultant that the holt is not occupied before any work is carried out in the area. In all cases where the holt shows signs of current use, the methodology for evacuation and mitigation must be agreed with English Nature or the equivalent statutory body.

The accurate siting of mitigation measures is essential. Ledges and underpasses should be placed in line with the natural paths of the otter along the river bank (Figure 7.5). To avoid having an underpass on both banks, planting on the opposite side of the river may encourage the otter to travel along the correct bank. It is important for the otter to associate the underpass with a road crossing, so the entrance should not be located at a distance from the road. Fencing should be used to guide the otter to the tunnel entrance and should be continued in both directions on both sides of the road. This is essential, or animals may cross the road and find themselves trapped, forcing them back on to the carriageway. The length of the fencing is difficult to define as it will be dependent on the topography of the site and the number of water courses, although most casualties occur within 100m of the watercourse. Fencing should also be used where the road bisects or passes between areas of otter habitat if an alternative route can be provided.



Figure 7.5: Otter culvert, A40 Haverfordwest, Wales

*Otter mitigation case studies:*

During the upgrading of the A74 between Abington and Moffat (from dual carriageway to motorway) Evan Water had to be diverted in 15 places. Otters were known to inhabit the Evan Water and tributaries. The affected stretches of river were surveyed for otter signs including footprints, spraints and holts. Although no holts were discovered during the



survey it was established that there was an otter population inhabiting Evan Water. Each river diversion was surveyed immediately prior to construction works commencing on site, to ensure that circumstances had not changed since the initial survey. To compensate for the lost habitat, a number of mitigation measures were established:

- the minimum amount of vegetation was cleared during enabling works;
- the landscaping works included large amounts of shrub cover;
- much of the cleared vegetation was left on the site to form temporary holts;
- ledges were built in the culverts to allow the otters safe passage during flood conditions;
- artificial holts were constructed in areas where the river was further from the motorway; and
- fencing was erected to prevent access to the motorway by otters.

Regular surveys were undertaken during construction work to ensure that the otters were still using the Evan Water, and monitoring of the population continues on a regular basis.

On the A49 Onibury-Stokesay, two artificial otter holts have been constructed to mitigate against the effects of the road on a river that runs parallel to, and within 150m of the scheme (Figure 7.6 and 7.7). The artificial holts aim to encourage otters to inhabit the area and increase in their range.

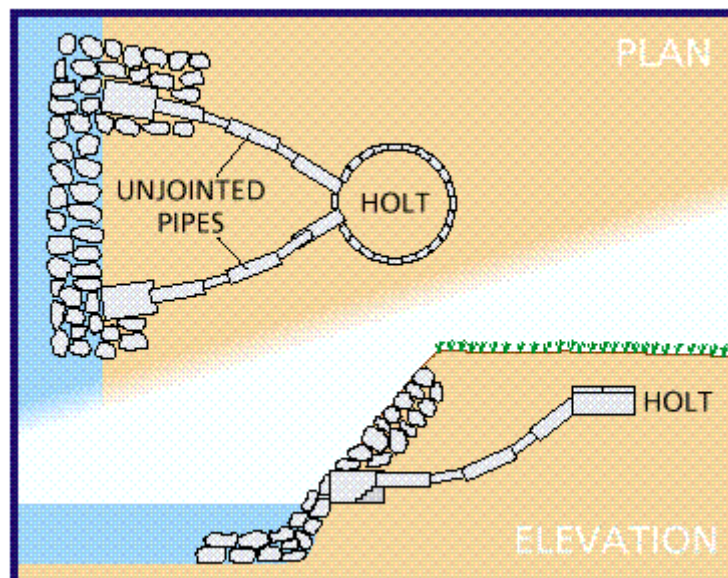


Figure 7.6: Plan and elevation of artificial otter holt

*Highways Agency initiative to help re-establish and safeguard the otter:*

Research by zoologists at the University of Oxford into deaths of otters on Britain's roads has led to the Highways Agency drawing up an advice note aimed at drastically reducing the number of casualties in the future. The Advice note advocates safe paths through river bridges under roads, fencing where roads run parallel to rivers, and otter tunnels where there are no other alternatives.



Figure 7.7: Installing an artificial otter holt

The recommendations are incorporated into the HA's DMRB, and work on modifying around 600 crossings on the network is set to start in 2002. A lot of the measures are relatively low-cost because they can be combined with other routine maintenance work on bridges. Newbury Bypass is one of 13 sites where determined efforts are being made to attract otters back to an area where they have not been seen for many years. The Agency and its design consultant, Mott MacDonald, have installed special fencing and 10 otter tunnels in a bid to prevent the animals from crossing over the bypass.

## Bats

Bats and their roost sites are strictly protected under UK and European legislation, and licenses are required for some activities likely to disturb them or damage/destroy their roosts. Activities relating to the development of land are not licensable however, and rely on defences in the Act. Bats are mainly nocturnal, using echolocation to navigate through their territory. The majority of British bat species use linear landscape features such as hedges and treelines to commute along. When the line of a new or improved road crosses traditional commuting flightways, special mitigation measures may be needed e.g. vegetated bat bridges, underpasses or tunnels, but in all cases linear planting corridors should be used to lead bats towards the crossings. Advice on mitigation for Bats is contained in an Advice Note of the DMRB (Vol.10) prepared by Cresswell Associates.

All highways operations should take account of the potential presence of bats by timely survey work and the development of appropriate mitigation. The potential effects of new road construction or road improvements include the loss of bat roosts, loss of habitat used by foraging bats, and severance of commuting routes during the construction phase. During the operational phase, effects include road traffic mortality and disturbance. It is possible to mitigate the effects of highways operations on bats by the provision of artificial roost sites, creation of feeding/commuting habitat, and the provision of safe routes to cross the road. Since many bat roosts are seasonally occupied, works should be timed to avoid periods



when bats are present. Where an existing roost would unavoidably be lost, consideration should be given to the provision of artificial roosts. In most cases, this is likely to involve the provision of bat boxes, which have been used widely in Britain since the 1970s. Eleven of the UK bat species have been recorded as roosting in them. Bat boxes are normally used in the summer or autumn months as mating roosts, and six species have used bat boxes as nursery roosts (pipistrelle (*Pipistrellus pipistrellus*), brown long-eared (*Plecotus auritus*), noctule (*Nyctalus noctura*), Leisler's (*Nyctalus leisleri*), Natterer's (*Myotis daubentonii*) and Daubenton's (*Myotis daubentonii*) bats). Alternative bat box designs include versions made of cement and sawdust, or of clay, which last longer than the standard wooden box. Various block or planking structures are easily constructed to attach to buildings or bridges. If a hibernaculum is to be lost, it may be appropriate to construct a replacement or to adapt an existing structure. Conditions within the existing structure should be carefully monitored prior to destruction in order that they may be replicated in the new structure. The most important design features for an effective hibernation site are:

- location and access (to ensure bats will find it during summer or autumn);
- high humidity (close to 100%);
- stable winter temperatures (within the range 2- 7° C, depending upon the species);
- suitable crevices for bats to hide in/ surfaces to hang from; and
- protection from predators (including people).

Alternative roost structures should be constructed as close to the original as possible. In some cases it may be appropriate to install artificial roost sites into bridges, particularly if the bridge is over water or over an access track or minor road. However, it is not usually appropriate to install artificial roosts in bridges over roads where bats may be encouraged into the path of on-coming traffic.

## Birds

The majority of bird species inhabiting an area will be adversely affected by the construction of a new road, either directly through severance and road mortality, or indirectly through disturbance and habitat damage. The importance of maintaining links for birds depends on the species concerned. Some birds are extremely vulnerable to impacts from road construction and may decline in both range and numbers if adequate links are not maintained. Other species have more adaptable behaviour and dispersal patterns, and are less affected due to their ability to cross gaps and colonise adjacent habitat. Specific mitigation techniques for birds involve the creation of connections between existing habitats, based on an understanding of minimum habitat area requirements and dispersal patterns for particular species. Links should be created and/or maintained to encourage birds to stay away from roads.

### *Bird mitigation case study:*

Nest boxes are sometimes used in association with road schemes. These can be for passerines e.g. tits (*Paridae*), Pied flycatchers (*Ficedula hypoleuca*), and for birds of prey e.g. kestrels (*Falco tinnunculus*). A successful example of the latter is along the M40 at Gaydon, where last year some 30 kestrel chicks, raised in nest boxes, were ringed. The boxes were provided as part of the mitigation package and sited on old trees and over flyovers at each motorway junction. Similarly, the A30 at Okehampton/Whiddon Down has

a nest box scheme which is intended to support a breeding of Pied flycatcher (*Ficedula hypoleuca*) population (although the boxes are also utilised by tit species). The site, purchased during the bypass construction, is largely oak/birch woodland and the RSPB is responsible for recording and holding annual nest box data.

## Amphibians

The UK has six native species of amphibian, three newt species, two toad species and one of frog. The great crested newt (*Triturus cristatus*), natterjack toad (*Bufo calamita*) and common toad (*Bufo bufo*) have declined greatly in numbers in the last century due to changes to and loss of areas where suitable land and water habitats occur together. Amphibians are afforded protection in Great Britain through the Wildlife and Countryside Act 1981, The Conservation (Natural Habitats and c.). Regulations 1994 and The Wildlife (Northern Ireland) Order 1985 (SI1985 No.171 (NI2)). It is widely accepted that amphibian species exhibit mobility in colonisation, and depend on the interchange between individuals at different pond sites in order to sustain their metapopulations (Boothby, 1995). However, in the UK few amphibian mitigation schemes have been reported in any detail. Examples of good and bad practice for amphibians in relation to route alignment and pond creation are shown in Figure 7.8.

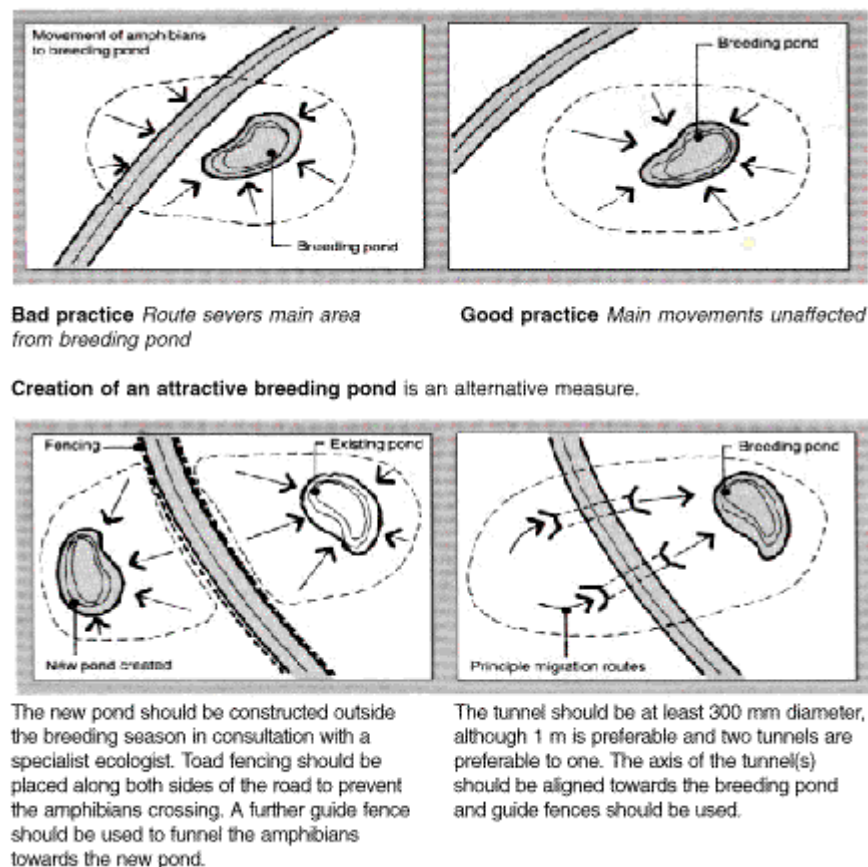


Figure 7.8: Mitigation for amphibians

The conservation of amphibians has become an increasingly important element for development projects, but until now there has been no definitive practical guidance on nature conservation management in relation to amphibians, but the Highways Agency has recently commissioned an Amphibian Advice Note for insertion into the DMRB (Vol. 10). The Amphibians Advice (currently in Draft form) recognises that roads, both existing and planned, may have a major impact on amphibians because of habitat loss and the effect that dividing up habitat and limiting dispersal has on their survival. There is increasing evidence that fragmented amphibian populations may suffer inbreeding, and some populations may decline or even fail to survive due to the direct loss or fragmentation of habitat. Amphibians may also be trapped and killed in a range of unfenced/unscreened drainage gullies and traps.

*Amphibian mitigation case study:*

Marshall *et al.*, (1995) report in detail on an amphibian mitigation scheme for the A34 (Wilmslow and Handforth Bypass) Cheshire, where a £206,500 scheme was implemented by Cheshire County Council to mitigate the impacts of the new dual carriageway on amphibians. This amphibian mitigation scheme is believed to be the most ambitious yet attempted in the UK, and has generated considerable publicity both locally and nationally. An extensive package of measures was put together comprising the protection and enhancement of terrestrial habitats, the construction of 17 new ponds and restoration of 6 others, the capture and transfer of 11,000 amphibians of 5 species (great crested newt (*Triturus cristatus*), smooth newt (*Triturus vulgaris*), palmate newt (*Triturus helveticus*), common frog (*Rana temporaria*) and common toad (*Bufo bufo*), and the protection of amphibians during and after road construction by fencing and tunnels. The road improvements form part of a link road for Manchester Airport, running through urban fringe, industrial areas, farmland and public open space. The Environmental Assessment highlighted the need to undertake further amphibian surveys of ponds situated on and adjacent to the route. These surveys identified pond clusters along the proposed route which were of importance as breeding sites for amphibians. 17 of the 64 ponds surveyed were due to be destroyed by the road, with 6 of these containing breeding populations of the great crested newt (*Triturus cristatus*), a species fully protected under Schedule 5 of the Wildlife and Countryside Act 1981. Table 7.1 gives a summary of the broader ecological impacts of the scheme.

Penny Anderson Associates were commissioned to prepare the detailed amphibian mitigation proposals (1992). The overall aim was 'no net loss to wetland wildlife arising from the construction of the new road' through replacing lost ponds and terrestrial habitat, maintaining and where possible enhancing the existing ecological value of retained ponds and terrestrial habitats, and minimising losses of amphibians of all species both during and after engineering works. Mitigation has been directed principally at sites which support populations of the protected great crested newt, and where possible measures were designed to retain amphibian populations in their existing locations. Separate measures were agreed by English Nature and prepared for each pond cluster. The package of measures are set out in Table 7.2.

Table 7.1: Summary of major ecological impacts, proposed mitigation and costs for the A34

FEATURES OF IMPORTANCE	IMPACTS	HABITAT CREATION	HABITAT RESTORATION/ MANAGEMENT/ TRANSLOCATION	COST OF WORKS (£)
Woodland	7,700m square lost	17 ha of new woodland planted		380,000
Hedgerows	4 km lost	17 km planted		80,000
Flower-rich grassland	1,200 sq. m lost	5 ha road verge sown with wild flower mix	1,200 sq. m translocated	9,750 (sowing) 6,000 (translocation)
Ponds	17 ponds lost Fragmentation of clusters	17 new ponds excavated	Restoration of 6 existing ponds	60,000
Riverine habitats	920m of channel lost	Installation of large culverts to allow re-establishment of natural processes. Natural river design of realigned channels.		
Bollin and Dean Valley Corridors	Disruption of ecological integrity	Minimise length of culverting		
Badgers	Two family groups effected through main sett disturbance, annexe and outlier sett destruction, and obstruction to foraging areas		Construction of 3,300m badger exclusion fencing along both sides of the road. Installation of 2 X 50m badger tunnels.	44,500 (fencing) 3,600 (tunnels)
Amphibians	Loss of 17 breeding ponds (6 containing great crested newts) and terrestrial habitat. Severance of territories.	17 new ponds	Improvements to 6 existing ponds. Capture and translocation of 11,000 amphibians of 5 species. Provision of hibernacula. Installation of 980m of permanent fencing and 2 X 45m tunnels.	92,000 (translocation) 24,500 (fencing) 30,000 (tunnels)
Earthworms	Loss of earthworms resulting in poor structure soils for planting.	27 ha inoculated to enhance drainage, aeration and soil structure	Turf plugs placed at various densities (screen mounds, embankments and cuttings).	7,500

Table 7.2: Summary of mitigation measures for the A34

MITIGATION MEASURE	DETAILS
<i>Pond excavation</i>	17 new ponds were excavated close to the road alignment, on sites with sufficient good quality terrestrial habitat and long-term security. Specifications for the new ponds were based on the findings of research work by Swan and Oldham (for the NCC, 1989) and Herpetofauna Consultants International (1991). The surface area of these varied between 300 and 900m <sup>2</sup> . Wherever possible excavated soil was taken off-site to minimise disturbance to the remaining terrestrial habitats. New ponds were filled by pumping in clean, fish-free water and appropriate aquatic and marginal vegetation rescued from the destroyed ponds was planted by hand and supplemented with native plants brought from local sources.
<i>Pond restoration</i>	6 existing but derelict ponds were restored by de-silting, re-grading to create shallow margins, removal of overhanging scrub and trees to reduce shading, removal of invasive marginals and removal of fish. Restored ponds were filled from a clean, fish-free water source.
<i>Amphibian capture and relocation</i>	The intended strategy was to catch as many amphibians of all species as possible by an intensive capture programme running from mid-February to late May 1993. This required capturing and translocating amphibians from both aquatic and terrestrial habitats that were to be destroyed or severely modified by the road. In addition, measures were required to temporarily exclude amphibians from areas which would be disrupted, and temporarily retain amphibians within safe areas until after the road construction was completed. Drift fencing (4.7km) and pit-fall trapping (700) were the principal techniques used to capture amphibians, alongside selective hand netting and bottle trapping. Once caught, amphibians, larvae and spawn were taken to a release site within the cluster group of existing and new ponds, surrounded by substantial areas of terrestrial habitat and enclosed by amphibian fencing. These 'safe' compounds prevented the translocated animals from moving into areas which would be disrupted by road development. Throughout the translocation programme an accurate record was kept of the captured amphibians detailing: date, site name, method of capture, life stage (larva, adult, immature), sex or sex class, point of capture and point of release. In total some 11,000 amphibians of five species were captured.

Monitoring of selected new and restored ponds has taken place in each of the three seasons following translocation (1992). The general trend is for the number of amphibians in each group of ponds to have been maintained or enhanced. The preliminary conclusion from the mitigation scheme is that amphibian populations can be sustained and even increased as long as programmes are planned well. An important factor is the need for sufficient flexibility to modify specific conservation measures in the light of monitoring results, and on the advice of trained amphibian ecologists.

### **Dormouse (*Muscardinus avellanarius*)**

Woodland and hedgerow management and creation is required in order to provide appropriate vegetation 'linkages' between dormouse habitat affected by transport infrastructure.

#### *Dormouse mitigation case study:*

The A2/M2 Cobham to Junction 4 Improvement Scheme in Kent includes specific mitigation for the dormouse. The proposals for mitigating the effects of the motorway

improvement have been set out in the 'Protected Species Strategy', designed by Cooper Partnership Limited (landscape Architects), and Cresswells (ecological consultants). The works have involved coppicing areas of dormouse habitat affected by the scheme, and this was done as an 'Advance Ecological Works Contract' during Winter 1998-1999. Subsequently a small number of fragments of motorway verge adjacent to some of the donor sites were identified as potentially suitable for dormice. Where possible, the coppicing works were extended to include these areas and where impractical dormouse boxes were erected in order to trap out any remaining individuals. Dormouse boxes were erected at the start of the active season (May 1999) and initially checked monthly. In the case of fragments of vegetation adjacent to existing donor sites, dormice were released in the nestbox in which they were trapped into a suitable habitat in the retained portion of the same wood. No females with pink young were moved due to the risk of abandonment. Before translocation, their condition was checked and if suitable for release they were provisioned with food in the nest box. 8 dormice were trapped and moved in this manner (by the end of October 1999) but there were still a few animals known to remain. Since dormice enter hibernation in early November the trapping would not be effective again until April/May 2000, representing a significant delay to the works. It was therefore recommended that coppicing using hand-held tools be carried out in an attempt to hand capture any remaining dormice, or at least allow any animals to escape during the active season. Although a time consuming process, this method aimed to prevent the danger of hibernating dormice being trapped in the area when the contractor begins work in Spring.

### **Red squirrel (*Sciurus vulgaris*)**

#### *Red squirrel mitigation case study:*

The preferred route of the Switch Island to Ince Blundell Highway Link, Merseyside, bisected an area of woodland inhabited by a population of red squirrels. RPS Consultants were commissioned by Sefton Metropolitan Borough Council to assess the potential impact of the proposed route in terms of the long-term viability of the red squirrel population on either side of the route after construction. The area of woodland was surveyed for dreys and squirrel activity. The results from the survey work and previous knowledge of squirrel population dynamics under various conditions were combined to assess the chance of the population surviving with the construction of the road. The principal effect of the road would have been to reduce the areas of foraging territory available to the squirrels. Additional planting of suitable species was recommended to compensate for the loss of habitat. Supplementary feeding was proposed while the planting reached maturity. RPS also recommended that the size of the population of red squirrels be monitored after the construction of the road to establish whether the predictive calculations were correct.

### **Deer**

Fences and underpasses or bridges can be used to prevent road casualties where this is a problem (see Chapter Six). Deer reflectors have been used as a deterrent, but their effectiveness over long periods is uncertain. Deer fencing is effective in channelling deer towards a road crossing point and in keeping them off the road for public safety. Well designed and constructed fencing is not conspicuous. Underpasses, constructed to the same

proportions as cattle underpasses, provide the best crossings and their location does not have to be as precise as for badgers.

## **Plants**

Some plant species are particularly sensitive to the effects of fragmentation. These include species which are poor colonisers e.g. many ancient woodland species. Links between habitats are important for plant dispersal and colonisation, with seeds carried by birds, and animals along wildlife corridors into new habitats. Roadside verges are often the only connection between areas of fragmented habitat and represent valuable corridors for dispersal. Non-specific ecological measures which may contribute towards the maintenance of habitat links include:

- the design of linear habitat links such as hedgerows, linear woodlands and roadside verges in order to maximise wildlife potential; and
- the design and construction of artificial and quasi-artificial links such as underpasses, tunnels and green bridges to maximise use by a wide range of species.

## **Watercourses**

Watercourses are important habitat links in their own right. The ideal nature conservation solution to watercourse crossings is to avoid any impacts on the watercourse and floodplain (i.e. realignment, culverting and tunnelling). Where this is unavoidable, river engineering provides opportunities for creating habitat to permit animal movement. Balancing ponds, designed to regulate the flow of runoff into watercourses, and constructed in association with road developments, represent a potential opportunity to create a landscape feature of wildlife interest. Marginal planting can be used to encourage birds and insects to the open areas of water. Examples of success include the A1(M) Walshford –Dishforth, where within 2 years of the motorway opening to traffic waterside planting has been established and the ponds are attractive to wildlife, and at New Inn Farm (Figure 7.9).

The DMRB offers advice regarding the design and management of balancing ponds (Figure 7.10). It advocates that good design needs sufficient landtake for flowing natural contours, with security fencing and access points integrated with the design. Shallow edges are necessary for vegetation establishment and membranes and concrete liners need to be well-buried. A commitment to proper management and maintenance is essential as wildlife will only become established if good water quality is maintained. Consideration should always be given to overdeepening dry balancing areas to ensure that they can provide a wetland habitat throughout the year.



Figure 7.9: New Inn Farm balancing pond



Figure 7.10: Good practice in balancing pond design M6, Lancashire. Shallow edges have created the right conditions for reed beds and wet grasses



## Habitat creation

Habitat creation often represents an attractive mitigative option for scheme designers, and is intended to compensate for habitats destroyed or damaged during infrastructure development. However, the practice of habitat restoration/re-creation is highly complex and successes are dependent on detailed planning and management. Planners face a number of decisions in addressing the process of restoration e.g. should topsoil be used, what species should be planted, how should the vegetation be distributed? A variety of guidance has been published that lays out the general principles of restoration and advocates the prioritisation of ecological considerations e.g. Oliver, Gilbert and Anderson (1998), DMRB supplements 'The Good Roads Guide' (DoE, 1993) and 'The Wildflower Handbook' (DoE, 1993), and English Nature (1994). With regards to habitat creation, the most important considerations are outlined below.

### *Habitat creation - wildflower meadows*

Unmanaged grassland with little visual or nature interest may be diversified and enriched with the planting of appropriate wildflower species. Wildflower areas may be provided in both new and existing schemes as part of improvements works. Such actions have visual benefits for road users and residents, provide habitat for insects and butterflies, and create 'nectar lanes' linking existing habitats (Figure 7.11).



Figure 7.11: Successful wildflower planting on rural bypass

### *Habitat creation - planting native trees and shrubs*

Planting native trees and shrubs in their natural associations can assist the creation of a range of linear vegetation types alongside roads. Such a planting strategy can help to integrate the road into the landscape, perform a screening function, and provides valuable habitats for native wildlife (Figure 7.12).



Figure 7.12: Mature planting in blossom

Woodlands planted alongside the M5 and M6 have been designed to reduce the impact of these major urban motorways (Figure 7.13).



Figure 7.13: Off-highway planting

Using HA funding, the National Urban Forestry Unit has implemented extensive off site planting (beyond the highway boundary) by agreement with adjacent landowners. The results include the creation of 63 hectares of new off-site woodland, which has significantly improved conditions for local wildlife, and created better views for road users.

In general, scheme designs should incorporate a package of mitigation measures that address the site-specific conditions. In some (if not most) cases, mitigation will be needed for more than one species. It is sensible to adopt an integrated approach under these circumstances e.g. combining the needs of badgers and amphibians, with the wildlife measures carefully designed and sited to benefit the widest range of species possible. An example of a comprehensive mitigation package is that produced as part of the CTRL and A2/M2 widening schemes. This has involved 3 carefully planned periods of advanced ecological works, to mitigate impacts on a wide range of species including (Rail Link Engineering, 1997):

- several bat species;
- dormouse (*Muscardinus avellanarius*);
- badger (*Meles meles*);
- tentacled lagoon worm;
- great crested newt (*Triturus cristatus*); and
- woodland.

More specific design issues associated with these various mitigation measures are discussed in the sections that follow.

### 7.3.1. Fauna passages

Wildlife passageways are a form of corridor developed specifically to facilitate the movement of wildlife species across roads, railways and waterways. Functionally, wildlife crossing structures are implemented with the purpose of:

- enabling the migration (animals) and dispersal (animals and plants) processes to continue;
- linking severed elements of a species home range; and
- reducing mortality (animal and human) due to road collisions.

It has been found that the species most likely to benefit from the construction of such passageways are those which:

- suffer high mortality due to vehicle collisions;
- show strong migratory behaviour;
- require large areas, both at the individual and population level; and
- are constrained in their dispersal by linear infrastructure.

