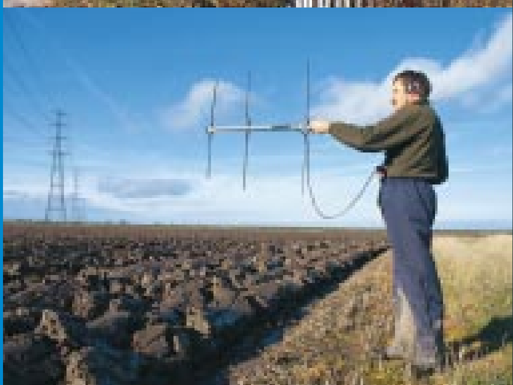
Report Number
626

Going, going, gone? the cumulative impact of land development on biodiversity in England

English Nature Research Reports



working today
for nature tomorrow

English Nature Research Reports

Number 626

Going, going, gone? the cumulative impact of land development on biodiversity in England

Land Use Consultants

January 2005

You may reproduce as many additional copies of this report as you like, provided such copies stipulate that copyright remains with English Nature, Northminster House, Peterborough PE1 1UA

ISSN 0967-876X
© Copyright English Nature 2005

Executive summary

1. The purpose of this report is to act as the first stage of what is likely to be a longer-term process looking at the cumulative effects of current and foreseeable development on terrestrial biodiversity in England. It aims to provide an analysis of cumulative effects, and to establish a framework for further research. It also seeks to explain cumulative effects to decision makers.

2. English Nature postulated the following hypothesis to be tested, that 'the cumulative effects of current and foreseeable development are unsustainable in terms of ecosystem resilience, functioning and ability to support characteristic biodiversity'. The hypothesis was supplemented by six specific research objectives.

- To investigate whether the cumulative weight of planned or desired development in England, is likely to exceed the capacity of England's ecosystems to support it and is likely to prevent recovery of biodiversity and ecosystem functioning and resilience to sustainable levels.
- To consider how best to understand and articulate these effects, to help us develop our evidence base and develop a convincing policy line.
- To identify where in England this is a particular problem and at what scale. The report needs to include overlay maps to show likely cumulative effects spatially, and to prepare a narrative summary of likely cumulative impacts, across England and in an example region.
- To consider whether any mitigating measures are possible to keep cumulative effects within manageable limits to allow the recovery of ecosystem resilience and of biodiversity.
- To consider the value and limitations for this debate of concepts such as the ecosystem-based approach (including ecosystem resilience and interactions between ecosystems), and environmental capacity / environmental limits.
- To consider the implications of this analysis for the implementation of the Strategic Environmental Assessment Directive and to advise on how best to use the Directive to ensure cumulative impacts can be taken account of appropriately.

3. To test the hypothesis and to address the six objectives it was important to define cumulative effects and ecosystem resilience. Cumulative effects are described as 'changes to the environment that are caused by an action in combination with other past, present and future human actions' (CEAA 1999). Cumulative effects can be a combination of direct impacts, indirect impacts or a combination of the two. They can occur both spatially over geographic areas from different sources, and temporally over time. This makes describing them, assessing them, and attributing responsibility for them very difficult. Nevertheless there is widespread acceptance that cumulative effects do occur and that they do pose a major environmental threat. This is best illustrated in the State of Nature Report- Lowlands- future landscapes for wildlife by English Nature in 2004.

4. England's biodiversity is a result of the interaction between species, their physical environment and human influence. This biodiversity has suffered a major decline in the twentieth century mainly due to the impact of human activities especially agriculture, forestry and development. The intensification of agriculture has resulted in the loss of lowland and upland habitats and the modification of fundamental processes. These losses and pressures are augmented by direct and indirect developmental impacts, particularly incremental impacts that are often not captured by environmental impact assessment criteria.

5. The effect of these impacts is that eventually the habitat no longer functions as a natural system. Cumulative effects are an increasingly significant threat to biodiversity in England. The protection of biodiversity is a major tenant of sustainable development, enshrined in the Rio Convention on Biological Diversity in 1992 and the UK Sustainable Development Strategy 1999, the new version of which is due to be published in 2005. Cumulative impacts threaten many of the government's sustainable development objectives. Consequently, development that ignores the threat of cumulative impacts cannot be called sustainable because it is contributing to a net reduction of biodiversity in England.

6. The main development-related issues in England arise from the following:

- urban development and construction;
- roads and transport;
- water supply;
- waste management;
- energy consumption;
- mining and quarrying.

7. The main types of cumulative impact, both direct and indirect, caused by these drivers are:

- Habitat Loss- The direct loss of habitats under development.
- Habitat Fragmentation- The breaking down of habitat units into a smaller number of units.
- Disturbance- Through noise, light, recreation, pet predation, vibration etc.
- Pollution- Either chemical or biotic.

8. Cumulative impacts often have a significant effect over time. Whereas an initial impact may not necessarily be assessed as significant,it is only when a number of such impacts come together to have a significant effect that the full extent is realised. With regards to their impact on biodiversity, cumulative impacts may reduce ecosystem resilience over time. 'Resilience provides the capacity to absorb shocks whilst maintaining function…this adaptive capacity in ecological systems is related to genetic diversity, biological diversity and the heterogeneity of landscape mosaics' (Swedish Environmental Advisory Council 2002). As an ecosystem's biodiversity is reduced so is its resilience. If these impacts continue to mount up the ecosystem may

pass a critical threshold resulting in the loss of the ecosystem and it's characteristic biodiversity. Considering thresholds is central to assessing cumulative effects and their effect on biodiversity.

9. Development comes in many shapes and forms all of which is likely to have some sort of cumulative effect on England's biodiversity. The most obvious types of development are housing and roads, however there are a number of other urban, transport and infrastructure schemes that all produce and contribute to a variety of cumulative effects. Recently the Government has paved the way for an increase in development around the country through a series of plans including The Sustainable Communities Plan for Housing, The Transport Ten Year Plan, and The Airports White Paper. These plans could result in more than 750,000 new dwellings, 100 new bypasses, 130 other road improvement schemes, and a number of new terminal and runway projects at England's airports. This will lead to increased consumption of water, minerals and energy and will produce increased amounts of waste. Together this poses, potentially, a significant threat to England's biodiversity, through habitat loss, fragmentation, disturbance and pollution, as well as other direct, indirect and cumulative impacts.

10. The statutory requirement for appraisal of development plans throughout Europe marks recognition that significant impacts can arise from development and land use change proposed in development plans. Such impacts can occur over time and space and can accumulate. The impacts of development may result in the direct destruction of habitats or their loss over time as a consequence of cumulative changes. Where critical thresholds are exceeded, such will be the degradation of the habitat that, from the perspective of biodiversity, the habitat may be as good as lost.

11. To highlight the potential threats posed by cumulative effects the Thames Basin Heaths proposed Special Protection Area (pSPA) was chosen for more detailed study. The pSPA and its wider environment were examined over time, by analysing 1905, 1947 and 2003 OS maps and looking at land use changes to assess habitat loss and fragmentation; and looking at the spatial extent of cumulative noise, pet predation and chemical enrichment. Although the methodology for assessment was crude, some important illustrative trends were identified:

- a 53% reduction in the area of heathland between 1904 and 2003;
- increased fragmentation illustrated by an increase in heathland blocks from 52 in 1904 to 192 smaller sites in 2003;
- 31% of the pSPA heathlands are currently adversely affected by nutrient enrichment;
- 33% of the heathlands are currently affected by noise to an extent that bird densities are likely to be reduced;
- 10% of the pSPA heathlands are currently adversely affected by domestic cat predation of ground nesting birds.

12. Analysing the national overview and the case study it was clear that habitats in the south of England are facing a number of cumulative impacts caused by development pressures. However these findings could neither support nor refute the hypothesis on

a national scale due to a lack of research and information. It is likely that the high levels of development that are expected in the next 10-20 years will adversely affect ecosystem resilience and result in a direct threat to some species. In order to assess and illustrate these impacts with a greater degree of certainty the following recommendations were made:

- raise awareness of the issues of cumulative impacts on biodiversity amongst decision makers and especially those concerned with planning and implementing future development;
- pursue scientific investigation and understanding of the implications of cumulative impacts on biodiversity, including the introduction of a comprehensive monitoring programme;.
- provide practical tools and methodologies for English Nature staff and those required to plan future development to ensure that cumulative impacts are fully taken into account in future development planning; and
- assess the practicality of using maps, zones of impact and geographic information systems (GIS) to illustrate and assess the cumulative impact of development, and determine the most appropriate means by which to present such information to decision makers.

Contents

Tables

Figures

1. Introduction

This report has been prepared by Land Use Consultants (LUC) on behalf of English Nature to look into the cumulative impacts of development and related pressures. The specification for the study defined the following hypothesis:

> "the cumulative effects of current and foreseeable development are unsustainable in terms of ecosystem resilience, functioning and ability to support characteristic biodiversity."

The above hypothesis was augmented by six research objectives:

- To investigate whether the cumulative weight of planned or desired development in England, is likely to exceed the capacity of England's ecosystems to support it and is likely to prevent recovery of biodiversity and ecosystem functioning and resilience to sustainable levels.
- To consider how best to understand and articulate these effects, to help us develop our evidence base and develop a convincing policy line.
- To identify where in England this is a particular problem and at what scale. The report needs to include overlay maps to show likely cumulative effects spatially, and to prepare a narrative summary of likely cumulative impacts, across England and in an example region.
- To consider whether any mitigating measures are possible to keep cumulative effects within manageable limits to allow the recovery of ecosystem resilience and of biodiversity.
- To consider the value and limitations for this debate of concepts such as the ecosystem-based approach (including ecosystem resilience and interactions between ecosystems), and environmental capacity / environmental limits.
- To consider the implications of this analysis for the implementation of the Strategic Environmental Assessment directive and to advise on how best to use the Directive to ensure cumulative impacts can be taken account of appropriately.

The work undertaken can be divided into three main areas. Firstly, an inception meeting to discuss the project was held in May 2004, and included discussions with a range of English Nature staff at headquarters in Peterborough, followed by completion of a Scoping Report. Particular attention was paid to the definition of cumulative impacts as defined in relevant literature. The findings from this work are summarised in Section 2 of the Report.

Secondly, we compiled and mapped various published data to illustrate where in England the cumulative impacts are likely to be significant. This involved concentrating on the main types of development and related land use change that give rise to such impacts – urban development (notably housing), transport, water, waste, energy and minerals. Summaries of the relevant land use data and maps are included in the Section 3 of this Report.

Thirdly, we looked in more detail at the Thames Basin Heaths pSPA, including the work being undertaken by the Thames and Chilterns Office of English Nature to address the cumulative impacts of planned housing development (*Thames Basin Heaths: towards a strategy for sustainable development*). This is summarised in Section 4 of the Report. One of the functions of this Report is to consider the key messages for decision makers relating to the cumulative impacts of development on the biodiversity of England.

Section 5 of the report brings together discusses the findings of the study and looks at the recommendations of the consultation workshop and the consultation responses. It then sets out the overall conclusions of the work.

2. What are cumulative impacts?

Consideration of cumulative impacts reflects a broadened perspective on the nature of the interactions between humans and the environment. This acknowledges that change originates not only from individual developments but also from interactions of multiple and varied developments over time, many of which may be small scale in themselves, and from the wider effects that they may cause. The impact of two actions on the environment can be complex and may result in environmental degradation that is worse than originally thought because of the chemical, physical and/or biological interactions between projects. These interactions need to be considered in planning and land management to ensure that environmental limits are not breached.

Cumulative effects have been discussed for many years and whilst much academic research has taken place the actual assessment of their impacts can be much harder to quantify. Nevertheless, several documents have provided useful guidance and definitions. A recent practitioner guide prepared for the Canadian Environmental Assessment Agency (CEAA, 1999) defined cumulative impacts as:

> "…changes to the environment that are caused by an action in combination with other past, present and future human actions"

The European Union has two pieces of guidance relating to cumulative environmental effects. The first from 1993 defines cumulative impacts as:

> "The accumulation of human induced changes in valued environmental components across space and over time; such impacts occur in an additive or interactive manner."

The second from 1999 states that cumulative effects are:

> "Impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project"

Cumulative impacts can occur in various ways. They can be either direct (e.g. loss of land to development) or indirect (e.g. diffuse pollution). Generally direct impacts are easier to measure and, therefore, appreciate than indirect impacts because of the clear link between cause and effect. Also, as can be seen from the definitions above, cumulative impacts tend to accumulate spatially and over time (with a number of impacts in a locality potentially having a greater impact on biodiversity than suggested by the sum of the parts) compounding the difficulty of appreciating the significance of impact at a single point in time. Table 2.1 below sets out the main forms of direct and indirect cumulative environmental impacts.

Table 2.1. Examples of cumulative impacts (Adapted from US Council on Environmental Quality, 1997)

Type	Main Characteristics	Example
Time crowding	Frequent and repetitive effects on an environmental system	Fishing rate exceeds breeding /replacement rate
Time lags	Delayed effects	Exposure to carcinogens
Space crowding	High spatial density of effects on environmental system	Pollution discharges into streams from non-point sources
Cross-boundary	Effects occur away from the source	Acidic precipitation Upland afforestation and grazing control improving water quality and reducing flooding downstream
Fragmentation	Changes in landscape pattern	Fragmentation of historic districts or habitats
Compounding effects	Effects arising from multiple sources or pathways	Synergism among pesticides
Indirect effects	Secondary effects	Induced development following construction of infrastructure. Water quality improvements in regeneration areas (e.g. dock areas contributing to property values)
Triggers and thresholds	Fundamental changes in system behaviour or structure	Global climate change

It is important to note that some cumulative impacts can be positive as well as negative. The examples in the above table are based on the model of source, pathway and receptor to consider the varied ways that impacts accumulate. Receptors are affected in different ways. Additive impacts are those that may be combined in a relatively straightforward way, while interactive or synergistic effects lead to a net decrease (or increase) in environmental quality that differs from the simple summation of the impacts, i.e. as already noted, the result may be greater than the sum of the parts.

There are various provisions in European Directives and UK laws and regulations which require some degree of cumulative impact assessment for plans and projects, including:

- The Conservation (Natural Habitats, &c) Regulations 1994.
- The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999.
- The Environmental Assessment of Plans and Programmes Regulations 2004.

The Environmental Assessment of Plans and Programmes Regulations 2004 relate to the Strategic Environmental Assessment (SEA) Directive. Under the Planning and Compulsory Purchase Act 2004, sustainability appraisal is mandatory for Regional Spatial Strategies (RSS), Development Plan Documents and Supplementary Planning Documents. Sustainability appraisal helps local planning authorities to fulfil the objective of contributing to the achievement of sustainable development in preparing their plans. At the same time, LPAs must also conduct an environmental appraisal in accordance with the requirements of

European Directive 2001/42/EC on the 'assessment of the effects of certain plans and programmes on the environment'.

The statutory requirement for appraisal of development plans throughout Europe marks recognition that significant impacts can arise from development and land use change proposed in development plans. Such impacts can occur over time and space and can accumulate.

2.1 Cumulative impacts of development

The main focus is development, although seeking to identify and respond to all development-related cumulative impacts on ecosystems and ecosystem resilience is too ambitious for this current time-limited study. Instead we have concentrated on a few significant cumulative impacts that are capable of generating headlines and grabbing the attention of key decision makers in Government, looking at both direct and indirect cumulative impacts.

Table 2.2 lists the main impacts associated with development (housing, roads, airports etc) and agriculture, and the principal cumulative impacts that arise. It also indicates whether or not we believe these impacts are considered to be very significant for the conservation of biodiversity. Although agriculture is not covered by this study, it is included in the table to reinforce the fact that cumulative impacts resulting from development are compounded by impacts from other forms of land use and management.

Table 2.2. Significance of cumulative impacts

Cumulative impacts	Significance of impact	
	Development	Agriculture
Water Abstraction increased per capita demand for water agricultural irrigation increasing through climate change	Very Significant	
Diffuse Pollution (Air, Soil and Water)		Very Significant
Point Source Pollution (Air, Soil and Water)	Very Significant	
River Channel Modification- land drainage and flood alleviation	Very Significant	Very Significant
Habitat Loss	Very Significant	Very Significant
Habitat Fragmentation	Very Significant	Very Significant

The danger in showing cumulative impacts in this way, however, is that virtually everything is judged to be very significant, potentially prompting a response amongst decision makers that the threat is being overstated. Indirect cumulative impacts are difficult to detect when compared to major direct cumulative impacts caused by a succession of development proposals, such as the direct loss of a habitat resulting from the construction of new roads. Indirect cumulative impacts are often remote from the cause of the impact, and they accumulate gradually over time. Without comprehensive monitoring, such impacts may be imperceptible.

Nevertheless, there is widespread acceptance that indirect cumulative impacts do occur, and that they do pose a significant environmental threat, especially when seen in addition to direct cumulative impacts. For example, the State of Lowland Nature Report published by English Nature in February 2004 highlights the fact that, while lowland areas have previously suffered a century of habitat loss, the main pressure now is that of fragmentation and chronic decline in the quality of the remaining lowland nature resource, due to multiple effects such as water resource and quality problems, air pollution and surrounding development pressures.

Another English Nature Report highlights the ecological effects of diffuse air pollution from transport (*English Nature Research Reports,* Number 580). Although the data are limited and in some cases difficult to interpret, the study concluded that evidence suggests that motor vehicle pollution affects a range of plant parameters. The impacts are both cumulative with other roads and in combination with other sources of diffuse pollution. In this regard, staff at English Nature have raised concerns about the Targeted Programme of Improvements. This is the delivery programme for the development of trunk roads across England. In the past year a large number of schemes has been added to the programme with varying potential impacts on biodiversity. It is the view of English Nature that many of these schemes would not individually be of concern but as part of a large road building programme could cumulatively have very significant impacts on biodiversity due to fragmentation of habitats, land take from habitats and diffuse air pollution.

The main forms of impact caused by development can be summarised as habitat loss; fragmentation; disturbance and pollution, as summarised below.

Habitat loss: Loss of habitat to development is probably the most obvious impact on biodiversity. It results in the direct loss of viable habitat for species. Even if the development is not sited on a particularly natural or rare ecosystem the loss of that habitat may hinder the spread of other species and interfere with an area's naturalness. In combination a series of developments can erode a habitat and the naturalness or tranquillity of an area.

