Herts and Middlesex

Hertfordshire's Ecological Networks

A report on the current situation and priorities for restoration

Hertfordshire Local Nature Partnership

Hertfordshire

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Foreword

The United Kingdom has a long history of protecting and conserving the natural environment and, for many years, a wide variety of organisations and individuals have been committed to this objective including Government Agencies, Local Authorities, Non-Governmental Organisations, local community groups, and dedicated individual members of the public. However, in recent years, a succession of reports (including the Lawton Review, the Natural Environment White Paper and the 2013 State of Nature report) have all clearly shown that, despite the best efforts of all concerned, both the health of our ecosystems and their ability to function properly are continuing to deteriorate. Looking ahead, the challenges posed by climate change, combined with an increasing human population and growing concerns about the security of food supplies, are likely to exacerbate these pressures upon the natural environment.

At the same time, the National Ecosystem Assessment has emphasised just how essential it is for our ecosystems to be healthy and fully functional, in order to support our own health, growth and prosperity. Healthy and functional ecosystems and networks are also generally accepted to be more resilient to the impacts of external influences such as climate change. One of the most important recommendations from the Lawton Review is that the traditional approach of protecting and conserving individual existing sites is no longer sufficient; instead we need to adopt a landscape-scale approach of restoring and creating habitats around and between those existing sites; in order to increase resilience, quality and connectivity of habitats. In response to this conclusion, a number of landscape-scale initiatives, most notably the Nature Improvement Areas, have been launched to address the restoration and creation of these wider habitat networks.

However, in this crowded island of ours, almost every piece of land is subject to a range of conflicting pressures and potential uses. This is especially the case in a relatively small and heavily populated county such as Hertfordshire. It is therefore vitally important that local authorities and other decision-makers should be equipped with the best possible environmental information upon which to base their decisions. In particular, before committing increasingly scarce resources to the restoration or creation of an area of habitat, it is important that we should be sure that it will be 'the right habitat in the right place'; offering the best possible prospects for successful habitat establishment and the highest environmental return from the resources invested.

The production of this new Hertfordshire habitat inventory and series of potential habitat network maps is therefore particularly timely. On behalf of Natural England, I welcome this report and congratulate its authors on their achievement. I hope that local authorities and other decision-makers will make good use of the habitat inventory and the potential habitat network maps and will find them to be valuable tools in their work to conserve the best features of Hertfordshire, whilst at the same time seeking to create an even better Hertfordshire for future generations.

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The project was developed and advised by a partnership steering group of knowledgeable experts on Hertfordshire's natural environment. This included representatives from Herts & Middlesex Wildlife Trust, Hertfordshire County Council, the Environment Agency, Natural England, the University of Hertfordshire, Hertfordshire Natural History Society and the Hertfordshire Biological Records Centre. Specialist input was also provided by the Hertfordshire Geological Society.

Datasets were kindly provided by the Hertfordshire Biological Records Centre, Hertfordshire County Council, the Environment Agency and Trevor James (the Hertfordshire Recorder for the Botanical Society of the British Isles and the Hertfordshire Natural History Society Botanical Recorder). Out-of-county datasets were also provided by the Bedfordshire and Luton Biodiversity Recording and Monitoring Centre (BRMC) and the Cambridgeshire and Peterborough Environmental Records Centre (CPERC).

1 Executive summary

The Natural Environment White Paper recognises that nature conservation cannot be purely focused on protecting existing sites. Remaining sites are now just too small and fragmented to safeguard our full range of habitats and species on their own. This is bad for our health, wellbeing and economy. The white paper calls for a much wider approach to reversing the long-term decline in biodiversity by expanding and linking habitats to restore ecosystem function.

A project was carried out in 2011-2013 to address gaps in Hertfordshire's evidence base to allow a better understanding of how and where to locally respond to the challenges outlined by the white paper and to provide guidance on how to locally apply the new national planning guidance. The project produced a new Hertfordshire habitat inventory with latest available data and then used these data to generate potential habitat network maps. Potential habitat network maps identify how our habitats are spatially related to each other and where the highest priorities are for expanding them and linking them together. This strategic approach ensures that efforts can be targeted to where they are of most potential benefit. It also ensures that the right combination of habitats are created in the right places, reflecting the historical context and physical factors and minimising unintended consequences of locking out the potential to restore functioning networks of one habitat for the sake of another.