(Reynolds, 1999)

In the UK, 5 broad types of wildlife crossing structure are currently in use:

1. Amphibian Tunnels
2. Ecopipes
3. Ecoculverts
4. Wildlife Underpasses
5. Wildlife Overpasses

### 7.3.1.1. *Amphibian Tunnels*

A variety of amphibian tunnel systems have been installed in the UK since 1987. Their position and size are critical considerations, as is the angle of approach by amphibians to tunnel entrances. Target species include frogs, toads, and newts, with tunnels being installed where annual migration routes to and from breeding ponds are severed by linear infrastructure. Amphibian tunnels may also be designed so as to accommodate larger animals such as badgers. This is often beneficial as it has been shown that in general the bigger the tunnel, the greater its chance of becoming successfully utilised (Langton, 1997). Designs for amphibian tunnels and fences are continually being developed, with the non-governmental organisation Froglife being one of the leaders in the field. Their work advocates that the most effective tunnels are rectangular, with diameters of 100cm for tunnel lengths of under 20m, and up to 150cm for tunnel lengths greater than 50m. Diameter can be reduced if the tunnel is made lighter by introducing an opening in the top, but disadvantages include traffic noise, dirt and water accumulation. It has been shown that for common toads (*Bufo bufo*), tunnel diameters of 30 to 40cms are sufficient, providing that tunnel length does not exceed 15m. Concrete tunnels are preferable to steel, PVC or other materials, and a layer of sand, humus or soil must be spread over the tunnel floor. Amphibian migration routes tend to be narrow, so the location of the tunnel is critical. Tunnels should be aligned as closely as possible with the direction of the migration route, otherwise animals become disoriented and stop migrating. At least one tunnel should be located at the heart of the migration route, with guide walls or fences used to lead animals to the tunnel entrance.

### 7.3.1.2. *Ecopipes*

There are many examples where ecopipes have been installed in the UK. However, in many instances, the success of these installations has not been assessed. Pipes of 30 to 40cm diameter are commonly used to provide wildlife crossing structures for small to medium sized mammals. In the UK they are often explicitly installed for badgers, but other species such as fox (*Vulpes vulpes*), rabbit (*Oryctolagus cuniculus*), hedgehog (*Erinaceus europaeus*), and pine marten (*Martes martes*) have been recorded using them (Reynolds, 1999). In Scotland, larger pipes of the order of 60 to 90cm diameter are used as otter passageways for road crossing lengths of up to 20 to 50m respectively (SNH, date unknown). Although research on the use of ecopipes by small mammals is sparse, the limited data available suggests that mice and voles appear to make little or no use of such structures. Without further research in this area it is difficult to assess whether the optimum material, location and size of the underpass has been applied.

### 7.3.1.3. *Ecoculverts*

Many small streams and rivers pass under trunk roads in enclosed culverts. These have traditionally formed barriers to wildlife due to the waterway becoming an underground channel devoid of vegetation and bank-side habitat. Opportunities exist to widen these culverts to provide space for wildlife to travel and to provide sufficient light for plant growth. Ecoculverts comprise conventional pre-fabricated concrete culverts to which raised ledges are added, thereby combining the drainage function with that of a crossing structure for terrestrial animals (e.g. hedgehog (*Erinaceus europaeus*), rabbit (*Oryctolagus*

*cuniculus*), badger (*Meles meles*), fox (*Vulpes vulpes*), water vole (*Arvicola terrestris*), wood mouse (*Apodemus sylvaticus*), voles and shrews), and amphibians (including frog, toad and newt). Best practice in design suggests wider and shorter culverts with wider ledges are used more frequently and by more species. Where specialised tunnels are to be used, the DMRB advises that these should be constructed of Class M 600mm diameter concrete pipes widened at the entrances if possible. Studies indicate that crossings will be more readily used if the approaches are ‘softened’ through the use of appropriate planting and if the floor of the ledges are comprised of soil or sand.

*Case Study - Culverts and Otters (Lutra lutra):*

The use of cylindrical culverts in road construction is well established as the quickest and most cost efficient way of spanning most water courses. However, cylindrical culverts represent a significant danger to otters because their design causes problems in times of flood. Cylindrical culverts fill rapidly so reducing the air space available at the top of the pipe and making swimming more difficult. If the watercourse is flooded, otters are more likely to avoid swimming due to the increased risk, and will instead attempt to cross directly over the road. In doing so, poor culvert design is thought to be one of the main causes for otter road casualties. The design of any culvert should therefore allow for plenty of air space above the water during times of flood, or if this is not possible an alternative route, such as an underpass installed above flood level should be provided nearby.

Culverts can also cause long-term damage to the riparian ecosystem as a whole, by removing the river bed and causing irreparable damage to bankside habitat. The loss of habitat removes areas of cover for otters and other animals, many of which may also feed on bankside vegetation e.g. the water vole (*Arvicola terrestris*). Damage to the river bed results in disturbed water flows, increased silting and possible reductions in fish populations due to damage to spawning grounds. These problems can be avoided by using box culverts which are larger than required for purely engineering reasons (Figure 7.14). The base of the culvert should be at least 150mm below the height of the river bed to allow the bed to reform, and planting on the banks along the culvert will help to re-establish cover.

Where it is not possible to allow a gap between the bridge abutments and the edge of the river then ledges should be incorporated in the design (Figure 7.15). These ledges can be used in bridges and culverts and can be built of solid concrete, or with a bolt on design using metal brackets and wooden planks or mezzanine flooring sections. All ledges should be at least 500mm wide, with a provision for the otter to gain access to the ledge from the water, either via the bank or by use of a ramp sloping down to below the water level. The ledge should be sited at least 150mm above the highest water level and allow for 600mm headroom. This will allow otters to pass through at all times and will also be a landmark, encouraging individual animals to use this route. As otters tend to use the bank for travelling, the ledge should be installed on the preferred bank as identified by pre-construction surveys. If such a preference does not exist, then otters should be guided to the crossing by planting dense scrub on the opposite bank to the ledge.



Figure 7.14. A 40 Haverfordwest, Wales. A typical cylindrical culvert.



Figure 7.15. Hole Bridge, Bovey Tracey, Devon. A ledge was incorporated into the bridge design during construction.



#### 7.3.1.4. *Wildlife Underpasses*

These consists of earth floored tunnels specifically constructed to permit the movement of wildlife beneath roads or railways. Depending on the target species (e.g. badger, deer) the structures range in diameter from 3 to 30m wide with a minimum height of 2.5m. The DMRB reports that underpasses suitable for badgers have been developed over a number of years, and if correctly sited on or near to an existing badger path, are proven to be effective. Studies have shown that badgers are fairly adaptable and will readily utilise a variety of different crossing structures including overbridges, culverts, agricultural bridges, and underpasses, provided that they are forced/encouraged to do so through use of appropriate fencing. Specifically, badger fencing is required at either side of the crossing point (preferably to a distance of 500m each side) and on both sides of the road.

##### *Case Study - Underpasses and Otters:*

DMRB provides detailed advice on the design of underpasses for otters. It advocates that where there is not room available to install a bridge with a ledge of the correct dimensions, an underpass should be constructed alongside and parallel to the river. The underpass should be located within 50m of the riverbank and above possible flood levels. The underpass entrance needs to be located near the road so the otter associates the underpass with crossing the road, and otters guided to the passage by means of a channel running from the riverbank to the entrance of the underpass. Fencing should be installed along the road, with rocks and other features included in the design to encourage otters to spraint (an indicator of the effectiveness of the mitigation). Underpasses should be installed in areas where the road passes between different types of habitat resource, such as a lake or reservoir and a water course, or between the sea and other potential otter habitats, or where areas of habitat will be bisected. This will allow otters to fully utilise the resources within their home range so that they will not be disadvantaged. Again they will need to be guided to the crossing by means of fencing and/or channels. The underpass should be constructed using a 600mm cylindrical pipe, to a length of 20m. In crossings over 20m in length, the width of the pipe should increase to 900mm so as not to deter the otters from entering. It is important that the underpass does not become water-logged. The pipes should be laid to falls and the joints between pipes should be sealed to prevent water seepage. The entrance to the crossing can be softened by the use of appropriate planting.

##### *Case Study - Underpasses and bats:*

Bats will use existing crossing points (such as culverts, side road and cattle underpasses, access tracks and pedestrian crossings) to cross roads. Where no suitable structures exist, new crossing points may need to be provided or existing structures adapted. Bats are more likely to use newly designed crossing points if linear planting 'corridors' are used to 'lead' them towards the entrances such that there is no break in cover. In exceptional circumstances, for example, where the traffic from a new road would be directly in the path of bats entering and leaving their roost, it may be possible to alter the vertical alignment of the road such that the bats existing flight path coincides with an underpass. Purpose-built bat tunnels may also be considered in circumstances where it can be demonstrated that bats need to cross the road (for example between their roost site and a valuable foraging area) and cannot do so by any existing structure. The form of this tunnel/culvert can vary but should be greater than 1m in diameter.

### 7.3.1.5. Wildlife Overpasses

Also known as ‘green bridges’, ‘landscape connectors’ or ‘ecoducts’, these structures comprise vegetated bridges designed and constructed specifically for the use of wildlife. They are installed to preserve the migratory movements of large mammals (primarily deer) and with greater awareness of habitat fragmentation effects, green bridges are increasingly being used to link animal habitats. Many countries in Europe and North America are well established in this field and have already installed a number of living bridges, but living bridges remain a relatively untried mitigation tool in the UK (with only 5 known examples: The Epping Forest over the M25, 2 overpasses on the Waterstock to Wendlebury section of the M40, Oxfordshire, and the 2 green bridges currently under construction as part of the Channel Tunnel Rail Link (CTRL) construction in Kent). The DMRB, as the primary source of advice on road crossings, junctions, bridges and environmental aspects of road design, contains no specific information on the concept of wildlife overpasses, so best practice relies on experience with the three existing schemes cited.

#### *Case Study - M40: J 8-9 Wendlebury to Waterstock, Oxfordshire:*

The construction of the M40 link in 1991 crossed an area known as Bernwood Forest, an area of high conservation value and known to have a high population of muntjac (*Muntiacus reevesi*) and fallow deer (*Cervus dama*). The M40 route cut across their regular migration routes and two overbridges were provided to encourage animal movements. Following construction of these structures, the opportunity now exists to monitor their performance and design. A research project commissioned by the Highways Agency is currently underway to assess the design details of the bridges and to examine the structures in more detail. It is proposed that site assessments will use the techniques of sand trapping and CCTV monitoring over a 12 month period, to assess the effectiveness and determine the performance of the overpasses.

#### *Case Study - Channel Tunnel Rail Link (CTRL):*

As part of the comprehensive mitigation package developed by CTRL, two land bridges (Temple Wood land bridge and Great Wood land bridge) have been constructed over the line of the new railway in north Kent, to provide a link between existing woodland on either side of the line (Figures 7.16 and 7.17). The bridges will be planted with a hedge of suitable species composition in order to promote, in particular, dormice (*Muscardinus avellanarius*) crossing. The design also includes an area of grass and track, which will allow deer, badgers (*Meles meles*) and other larger woodland mammals to cross safely. At present the bridges remain under construction, and at the time of writing (February 2000) the decks of both bridges are complete, with soiling due to commence in summer 2000, and planting with trees and shrubs planned for autumn 2000 (Michael Hall, Pers. Comm). Once the planting has become stabilised, a comprehensive monitoring programme will subsequently be put into operation, to assess the success of the structures. The monitoring will continue for long enough to establish the long-term effects of the construction and operation of the CTRL.

Experience from these two ongoing ‘green bridge’ initiatives will form the basis for establishing best practice to be applied in the construction of any future wildlife crossings.





Figure 7.16: Construction of Land Bridges over CTRL route (November 1999) (RLE)



Figure 7.17: Construction of Land Bridges over CTRL route (November 1999) (RLE)

The success of ecopipes, ecoculverts and wildlife underpasses and overpasses for mammals has been examined in detail by Janssen *et al.*, (1995). However, the success for reptiles and amphibians has not been very well researched in the UK (EN, 1995). In America, larger tunnels have been constructed for deer and large predators. Monitoring of these has shown that they are successful in reducing the road mortality rate and are used frequently by the target species. Rossell *et al.*, (1995) describe the taxonomic group requirements for wildlife passages as follows:

- Ungulates: structures with high dimensions and specific crossing points;
- Carnivores: woody or shrubby vegetation near to the entrance of the structures (which are at the same height as the surroundings);
- Lagomorphs: structures with a natural substrate base and a good view from the far side of the structure; and
- Amphibians: presence of a damp/wet substrate and dense vegetation at the entrances to the structure.

#### **7.4. OVERVIEW OF COMPENSATION MEASURES**

A series of English Nature guides describe the current position of habitat creation in the UK and make an important distinction between the three main approaches of habitat creation, translocation and enhancement (ENRR 1997; 1998; and 1999). EN observe that the key to successful habitat creation and translocation is a competent and experienced ecologist who fully appreciates the ecological character of the species concerned, and the processes that take place before, during and after disturbance. Modern road schemes tend to include substantial cuttings and embankments which offer opportunities for habitat enhancement, and providing something of value to nature conservation. A number of general principles have been advocated to maximise the success of habitat creation, notably the consideration of adjacent existing habitat and soil type in the choice of species to plant (Dove, 1997). It is also advised to consider future management before any habitats are designed or established, ensuring a long-term funding mechanism is in place to support the ongoing maintenance requirements.

##### **7.4.1. Habitat creation**

The HA has implemented a number of off-site habitat creation schemes (including areas of new woodland and wetland) as part of mitigation packages to address the impact of habitat loss. The DMRB (Vol. 10) gives specific guidance and advice on habitat creation and re-creation in the Nature Conservation Advice Note according to habitat type:

- Wetland and Aquatic Habitats;
- Grassland;
- Heathland;
- Woodland and Scrub;
- Rock Faces and Scree;
- Walls, Hedgerows and Hedgebanks;
- Shingle; and
- Urban.

For each of these habitats, concern is given to specific design issues including areas such as soil handling and treatment, choice of species, seed sourcing, timing of planting and management and aftercare. Best practice relating to the translocation and creation/re-creation procedures for some of these habitats is discussed below.

#### **7.4.2. Habitat Translocation**

Some plants and, occasionally, animals, can be moved after very careful planning, but such efforts have met with limited success. Attempts at moving should not be last-minute efforts, but adequately planned and researched. It is essential to carry out a very thorough study of the donor site so that a suitable receiver site can be identified and a full management plan drawn up before work begins. A receiver site must be suitable even if it is at some distance from the donor site. The most significant difficulty in translocating vegetation is recreating the right soil conditions. Two methods that have proved most successful are removal of the complete soil layer (where the soil is shallow e.g. those over chalk and limestone), and reinstatement in controlled layers, keeping all soil horizons separate, following the methods used in agricultural restoration. Very few translocation projects have been researched or monitored properly, and this is vital for enabling better practice to be developed. Timing is critical so the construction programme (in particular the advanced works) must take account of this. Properly-conducted translocation can be expensive due to the high labour requirement and the need for purpose-made lifting equipment. Provision must also be made for management, which needs to be flexible since much work is still experimental. Above all, specialist advice from English Nature, experienced ecologists and horticulturalists is essential. Some habitats are almost impossible to translocate (e.g. delicate wetland systems) as it is difficult to find suitable receptor sites, but higher rates of success have been experienced with the simpler habitats such as grassland, and to some extent woodland.

##### *7.4.2.1. Grassland translocation*

Three techniques have been tried and tested during translocation projects:

- lifting large turves with purpose-designed machinery and re-laying in the same way as turfing a lawn;
- lifting and laying individual turves and leaving intervening areas of bare soil; and
- skimming off and spreading a thick layer of topsoil with its surface vegetation (blading) to introduce seeds, roots and stems that will create a plant community similar to that on the original site. This technique depends on the right soil conditions and harvesting the bladed material at the right time.

The choice of technique must be determined on a case-by-case basis, according to individual site conditions and the scale and overall objectives of the project. Two successful grassland translocation schemes that have been documented are those on the M40 and at Twyford Down.

*Case study - M40 Grassland:*

Bickmore and Thomas (1999) and Bickmore (1992) provide a comprehensive account of the habitat creation programme associated with the M40 in Buckinghamshire. In 1990 an area of 4 ha of former arable land over clays was designed to create new grassland and scrub habitat for regionally rare butterflies, particularly the hairstreak (Morris *et al.*, 1994). This required the establishment of a network of scrub dominated by Blackthorn (*Prunus spinosa*) with species rich grassland patches in-between. Blackthorn was planted as shrubs, and the area sown with seed from a local species rich meadow. Monitoring of the grassland from 1991 to 1994 showed the initial dominance by annuals and ruderals to a more balanced flora including species such as Green-winged Orchid (*Orchis morio*) and Grass Vetchling (*Lathyrus nissolia*). Butterfly colonisation has occurred successfully with two of the hairstreak target species (*Thecla betulae* and *Strymonidia w-album*) becoming established and related to the establishment of the woody vegetation. Brown hairstreak densities increased throughout the monitoring period, becoming one of the largest colonies in Britain in 1993. It was proven that the area of sown grassland improved in importance for grassland species of butterfly within five years of establishment.

This project differs in three respects from most attempts to restore valued communities of wildlife to former arable land: (i) involving heavy clays rather than well-drained acid or calcareous soils (on which success is more readily attained), (ii) including scrub in addition to grassland habitats, and (iii) the specialised requirements of insects were incorporated in the design. It is too early fully to assess the success of a project that was expected to take twenty years to achieve fruition but the early results are encouraging. Further monitoring of the sward, insects, and the nutrient status of the soil is clearly needed to make a full assessment of the efficacy of the original design and subsequent site management. Already, the initial results suggest that it is possible to restore valued communities of wildlife to heavy, intensively-farmed lowland arable fields.

*Case study - Twyford Down SSSI (M3 Bar End to Compton) grassland:*

In February 1990 the decision was taken that the final section of the M3 motorway around Winchester, Hampshire, would follow a route through Twyford Down. A wide range of measures were employed to create rich communities of downland plants and animals on arable land left untouched by the motorway and on the verges of the new road. Preliminary surveys of the route and the surrounding SSSIs took place prior to any works, over the summers of 1991 and 1992 (ITE, 1997). The survey highlighted a valuable area of flood meadow in the Itchen valley which would be lost, so translocation was proposed. It also raised awareness of the opportunities to use the turf from St Catherine's Hill for downland restoration. Restoration methods aimed to create new areas of herb-rich downland with a characteristic rich invertebrate fauna, and specifically habitat for the chalkhill blue butterfly (*Lysandra coridon*). Restoration techniques included turf translocation (0.5 ha), seeding and use of plug plants. During turf translocation: 500m<sup>2</sup> of herb-rich turf were moved by traditional hand methods, supplemented by larger-scale macroturfing (moving turves 2.4m x 1.2m and up to 30cm thick). 260kg of seed was needed for the 6.5ha, and local collection of such volumes of seed was impossible so commercial seed mixes of known origin were used. Around 100,000 plug plants of 8 important butterfly food plants supplemented the seeding. Results of the two main projects are outlined below.

- *Hockley Flood Meadow, Itchen Valley*: It was intended to translocate the Hockley Flood Meadow from the path of the new road to enrich less species-rich meadows nearby. The receptor site, an area of poor, agriculturally improved pasture situated on an island in the River Test, was found 26km away. Careful measurements were needed to ensure the turves would be laid at the same hydrological level at the receptor site, which was stripped and prepared before the new turves were laid and packed down.
- *Arethusa Clumps and the redundant A33 downland restoration*: Topsoil was stripped to remove the nutrient rich layer and buried agricultural weed seed. Turves were cut by hand and bare areas seeded with a downland mix of 51 species or planted with plugs grown from local source material. All the downland restoration areas have been surrounded by rabbit and stock-proof fencing, which will remain in place until the habitat is sufficiently robust to endure animal disturbance. Apart from the newly created steep banks, all the created downland will require annual management if it is to develop a wildlife interest. A combination of grazing and mowing is proposed once the habitats are sufficiently established. A rich flora and fauna has developed quickly across the former arable land and along the 2km route of the A33 (the former Winchester bypass). The reconstructed chalk grassland bears a diversity of wild vetches, scabious and orchids, and a host of butterfly species, including the Small Blue (*Cupido minimus*), unknown in this region since the 1950s. Moreover the Chalkhill Blue Butterfly (*Lysandra coridon*), the *cause celebre* of early protests, has positively prospered on the site with two original colonies containing record numbers in 1996, being joined by a new breeding population.

It has been a major criticism of most previous attempts at habitat translocation and restoration that there has been little or no follow-up to ascertain the ‘success’ of the work. This means that little has been learnt about the processes involved or what can be done to improve methods for use in the future. However, at Twyford Down the HA is funding botanical and invertebrate monitoring (of all the reconstructed downland areas and translocated flood meadows) for a period of ten years to assess the success of the work and to give feedback to ‘fine-tune’ the management works. Monitoring will take place in the summers of years 1, 2, 3, 4, 6, 8, and 10 of the development of each area, and comprises a comprehensive range of fixed botanical quadrats to follow the progress of the developing sward. In addition, on the Arethusa restoration areas several invertebrate groups, including beetles, spiders, bugs and ants, are being monitored in order to assess the development of the downland fauna. The butterfly populations are being monitored by means of a standard ‘Butterfly Monitoring Scheme’ transect which is walked once a fortnight and takes in all the downland restoration areas. Preliminary results suggest that both turf translocations and development of turf from seed is progressing well, and the development of the invertebrate community is also following expected trends. The initial large numbers of early invasive species are decreasing, to be replaced by the true downland species.

#### 7.4.2.2. Woodland translocation

Woodland is the most complex and diverse of plant communities and cannot be moved as a complete habitat. Transplanting anything other than the smallest trees and shrubs is not recommended. It is far better to use nursery stock which is grown to be transplanted with a small root ball, rather than using naturally-grown trees with extensive root systems which will not survive lifting without prior treatment by undercutting. However, the movement of

woodland soils can be undertaken in the same way as that described for grassland. Blading of the woodland ground layer has been attempted with limited success, but it is still worth attempting with appropriate advice.

*Case Study - CTRL A2/M2 Ancient woodland soil translocation:*

Heliwell *et al.*, (1996) report on an ambitious project adopted as part of the mitigation package for the M2 widening works to move 11,000m<sup>2</sup> of ancient woodland soil to a designated area of Outstanding Natural Beauty. The ancient woodland stands in the way of the Channel Tunnel Rail Link (CTRL) works on the A2/M2 between Cobham and Gillingham, Kent. Using a novel approach to woodland creation, the project represents the largest translocation of ancient woodland soils attempted in the UK. The scheme had the potential to impact upon 19 woodlands which were classified as semi-ancient, amounting to a land-take of approximately 42 ha. In order to compensate for this loss, soil from some of these woodlands has been relocated to suitable receptor sites nearby, which are currently in agricultural use. The technique for translocation included spreading the donor soil over the receptor sites, and planting with trees and shrubs (grown from seed collected from the original woodland) and then fenced off. The receptor fields were prepared by stripping off the topsoil and loosening the subsoil to a depth of 400mm, in order to eliminate any remnant crop seeds and weeds that could contaminate the woodland soil and compete with the ancient flora it contains. Trees have been planted in single species clumps to mimic natural dispersal, with a hedge of predominantly Hawthorn (*Crataegus laciniata*) and Hazel (*Corylus avellana*) grown around the edge to provide shelter from the wind. The woodland types encouraged are Ash (*Fraxinus*)/Hazel (*Corylus*) or Oak (*Quercus*)/Hazel (*Corylus*) mixes, with smaller quantities of other species including Hornbeam (*Carpinus betulus*) and Field Maple (*Aceraceae campestre*). It is an objective that the new plantings will provide ideal conditions for dormice and link up patches of woodland along the southern side of the M2. Quantitative botanical surveys of the receptor sites form part of the ongoing 5 year monitoring programme to assess the colonisation of ground flora. At the end of the recording period 16 of the original 99 species had not been re-recorded, but 93 additional (mainly ruderal) species had been found. Of the remaining original species, several ruderals and some woodland species in the soil seedbank increased, but wetland species showed a decrease. Vegetation composition was seen to be affected both by the position of collection from the original wood, and by the maintenance regime adopted. The exercise appears to have been at least partly successful in establishing the original species, and certainly useful experience has been gained.

### 7.4.3. Translocation of protected animal species

Moving animals is a difficult, time consuming and costly procedure, only to be considered when all other options have been exhausted. For species of protected animals (e.g. great crested newts (*Triturus cristatus*); reptiles; and dormice (*Muscardinus avellanarius*)) which have relatively low capabilities for dispersal, translocation is the recommended method for mitigating loss of habitat. Translocation programmes should be implemented using best practice techniques agreed with English Nature. For some other species (e.g. badger (*Meles meles*), bats and birds) translocation is not recommended, and where an impact on such populations is identified, appropriate alternative mitigation measures should be implemented.

An example of a successful translocation effort is the amphibian mitigation scheme for the A34 Wilmslow and Handforth Bypass, Cheshire (see section 7.3). Here, the capture and transfer of 11,000 amphibians of 5 species has provided valuable information which can guide future amphibian translocation attempts. Translocation of protected animal species is also part of the mitigation package in the CTRL scheme (see section 7.4.4.2). For great crested newts (*Triturus cristatus*) new ponds will be provided to replace each known breeding pond which is lost. For dormice (*Muscardinus avellanarius*), trapping and woodland clearance works have been carried out to capture the population, before moving them to suitable receptor sites.

#### 7.4.4. Habitat Enhancement

The enhancement of existing habitat can also assist in mitigating the effects of any new transport proposals. Opportunities for habitat enhancement may occur on severed land or where land has to be acquired but is not needed for construction purposes. Restoration work should be designed to return disturbed habitat to at least its former quality and where possible to improve it. This applies particularly to rivers and wetlands, the degradation of which will adversely effect a wide variety of species. For example, where a section of river has been re-aligned, it should be returned to as near a natural state as possible. If bank reinforcement is required, hard vertical surfaces should be avoided as far as possible, and the use of gabions limited to small stretches of river. Alternatives for bank revetment include the use of log piling, woven hurdles, or faggoting. Trees such as Willow (*Salix*), Ash (*Fraxinus*) and Oak (*Quercus*) should be planted on the river banks to provide shelter in the future. Emergent vegetation and dense scrub such as Bramble (*Rubus*) should be encouraged to provide cover for wildlife. This may require livestock to be excluded from the river bank by fencing, except for discrete points where access to drinking water is required. The restored vegetation should have a species composition that is comparable with the local riparian flora. If the disturbed river banks include bends or meanders, opportunities exist for fencing on the inside of the bend and planting up this area with trees and scrub. Fencing and underpasses should be provided so fauna can utilise this area without being at risk from traffic. The aim should be to repair damage to the habitat and encourage animals to pass the potentially dangerous area of the road in safety. Attempts at habitat enhancement may be general, or species-specific. Habitat creation schemes particularly worthy of note for their value as best practice are:

- Bathampton Meadows (A4/A46 Batheaston to Swainswick): wetland/wet grassland with scrub;
- M4 Second Severn Crossing Approach Road, Monmouthshire: scrub and created wetlands;
- A5 Fazeley Two Gates: balancing pond;
- A564 Hilton bypass: mosaic of ponds and marshy grassland for amphibians;
- A38: grassland to benefit breeding skylark;
- A47 Norwich/Great Yarmouth: wet grassland; and
- M3, north of junction 3, Surrey: lowland heath.

#### 7.4.4.1. Habitat enhancement for bats

Schemes for bats should endeavour to preserve or enhance the availability of features which generate large volumes of insect food, as lack of continuity of the landscape, or the loss, fragmentation or degradation of habitat patches may pose a threat to bat populations. Where habitats of value to bats have been lost as a result of infrastructure development, these should be replaced on a like-for-like basis. Consideration should be given to the creation of new wetland or woodland features or the creation of new links between isolated patches of potentially valuable bat habitats. Normal pollution control measures such as petrol interceptors, silt traps and balancing ponds will also help to enhance the surrounding habitats for bats.