Habitat fragmentation: Habitat fragmentation is 'the breaking down of habitat units into smaller numbers of units' (Treweek 1999). It mainly results from linear developments such as roads that can cut through large areas of habitat, although other development types and, particularly the effects of agricultural intensification, have led to a very significant fragmentation of semi-natural habitats. Often the fragmentation of a habitat will involve an initial loss of habitat and the subsequent development of a barrier to the movement of various species. This in turn may lead to habitat and species isolation, which eventually may affect the gene pool of a species and the quality and resilience of an ecosystem.

The fragmentation of a habitat will also increase the 'edge' of the habitat and reduce its 'core'. While edge or transition habitats can be rich in biodiversity they will not suit species that have evolved for the core habitat and, depending on the areas of core habitat remaining, such species may not be able to survive.

A new development can increase the amount of 'edge' by changing the abiotic factors along its length. Developments can affect the amount of light and noise a habitat is subjected to, and its temperature and hydrology. Developments may also increase or decrease wind levels. In combination, these change the character of the area and allow different 'edge species' to colonise, reducing the size and quality of the core ecosystem and isolating it further. Concerns over the effects of fragmentation have led some commentators to conclude that:

> 'Fragmentation and the loss of continuous habitat are now considered one of the most important factors worldwide in accelerating reduction in biodiversity' (Wilson 1992).

Disturbance: Development can also give rise to various forms of disturbance to habitats. Disturbance can take many forms and give rise to a range of different impacts. The principal forms of disturbance arising from development are:

- Noise
- Light
- Vibration
- Pets (Dog-walking and cat predation)
- Recreation use

Disturbance may cause species to move to other areas, may upset delicate biorhythms for nesting or flowering and may cause direct habitat destruction.

Pollution: Pollution is a major cause of indirect cumulative impacts. The pollution of an ecosystem can be from both abiotic and biotic sources, with abiotic pollution representing the 'normal perceptions' of pollution, i.e. chemical compounds and elements detrimentally affecting the quality, nature and resilience of the ecosystems around them. These pollutants may be toxic to a particular species and can originate from diffuse or point sources. Cumulatively these can build up largely un-noticed, slowly poisoning an ecosystem. For example, the effects of agricultural chemicals entering the food chain of birds of pray have been well documented,. More recently the deleterious effect of Nitrogen Dioxide and Sulphur Dioxide on lichen and heath species has been noted along the side of roads (English Nature 2004c, Purvis and others 2003, Angold 1997 & 2002).

Biotic 'pollution' usually occurs as a result of a changing abiotic situation. Edge effects, abiotic pollution and certain disturbance impacts can lead to a change in an area's abiotic character, e.g. increasing or decreasing the amount of light an area receives, changing the soil pH, increasing soil nutrients, and increasing or decreasing the exposure of the site thus affecting temperature and humidity. The combined effect of these changes may lead to an invasion of non-endemic (possibly weed) species that change the character of the ecosystem and out compete core or dominant habitat species, thus increasing the edge effect.

It is the combination of these impacts of development that create cumulative impacts. The scale of cumulative impacts becomes significant when ecosystem resilience is threatened. The concept of ecosystem resilience is discussed below.

2.2 Ecosystem resilience and thresholds

The concepts of ecosystem resilience and thresholds are very important when considering cumulative impacts. Ecosystem resilience relates to the ability of ecosystems to maintain their integrity in the face of natural or anthropogenic stress and disturbance. 'Resilience provides the capacity to absorb shocks whilst maintaining function' (Swedish Environmental Advisory Council 2002). This resilience is born from an ecosystem's genetic and biological diversity.

At a species level the genetic variation available within a large gene pool allows individual species to meet natural challenges and those resulting from human activity. This resilience is augmented by the biological diversity within ecosystems where a wide variety of species interacting with each other provides a reservoir of genetic forms with the potential to adapt to changing conditions (Harris, 2003). Indeed most research suggests that as an ecosystem's biodiversity increases so does its ability to adapt to changing conditions, which equates to an increase in its ecosystem resilience. Thus ecosystem resilience can be thought of as 'the magnitude of disturbance that can be experienced before a system moves into a different state and a different set of controls' (Holling 1973).

This resilience is present in ecological systems and provides them with the adaptive capacity to recover. The adaptive capacity of an ecosystem to recover is determined not only by the diversity of its gene pool but will also depend on the susceptibility of its component species to differing stresses and disturbances. For example, heathlands can withstand deer grazing pressures better than woodland habitats but are more vulnerable to increased nitrate deposition from nearby roads. As identified by Clayton and Radcliffe (1996) generally, the more complex an ecosystem, and the more interlocking feedback systems there are, the more robust and better able it is to resist change.

> 'Adaptive capacity in ecological systems is related to genetic diversity, biological diversity and the heterogeneity of landscape mosaics' (Swedish Environmental Advisory Council 2002)

The susceptibility of species and ecosystems to change is built around the limits of their own evolution. Organisms of any given species can survive, grow, reproduce and maintain a viable population only within certain limits. Between these limits is a range and it is this range that makes up a species' ecological niche. In turn, a series of niches make up an ecosystem, such as a woodland or heathland ecosystem. The range of each niche will include an optimal range and a sub-optimal range. Ideally a species will inhabit areas within the optimal range, but can also live in sub-optimal conditions (Hutchinson 1957; Vandermeer, 1972; Begon and others 1987). Within its niche a species will have an advantage over other competitors, allowing it to survive and flourish. If conditions change it will alter the limits of the ecosystem and the individual niches within it. Ecosystem resilience will provide some resistance to change but there may be a point when a particular variable or a series of variables change the environmental conditions enough to cause irreparable damage to the ecosystem and its niches. This point is referred to as the critical threshold and crossing it can lead to the complete loss of an ecosystem (Schmitz 2003).

> 'These limits apply to all biological systems and while humans may appear to evade them for a time they must ultimately accept the boundaries of a finite planet' (Harris 2003).

The impacts of development may result in the direct destruction of habitats or their loss over time as a consequence of cumulative changes that ultimately exceed the critical threshold of individual ecosystems. Where critical thresholds are exceeded, such will be the degradation of the habitat that, from the perspective of biodiversity, the habitat may be as good as lost.

2.3 Thresholds

The consideration of thresholds is important in thinking about cumulative effects. Over time the cumulative impacts of factors such as pollution may get nearer to exceeding the critical threshold which indicates risk to ecosystems. Equally, as cumulative impacts mount up, ecosystem resilience, diversity and core integrity will be slowly diminished. However, cumulative impacts should be considered significant before this point is reached so that a degree of ecosystem resilience and integrity remains. This, at the very least, gives a habitat the potential to provide the same natural capital to the local environment as it did before the development.

This is illustrated in Figure 2.1 below, which shows that as pressures, or impacts increase, so ecosystem resilience, biodiversity and natural capital decrease. It also shows that biodiversity and natural capital will remain once the critical threshold is passed but in a much diminished form. Where there is no impact on a site, biodiversity, ecosystem resilience and natural capital are at their highest.

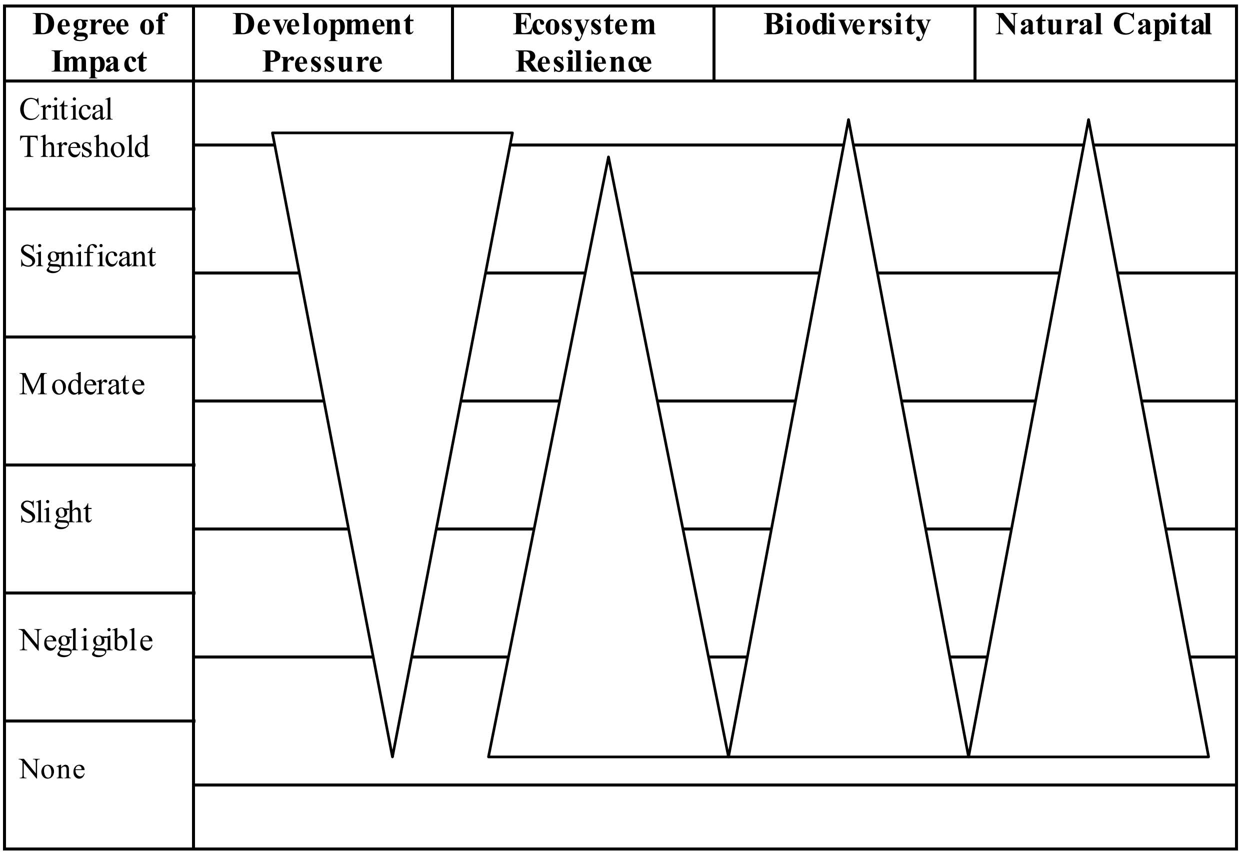


Figure 2.1: The effect of development on Ecosystem Resilience, Biodiversity and Natural Capital

The use of such thresholds is illustrated by Peterkin (2002) who used them to suggest targets for woodlands, to maintain and improve their networks, core habitat and resilience of the woodland ecosystem. Peterkin identified three thresholds of potential significance to woodland planning:

- **Minimum areas of individual woods:** Dormouse populations can be sustained only in woods of 20ha or more. Most woodland bird species require at least 10ha before they will breed. The probability of woodland birds will increase as the wood does.
- **Threshold separations between woods:** Female red squirrels will not travel more than 680m in one day. Dormice rarely colonise woods more than 800m from their established territory, and many ancient woodland plants do not colonise new woodland if it is more than 200m from an existing ancient woodland.

- **Minimum woodland density:** As a general rule, at least 30 % woodland cover is needed to allow most woodland animals to function as if the landscape is one wood.

Such thresholds are likely to exist for all ecosystems but in the majority of cases have yet to be clearly identified. When such thresholds are exceeded then biodiversity is likely to be reduced and the ecosystem degraded.

A different and very important example of thresholds is provided by the Critical Load Maps now prepared for Defra by the Centre for Ecology and Hydrology at Monkswood. These give a spatial representation of the potential implications of acid and nutrient nitrogen deposition on a range of different habitats across England (Table 2.3) and the extent to which the habitats can tolerate these loads or not. By linking to a computer model[1], these maps can be used as a predictive tool to indicate the likely implications for different habitats of agreed or proposed emissions reductions. Thus, taking a hypothetical example, if the model shows that the emissions cuts proposed by the UN will still result in 20% of UK heathlands exceeding their critical load, then this will be a signal to Defra to consider imposing further cuts to aid heathland recovery / prevent more damage. The ultimate aim is to minimise the number of vulnerable habitats receiving more acidity / eutrophying agents than they can cope with, i.e. exceeding identified thresholds. An example of a critical load map is shown in Figure 2.2 below, illustrating the maximum critical load for nitrogen for all habitats.

Table 2.3: Critical Load Maps – habitats assessed

Critical Load Maps for acid deposition consider the following habitats:	Critical Load Maps for nitrogen deposition consider the following habitats:
Acid Grassland	Acid Grassland
Calcareous Grassland	Calcareous Grassland
Dwarf Shrub Heath	Dwarf Shrub Heath
Bog	Bog
Montane	Montane
Coniferous woodland (managed)	Coniferous woodland (managed)
Broadleaf woodland (managed)	Broadleaf woodland (managed)
Unmanaged woodland	Unmanaged woodland
Freshwaters	Atlantic Oak (epiphytic lichens)
	Supralittoral sediments

This consideration of ecological thresholds is a very important point and is returned to in Chapter 5.

[1] This predictive model takes account of such factors as rock type and soils. Soils from calcareous rocks have a greater buffering capacity than peat or acid soils, against acid deposition (largely resulting from traffic, aircraft and industry). Thus calcareous areas can handle more acid deposition than moor or heathland, and so can maintain their ecosystems longer

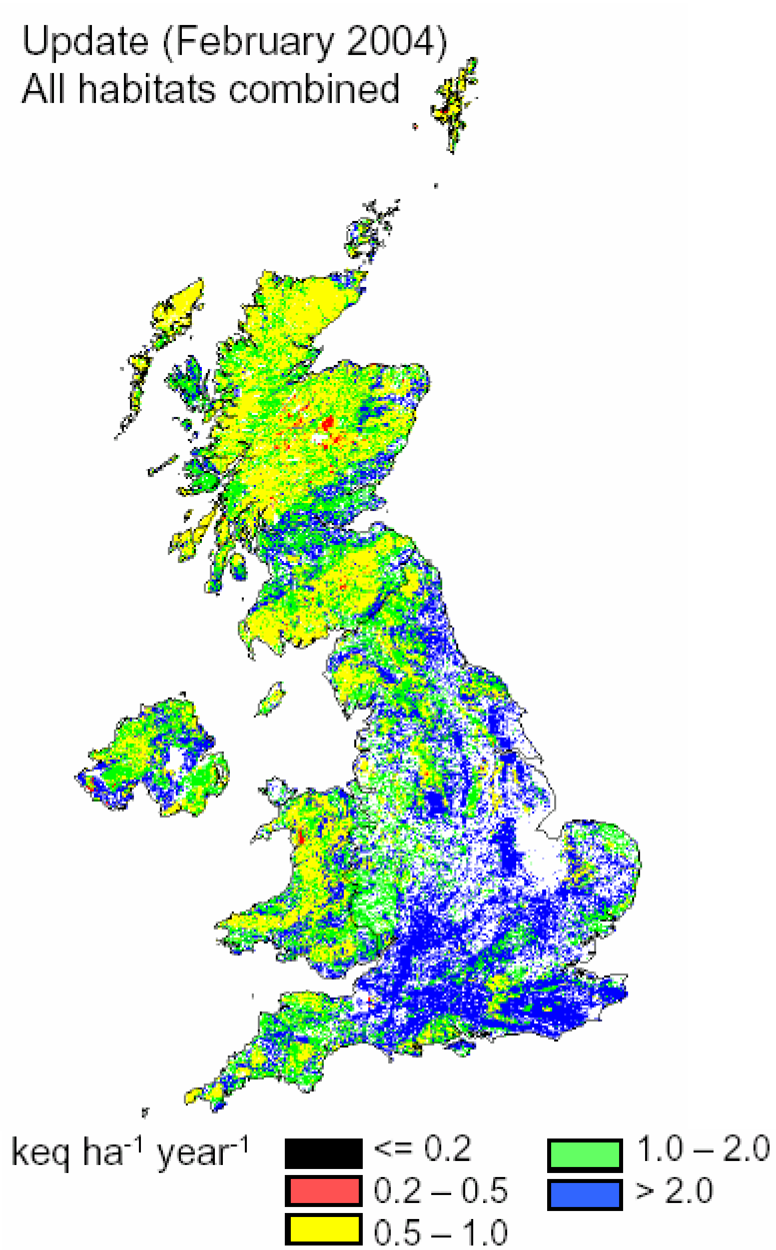


Figure 2.2. Maximum Critical Loads Map for Nitrogen over all Habitats
(5^{th} percentile critical loads: $CL_{MAX}N$, February 2004 All Habitats Combined)
Source: Centre of Ecology and Hydrology, Monks Wood

3. The implications of different types of development

England's biodiversity is a result of the interaction between species, their physical environment and human influence. Indeed, it is the diversity of these interactions which has created the wealth of wildlife for which England is internationally renown, reflecting a diversity of geology and soils, climate and land management systems.

This wildlife resource, however, has suffered major decline in the 20^{th} Century as a result of the impact of unsustainable human activities, particularly agriculture, forestry and development, with unprecedented changes between the 1950s and 1980s.

3.1 Agriculture and forestry

In the case of agriculture, agricultural intensification driven by a strong policy demand for increased food production and the industrialisation of agricultural processes, has led to the intensification of grassland, drainage of wetlands, and conversion of grassland to arable production. Equally the past policy emphasis on self sufficiency in timber production led to softwood planting in the uplands and on lowland heathlands and on ancient woodland sites. The consequence of these changes has been a major decline in lowland habitats (English Nature 2004a) as illustrated below:

Table 3.1. Summary of historical habitat loss

Summary of historical habitat losses	
Habitat	**Historical losses**
Hedgerows	Over 20% of hedgerow length in England was lost between 1984 and 1990
Lowland unimproved grassland	97% lost between 1930 and 1984
Heathland	84% loss between 1800 and the late 1980s
Grazing marsh	20,000km were drained between 1940 and 1980
Fens	In East Anglia, fens declined from an estimated 3,400km^2 in 1637 to just 10 km^1 by 1984
Raised lowland bog	44% of the original 1% has been drained, cut or reclaimed for agriculture and just 1% remains undisturbed
Ancient woodland	Between 1930 and 1985, 45% of the area of ancient woodland was cleared or replanted.