The results clearly show that Hertfordshire has very little semi-natural habitat remaining and that existing habitat networks are highly fragmented and failing. Woodland makes up about 10% of the county area, which is over half the total remaining area of all habitats. However, even woodland networks are highly fragmented and only a small proportion of those sites are classed as ancient – those of the highest value. Heathland is our most threatened habitat, with only 13 ha remaining from roughly 5,000 ha in existence as recently as 175 years ago. Remaining fragments are now so small and fragmented that this unique habitat is in danger of being lost from Hertfordshire entirely.

Because habitat networks are so fragmented, the computer-modelled outputs could only identify the highest potential contributions to habitat networks. These inform where developments should be the most sensitive and where the highest priorities can be found for habitat restoration and creation projects. However, it is recognised that many potential useful contributions could be made to habitat networks outside of those modelled top priorities. A number of interesting patterns in the data, along with four strategic core areas are identified. The strategic core areas are the chalk to the north, the acid soils to the south and the two main river catchments of the Lea and the Colne.

This report is purely a spatial framework, not an action plan. It puts the new work in context of existing knowledge relating to the history of Hertfordshire's countryside and Natural England's National Character Areas framework. It also complements detailed guidance within the Hertfordshire Biodiversity Action Plan[1] and can be used in conjunction with high-level guidance relevant to different land uses illustrated by the Wildlife Trust's publication 'How to Build a Living Landscape'[2]. Together, these provide a single combined local framework for understanding what makes each part of Hertfordshire special, what needs to be achieved and where specific actions can be targeted to be of greatest benefit. The results are of direct relevance to local plans, policies and development control, as well as landowners and conservation projects and partnerships.

2 Introduction

2.1 Background

The Lawton Review[3], the Natural Environment White Paper[4] and the 2013 State of Nature report[5] clearly demonstrate that our natural environment is in long-term decline and that the health of our ecosystems and their ability to properly function are becoming increasingly degraded. The National Ecosystem Assessment[6] clarifies just how essential it is for our ecosystems to be healthy and functioning for our own health, growth and prosperity.

We cannot continue to rely just on protecting increasingly small, beleaguered and isolated sites to safeguard our natural environment of which we are dependent upon. Despite the last few decades of concerted conservation efforts by many organisations, declines and extinctions are continuing. Some of the most important recommendations from the Lawton Review[3] and the Natural Environment White Paper[4] are that we need to think bigger than just protecting existing sites; we need to restore and create habitats around and between existing sites, in order to increase resilience, quality and connectivity of habitats. A landscape-scale approach is needed; that of considering ecological networks, rather than just individual nature reserves and protected sites.

So what does this mean for Hertfordshire? Its habitats are experiencing some of the greatest pressures of anywhere in England. Hertfordshire has one of the highest population densities of any two-tier authority counties at over 1.1 million people (656 people per km^2), despite approximately two-thirds of the county being rural. Rural areas are dominated by intensive arable farming and the county is crossed in multiple places by major transport corridors, including three motorways and a number of trunk roads and railways. It is also one of the most water stressed counties in England, impacting on the quality and flow of its rivers and streams. Being a relatively affluent county and next to major urban centres, the importance of Hertfordshire's 'green and pleasant land' for recreation is reflected in its wealth of green spaces and recreational areas, including over 70 golf courses. However, these green spaces are often rather sterile and lacking in biodiversity.

All these factors mean that remaining habitats are now small and highly fragmented. Many are also in danger of further deterioration through diffuse pollution, land-use change and lack of active conservation management.