#### 7.4.4.2. Habitat enhancement for otters (*Lutra lutra*)

For otters, the restoration of scrub and reedbed habitats is desirable to encourage the siting of holts and couches. If old trees need to be removed the root systems could be retained as possible holts and any other wood stacked beside the river then used for log pile holts or bank revetments. Boulders and stone filled gabions, although not always ideal, can produce cavities which will also provide shelter. The building of artificial holts is sometimes suggested in areas of poor vegetation cover, particularly if the vegetation has been removed or damaged as a result of road construction. However, unless the safety of otters can be assured, it is unwise to place an artificial holt in the vicinity of a scheme. A consultant with experience in otter conservation will have designs of holts which can be adapted to suit conditions. Artificial holts normally consist of one or two chambered structures built from breeze blocks or log piles with at least two entrances. One entrance should lead into the river, sloping down to reduce the chances of flooding. Another entrance should provide an exit onto the river bank. Both entrances need to be well concealed. A successful example of an artificial otter holt is that alongside the Ely-Peterborough railway line, following flooding in 1998 which caused serious soil erosion to an embankment alongside. Repairs could not be carried out without destroying the habitats of several otters. Working with the contractor, May Gurney Construction, English Nature and other conservation consultants, Railtrack created artificial holts (otters' dens) from fallen trees to replace those removed during the works.

In addition to enhancement for bats and otters, the DMRB provides guidance on measures that can be implemented to compensate for impacts on:

- Mammals: (Badger, *Meles meles*; Dormouse, *Muscardinus avellanarius*; Pine marten, *Martes martes*; Red squirrel, *Sciurus vulgaris*; Scottish Wildcat, *Felis silvestris*; Water vole, *Arvicola terrestris*);
- Birds;
- Reptiles;
- Amphibians
- Fish;
- Invertebrates; and
- Plants.



#### 7.4.4.3. *Enhancement in the wider countryside*

In order to mitigate fully the wider nature conservation impacts of a transport infrastructure development an initiative called the Countryside Management Scheme has been (CMS) developed and tested in the UK. The pioneering CMS was linked to the Channel Tunnel Project and acted as a catalyst for the establishment of the White Cliffs Countryside Project (WCCP). The WCCP is a successful example of the co-operation between the private sector, local and county authorities and the local community, in working towards nature conservation enhancement. Further details of the CMS are included in section 7.6.3.

### 7.5. EXISTING QUALITY STANDARDS FOR MEASURES; JUSTIFICATION, MINIMUM REQUIREMENTS

The previous sections have confirmed that corridors, stepping stones and passageways have a potentially critical role to play in re-establishing lost connections in highly fragmented landscapes. But important questions remain over where exactly mitigation and compensation measures should be located in order to gain the greatest possible defragmentation benefits. Further design decisions relate to how big each structure should be, how many are needed and in what combination, and the exact manner in which they should be implemented and managed. These are just some of the many questions which ecologists and planners are currently trying to grapple with in the UK (as in many other parts of the world) in their endeavour to halt the process of habitat fragmentation. At present there are no formal standards to guide the design of mitigation measures, or to ensure consistency across the various transport sectors. The justification for implementing measures is usually based on the outcome of an Environmental Assessment (EA), a procedure which represents the only legislative control over the provision of appropriate mitigation. The relationship between the EA process and ecological mitigation is outlined below, with reference to roads (as this is the area where most work has been done).

In the past, road engineers have not found favour with ecologists, mainly because irreplaceable habitats have been destroyed by road schemes. To make it worse, there has been a lack of willingness by road engineers to take nature conservation seriously and to give it due weight in policies or practice (Box and Forbes, 1992). However the DETR and EN have co-operated at regional level to produce joint guidance for road engineers on the ecological impacts of road schemes (Forbes and Heath, 1992). Despite this, the DMRB remains the primary source of detailed guidance on the method of EA for trunk road schemes, providing comprehensive guidance on:

- the management and maintenance of existing vegetation (according to habitat type);
- contract management;
- methods for improving existing roads through new planting; and
- appropriate mitigation measures and good design (habitat creation, off-site planting, specialised fencing, tunnels).

A core body of independent researchers have employed a process of audit and review of ESs produced for road schemes, the most widely reported being those by SACTRA (DoT 92a) and the National Audit Office (NAO 1994). Others have focused on specific aspects

of the ES, such as the treatment of ecological impacts (Byron *et al.*, 1999; Thompson, 1997; Treweek and Thompson, 1997; Treweek, 1996; and Treweek *et al.*, 1993). These studies have widely criticised road scheme ESs for their significant deficiencies and short-sightedness. In a survey of 37 road ESs Treweek *et al.*, (1993) found that ecological assessment was often ‘woefully inadequate’, with many ESs failing even to meet the basic legal requirements of the Directive. The ability to assess the potential ecological impacts of road schemes was severely impaired by a general lack of baseline data, confounded by inadequate funding and lack of sufficient time (Glasson, 1999). These findings suggest there is an urgent need to improve the general standard of the ecological input to EA, and one of the methods advocated for achieving this is for ecological assessment to be carried out earlier in the planning and design stage of new roads. Box and Forbes (1992) have seen the process of liaison between highway engineers and conservationists as the key to ensuring ecology is given due consideration. Information flows need to be in both directions in order to build up mutual trust and understanding, with ecologists and landscape architects liaising daily onsite during construction.

Treweek and Thompson (1997) attributed the poor performance of mitigation to the lack of detailed ecological knowledge of species and habitat requirements. Under the UK legislation, developers are required only to recommend suitable mitigation measures, but the implementation of proposed measures is not subject to any formal regulation. ‘There is, therefore, no guarantee that ecological impacts will be mitigated in accordance with the undertakings made in ESs and the risk that significant adverse ecological impacts will go unmitigated remains’ (Treweek and Thompson, 1997). In addition they argue that no mitigation measure should be proposed without some indication of its likely effectiveness and decision-makers should not be expected to take recommendations for mitigation on trust, especially on specific areas such as ecology where they may lack expertise.

### **7.5.1. Design Manual for Roads and Bridges**

As noted above, the DMRB remains the primary source of detailed guidance on the method of EA for trunk road schemes, and provides the only indicative standards for the good design of appropriate mitigation measures (e.g. habitat creation, off-site planting, specialised fencing, tunnels). The Good Roads Guide is the name given to the series of documents contained in Sections 1, 2 and 3 of Volume 10 of the DMRB. The Guide is written in nine Parts each of which is published as an Advice Note:

#### Section 1 New Roads

- Part 1 HA 55/92 Landform and Alignment
- Part 2 HA 56/92 Planting, Vegetation and Soils
- Part 3 HA 57/92 Integration with Rural Landscapes
- Part 4 HA 58/92 The Road Corridor
- Part 5 HA 59/92 Nature Conservation
- Part 6 HA 60/92 Heritage
- Part 7 HA 61/92 Contract and Maintenance Implementation

#### Section 2 Motorway Widening

- Part 1 HA 62/92 Environmental Design Widening Options and Techniques

### Section 3 Improving Existing Roads

#### Part 1 HA 63/92 Environmental Design Improvement Techniques

The Good Roads Guide is not a step-by-step guide on how to build a road or a substitute for professional advice. It is intended to be used by the designer to help in the identification of areas and issues where careful consideration of environmental factors is required. The division of the Guide into Parts and the Parts into topics has been done to aid this process. Environmental design of roads is a matter of respecting the special character of each individual location. The illustrations included show solutions devised to meet the requirements of specific sites. The use of standard solutions, irrespective of the location, is not appropriate.

Although the DMRB only strictly applies to road developments in England, its principles are adopted in the other countries of the UK. In Wales the DMRB is supplemented by the publications 'Roads in Upland Areas: Design Guide' (Welsh Office 1990), 'Roads in Lowland Areas: Design Guide' and 'Rock Profiling and Vegetation Re-establishment' (Welsh Office, 1993). Similarly, the Scottish Office Roads Directorate endorses the practice given in the Good Roads Guide. More specific guidance is provided by the Roads Directorate's Landscape Officer. The Scottish Office discussion document published in February 1992 "Roads, Bridges and Traffic in the Countryside" addresses related issues. The principles set out in the DMRB are also endorsed as good practice by the Department of the Environment (NI), and are taken into account in preparing schemes for the construction or improvement of all roads in Northern Ireland.

#### **7.5.2. Standardising Design measures**

Recognition of the need to establish consistent quality standards for ecological mitigation has underpinned much of the research and development work being undertaken by the Highways Agency in recent years. It has been recognised that before any standards can be established, it is first necessary to have a greater understanding of the value and specific functions of each design measure. One project that has attempted to assess design and habitat features of value, is that by Ecoscope Applied Ecologists, who were commissioned in 1998 to undertake a review of the value of highways land to birds. The Stage 1 (February 1999) report presented a database of species habitat requirements and described design features, habitats and management which could benefit birds on highways land. The preliminary findings are summarised below.

The design features described by Ecoscope (1999) in relation to bird use include: road verges, cuttings and embankments, overbridges and ecoducts, rock faces/escarpments, balancing ponds, watercourses and riparian habitats, central reservations, lighting, roundabouts, design features in undulating and flat landscapes, designs to limit fragmentation and disturbance and nest boxes. The habitats described in terms of their provision and basic management (whether within the highway area or off-site) include: hedges, scrub, woodland, plantations, dry grassland (wildflowers), wet grassland, freshwater, brackish-saltwater, rock face-scrub, moorland/heathland, arable-cropped habitat, unvegetated ruderal habitat. Table 7.3 presents the recommendations forthcoming from the research, but it is important to highlight the fact that not all highway verges and land are the same width, or share the same physical or biological characteristics, so not all

recommendations may be applied to all cases. Table 7.3 merely gives a useful checklist to be used in conjunction with ecological survey results for guiding design and management

**Table 7.3:** A summary of road design features and habitats in terms of their positive and negative attributes for nature conservation (relating specifically to birds).

FEATURE	POSITIVES	NEGATIVES
Road verge	Best areas >25m from carriageway. Hedgerow with wide margin to road is best design, with hedge cut to encourage berries on side away from road. Grass and shorter scrub more appropriate in naturally open areas.	Design-out use within 25m to avoid collisions with traffic. Avoid rank habitat with litter close to carriageway which will encourage invertebrates and use by birds. Avoid tree cover close to carriageway on verge.
Cuttings and embankments	Rocky outcrops set back from carriageway may be useful. Scrub-grassland mosaic set >25m away from carriageway.	Avoid berry bearing shrubs on embankments at vehicle height.
Overbridges and ecoducts	Use to reduce fragmentation effects. Scrub-grassland mosaics over carriageway may provide cover for warblers/general passerines.	
Rock faces/escarpments	Best if set well back from carriageway.	Avoid berry bearing shrubs within height of vehicles.
Balancing ponds/borrow pits	More useful if set well back from carriageway (100-200m). Grass sloping shores, submerged aquatic and emergent macrophytes, scrub planting >50m from edge. Plant reed if in noisy location. Make the pond as large as possible.	Very small ponds may be isolated for birds, though may support 1 pair of Reed warblers for example.
Water courses, riparian habitats	Buffer habitat of grassland or scrub between wetland and carriageway to discourage birds entering road. Widened and flattened ditch margins.	Avoid road abutting right up to the edge of wetland.
Central reservations	Larger the better. Rank grass rather than trees and shrubs, to provide accessible habitat for Kestrels. If trees are used for landscape purposes avoid scrub edges.	Avoid planting berry bearing shrubs.
Lighting	Some species at coastal sea-fronts will use artificial lighting to aid deeding at night. Little is known of the ecological effect on individuals of this.	Avoid spillage into sites of nature conservation importance.
Roundabouts/interchanges	The larger, the better, providing more niches e.g. wetland centre and tall trees for breeding Rooks.	Avoid berry bearing shrubs and plantings right up to the carriageway. Retain existing trees where safe to do so.
Nest boxes	Tits, Pied flycatcher, Redstart, appropriate to geographical distribution. Useful in early stages of woodland planting. Kestrels also a good species.	Avoid establishing boxes for barn Owls too close to roads. Also ensure grassland management does not create situations where Owls are affected by road casualties or loss of food sources.

Design features in undulating landscapes	Provide off-site woodland, rank grassland mosaics, scrub and hedgerows for landscape purposes, at least 25m from carriageway. Woodland may, however, penetrate further to the road where traffic volumes are expected to be less than 5,000 cars per day. Natural forest edge should then be encouraged.	Avoid on single habitat type. Avoid regular cutting of large areas – cut in smaller blocks, and cut the first 25m from road where possible.
Design features in flat landscapes	Provide off-site woodland, rank grassland mosaics, scrub and hedgerows for landscape purposes, at least 25m from carriageway. Plant trees at c.50m from carriageway to aid flight of birds up over road. Woodland may, however, penetrate further to the road where traffic volumes are expected to be less than 5,000 cars per day. Natural forest edge should then be encouraged. In cuttings, plant scrub at the top edge to push birds to a higher flight path thereby avoiding collisions with vehicles.	Avoid on single habitat type. Avoid regular cutting of large areas – cut in smaller blocks, and cut the first 25m from road where possible.
Limiting disturbance	Noise reducing surfaces through sensitive sites. Also appropriate screening and noise buffers.	Prevent people being visible at sensitive sites.
Hedges	>1.5m wide set back from road.	Berry bearing shrubs on side of road.
Scrub	Set back >25m from road. Where embankment falls away below a road use grass verge, then scrub, and perhaps trees at the base of the embankment. Again this has the effect of pushing birds into higher flightpath. Have 50-60% open areas of a grassland mosaic. Manage as a range of ages and growth stages. Use of Gorse ( <i>Ulex</i> ) is valuable to wintering species as shelter, but needs to be at a distance from the road.	Maintenance to avoid encroachment (especially a problem with Blackthorn ( <i>Prunus spinosa</i> )). Cutting required on rotation of 5-8 years depending on local conditions. Where cover >75%, use by birds is less.
Woodland	Preferably planted at a distance from road, ideally 100-200m away. Roads with minor traffic can have woodland much closer to edge of road. High fertility ensures better tree establishment but can affect ability to establish ground flora. Retain dead wood areas. With larger plantings incorporate edges and glades within wood rather than on edge adjacent to road. Coppice management is useful within the wood. Use nest boxes to improve value to birds in initial phases. Regional provenance broadleaves will be most beneficial to local woodland bird populations.	If woodland is close, ensure few berry bearing shrubs along edge. Avoid coppicing along an edge with the road unless wood is set back >100m.

Wet grassland	Open habitats, wetland best located some distance from the road. Use screening where people may be highly visible. Provide a mosaic of short swards with drier patches, tall tussocky swards, larger wet areas (shallows), and limited grazing in breeding season where this can be accomplished. Consider ditch and tall grass buffer adjacent to road to prevent birds entering carriageway.	May need to incorporate fencing to prevent chicks wandering into road. Embankments of hedges in open wet grassland sites should be avoided. Prevent, through design, hydrological integrity being affected.
Freshwater	New or existing sites are better if >200m away from road. These also benefit from islands, promontories, extensive shallows, aquatic in-water and emergent macrophyte planting.	Small sites <0.25ha will have minimal interest. Bad practice would be to place a car park adjacent to a wetland without screening.
Brackish-saltwater	Largely estuarine sites. Likely to have high bird interest. Consider issues such as lighting, proximity of road to feeding areas and high tide roost sites.	Disturbance from vehicle movements, people and lighting.
Rock face/scree	Scattered scrub at a distance from carriageway.	
Moorland/heathland	Retain open character.	Avoid clumps of gorse too close to road. Avoid tall leggy heather along roadside.
Arable/cropped	Beyond a buffer zone (may be managed to prevent birds entering carriageway), incorporate low intensity farmed habitat, or weedy strips such as Conservation Headland. Also retain stubbles through winter. Spring cereals with undersown ley can be left for birds.	Winter cereals ploughed in after harvest right up to grass verge provide no habitat for birds at any time of year.
Unvegetated and ruderal habitats	Gravel areas and shorelines in off-site habitats. Weedy patches benefit seed-eating finches.	Avoid occurrence within 50m from busy roads (>500 cars/day).

Source: Ecoscope, 1999

The main gaps in knowledge identified during the course of Ecoscope's work were the lack of quantified information of the effects of different road designs, landscape features, plantings and layouts, on bird populations, and the lack of detailed information which could be applied generally across a range of topographic, geographic and human density conditions. These represent important areas of future research, which will form the baseline of information for developing design quality standards.

### 7.5.3. Technical guidance

Further technical guidance, other than the DMRB, may be obtained from a variety of private and charitable organisations. Such non-governmental organisations represent a valuable source of knowledge on issues such as soil handling, landscaping methods, and species provenance. Flora locale is an example of a non-profit making organisation that has

been established to promote and advance the conservation and enhancement of native wild-plant populations and plant communities in relation to creative conservation and ecological restoration. Its principal concern is to promote good practice in the sourcing and use of native plants for large scale projects, such as those associated with ‘naturalistic’ landscape construction, ecological restoration and native woodland establishment. As well as providing technical and non-technical advice, flora locale focuses on encouraging Government (at European, national and local level) to develop and apply policies that will promote the use of native plants of local native origin and local provenance e.g. in highway verge planting schemes. Millions of pounds are currently provided by central government for native plant schemes, but a large proportion of plants currently used are not sourced from within Britain. Expertise from groups such as Flora Locale will be vital to the development of successful quality standards, and their knowledge should not be overlooked when it comes to standard establishment.

#### **7.5.4. Government guidance**

For major infrastructure development projects (particularly railways) guidance on design measures is laid down by Government, and this invariably includes an environmental element. An example of a typical Government remit issued to a developer is that which has guided the design and construction of CTRL. This requires that:

- the route should be a two-track passenger line with potential freight capacity;
- its alignment should allow for construction of a line to large continental gauge;
- options bringing benefits to commuters should be considered;
- options for promoting development where appropriate should be considered;
- the views of relevant local authority officers should be taken into account;
- the costs and benefits of the project should be assessed against a realistic ‘do minimum’ case; and
- the robustness of the cost and revenue forecasts should be subject to a risk assessment (CTRL, 1994).

Although the provision of mitigation measures are not directly covered by the remit, it provides a general overview of the minimum ecological requirements and justification for the inclusion of measures to address specific problems.

#### **7.6. MAINTENANCE ASPECTS**

Maintenance of onsite ecological mitigation measures and areas of value or interest on highway land will normally be managed with the road. The Department’s Representative is responsible for the maintenance of the road and for incorporating the management and, where necessary, monitoring of the nature conservation features into the soft estate management plan for the road, and for regular survey and recording of the nature conservation value of the road. For offsite measures, the situation however, is not so clear-cut. The sponsor is normally held responsible for these for a specified length of time after

the project becomes operational, before transferring this to another party. The Highways Agency policy commits them to maintaining habitats created or translocated as part of mitigation for 3-5 years after establishment. They then aim to hand over the habitat to an environmental organisation (e.g. EN, the Wildlife Trusts) for long-term management. Such agreement has been made for management responsibilities to be transferred to the local wildlife trusts in the cases of Twyford Down SSSI and Bathampton Meadows. Similarly a community-based approach to pond conservation is being actively promoted following the A34 amphibian scheme in Cheshire and Lancashire (see Section 7.3). The project is being led by the 'Pond Life Project', which encourages the local people to care for their ponds and amphibians. Such local, voluntary agreements offer the best strategy for the long-term maintenance of mitigation measures. There are other schemes, however, for which no agreement has yet been reached and local wildlife trusts, the woodland trust or local authorities have indicated that they will not agree to maintain them without a commuted sum. HA anticipate an increase in the number of habitat creation schemes required by the statutory consultees as mitigation for improvement projects, therefore a consistent maintenance policy must be devised. Broadly the options are for the HA to manage off-site habitat creation schemes in perpetuity as part of normal routine maintenance, or for a standard agreement to be developed with third parties (e.g. EN, Woodland Trust, local wildlife trust, local authorities) and funded by HA. The financial implications of the long-term maintenance of a growing number of structures and sites are a great concern, and need to be budgeted for sooner rather than later. Forward-thinking is thus vital when proposals for new mitigation measures are being considered.

Effective maintenance can only be achieved through regular communication and liaison between the designer, contractor, manager and maintainer of a structure or site. Ideally this should include an understanding of why a particular area is to be managed in a certain way e.g. the cutting of a meadow after the plants have flowered and set seed. Timing is often crucial in the maintenance of wildlife habitats, so as to cause minimal disturbance to plants and animals. The reason for planting native species and the removal of invasive plants should be explained by those involved in maintenance. Similarly, how a simple act like a log or stump left to rot naturally, or a pile of brushwood can provide rich habitats should be explained. Over-tidiness should be discouraged as it is often harmful to wildlife as well as being costly. The labour intensity cost of maintaining ecological areas varies both according to habitat type and the formality of maintenance desired (Table 7.4).

Table 7.4: Differences between formal and ecological maintenance

FORMAL	ECOLOGICAL
Management Plan	Management Plan
Basic biological knowledge	Higher biological knowledge
Frequent and regular	Mainly infrequent and irregular
Highly mechanised	High use of hand tools
Few people involved	Large work teams possible
Repetitive	Less repetitive
Routine use of chemicals	Selective use of chemicals

Source: Nature Conservancy Council, 1988. (Tyne and wear Nature Conservation Strategy, NCC, Peterborough)



*Licensing issues:*

When considering maintenance issues, particular regard must be given to licensing issues relevant to any protected species that may be affected by activities. The DMRB provides guidance on such matters, but specific advice must be sought from the relevant statutory authority. For example, with regard to badgers (*Meles meles*), under the terms of the Badgers Act 1992, English Nature consider that all work (above and below ground) within 10m of a sett entrance, whether involving the use of machinery or of hand-held tools requires a licence. Where maintenance or management operations on the mitigation structures is required, advice must be sought from EN on the working practices to be utilised.

*Post-construction maintenance:*

The intensity of maintenance activity required to keep structures or sites in optimum condition varies according to the type of habitat or species involved. Naturally, some measures are more labour-intensive to maintain than others. Some of the issues involved in post-construction maintenance are outlined below.

*Bats:*

- Bat boxes: some boxes will become occupied by nesting birds, and those occupied by bats may harbour various ectoparasites. It is therefore important for an experienced, appropriately- licensed bat worker to clean out bat boxes annually, outside of the breeding season. If bat boxes have not been occupied within three years of erection, they should be moved to alternative sites nearby.
- Artificial bat roosts: where existing bat roosts have had to be altered, it may be necessary to ensure that certain physical parameters have not changed beyond acceptable limits. Factors such as temperature and relative humidity can be measured using thermistor probes and data loggers. Small adjustments to structures, such as the addition of insulation or the modification of ventilation, can then be made to adjust the physical conditions as necessary.
- Habitat management: the management and maintenance of habitat features of value to bats should form part of the routine management of roadside vegetation. Of particular importance to bats are: the maintenance of intact linear features and the re- planting of gaps; and the maintenance of good water quality and pollution control measures by routine inspection.

*Otters:*

- Post construction monitoring: following the completion of each project the measures installed should be monitored by an otter consultant to ensure their effectiveness. In areas where otters are known to be present, spot checks should be conducted on the different bridges, culverts and underpasses, looking for spraint. This survey should be conducted every week for a month after completion and then again after six months, and 1 year. This allows a measure of success to be recorded. If no signs are found, the consultant may need to expand the survey to see if otters are still using the area and to ensure they are not crossing the road elsewhere.

- The consultant should also look for other evidence, such as holes in fences, or other casualties.
- Other checks should include an inspection of the mitigation design to see if any defects are apparent. This could include holes, gaps in or under fencing, bolt on ledges coming loose, underpasses obstructed by stones or debris, flooding, and gates not closing properly. Any defects should be made good immediately. Members of the public and maintenance staff should also be made aware of the importance of recording all other casualties and that they will be collected by the Environment Agency. In Scotland, casualties are collected by the Institute of Terrestrial Ecology.

#### *Fencing:*

Fencing is prone to damage, either by vandalism, corrosion, traffic accidents or animals. Any breach in the fence negates the effectiveness of all other measures, so fences must be maintained intact. The fence should be checked every 6 months to ensure no breaches have occurred. Roadside fences should also be checked after any reported accidents on the stretch of road concerned. Grills used to prevent access to drainage systems should also be checked regularly and cleared of debris. If reflectors are used, they will need to be kept free of vegetation and cleaned every 3 months (more frequently in the summer). Underpasses and ledges should be checked every 6 months for obstructions or damage. Maintenance staff and managers should be made aware of the existence and location of mitigation measures for maintenance and repair schedules.

#### *Waterways Standards and Maintenance:*

Subject to its statutory obligations, British Waterways is required by the Government to operate and maintain its waterways to standards that reflect their intensity of use, and any land drainage requirements. *Waterway Standards* (British Waterways) details maintenance standards under seven core water channel categories. Standard 1 is appropriate for a busy river navigation with large river boats, Standard 7 is appropriate for a non-navigable waterway that might have high ecological value but no requirement for dredging. Alongside the water channel standards are four 'environ' standards (A to D) that relate to general maintenance of the surroundings such as towpaths, hedges, etc. Both water channel and 'environ' standards are further divided into infrastructure and on-going operation and maintenance standards. Infrastructure covers such matters as mooring sites, effluent disposal, signage, and car parking. Operation and maintenance covers such matters as operational presence, cleanliness, water quality, and general day to day maintenance elements. In addition, British Waterways has established standards for the structural integrity of all assets from bridges to embankments. To ensure these assets are kept in a safe and sustainable condition over their full life cycle, target conditions have been set and are regularly reviewed. The target conditions form the basis of an on-going asset management plan which identifies the level of investment required to secure the assets for the future. Overall British Waterways seeks to ensure that its waterways are maintained in a safe condition so that they do not impose unreasonable risk on users or neighbours. In setting standards British Waterways seeks to co-operate and work in partnership with the relevant statutory bodies to ensure standards are appropriate to heritage, environmental and public access aspirations. British Waterways issues and maintains an Environmental Code of Practice and a Biodiversity Action Plan to ensure compliance with its statutory

environmental and recreational obligations, and to give appropriate emphasis to environmental and heritage aspects in its management of the waterways.

*Environmental implications of maintenance:*

There are concerns that trunk road and motorway maintenance schemes, which alter the characteristics of highway land, can cause environmental effects both within and outside the highway boundary. In some cases this may lead to legal proceedings being undertaken against the HA and its Agents and/or Contractors. In order to reduce this risk the HA has issued draft advice on the environmental implications of its maintenance activities. This advocates that for future trunk road and motorway maintenance schemes, a check of all known information such as network surveys, LBAPs and surveys relating to other nearby projects should be carried out at an early stage to ensure that maintenance works do not:

1) cause a significant detrimental effect on:

- nearby properties and local communities in both visual and noise terms;
- water, air and soil resources including sensitive receptors;
- landscape and archaeology including protected areas and areas of local character;
- ecology and biodiversity including protected species, habitats and sites; or
- habitats and species listed in the UK Biodiversity Action Plan;

or

2) contravene relevant legislation, such as the Wildlife and Countryside Act, Habitats Directive, related to the areas in 1) above.