Source: English Nature (2004) *State of Nature. Lowlands Future Landscapes for wildlife*

As identified by English Nature (2004a), a key aspect of past changes in land use has been the loss of fundamental life support processes (increasingly known as ecosystem functions) for wildlife. The water cycle is now greatly modified to facilitate agricultural operations. Modern cultivation and use of chemicals have broken the natural cycles of decomposition and depleted the soil fauna. Furthermore, the structure of the countryside is now less varied through the loss of small copses, hedgerows and field corners, so that species movement is now severely restricted. As a result it is difficult for the remaining fragmented habitats to retain a full range of species.

3.2 Implications of development

Superimposed on the above losses are the implications of development. Development, as explored in the remainder of this Chapter, has had, and continues to have, a cumulative impact on the remaining wildlife resource. While national and international legislation and regulation have sought to curb the direct impacts of major development (and a wider reduction in pollution and the safeguarding of remaining habitats), policy and practice has yet to fully respond to the incremental cumulative impacts that arise from development, which is the subject of this report.

3.3 Urban development

Figure 3.1 shows the extent of built-up area in Great Britain. The areas shown as dark red corresponds to a 1 km^2 grid square that is at least 50% developed[2]. It confirms what we already know – we are small densely populated island, with concentrations of people and activity in our major cities. South East England in particular displays more dark than light red.

Built development can take many forms – housing, roads, factories, schools, etc. However it is housing that is probably most significant in terms of landtake. Population growth, changing demographics and economic stability have all led to an increase in housing development. The pattern of this growth has been well documented, with first a concentration in urban areas, followed by growth around these urban areas and then in the wider countryside. The land use planning system has responded to the pressure for housing development in many different ways. For example, the introduction of Green Belts was an attempt to contain urban sprawl and protect the countryside around towns. New development was diverted to areas beyond the Green Belts, resulting in the major expansion of smaller towns.

More recently, Government policy has sought to concentrate new housing development within existing urban areas, utilising 'brownfield land' and developing at higher densities. This policy shift was in part recognition of the damaging impact of continued large scale release of greenfield land. Land use change data complied by the ODPM for the decade 1993 – 2003 indicate that on average, nearly 60% of all new dwellings have been built on previously developed land[3]. Above average percentages have been achieved in London, the North West and the South East (90%, 67% and 63% respectively). In parallel, there has been a steady increase in the density of residential development, from 26 dwellings per hectare in 1993 to 30 in 2003.

Consequently, in terms of land take, it could be argued that the trend is moving in the right direction. Reusing previously developed land means that greenfield land is not developed, hence helping to preserve the overall area of open countryside. Also, higher densities represent more efficient use of land. However the per capita consumption of water and energy, rates of waste generation and so forth do not correspondingly decrease, and it is these that give rise to many of the indirect cumulative impacts refereed to in the previous section of the report.

[2] Land Cover Map 2000 Natural Environment Research Council
[3] Land Use Change in England: Residential Development to 2003 (LUCS 19) ODPM

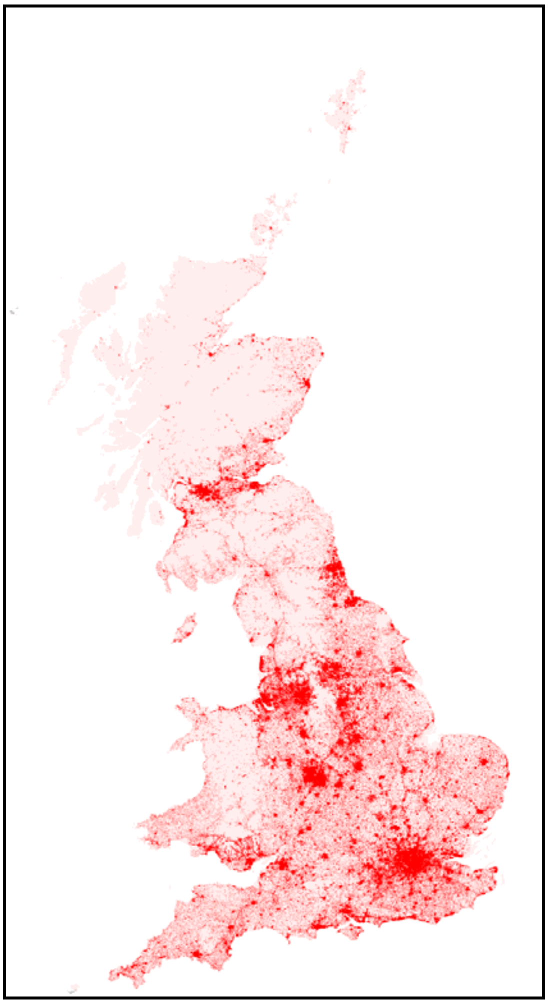


Figure 3.1. Extent of the built up area in Great Britain

Also, the underlying trend is for more houses. This is due to the impact of affluence and changing demographics. Rising living standards mean that each household today expects to live in a self-contained house or flat. In the early 1900s, a terraced urban house or a rural cottage might have been occupied by three generations, including five or six children; today it may be the home of a childless couple or a single pensioner. From a demographic perspective, it is the number of households – not the number of people – which determines how many homes the nation requires. We are living longer, and longer life expectancy means that natural growth (i.e. the excess of births over deaths) will continue to be positive. Also patterns of family life have changed, such that there is a trend to more single households. Projections suggest that these trends will continue over the next 20 years[4].

The Government's Sustainable Communities Plan[5] is a response to the current and projected shortfall in housing provision illustrated in the Barker Report[6]. Central to the plan are the four new growth areas in southern England – Stansted/Cambridge/Peterborough, Milton Keynes and South Midlands, Thames Gateway and Ashford, with 250,000-500,000, 370,000, 120,000 and 31,000 projected new houses respectively up to 2031. In addition, CPRE has

[4] Britain's housing in 2022. More shortages and homelessness? A working paper for tackling disadvantage: A twenty-year enterprise. 2002 Joseph Rowntree Foundation

[5] Office of the Deputy Prime Minister (2003) *Sustainable Communities Plan: building for the future.* ODPM

[6] Barker K. (2004). *Delivering stability: securing our future housing needs.* HM Treasury

highlighted a number of other "Greenfield Housing Hotspots" including 4,500 new houses in Swindon, 3,500 in South Hams in Devon and 3,000 in Eastleigh in Hampshire. New development on this scale will also require substantial investment in new roads and other transport infrastructure, community facilities, flood defence, water treatment and so on. Whilst this is a lot of development, the Barker Report had recommended even more for reasons of macro-economic stability and housing affordability.

3.4 Transport

Moving around is a fundamental part of modern life. All activities require some form of travel – on foot, cycling, by car, bus or train, or by boat or plane. In the UK since 1980, road traffic has grown by 77%. Many factors have affected travel levels including increasing car ownership and numbers of drivers, falls in car occupancy levels, fuel price changes and varying levels of expenditure on roads, both capital and current. Over a quarter of households now have two or more cars[7].

Conversely walking and cycling have declined significantly over the past 20 years. Indeed both have been in long term decline as car ownership and use have increased. For example, Department for Transport data show that the number of stages (journeys) on foot fell by 39% between 1985/86 and 2002, from 480 to 290 a year, on average. Distance walked has fallen by 22%, from 240 to 190 miles a year. The number of cycle stages declined steadily over the same period, from 25 to 15 per person per year (a 39% reduction). There has been a smaller decrease in the average distance cycled of 25%, from 44 to 33 miles a year.

The decline in cycling and walking and the accompanying growth in motorised transport has resulted in a 62% increase in greenhouse gas emissions from transport, which now accounts for 27% of all UK emissions. Local air pollution has declined with the advent of catalytic converters and cleaner fuels, however improvements in fuel efficiency for individual vehicles have been balanced out by the growth in the volume of traffic. Growth in aviation has driven up fuel consumption for transport.

Transport requires infrastructure – roads, rail, terminals, etc. The total length of roads increased by about 10% between 1980 and 2002. Investment in roads, encompassing new construction, improvement and structural maintenance, increased during the late 1980s, and then remained static during the mid-1990s. It has since fallen, and although increasing in 2000/01 and 2001/02, was still nearly 20% below the level of the mid-1980s.

[7] Source: Transport Statistics. Department for Transport.

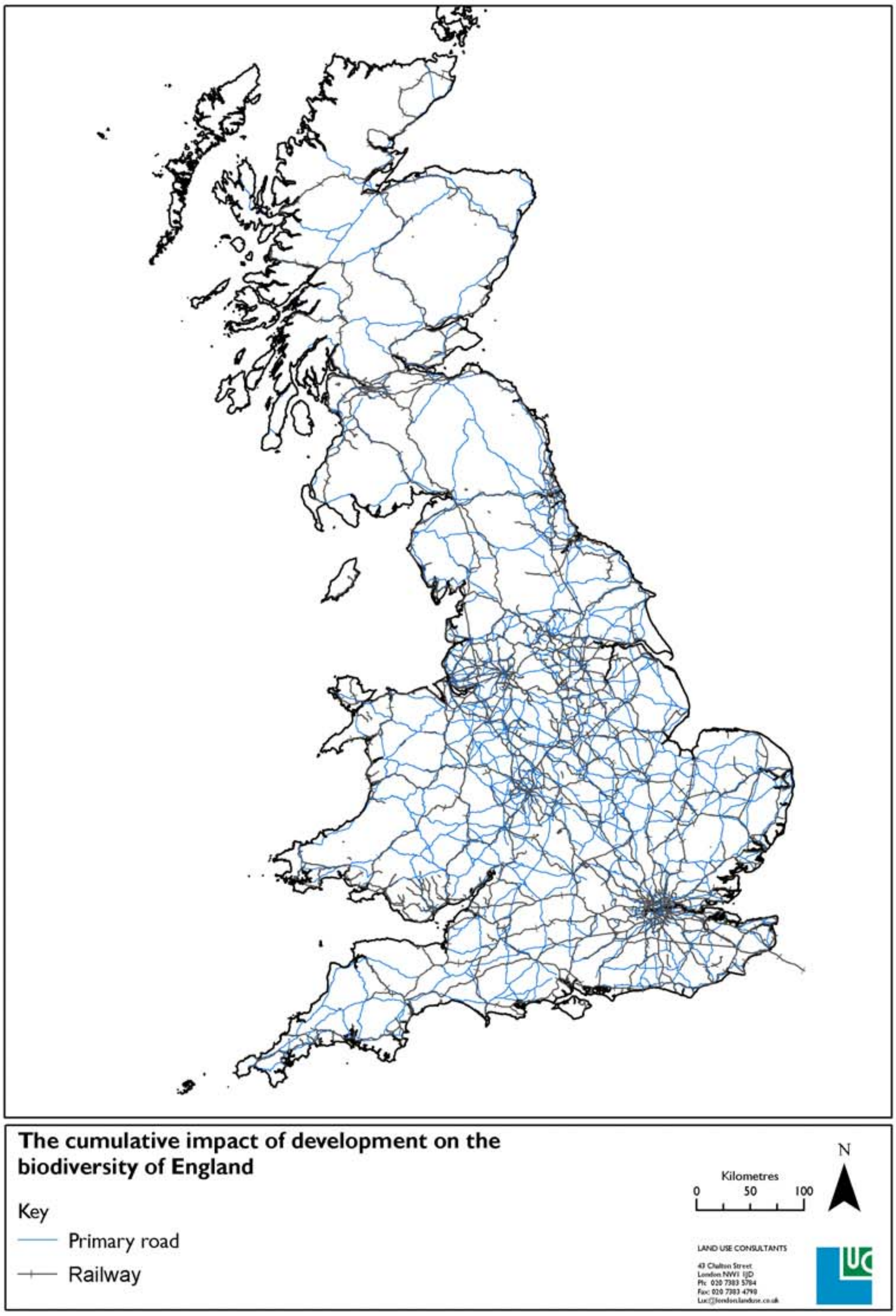
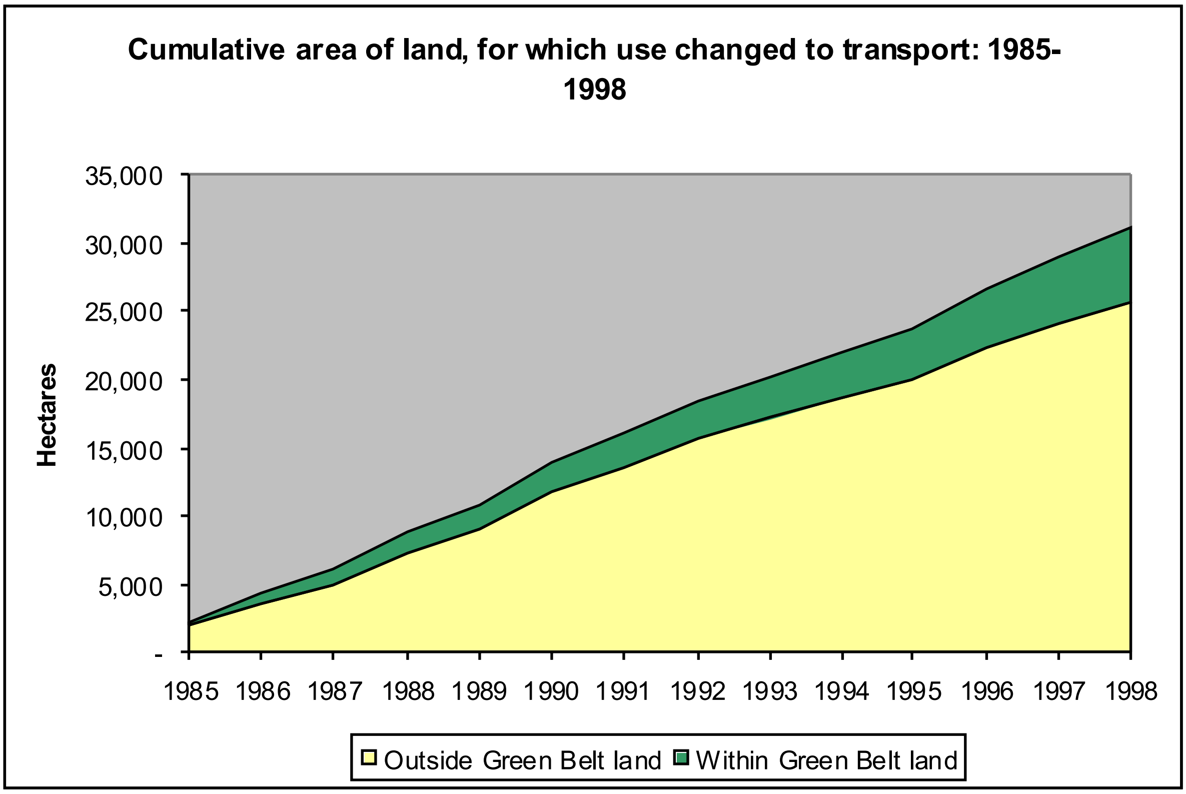


Figure 3.2- Trunk road and rail network in the UK

Overall the Department for Transport has calculated that since 1985, an area of land three times the size of the urban area of the City of Nottingham has changed to transport use from previously undeveloped land, i.e. some 31,000ha (See Figure 3.3 below). Thus as well as being a major cause of habitat fragmentation, transport uses such as roads have also significantly contributed to the continued reduction in the total area of undeveloped open land

and may have directly and/or indirectly accounted for reduction in extent of several natural habitats.

However investment in transport infrastructure shows no signs of abating. For example, the Airport White Paper (*The Future of Air Transport* 2003 DfT) provides a strategic framework for the next 30 years for the whole of the UK. Air travel is projected to be between 2-3 times current levels by 2030 and accordingly the White Paper suggests increasing terminal and in some cases runway capacity at Manchester, Liverpool, Newcastle, Teeside, Birmingham, Bristol and Bournemouth. Also, two new runways will be needed in the South East by 2030, the first of which will be at Stansted and is planned to be in place by 2012.



Source: Department for Transport Website

Figure 3.3. Cumulative area of land, for which use changed to transport: 1985-1998

The Transport Ten Year Plan 2000 also points towards significant new investment in the road network, including easing bottlenecks by widening 360 miles of the strategic road network: improving safety and traffic flows around junctions through 80 trunk road schemes; creating 100 new bypasses on trunk and local roads to reduce congestion and pollution in communities plus a further 130 other major local road improvement schemes; and completing the 40 road schemes in the Highways Agency Targeted Programme of Improvements. Since publication, the number of road schemes in the Programme has grown to 85, the majority for completion in the period of the Ten Year Plan. Figure 3.4 overleaf shows the location of the original 40 schemes.

This number of road improvements will have knock-on effects for urban development and land use planning where they occur. This effect is particularly noticeable with bypass developments as they often create a new artificial boundary around towns and villages, which in turn opens up more greenfield sites to urban development. However the prospect of infilling development is not solely limited to bypasses, as any new road through un-developed land carries the potential threat of linear or urban sprawl, which in turn reduces and fragments the natural environment.

Figure 3.4. Location of the original 40 Budget 2000 road improvement schemes

Source: The Highways Agency Website

The combined effects of transport movement and infrastructure development can give rise to significant cumulative impacts, some of which are considered in detail below.

3.4.1 Barrier effects

Due to their nature, roads and railways form barriers that split up continuous habitat and the wider natural landscape. This produces a large amount of edge effect and in some cases a barrier to species movement, an impact that is augmented by the larger fragmentation effect of agricultural intensification. The significance of the edge effects barrier impacts will depend on the size of the road. Minor roads are often quieter and produce less of a barrier. Their edge effect is also smaller, at least from a pollution and interference standpoint, because less vehicles use them.

The larger roads such as the trunk roads and the motorways produce more significant impacts. These roads become absolute barriers to many species and their edge effects are particularly pronounced (Berris, 1995 and Lichtendahl & Stam 1992). This leads to species becoming isolated in islands of habitat, which will have knock-on effects for the species at a genetic level and for ecosystem resilience. These barrier effects are well illustrated by Figure 3, which shows beetle movements between patches of woodland isolated by a road. 'Major losses of insect species have already occurred as a result of fragmentation, especially during the last 50 years' (Warren and Key, 1991).

However the barrier effect of roads is not limited just to invertebrates. Birds, mammals, reptiles and amphibians are also hindered by the presence of roads (English Nature 1996). In Europe studies have indicated that roads inhibit many small mammal species from crossing and in Europe, bank vole, yellow-necked mice and dormice are particularly vulnerable (Mader 1984).