So there are a number of challenges for Hertfordshire's ecosystems but there are also a number of opportunities. We need to find space for nature within Hertfordshire's existing land uses whilst continuing to respect those land uses in their own right. It is possible to strategically connect up habitats through each of Hertfordshire's land uses without compromising the purpose of those land uses. Indeed, some of this is already happening but much more is needed. This can only be achieved through partnership involving landowners, local authorities, businesses, other organisations and local people. It is not practical to think we can turn the clock back to a time before roads were laid down, rivers were canalised, houses were built and farming intensified. But there is a huge amount we can do with the landscape we live in now, to improve and secure the future for our natural habitats and species.

Herts & Middlesex Wildlife Trust recently produced a high-level guidance document (How to Build a Living Landscape[2]), which identifies these issues, highlighting what can be done within some of Hertfordshire's most common land uses. Alongside this, an evidence-based mapping approach is needed to better understand where the highest priorities can be found, and what types of habitats are to be restored where.

2.2 Summary of the historical context of Hertfordshire's natural environment

A brief history of Hertfordshire's natural environment is given here for context when considering what ecological networks need to be restored. An excellent detailed account of the history of Hertfordshire's habitats is given by Sawford[7]. Other important sources of information and context include those by James[8], Rackham[9] and Rowe & Williamson[10]. Rather than reproduce the detail provided in the literature, some key points are summarised here, where they add context to interpreting the project results and informing future conservation actions on the ground.

The reason for summarising the history here is not to bemoan what we have lost but to better understand what we have left, where it came from and what we need to restore. This way we can look forward to a more positive future and understand what it is we need to achieve within the constraints of our modern landscape.

Following the retreat of the last ice age, all of Hertfordshire, as with most of the rest of the country, became natural wilderness. Since then we have altered our environment to such an extent that it is impossible to know for sure what this part of the country's natural wilderness would have been like, and not all researchers agree on the detail. What is clear is that it would have been some combination of dense forest and open habitat patches and wetlands. It would have likely been a dynamic system affected by natural processes, such as succession, disturbance and large herbivores grazing. Whilst it might be appealing to think we could allow our remaining habitats to naturally get back to this state and 'let nature take its course', it is unrealistic to aim for this anywhere in lowland England. Prehistoric habitats were able to be diverse because they were of a large enough scale for the full range of natural processes to occur. Roaming large herbivores, in balance with their own predators, would have been a major natural process contributing to a dynamic system allowing a range of different conditions to coexist. Alongside today's human population and intensive land uses we simply cannot re-create such massive wild areas or the natural processes, such as variation in disturbance and succession, needed to sustain them. Small areas of land in absence of such large-scale natural processes degenerate if left to 'grow wild'; they become over-shaded and lose the rich diversity of plants and animals they used to support. Instead, when considering what to restore, we have to look to within the last four thousand years or so when humans have had a major part in shaping our landscape. Prior to the last couple of centuries, although humans have increasingly changed and managed the land, we have largely managed to maintain the diversity of species, as well as introduced new ones that have since become naturalised and part of our ecosystems. It is these interactions over the last four millennia that have made Hertfordshire into Hertfordshire and from which our remaining habitats are derived.

Even as early as Neolithic times, much of Hertfordshire had been altered and used by humans in some way. As Neolithic humans settled, cleared and farmed the land, the proportion of wilderness decreased and new habitats and conditions took its place. These new habitats replicated features of their predecessors. For example, livestock pastures would have shared a lot of characteristics with woodland openings and trails, as grazed by wild cattle and boar. This allowed existing species to colonise and readily adapt to these new areas. New species would have been introduced very early on in our history, such as arable wildflowers with imported grain, increasing diversity. By the time of the Domesday book in 1086 just less than a third of Hertfordshire was wooded, and these woodlands themselves were highly modified and used productively for building materials and firewood. Hertfordshire has in reality been a relatively open and productive landscape for a very long time.

It is only in the space of the last three or four generations that humans have had a devastating impact on the natural environment. It is this very recent damage that we urgently need to repair.

2.2.1 Woodlands

Today's woodlands are made up of a combination of ancient woodland and more recent plantations or naturally grown woodlands on previously cleared land.