In addition to checking land within the highway boundary affected by the works, areas immediately adjacent to the works but outside of the highway boundary should be investigated. If there is a likelihood of a scheme having a detrimental effect on the area and/or a potential contravention of relevant legislation, then a walk over survey of the area by a competent environmental specialist from the Managing Agent and/or Contractor, should be undertaken at the earliest opportunity. There is a need to be aware that in certain circumstances (e.g. protected species) more detailed surveys may be required. Time and sufficient resources should be allowed a) to undertake the surveys, b) for official consultations with the Statutory Consultees (e.g. English Nature/ Environment Agency etc.) and c) for any additional works which may need to be carried out within the project because of these discussions.

Design teams should also consider, when designing the maintenance scheme, whether any environmental enhancements could be achieved e.g. better protection of watercourses, increasing the area of land suitable for nature conservation/biodiversity interests, without prejudicing other road related issues such as safety. Design teams should ensure that the results of any considerations are recorded on an appropriate file, in particular detailing the checks made, the results of those checks, and any actions taken (especially in terms of compliance with any relevant legislation).

### 7.6.1. Verge management

Verges can be valuable habitat. Herb rich verges within a landscape of intensive agriculture provide cover and foraging for a number of species. The rich flora and warmth give rise to a good invertebrate population which attracts small mammals (rodents) and birds. Roadside verges also contain significant areas of original woodland and new tree planting which may provide considerable deadwood, a resource that is limited and declining over much of the UK. However, there may be problems in managing this valuable resource for conservation whilst meeting the requirements of road user safety and maintenance access. As part of an integrated environmental quality plan, road operators must in particular maintain the grass verges whilst respecting biodiversity as much as possible.

Despite the great variety in structure and function of roadside verges, the common thread is that they all require careful management. The agent responsible for that management is determined by the law, which sets out the ownership rights to the land. Prior to the 1970s, the road verge was normally owned or tenanted to the adjacent farmer, or belonged to the Parish, and these parties managed the verge land through grazing or harvesting. Currently responsibility for maintenance of motorways and trunk roads falls to the Highways Agency, whilst Local Highways Authorities are responsible for all other public roads in their areas. Under this system they have a duty to manage the vegetation in order to maintain an efficient, reliable, safe and environmentally acceptable road network. The verge maintenance policy remains constantly under review, but financial considerations remain at the forefront, determining intensity and focus of the management strategy.

Atkinson's 'Highway Maintenance Handbook' (1997) provides a useful overview of UK highway maintenance operations. Two distinct aspects of highway maintenance are activities relating to engineering goals of the highway structures, and more general tasks such as grass cutting, hedge trimming and tree pruning. The grass cutting operations are themselves divided into two aspects: driven by i) safety and ii) amenity considerations. Specific maintenance policy is determined primarily by the level of finance allocated. In recent years the need for economy has reduced the frequency of routine cutting, and annual expenditure on routine maintenance tasks is now in the order of 12% (County) and 15% (District) of the respective highway budgets (Atkinson, 1997). The class of road and type of verge component also influence the approach taken (Table 7.5).

Maintenance has, in the past, largely depended on direct labour organisations (DLO) employed by the Local Authority. However, major re-organisation of local government means highway maintenance is now subject to competition (Local Government Planning and Land Act, 1980). In 1983 the Local Authority Association published 'Highway Maintenance: A Code of Good Practice' providing a range of standards for highways maintenance on local roads. In addition, the Trunk Roads Maintenance Manual (TRMM) (DoT, 1983) sets out a framework to be applied specifically to motorways and trunk roads. Together these Codes of practice, accompanied by departmental standards (e.g. HD15/87) lay down national objectives and standards for road maintenance.

Table 7.5: Verge Maintenance Policy (guidelines for current standard practice)

Rural	Visibility Areas	Two cuts/year plus a third cut where necessary to deal with fast growing vegetation.
	A and B Roads	One 900mm swathe cut/year plus a second cut where necessary to deal with fast growing vegetation.
	C and D Roads	One 900mm swathe cut/year but no cutting of verges on open land and in wooded areas where vegetation grows slowly.
	Sites of Special Scientific Interest	No cutting on approximately half the sites. One full width cut/year on the remaining sites every October.
	General	A full width cut every 4 years
Urban		As for rural highway purposes, but in amenity areas 4 full cuts/year. District Councils may wish to contribute towards the provision of higher standards.
Unwanted Weeds		Spraying to keep unwanted weeds under control.
Central Reservations		Spraying selective herbicides and growth retarders once a year.
Kerbs, channels, block Paving and footways		Spraying once a year to prevent the growth of vegetation.

Source: Kent County Council Highways Department (1999)

In March 1996 the Government announced that it was to instigate a radical shake-up of the 50 year-old road management structure by proposing that the 6,000 miles of motorways and trunk roads be opened up to private sector competition. Under the old system dating back to the 1940s, 91 LHAs acted as agents for the HA, and were indirectly responsible for all motorway and trunk road maintenance. Reorganisation has involved the shift of responsibility to 24 new motorway and trunk road agencies, chosen under competitive tender by the HA. The tendering process has opened up competition between private consulting engineers and Local Authorities, and there have been several partnering agreements developed. The new structure has emerged because the Government is transforming the HA from trunk road builder to road network maintainer and operator, under the integrated transport policy set out in the New Deal for Transport White Paper (1998). The new approach is for England to be split up into 'Super Agency' areas based on stretches of road, rather than according to the more traditional local council boundaries. Super Area plans are already becoming outdated, following the Government decision to de-trunk 40% (3,000km) of the trunk road network (announced in 1998) whereby responsibility for the de-trunked roads will be transferred to the LHAs. The Government will have to ensure sufficient finance is made available in order for this proposal to work. There is plenty of time to put the necessary framework and safeguards in place though, as the bulk of de-trunking is not expected to happen until 2002/2003, when the current super-agency contracts expire.

After de-trunking, the remaining network will be re-packaged by the HA into a four-region structure. The 24 Super Agencies and term maintenance contractors will be superseded by

single entity 'service contractors'. Consultants and contractors will be required to form joint ventures to deliver a defined level of service, bidding for 5-7 year contracts. Together, the joint managers will act as the 'road owner' to determine which maintenance and improvement projects are carried out on the network. The HA hopes that establishing this new framework and longer-term work programme will be the key to putting maintenance back at the top of the list of priorities.

A further recent change in approach to verge management seems to have been brought about by a growth in public awareness over general conservation issues. A variety of organisations (e.g. the Wildlife Trusts, the Council for the Protection of Rural England (CPRE) and the Farming and Wildlife Advisory Group) have expressed the opinion that once road safety considerations have been taken into account, verges should be managed for wildlife.

#### *7.6.1.1. Priorities for verge maintenance*

The main deficiencies in the management of highways maintenance found by The Audit Commission (1988) included a frequent lack of information on highway condition and inventories, unclear policies, inadequate funding, confusion between client and contractor roles, and the poor basis of many County-District arrangements. A lack of management information was considered to be the main problem, with around one quarter of highway authorities not possessing even an estimated inventory of its roadside resources (Audit Commission, 1988). In response to the urgent calls for an up-to-date inventory of the entire road estate, the Highways Agency is currently developing an environmental database, covering landscape, ecology and other environmental features and designations. The database aims to inform the strategic development of the network, and inform other HA initiatives such as route strategies. It is further hoped the database will be expanded in the future to encompass other environmental data relating to noise, and air and water quality.

### **7.6.2. Management of other surfaces**

Maintenance of the network includes a multitude of tasks e.g.

- Major repairs such as resurfacing and reconstructing roads and strengthening bridges;
- Minor repairs to surfaces and renewing white lines and road signs; and
- Routine regular activities such as cleaning signs and drains, changing light bulbs, grass cutting and clearing snow and ice.

Responsibility for these management and maintenance tasks is organised within the same structures as for verge maintenance (section 7.6.1). In terms of procurement of maintenance, the Highways Agency has been developing Private Finance Initiatives (PFIs) for capital works and forming 'super-agency' areas (as discussed in section 7.6.1). The new arrangements will ensure that routine activities and minor works will be carried out more efficiently and effectively. In addition 5% of the trunk road network is now covered by the maintenance obligations of the first eight Design, Build, Finance and Operate (DBFO) projects. HA continues to explore public-private partnerships to improve road maintenance. In particular the prospect for Maintain, Finance and Operate (MFO) contracts (long term

contracts for capital maintenance works and for continuing routine maintenance of a part of a network) seem a promising development of the DBFO concept.

### **7.6.3. Co-ordinating land-use in adjacent areas**

Off-site planting is used to screen property and public places at some distance from the road. Designers need to be fully aware of their off-site planting powers and the maintenance required to gain full benefit from this planting. Under Section 253 of the Highways Act 1980, the HA can enter into agreement with a landowner affected by a new trunk road for planting on his/her land. After a minimum three-year maintenance period, the landowner is obliged to maintain the planting for 25 years. Off-site planting is most often achieved on the land of people who wish to be screened from the road. Planting on third-party land where the owner receives no benefit from it can be difficult to arrange. Off-site planting is an opportunity not only to provide mitigation by screening but also to integrate the road with the landscape. Problems have arisen in the past on trunk road schemes where it has not been possible to provide the full required mitigation measures because landowners have been unwilling to allow them to be installed, or have failed to properly maintain this aspect of the accommodation works. An innovative solution to the problems relating to co-ordinating land-use in adjacent areas is the Countryside Management Scheme (CMS), which attempts to mitigate fully the wider nature conservation impacts of a transport infrastructure development.

#### *7.6.3.1. Countryside Management Scheme*

In order to mitigate fully the wider nature conservation impacts of the CTRL scheme and the adjacent A2/M2 widening scheme in Kent, a Countryside Management Scheme (CMS) (subsequently renamed the Rail Link Countryside Initiative – RLCI) was set up, following recommendations from English Nature and other statutory bodies. A primary objective of the CMS is to deliver a range of land management, landscape and ecological measures falling within the visual envelope of the CTRL and A2/M2 corridor, but outside the direct mitigation provided as part of the scheme. The CMS provides a means of co-ordinating off-line mitigation and of helping to implement agreed nature conservation and landscape strategies. A secondary aim of the CMS is to reduce the need for compulsory purchase of land outside the scheme boundary, and hence promote good relations with communities affected by construction. Union Railways are providing initial funding of £2 million, which is intended to sustain the CMS for at least 10 years, and the project is being overseen by a Steering Group (consisting of representatives from the Countryside Agency, the Environment Agency, English Nature, English Heritage, Kent County Council, Kent Wildlife Trust, Thurrock Council, the London Ecology Unit and Union Railways).

The scoping study for the CMS carried out by Entec in 1996, identified 243 possible projects for inclusion in the CMS along the full 108km length of the CTRL. The estimated cost of implementing these projects was around £12 million. Projects put forward for inclusion under the remit of the CMS covered a broad spectrum of environmental issues, including proposals to mitigate/compensate for specific and routewide issues arising from the construction and permanent operation of the transport proposals, and also any suitable known ongoing projects. A number of common themes have been identified amongst the 243 proposed projects as follows:

- Restoration and enhancement of derelict land and land severed by the transport proposals.
- Enhancement, protection and management of grazing marshes.
- Provision of a secure high tide wader roost on the Inner Thames Marshes.
- Restoration, management and public access to historic parkland.
- Creation of new woodland and management of existing woodland.
- Promotion of a market for rural goods and in particular coppice products.
- Restoration and creation of hedgerows and shaws along country lanes, public rights of way and traditional field boundaries.
- Habitat creation and landscape enhancement to wetlands and watercourses.
- Restoration and management of chalk grassland.
- Green corridors from urban areas in to the countryside.
- Environmental improvements in and around villages.
- Off-site planting to improve views blighted by the transport proposals.
- Promotion of environmental education through construction and operation of the transport proposals including a field studies centre.
- Development of community led projects.

Detailed criteria were developed in order to prioritise between the 243 possible projects. In general, those with nature conservation benefits were considered over and above the others.

#### *7.6.3.2. National Urban Forestry Unit*

The National Urban Forestry Units 'Woodlands by the Motorway' programme represents a further attempt at co-ordinating land-use in the environs of the transport development (NUFU, 1998). The scheme involved land within sight of a 26km stretch of the M5 (Junction 3 to the M6 interchange) and M6 (Junction 7 to Junction 10a) motorways in the West Midlands. The project partners were the Black Country Urban Forestry Unit (BCUFU) (now the National Urban Forestry Unit, NUFU), Department of Transport/Highways Agency, the Countryside Commission (now the Countryside Agency), Esso UK plc, Dudley MBC, Sandwell, MBC, Walsall MBC, Black Country Development Corporation, and various private landowners. The programme objectives were:

- to enhance the environmental quality of the principal road transport route through the urban West Midlands by maximising woodland cover on land within sight of the motorways;
- to improve the environment for people living and working close to the motorways; and
- to demonstrate a strategic approach to urban forestry.

The programme involved the planting of new woodland on a wide variety of discrete sites, including parks and other public open spaces, school grounds, derelict land, surplus industrial land, development sites and residential areas. It ran from 1992 until 1996, over 4 planting seasons and involved 225 separate sites ranging in size from 0.5ha to 30ha. Landowners such as local authorities, government agencies and private companies and individuals were required to take long term care of the new woodland in their ownership. Where planting was funded by the Highways Agency, a licence was required from the



landowner to ensure that the woodland remained on the site for at least 25 years. The overall achievement was that woodland cover was increased within the project area from 7.2% to 9.4% and over 4,000 local people were personally involved in the planting programme. In terms of wider application, intensive survey reveals a surprisingly large amount of land, much of which is suitable for the establishment of new woodland. The approach adopted in this project is therefore applicable wherever road and rail routes pass through urban Britain. 'Woodlands by the Motorway' is being used as a model for a similar strategic programme in the A4/M4 corridor in West London.

## 7.7. EVALUATION AND MONITORING OF THE EFFECTIVITY OF MEASURES

A review of proposed ecological mitigation measures in UK Environmental Statements suggests there might be problems under the current legislation in ensuring that ecological impacts are mitigated effectively. Treweek and Thompson (1997) reviewed 53% and 32.7% of all road Environmental Statements produced in 1990 and 1991 respectively, and report that ecological mitigation is widely acknowledged by developers, but the measures proposed do not always relate directly to the ecological impacts identified. A number of potentially serious ecological impacts often remain unmitigated. Treweek and Thompson also emphasise the lack of any generally accepted method for evaluating the likely *effectiveness* of proposed mitigation measures, despite a clear recommendation from the DoE (1989) that such a method should be developed. Concerns are also raised that the most important international and national designations for nature protection and conservation in the UK fail to act either as a deterrent to development or as a trigger for comprehensive mitigation proposals. A recent study by Chinn *et al.*, (1999) focuses specifically on determining the success of mitigation measures implemented as part of road schemes, in addressing adverse ecological effects on designated sites (e.g. SSSIs, NNRs) and the habitats of protected species. Only 3 of the 14 schemes studied were regarded as 'successful', these 3 being those most recently implemented. Chinn *et al.*, (1999) considered that the main reason for failure of many mitigation measures was inadequate management of the scheme and/or inadequate post-implementation management. It was noted that insufficient information (on the history, outstanding works and future management of the site) was made available during the 'handover' of schemes from one managing agent to another. Management beyond five years is usually required to ensure establishment, development and maintenance of the wildlife value of mitigation sites. Proper arrangements for the aftercare and continuing management of mitigation measures is essential to their success and should be considered a key element of the provision. Legally binding management agreements need to be made and funded for the long term management of the site and achievement of design objectives. It is proposed such management agreements should include (Salveson, 1990):

- a clear statement of the objectives of mitigation;
- a description of what action will be taken and when (e.g. planting proposals);
- a monitoring and maintenance plan and a contingency plan.

Monitoring is deemed to be the key element in the mitigation plan, a process that is severely neglected by developers at present due to the lack of a statutory requirement. Good practice dictates that ecological monitoring, funded by the developer, should be prescribed

in the ES, and conducted throughout the construction, operational and decommissioning phases of the project. In the short-term monitoring may seem expensive, time-consuming and unnecessary, but in the long run it will make environmental prediction more efficient and reliable (Hollick, 1981) and will improve the efficacy of ecological mitigation. In this light, Chinn *et al.*, suggest that further exploration needs to be made of the role of the county wildlife trusts in managing the areas. Legally binding management agreements need to be made, and funded, for the long-term management of the site, and there is also a clear need for on-site supervision by ecologists, to protect the most valuable and sensitive areas, especially during construction. At a broader level, SEA has been advocated as a tool that has the potential to create a more sustainable road planning system, steering development away from sensitive areas. By being carried out at an earlier stage in the decision-making process (i.e. assessing plans and programmes) SEA can ensure that mitigation measures are adequately assessed and the most ecologically sensitive measures are designed, implemented managed and monitored.

### 7.7.1. Developing best practice

To date there has been little systematic monitoring of the long-term changes that follow a major infrastructure scheme. However, a limited number of examples are available which provide best practice guidance.

#### *Case study – CTRL:*

One such example is the CTRL project, where an extensive monitoring strategy has been developed in order to assess the effect of the railway on residual and translocated habitats and species (Rail Link Engineering, 1997). The objectives for monitoring the existing habitats are to:

- determine the effect of construction and operation at selected sites;
- confirm that mitigation measures are successful; and
- provide additional baseline data against which the successes of compensatory habitat creation works can be compared.

Monitoring began prior to construction, in 1997, and will continue until 2007, although the duration of monitoring varies for different species e.g. breeding birds will be monitored between 1999 and 2007, whilst reptiles will only be surveyed for 3 years following translocation. Sites for monitoring were selected using the criteria listed below:

- priority species as defined by members of the Environmental Forum;
- distinct and good example of a particular type of habitats;
- particularly valuable or sensitive sites;
- distinct example of a particular impact or effects;
- subject to a significant effects;
- distribution along the length of the CTRL route; and
- readily accessible with landowner amenable to the monitoring methods identified.

The complete monitoring strategy covering the habitat works (380ha of grassland, 230ha of woodland, 25km of hedgerow and 9ha wetland and 3ha floodplain forest) is published in

the CTRL Technical Report (1999). To adhere to the Environmental Minimum Requirements imposed on the project as part of the development agreement, this monitoring will continue for long enough to establish the long-term effects of the construction and operation of the CTRL.

*Case study - The Skye Agreement:*

The disturbance of wildlife was a serious consideration during the design and construction of the Skye Bridge. Mitigation measures were provided to reduce the effect on the otter population. A post-construction study is now underway to assess the effectiveness of the mitigation measures. In April 1999 a workshop was held to present the preliminary findings (Black, 1994). The following points were agreed:

- *Contract certification:* future construction contracts shall include wildlife mitigation measures, design, implementation and maintenance check certificates. These certificates shall be signed by the wildlife professional responsible for the scheme.
- *Provision of multi-use wildlife mitigation measures:* after giving due consideration to the specific mitigation needs of individual species, further consideration shall be given to the needs of other species and habitat fragmentation in the wider road corridor with a positive aim of providing multi-purpose mitigation measures.
- *Wildlife crossing opportunities:* all underpasses and overstructures shall be designed and located so as to maximise the opportunity for wildlife crossing whilst not impairing the function of the structure.
- *Dimensions of wildlife tunnels:* the professionals responsible for the design of badger and otter underpasses shall recommend the size of pipe or other form of pass.
- *Mitigation measure management:* road managers responsible for wildlife mitigation measures shall be given information and training about wildlife needs. Mitigation measures shall be inspected regularly and remedial actions that are required defined in Landscape Action Plans. At defined intervals performance shall be assessed by a specialist and where necessary recommendations for change made.
- *The need for temporary or permanent measures:* professional consideration shall be given to assess whether expensive mitigation measures shall be provided where experts agree that population fragmentation will only be affected in the short term and then not seriously. Temporary measures shall be considered in such circumstances.
- *Provision of artificial otter holts:* artificial otter holts shall only be constructed in exceptional circumstances. Where they are considered necessary by an appropriately experienced wildlife professional, they shall be constructed of natural materials and need not necessarily be below ground.
- *The appearance of wildlife mitigation measures:* the wildlife professional, engineers and a landscape architect shall work together on the design of wildlife mitigation measures so that impacts on landscape character are minimised.

- *Public information*: consideration shall be given to the provision of public information, through literature or signage on wildlife mitigation and biodiversity aims.

### 7.7.2. National monitoring

Scotland is the only country that has completed the production of a national inventory of all the mitigation measures in place on the trunk road network. It comprehensively catalogues the location, features and condition of the individual measures, and lists their management requirements. Such a document represents a valuable resource that can guide the continual evaluation of the effectiveness of mitigation measures, but requires significant commitment to keep the information up-to-date. Similar efforts are being progressed in England, to complete the coverage of the information base.

## 7.8. SUMMARY

Mitigation should never be viewed as a substitute for avoiding ecologically sensitive areas in the first place. In planning new roads which cut across the territories of wide ranging animals, however it may prove difficult to avoid adverse ecological impacts. In such instances every effort should be made to reduce fragmentation and barrier effects through sensitive road design and construction, and the incorporation of comprehensive conservation measures. The successful outcome of mitigation depends on a number of factors such as:

- *advance planning*: the preparation of detailed proposals, drawings and timetables, based on adequate survey information is an essential precursor to any mitigation scheme;
- *flexibility in the mitigation programme*: requiring retention of competent ecologists to monitor mitigation measures, instigate immediate action to remedy unforeseen problem and to co-ordinate closely with the road engineers;
- *land availability and co-operation of landowners*: in the UK compulsory purchase powers are available to local authorities under the Highways Act 1980 for 'mitigating adverse effects' and may be used by agreement to acquire land to mitigate habitat damage via offsite ecological works; and
- *commitment to the long term maintenance of conservation measures*: only structures within the highway curtilage remain the responsibility of the Highways Authority and subject to routine maintenance. The long-term survival of offsite ecological measures cannot be guaranteed, and local individuals need to be encouraged to become involved in their maintenance.

The earlier in the process that ecologists and conservationists are consulted, the easier it is likely to be to incorporate their views, and minimise unnecessary impacts. For example, in the enquiries into the Birkham Wood by-pass (Yorkshire) it was accepted by the highway authority that had the full value of the wood been made clear to them earlier in the route planning process, an option that avoided the wood altogether might have been possible.

Unfortunately the Nature Conservancy Council (as was) were late in realising the significance of the site and only minor improvement to the road route was possible. Decisions had to be made as to whether a short route through a rich area of the wood was more damaging than a longer route through a poorer area, and whether splitting the wood into a large and a small section was more damaging than creating two equal sized (14 ha) blocks. EAs should pick up the presence of sensitive sites but by the time these are complete the broad route corridor may already be fixed.

Some principles for better management of biodiversity include:

- avoid crossing areas with a high degree of biological and landscape diversity;
- control related operations which result in larger areas being affected;
- use the areas affected directly or indirectly by the road to encourage biological and landscape diversity;
- integrate the affected areas as far as possible into biological and landscape systems by creating interfaces and continuities with surrounding environments; and
- control road operation procedures in order to maintain in the road corridor the highest possible level of diversity compatible with technical and safety requirements.

Basic principles for better site management are to:

- draw up ecological specifications for managers;
- designate a site manager responsible for environment quality;
- plan site work in the light of seasonal biological cycles;
- confine work sectors to the minimum area necessary; and
- provide for ecological monitoring of the construction site.

There is no doubt that habitat creation is a developing science but there is far more written about the subject than has actually been put successfully into practice. This review has revealed that only a small proportion of restoration projects are being properly recorded and published, and that there is a fundamental lack of ecological scientific information and documented practical examples relating to the topic (Parker, 1995). The few follow-up reports show that the resulting habitats do not appear to be self-maintaining and they require very heavy management. The underlying problem is that the theoretical science upon which restoration ecology is based is weak (Bradshaw, 1983; Harper, 1987; and Wilson, 1988), therefore repair of damaged ecosystems cannot be perfect. In the 1990s the value of ecological restoration has been brought into question with EN, in particular, arguing that restoration can never compensate fully for the value of lost habitats (Gillespie and Shepherd, 1995). In specific relation to road environments EN argues (1995):

- new habitats cannot replace ancient ones of importance lost through road construction;
- the roadside banks are a pollution-stressed environment, and do not provide ideal conditions to which plants and animals should be attracted;
- the road remains a barrier and death trap to many species;

- there are limited number of habitats that are suited to roadside banks (due to the soil conditions); and
- new habitats are often crude and rather bland approximations to the 'real thing' (due to the present limits of ecological knowledge).

With regards to the role of EA in the creation of species-rich habitats, the major concern is that it is currently being applied too late in the planning process, and a short-sighted 'build it and forget it' approach has resulted (Culhane, 1993). While the need for ecological monitoring and EA follow-up is widely acknowledged, it has been much neglected to date. Glasson (1999) emphasises that discretionary measures are not enough; monitoring and auditing need to be more fully integrated into EA procedures on a mandatory basis. Until this happens, an essential first step is to ensure the proposed mitigation measures match the impacts that have been identified (Treweek and Thompson, 1997). Failure to recommend mitigation measures for significant adverse ecological effects is clearly unacceptable, as is the use of cosmetic measures such as tree planting to substitute for wildlife habitat.

Pienkowski (1993) suggests national environmental datasets are required that provide 'reasonably complete and uniform national coverage' on the distributions of habitats and species, if the real impacts of roadbuilding are to be evaluated. Such datasets would simultaneously help to address the emerging concerns that a broad regional view of habitat creation is not being taken (Zedler, 1996) and that landscapes are being re-configured, with landscape-scale patterns of biodiversity being adversely affected. Planning and monitoring of restoration needs to be done on a regional scale to ensure that appropriate habitat replacement is taking place, and this is where SEA could prove so useful. A further recent development is the emergence of Ecological Impact Assessment (EcIA). Treweek (1999) gives a comprehensive commentary on the status and prospects for EcIA, suggesting the following for raising the overall standing of ecological input in the EA process:

- review of ecological input by independent ecologists;
- formal monitoring of project impacts;
- official guidance for standard sampling and survey methods;
- minimum requirements for quantification of predicted impacts (e.g. habitat loss);
- mandatory post-development monitoring; and
- injection of resources into development of local, regional and national databases.

Complaints over the general lack of ecological information available to assist EA are seemingly justified, with Treweek (1996) amongst others, considering that deficiencies in the EA Directive (97/11/EC), particularly ambiguities in its wording are responsible for these shortcomings. Further review and amendment to the Directive is required to take into account the recommendations set out above, especially those relating to the requirement for post-project monitoring. This is likely to be a lengthy process, so in the meantime it is the responsibility of member countries to promote best practice in the design, implementation and monitoring of mitigation and compensation measures.

## Chapter 8. Habitat Fragmentation and Future Infrastructure Development

### 8.1. INTRODUCTION

The impact of new infrastructure developments has been vigorously debated at both a national and local level in recent years. The latest national policy guidance on transport (PPG13) recognises the need to ‘strike the right balance between securing economic development, protecting the environment and sustaining the future quality of life’. Whilst the limits to traffic growth and road development have been recognised, there will still be a need to build some new sections of carriageway (i.e. widening and upgrading) and maintaining the existing infrastructure will become even more important.

Infrastructure development may be a relatively minor (although not insignificant) cause of direct habitat loss, but its linear nature makes it a more serious problem in terms of habitat fragmentation (Kirby, 1995). Even if a track or line is sufficiently small that the fragmentation effect when it is first created is minimal, there is a risk that it will be upgraded in future. A single lane road may be widened to a dual carriageway or motorway, with changes in its surface and levels of traffic use. Infrastructure development poses distinct problems in fragmentation terms therefore because even if the initial impact is small there may be subsequent increases in the nature and width of the barrier created. In Southern England the orbital motorway around London caused major fragmentation of ancient woodland when it was first built (Table 8.1). Now extra lanes are proposed for sections of the route and further damage to some of these woods is unavoidable.