> 'In landscapes where road densities are already very high (e.g. Southern England), most of the species sensitive to habitat fragmentation are likely to have already disappeared, but any left may well be pushed beyond their viability thresholds if further fragmentation occurs.' (English Nature 1996).

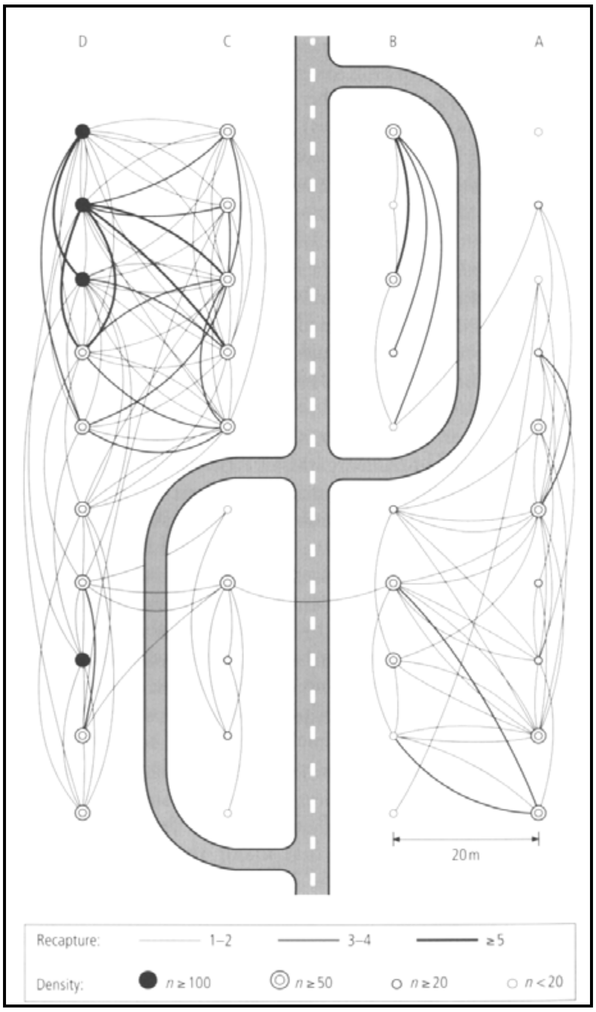


Figure 3.5- Movement by *Abax ater* beetles between patches of woodland isolated by a road and two parking loops.

Source: Treweek 1999

3.4.2 Edge effects and disturbance

During construction and operation the road will also cause disturbance and edge effects to the surrounding habitats and species. Roads can produce a number of disturbance effects, most notably noise, but also light and vibration. Again, the size of the disturbance will depend on the size of the road and its traffic volume. 'For major roads the zone of effect could be up to 1000m on either side of the carriageway' (Treweek 1999). These disturbance effects will be augmented by the other edge effects that roads cause such as the introduction of new species and biotic and chemical pollution. These factors can all add up to cause a very large edge effect which most major roads will produce. The range that some of these factors may have is illustrated in Figure 3.6 below.

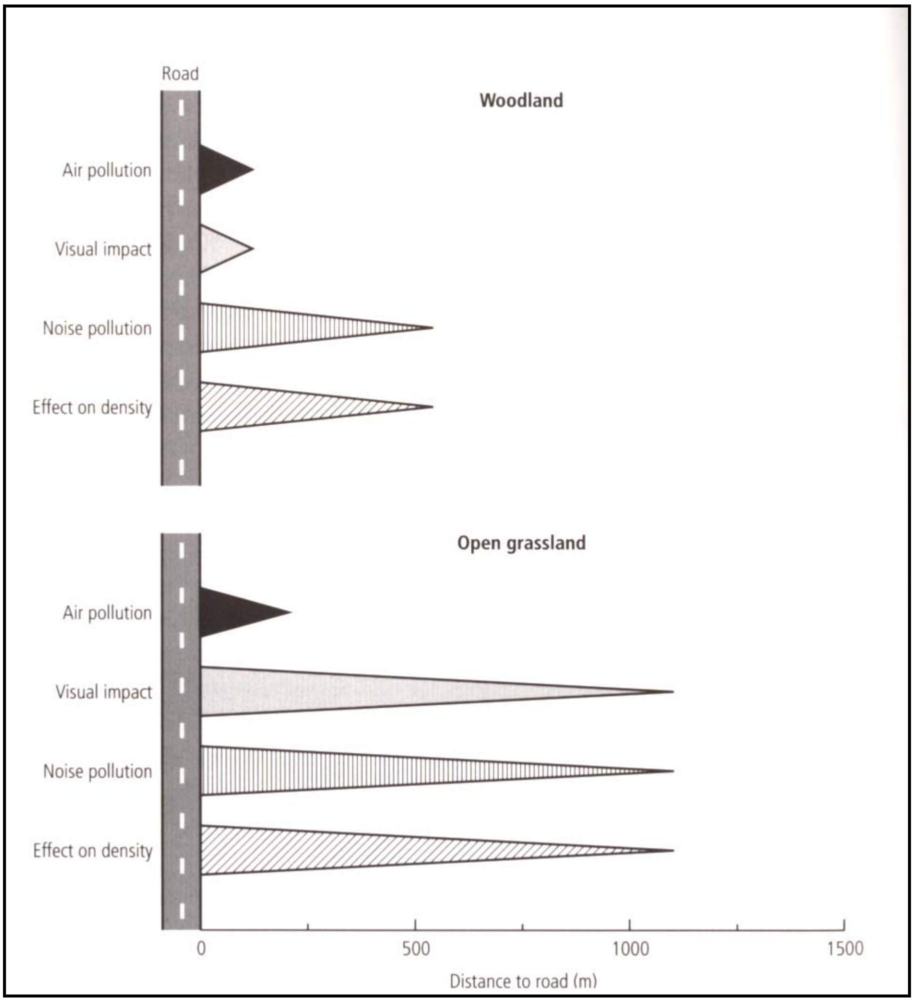


Figure 3.6. The range of possible factors that reduce bird densities in Woodland and Grassland adjacent to roads (Reijnen and others 1995)

Source: Treweek 1999

Noise is the most obvious disturbance effect. It has been found that noise is the key factor linking traffic levels and the density of breeding birds. Reijnen & Foppen (1995) recorded lower densities of birds close to roads as compared with populations remote from roads, in more than half of the 43 songbirds that were surveyed. Effects on the willow warbler were particularly marked with females unable to hear the male's song up to 200m from the road.

Light pollution can also have adverse effects on the environment. Many plants, birds and mammals are affected by artificial light. In plants excess light can affect growth regulation. Excess light can affect birds by initiating breeding seasons early. Studies have found that up to 60 wild bird species have been brought into breeding condition prematurely by exposure to artificially long days in winter. Nocturnal animals are likely to be disturbed by light too, either avoiding lit areas completely or being drawn to them in greater numbers e.g. moths. A report in 1993 by Rydell and Racey reported that some species of bat (*Nyctalus, Vespertillo, Eptesicus, Pipistrellus*) benefited from feeding around street lamps, whereas some species (*Myotis, Plecotus* and *Rhinolophus*) avoid lit areas. The bat species that avoid the light are also some of the rarest and it has been noted in Europe that continuous lighting along roads creates barriers which bats will not cross.

When the light from the roads and the light from urban development are combined the effects on the natural environment can be severe. The growth of light pollution is shown in Figures 3.7 and 3.8 below, taken from the CPRE's Night Blight analysis. The most obvious increase in light pollution has occurred not in the main conurbations but across the wider Midlands and South of England. Figure 3.7 indicates that in 1993 there was still a considerable extent of dark night skies (dark blue) outside the major cities, indicating less light pollution. However by 2000 much of the dark blue colour had been replaced by light blue, indicating an incremental increase in light pollution across the whole of the Midlands and the South. With the other impacts of development, light pollution will add to the cumulative effects on England's wildlife resource.

Pollution also has a very significant edge effect. Road vehicles release a cocktail of gaseous, particulate and aquatic pollutants that all have an effect on the environment. These pollutants mainly come from the vehicle's exhaust fumes or its tyres.

Aquatic impacts are often the result of construction that can affect the turbidity, sedimentation and flow of the river, while operational events are most frequently associated with chemical spills. In addition, oil, tyre compounds and other pollutants from motor vehicles can find their way into watercourses as a result of increased run-off. This happens a lot more during heavy periods of rain and can lead to chemical bioaccumulation in large river species and the poisoning of invertebrate species. A further issue is salt runoff arising from de-icing of roads which may increased the salinity of watercourses.

Air pollution caused by exhaust fumes produce a more regular cumulative impact. Exhaust fumes contain a variety of pollutants including, Nitrogen compounds (NOx), Sulphur compounds (SOx), Ozone, polycyclic aromatic compounds (PAH), metals, ammonia, and particulates. Each of these compounds has a variety of impacts and as road development has increased so has their cumulative impact. Plants and animals are negatively affected in many ways, such as poisoning, poisoning their prey, changing the make up of the habitat, acidification, nutrient enrichment etc. All of these impacts contribute to reducing the ecosystem resilience and biodiversity of the natural environment. Figure 3.9 shows the extent of one of these exhaust pollutants in combination with other sources of Nitrogen Dioxide, such as airports and industry. When compared to Figure 3.10 it is easy to see that the highest levels of background Nitrogen Dioxide are found around major urban areas and along major road corridors.

It is also important to recognise that the negative effects caused by roads and vehicles are further compounded by many other sources of pollution, including agriculture, power stations and other industry.

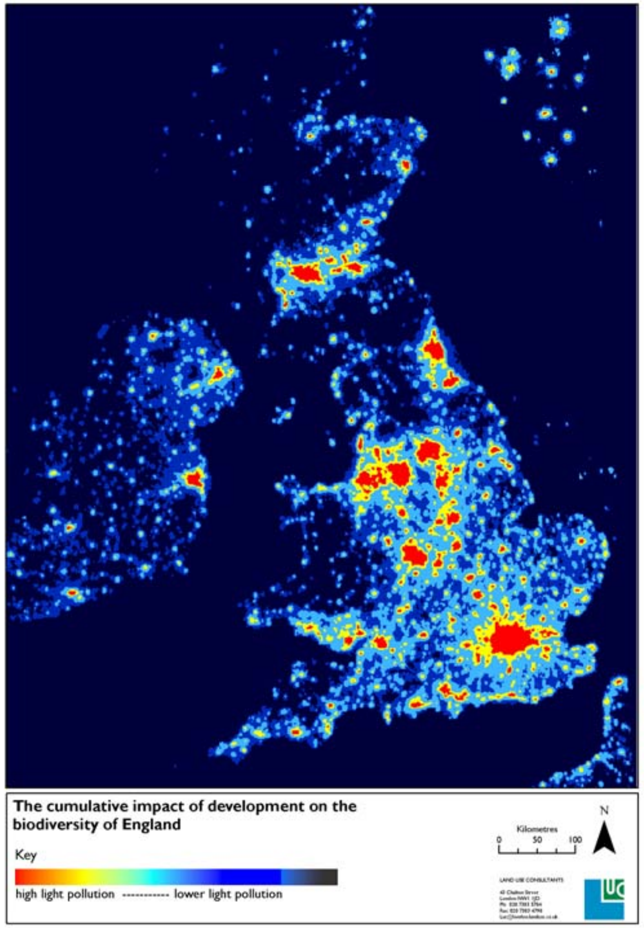


Figure 3.7. Light Pollution in 1993

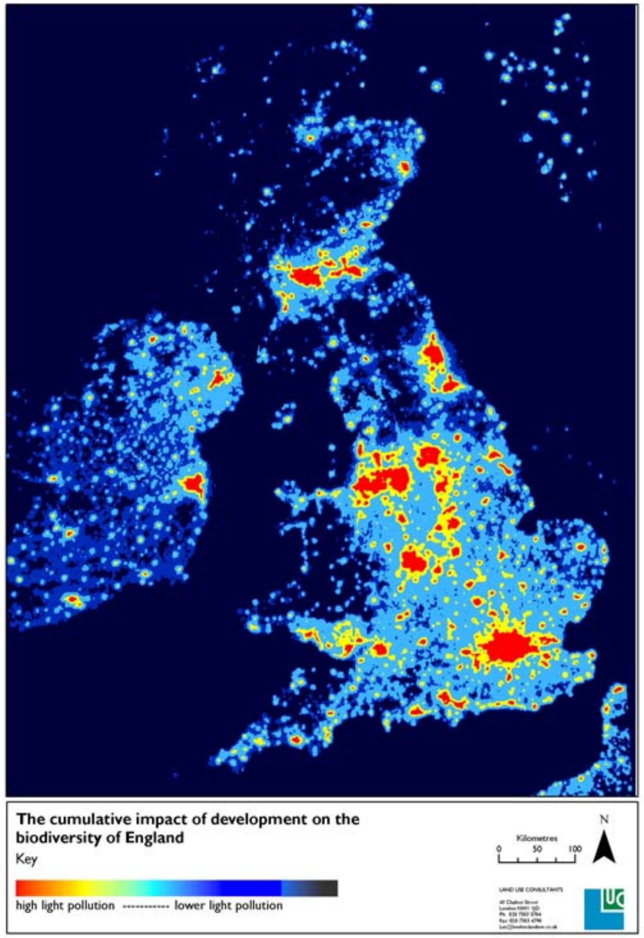


Figure 3.8. Light Pollution in 2000

Source: For both maps the source is the CPRE

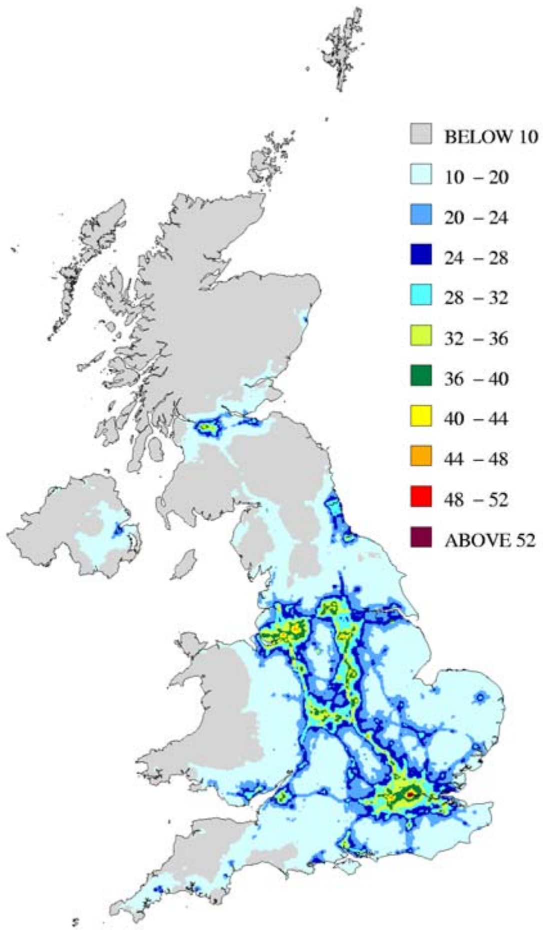


Figure 3.9: Annual average background NO_2 concentration ($\mu g\ m^{-3}$) for 2001

Source: Air Quality Expert Group DEFRA.

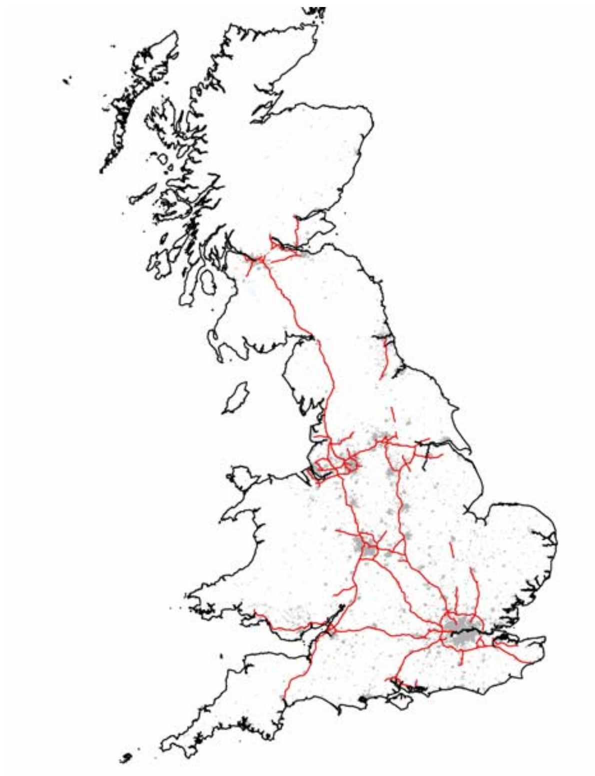


Figure 3.10- Motorways and urban centres

3.4.3 Interference and wildlife casualties

Roads and the vehicles that use them also result in wildlife casualties ranging from insects to large mammals. With just over 245,000 miles of road in Great Britain, the affect of wildlife casualties can be quite significant to particular species. As already noted, to many species roads are a barrier to movement, while some species will attempt to cross them. A common casualty is the hedgehog (58% of hedgehog deaths may be due to roads). Barn Owls, a protected species, are particularly prone to collisions with road vehicles and with annual estimates of 5,000 individuals to be killed on the roads. This is twice the number killed in the 1950's and some areas have lost an entire Barn Owl population as a result of a new road, although it is thought that this has as much to do with the habitat loss and fragmentation associated with road construction as with the subsequent road traffic. Road deaths also account for the loss of various other mammal species, such as foxes and badgers whose territories are reduced, and a variety of invertebrates, amphibians, reptiles and other bird species.

The effects of litter are much less known. It is expected that both roads and urban development will produce litter, but little research has been done on its effect. The most damming evidence for its cumulative effect comes from small mammals getting stuck in plastic bottles (up to 28 in one bottle) (English Nature 1996) and the devastating effects litter can have when trapped around the neck, leg, head etc. of a wild animal.

3.5 Minerals, water, waste, and energy

Development requires raw materials for construction, the provision of water and energy, and the removal of waste. Meeting each of these essential requirements inevitably gives rise to environmental impacts.