One of the reasons our remaining ancient woodlands are so special is that most were not planted on previously cleared land but usually instead were modified from existing un-cleared wildwood. This meant that although their character was changed, their associated plants and animals were already there and able to adapt to the new conditions. In fact woodland management practices, such as coppicing, provided a broader range of structure, light and other conditions, allowing for a huge diversity of existing and new species to thrive.

Coppice with standards was the most significant form of woodland management across much of Hertfordshire until the 19th century. Standards are trees allowed to grow tall for timber. Coppicing is the practice of cutting trees near to ground level every 5-15 years. Rather than killing the tree, this rejuvenates it and encourages bushy growth for firewood and many other uses. Together, these create a diverse structure and a variety of light conditions, essential for a great number of plants and invertebrates to thrive. Because standards were harvested for timber as soon as they were large enough, very few ancient standard trees exist in ancient woodlands. However, coppiced trees can be thousands of years old.

Without getting into the complexities of detailed woodland classification, such as NVC types[11], several characteristic woodland stand types, as classified by Peterken[12], can be recognised in Hertfordshire. These characterise different parts of the county, reflecting differences in soils, hydrology and past economic drivers. A basic understanding of these historical differences allows a much more tailored approach to woodland restoration and creation, relating to geographical area.

Although a simplified picture, Hertfordshire can be broadly split into three main areas in relation to its dominant types of ancient woodland. Ash/maple/hazel in the north and east, oak/hornbeam in the south, central and south-east, and beech in the west and chalk escarpment.

Ash/maple/hazel woodlands

Ash, maple and hazel ancient woodlands thrived well on the damper and more neutral soils. Ash is a strong and elastic wood, highly prized for tool making. Maple was used for livestock fodder and for carving fine items. Hazel was almost exclusively coppiced and used for a great variety of purposes including building and firewood. It is also the only native tree to bear large edible nuts - a valuable food source.

Remaining fragments have escaped clearance for agriculture mostly due to often sitting on the very damp and stony soils of boulder clay. However, most of these woodlands are now becoming over-shaded through lack of traditional management. Ancient coppice trees are in danger of becoming too tall and breaking apart. These threats, combined with increased drainage of adjacent arable land and spray drift of fertilisers, are resulting in major loss of the diverse and distinctive ground flora.

Oak/hornbeam woodlands

A large area of central and southern Hertfordshire is characterised by woodlands consisting mainly of hornbeam coppice under oak standards. These ancient woodlands have a highly restricted distribution in the country, with hornbeam only considered native to parts of the Home Counties. Hornbeam is a very hard wood, literally translated in old English from 'horn' meaning hard and 'beam' meaning wood. These properties made it very good for making tough tools and for firewood.

The associated oaks were prized for timber and two species are common in Hertfordshire. Pedunculate oak is the most common but this gives way to areas of sessile oak on the shallower, more acidic soils, particularly of the south west.

Depending on the soil conditions, ground flora of these woodlands varies a great deal. In the more acidic areas, ground flora is much more akin to heathland and acid grassland.

Beech woodlands

Very few true ancient beech woodlands survive in Hertfordshire today. Most of today's beech woodlands are the result of more recent plantations, mainly during the early 19th century. Beech has always been highly valued as a source of timber, particularly for furniture making and this was an economic driver for planting beech woodlands on the chalk and clay-with-flints soils on the Chilterns dip slopes, where it thrives.

Unlike the other ancient woodland types, beech woodlands have a very sparse ground flora because their fallen leaves take a long time to decay, smothering any growing plants.

Recent woodlands

Many of our extant woodlands today are not ancient. In recent centuries many new woodlands were planted or ancient woodlands replanted with non-native trees to satisfy changing markets, fashions and economic drivers. Plantations on ancient woodland sites resulted in loss of traditional coppice and woodland structure, with resultant declines in biodiversity they supported. Also, successive agricultural booms and subsequent slumps led first to clearance of ancient woodland sites and then abandonment of low productivity farmland, which turned into poor secondary woodland through natural succession.