Table 8.1: Fragmentation of woodlands caused by the M25

SIZE CATEGORY (HA)	NO. OF WOODS IN EACH CATEGORY					
	0	1-5	6-10	11-20	21-50	51-100
Area c.1930		8	8	9	9	2
Area c.1985	1	29	14	6	7	2

Source: Kirby and Thomas, 1994

Sometimes expansion along the existing line may not be possible and a completely new route chosen, which while in itself may cause new fragmentation may also allow restoration of the old route. While damage to both nature conservation and archaeological interests was caused by the new section of the M3 motorway in Hampshire, parts of the road have now been taken up, allowing the restoration of at least something of a grassland link between two parts of a previously fragmented site.

### 8.1.1. The effect of road density

Very high road densities such as in Southern England tend to occur in areas which have relatively little surviving natural or semi-natural habitat. In such landscapes the choice of new road routes and expansion of existing ones may be severely constrained because alternative land uses (e.g. urban, intensive agriculture) are very high value. For example, in south London the only feasible alternative to a road through Oxleas Wood was a tunnel. In such constrained landscapes, most of the species sensitive to habitat fragmentation are likely to have already disappeared, but any that are left may well be pushed beyond their viability thresholds if further fragmentation occurs. The opposition to further fragmentation of what is already a scarce resource is likely to be high, and at Oxleas it was sufficient to lead eventually to the cancellation of the scheme. If fragmentation does occur, the potential benefits from habitat creation or other mitigation works are likely to be relatively high because of the generally low wildlife interest of much of the surrounding landscape. Where road densities are low and the extent of semi-natural vegetation is high (e.g. Scandinavia, mountainous regions of southern Europe) disturbance from infrastructure development may be relatively small, with only the most sensitive species likely to be affected. However, the greatest impacts on nature conservation interests are found in landscapes where sufficient natural and semi-natural habitat exists that all routes are likely to involve some damage to sites. In these circumstances fragmentation is likely to have already put some species close to their limits (so further fragmentation may lead to rapid decline), but the relative benefits from mitigation work are likely to be small (unable to compensate for lost areas at least in the short term). The case of the A34 Newbury bypass in Berkshire provided a good example of this dilemma, with one of the proposed routes having major impacts on heathland and woodland, and the other having potentially greater losses of important wetland. Broad debate on the preferred route amongst local residents and campaign groups was taken into account during the public inquiry and the subsequent review ordered by the Secretary of State. This inquiry procedure represents the formal process by which schemes are weighed up, and decisions taken on the most acceptable route.

## 8.2. POLICIES AND STRATEGIES/TRENDS

### 8.2.1. Land-use planning strategies

#### 8.2.1.1. *Pan-European Biological and Landscape Strategy*

The UK is a signatory to the Pan-European Biological and Landscape Diversity Strategy, a European response to support implementation of the Convention on Biological Diversity. The Strategy requires careful decision making, avoidance, precaution, translocation, ecological compensation, ecological integrity, restoration and (re)creation, best available technology and best environmental practice, polluter pays, and public participation/public access to information. A key objective is the development of a European Ecological Network, in order to address the growing concern that the creation of protected areas in isolation is an ineffective measure for preventing ecological decline. Implementation of the network is being jointly co-ordinated by the Council for Europe and the European Centre for Nature Conservation. The project is ambitious in scope, and to date the network is little



more than a concept. Success will require the involvement and support of all economic sectors across regional, national and international administrative and political boundaries. In Cheshire, the UK's first county ecological network ('econet') is being planned within the context of the Cheshire County 2011 Structure Plan. If successful, similar plans could be developed for other regions and counties. Initiated in 1996, the project uses a geographical information system (GIS) as an analytical tool. Data collection, analysis and the development of a rule-based system to guide habitat restoration and creation are expected to be complete by 2000, with realisation of the network on the ground predicted for the year 2020.

#### *8.2.1.2. Council of Europe*

The UK is actively involved in the Council of Europe initiative to develop a Code of Practice relating to 'Transport and Landscape and Biological Diversity', concentrating in particular on linear transport infrastructure. Development of the Code has involved the sharing of information between 7 Countries, with completion of the work of the Group due in October 2000 and publication of the Code due in 2002. It will include sections on: habitat/species/landscape (trends, problems and opportunities), construction and improvement of infrastructure, management and use, planning, research and transboundary co-ordination. Catherine Bickmore Associates (UK) are one of the parties currently involved in drafting the code.

#### *8.2.1.3. The Countryside, Amenity and Conservation Bill*

Evidence of unfavourable conditions in some 30% of the UK's 5,000 SSSIs has led to the call for stronger legislation to be put in place to protect them. The new Countryside and Conservation Bill (currently going through Parliament) has been proposed for this purpose, not only to strengthen the legal protection of SSSIs, but also that of species and habitats outside formally designated areas. The proposal includes:

- A statutory purpose for the SSSI network and duties on public bodies to protect them;
- Powers of entry for wildlife agency staff to wildlife areas;
- Extension of powers to protect species at sea;
- Greater protection for species outside SSSIs;
- Powers for management and 'stop' orders when voluntary agreements break down ;
- Increased penalties and restoration orders;
- Powers to protect SSSIs with bye-laws;
- Powers to designate local wildlife sites;
- Incentives for positive management;
- Tighter planning rules and powers to revoke old mineral permissions (e.g. for peat);
- Planning controls on certain bodies; and
- Similar laws in Northern Ireland.

#### 8.2.1.4. Multi-Modal Environmental Assessment (MMEA)

The context for the development of MMEA is the Draft European Commission Directive on Strategic Environmental Assessment (SEA) (December 1996). Multi-modal transport studies at a strategic level are only now beginning to emerge, and few completed case studies exist. Guidance on a standardised Methodology for Multi-Modal Studies (GOMMS) (DETR, 2000) has moved the emphasis for project appraisal away from designated areas to a more strategic methodology based on the 'Environmental Capital' approach. This uses characterisation as the basis for assessing the impact of multi-modal transport options. In terms of biodiversity and ecology, the key stages in the strategic MMEA methodology for ecological resources are scoping and consultations (establishing ecological character, evaluating ecological resources, mapping ecological sensitivity), and impact assessment (testing ecological sensitivity mapping against impact criteria, describing/assessing overall impacts on ecological character). Initial studies show that there is a fundamental problem in using a strategic approach for ecological comparisons, due to the scale of ecological data available at present (at individual habitat and species level) and the lack of consistent coverage over the whole of the UK.

#### 8.2.2. Transport Strategies

In July 1998 DETR published a key policy document in the form of an Integrated Transport White Paper entitled 'A New Deal for Transport: Better for Everyone', which outlined a significant change in priority for transport investment and development. A major component of this policy is concerned with how the environmental impact of transport should be dealt with, and in particular aims at:

- i) reducing the direct impact of transport on the built and natural environments through which it passes;
- ii) giving greater weight to the local environment, including sensitive sites, in the appraisal of transport investment proposals through the use of the 'New Approach to Appraisal' (NATA); and
- iii) reducing greenhouse gas emissions and pollutants from traffic.

The White Paper has been implemented through a series of sector-specific policies, following individual reviews of the roads, railways and waterways sectors. The output of the Roads Review was 'A New deal for Trunk Roads in England' (DETR, 1998) which has set the framework for a significant shift in emphasis away from building new roads to maintaining the existing network.

##### 8.2.2.1. Highways Agency (HA) Strategies

Having taken this policy change on board, the HA published a new strategic aim: 'to contribute to sustainable development by maintaining, operating and improving the trunk road network in support of the Government's integrated transport and land use policies'. The HA's main role is now as a network operator, with all operations guided by a family of Strategic Plans covering the 3 investment areas (Maintain, Operate and Improve) and the 5 investment criteria (Safety, Environment, Economy, Accessibility and Integration). The Environmental Strategic Plan 'Towards a Balance with Nature' (HA, 1999) provides a

clearly defined set of new environmental policies replacing those in 'Living with Roads' (HA, 1994), pertaining to the management and improvement of the road network, emphasising in particular the need to protect environmentally sensitive areas within the linear soft estate.

*Nature Conservation Advice Note:*

The HAs current practice in nature conservation continues to develop in response to the latest knowledge on species and habitats and their protection. Guidance on highways and otters, and highways and bats was published in May 1999, as part of the Good Roads Guide Series in the DMRB. These Advice Notes follow the successful formula of the advice on badgers and provide guidance on all aspects of these species, and how to protect them from the effects of both highway construction and use. Further Advice Notes in this series are in preparation, dealing with reptiles and amphibians. The Agency is committed to a programme of research and consultancy projects to widen knowledge of the impact of highways on the natural environment, and dealing with habitat fragmentation will feature significantly in this work.

*Highways Agency Biodiversity Action Plan (HABAP):*

Ministers require the HA to play its full role in the delivery of the Government's objectives for biodiversity set out in the UK Biodiversity Action Plan (BAP). A good example of how the HA can do this is with regard to the protection of the otter, listed as a priority species in the UK BAP. The HA is identified in the Species Action Plan (SAP) with a requirement to limit accidental killing or injury of otters where trunk roads cross otter territory. This can be achieved through the provision of otter tunnels and requires the route manager to identify protected areas and sites and assess the need for any mitigation measures. To this aim, Managing Agents are now charged with undertaking a data-gathering exercise to obtain information on the nature conservation status of the trunk road estate. Information from this survey and from existing Local Biodiversity Action Plans (LBAPs) are being collated as part of the HA's own Biodiversity Action Plan, planned for publication in Spring 2001. The Scottish Executive has recently published a draft of its 'Trunk Road Biodiversity Action Plan' (TRBAP) (Scottish Executive, February 2000) and a similar Welsh publication is due out later in 2000.

### **8.3. INDICATORS/INDEXES OF FRAGMENTATION**

Indicators are quantified information which help to explain how things are changing over time. They are broad brush, aggregated statistics which give an overall picture, but they do not aim to explain why particular trends are occurring. Overall they provide policy-makers and the public with reasonable indicators of changes to assist with decision-taking. The three basic functions of indicators are simplification, quantification, and communication. More specifically, indicators can provide a means of linking environmental impacts to socio-economic activity, and may in some cases provide early warning of potential environmental problems arising from human activity. However, while indicators certainly help to focus on the key issues and highlight some significant trends, they do not by any means give the whole story. They are by their nature simplifications, and only relate to areas which can be readily quantified and aggregated. Some issues are easy to quantify e.g. concentrations of pollutants, but other environmental qualities such as natural beauty or

tranquility do not lend themselves as easily to quantification. It is important to recognise these limitations, and not focus solely on quantified indicators as measures of sustainable development. Qualitative information will also be needed in order to make judgements about the reconciliation between the benefits of development and the potential environmental costs.

In 1994 the Government published its Strategy for Sustainable Development following the commitment made at the Rio Earth Summit in 1992. Subsequently in 1996, to help measure progress with the Strategy, the Government published a set of sustainable development indicators. The framework of indicators, listed in 21 ‘families’ of sustainable development issues, attempted to go beyond environmental indicators by including factors which explicitly link environmental impacts with socio-economic activity:

- |                         |                            |                       |
|-------------------------|----------------------------|-----------------------|
| ▪ The economy           | ▪ Overseas trade           | ▪ Transport use       |
| ▪ Land use              | ▪ Energy                   | ▪ Leisure and tourism |
| ▪ Water resources       | ▪ Fish resources           | ▪ Climate change      |
| ▪ Freshwater quality    | ▪ Ozone layer depletion    | ▪ Radioactivity       |
| ▪ Acid deposition       | ▪ Soil                     | ▪ Forestry            |
| ▪ Air                   | ▪ Land cover and landscape | ▪ Marine              |
| ▪ Wildlife and habitats | ▪ Waste                    | ▪ Minerals extraction |

The key sustainable development objectives for wildlife stated in the 1994 Strategy were to ‘conserve, as far as reasonably possible, the wide variety of wildlife species and habitats in the UK, and to ensure that commercially exploited species are managed in a sustainable way’. The indicators within the ‘Wildlife and habitats’ family were:

- r1: Native species at risk
- r2: Breeding birds
- r3: Plant diversity in semi-improved grassland
- r4: Area of chalk grassland
- r5: Plant diversity in hedgerows
- r6: Habitat fragmentation
- r7: Lakes and ponds
- r8: Plant diversity in streamsides
- r9: Mammal populations
- r10: Dragonfly distributions
- r11: Butterfly distributions

In May 1999 the Government revised its Sustainable Development Strategy with ‘A Better Quality of Life: a strategy for Sustainable Development in the United Kingdom’, which advocates ‘effective protection of the environment’ as one of its four main aims. The 1996 set of sustainability indicators were revised as part of this to produce a new framework of 150 indicators. These have been developed following wide consultation and with reference to work in other countries and international organisations e.g. UNCSO, OECD, the European Commission and the European Environment Agency. An important new element is a subset of 14 key *headline indicators* (Table 8.2) intended to focus public attention on what sustainable development means, and to give a broad overview of whether a ‘better quality of life for everyone and future generations’ is being achieved.

Table 8.2: Headline indicators issued as part of the UK Sustainable Development Strategy

THEMES	HEADLINE INDICATORS
Maintaining high and stable levels of economic growth and employment	1. Total output of the economy (GDP) 2. Investment in public, business and private assets 3. Proportion of people of working age who are in work
Social progress which recognises the needs of everyone	4. Qualifications at age 19 5. Expected years of healthy life 6. Homes judged unfit to live in 7. Level of crime
Effective protection of the environment	8. Emissions of greenhouse gases 9. Days when air pollution is moderate or high 10. Road traffic 11. Rivers of good or fair quality 12. Populations of wild birds 13. New homes built on previously developed land
Prudent use of natural resources	14. Waste arisings and management

Source: DETR, 1999

The list of 14 headline indicators is accompanied by a set of *core indicators*, and these together make up the 150 strong framework. Under the 'Managing the environment and resources' theme, core indicators have been set relating to: integration; climate change and energy supply; air and atmosphere; freshwater; seas, oceans and coasts; soil; landscape and wildlife; forests and woodlands; and minerals. Although habitat fragmentation is not included specifically as an indicator, it may be measured indirectly by considering the headline indicator 'populations of wild birds', discussed further in section 8.3.4. It is intended that the UK national framework of indicators will be used by those developing indicators at a sub-national and local level. At a local level, communities (i.e. local authorities) are required to have their own sustainable development ('Local Agenda 21') strategies in place.

### 8.3.1. Using species as indicators for biodiversity

With regard to the use of individual species as indicators for biodiversity, it must be noted that some species are much more sensitive to fragmentation at a particular scale than other species. In many landscapes, habitats are clustered (or there are variations in habitat quality which may be perceived as gaps in the habitat for some species). The gaps may be more or less of a barrier depending upon the mobility, behaviour and habitat specificity of the species concerned. Thus for a plant with a likely movement range of about 15m, a road may be more of a barrier than for a butterfly likely to move about 500m, or a small mammal likely to move 2km. Even a relatively immobile species could however, colonise greater distances with time, as most species may move much greater distances than normal under rare circumstances. Thus a range of indicators with different mobility and behaviour characteristics are needed to understand the effects of fragmentation on the wider environment; and it should be understood that the overall effect of fragmentation may only

be detected over the very long term. A range of characteristics have been identified for further indicator species which would give information about the degree of fragmentation:

- Large minimum area requirement;
- Poor mobility outside a specific habitat;
- Dependence on habitats that were previously continuous in time and space rather than habitats occurring sporadically in widely dispersed locations; and
- Interior habitat not edge species.

A report to English Nature by Therivel and Thompson (1996) outlines the types of indicators which could be used to assess impacts as part of SEA, though some of these, e.g. biodiversity measurements, are very vague and difficult to define:

#### *Habitats*

- Number of designated sites damaged each year; long-term and short-term;
- Area of loss of designated/non-designated habitats, or loss as a proportion of the extent of each habitat;
- Area/proportion of habitats lost or gained, damaged short/long term;
- Changes in quality of selected habitats;
- Number of planning consents on designated areas which are deemed to detract from the areas quality; and
- Changes to linear features including hedges, dykes, water features and tracks.

#### *Species*

- Changes in the status and distribution of threatened/protected indicator species;
- Changes in the population of species of native wildflower under various conservation statuses;
- Species extinction (e.g. number of extinction in each 20-year period); and
- Species decline (e.g. number of species declining by more than a fixed amount over a given period).

### **8.3.2. LANDECONET**

The LANDscape ECOlogical NETwork (LANDECONET) is a European Commission funded research programme, which the Institute of Terrestrial Ecology (ITE) is currently involved in. LANDECONET aims to:

- explain and illustrate the problem of habitat fragmentation in agricultural habitats;
- relate landscape pattern to the probability of survival of species populations;
- produce guidelines and standards for landscape planning to promote the conservation of biodiversity;

- develop GIS-based tools to aid the integration of ecological research with landscape planning ;
- illustrate by example how these tools can be used to predict the impacts of landscape change and restoration on biodiversity; and
- contribute to a list of indicator species which can be used to detect problems of fragmentation.

The ITE LANDECONET research has made a detailed investigation into the application of indicators in order to achieve these aims. It has produced the following general principles.

An indicator should be easy to measure and should respond predictably to the process of study. An indicator species should therefore be easy to find and identify, and should respond closely to the factors under investigation at the same scale as other species of interest. If we are concerned with habitat fragmentation, and with the processes of extinction and colonisation, the three most important characteristics are distance over which migration to other habitat patches is possible, the area needed to maintain a stable core population (one which is unlikely to go extinct purely by chance, assuming it is not isolated from other populations), and the timescale over which the species can respond to change. These vary greatly between species, and so it is useful to adopt a small number of indicator species which are typical of larger groups of species, and which are relatively unresponsive to other factors such as weather and management. In this way, studies on these indicator species will tell a great deal about the suitability of the landscape for a large number of other species. The choice of an indicator species should follow several steps:

- select a range of species which are found in the planning area that are thought, or known, to have appropriate habitat needs and a range of dispersal abilities and area requirements;
- analyse the landscape needs of each of these species;
- select the species that seems to be most sensitive to likely changes in the planning area; and
- assess the reliability of using the species as an indicator, including its likely rate of response to change and the possible effects of non-landscape factors such as weather.

Full lists of indicator species are not yet available, not least because they differ from region to region, but Table 8.3 gives a valuable starting list.

If a few species are to be selected as key indicators they must truly reflect the behaviour and sensitivities of the important species or groups concerned, and not be chosen purely for their ease of recording. Process-oriented research is needed to understand why 'indicators' behave as they do. Ancient woodland indicator plants (Peterken and Game, 1984) may be sensitive to habitat fragmentation if their association with ancient woodland depends on them being poor colonists. In some cases however their occurrence is more related to the nature of the soils on which ancient woodland tends to survive, which is usually different to normally found in the soils of recent woods. If so, then fragmentation is not necessarily a threat to the survival of these species, nor will linkage of sites assist their survival.

Table 8.3: Possible indicator species for different scales of landscape fragmentation

AREA FOR CORE POPULATIONS  DISPERSAL CAPACITY	< 1 HA	< 10 HA	< 100 HA  < 1 KM 2	< 10 KM 2	> 10 KM2
local scale < 200 m	most plants May Lily ( <i>Maianthemum biflimum</i> )	small mammals butterflies water shrew ( <i>Neomys todiens</i> )	butterflies		
local scale < 3 km	butterflies bird-dispersed plants Honeysuckle ( <i>Lonicera</i> )	small mammals butterflies Root vole ( <i>Microtus arvalis</i> ) Heath fritillary ( <i>Mellicta athalia</i> )	small mammals lizards amphibians butterflies Tree frog ( <i>Hyla meridionalis</i> ) Green hairstreak ( <i>Callophrys rubi</i> )	small mammals frogs and toads lizards	
Regional scale < 10 km	some plants Beech Fern ( <i>Phegopteris connectilis</i> )		forest birds small marshland birds butterflies Marsh tit ( <i>Parus palustris</i> )	medium sized mammals small birds butterflies Nuthatch Grass snake ( <i>Nitrix nitrix</i> )	medium-large mammals small birds snakes butterflies Pine martin ( <i>Martes martes</i> )
National scale <100 km			meadow birds	medium sized birds Middle spotted woodpecker ( <i>Dendrocopus major</i> )	medium sized birds migrating butterflies
National / European scale < 300 km			medium - large birds	marshland birds	large birds black stork
European scale > 300 km					large birds white tailed eagle ( <i>Haliaeetus albicilla</i> )

Source: ITE

### 8.3.3. Otters as indicators

A good indication of fresh water quality is that of the presence or absence of otters. A broad assessment of the distribution of otters in Great Britain was made in 1993 (Figure 8.1). The general indications are that otters are beginning to return to river catchments as river quality improves. Populations in Wales are expanding and otters are beginning to move down the Rivers Severn and Teme. They have also been found in the Avon as far as Coventry, and in tributaries of the River Severn below Tewkesbury. In order to aid this



recovery, the Agency has a strategy to protect and encourage otter recolonisation, as indicated in Figure 8.2.

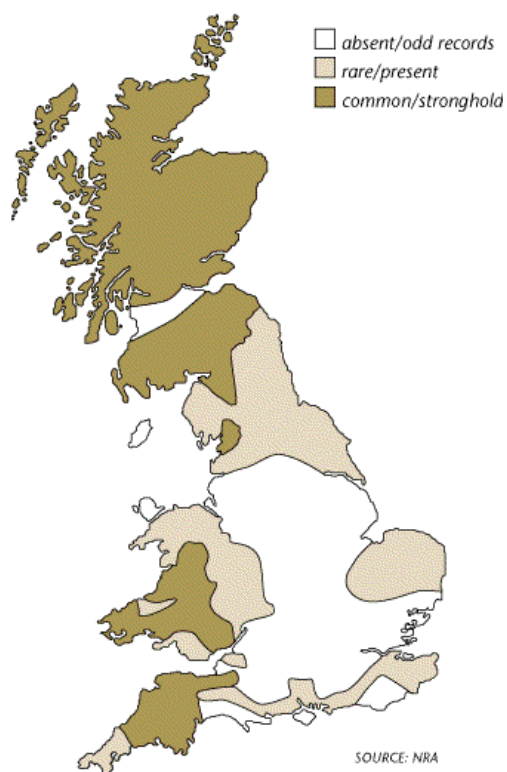


Figure 8.1: Otter management by river catchment in England and Wales

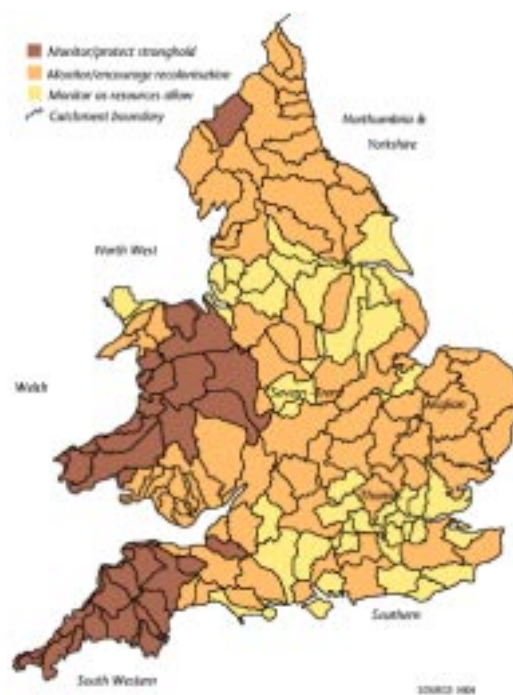


Figure 8.2: Plan for otter recolonisation

### 8.3.4. Birds

Birds can provide a key indicator of the quality of the environment as a whole, even though changes in their numbers can be difficult to explain. Data on bird populations are being used increasingly for this purpose, as well as providing information on the species in their own right. There are 220 species of birds breeding in Britain. Many are well-known and conspicuous, and they are appreciated for their natural history interest and their aesthetic value. Birds are dependent upon particular habitats for nesting and feeding, the availability of certain plants and animals for food, and the climate and weather affect all the conditions influencing their survival. Monitoring is undertaken mainly by volunteers co-ordinated by the British Trust for Ornithology (BTO), the Joint Nature Conservation Committee (JNCC), the Wildfowl and Wetlands Trust (WWT) and the Royal Society for the Protection of Birds (RSPB), and is funded by charitable organisations and through government grants.

## 8.4. MODELS TO PREDICT FRAGMENTATION BY NEW INFRASTRUCTURES

Linear developments such as roads often affect large areas and impact on a wide range of habitats. Sustainable development requires that environmental considerations be integrated into the planning and regulation processes of Government, so at a strategic level it is important for policy makers to understand the cumulative ecological effects of infrastructure development. At present, impact assessments are based on project-based approaches carried out at a small-scale spatial resolution. However, European Directives create a legal commitment to ensure that biodiversity is addressed at the strategic level (i.e. considering regional and national impacts) with respect to infrastructure projects. One of the problems with biodiversity assessment is that development of thresholds for biodiversity are ongoing (see section 8.3), hence their integration into structure planning is not yet apparent. SEA has been identified as an appropriate method for assessment of fragmentation at the wider scale, and much of the discussion for the need for SEA, the methodologies and evaluations is contained in Therivel and Thompson (1996). The main advantage of SEA over project-based EA is that trans-boundary, widespread, indirect and synergistic ecological effects are taken into account. The need for SEA has already been acknowledged through the development of the proposed SEA Directive.

Computer models have a use in providing a strategic overview of the spatial effects of transport proposals by helping ecologists address questions such as:

- At what point does the degree of habitat fragmentation become critical?
- What is the optimum spatial configuration of linked habitat patches?
- Where are the optimum locations for wildlife corridors?
- Where are movement barriers or bottlenecks located?
- What effect will the restoration of habitats (e.g. the creation of a corridor) or the development of a road or railway which will add to fragmentation, have on specific species?

By simplifying reality, models can facilitate:

- the identification of the crucial parameters of the fragmentation process and therefore the focus for mitigation effort;
- the identification of gaps in our knowledge regarding species ecology (e.g. aspects of dispersal behaviour and habitat selection); and
- the comparison of different landscape scenarios.

There are no models in regular use in the UK that specifically predict fragmentation in relation to new infrastructures. However, Hill *et al.*, (1997) has reviewed a series of different approaches and data for a strategic assessment of the impact of infrastructure plans on biodiversity. He considers the application of SEA to assess habitat loss, habitat fragmentation' and off-site disturbance. The approaches analysed were:

- atlas-based studies for key wildlife groups;
- countryside character map;
- tranquil areas;
- autecological studies (investigating the biological basis for species disturbance);
- GIS-based spatial assessments; and
- assessments based on satellite mapping.

Hill concludes that of these, GIS and satellite mapping are the techniques that have the most potential for use in modelling to predict fragmentation. When used within a GIS environment, models enable us to 'see' habitat fragmentation, corridors, barriers and bottlenecks in an electronic landscape, as they would be seen by a dispersing animal. The identification of impediments to animal movement is the first step in the defragmentation of landscapes and the establishment of fully functional corridors and wildlife crossing structures on the ground.