3.5.1 Minerals

All development requires raw materials for construction, including aggregates for the production of concrete, clay for bricks and other materials for a range of specialist end products. For example, the British Geological Society has calculated that about 60 tonnes of aggregates are used in building a typical house. Although some of these materials are sourced from outside the country, the majority originate from within the UK. This is especially the case with low value, bulk materials such as aggregates and crushed rock. Mineral extraction can only take place where the minerals naturally occur, which is not necessarily close to where they are required, so they have to be transported across the UK.

The last 30 years has seen considerable economic growth in the UK. One of the key measures of economic growth is construction, hence the demand for construction materials tends to mirror economic cycles. Each year, between 250 and 270 million tonnes of aggregates are used in the UK for construction purposes. About 50 million tonnes of this is supplied for recycling, with the remainder coming from primary sources. This is less than the 1980s peak of 300million tonnes but remains a significant amount, and is likely to rise in the face of continued housing development, especially in the South East.

The Survey of Land for Mineral Workings in England 2000 (ODPM) indicates an overall reduction in the area of surface working for sand and gravel for construction from almost 30,000ha in 1994 to just over 27,000ha in 2000. The total area of surface working for all minerals decreased from 118,000ha to 113,500ha over the same period. The British Geological Society has calculated that the total area of land permitted for mineral extraction accounts for about 0.3% of the total land area of the UK.

Despite the relatively small land area directly affected, mineral extraction and transportation gives rise to significant environmental impacts and cause public concern. Impacts include traffic along roads, noise, vibration and dust caused by machinery, the visual impact of the quarrying operations and potential effects on groundwater and river systems. Consequently extensive planning and environmental regulations are in place to control the industry, the aim being to minimise the environmental impact of extraction and to ensure mitigation of impacts where extraction is permitted.

Once a mineral has been extracted from an area of land, the operator is required to restore the land to an agreed after use – agriculture, forestry, recreation, nature conservation, etc. The restoration of mineral workings has resulted in the creation of some important areas for wildlife, for example where lowland sand and gravel workings have become important wetlands for migrating birds and reedbed habitat. In addition, it needs to be borne in mind that some of the most valuable sites for wildlife close to urban populations are past mineral workings that have naturally colonised, developing their own unique plant assemblages, many of which are now designated as SSSIs.

3.5.2 Water

Water is vital to public health and the environment. The principal sources of water are groundwater and surface water, from which water is abstracted, treated and supplied to consumers. These sources are replenished during the wetter months of the year, with reservoirs, rivers, lakes and aquifers refilling. This replenishment usually provides enough water for the drier summer months when rainfall is less.

However, water use is growing. Water consumption per household increased by 7% between 1992 and 2001 in England and Wales. In 1995, the average and peak demands for public water supply were higher than in other years because of the unusually hot dry weather that year. In 1972, only 66% of households owned a washing machine. Ownership increased to 90% by 1996 and is projected to increase further to 94% by 2010. Household consumption has risen by 70% over the past 30 years mainly due to the introduction of water demanding appliances.

Increased per capita use of water is placing ever-greater strain on water resources, especially when resources are not adequately replenished due to periods of low rainfall. The actual and predicted effects of climate change create further uncertainty for the planning of water resources. Figure 3.11 below shows the areas of the country which have a sustainable or unsustainable abstraction regime during the summer months, as defined by the Environment Agency. Those areas with an unsustainable abstraction regime will have to develop new resources if projected demand is to be met.

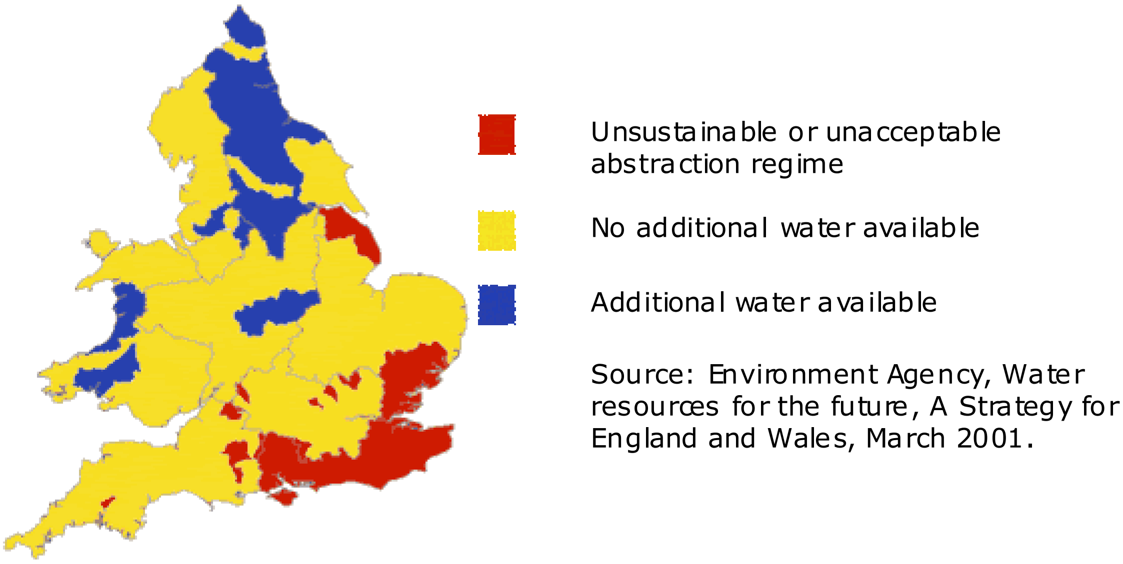


Figure 3.11. Current indicative availability of water during the summer months

Source: Environment Agency 2001

Water companies are running campaigns to gain public support for reducing the overall amount of water that we use. Many are also upgrading their supply networks to minimise and prevent loss of water from leaking pipes. At the same time, there is clear evidence that some water companies are planning new investment in major water resource infrastructure projects. Such investment is regulated by OFWAT through the Asset Management Planning (AMP) process. The water companies made their AMP 4 submissions to OFWAT in 2003 and a number of these include infrastructure projects. For example, Thames Water is actively considering the construction of a major new reservoir in the Upper Thames catchment to meet the long-term water needs of London. Thames Water have also recently submitted a planning application for a desalination plant on the tidal stretch of the River Thames.

Unsustainable abstraction regimes put a number of pressures on several ecosystems. The drying out of rivers and streams will alter the riparian ecology, with species either moving away or dying as a result. Reduced river flows are likely to carry a higher concentration of toxins and pollutants, as there is less water in the system to dilute them. Reduced river flows may affect the oxygenation and nutrient fluxes of the water. This effect may be exacerbated in lakes, reservoirs and large rivers where reducing the amount of water in the hydrological system may make it more susceptible to an increase in temperature and so a reduction in dissolved oxygen. Reducing the amount of oxygen in a river or lake adversely affects plant, invertebrate and all sorts of vertebrate types. Wetlands too are particularly sensitive to changes in water level and stability. Fojt (1992) noted that many wetlands such as fens had been lost or degraded as a result of land drainage and water abstraction, and the RSPB concluded that '*Abstraction can result in water being pumped from protected wetland sites, these reduced water levels are estimated to adversely affect 14% of wetland SSSIs*' (RSPB. 1999). These impacts have the effect of reducing habitat size and so decreasing the amount of minimum habitat area needed for viable populations.

Other impacts are caused by the treatment of water after it has been used. As more houses are built, new facilities to deal with sewage will be required. Raw sewage is treated at sewage plants treatment works, and the treated effluent is usually returned to surface watercourses. Indeed treated effluent helps sustain flows in many rivers and streams during dryer periods. Although discharges to watercourses are controlled by the Environment Agency, they can still have an impact on the ecology of a watercourse, especially in combination with the equivalent threat of diffuse pollution from agriculture.

The implementation of the Water Framework Directive (2000/60/EC) is in direct response to the adverse development-related cumulative impacts on the water environment at a European level. The new generation of river basin management plans require an inclusive and integrated approach to managing water as it flows through catchments from lakes, rivers and groundwater to estuaries and the sea.

3.5.3 Energy

Energy forms a key part of our everyday lives. It is required to switch on our lights, drive our cars, and make the products we use and to heat our houses. Energy consumption in 2001 was higher than in any other year over the last 30 years. Overall energy consumption in the UK has increased by 13% since 1970 and by 11% since 1990[8]. Since energy consumption is partly dependent on the weather, in a cold year more energy is consumed than in a warmer year, the DTI adjusts the data to identify the underlying trend. On the adjusted basis, energy consumption increased by 15% between 1970 and 2001 and 10% between 1990 and 2001.

To allow comparison, the DTI calculates final energy consumption using primary energy equivalents (million tonnes of oil equivalent). Between 1990 and 2001, energy consumption increased from 213.6 to 237.7 million tonnes of oil equivalent. On a sectoral basis, industrial energy consumption fell by 5% over this period while energy consumption in transport, domestic and service sectors increased by 18%, 17% and 19% respectively. By 2001, the domestic sector was the largest consumer. The majority of fuel is used to generate electricity, which is distributed via the National Grid. Figure 3.12 below shows the electricity supply system in the UK in 2003.

This supply system contributes to the cumulative effects of development in many ways. Power stations and sub-stations occasionally impact biodiversity directly by causing habitat loss. Some power stations and oil and gas refineries will also cause a number of pollution impacts, especially to the air, but also to the terrestrial and aquatic environments. Even pylons, underground power lines and pipes can cause cumulative impacts by fragmenting core habitats. As the need for electricity and other forms of energy increases so will the cumulative impact of this sector, although the impacts may change with the expansion of renewable energy schemes. Broadly the increase in renewables is likely to be beneficial because of reduced carbon emissions, but may itself bring different challenges in terms of impacts.

[8] Energy Consumption in the United Kingdom. Department of Trade and Industry and National Statistics

Figure 3.12. The electricity supply system in the UK 2003

The above map is reproduced by permission of DTI, Reed Business Publishing and National Grid Transco

3.5.4 Waste

Until relatively recently it was extremely difficult to assemble reliable data on the amount of waste produced by society. Although it was evident that the total amount was rising, there was no hard evidence to validate this. Thus starting in 1995/96, the then Department of the Environment, Transport and the Regions (DETR) and the Welsh Office commissioned an annual survey of local authorities in England and Wales, to collect information on the collection, treatment and disposal of municipal and household waste. Information from the first three years of the survey showed that:

- there were around 27.9million tonnes of municipal waste in 1998/99, up from 25.9 in 1995/96
- of this total around 83% was landfilled, while 9% (over 2.5 million tonnes) was recycled and 8% was incinerated with energy recovery, giving a total municipal recovery figure of 17%
- each household generated about 22kg of waste per week in 1997/98.

Significant volumes of waste area also generated by industry and commerce (the commercial waste stream). The increased production of waste associated with increased development puts further pressure on the natural environment. For Example landfill sites require land and so contribute to direct habitat loss. Even when capped there can still be problems for any habitat re-creation that might take place. Landfill sites can also attract invasive species into an area which in turn out compete or prey on endemic species, reducing biodiversity. Noise and other disturbance impacts can also be a problem.

As internationals and national policy moves away from landfill to other forms of waste management, the nature of impacts will change. For example there is likely to be a greater reliance on large scale waste incinerators potentially giving rise to increased levels of air pollution directly from the facilities themselves and indirectly from increased traffic movements.

3.6 Cumulative impacts within a locality

For English Nature regional staff, a key concern is the likely cumulative effects of a number of parallel developments occurring in relatively close proximity and the cumulative effects of development over time. In these circumstances a single new development proposal may not have significant implications for biodiversity when considered in isolation but may well do when considered in combination with other cumulative effects.

Of particular concern to English Nature regional staff are the likely cumulative implications of current housing proposals (The Sustainable Communities Plan); road proposals (The Transport Ten Year Plan, 2003): and proposals for air travel and airport development (The Future of Air Transport, 2003). In this respect, as an example, it is useful to look at the ecological footprint of a typical household and to relate this to the level of housing development which is currently proposed

3.7 Ecological footprint

The main impacts of new housing will be highly dependent on local circumstances such as proximity of the housing in relation to existing housing, source of employment and transport routes, housing density (per hectare), type of construction and the extent of nature conservation, landscape, agricultural or other values associated with the land required.

Impacts arise in two categories, one-off impacts due to construction of the housing and the associated infrastructure and ongoing impacts due to occupation of the housing. There may also be further impacts associated with the construction and operation of businesses, schools and other services directly linked to the housing, but these have not been considered.

Housing construction impacts will include:

- The land required for the housing units themselves and for all associated infrastructure such as roads, car parking, footpaths, parks, pipelines and sewage treatment facilities.
- Materials used in construction such as aggregates and cement, wood, insulation materials, glass, paints, as well as the associated waste.
- The land and other resources used to produce those materials.
- The energy used in construction, including energy embodied[9] in the building materials.
- The emissions associated with energy use and transport, principally carbon dioxide from fossil fuel use but also transport emissions such as sulphur and nitrogen oxides and soot particles. Increasingly, a component of the energy impact is the requirement for additional land for alternative energy generation such as windpower.
- Other emissions such as volatile compounds from paints.

Housing occupation impacts will include:

- Energy consumption by the house occupants (mainly electricity and gas), and associated emissions (mainly CO_2) and other impacts.[10]
- Water consumption.
- Energy consumption in transport and the associated emissions of CO_2 and other pollutants.
- Consumption of food and other consumables and generation of waste.
- Emissions of some pollutants to water, mainly through the wastewater system (e.g. cleaning products).

While the construction impacts can be wholly attributed to the new housing, the occupation impacts are only partially due to the new housing. The latter are, to a large extent, linked to population rather than housing stock *per se*, but are likely to be higher where people are spread across more housing units. In other words, we should ideally be concerned with the

[9] Embodied energy includes the energy used in extraction, manufacture and transport of goods.
[10] In 2000, 82% of energy

marginal impacts due to occupation of new housing, rather than total impacts. The proportions due to the housing itself are very difficult to quantify but one would expect, based on limited available data and on first principles, that:

- As household formation rates increase, so will the volume of waste produced, albeit this may be offset by policy initiatives promoting reuse and recycling. [11]
- Water consumption would rise with additional households due to, for example, more washing machines and gardens.
- Energy consumption (and associated emissions and other impacts) would rise with additional households due to additional appliances such as ovens and televisions and additional heating requirements. In 2000, 58% of household energy use was for space heating.[12] To offset this somewhat, new appliances are generally more efficient than those in the existing housing stock and house insulation is better.
- Transport impacts (energy and emissions) would increase somewhat due to a more dispersed population.

3.7.1 DEFRA Study of environmental impacts of housing

Defra recently commissioned a research project entitled Study into the Environmental Impacts of Increasing the Supply of Housing in the UK, completed in 2004. The study "explores the potential environmental implications of increasing housing supply under a number of different growth scenarios", in line with the Barker Review completed in 2004. Aspects considered included the requirements for greenfield or previously developed land, other impacts of construction and impacts of ongoing occupation. It did not consider some other impacts such as transport impacts and new infrastructure requirements, due to timeframe and resource limitations. Four scenarios of differing housing growth rates, densities and construction methods were considered for the period 2001-2016. One scenario used baseline growth rates (average 149,000 dwellings per annum) while the other scenarios included up to 288,000 new dwelling per annum.

The study assumed that almost half of the new housing would be built in the South East and East of England and in London. National losses of greenfield land over the study period would range from 42,400 ha to 77,500 ha, with similar but slightly lower requirements for previously developed (brownfield) land. A higher density of housing was assumed for previously developed land so that up to two thirds of new houses would be located there. Most of the direct environmental impacts would occur in the south and south west of England, including loss of habitats, water and air impacts and loss of recreational opportunities. Summary data for other resource impacts such as energy and water use and CO_2 emissions were also presented.

3.7.2 Footprint analysis

Table 3.2 estimates the 'footprint' of an average housing unit, based on a range of data sources including reports available from the DTI, DEFRA and Office of National Statistics

---

[11] Waste Strategy 2000: England and Wales Part 2 (2000) DEFRA and The South East Regional Waste Management Statement (2002) SERTAB, both use household formation rates as a key driver for predicting future waste volumes.
[12] DTI and Office of National Statistics. Energy Consumption in the United Kingdom.

websites and other published reports. The average house is assumed to be a 90m^2, three-bedroom house with average occupancy of 2.4 persons.

Table 3.2. Footprint for construction and occupation of an average house

CONSTRUCTION	**Impact per unit**	**Impact per 1000 units**
Land (includes roads and services)	333 m^2	33 ha
Aggregates (not including other materials)	60 tonnes	60,000 tonnes
Construction waste (all waste)	11 tonnes	11,000 tonnes
Energy (materials and construction)	280 GJ	280 TJ
CO_2 emissions (materials and construction)	35 tonnes	35,000 tonnes
OCCUPATION	**Impact per unit per year**	**Impact per 1000 units per year**
Energy consumption	120 GJ	120 TJ
CO_2 emissions (energy consumption)	4 tonnes	4,000 tonnes
Water consumption	0.2 Ml	200 Ml
Waste production	1.25 tonnes	1,250 tonnes

Notes: GJ – gigajoules; TJ – terajoules, Ml – megalitres

3.7.3 Trends

Some examples of the trends in consumption and resulting impacts are shown below to illustrate the complexity of factors at work. The general picture is that gains in efficiency have tended to be offset by increases in consumption or use.

3.7.4 Energy use in houses

Uptake of energy efficiency measures such as loft insulation and efficient boilers has increased greatly over time, but at the same time so has the purchase of energy using appliances such as washing machines, dishwashers and personal computers. Overall, energy use per house has fallen very slightly since 1970 but has remained in the region of 80 GJ per house (delivered energy, not including losses in generation and transmission). Against this, population has increased and average occupancy per dwelling has decreased, resulting in an increase in total domestic energy consumption in Great Britain from about 1500 PJ per annum in 1970 to about 1900 PJ per annum in 2001. (Source: BRE (2003) Domestic Energy Fact File).

3.7.5 Vehicle use

Average car use per person has almost doubled from 6,600 km per person in 1970 to 11,700 km per person in 2001, while average car occupancy has declined very slightly from 1.7 to 1.6 persons. 74% of households had access to at least one car in 2002, compared with 59% in 1980. 29% of households had access to two or more cars in 2002, compared with 15% in 1980. To offset the figures somewhat, vehicle efficiency has improved steadily over time. The net effect is that fuel consumption per passenger mile has been almost static since 1970, while road passenger miles and total fuel consumption have increased by about 80% since 1970 (Source: DTI and DfT websites).