Finally, during the 20th century, a combination of a cessation of traditional woodland management practices and the destruction of woodlands for timber, agriculture and development resulted in a major loss, degradation and conversion to secondary woodland of our remaining ancient woods and wood-pastures. It is estimated that we lost over half of these ancient habitats in Hertfordshire between 1940 and 1985 alone.

In Hertfordshire we therefore have a mixture of relatively few highly important ancient woodlands and a much larger number of less diverse, more recent woodlands. Despite only having a small number of ancient woodlands left, the county is relatively well-wooded, comprising approximately 10% of the land cover.

Wood-pasture

In some parts of Hertfordshire, particularly in the south where soils were poor and free-draining, grazing was not very productive. Many previously cleared areas were managed neither as pure grassland nor woodland but instead as wood-pasture, characterised by ancient pollarded trees and wild flowers more akin to grasslands than ancient woodlands. This was sometimes the best way of getting the most from the land, given its poor productivity. Here woodland products such as firewood and building materials could be harvested from higher up in trees (pollarding), out of the reach of livestock, whilst allowing livestock to graze between the widely-spaced trees. Especially in the south of the county wood-pasture is an important and long-established part of Hertfordshire's history. Following a cessation of grazing in recent times as a common land use in Hertfordshire, these wood-pastures have degenerated into secondary woodland, threatening the future of their ancient pollards and grassland communities. These mustn't be overlooked when focusing on woodland networks or restoring existing sites.

Parkland

Parkland also played an important part in Hertfordshire's history in relation to wooded habitats. A trend of parkland creation was started by the Normans and continued through the next few centuries. Some may have included ancient woodlands or wood-pastures but many would have been newly planted. Over 90 parks are known for Hertfordshire, most of which were in existence before the 14th century. These parks would have been diverse mosaics of different habitats, from woodland and wood-pasture to heathland and grassland. Many have since been abandoned as parks and put

to other uses, although the 18th century saw a new fashion for landscaped parks. Hertfordshire is famous for its Capability Brown and Humphrey Repton designed landscapes. However, contemporary parks were designed to be more picturesque than functional, and lacked some of the diversity and traditional habitats of medieval and Tudor parks. The planting of non-native trees was also popular.

2.2.2 Grasslands

Pastures and meadows were major land uses of Hertfordshire from early Neolithic times until at least the 19th century. This is because they are a principle requirement for farming livestock, upon which we have so strongly depended throughout our history. However, agricultural booms of the 18th and 19th century, coupled with the need to increase food production during the two world wars, meant that many of our grasslands were ploughed up and lost to arable farming. But despite this, roughly 40% of Hertfordshire's land cover remained as permanent pasture in the 1930s. Very little of this now remains. These losses have been exacerbated by much of today's remaining pasture being agriculturally improved and re-sown with more productive grasses or allowed to grow into scrub and woodland. The cessation of grazing in the county has been a major driver for the loss of our grasslands and the degradation of those remaining.

Grasslands can be classified broadly according to the soil pH they occur in, from chalk (alkaline), through neutral, to acid. Each of these support different and distinctive plant and invertebrate communities. Hertfordshire's grasslands range from the chalk downland in the north of the county, through the hay meadows on damper and more neutral soils of the middle and east, to the acid grasslands, heathlands and wood-pastures on the gravels and acidic clays of the south. This is a highly simplified picture, and as with the different ancient woodland types, the nature of the grasslands in an area were defined more by the physical geography than any external cultural or economic drivers. Therefore, dependent on local differences in geology or hydrology, different grassland types were interspersed with each other. Neutral grasslands would have thrived all over the county, particularly in damper places or where the soils were deeper. Even today, mixtures of different grassland plant communities can clearly be seen on many individual ancient grassland sites.

Whilst each of the grassland types has broadly followed the same trends through history, each has been subject to slightly different physical and human factors, summarised below.