#### 8.4.1. GIS

Treweek and Veitch (1996) represents one of the initial attempts to assess the potential application of GIS and remotely sensed data to the ecological assessment of road schemes. The potential recognised in this report was investigated further by Bina (1996) and Bina *et al.*, (1997), who aimed to quantify impacts of road and rail developments on Important Bird Areas and nationally designated sites in Europe using GIS. It looked at the distance of sites to planned road and rail developments and calculated the percentage area, or number of sites within 10km and 2km of these proposed routes. Bina *et al.*, suggest that as well as basic topographical data, and information on cities and the road/rail network, GIS should include the following environmental information:

- climate;
- forest area;
- wetland areas;
- internationally designated areas (Ramsar sites, SPA's, Important Bird Areas, World Heritage Sites, Man and Biosphere reserves, Biogenetic Reserves and proposed sites);
- nationally designated areas; and
- CORINE Biotopes and land use cover.

Steer Davis Gleave (1996) has further written a State of the Art in SEA for Transport Infrastructure. He showed that understanding the environmental impacts of transport infrastructure on 'Nature and Biodiversity' is restricted to 'loss of or damage to habitats or species', indicated by the 'number of each type of site affected, land area of habitats affected, number of designated sites affected, and land area of designated sites affected. Steer Davis Gleave's review shows the poor quality in understanding of biodiversity impacts and, even more seriously, the lack of knowledge about what data need to be collected to enable a full SEA. Steer Davis Gleave considers that GIS is a useful tool for producing a geographic model of topographic, demographic, environmental and transport characteristics. Interactions between these can be assessed and impact indicators produced by analysing the data sets using common spatial objects. One of the problems revealed, however, was that Member States are inconsistent in the data they collect and the way they interpret it. The review recommends that a corridor assessment should be sub-divided into administrative areas, and areas of similar landscape and topographical characteristics. None of the examples reviewed by Steer Davis Gleave provided GIS models of the impacts of traffic from the increased road and rail network on biodiversity. The European Environment Agency (1998) have furthered this work by producing a spatial and ecological assessment of the Trans-European transport Network (TEN) using GIS. The only other general environmental models so far developed are for energy use, pollution emission and pollution concentration. The review recommends that indicators used in SEA should be quantifiable and capable of being monitored. Important considerations for successful implementation of GIS are:

- Sufficient mapping accuracy to provide reliable results;
- Data needs to be in vector format as points, lines, polygons, polylines (raster data is insufficient);
- All data sources need to be consistently accurate and complete in terms of coverage;
- Mapping layers need to contain sufficient information to allow the production of suitable indicators; and
- There needs to be a degree of confidence in the route alignments being mapped.

GIS has weaknesses or pitfalls relating to the accuracy of grid referencing of the base map and the various layers of information relating to assets such as the biodiversity resource, protected areas, and transport network etc.

#### **8.4.2. Satellite mapping**

Treweek *et al.*, (in press) used satellite-based data to assess the impacts of the roads programme on lowland heathland and associated species. They used land cover data derived from satellite imagery for the 'dense shrub heath' distribution, and overlaid this with a map of the trunk road system. 10km<sup>2</sup> distributions of two indicator vertebrate species were then overlaid on these, to produce maps which could be used to assess proposals for new road developments at a county scale. Such mapping has the potential to allow the area of habitat which might be lost to be estimated, and the viability of protected species within those habitats to be assessed. Treweek *et al.*, found that once the data were configured as overlays, they could easily be manipulated within a GIS framework, and calculation of the

impact layer i.e. how much of certain habitat types, areas, designated sites, ranges of protected species etc. was a relatively simple operation. The main weaknesses relating to the use of satellite mapping concern the lack of ecological information and/or principles available to use for the interpretation. For example, SEA requires that there be more information that at present on:

- the relationship between habitat distribution and fragmentation on the viability of species and populations;
- effects of barriers on genetic exchange on metapopulation dynamics;
- minimum variable habitat and population sizes; and
- species-area relationships

The review of existing data and methodologies lead to the conclusion that SEA requires the following main information or important criteria:

- accuracy (scale of maps);
- correct format of data (point, line, polygon, polyline);
- important sites and important species;
- an ability to aggregate species data for certain wildlife groups; and
- vulnerability to the range of impacts: i) habitat loss (impacts on range and abundance); ii) habitat fragmentation (colonising ability, dispersal movements); iii) disturbance (reduction in habitat quality) at the species level, accounting for habituation.

Vulnerability to disturbance impacts has been poorly studied for all taxa. However, to achieve production of initial SEA guidelines, guidance on differential disturbance impacts is required. One possible solution would be to use ‘expert groups’ on a taxa by taxa basis within workshops, in which experts would be asked to rank species/communities on the basis of their relative vulnerability to disturbance, habitat loss, minimum habitat size and fragmentation, and population viability. A similar approach was used for the assessment of conservation threats to UK Red Data Birds.

#### *8.4.2.1. Case study - Integrating ecological models with landscape data:*

The Institute of Terrestrial Ecology (ITE) is active in researching landscape-scale patterns of biodiversity, including the use of GIS for exploring spatial interactions (Firbank *et al.*, 1997). However, thus far they have not focused on the cause-effect relationships between transport infrastructure and habitat fragmentation. ITE collaborated with a number of European institutions on the LANDECONET project (see Section 8.3.2), one of the aims of which was to develop models relating the abundance and distribution of organisms to the structure of the landscape. These models can be used to provide guidance for planners, especially if it is accepted that landscape is assumed to affect species, but not vice versa, and that it is human activity that controls landscape. It is possible to give not only general guidance but to generate the likely impacts of possible changes to specific landscapes for specific species. For this approach to be successful, landscape data are required which account for substantial variation in distribution and abundance of the species under study, and at the scale of interest.

Maps of land cover and land use have been produced for centuries by a range of ground-based methods, and these can be readily analysed and incorporated into landscape ecological models. This was the approach adopted by Hinsley *et al.*, (1994) working on the effects of woodland fragmentation on British bird population dynamics. Having obtained presence-absence data for birds in small woodlands in eastern England over a number of years, Hinsley *et al.*, (1995a) have generated a series of logistic regression models showing the probability of woodland occupancy on the basis of the landscape variables of patch area, distance to other patches, and measures of the intervening matrix. The landscape can be manipulated within the GIS, for example, by removing some of the woodlands, and the models can be re-fitted to suggest where the species will be found in the new landscape. Bright (1993) and Thomas *et al.*, (1992) have undertaken similar studies for populations of dormice and butterflies respectively.

The main problem with ground-based data is the cost. They must be converted to digital form before they can be combined with all but the simplest landscape ecological model (in the UK digital Ordnance Survey maps are available but remain expensive). Ground-based maps show clear boundaries and linear features, but more transient and finer scale elements, such as the crop cover or the distinction between different vegetation communities, need to be obtained from other sources. Landscape ecologists are increasingly taking advantage of remotely sensed data such as aerial photography and satellite imagery. These data sources vary greatly in cost, resolution, accuracy and repeatability, and so the optimum data source depends upon the requirements and available resources. Furthermore, as a greater variety of satellite data become available, the present optimum data source may be outdated in five years time. One important resource is the ITE Land Cover Map of Great Britain, constructed from a series of images of the country by the Landsat Thematic Mapper. This generates a pixel size of 25m, which is too great for landscape ecological applications which rely on identifying linear features, but may be suitable for applications where larger areas only need to be identified. The great value of the Land Cover Map is that data have been classified on a national basis, and the interpretations based on ground-truth observations. Accuracy and repeatability are therefore known, and models developed in one part of the country can be applied to other parts of the country in the knowledge that the landscape data are consistent. Having obtained the landscape data, it must be integrated with ecological data to generate models, which is greatly assisted by the use of Geographic Information Systems (GIS) and related software (e.g. Goodchild, Parks and Steyaert, 1993). Essentially GIS provides a means of visualising the results of landscape ecological models.

The combination of environmental data at the landscape scale with tested ecological models promises to raise environmental planning to new levels. The technology available can allow the impacts of a wide range of changes to be explored within a computer, allowing optimal solutions to be discovered. There are caveats, however. The first is that the models are only as good as the data available, and for all but a very small number of species very little such data exist. Even where data does exist, it is often restricted to part of the range only, or may be sensitive to weather and environmental fluctuations. Process models, in particular, are very data-hungry and the processes of colonisation and extinction may be too slow or too rare to be estimated accurately from field data. The second point is that landscape ecological models are, and never will be, perfect descriptors of the ecology of species. In particular, the landscape units recognised within the model may not be the ones recognised by the species. At best, simulations provide general forecasts, but should

not be expected to mimic the future situation perfectly. They are therefore of greatest value at a strategic, rather than at a site-specific level. Finally, landscape ecological models should inform, but not replace, decision making.

## 8.5. DATA ON TRANSPORTATION NETWORKS DEVELOPMENT

Future development of the transport network in the UK is guided by the integrated transport policy. This advocates integration:

- *within and between different types of transport*, so that each contributes its full potential and people can move easily between them;
- *with the environment*, so that our transport choices support a better environment;
- *with land use planning*, at national, regional and local level, so that transport and planning work together to support more sustainable travel choices and reduce the need to travel; and
- *with other policies* for education, health and wealth creation, so that transport helps to create a fairer, more inclusive society.

Trunk roads, railways and inland waterways form the UK's strategic transport infrastructure. Each must play a full part in an integrated transport policy, to enable people to depend on cars less and ensure that more freight is carried by water and rail.

### 8.5.1. Roads

A New Deal for Trunk Roads in England (1998) reports on the Government's strategic review of the roads programme against criteria of accessibility, safety, economy, environment and integration. It is one of several publications which implement the policies in the transport White Paper 'A New Deal for Transport: Better for Everyone'. The HA, as the executive agency responsible for trunk roads in England has new strategic aims and objectives. As a network operator HA aims to give higher priority to maintenance, make better use of existing roads, and give greater emphasis to environmental. HA has identified a core network of nationally important routes (comprising some 60% of the existing trunk roads) which it will retain responsibility for, whilst passing responsibility for the remaining 40% to local authorities. In terms of transport planning, trunk roads must play a full role in the integrated transport policy, with the aim being to:

- bring transport and land use planning together at regional level;
- plan future improvements to trunk roads at regional level;
- focus on strategic road and rail transport corridors, ensuring that these are planned together in an integrated way;
- provide safer and more accessible interchanges between different forms of transport e.g. park and ride and freight transfer facilities; and
- consider trunk roads as a part of an overall transport network which includes local roads, railways, inland waterways, ports, airports and public transport interchanges.

To support HA's new objectives for trunk roads policy, new priorities for investment have been set, including improving trunk road maintenance, and tackling some of the most serious and pressing problems through a carefully Targeted Programme of improvements (TPIs). A common strand throughout, however, is the aim to support the protection and enhancement of the natural environment i.e. to:

- operate a strong presumption against major new transport infrastructure which damages environmentally sensitive sites (with schemes not going ahead unless all other options have been explored, and the benefits having clearly been shown to override the environmental disadvantages);
- manage the trunk road network to support the protection of species and habitats;
- promote the use of recycled construction materials in road building; and
- manage traffic flows to help reduce emissions which contribute to ill-health and climate change.

To help HA make investment decisions a new approach to appraisal (NATA) has been developed enabling assessment of scheme proposals against criteria of accessibility, safety, economy, environment and integration. NATA promotes the comparison of the advantages and disadvantages of different options for solving transport problems.

#### *8.5.1.1. The targeted programme of improvements*

On present trends and unchanged policies, traffic is forecast to grow by more than a third on all roads over the next 20 years, and by more than half on trunk roads. Few would suggest that this level of traffic growth could or should be accommodated by new road building, although there is a case for improving some existing roads. In response to this, the carefully targeted programme of improvements (Table 8.4), costing £1.4 billion, includes 37 schemes which will start within the next seven years. This represents a significant scaling down of road building operations from the 150 schemes inherited from the previous government, and the 500 proposed in 1990.

Table 8.4: Summary of Scheme Decisions

	<b>Scheme</b>	<b>Cost £m*</b>	<b>Primary Objective</b>	<b>Next Stage</b>	<b>Standard</b>	<b>Length Km</b>
A1	Willowburn-Denwick	7	Safety and Healthier Communities	OM	D2	4.2
A1(M)	Ferrybridge-Hook Moor	160	Safety and Healthier Communities	OM	D3	16.3
A1(M)	Wetherby-Walshford	50	Safety and Healthier Communities	SOW	D3	5.9
A2	Bean-Cobham Widening (Phase 1 Bean-Tolgate)	44	Jobs and Prosperity	PC	D4	6.0
A2	Bean-Cobham Widening (Phase 2 Tolgate-Cobham)	35	Jobs and Prosperity	PC	D4	4.0
A2/ A282	Dartford Improvement	38	Jobs and Prosperity	OP	D4	3.4
A5	Nesscliffe Bypass	14	Safety and Healthier Communities	SOW	D2	4.5
A5	Weeford-Fazeley Improvement	31	Regeneration and Integration	SOW	D2	5.0



A6	Great Glen Bypass	15	Safety and Healthier Communities	SOW	D2	5.6
A6	Rushden and Higham Ferrers Bypass	9	Safety and Healthier Communities	SOW	D2/SC	5.5
A6	Rothwell-Desborough Bypass	11	Safety and Healthier Communities	SOW	SC	6.0
A6	Clapham Bypass	31	Safety and Healthier Communities	SOW	D2	5.0
A6	Alvaston (formerly Derby Southern Bypass Contract C)	14	Safety and Healthier Communities	OP	D2	2.3
A10	Wadesmill Colliers End	24	Safety and Healthier Communities	SOW	D2	10.7
A11	Roundham Heath-Attleborough Improvement	27	Regeneration and Integration	SOW	D2	9.9
A14	Rookery Crossroads Grade Separated Junction	5	Safety and Healthier Communities	PC	D2	N/A
A21	Lamberhurst Bypass	12	Safety and Healthier Communities	SOW	D2	3.0
A23	Coulsdon Inner Relief Road	40	Safety and Healthier Communities	SOW	D2	1.7
A27	Polegate Bypass	24	Regeneration and Integration	SOW	D2	2.9
A34	Chieveley/M4 J13 Improvement	36	Jobs and Prosperity	OP	D2	2.1
A41	Aston Clinton Bypass	21	Safety and Healthier Communities	SOW	D2	6.4
A43	Silverstone Bypass	18	Safety and Healthier Communities	SOW	D2	8.0
A43	Whitfield Turn-Brackley Hatch Improvement	13	Safety and Healthier Communities	SOW	D2	4.5
A43	M40-B4031 Improvement	18	Safety and Healthier Communities	SOW	D2	6.5
A46	Newark-Lincoln Improvement	29	Regeneration and Integration	OM	D2	12.9
A63	Selby Bypass	41	Safety and Healthier Communities	SOW	SC	9.8
A66	Stainburn and Great Clifton Bypass	10	Safety and Healthier Communities	SOW	SC	3.9
A120	Stansted-Braintree Improvement	92	Regeneration and Integration	OM	D2	24.0
A249	Iwade-Queenborough Improvement	79	Regeneration and Integration	OP	D2 + Bridge	5.3
A303	Stonehenge	125	Exceptional Environmental Scheme	PC	D2	9.2
A421	Great Barford Bypass	25	Safety and Healthier Communities	OP	D2	7.5
A500	City Road and Stoke Road Jcts Improvement	24	Regeneration and Integration	OP	D2	1.6
A500	Basford/Hough/Shavington Bypass	28	Regeneration and Integration	OM	D2	4.0
A650	Bingley Relief Road	59	Safety and Healthier Communities	SOW	D2	5.0
A1033	Hedon Road Improvement	53	Jobs and Prosperity	SOW	D2	6.7
M25	J12-15 Widening	94	Jobs and Prosperity	OM	D5/D6	10.9
M60	J5-8 Widening (formerly M63 J6-9)	82	Jobs and Prosperity	OM	D3/D4	7.4

\* Estimated costs at 1997 prices, rounded to nearest £m

#### Glossary of Abbreviations:

PC Public Consultation  
OP Draft Orders Published  
OM Orders Made  
SOW Start of Works  
D2 Dual 2-lane carriageway  
SC Single carriageway

Source: Highways Agency, 1998.

The targeted programme of improvements consists largely of bypasses which will relieve towns and villages blighted by heavy through-traffic and schemes to ensure that the core network functions effectively in support of the economy and regeneration. It includes a small number of schemes to widen motorways and other major trunk roads at particularly highly stressed points, but these are only being taken forward where they support an integrated and sustainable strategy that will involve traffic management measures to ensure that we do not need to add yet further lanes in future years.

The schemes listed in Table 8.4 have only been accepted following a rigorous NATA assessment, involving the consideration of the investment proposals against the five criteria of accessibility, safety, economy, environment and integration. Only those schemes where there are serious existing problems, where other options have been explored and where the new schemes support our integrated transport policy have been adopted. Priority is to be given to making better use of the existing network, before consideration is given to adding additional infrastructure either by widening roads or building new ones (n.b. 'making better use' means any action on the trunk road network, short of significant additions to the infrastructure, which delivers the stated objectives). The Highways Agency has drawn together a number of techniques to make better use of the network into a toolkit for use both within and outside the Agency to share, develop and trial ideas for solving transport problems.

### 8.5.2. Railways

As part of the integrated transport strategy, the Government believes it is essential to reduce road traffic growth in favour of rail passenger and freight traffic, and is investing a record £2.5 billion on the train network in 2000. The spending plan is a £500 million increase on 1999 levels, with £1.5 billion earmarked for upgrading signals, stations and bridges, £600 million on long-awaited improvements to the West Coast Main Line, and £500 million dedicated to the Channel Tunnel Rail Link (CTRL) (under construction since October 1998). The £4.2 billion (CTRL) between the Channel Tunnel and St Pancras in London (Figure 8.3) will double the capacity for international passenger services and reduce international journey times by over half-an-hour.

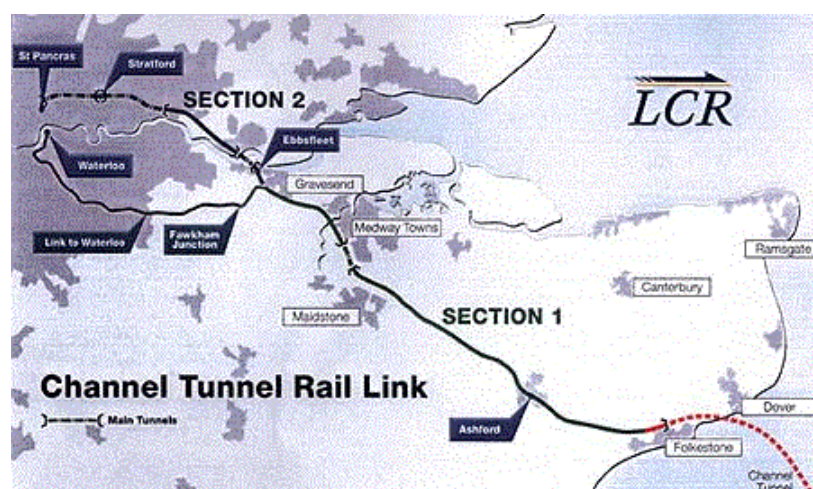


Figure 8.3 Route of the CTRL from Folkestone to London through Kent

It will also cut journey times for Kent travellers by 30 minutes or more, and carry some freight. The project is being taken forward through a public-private partnership and the entire link is due for completion by 2007.

DETR has set a target to increase the number of passenger miles travelled on national railways by 15% 1997–98 levels by 2001–02. It aims to achieve this through the sponsorship of the railway industry, and, subject to legislation, establishing a Strategic Rail Authority by 2000–01. The new Strategic Rail Authority (SRA) will ensure that the railways are run in the public interest and properly integrated with other forms of transport. Since 1 April 1997, passenger train services and rail freight services formerly provided by British Rail (BR) have been entirely in the private sector. Under agreements with the Franchising Director, 25 Train Operating Companies operate passenger services. The main rail freight operator, English, Welsh and Scottish Railway (EWS) aims to double its traffic over five years, and triple it over ten. Freightliner Ltd, which specialises in the haulage of containers between deep sea ports and inland terminals, aims to increase its traffic by 50% over five years.

### **8.5.3. Waterways**

The UK's inland waterways are an important national asset for future generations to enjoy. The Government is keen to see them maintained and developed in a sustainable manner so that they fulfil their full economic, social and environmental potential. Research has indicated that there may be potential to divert about 3.5% of the UK's road freight traffic to water, so Government policy is to encourage greater use of inland waterways, where that is a practical and economic option, to keep unnecessary lorries off our roads. Revised planning guidance will encourage more freight to be carried by water and local authorities in their development plans will be expected to consider opportunities for new development which are served by waterways.

British Waterways is a public corporate body set up under the Transport Act 1968 to manage and maintain over 3,200km of the nation's historic network of canals and inland waterways, including 4,763 bridges, 397 aqueducts, 60 tunnels, 1,549 locks, 89 reservoirs, nearly 3,000 listed structures and ancient monuments, and 66 Sites of Special Scientific Interest. Built to service the transport needs of the world's first industrial revolution, today the waterways are valued as a leisure and recreation resource and as part of the land drainage and water distribution systems, whilst still providing an environmentally friendly means of transport for coal, aggregates and other materials. British Waterways is required, under the Transport Act of 1968, to maintain its canals and rivers in a safe and satisfactory condition in accordance with standards defined in the Act. To help it achieve this, British Waterways receives grant from the Government and gains additional funding from grant awarding bodies, such as the Lottery Distributive Bodies, and European, regional and local agencies. Total income has been insufficient to meet the needs of the canal network and a backlog of maintenance, currently estimated at £260 million has built up. Of this, some £90 million is for work that poses a serious public safety risk. The Government considers that this backlog of safety-related maintenance is unacceptable, and following the recent Comprehensive Spending Review, the Government has decided to allocate an additional £8 million per annum in grant to British Waterways.

There has been no fundamental review of British Waterways' objectives since 1968. Since then the world in which the organisation operates has changed beyond recognition, and the Government now considers it vital to modernise the way in which British Waterways works. A new Framework Document contains aims and objectives for British Waterways, and provides a clear basis for British Waterways to carry out its work. Although British Waterways will remain in the public sector as a public corporation, its status as a nationalised industry, however, is no longer appropriate. For many years British Waterways' trading activities have been a small and declining part of its operations. Abandoning that status (from 1st April 1998) allows British Waterways to emphasise its role as the custodian of a valuable national asset with activities which are focused on leisure, tourism, heritage and regeneration. In addition, under the provisions of the Scotland Act 1998, responsibility for British Waterways' activities in Scotland will in due course transfer to the Scottish Executive. As British Waterways' activities are limited in Wales, there are no plans to transfer them to the National Assembly for Wales. British Waterways has been progressively making agreements with local authorities and other public sector organisations under which funding for improvements to canal towpaths and other infrastructure has been secured for the benefit of the local area. The Government welcomes this approach and is encouraging British Waterways to broaden it into long term partnerships, which will provide agreed environmental, economic and social benefits in each local area.

In 1998, British Waterways published a document 'Our Plan for the Future 1999-2003', containing proposals for its future activities. Broadly these encompass significant regeneration of the existing inland waterway network. All the planned operations are guided by the British Waterways Environmental Code of Practice and their Biodiversity Action Plan, to ensure compliance with its statutory environmental and recreational obligations. Another aspect of network development being investigated is that of water transfer. British Waterways' network offers a ready made infrastructure with real potential to transfer water from places of surplus to places of shortage at a competitive cost. Substantial investment would be required and the environmental impact of such schemes would need careful evaluation. There would be indirect benefits to British Waterways and to canal users, as improvements to the infrastructure would mean improved navigation depths and greater security of water flow, and a possible reduction in the backlog of safety maintenance.

## **8.6. ON-GOING RESEARCH AND REVIEW OF RELEVANT STUDIES**

### **8.6.1. DETR**

The DETR has an ongoing programme of research and development, of which English and European Wildlife Issues form one part. The main targets for 1999/2000 to 2001/02 are:

- to support biodiversity targets and data requirements by publishing a new plant atlas for the year 2001;
- developing and implementing a framework for monitoring of selected bat species within the UK;
- to improve understanding of the consequences of land-use and climatic change for wildlife, landscape and rural development;

- to improve understanding of interactions between protected wildlife and agricultural, commercial, sporting and recreational interests in the countryside;
- to improve the co-ordination and accessibility of important data sets on biodiversity and the countryside by supporting the development and marketing of the Countryside Information System;
- to monitor cetacean populations and investigate the causes of disease and death in cetaceans stranded around the coasts of Great Britain in support of the Department's obligations under the Agreement on Small Cetaceans in the Baltic and North Seas;
- to support the information base to ensure that decisions on derogations under the EU Birds and Habitats Directives are consistent with maintaining favourable conservation status;
- to develop improved methods for assessing the health of amenity trees and for reconciling their needs with those of other users of the urban environment;
- to develop improved forensic methods for detecting wildlife crime and regulating the use of endangered species held in captivity;
- to produce baseline monitoring data to assist in the development of effective strategies for resident species of bat required by the European Bats Agreement under the Bonn Convention;
- to test the feasibility of eradicating the UK's population of ruddy duck within 10 years; and
- to identify the cross-cutting research agenda needed to support Government commitments under the UK Biodiversity Action Plan.

The particular projects of relevance to habitat fragmentation are outlined below.

#### *8.6.1.1. Countryside Survey 2000 (CS2000)*

The Countryside Survey 2000 is a major national survey to provide an up to date assessment of the state of the British countryside at the end of the Millennium, and give a measure of the changes which have occurred in the 1990's. The survey (carried out in the summer of 1998/99) recorded changes in the land cover, ecological characteristics and landscape features of the wider countryside in Great Britain. Repeating the ongoing programme of Countryside Surveys previously undertaken in 1978, 1984 and 1990, this provides a time series of countryside change. It is the first survey to be based on the integration of information from satellite imagery and traditional field survey methods. Results from previous surveys have informed policy on protection of field boundaries, agri-environment measures, access to open countryside and indicators of sustainable development. The data are also contributing to EU requirements for a harmonised land cover map of Europe. The survey involves a partnership of several Government Departments, Agencies and Natural Environment Research Council (NERC) in the form of a jointly funded research programme. The Countryside Survey 2000 research programme is presently divided into the following modules, with the main module due for completion by 31/01/02.:

1. Survey of broad habitats and landscape features;
2. Survey of agricultural key habitats;
3. Survey of Uplands in England and Wales;
4. Survey of breeding birds;
5. Airborne scanner applications;
6. Integration of sample and census data;
7. Links to the Environmental Change Network;
8. Links to the Northern Ireland Countryside Survey;
9. Links to monitoring agri-environment schemes;
10. Access to data and scientific support;
11. Drivers of countryside change;
12. Ecological processes of change; and
13. Programme co-ordination and liaison.

#### *8.6.1.2. Countryside Information System (CIS)*

The Countryside Information System (CIS) desktop software package has been designed to give policy divisions easy access to information about the British Countryside and rural environment. In designing the system the aim has been to develop a tool which is simple to use, presents data in ways which are policy relevant, and enables the easy exchange of information between organisations. The system allows the user to access information about the environment for a selected locality or to identify where in the UK a particular environmental characteristic is likely to occur.

The initial stimulus to the development of CIS was the need by DETR and other government agencies to gain easy access to and wide dissemination of the results of Countryside Survey 1990. The system holds census and sample based information for each 1km<sup>2</sup> cell of the Ordnance Survey National Grid, and can be used to display these data for any geographical region defined by the user. CIS displays information by means of maps and tables, and allows the user to transfer information to other computer packages. It also presents information upon the errors (both statistical and logical) associated with different data sets and offers definitions of the various data items. Meta data is held in an additional environmental catalogue. Recently the system has been extended to include a wide range of environmental data (e.g. species distribution, biological records, OS data, critical loads) and administrative data (e.g. designated conservation areas and local authority boundaries). It is commercially available and has been purchased by over 70 organisations.