4. Thames Basin Heaths case study

To give more focus to some of cumulative impacts discussed in the previous Chapter, the proposed Thames Basin Heaths Special Protection Area (pSPA)[13] has been taken as a case study area.

The pSPA is the subject of a major initiative by the Thames and Chiltern Office of English Nature and other partners, notably the 11 local planning authorities and the Government Office for the South East (GOSE). The overall aim of the initiative is to prepare an agreed plan for the delivery of regional housing targets that does not adversely affect the integrity of the pSPA.

4.1 Background

The Thames Basin Heaths pSPA covers an area of some 8400ha stretching across the three counties of Berkshire, Hampshire and Surrey in South East England. Map 4.1 shows the location and extent of the area.

4.2 Designations

Today the area is covered by a number of international and national designations. Sites of international importance include the Thames Basin Heaths pSPA, two Candidate Special Areas for Conservation (cSAC), and two RAMSAR on the north east boundary of Surrey.

The Thames Basin Heaths pSPA is proposed for designation under the European Commission Directive 79/409 on the Conservation of Wild Birds (the Birds Directive). Planning Policy Guidance note 9 (PPG9) *Nature Conservation* clarifies that for the purpose of considering development proposals affecting them, potential SPAs and candidate SACs should be treated in the same way as classified SPAs and designated SACs.

The site was formally confirmed as a pSPA in October 2000 because of its ornithological importance. It qualifies under the Birds Directive as it is regularly used by 1% or more of the Great Britain population of species listed in Annex 1 of the Directive in any season. Table 4.1 below shows the Annex 1 species that the pSPA qualifies for.

Table 4.1. Population of bird species listed in Annex 1 of the Birds Directive

Annex 1 species	Population	% of GB population
Nightjar *Caprimulgus europaeus*	264 churring males (1998/99)	7.8
Woodlark *Lullula arborea*	149 pairs (1997)	9.9
Dartford Warbler *Slyvia undata*	445 pairs (1999)	27.8

These species are characteristic of heathland habitats. The site also supports a range of other species associated with open habitats including:

Hobby *Falco Subbuteo*
Little Ringed Plover *Charadrius dubius*
Woodcock *Scolopax rusticola*
Redstart *Phoenicurus phoenicurus*

[13] As proposed under the European Commission Directive 79/409/EEC on the Conservation of Wild Birds.

Skylark *Alauda arvensis*
Stonechat *Saxicola torquata*
Tree Pipit *Anthus trivialis*
Yellowhammer *Emberiza citrinella*

In winter, a number of Annex 1 species occur in small numbers:

Hen Harrier *Circus cyaneus*
Merlin *Falco columbarius*
Short-eared Owl *Asio flammeus*
Kingfisher *Alcedo atthis*

A number of national designations also exist. These include a total of 13 individual Sites of Special Scientific Interest (SSSIs) and three National Nature Reserves (NNRs). PPG9, paragraph 13 clarifies that all NNRs, terrestrial RAMSAR sites, SPAs and SACs are also SSSIs under UK national legislation.

4.3 The habitat and surrounding land use characteristics

Lowland heath is generally found on thin sandy or peaty acidic soils that are normally deficient in available nitrogen and calcium. Over previous millennia the area of lowland heathland grew in extent from small areas inhospitable to tree growth to large swathes of habitat as a result of climate change and, more importantly, the clearance of trees by Man and subsequent grazing. 'Heathland is predominantly a man-made landscape' (Gimingham, 1975; Webb 1986), and requires management by Man to prevent succession back to woodland.

The Thames Basin Heaths comprise a number of habitats. The pSPA consists of dry heathland, with oak and birch acid woodland, gorse scrub, acid grassland, wet heathland, mire habitat, acid ponds and mosaics of all of these, with additional areas of conifer plantation. These habitats are all found on the same soils, but different forms of management, differing water table levels and, to some extent, nutrient levels, have created this diverse range of habitats and habitat mosaics.

In turn, these habitats support a considerable number of species which benefit from the protection offered by the three European protected birds and the other nationally designated species. Some species rely on just one habitat, whereas others rely on the habitat mosaics found in the area or the continuing naturalness of the larger parts of the area.

The surrounding land is predominantly made up of a mixture of pony paddocks and residential development. It is bordered to the south by the A3 and A31 and intercepted by a number of B roads with links to Woking, Bracknell and Aldershot. There are also a number of river valleys cutting through the area including the Rivers Blackwater, Wey and Bourne.

4.4 Plans and policies covering the heaths

The Thames Basin Heaths fall within several strategic and land use development plans.

- At the regional scale Regional Planning Guidance for the South East (RPG9) runs from March 2001-2016. A number of key topics such as waste and transport are undergoing an early review and a full review is taking place within 2004/5. Existing RPG9 proposes a total of 23,000 houses to be built each year between 2001-2006 within the region;

- Hampshire Structure Plan runs from 2000-2011 and covers the western half of the pSPA including the Districts of Hart and Rushmoor. Local plans for both of these areas will need to accommodate nearly 5,000 and 3,000 dwellings;
- Berkshire is split into unitary authorities that come together to decide the county's development policies in conjunction with regional planning guidance. Proposals include the provision for 2,500 houses to be accommodated in Bracknell District each year, the location of which will be determined by the Bracknell District Local Plan;
- The Surrey Structure Plan runs from 2004 to 2026. It proposes 35,400 dwellings to be accommodated within this time period within the County. In terms of the area covering the pSPA, this will have a bearing on Local Plans for Woking and Guildford;
- Each of the plans above translate their allocations into one of the 11 local plans, which aim to give a greater degree of accuracy to the strategic allocations presented in the structure plans and any phase one unitary plans;
- A host of other strategic plans cover the area at county and local level, including waste and minerals plans, economic and transport plans, rural strategies.
- For ease of reference Map 4.1 shows the county and district boundaries around the pSPA.

4.5 Cumulative impacts of development

The Thames Basin Heaths is an area which has been, and continues to be, under very considerable development pressure due to its location within easy commute of London, on the M3 corridor and caught between the rapidly growing centres of Guildford, Woking, Reading Bracknell, Staines, Frimley, Camberley, Aldershot, Fleet and Farnham.

The cumulative impacts resulting can be summarised as:

- Habitat loss;
- Habitat fragmentation;
- Disturbance (noise, recreation, pet predation);
- Pollution;
- Nutrient enrichment;
- Hydrological impacts.

4.6 Habitat loss - development expansion over the 20th Century

Taking an historical perspective first, the area experienced very considerable growth over the last Century.

Maps 4.2, 4.3 and 4.4 are Ordnance Survey edition maps, dating from 1904, 1947 – 1959 and 2003 respectively. Map 4.3 is a composite of a number of different editions and had to be scanned from paper copy, whereas Maps 4.2 and 4.4 were obtained as digital copies. The pSPA is shown on each map for ease of reference. Below is a brief synopsis of the land use change in the area over the last 100 years.

4.6.1 1904 – 1947/1959

At the turn of the 20th Century much of this area was still open land, comprising an extensive mosaic of woodland and heathland habitats with intervening low-grade pasture. The areas of heathland that now make up the pSPA were contiguous with the surrounding open land.

The railways had recently been constructed, including the mainline from London to the south coast (Southampton and Portsmouth), resulting in railway-related development, notably at Woking, Aldershot (a garrison town) and to the south of Broadmoor and Bagshot Woods and Heaths (the town now known as Camberley).

By the middle of the Century, the growth of the towns served by the railway network was more apparent. This was particularly marked at Guildford and Woking. To the north east of the pSPA is the Thames Valley itself. This was subject to very considerable land use change in the first half of the 20th Century, including the development of Heathrow Airport (on heathland, as its name suggests), the construction of water supply reservoirs for London, and extensive extraction of river valley gravels. The large expanses of open water to the south west of London are now a candidate SAC.

4.6.2 1947 – 2003

The second half of the 20th Century saw a dramatic change led by two main forces – the planned expansion of London and development of the road network. In the 1960s a new generation of towns and town expansion programmes was the driving force behind the expansion of Bracknell (immediately to the north of Broadmoor to Bagshot Woods and Heaths) and Reading. Further, with the construction of the M3 Motorway from London to Southampton, the focus of development shifted from the railway corridors to the motorway and main road corridors, with rapid development growth focused on the Frimley, Camberley, Farnborough, Blackwater area which separates the heathlands that now form the central core of the pSPA. Camberley and Farnborough, in particular, grew almost out of all recognition. However since the designation of the heaths as a pSPA the heathland has been well protected in terms of extent, but has suffered from other indirect and secondary impacts.

4.6.3 Summary of changes

The pattern that is left is one of the designated parts of the pSPA now being almost entirely enclosed by urban development, transport corridors and a variety of other development types.

This picture is summarised by Map 4.5 which shows the steady erosion of the heathland habitat over the last 100 years and the development of much of the intervening open land, resulting in the removal wildlife corridors and isolation of the remaining blocks of heathland. However, as is discussed below, perhaps the key issue now is the ongoing fragmentation of the remaining resource.

Significantly, the total area of heathland habitat declined by 104 km^2 between 1904 and 2003 from 196km^2 to 92 km^2. This is a drop of 53% in the total area of heathland habitat over the last 100 years. Similarly, the area of intervening open land declined by 222 km^2 between 1904 and 2003, from 765km^2 to 543 km^2. This is a drop of 29% in the total area of open land other than heathland over the last 100 years.

4.7 Habitat Loss – future development proposals

While Map 4.5 illustrates the level of habitat loss over the last 100 years, the future could experience similar levels of development and habitat loss.

Map 4.6 illustrates each district's housing allocation up to 2016, except for Hart and Rushmoor District Councils, which only have information up to 2011. These figures indicate where the greatest development pressure will be over the next decade and beyond. From the map it is clear that the largest pressure will be placed on the pSPA sites in and around the Berkshire Unitary Authorities of Bracknell, Wokingham and Windsor & Maidenhead as they have the largest housing allocations. There will also be increasing pressure on the pSPA in Guildford, Woking and Hart. By looking at the Structure Plan allocations and making an adjustment for those allocations falling within the Thames Basin Heaths area, it is calculated that over the next 12 years a total of 35,170 houses will need to be built within the area, equivalent to at least 12 km^2[14] lost to housing development (with no allowance for associated infrastructure).

Furthermore, the Ten Year Transport Plan includes the following schemes in the Thames Basin Heaths area:

- M3/A322 Lightwater Junction improvements
- M3/A331 Camberley Junction improvements
- A3 Guildford improvements

Also, the Hampshire Structure Plan safeguards land for a 'Fleet Eastern Bypass' (policy T19). The route and scale of the project is unknown, but is in the vicinity of Bourley and Long Valley SSSI, part of the pSPA. In addition, planning permission has been granted for the expansion of facilities at Farnborough Airport, comprising a new terminal building with a business aviation centre and offices.

Combined with the housing allocations, these infrastructure developments suggest that at a minimum 1,800 hectares will be lost to development over the next 12 years (equivalent in size to 25% of the area of the pSPA) (Figure 4.1), not taking account of the myriad of minor infrastructure developments that will flow from significant urban expansion.

While there is no suggestion that future development will occur within the pSPA, it will almost certainly lead to a nibbling away of peripheral areas of heathland, and further fragmentation and isolation of habitats with the loss of other remnant areas of intervening open land. In turn, this will lead to additional pressure being placed on the remaining areas of core heathland habitat.

[14] Based on a housing density of 30 houses per hectare

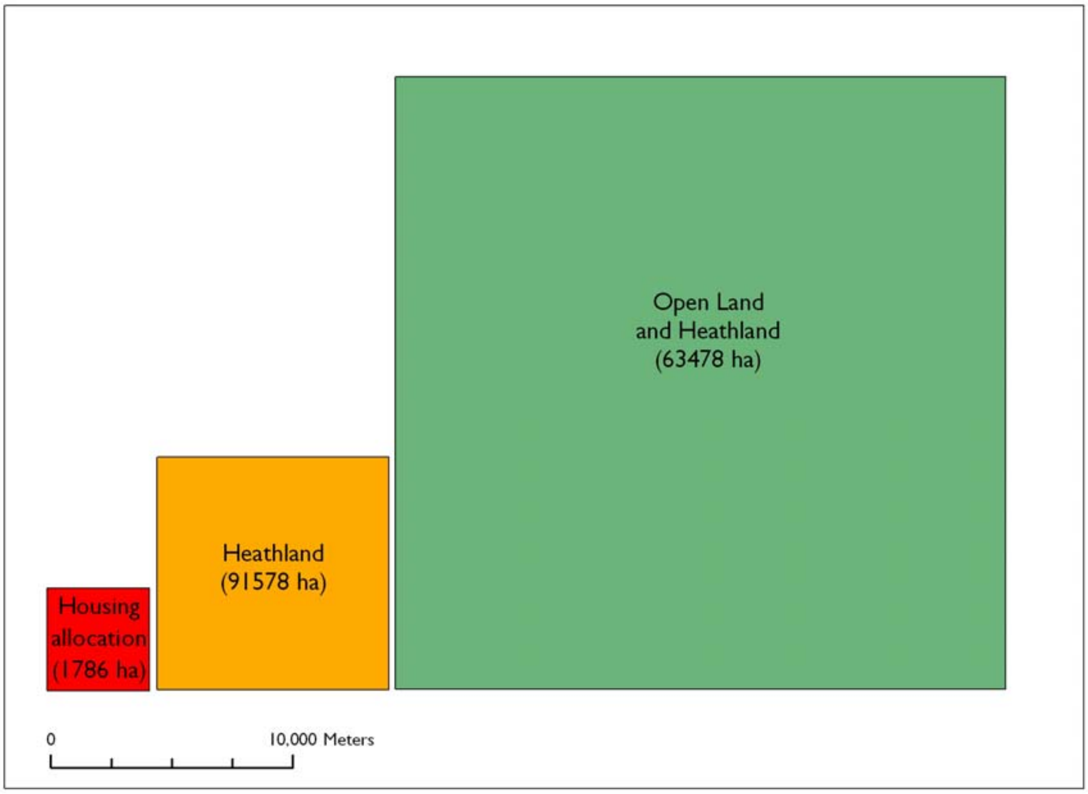


Figure 4.1. Diagrammatic representation of the area of land allocated to housing relative to heathland and open space of the same area

4.8 Habitat fragmentation

The fragmentation of the Thames Basin Heaths is apparent from Maps 4.2, 4.3, 4.4 and 4.5 and has already been discussed. Potentially most significant has been the loss of interlinking habitats between the five core heathland blocks with completion of the M3, and the dramatic expansion of Camberley and surrounding settlements. Areas of intervening river floodplain with their meadows and pasture and linking areas of heathland, acidic grassland and woodland have been lost. This has isolated the individual heathlands and removed important intervening natural buffers, such that the remaining heathlands are directly exposed to an increasing range of external pressures.

The level of fragmentation is highlighted by the fact that in 1904 there were 52 main heathland blocks within the area while by 2003, as a result of the overall reduction in heathland area, these had fragmented to a total of 192 smaller blocks. This will have significantly increased the proportion of edge to core habitat on each of the heathland blocks greatly increasing the vulnerability of the habitat to external forces.

With this fragmentation some species will have become isolated on their particular heathland area. The large-scale habitat loss will have also reduced the territories of some of the larger species and pushed them back onto the remaining heathland, putting them in direct competition with other members of the same species. This may have resulted in a reduction in the population or, where the remaining habitat was not large enough to support a viable population, then that species may have been lost from the area altogether.

4.9 Disturbance

Three main types of disturbance have the potential to affect the pSPA. These are:

- Noise - from roads, houses, airports, army activities and other development
- Human disturbance
- Pet disturbance and predation

The impacts of artificial light may also have an effect, but little work has been completed on how exactly increased lighting at night affects heathlands and the species that live on them.

4.9.1 Noise

Noise is known to have an adverse effect on bird densities. Most studies looking into the effects of noise have concentrated on traffic impacts. Recent studies in the Netherlands indicate that the effects of road traffic on breeding bird density are due to noise emissions rather than visibility or air pollution (Reijnen and others, 1995). However, the effect that noise has on each bird species is different. Some birds are more sensitive to noise than others and some bird species live in habitats that buffer the effects of noise more efficiently.

The Thames Basin Heaths consist of a variety of habitats including woodland and open heath. The work by Reijnen in 1995 mainly centred on woodland and open grassland habitats. These habitats are found as part of and around the pSPA. In the Dutch research noise from major roads was found to reduce bird density by 34% in woodlands with noise affecting diversity for distances up to 46m. The same figures for open grassland were 39% and 710m respectively. The affected distance was found to increase with greater traffic intensity and speed.

A similar reduction in bird density is likely to occur around the Thames Basin Heaths. Work by van der Zande (1980) suggested that quiet rural roads have a disturbance distance of 500 km – 600km while busy highways have a disturbance distance of 1km. Map 4.7 shows the areas of the pSPA that could possibly be affected by noise. Taking a conservative approach a 500m disturbance zone has been put around all A roads and Motorways in the area, and a 2km disturbance zone around mineral sites (reflecting Environment Agency guidance). In addition, Farnborough Airport will be a very significant source of noise, although no specific allowance has been made for this on the Map.

The results of this mapping suggest that across the heathlands of the pSPA, 27 km^2 (or 33% of the area) will be sufficiently affected by noise to reduce bird densities. These figures should be treated with some caution, as noise impact can be increased or decreased depending on the wind, the flow of traffic, the gradient of the land and the characteristics of the site. Nevertheless, they are indicative of the issues that the area is facing.

4.9.2 Human disturbance

Residential developments bring with them an influx of people into an area. Some of these people will want to use the heaths for recreation. People cause a number of indirect impacts on the heath including noise and bringing pets onto the heath. However it is often the various recreational pursuits on the heathland that cause the biggest impacts. How significant the impact is will depend on what the activity is. Walking has the smallest impact, but can still cause trampling of plants and bird disturbance. Mountain biking can exacerbate these problems further, but driving motorbikes and other off-road vehicles on the heaths will cause the most severe impacts. This is because heaths have very thin sandy and peaty soils that can be easily disturbed. Continued use by motorised vehicles can erode the thin heathland soils which will facilitate the loss of the habitat and the fragmentation of the heath. These pursuits can also affect the plants and animals directly, through collision and other disturbance effects, and in wetter areas cause channelling, which impacts the hydrology of the area.

4.9.3 Pet predation

A major secondary effect of residential development is the introduction of cats and dogs to the heathland habitat. This is a particularly important impact for the Thames Basin Heaths because of the high populations of ground-nesting birds, including Nightjar (one of the species on which the pSPA designation is based) and Woodcock. Cats and dogs are predatory animals by nature and will actively seek out prey, however they impact the heathland in very different ways. Cats often have territories that extend around residential areas and on to heathland. The RSPB states that "*cat predation can be a problem where housing is next to scarce habitats such as heathland, and could potentially be most damaging to species with a restricted range (such as cirl buntings) or species dependent on a fragmented habitat (such as Dartford warblers on heathland)"* (RSPB 2002). Heavy predation pressures could seriously compromise the viability of a bird species where they exist as small, relatively isolated populations. The potential influence of cat predation is shown on Map 4.8. This identifies a potential predation zone within 200m of all built up areas. This suggests that up to 8.6 km^2 of the pSPA could be adversely affected by pet predation, an impact that is likely to increase with further development.

Dog Predation is different still as it mainly depends on the route that the dog walkers take and the length of the walk. Dogs do not range like cats and are taken to the heaths by their owners. They are either driven to car parks or walked to access points. Once on the heath they are often let off their leads and as a consequence most of the impacts on the birds will take place around footpaths and around car parks. Little research has been carried out to assess this impact.

4.10 Pollution and Nutrient Enrichment

The Thames Basin Heaths are very sensitive to air-borne pollution. Within the area the main sources of air-borne pollution are the extensive and very busy road network, aircraft (both from Heathrow and Farnborough) and the industries of the area. Particular sensitivities relate to nitrogen and sulphur compounds which have two main impacts on heathland. Both sulphur and nitrogen contribute to the acidification of the soil, with the acidic soils that support heathland having little natural buffer against additional acidity. At the same time the nitrogen also acts as a nutrient, artificially fertilising the heath which is naturally adapted to the characteristically nutrient poor soils.

Studies by Angold in 1997 and 2002 demonstrated that the effects of traffic derived pollution extended approximately 200m either side of the A31 (dual carriageway) as it passed though the New Forest. The New Forest is an area of acid woodland interspersed with large expanses of heath and as such is similar in character to the Thames Basin Heaths. Emissions from traffic (both sulphur and nitrogen) on the A31 had increased the level of nitrates from 60ppb to 100ppb in a corridor extending 200m either side of the road, resulting in changes to local vegetation (i.e. a reduction in heath species (*Calluna*) and an increase in grass species (*Molinea*) in response to increased nutrient levels. Furthermore, modelling by Bignal and others in 2004 suggests that the likely impacts of the A31 could reach as far as 2 – 3km, although these effects could be very species specific at this distance.

Map 4.9 seeks to illustrate the potential pollution impact of the principal roads crossing the Thames Basin Heaths. However it must be remembered that in addition to the impacts of road vehicle exhaust fumes, the heathland will also be impacted by other sources of air pollution that Map 4.9 cannot easily incorporate. For the purposes of our example the M3 and the dual carriageways have been given a 200m zone of influence, highlighted in red, in keeping with Angold's evidence above. These primary roads have also been given a yellow 1km zone of influence showing that major roads may have an impact on a species level further than 200m. The other A-roads have been given a smaller 200m yellow zone of influence, as the effects of these roads is not known, but some impact on habitats and species appears likely. Farnborough Airfield is also thought to have an additive impact on Nitrate deposition and so has been shown on the map with a 10km zone of influence. This distance is derived from the Environment Agency's 'Habitat Directive and Regulation Guidance: Work Instruction (Appendix 7) (RA2003), which the Agency uses for 'in combination assessments' under the Habitats Regulations.

The results of this mapping illustrate that 4.08 km^2 (or 5% of the area) of the pSPA designated heathlands will be directly suffering from nutrient enrichment from the road network, while 25.4 km^2 or 31% of the designated heathlands of the pSPA are likely to be influenced by nutrient deposition from the roads within and around the area.

Significantly, looking specifically at increased acidity, a report by the Environment Agency National Air Quality Monitoring and Assessment Unit (NAQMU) has concluded 'that the levels of acidity due to sulphur and nitrogen deposition … exceed the critical levels, even when background levels are considered alone. Background sources are therefore determined as having an adverse affect on the integrity of the designated features of the Thames Basin Heaths' (Atkins 2004)[15].

It is important to note that this exceedance of the critical levels of acidity and the current extent of likely nutrient enrichment is before any account is taken of the significant further increases in traffic that can be expected to result both from proposed road improvement schemes in the area and the cumulative impact of further significant housing development.

[15] This quote is from the Environment Agency's work reviewing their consents around the Thames Basin Heaths. The in combination part of this study was completed by Atkins Environmental and the above quote is from their document.

4.11 Hydrology and waste

The Environment Agency has recently completed a review of consents in the Thames Basin Heaths area, based on an 'alone' and an 'in combination' assessment. Map 4.10 shows the location of the consents covered by the review with the exception of Radioactive Substances Consents, for which data were not available. The data shown on the map comprise:

- discharge consents;
- abstraction licences;
- Integrated Pollution Control (IPC) authorisations;
- waste management licences inc. landfills.

Each of the permissions has the potential to cause significant effects on the heaths. However, once the assessment was finished only one waste management licence was found to have a significant in combination effect on the pSPA, and this was in relation to noise not hydrology or waste.

Looking to the future, no current water abstraction sites place pressure on the pSPA. But it is also an area where no or little excess water is available. Thus to service any new development, water will need to be supplied from elsewhere if adverse effects on the pSPA are to be avoided. Equally future housing will put increasing pressure on the area's waste disposal capacity, possibly leading to further landfill sites with their potential to change local water tables and introduce further disturbance.

4.12 Aggregate of cumulative pressures

Taken together this assessment of the Thames Basin Heaths suggests a significant combination of cumulative impacts which have the potential to have a significant effect on the integrity of the remaining heathlands. The main impacts are listed below:

4.12.1 Habitat areas

- A 53% (104 km^2) reduction in the overall area of heathland within the area between 1904 and 2003;
- A 29% (222 km^2) reduction in the overall area of other open land within the area between 1904 and 2003, with some areas of heathland now almost entirely surrounded by development;
- A total of 192 fragmented blocks of heathland in 2003 compared to 52 intact blocks of heathland in 1904;
- A further allocation of housing and other infrastructure over the next 12 years equivalent to 1,800 hectares of new development which may lead to further isolation of heathland areas and greater pressure along their boundaries.

4.12.2 Quality of habitat

- Exceedance of critical levels of acidity across the whole pSPA as a result of sulphur and nitrogen deposition, even when background levels are considered alone;

- 31% of the pSPA heathlands (25.5 km^2) currently adversely affected by nutrient enrichment as a result of nitrogen deposition from aerial pollution (primarily from roads and industry);
- 33% of the SPA heathlands (27 km^2) currently affected by noise (from roads) to the extent that bird densities are likely to be reduced;
- 10% of the pSPA heathlands (8.5km^2) currently adversely affected by domestic cat predation of ground nesting birds.
- Taken together, these figures indicate a habitat under significant pressure.

5. Conclusions and recommendations

5.1 Conclusions

The initial hypothesis for the study was that:

> "the cumulative effects of current and foreseeable development are unsustainable in terms of ecosystem resilience, functioning and ability to support characteristic biodiversity".

At the national level there is currently insufficient scientific data to clearly substantiate or refute this hypothesis. But, at the more local level, as indicated by the case study of the Thames Basin Heaths, the hypothesis almost certainly stands in relation to characteristic semi-natural habitats and the species that they support. This underlines that development in such locations is unsustainable from the perspective of biodiversity and provides a central challenge to future development in pressured areas containing significant areas of semi-natural habitat.

The anticapted scale of development proposed in southern England and especially the lowlands will have a significant and potentially deleterious effect on the region's biodiversity and ecosystem resilience. Habitat will be lost, fragmentation will occur, user pressure, pollution, vehicle use, and many other impacts associated with development will increase. Similarly, on a national scale it is very likely that cumulative effects of development will negatively impact England's biodiversity. Whether or not this negative effect leads to the most vulnerable areas losing their characteristic biodiversity is uncertain, but current trends, as indicated by the headline quality of life indicator for wildlife H13, suggest that in the southeast farmland and woodland bird populations are still declining, despite continued best efforts (Foley 2004). Continued development will exacerbate this trend.

There is, therefore, a strong argument to continue work on cumulative effects. One of the main findings of the consultation exercise undertaken as part of this work was the need to increase research and awareness of this subject, to supplement any gaps and increase understanding. It was noted in the consultation exercise by English Nature and Forum for the Future, that new research on Annex 1 birds and recreation impacts is to be made available in 2005 and should be incorporated into any future study.

There are a number of measures that need to be promoted if cumulative impacts are to be better assessed. The lack of robust research into cumulative effects, especially thresholds, indirect impacts and how different impacts inter-relate, has held back practical assessment. There is also a need for better research on individual species, relevant species and relevant groups of species. Monitoring impacts post-development is a much lauded but rarely used research approach that could really improve knowledge and understanding. Once complete it is important that the research is defendable and that any studies, monitoring or assessment tools are shared between organisations and individuals.

There is also a need to continue raising awareness amongst English Nature's local planning teams, and externally, about cumulative effects and how to address them through the planning system. Joint working between local authorities, regional authorities and other relevant organisations will help in this regard. More specifically, baseline information will need to be assembled for all regions and from that research, work into receptor thresholds should be carried out in order to assess how much development an area can sustain before ecosystems lose their resilience and characteristic biodiversity. The actual assessment of ecosystem resilience may also require further research, perhaps looking at indicator species across different taxa for each habitat. As an area of habitat loses key species its resilience will decrease. In such circumstances, it may be appropriate to enhance the level of protection afforded to a habitat. Such an approach will be dependent upon a considerable commitment of resources to monitor trends, but it is perhaps only by making such a commitment that sufficient evidence will be assembled, and appropriate policy responses formulated.

From this initial review of cumulative impacts associated with development, it is clear that their implications for biodiversity are of profound significance, both spatially and in terms of the combination of impacts that have the potential to affect individual species and habitats. Looking at the selection of maps of cumulative impacts associated with development presented in Chapter 3, it is clear that some parts of England are worse affected than others. The South East of England, and in particular the lowlands, is under severe pressure from cumulative impacts, especially when full account is taken of the proposed future housing allocations within the region, and the further cumulative impacts that these will generate. However, it is equally important to note that the effects of development are increasingly all pervading across much of England, as demonstrated by the figures illustrating light pollution (*Night Blight*) developed by CPRE (Figures 3.7 and 3.8).

It is also clear that cumulative impacts, because of the difficulty of predicting, identifying and quantifying them, have received proportionally little attention when compared to the direct impacts (primarily habitat loss) associated with individual developments.

Furthermore, this study has focused only on the cumulative impacts associated with development. Yet if these are combined with those associated with agriculture and with the potential increased fragility of certain habitats and species populations in the face of climate change, then it is likely that their implications for biodiversity will be of even greater significance. For areas of England under severe development pressure, such as the South East of England, there is a clear message that the likely implications for biodiversity and quality of life are far greater than simply the physical loss of habitat and species associated with individual developments.

It is both essential and timely therefore that English Nature has identified cumulative impacts as an area requiring far greater attention as part of wider initiatives to conserve and enhance biodiversity and quality of life in England and seek more sustainable solutions. In particular there is a need to:

- raise awareness of the issues of cumulative impacts on biodiversity amongst decision takers and especially those concerned with planning and implementing future development;
- raise scientific investigation and understanding of the implications of cumulative impacts on biodiversity;
- provide practical tools and methodologies for English Nature staff and those required to plan future development to ensure that cumulative impacts are fully taken into account in future development planning;
- develop mapping approaches to communicate the impacts.

The brief identified a number of challenging research objectives. While this initial report has gone some way to address the objectives in terms of the evidence presented, it is clear that current scientific knowledge is not sufficiently developed to provide definitive answers. Nevertheless, the work has resulted in the identification of a range of more specific recommendations, summarised below.

5.2 Recommendations

The recommendations are split into two sections. The first section seeks to provide pragmatic solutions to the complex problem of cumulative effects, and aims to highlight further avenues of research that could be undertaken ('Cumulative Effects'). The second looks to the other research that could take this work forward ('Next Steps').

5.3 Cumulative effects recommendations

5.3.1 Raising awareness

The data collected as part of this study has begun to illustrate the scale of cumulative impacts. To further understand this, accurate graphic representation of the spatial influence of cumulative impacts arising from development needs to be developed. This should be a tool that both:

- conveys a clear indication of the extent, severity and potential interplay between different cumulative impacts; and
- has the potential to become a simple national and regional representation that demonstrates the spatial extent of the problems associated with cumulative impacts.

An initial proposal might be to take three to five contrasting Natural Areas in different parts of the country and for each to map the extent of key indicators of cumulative impact. These key indicators should be based on readily available national data sets and might include, for example:

- *Air Quality Maps* of background Nitrogen Dioxide and Sulphur Dioxide concentrations taken from the air quality data produced by the Defra Air Quality Expert Group.
- *Characterisation of the ecological status of all watercourses* adapted from the current maps being prepared by the Environment Agency in support of the Water Framework Directive.
- *Water abstraction data* taken from the Catchment Management Abstraction Strategies (CAMS) prepared by the Environment Agency.
- *Light pollution* taken from the CORE national dataset on Night Blight.
- Noise pollution taken from the forthcoming Ambient Noise Strategy (ODPM).

The aim for each Natural Area would be to build up a 'contour map' (based on the level of impact) for each of the chosen indicators and then to overlay these 'contour maps' to show the interaction between the chosen indicators of cumulative impact. This would help identity both 'islands' that remain relatively unaffected by development and key 'hot spots' of cumulative impact. In turn, this information should be overlaid with any information on habitat distribution within the Natural Area – SPAs/SACs and SSSIs, non-statutory designations and, ideally, Phase 1 habitat information. Not only would this show the extent of habitats, but also it would convey an impression of the fragmentation of the existing habitat resource. Comparing this habitat information with the contours of cumulative impact it should be possible to indicate the areas and habitats under most and least pressure from cumulative impacts.

In preparing such maps there are clearly a number of questions that require further debate. In particular:

- what are the most appropriate indicators of cumulative impact and the most appropriate data sets to reflect these?; and
- what are the most appropriate 'contour intervals' of impact for each of the identified indicators?

As well as providing a political and awareness-raising tool, the maps should assist in future planning decisions. They should help highlight the pressure that existing habitats are under and the need to either avoid development in some cases or introduce very significant mitigation measures to prevent further cumulative impact on sensitive habitats. Equally, if linked to a predictive model, there would be the opportunity to indicate the potential cumulative implications of individual developments and groups of development for the chosen indicators.

From these Natural Area maps, once tested and refined, the objective should be to develop a simplified map for England as a whole, identifying the national distribution of cumulative impacts. This would become the central tool for bringing to wider public attention the extent of current cumulative impacts and thus the wider implications of future development proposals.

The preparation of these Natural Area Maps and national maps of cumulative impact is not a small task. Yet their impact on ways of thinking have the potential to be as significant as the Natural Areas programme itself.

5.3.2 Improving scientific understanding – consideration of ecological risks and limits

Mapping the influence of cumulative impacts as suggested above only helps explain the problem. It cannot indicate the likely effects on individual habitats and species. While the identification of thresholds for different habitats and species to different cumulative effects has its dangers (suggesting that it is acceptable to allow impacts to accumulate to just below the threshold level), continuing to allow development without any reference to thresholds is not an option. Without any thresholds or guiding principles, no 'lid' is placed on the cumulative build up of impacts and their effects on habitats and species.

However, the science that would be required to identify the thresholds of all species to all potential cumulative impacts is vast and well beyond current likely resources available. Nevertheless, some basic principles or rules of thumb to take this debate forward are essential. The following three tools are suggested for further consideration.

Critical Load or Exceedance Maps: The potential value of Critical Load Maps or Exceedance Maps has already been demonstrated by the work of Monkswood for Defra, looking at nitrates and acid deposition and their effects on individual habitats. There is equally the potential to develop Exceedance Maps to explore other types of cumulative impact. From this study two obvious candidates come to mind:

- noise exceedance relative to song bird populations; and
- light exceedance relative to certain bat species.

Habitat sensitivity: For key habitats there is the potential to identify a number of representative indicator species and, based on the thresholds of each of these (in terms of abundance /presence) to Nitrates, Acidity, Noise Light and Hydrology, to identify the critical thresholds of these habitats to certain cumulative impacts. Certainly there is likely to be debate about the choice of indicator species and the thresholds that are subsequently identified. These will inevitably evolve over time but some rules of thumb are important for taking the debate forward.

Management guidelines: The above two tools would not necessarily consider habitat size and linkage. The work of George Peterkin in relation to woodlands has been very helpful in setting parameters to the desired size and linkage between woodlands. Similar management guidelines would be very helpful for other important habitats, both in assessing the impacts of potential development (especially the likelihood of fragmentation) and in considering mitigation options required.

5.3.3 Practical methodologies for assessment

One of the key concerns of English Nature regional staff is the difficulty of assessing the range of different cumulative impacts within an area. Equally there is a question of how to 'score' the variety of cumulative impacts. To take a simple example, how should the impacts be judged of a road proposal that leads to the loss of parts of five sites of local nature conservation importance compared to another option which affects a single site of national importance for nature conservation? In the past the standard approach has been to view the impact on each site separately, making no allowance for the cumulative impacts on the habitats of the locality.

It is hoped that tools such as those outlined above, could, over time, help in identifying the severity of cumulative impacts in terms of approaching or exceeding critical thresholds of key species and habitats. Nevertheless, Regional staff require help now to address issues associated with household, road and airport expansion. This requires development of an appropriate assessment methodology or methodologies or other basic principles. The development of such a methodology is beyond the scope of this study but certain guiding principles should be promoted by English Nature to start the ball rolling.