#### *8.6.1.3. Ecological Factors Controlling Biodiversity of the British Countryside (ECOFACT)*

The UK Biodiversity Action Plan and Sustainable Development Strategy set the agenda for conservation of biological diversity in the UK. This agenda requires the targeting of policies and management of advice where it can be most effective in maintaining and enhancing biodiversity. ECOFACT's objectives are to inform ministers about the ecological factors underlying recent changes to the biodiversity of the British countryside, to extend and develop the presentation and dissemination of the results of Countryside Survey 1990, and to improve the understanding of the survey by non-specialists. Modules 1 and 2 of ECOFACT aimed to describe, measure and evaluate changes in vegetation

using the Countryside Survey 1990 (CS1990) vegetation plot data. Multivariate statistical techniques were used to allocate vegetation plots into classes with similar botanical composition and to identify groups of species with similar ecological affinities. This exercise has resulted in a new classification of vegetation found in the wider countryside of Great Britain, known as the Countryside Vegetation System (CVS). The CVS contains 100 vegetation classes which describe the floristic character and variation of vegetation.

#### *8.6.1.4. Biodiversity research support services*

A recent review of research requirements arising from the UK Biodiversity Action Plan identified a significant gap in addressing large-scale, cross cutting topics, which seem to fall between the major strategic programmes funded by the research councils such as NERC and practical species and habitat-orientated research commissioned by the statutory agencies and NGOs. The outcome was the establishment of the Biodiversity Research Working Group (BRWG) in May 1998. The Biodiversity Research Support Services contract was conceived to identify a cross cutting research agenda needed to support Government commitments under the Biodiversity Action Plan and promote the exchange of information about Biodiversity Research. The focus of the group is on the needs of the UK Biodiversity Action Plan, and UK Steering Group report, cross-cutting, strategic issues defined as those which either impinge on many key species and/or habitats or which operate across several different sectors of human activity or research funding responsibilities, and on identifying medium to long term issues, i.e. those likely to arise within a 3-10 year time-frame, and those likely to have a wide impact.

The Biodiversity Research Support Services contract is being undertaken by a consortium comprising the Nature Conservation Bureau, Institute for Terrestrial Ecology and independent consultant Martin Newman. The NCB/ITE consortium will be organising a series of five workshops on selected cross-cutting themes, developing a mechanism for the exchange of information about biodiversity research, establishing liaison with related initiatives and, towards the end of the contract, organising a senior-level seminar to raise the profile of biodiversity issues amongst research sponsors and leaders of the scientific community. The workshop programme is as follows:

WORKSHOP TITLE	HOST	LOCATION	DATE
1. Biodiversity and agriculture, focus on pastoral systems/ grazing management and policy	MAFF	London	July 1999
2. Introductions, translocations and genetic conservation	NERC	Swindon	November 1999
3. Coastal and marine issues, with a focus on processes and protected areas	EN	Peterborough	January 2000
4. Landscape ecology, habitat fragmentation and land use change scenarios	FC	Edinburgh	July 2000
5. Monitoring methodologies	EA	Bristol or ITE Monks Wood	October 2000

#### *Key to abbreviations:*

MAFF: Ministry of Agriculture, Fisheries and Food  
 NERC: Natural Environmental Research Council  
 EN: English Nature  
 FC: Forestry Commission  
 EA: Environment Agency

The workshops will review existing research, produce a prioritised list of research needs and seek to identify the funding mechanisms and potential partnerships. The information exchange mechanism on biodiversity research is envisaged as a pilot WWW-based search facility which will act as a 'one-stop shop' for information about biodiversity research. Key stages include reviewing and assessing existing models, including work currently being undertaken as part of the National Biodiversity Network, identifying a small number of volunteer organisations who are willing to provide registers of their research projects electronically, and developing a common electronic format to enable information exchange. The system will be piloted via the UK Biodiversity WWW site and is to be completed by February 2002.

#### *8.6.1.5. Plant Atlas 2000*

Article 7 of the Convention on Biological Diversity required contracting parties to identify and monitor components of biological diversity and to maintain and organise data derived from these activities. The original Atlas of British Flora, published in 1962, broke new ground in showing the distribution of species on a 10km<sup>2</sup> basis for the whole of Britain and Ireland. The Atlas is an important building block for many areas of work which feed into policy such as assessing rarity for species conservation purposes, monitoring the rate of spread of new introductions, knowing which plants are locally appropriate in habitat restoration schemes and predicting the effects of policy and climate change. The Scientific Advisers' Unit is currently managing the 'Atlas 2000' project which will produce a replacement of the original Atlas, since most of the records on which it is based are at least 40 years old. It is due for completion by April 2001.

#### *8.6.1.6. UK Climate Change: Impacts on UK Habitats and Species*

The prospect of rapid climate change and sea level rise raises some fundamental questions about the objectives of, and approaches to nature conservation in the UK. Current policy broadly aim to protect and conserve the most important species and habitats in situ and, in some special situations, to reintroduce species or restore and recreate habitats in areas from which they may have been lost in recent past. In a rapidly changing climate, these policies and practices may be less effective and may need to be adapted to improve opportunities for species to move to and successfully colonise new sites, emphasising the importance of habitats within the wider countryside. Rising sea levels will pose a particular problem for some internationally important coastal mudflat, salt marsh and strandline habitats. The project currently managed by the Scientific Advisers' Unit aims to review (based on current knowledge) the direct and indirect impact of climate change on species and habitats protected in the UK by national and international agreements and legislation, and consider the implications for local biodiversity action plans and agri-environment schemes. It will also, on the basis of existing monitoring frameworks, recommend a system for the early detection of climate change impacts and a prioritised programme of further research. It was due for completion in February 2000.

#### *8.6.1.7. EU Fifth framework programme*

The Countryside Research Programme is only part of the overall research effort in this area and is supported by work in other Directorates within DETR, other Government



Departments, the Research Councils, the statutory conservation agencies, Non-Governmental Organisations and the European Union. The EU Fifth Framework Programme (FP5) covers EU research and development activity for the next 4 years, and first calls for FP5 project proposals have now been launched in most research areas. The themes and key actions most likely to be of relevance to the Department's Wildlife and Countryside interests are: Theme 1, Quality of life and management of living resources: Key Action 4: sustainable agriculture, fisheries and forestry including integrated development of rural areas; and Theme 4, Energy, Environment and Sustainable Development (Preserving the Ecosystem): Key Action 2: Global change, climate and biodiversity. A proposed Transport Research Laboratory (TRL) project for inclusion in the European 5th Framework is 'Integrating Roads in the Landscape'. If approved, this will include the investigation of measures to reduce habitat fragmentation, methods to enhance the ecological design of road schemes and optimise the design of fauna passages and other mitigation measures, and the development of indicators of habitat fragmentation.

#### *8.6.1.8. Development of Countryside Indicators*

As part of the Sustainable Development Strategy the Government has published a set of 'headline' indicators. Other sectors and agencies at international, country and local levels are also preparing their own groups of indicators. Changes in countryside and biodiversity are key elements of these indicators but the available data are limited and frameworks for evaluating change are poorly developed, especially with respect to landscape quality. Although a number of indicators on biodiversity, agri-environment and landscape have already been developed from Countryside Survey data, these are not formally linked with frameworks for local biodiversity and landscape assessment such as Natural Areas and Countryside Character Areas or developing ideas about 'environmental capital'. There is a need to make more effective use of the available information on countryside change, including satellite land cover data, and to develop a more co-ordinated approach with the Countryside Agency and English Nature. A DETR objective is thus to review the use of CS2000 data (including Land Cover Map 2000) in countryside indicators, review other sources of countryside information and systems for assessment (including Countryside Character, Natural Areas and environmental capital), explore how these data and assessment frameworks can be linked and used together to provide countryside indicators for England, and produce pilot indicators and test their validity.

#### *8.6.1.9. Biodiversity Research Programme*

Work on the calibration of bird monitoring schemes has been commissioned to ensure that decisions on derogations under the EU Birds and Habitats Directives are consistent with maintaining favourable conservation status. DETR in collaboration with JNCC has also recently published proposals for a new framework to provide reliable and cost-effective monitoring of British mammal species. Current research includes the monitoring of cetacean populations around the coasts of Great Britain in support of the Department's obligations under the Agreement on Small Cetaceans in the Baltic and North Seas. There is also a series of projects, nearing completion, seeking to resolve perceived conflicts between bird predators and game and fisheries management, on raptor predation of red grouse and racing pigeons. Recently let contracts include the monitoring on the Dorset Heaths following an appraisal visit by the Standing Committee of the Convention on the

Conservation of European Wildlife and Natural Habitats (Berne Convention), and a review of UK biosphere reserves following the decision by Government to re-subscribe to UNESCO.

#### 8.6.1.10. *Independent Evaluation Of UK Progress On Biodiversity*

The UK Biodiversity Action Plan (BAP) derives from obligations under the Convention on Biological Diversity, signed by the UK at the 1992 Rio Earth Summit. The development and implementation of the BAP is now being co-ordinated by the UK Biodiversity Group. Government has accepted the need for periodic progress reports on BAP with the first report due in 2000. DETR aims to provide a summary of the views of those engaged in the biodiversity process as to its successes and failures, matching these views against the perceptions of a range of key partners outside the biodiversity process, but with whom it seeks to work. Conclusions will be drawn as to where the process has scored its successes and failures and why, and recommendations will be made regarding amendments to the biodiversity process' objectives and priorities (but not its structure).

#### 8.6.1.11. *Piloting a Terrestrial Mammal Monitoring Network (MaMoNet)*

While some of Britain's mammals are thought to be declining and possibly threatened, others are increasing in numbers and range. National monitoring methodologies need to be as consistent as possible between species, field surveyors and regions, to enable results to be drawn together for national analysis. Presently, whilst a range of organisations undertake monitoring, the methods used and the means of data storage are not integrated or consistent. The DETR and the Joint Nature Conservation Committee (JNCC) therefore let a scoping study in 1996 to ascertain the task that would be required to monitor terrestrial mammals effectively. This study, published in 1998, proposed that a new system should be tested by a pilot study. The JNCC and the DETR have consulted on the proposals and received positive feedback. Other Government bodies, such as the Ministry of Agriculture, Fisheries and Food, English Nature, Scottish Natural Heritage, Countryside Council for Wales, Farm Research and Conservation Agency and Forestry Commission as well as non-government organisations (NGOs) that carry out different levels of monitoring, are being approached with regard to their possible involvement in the project. As well as meeting international obligations to survey and monitor mammal species, the data provided will provide much of the information required by the National Biodiversity Network being prepared to commence in the year 2000.

#### 8.6.1.12. *Butterfly Monitoring in the Wider Countryside*

The status of butterflies in the wider countryside has great potential as the basis of a robust wildlife indicator of sustainable development, that could be linked to changes in land cover and plant communities detected by Countryside Survey. The Butterfly Monitoring Scheme (BMS) is an established long-term monitoring methodology that has a proven ability to measure trends in butterfly populations. Over the past 18 years it has established a unique resource of quantitative data on fluctuations in butterfly abundance throughout the UK, at local and national levels. The results of BMS have been widely published and have been used to provide national wildlife statistics to the Department. There are initiatives to extend the BMS methodology to give greater coverage to scarce and

threatened species and to investigate butterfly populations, including UK BAP priority species, in Environmentally Sensitive Areas. Extending the BMS methodology to the wider countryside will complement these initiatives, as well as potentially providing a valuable indicator of sustainability. A DETR proposal is for a short feasibility and planning pilot study to evaluate the specific benefits and costs of extending the existing BMS methodology for wider countryside monitoring, including identifying potential new monitoring sites and evaluating existing sites that could potentially contribute to a wider countryside network.

#### *8.6.1.13. Geographical and Administrative Database of Designations and Schemes*

Since the Second World War the UK has developed a complicated and overlapping system of designations for landscape protection, nature conservation and development control. Areas are designated and administered by several different government departments, statutory agencies and local authorities. DETR requires rapid and flexible access to information about designations on an irregular and ad hoc basis, to provide advice to Ministers, support case work on individual sites, provide information for policy development and respond to general enquiries. ADAS have recently completed a short scoping study which reviews the options for implementation of GADDs and the Department is considering the findings. The aim of this project therefore is to meet the needs of the Wildlife and Countryside Directorate for geographical and administrative information about wildlife and countryside designations and schemes in the UK. The project will identify data sources and protocols, and negotiate for access to information held by other government departments (OGDs) and non departmental public bodies (NDPBs). It will also design and develop a system for holding, manipulating and presenting information on designations and schemes.

#### *8.6.1.14. Modelling Environmental Impacts of Land Use Change (MEILUC) Part 2*

In the Post War period changes in land use and land management have had far-reaching effects on wildlife, landscape and water resources in the UK. In developing policies which impinge on the countryside it is important to be able to forecast how policies will affect land use and how, in turn, land use change will affect wildlife and the appearance of the countryside. The Department has commissioned a review of models designed to forecast the environmental impacts of land use. The review has considered the application of the Reading University Land Use Allocation Model (LUAM) and the use of data from the Countryside Survey. The review makes recommendations for how models may be developed to be more useful to the policy-making process. This proposal is for the second part of the research aimed at taking forward the recommendations.

### **8.6.2. Highways Agency Research**

The Highways Agency has an extensive programme of research and development programmes relating to biodiversity and nature conservation and their application in trunk road management. Of particular interest is sub-project DE4 'Community, Landscape and Habitat Fragmentation', which is one of fourteen sub-projects in the 'Managing Integration' commission for the Traffic Safety and Environment (TSE) division of the

Highways Agency. The specific aim of the sub-project is to examine the potential to overcome or reduce the impact of severance and fragmentation of the environment (in the broadest sense of the terms), particularly relating to trunk roads in England (but also involving rail links, freight paths, LTR routes, bus routes, pedestrian and cycle routes and wildlife corridors). The project revolves around the investigation of the 'living bridge concept' to provide effective mitigation to severance and fragmentation. Living bridges is a wide-ranging concept that addresses issues of community, ecological and social fragmentation. It endeavours to:

- reduce fragmentation;
- reduce severance;
- reduce disruption of ecology;
- promote biodiversity;
- maximise opportunities to enhance the environment;
- provide connectivity of the environment; and
- connect points of origin and destination for all creatures.

The study encompasses not only bridges and underpasses but also linkages and connections of all kinds, and will highlight opportunities to reduce fragmentation and severance in both the urban and rural environment. It will assist in the creation of conditions that ease movement or enhance connections previously hampered by the trunk road network. The project is now at Stage B, with a detailed scoping exercise on the research pilots being carried out in order to determine the best way to take the programme forward. The initial results from the extensive literature search carried out on habitat fragmentation (Halcrow Fox Consultants, 1999) has shown that the predominant source of UK information on fragmentation and severance remains within DETR and HA documentation. The published information and guidance that is available however, is strictly limited. The Stage A report has revealed a significant and growing interest in the living bridge concept, with the following key issues apparent:

- there are gaps in current guidance;
- there are immense opportunities for innovative research and new ideas;
- there is considerable interest in the field;
- there is a latent demand for advice and guidance; and
- there are opportunities for links with other organisations and research bodies especially within Europe and North America.

There is considerable scope via the concept of living bridges to improve some of the worst effects of fragmentation and severance both in relation to the existing transport infrastructure, and in planning new development or improvement proposals. Stage B of the project will identify case studies to assist in investigating design issues and solutions, specific construction issues and solutions, and performance monitoring of living bridges. Further consultation will concentrate on ascertaining:

- known locations of living bridges;
- the location of known fragmentation and severance;
- examples of existing good practice/solutions; and
- the appropriate application of mitigation techniques.

Provisional draft guidance is to be prepared as a 'Living Bridge' supplement to DMRB (Volume 10 Good Road Design). This will include guidance on the application of appropriate design solutions, supported where possible by established examples of best practice. Ultimately this advice will be incorporated in the HA Toolkit and NATA.

### 8.6.3. Forestry Commission Research

In its role as the forestry authority, the Forestry Commission (FC) funds a programme of research organised by topic into the following groups:

- biodiversity;
- economic value;
- economics and statistics;
- health and safety;
- monitoring and forecasting;
- physical environment;
- protection;
- social forestry and heritage; and
- systems and operations.

The Biodiversity Programme Group is aimed at supporting the forestry policy objective of conserving and enhancing the biodiversity associated with woodlands in ways which contribute to the conservation of biological diversity in the UK as a whole. This overall policy aim is divided into two major objectives:

- conserving and enhancing the overall populations and natural ranges of native species and the quality and range of wildlife habitats/ecosystems within all types of forests; and
- helping to conserve and restore UK priority habitats and species (internationally or nationally important and/or threatened) and also habitats which are characteristic of local areas.

Current research programmes have reflected this division. The first objective is addressed by the FC Biodiversity Research Programme, which started in 1995, and concentrates on investigating ways of diversifying planted forests. Research under the second objective supports the implementation of UK Habitat and Species Action Plans (under the UK Biodiversity Action Plan). The main programmes here aim to improve the understanding and management of native woodlands, but also of non-woodland habitats and important woodland species such as red squirrel (*Sciurus vulgaris*). Current programmes include:

- Assessing Biodiversity in Planted Forests;
- Decision Support for Biodiversity;
- Forest Habitat Management;
- Genetic Conservation;
- Landscape Ecology;
- Lowland Native Woodlands;
- Species and Habitat Action Plans; and
- Upland Native Woodlands.

The FC also contributes to the UK Environmental Change Network programme (see section 8.6.4) and has published valuable research as part of the 'Deer Population Ecology Programme'. The latter has taken on the important task of translating the results of research (by Forest Research and other organisations) into practical advice for woodland managers. Current work is aimed at increasing the understanding of deer population dynamics and behaviour, improving the ability to estimate population density and relating density to impact on habitats.

The work of the Forestry Commission is guided by one main policy document: the England Forestry Strategy (Forestry Commission, 1998), which recognises the importance of taking action to work towards reversing fragmentation of ancient and semi-natural woodlands. A priority is to encourage the creation of new native woodlands to form more viable woodland units (Figure 8.4).



Figure 8.4 Linear woodland planting beside a motorway

Following consultation in 1997, the Forestry Commission will be introducing new guidance to help identify appropriate sources of planting material. The creation of new woodlands along transport corridors is seen as a key part of a programme of environmental improvements.

#### **8.6.4. Environmental Change Network**

The detection of long-term environmental changes caused by natural and human-induced changes in climate and other factors requires careful monitoring. The Environmental Change Network (ECN) was launched in 1992 as the UK's integrated network for monitoring environmental change (Figure 8.5).

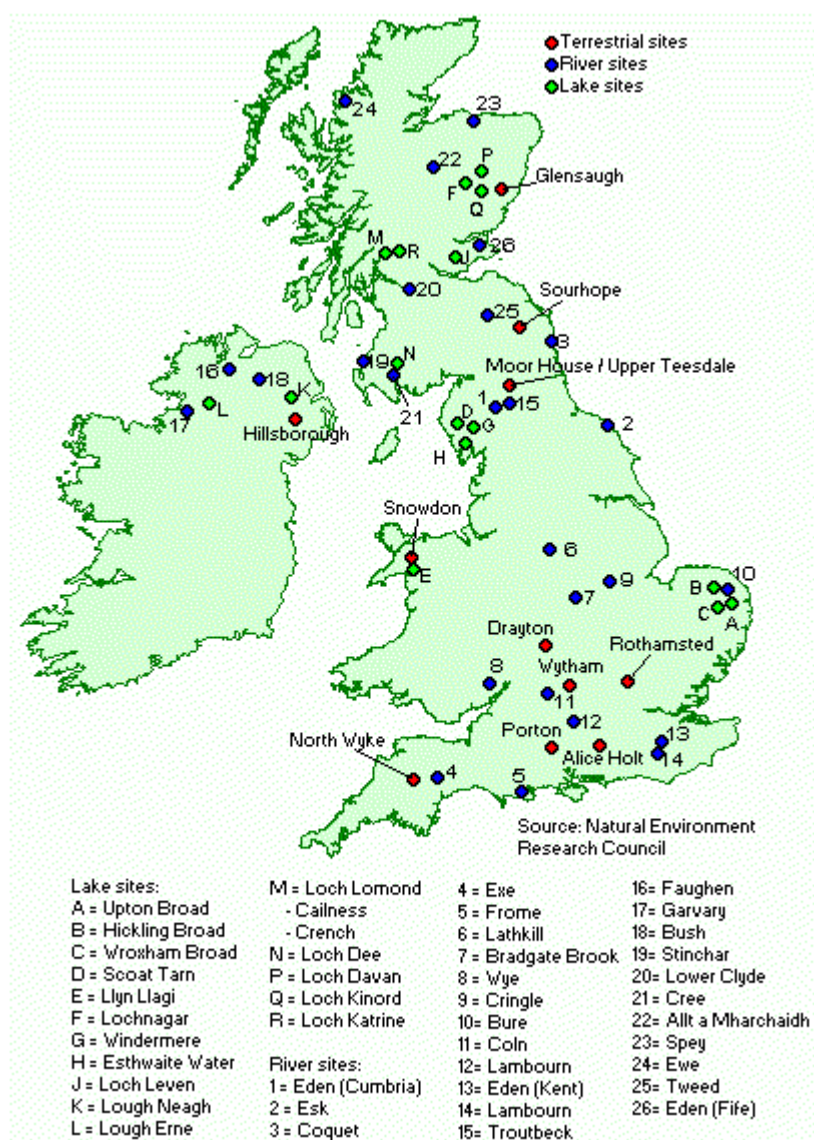


Figure 8.5: Location of Environmental Change Network sites

The 14 sponsoring agencies are co-ordinated by the Natural Environmental Research Council (NERC), with the objectives to:

- maintain a set of sites within the UK to obtain comparable long-term data sets of variables identified as being of major environmental importance;
- provide for the integration and analysis of these data sets, to identify changes, and to understand the causes of change;
- make these data sets available as a basis for research and prediction; and
- provide, for research purposes, a range of representative sites where there is good and reliable environmental information.

The network comprises 11 terrestrial and 42 freshwater sites spread across the UK (Figure 8.5), but it is intended to expand the network in the next few years to ensure a more complete coverage. A set of standard protocols have been developed for monitoring, to ensure consistency in data gathering, collection and interpretation. Measurements at

freshwater sites include meteorological data, water chemistry, physical variables, flow, macroinvertebrates, macrophytes, diatoms and plankton species. Measurements at terrestrial sites include meteorological data, atmospheric chemistry, precipitation chemistry, vegetation, soil solution chemistry, vertebrate and invertebrate data.

Consistent data collection, with good quality control, is essential to meet the long-term aims of the programme. These are to be able to interpret future changes in the environment and to provide early indication of potential changes, not yet identified. The network has not been running for sufficient years yet to provide data on long-term trends, but useful data on the state of the environment and for the development of models are already available and can be accessed through the ECN web pages.

#### **8.6.5. Environment Agency**

The Environment Agency is looking for opportunities to de-culvert short stretches of river in south London. Although an expensive and time-consuming operation, EA would like to de-culvert rivers where such plans won't interfere with development and won't compromise flood defences. If they can secure the funding, EA foresee one de-culverting project a year in South London. Work has already begun on restoring almost 400m of the river Ravensbourne, south of Bromley, funded jointly by the EA and Bromley Council. When work is finished, the section's bends and fish spawning areas will be restored, and although there are no guarantees that uncovering short sections of London's rivers will result in fish spawning, it is a distinct possibility.

#### **8.6.6. Life ECONet Project**

The LifeECONet project has gained £1.55 million from the European Commission (EC) Life Environment Programme to fund a four year demonstration programme (which began in Autumn 1999). This aims to test the hypothesis that 'the integration of environmental issues in land use planning and management can be facilitated by the use of an holistic model that focuses on the realisation of regional ecological networks'. A multi-national partnership will record the achievements and experiences of three study groups located in the European regions of North West (UK), Abruzzo (Italy) and Emilia-Romagna (Italy). Each study group is centred on local authorities with their land use planning responsibilities and links with community, practitioners, and local universities, who will offer support and specialist guidance.

In the UK, Life ECONet will build on work undertaken since 1996 by Cheshire County Council, English Nature, and the Universities of Salford and Liverpool John Moores (Cheshire County Council Environmental Planning Service and English Nature, 1998; and Clark, 1998) (see section 4.6). These original four partners have been joined in the initiative by North West Water Limited, Vale Royal Borough Council, the Department of Horticulture and Landscape at Reading University, the Environment Agency, the University of Cambridge, and Sustainability North West (Europe's first cross-sectoral regional partnership on sustainable development). Using the ecological network approach, these UK Project Partners, alongside their Italian counterparts, will study wider landscapes in Cheshire and the two Italian regions of Emilia-Romagna and Abruzzo in order to



identify and target possible areas where wildlife could, with positive management, expand, flourish and coexist on land that is also being used for other purposes. The three study groups are at different stages in the development of their regional "ecological network". A fourth group in this programme is based in Gelderland (North of Netherlands). As the recognised European leaders in the construction of "ecological networks" this group will contribute its experience in establishing ecological networks, and will assist in developing the work already begun in the other partner locations.

The first part of the Project will produce a more detailed mapping of landscape features and ecology in the study areas using computer Geographical Information Systems (GIS). The output from this stage will be a series of integrated land management plans, which will identify concentrations of sites and features of high value for wildlife, as well as areas on which wildlife habitats could be restored and re-created. The Project will then look at how these masterplans can be used by local authorities, landowners, and developers in putting together and agreeing proposals for development and land use. The Project will also highlight where changes in policy, instruments and schemes are necessary to realise ecological networks. The partners will also demonstrate the practicalities of integrating ecological objectives with a number of different land uses, including highways and farming, by the use of an holistic model that focuses on the realisation of regional ecological networks. Each study group will demonstrate a model that promotes the realisation of a regional ecological network as a mechanism for integrating ecological objectives in sustainable land use planning and management. The model is based on concepts drawn from the discipline of landscape ecology, tools of Geographical Information Systems (GIS) and existing practice of community involvement. The model has five, equally important and co-dependent elements or tasks:

- technical development of Geographical Information Systems and the application of landscape ecology principles;
- assessing and influencing land use policy and instruments;
- demonstrating integrated land management;
- engaging stakeholders; and
- dissemination.

The realisation of an ecological network will help local authorities and land managers to integrate environmental considerations in land use planning and management. It has the potential to be a targeting mechanism and an aid to decision-making, providing a methodology for advancing nature conservation in Europe in ways that make ecological sense and are consistent with European directives and initiatives. It is intended that the model proposed will be easily applied in other similar European locations.

## 8.7. SUMMARY

Transport policy is still undergoing reassessment in the UK. It is now recognised that many changes are needed to reduce environmental impacts, primarily by reducing traffic and pollution. A number of environmental objectives need to be set, against which progress can be measured and policy measures targeted. In particular, given the significant impacts of transport, especially of roads on habitat fragmentation and biodiversity, a series of specific pledges are needed:

For new infrastructure this should include:

- no destruction of or damage to internationally important sites;
- a strong presumption against destruction of or damage to nationally important sites;
- a presumption against destruction of or damage to habitats or species listed in international or national legislation; and
- a presumption against destruction of or damage to or identified sites of wildlife importance (where it is recognised that 'damage' includes increasing the fragmentation or ecological isolation of such sites).