At the same time, more use could be made of ecological footprinting to help expose the full range of impacts that will arise from particular types of development. This in turn leads to the conclusion that English Nature should become more active at the regional and national level in pro-actively promoting more sustainable forms of development as well as reacting to the potential impact on individual habitats and species associated with specific development proposals.

5.3.4 Ecological monitoring

Finally, it has become clear that there is relatively little monitoring on the effects of cumulative development. Habitat loss is fairly well recorded but issues associated with the quality of habitats are often less well known. Even on SSSIs where condition monitoring is undertaken, this tends to relate to the management condition rather than to underlying trends, such as increases in acidity or nutrients, which have the potential to alter the habitat composition and may ultimately exceed habitat thresholds. It is therefore important that future biological monitoring programmes take account of the likely cumulative impacts from development and use the results of such monitoring to inform future decisions on development in a locality.

5.4 Next steps

5.4.1 Scope of the work

One of the most important outcomes of the consultation element of the work was that the means of demonstrating cumulative effects will need to differ according to the audience. For national policy makers, it is necessary simply to convey the key facts and headlines, and not dwell on detail. Conversely at the local level it is important to define how cumulative effects actually work and to support this with factual evidence. At a local scale it will also be important to describe methods of assessment.

Consultees also commented on the actual assessment of cumulative effects, rather than just the reporting of them. They suggested a need to address the issue of cumulative effects at three distinct scales. These were:

- At the national policy level- the approach needs to address assemblages and must include policy recognition of a baseline past which no further loss of all taxa will be tolerated;
- At a local geopolitical level- addressing the problem strategically and providing the framework for informed decision-making and the establishment of tools to address loss through policy allocations of land; and
- At a site level in the context of protection legislation. This includes protecting sites against *de minimus* damage which will lead ultimately to "death by a thousand cuts" to England's most susceptible habitats.

Of these the geo-political scale was seen as the most useful. Much of England's plan making and strategic assessment already takes place at this scale. Cumulative effects can often more easily be identified through the assessment of regional or local plans, but this can take time and will not identify all cumulative impacts. However this spatial level assessment needs to be researched further, as it provides an opportunity to remove adverse impacts at an early stage. Sustainability appraisal of Regional Spatial Strategies provides an ideal mechanism for doing this.

Producing cumulative impact risk maps for each of England's regions was also mentioned as a possible avenue of research. These maps could be based along the lines of the zone of impact maps included in this report but could look at the wider countryside and include more impact sources, types and receptors. Such an assessment could them be used to identify areas of the country that are at risk from significant cumulative impacts and areas that need to be safeguarded because of their sensitivity. The recommendation to consider the preparation of a new generation of Natural Areas maps addresses this point.

5.4.2 Focus of the work

The work concentrated on development impacts at a national scale. The danger in focusing solely on national level statistics and maps is that the concentration of pressures in the lowlands and on lowland habitats is not sufficiently highlighted. Future work should focus on lowland areas where there are fewer protected sites and where both the un-protected and protected sites are under the biggest threat from direct and indirect cumulative effects. For example, comparing upland, lowland and national data for SSSIs and development trends would produce useful findings.

This report also solely concentrated on the terrestrial environment. However the marine environment is increasingly being affected by developmental cumulative impacts too. Future iterations of this report should consider this avenue of research. Examples that could be used include looking into the collapse of fish stocks on the Grand Banks for Cod or the North Sea Herring fishery in 1970's/1980's, as well as the relationship between marine nature conservation sites and offshore windfarms.

5.4.3 Evidence

The consultation exercise identified a number of additional sources of information that could be used in future iterations of the work. They are listed below:

- Inclusion of data from the Countryside Quality Counts. See the Countryside Agency Website: http://www.countryside-quality-counts.org.uk/indepth.htm
- The positives of green space, green roofs and other ecological design, covered in such documents as 'Biodiversity by Design. A guide for sustainable communities' 2004 by the Town and Country Planning Association.
- Consideration of how the SEA Directive and its UK regulations can deal with cumulative effects at a strategic level, covered by SEA and Biodiversity Guidance for Practitioners', June 2004, and 'A draft practical guide to the SEA Directive', July 2004.
- Two research studies into the interaction between environment and economy: Resilience and Sustainable Development- Building adaptive capacity in a world of transformations by the Swedish Environmental Advisory Council, 2002; and The Problems of Success- Reconciling economic growth and quality of life in the South East, by the Institute for Public Policy Research, 2004.
- Local Biodiversity Action Plans and their targets may also prove useful.
- Further case studies could also be used to illustrate specific points and test run different methodologies at various strategic levels.
- The work undertaken on the impacts of human recreation on heathlands by the Dorset Office of English Nature. This has been driven by concern over the impact of residential development and associated increased recreational pressure on biodiversity. The resulting research has been used in part to formulate a joint

approach with local planning authorities to secure appropriate mitigation measures from developers.

5.4.4 Case study

The Thames Basin Heaths pSPA was chosen as a case study because of the amount of 'in combination assessment' work that had been carried out on the heathland. This provided useful information on cumulative effects, albeit at times it shifted the focus to the pros and cons of 'in combination assessment' pertinent to the Habitats Directive, and away from cumulative effects on the wider countryside.

There is also scope to look in more detail at recreational impacts on the pSPA in the light of ongoing research being undertaken by English Nature. The Dorset Heaths Natural Area would provide an appropriate geographical area for such work because:

- Dorset has been selected as the SW region's "Pathfinder" local area for innovative implementation and delivery of DEFRA's new rural strategy. This provides a very real and timely opportunity to join up local, regional and national concerns over cumulative development in the context not only of the Rural Strategy, but also of ODPM's Sustainable Communities Plan for regional roll out.
- The Dorset Heathlands seem to be relatively safe from further new development, but are under considerable 'user pressure' from existing development and day-trippers and weekenders coming from the SE and other parts of the SW, exacerbating the effects of fragmentation.
- There is considerable concern that dealing with cumulative effects is a real drain on officer time, a point raised by the Dorset Heathland Forum. There is concern about having continually to re-iterate concerns about cumulative effects, despite applications for similar uses having previously been refused.
- Heathland management projects for the Dorset Heaths Natural Area have already been used as a case study for a sustainability appraisal process by Forum for the Future, in conjunction with Sustainability South West. There are elements of this work that indicate where closer links to the planning system would be worth exploring.

Appendix 1 Bibliography

ANGOLD, P.G. 2002. Environmental Impacts of transport infrastructure: habitat fragmentation and edge effects. *In.* B. SHERWOOD, D. CUTLER & J.A.BURTON, eds. *Wildlife and Roads*, 161-168. Imperial College Press

AIR QUALITY EXPERT GROUP. 2004. *Nitrogen Dioxide in the United Kingdom*. Defra, Scottish Executive, Welsh Assembly Government and the Department for the Environment in Northern Ireland

ANGOLD, P.G. 1997. The impact of road upon adjacent heathland vegetation: effects on plant species composition. *Journal of Applied Ecology*, 34, 409-417

ATKINS. 2004. *Multifunctional in combination assessment for Thames Basin Heaths pSPA*. Environment Agency Thames Region. (Final version pending approval from English Nature).

BARKER, K. 2004. *Delivering stability: securing our future housing needs*. HM Treasury. Available from:: http://www.hm-treasury.gov.uk/consultations_and_legislation/barker/consult_barker_index.cfm

BEGON, M., HARPER, J.L, & TOWNSEND, C.R. 1987. *Ecology- Individuals, Populations and Communities*. Blackwell Scientific Publications

BERKSHIRE UNITARY AUTHORITIES JOINT STRATEGIC PLANNING UNIT. 2002. *Berkshire Structure Plan- Deposit Draft*

BERRIS, L. 1995. Ecoduct-Terlet Paper presented at the International Conference on Habitat Fragmentation, Infrastructure and the role of Ecological Engineering, MECC, Maastricht, 18-21 September 1995

BRE. 2003. *Domestic Energy Factfile 2003*. BRE Bookshop

CANADIAN ENVIRONMENTAL ASSESSMENT AGENCY. 1999. *Cumulative Effects Assessment Practitioners Guide*. Canadian Environmental Assessment Agency

CLAYTON, A.M.H, & RADCLIFFE, N.J. 1996. *Sustainability: A systems approach*. Earthscan, London Publications Ltd.

COUNTRYSIDE COUNCIL FOR WALES, ENGLISH NATURE, ENVIRONMENT AGENCY, & ROYAL SOCIETY FOR THE PROTECTION OF BIRDS. 2004. *Strategic Environmental Assessment and Biodiversity: Guidance for Practitioners*. Countryside Council for Wales, English Nature, Environment Agency, Royal Society for the Protection of Birds

CULLINGWORTH B, NADIN V. 2002. *Town and Country Planning in the UK*. Routledge.

DEPARTMENT FOR TRANSPORT. 2003. *The Future of Air Transport*. Department for Transport

DEPARTMENT OF ENVIRONMENT, FOOD AND RURAL AFFAIRS. 2004. *Environmental Impacts of Increasing the Supply of Housing in the UK*. DEFRA

DEPARTMENT OF ENVIRONMENT, FOOD AND RURAL AFFAIRS. 2000. *Waste Strategy 2000*. HMSO

DEPARTMENT OF TRADE AND INDUSTRY. 2003. *Energy White Paper- Our Energy, Our Future, creating a low carbon economy*. Department of Trade and Industry; Department of Environment, Food and Rural Affairs; Department for Transport

DEPARTMENT OF TRADE AND INDUSTRY & NATIONAL STATISTICS. 2002. *Energy Consumption in the United Kingdom*. Department of Trade and Industry.

ENGLISH NATURE. 2004. *State of Nature: Lowlands- future landscapes for wildlife*. English Nature

ENGLISH NATURE. 2004a. *State of Nature- Lowlands- future landscapes for wildlife*. English Nature.

ENGLISH NATURE. 2004b. *Planning Update No. 4- September 2004*. English Nature

ENGLISH NATURE. 2004c. The ecological effects of diffuse air pollution from road transport. *English Nature Research Reports*, No. 580.

ENGLISH NATURE. 1996. The significance of secondary effects from roads and road transport on nature conservation. Peterborough: English Nature

ENTEC. 2004. *Study into the Environmental Impacts of Increasing the Supply of Housing in the UK*. DEFRA. Available from:
http://statistics.defra.gov.uk/esg/reports/housing/default.asp

ENVIRONMENT AGENCY. 2001. *Water Resources for the Future: A strategy for England and Wales*. Environment Agency

FOJT, W. 1992. East Anglian fens and ground water abstraction. *English Nature Research Reports*, No. 30. Peterborough: English Nature.

FOLEY, J. 2004. *The Problems of Success- Reconciling Economic Growth and Quality of Life in the South East*. Institute for Public Policy Research

GIMINGHAM, C.H. 1975. *An Introduction to Heathland Ecology*. Edinburgh: Oliver and Boyd.

HARRIS, J.M. 2003. *Sustainability and Sustainable Development.* For the International Society for Ecological Economics. Available from:
http://www.ecoeco.org/publica/encyc_entries/Susdev.pdf

HAMPSHIRE COUNTY COUNCIL. 1996. *Hampshire County Structure Plan*. Available from:
http://www.hants.gov.uk/structureplan/

HOLLING, C.S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecological Systems*. 4, 1-24.

HUTCHINSON, G.E. 1957. Concluding remarks. *Cold Spring Harbour Symposium on Quantitative Biology*, 22, 415-427.

HYDER. 1999. *Guidelines for the assessment of indirect and cumulative impacts as well as impact interactions*. EC DG XI Environment, Nuclear Safety & Civil Protection

LICHTENDAHL, M.E, & STAM, S.M.E. 1995. *The ecological corridor between the wetland areas De Venen and De Vechtplassen; impossible or exciting challenge?* Paper presented at the International Conference on Habitat Fragmentation, Infrastructure and the role of Ecological Engineering, MECC, Maastricht, 18-21 September 1995,

MADER, H.J. 1984. Animal habitat isolation by roads and agricultural fields. *Biological Conservation* 29, 81-96. *In*: J. TREWEEK (1999) *Ecological Impact Assessment*. Blackwell Science.

OFFICE OF THE DEPUTY PRIME MINISTER. 2004. *A Draft Practical Guide to the SEA Directive*. ODPM

OFFICE OF THE DEPUTY PRIME MINISTER. 2003. *Sustainable Communities Plan: building for the future*. ODPM. Available from: http://www.odpm.gov.uk/stellent/groups/odpm_control/documents/contentservertemplate/odpm_index.hcst?n=3657&l=1

OFFICE OF THE DEPUTY PRIME MINISTER & DEPARTMENT FOR TRANSPORT. 2000. *Transport Ten Year Plan*. ODPM & DfT

PETERKEN G. 2002. *Reversing the habitat fragmentation of British woodlands*. WWF

PRICE, E.A.C. (2003) *Lowland Grasslands and Heathland Habitats*. Routledge

PURVIS, O.W, and others. 2003. Which factors are responsible for the changing lichen floras of London? *The Science of Total Environment*, 310, 179-189.

REIJNEN, R., VEENBAS, G., & FOPPEN, R.P.B. 1995. *Predicting the effects of Motorway Traffic on Breeding Bird Populations*. Delft: Road and Hydraulic Engineering Division, DLO-Institute for Forestry and Nature Research.

REIJNEN, R., & FOPPEN, R. 1995. The effects of car traffic on breeding bird populations in Woodland III: Reduction in density in relation to the proximity of main roads. *Journal of Applied Ecology*. 32, 187-202

RPS. 2003. *Charles Church (Southern) Ltd. Notcutt's Nursery, Bagshot. Report towards an Appropriate Assessment*. Surrey Heath Borough Council

ROYAL SOCIETY FOR THE PROTECTION OF BIRDS.. 2002. *Cats and Garden Birds*. Wildlife Information Leaflet. Sandy: RSPB

ROYAL SOCIETY FOR THE PROTECTION OF BIRDS. 1999. *Focusing on UK Wetlands*. Sandy: RSPB

RYDELL,J, & RACEY, P.A. 1993. *Street lamps and the feeding ecology of insectivorous bats* in *recent advances in bat biology*. Zoological Society of London (Symposium abstracts)

SCHMITZ, O.J. 2003. Perturbation and abrupt shift in trophic control of biodiversity and productivity. *Ecology Letters* Vol 7, Iss 5, 403-409. Found on the World Wide Web: http://www.blackwellpublishing.com/abstract.asp?aid=7&iid=5&ref=1461-023X&vid=7

SOUTH EAST REGIONAL TECHNICAL ADVISORY BODY (SERTAB). 2002. *South East Regional Waste Management Statement*. SEERA, Prepared by ERM and Land Use Consultants.

SURREY COUNTY COUNCIL. 2001. *Surrey Structure Plan.* Draft and amended after consultation. Available from: http://www.surreycc.gov.uk/sccwebsite/sccwspages.nsf/LookupWebPagesByTITLE_RTF/Surrey+Structure+Plan?opendocument

SWEDISH ENVIRONMENTAL ADVISORY COUNCIL. 2002. *resilience and sustainable development- building adaptive capacity in a world of transformations*. Swedish Environmental Advisory Council

TREWEEK, J. 1999. *Ecological impact assessment.* Blackwell Science Ltd

TURNER, R.K, BROUWER, R, GEORGIOU, S. 2001. *Ecosystem functions and the implications for economic evaluation*. Peterborough: English Nature

VANDERMEER, J.H. 1972. Niche theory. *Annual Review of Ecology and Systematics*, 3, 107-132

VAN DER ZANDE, A.N, TER KEURS, W.J, & VAN DER WEIDJEN. 1980. The impact of roads on densities of four bird species in an open field impact habitat- evidence of a long distance effect. *Biological Conservation.* 18, 299-321

WARREN, M.S, KEY, R.S. 1991. Woodlands past, present and potential for insects. N.M. COLLINS & J.A. THOMAS, eds. *The Conservation of Insects and their Habitats*, 155-212. London: Academic

WEBB N.R. 1986. *Heathlands*. London: Collins

WILSON, E.O. 1990. Threats to biodiversity. *In*: *Managing Planet Earth. Readings for Scientific American*, 49-60. New York: W.H. Freeman

Appendix 2 Consultation event attendees

Sue Collins	English Nature- Policy Director
Jonathan Burney	English Nature- Team Manager Environmental Impacts Team
Ian Smith	English Nature- Head of Development and Regional Policy, Environmental Impacts Team
David Markham	English Nature- Transport and Recreation Advisor
Allan Drewitt	English Nature- Senior Ornithologist, Terrestrial Wildlife Team
Roger Morris	English Nature- Head of Estuaries Conservation, Maritime Team
Alan Law	English Nature- Team Manager, Thames and Chiltern Team
Caroline Chapman	English Nature- Conservation Officer, Thames and Chiltern Team
Sam King	English Nature- Conservation Officer, Thames and Chiltern Team
Catherine Chatters	English Nature- Conservation Officer, North and East Hampshire
Kathryn Ross	Environment Agency
Lisa Palframan	Royal Society for the Protection of Birds
Andrew Dodd	Royal Society for the Protection of Birds
David Brooke	Countryside Agency
Kate Swade	Department of Environment, Food and Rural Affairs
Paul Hamblin	Council for the Protection of Rural England
Carol Somper	Forum for the Future
Lourdes Cooper	Imperial Collage London, Environmental Policy and Management Group
Lyndis Cole	Land Use Consultants
Jon Grantham	Land Use Consultants
Will Miles	Land Use Consultants

ENGLISH NATURE

English Nature is the Government agency that champions the conservation of wildlife and geology throughout England.

This is one of a range of publications published by:
External Relations Team
English Nature
Northminster House
Peterborough PE1 1UA

www.english-nature.org.uk

© English Nature 2002/3

Cover printed on Character Express, post consumer waste paper, ECF.

ISSN 0967-876X

Cover designed and printed by Status Design & Advertising, 2M, 2M.

You may reproduce as many copies of this report as you like, provided such copies stipulate that copyright remains with English Nature, Northminster House, Peterborough PE1 1UA

If this report contains any Ordnance Survey material, then you are responsible for ensuring you have a license from Ordnance Survey to cover such reproduction.

Front cover photographs:
Top left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Middle left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Bottom left: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888
Main: Using a home-made moth trap.
Peter Wakely/English Nature 17,396

Awarded for excellence