For existing infrastructure initiatives should address:

- targeted reductions of atmospheric pollutants such as carbon monoxide, oxides of sulphur and oxides of nitrogen;
- targeted reductions of other pollutants, with especial reference to surface and sub surface water pollution; and
- accelerated research on issues such as habitat fragmentation and isolation including the effects of noise, lighting etc.

This chapter has highlighted that there is a distinct need for ecology to be pushed up the transport planner's agenda. Themes such as biodiversity have been integrated into other areas of planning, but are yet to be given due regard in the transport policy sector. Environmental Assessment, and more particularly SEA, provide a systematic framework by which the previously overlooked ecological and biodiversity issues associated with new infrastructure schemes could be flagged up. An increasing body of research illustrates the interest in the topic of habitat fragmentation, but at present there is limited evidence of any attempts to promote defragmentation. It has been proven that tools such as GIS-based models and satellite imagery should be utilised to promote an approach to planning which recognises and takes into account the consequences of habitat fragmentation for wildlife. Embracing such an approach could help the UK cast aside its current reliance on piecemeal, sectoral planning in favour of a more integrated landuse strategy. In addition, co-ordination across international boundaries on transport infrastructure issues is required (especially relating to waterways and the high speed rail developments) in order to address the need for a strategic approach to be taken towards habitat fragmentation.

## Chapter 9. Economic Aspects

### 9.1. INTRODUCTION

The economic costs and benefits of transport infrastructure are traditionally measured using cost-benefit analyses (e.g. COBA in England and NESA in Scotland). However, both of these have recently been criticised for taking too narrow a view of 'economic benefit' and for not taking full account of environmental and social costs and benefits (Higman, 1995). The direct and indirect impacts of infrastructure development can be considerable, and are increasingly recognised as important considerations in proposed schemes, however there is no standard methodology in evidence in the UK for valuing the wider external costs of fragmentation.

### 9.2. ENVIRONMENTAL ACCOUNTING

In the Sustainable Development Strategy 'A Better Quality of Life' (1999), the Government makes a commitment to take forward work on environmental accounts. To this end, a unit has been established in the Central Statistical Office to develop them. These accounts will ultimately adjust measures of income for depletion of natural resources, and report physical quantities of pollutant emissions and expenditure on environmental protection. Environmental accounts present the links between the economic and environmental impacts of different sectors of the economy. They can also be used to model environmental change. Some argue that a modified or 'green GDP' could be used as a comprehensive measure of sustainable development. However, there are significant problems before we can place reliable and robust money values on the cost of environmental degradation. Indicators (as discussed in Chapter 8) are able to highlight key environmental issues, such as loss of biodiversity, some of which are difficult to associate with specific sectors of the economy and cannot be easily integrated into the environmental accounts. The Government is therefore taking a joint approach in developing both a set of indicators and a system of accounts which will complement one another. The basic information underlying both measures will, of course, be the same.

Increasingly research is being carried out into the economic aspects of the environmental resource. Several initiatives have attempted to address the problems associated with valuing the environment, and have suggested alternatives to monetary valuation. Such projects include Countryside Characterisation (Countryside Agency) and Environmental Capital (Countryside Agency and English Nature). These are based on assigning value to environmental attributes rather than environmental features, using criteria such as 'tranquillity' and 'sense of place'. However, theoretical methodologies such as these are proving difficult to apply and the projects are very much at a pilot stage.

### 9.3. PRIORITISING MITIGATION

Mitigation measures are funded by the transport developer, either entirely voluntarily or at the request of the planning authority to satisfy the requirements of EA. The priority of mitigation measures within a project depend on placing values upon the various environmental discipline including: nature conservation, landscape and visual, heritage and culture, agriculture, education, recreation and community. The weighting given to these disciplines will vary with location and over time. Criteria for assessing value must be established by each environmental discipline, and preferably on a site by site basis. For example, to prioritise nature conservation projects the following criteria might be adopted:

- the magnitude of the impact on the resource as a result of the transport proposals;
- losses and decline suffered by the habitat/species in this Century;
- concern about the status of the habitat/species as recognised in UK and/or European legislation;
- consensus of concern expressed by environmental interest groups; and
- scope for the opportunity to address more than one discipline (e.g. heritage, landscape and nature conservation benefits).

One important economic aspect of providing mitigation is the consideration of long-term maintenance costs. This is one area that has often been overlooked in the past, leading to deterioration of the structures and a decline in their efficiency. Best practice advocates that the long-term economic commitment towards maintenance needs to be secured at the outset of the project, with each of the involved parties fully aware of the financial implications involved in carrying out their parts of the contract. At present the lack of regulatory control over post-construction monitoring and maintenance represents a significant weakness in the EA system, and one area which lowers the cost efficiency of providing mitigation measures.

## Chapter 10. General Conclusions and Recommendations

### 10.1. OVERVIEW

Worldwide, the fragmentation, degradation and loss of natural habitat is recognised as a major cause of decreasing biodiversity (Ehrlich and Wilson 1991; and Wilson 1992). Impacts of habitat and population fragmentation are important priorities for conservation. Habitat fragmentation can take a number of forms, from purely physical in which successive blocks of habitat are subdivided, to visual in which a barrier is positioned between the two newly created blocks of similar habitat. Fragmentation involves a reduction in the overall area of habitat and habitat patches, isolation of one patch from another, an increase in the amount of edge habitat relative to interior habitat, and alteration of the spatial arrangement of habitat patches. As fragmentation of natural landscape continues, sensitive species face both a loss and deterioration of necessary habitat, which increases the rarity of sensitive species. Declining species then become rarer through density reduction, range restriction, combined range and density reduction, or concentration of the local population in to smaller remnant areas. If fragmentation leads to increased landscape-scale patch heterogeneity, there may be increases in bird or other wildlife group diversity due to the prevalence of favourable conditions for edge or adjacent habitat species, at the expense of habitat specialists which may be of greater conservation interest. In general, however, a decrease in fragment area and increase in isolation leads to a decrease in species diversity. Exploitation of habitat fragments depends on dispersal capabilities of the species, migratory tendencies, habitat specialisation, connectivity of fragments (which effectively reduces the isolation effect) and the pattern of the juxtaposition of the fragments. The spatial scale for detecting the effects of fragmentation depends on the species concerned, with smaller scales operating on sedentary species with specialist and restricted habitat requirements and small ranges. The latter are exemplified by a number of species of butterflies and other invertebrates which are restricted to small patches of food plants which flower at restricted periods of the year.

The United Kingdom has wide variety of wildlife. Within this relatively small area, large variations of habitats and species exist and as a result the stresses and strains on each of them are many and varied. Water and mineral abstraction has led to the loss of habitats and species, and significant areas of the countryside are impacted by discharges to air and water causing problems such as acidification and eutrophication. Societal influences, such as the demand for additional land for housing and infrastructure developments, are also having an impact in relation to fragmentation, but it is invariably difficult to attribute and quantify the impacts on habitats and species created by each type of development in isolation. Many habitats in the UK have become more fragmented in recent years, but the evidence for direct and indirect effects of such fragmentation as distinct from habitat loss on species populations is limited. There is however sufficient evidence to suggest that it is a potentially important cause of species decline to justify opposition to further habitat fragmentation.

The way that fragmentation effects are considered depends on the interests of any particular group of people. Research ecologists may be concerned to unravel the relationships between species occurrence, site size and isolation, and how these fit with concepts such as

island biogeography, source-sink systems and metapopulations. This is essential if we are to advance our knowledge of ecological processes, but the results may not be directly translatable into conservation practice because they involve only common species or habitats of no great conservation significance. The general public may be more worried about the direct killing of a species when a road goes through a patch, the possible pollution effects, or increased disturbance. Land managers may concentrate on the extra problems that follow from having to work in two patches rather than one, or about the changed nature of newly created edges. When these different impacts are presented to politicians, planners and engineers the response may vary from 'fragmentation problems are not important', 'they are important but no practical or affordable solutions are available' to 'yes something can and will be done'. The level of response is usually determined by the perceived rather than real level of the impact, and by the cost of the solution (Kirby, 1995).

The perceived effects on animal populations that are usually raised in discussions on habitat fragmentation may be grouped into four broad categories:

- Large animals with high population levels (e.g. deer, badgers) suffer road casualties which may lead to concerns from both road safety and animal welfare point of view without there being any obvious short-term effects on population. Thus badgers in the UK are increasing despite substantial annual road deaths.
- Large animals with small populations may be threatened, because the loss of even a few individuals might lead to their local extinction.
- The interruption or hindrance of small animals including vertebrates across a new road may not attract much public attention, but has raised concerns about reduced genetic interchange or the increased risk of chance extinctions of species of species from one or other part of a fragmented system.
- Reasonably predictable mass deaths of migratory species such as amphibians at particular spots where specific mitigation measures may be applied e.g. toad tunnels, deer bridges (EN, 1993).

Early consultation for any proposals is essential so that a proper evaluation of the potential environmental impacts is undertaken at an early stage. Where decisions are taken that schemes which have a negative impact on wildlife should proceed, compensatory projects, close supervision of contractors, and on-going monitoring and maintenance guarantees are essential to minimise or prevent degradation of the environment.

In the UK experience, providing more and bigger roads results in ever greater traffic volumes which grow to fill the provided capacity. Policy governing the scope and focus of national and local transport provision has over recent years moved from a 'predict and provide' approach based on projections of traffic volumes, towards complex evaluation procedures including environmental, ecological, financial and operational issues. Strategic planning and the development of an integrated transport policy is now advocated to minimise the necessity for travel and to ensure environmentally acceptable transport of goods.

Such is the extent and intensity of habitat fragmentation, that protected reserves and special sites alone are very limited measures for conserving wildlife in the wider countryside. What is desperately needed is a more holistic approach involving the integrated management of whole landscapes (Reynolds, 1999). Current knowledge of the barrier and isolation effect of roads in the UK is concerned with the individual animal. There is an urgent need for information concerning the significance of these effects at population level, on the genetics, and the ecological community. Worryingly, there is no research at all on plants, so urgent work is required in this area.

Ecopassages may allow fauna to cross an otherwise insurmountable barrier and prevent local extinction, but many species can cross most roads to a greater or lesser extent, and the very susceptible species which cannot, need corridors of excellent habitat. Other animals such as terrestrial migrants, including many amphibia, need very reliable ecopassages, as the majority of individuals in a population must cross easily. Unlike metapopulation species, proof that some individuals cross is inadequate to assess success of the ecopassage.

## **10.2. BASIC PRINCIPLES FOR BETTER MANAGEMENT OF THE FRAGMENTATION EFFECT**

- Take account of the existing level of fragmentation of the area to be crossed when siting new infrastructure or proposing repairs to existing structures;
- Determine the most critical or fragile 'target' species in the context of fragmentation;
- Re-create, if necessary, the missing (or reduced) habitats corresponding to the biological needs of the affected species;
- Identify animal movement routes in order to optimise location of compensating structures; and
- Identify periods of movement in order to ensure ecological management of the construction site and avoid isolating the whole population in one particular part of the land area when fences are built.

## **10.3. POTENTIAL FOR FURTHER INVESTIGATION**

The predominant source of information on fragmentation and severance in relation to transport infrastructure remains within DETR and HA. A limited (but growing) number of documents and research papers exist that address the wider aspects of severance and fragmentation, but the vast majority of these relate to ecological theory and to other types of land use, predominantly agriculture. Following the review of existing literature, several key issues have become apparent:

- there are gaps in current guidance;
- there are immense opportunities for innovative research and new ideas;
- there is considerable interest in the field;
- there is a latent demand for advice and guidance; and
- there are opportunities for links with other organisations and research bodies especially within Europe and North America.

Recommendations for further work are therefore to address these issues. Undoubtedly the opportunity is there and the timing is right for innovative and co-ordinated research to be carried out. It is essential that close links are developed and strengthened within Europe to further the exchange of information, in order to develop effective guidance and best practice for defragmentation.



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## Mapping



## **Directory of Organisations and Competent Authorities**



## **Bibliography**

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**COST 341 Memorandum of Understanding****Brussels, 14 May 1998****COST 242/98****COLLAGE DONE ON PAGE 12.****Memorandum of Understanding****for the implementation of a European Concerted Research****Action designated as****COST Action 341****"Habitat fragmentation due to transportation infrastructure"**

The Signatories to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the Technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 400/94 "Rules and Procedures for Implementing COST Actions", the contents of which are fully known to the Signatories.
2. The main objective of the Action is to promote a safe and sustainable pan-European transport infrastructure through recommending measures and planning procedures in order to conserve biodiversity and reduce vehicular accidents and fauna casualties.
3. The overall cost of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at ECU 3 million at 1997 prices.
4. The Memorandum of Understanding will take effect on being signed by at least 5 Signatories.
6. The Memorandum of Understanding will remain in force for a period of 4,5 years, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

## **TECHNICAL ANNEX**

### **COST Action 341**

#### **Habitat fragmentation due to transportation infrastructure**

##### **A. BACKGROUND**

Recently more attention has been paid to the causes that lead to decreasing biodiversity. Besides the reduction in surface of large natural areas habitat fragmentation (splitting of natural ecosystems into smaller and more isolated units thus endangering the survival of animal and plant species and communities) plays here an important role. This negative phenomenon threatens the biodiversity on a European scale. One of the main causes of habitat fragmentation, besides agriculture and urbanisation, is the construction and use of linear transportation infrastructure (roads, railways, waterways). By good planning, disturbance of natural areas can be avoided. By using mitigation and compensation measures the fragmentation effects can be reduced.

The existing networks of transportation infrastructure in Europe have already produced substantial fragmentation of the natural landscape. More European countries have become aware of the need to develop national programmes of research on effects of infrastructure on biodiversity and implementation of measures that could minimise the impacts. The results of the programmes will be used, on the one hand, to adapt the existing transportation routes to ecological requirements so as to ensure the maintenance of viable population levels of affected species and, on the other hand, to integrate fragmentation aspects within the planning procedures when new infrastructure is planned and constructed. The results of research and consequently the solutions offered could be used when implementing the planned Trans-European Networks (TENs).

A preliminary overview on the current situation of habitat fragmentation due to infrastructure has been undertaken in 12 European countries. The conclusions of this first assessment can be summarised as follows:

- the amount of research carried out so far (when applicable) is not enough to offer sufficient scientific background so as to give comprehensive solutions to the problem;
- measures to mitigate and/or compensate the losses and disturbances generated by fragmentation are very rarely implemented and/or planned;
- great differences exist among European countries regarding the scientific background and know-how, affected species and landscape, awareness and development.

The representatives of 12 European nations present at the meeting of the European Expert Group Infra Eco Network Europe (IENE) held in Romania, 9-11 October 1996 have stressed the need for Cupertino and exchange of information in the field of habitat fragmentation caused by infrastructure at European level. The participants have recognised that concerted action is urgently required.

First of all a comprehensive detailed inventory of the current situation at European level of habitat fragmentation caused by construction and use of the transportation networks is needed. All information will be gathered into a "European state-of-the-art report on habitat fragmentation due to infrastructure".

Secondly, a "European Handbook on habitat fragmentation due to linear transportation infrastructure" will be produced that will include: guidelines, methods, indicators, technical design for, and examples of, measures. A short version of the handbook is desirable for decision-makers.

Simultaneously with the above two products, a "Database on-line" will be developed. This will contain: a list of European experts in the field of infrastructure and habitat fragmentation, data on existing literature, keywords list and list of reference to allow common language on European level. For a rapid access and exchange of information, the World Wide Web will be used. The database will be hosted by the Road and Hydraulic Engineering Division in the Netherlands, as part of an already developed home site of the Infra Eco Network Europe. Its URL address is: <http://www.minvenw.nl/projects/iene>.

Although the degree of fragmentation of nature is not as high as in Europe where the density of infrastructural works is the highest in the world, in the United States research is carried out and mitigation measures are implemented. Recommendations to take measures to diminish the impact of infrastructure on the natural heritage have also been drawn up in Japan.

## B. OBJECTIVES AND BENEFITS

The main objective of the Action is to promote a safe and sustainable pan-European transport infrastructure through recommending measures and planning procedures in order to conserve biodiversity and reduce vehicular accidents and fauna casualties. Further on, the secondary objectives of the proposed Action are defined as follows:

- to enhance the level of knowledge in the field of habitat fragmentation and infrastructure;
- to improve co-operation and exchange of information among experts working in transportation and environmental sectors at national and European level;
- to influence the sectoral policy decision-makers;
- to improve mitigation and compensation measures at European level;
- to stimulate national strategies on environment and transportation;
- to promote international and multidisciplinary research and monitoring;
- to improve awareness on habitat fragmentation due to infrastructure.

These goals will further enhance the realisation of national and international agreed objectives to conserve biodiversity at the ecosystem/habitat, species and genetic levels. The objectives of the proposed Action will improve the implementation of several international agreements:

- The Convention on Biological Diversity (Rio, 1992);
- The Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1979);
- The Pan-European Biological and Landscape Diversity Strategy – strategy 1996-2016 for the "Transportation" sector;
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (1992);
- The EECONET Declaration (Maastricht, 1993).

The proposed Action is expected to bring via its products the following benefits:

- reducing the stress produced by infrastructure on the European biological heritage by implementation of a scientifically-based uniform set of measures so as to decrease the existent habitat fragmentation and to prevent future damage;
- saving time and money by learning from mistakes and by avoiding overlapping research;
- enhancement of road safety;
- implementation of measures will allow producers around Europe to enlarge and diversify their production (ecoducts, tunnels, fences). That means consequently more work opportunities;
- European integration in the field of planning procedures and technical requirements for implementation of mitigation and compensation measures. This information could be used for transboundary European infrastructure projects;
- an immediate application of the results of the proposed Action could be used as scientific and technical support to the implementation of the Trans-European transport network (TEN). As stipulated in Article 5 of the Community guidelines for the TEN (Decision 1692/96/EC), integration of environmental concerns is one of the key priorities in the design and development of the TEN. In addition, the proposed Action can contribute to the development of methods for impact assessment. The TEN community guidelines stipulate explicitly the need for such methods (Article 8(2)).

### C. SCIENTIFIC PROGRAMME

The proposed "European state-of-the-art report on habitat fragmentation due to infrastructure" will contain the following information:

- recognition of the problem,
- legislative framework,
- institutional development,
- scientific background and available sources,
- solutions and implementation of measures,
- co-operation between transportation and environmental sectors,
- Environmental Impact Assessment and Strategic Impact Assessment,
- national strategies and proposed actions,
- relevant case studies.



In the first stage, the research will be carried out separately by each participating country. It is desirable that every country is represented by institutions from both sectors, transportation and environment, in order to rise the quality of the survey. The following activities have to be carried out:

- literature survey,
- public relations,
- gathering information,
- writing final report.

In the second stage, the information given by the national overviews will be analysed and compiled in order to draw a single European Report. This final "European state of the art report" will give information on: the dimension of habitat fragmentation due to infrastructure (both qualitatively and quantitatively), existent knowledge and new research areas, various approaches to solve conflicts and results. The CORINE database hosted by the European Environmental Agency will be consulted in order to get updated geographical information especially on biotopes and protected areas.

The "European Handbook on Habitat Fragmentation due to Linear Transportation Infrastructure" will contain:

- guidelines for the maximum amount of habitat fragmentation that is allowed (comparable to e.g. Limit values for pollution);
- methods to define priorities when tackling intersections between infrastructure networks and nature;
- indicators for "fragmentation" of habitats;
- technical description and design specifications of successful mitigation and compensation measures;
- requirements for the design of various measures;
- methods for the evaluation and monitoring of the effectiveness of measures;
- guidelines for the maintenance of measures;
- overview on European case studies and recommendations on methodological aspects of a monetary evaluation of external effects due to traffic-related habitat fragmentation and impacts on biodiversity;
- recommendations on behalf of Eurostat, European Environmental Agency and the national statistical authorities describing the type and the structure of data needed for a continuous survey of traffic-related habitat fragmentation and impacts on biodiversity and their external costs;
- keys for planners to help them with planning procedures;
- relevant case studies and developed projects.

The results of COST Action 332 (Transport and Land Use Policies) will be taken into consideration when describing and making recommendations to improve the co-ordination between transport planning and nature management policies.

A short version of the handbook will be produced for decision-makers.

The "On-line database" will comprise:

- list of European experts in the field of infrastructure and habitat fragmentation;
- database on existing literature and video;
- keyword list and list of reference to allow common language on European level.

The above products can be used by: European Union, central governments, governmental agencies, infrastructure construction companies, consultancy companies, research institutes, education institutions, non-governmental organizations.

#### D. ORGANIZATION AND TIMETABLE

In different stages of the Action, Working Groups of experts will be designated by the MC in order to fulfil the proposed objectives. The proposed COST Action will be carried out in 5 phases, as follows:

Phase 1: The first meeting of the MC will be organised within a period of maximum six months after the formal start of the Action. The aim of the first meeting of the MC is:

- to prepare a detailed plan of action, containing:
  - tasks of the Working Groups;
  - detailed content of the proposed products;
  - timetable of reporting results;
- to elect a Chairperson and a Vice Chairperson;
- to appoint the Working Groups.

Within three months after the meeting of the MC, the Working Groups will start working for the implementation of the Action. The MC will continuously monitor and adapt the working plan.

Duration: 9 months.

Phase 2: Preparation of the National Surveys on habitat fragmentation due to infrastructure. On a national level Working Groups of experts are nominated (one Group in each participating country). They will deliver the current situation in the field in every participant country.

In this phase two workshops and a meeting of the MC will be organised.

Duration: 12 months

Phase 3: An Editorial Group will be formed that has the task to analyse the national reports and to compile the information in order to prepare the final "European state-of-the-art report on habitat fragmentation due to infrastructure".

One meeting of the MC is planned to take place within this phase.

Duration: 6 months

Phase 4: A number of international Working Groups will be formed in order to prepare the "European Handbook on Habitat Fragmentation due to Linear Transportation Infrastructure" and the database. Each of these Groups will be responsible for the preparation of a specific part of the Handbook and database. The tasks might be given according the content of the proposed Handbook. For example: an Expert Working Group might be responsible

for the chapter: Mitigation and Compensation Measures and another with the preparation of the List of Terms of Reference. The number of Working Groups will be defined by the MC within the planning procedure (Phase 1).

Two Expert Working Group meetings and one of the MC are planned during this phase.

Duration: 18 months

Phase 5: The final preparation of the Handbook will be the task of an Editorial Board (this might be the same as for Phase 3). A co-ordination meeting of the MC will take place in this stage of the Action.

Duration: 9 months

The total estimated duration of the Action is 4,5 years. The first product (the European state-of-the-art report) will be delivered after 2 years and the European Handbook and database after the next 2,5 years.

## E. ECONOMIC DIMENSION

The following COST countries and the European Commission have actively participated in the preparation of the Action or otherwise indicated their interest: Austria, Belgium, Czech Republic, Estonia, Finland, France, Hungary, Italy, Netherlands, Romania, Spain, Sweden, Switzerland and the United Kingdom.

Furthermore, the Moscow State University has indicated its interest to participate in the proposed COST Action.

The estimated total cost of the project, assuming participation of 14 countries would be about ECU 3 million at 1997 prices.

## **COST Transport Overview**

COST Transport is one of 17 domains existing in COST at the present time. It was to be one of the seven areas seen as best suited for this new form of collaboration, which was officially set up by a Ministerial Conference in November 1971. The Transport area lends itself particularly well to the COST framework, both because it combines aspects from a number of disciplines, and because of the need for harmonisation at European level. Liaison with the Transport Ministries and Administrations in the various countries is a key element of these COST Actions.

The COST Transport Secretariat is located within the Directorate General for Transport of the European Commission. The location with the staff managing the Fourth and Fifth Framework Transport RTD Programme, as well as the proximity with the Common Transport Policy Directorates, enables close collaboration between Transport Research activities and serves as a basis for further political action.

COST Transport Actions are authorised and supervised by the COST Technical Committee on Transport which, in turn, reports to the COST Committee of Senior Officials. Both of these decision-making bodies comprise representatives of the national governments of the COST countries.

By the end of 1999, the COST Transport domain comprised 13 ongoing Actions, with a total estimated cost of EURO 42.5 Million. 32 Actions have been completed, and a further 4 Actions have been selected and are under preparation.

### **Completed Actions**

- COST 30: Electronic Traffic Aids on Major Roads
- COST 30 bis: Electronic Traffic Aids on Major Roads: Demonstration Project and Further Research
- COST 301: Shore Based Marine Navigation Systems
- COST 302: Technical and Economic Conditions for the Use of Electric Road Vehicles
- COST 303: Technical and Economic Evaluation of National Dual-mode Trolleybus Programmes
- COST 304: Use of Alternative Fuels in Road Vehicles
- COST 305: Data System for the Study of Demand for Interregional Passenger Transport
- COST 306: Automatic Transmission of Data Relating to Transport
- COST 307: Rational Use of Energy in Interregional Transport
- COST 308: Maintenance of Ships
- COST 309: Road Weather Conditions
- COST 310: Freight Transport Logistics
- COST 311: Simulation of Maritime Traffic
- COST 312: Evaluation of the Effects of the Channel Tunnel on Traffic Flows
- COST 313: Socio-economic Cost of Road Accidents
- COST 314: Express Delivery Services

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COST 315:	Large Containers
COST 317:	Socio-economic Effects of the Channel Tunnel
COST 318:	Interactions between High-speed Rail and Air Passenger Transport
COST 319:	Estimation of Pollutant Emissions from Transport
COST 320:	The Impact of E.D.I. on Transport
COST 321:	Urban Goods Transport
COST 322:	Low Floor Buses
COST 323:	Weigh-in-Motion of Road Vehicles
COST 324:	Long Term Performance of Road Pavements
COST 325:	New Pavement Monitoring Equipment and Methods
COST 326:	Electronic Charts for Navigation
COST 328:	Integrated Strategic Transport Infrastructure Networks in Europe
COST 329:	Models for Traffic and Safety Development and Interventions
COST 330:	Teleinformatics Links between Ports and their Partners
COST 331:	Requirements for Horizontal Road Marking
COST 333:	Development of New Bituminous Pavement Design Method

### **Actions Underway**

COST 327:	Motorcycle Safety Helmets
COST 332:	Transport and Land-Use Policies
COST 334:	Effects of Wide Single Tyres and Dual Tyres
COST 335:	Passengers' Accessibility of Heavy Rail Systems
COST 336:	Use of Falling Weight Deflectometers in Pavement Evaluation
COST 337:	Unbound Granular Materials for Road Pavements
COST 339:	Small Containers
COST 341:	Habitat Fragmentation due to Transportation Infrastructure
COST 342:	Parking Policy Measures and their Effects on Mobility and the Economy
COST 343:	Reduction in Road Closures by Improved Maintenance Procedures
COST 344:	Improvements to Snow and Ice Control on European Roads and Bridges
COST 345:	Procedures Required for Assessing Highway Structures
COST 346:	Emissions and Fuel Consumption from Heavy Duty Vehicles

### **Actions in preparation**

COST 338:	Drivers' Visual Information Overload
COST 340:	Towards a European Intermodal Transport Network: Lessons from History
COST 347:	Pavement Research with Accelerated Loading Testing Facilities
COST 348:	Reinforcement of Pavements with Steel Meshes and Geosynthetics

Up-to-date information on COST Transport can be found on the World Wide Web, at the following address: <http://www.cordis.lu/cost-transport/home.html>.