Chalk grassland

The chalk downland was rapidly cleared of wildwood from early Neolithic times because the thin, poor soils are a tough environment for trees, meaning that the area would originally have been much less densely covered than most. The most notable area is the chalk escarpment from Tring to Royston. Certainly by Roman times most of this would have been continuous pasture. It was almost exclusively grazed by sheep because other livestock struggle with chalk's poor productivity and tendency to dry out. This was a stable system for centuries, resulting in some of our most diverse and flower-rich habitats. Extensive tracts of chalk downland existed until the 17th-18th centuries,

after which there were increasing losses to arable. It is estimated that by the 1940s only 250 hectares remained. Over the next 45 years over half the remaining was destroyed and most of the rest seriously degraded, largely through conversion to arable or lack of grazing.

Neutral grassland

A high proportion of Hertfordshire's soils are towards neutral. In the east of the county they are generally on the alkaline side of neutral, whilst in the west they are more generally on the acid side of neutral. This means that the county's neutral grasslands were quite widespread. The greatest exception is where the chalk is most prominent along the escarpment in the north of the county. Even in the acidic stronghold in the south of the county, there are many patches tending towards neutral, particularly in the damper areas.

Classic neutral grasslands were managed as meadows in that they were cut for hay. Often this was mixed with a grazing regime following the hay cut. Of all the grassland types, these were on the most productive and deeper soils, least at risk from excessively drying out in the summer. Favourite locations were within river floodplains, where floodwaters could bring extra nutrients. The productivity of these meadows meant that they were an important part of our rural economy between Anglo-Saxon times and the 19th century. Even so, it took a number of years for an established meadow's ecosystem to fully function and become naturally productive, prior to modern intensive methods. Therefore, once a meadow had become well established it was highly valued and became a permanent use of that piece of land. It is this permanence that allowed such a diversity of plants and invertebrates to evolve within these meadows.

Although hay meadows were highly productive by traditional land use standards and needed nutrients to be successful, nutrients in a traditional meadow were far below levels being applied or diffusing today. Modern fertilisers and flooding from today's high-nutrient polluted rivers quickly destroys the botanical diversity of traditional hay meadows.

Unfortunately, the location of hay meadows on Hertfordshire's most productive soils was also their downfall. Enclosures and agricultural changes of the 18th century hit neutral grasslands in particular. The same productive soils that made hay meadows so good were the obvious places to plough to make way for arable farming. However, by 1930 there were still 25,000 hectares surviving. Over the next fifty years these all but disappeared, as arable became the county's dominant rural land use.

Acid grassland and heathland

Hertfordshire's acid soils, upon which its acid open habitats depend, are broadly of two main types. These are sandy/gravely free-draining soils and damper London clays.

The thin, free-draining and looser soils of the acidic sands and gravels would have been very easy to clear of wildwood. Much of the early cleared land would have been farmed but productivity short-lived. This is because the poor, free-draining soils readily lose their nutrients through leeching. Farming would then have been abandoned and the land used instead for rough grazing. Only a

relatively small number of plants can tolerate these conditions. The resulting acid grasslands and heathlands are therefore some of our most ancient types, with some dating back possibly as far as 6,000 years.

There are several places where these soils and associated habitats occur, with the major stronghold being the south of the county, such as Northaw, Cheshunt, Hoddesdon and Bricket Wood. Other notable areas include around Berkhamsted and Ashridge in the west and Patmore Heath in the east. In Medieval times many such areas were 'wastes' – land outside of agriculture and settlements. Some wastes were enclosed to become medieval parks and others unenclosed, remaining as common land. Many of these commons would have been heathland or, in places, wood-pasture.

Unlike the neutral grassland areas, over 5,000 hectares of acid grassland and heathland escaped agricultural enclosures during the 18th century because the land was just too unproductive to farm economically. These places instead remained as commons, which safeguarded their future for the next few hundred years or so.

However, these commons and other acid grassland patches are now losing their nature through a lack of grazing, leading to encroachment by scrub and degeneration to secondary woodland. Moreover, the scale of heathland loss in Hertfordshire is now worse than that of any other habitat and has been almost totally obliterated in the county. Now only 13 hectares of heather-dominated heathland remains, the most staggering habitat loss for Hertfordshire. Much of this loss was only since the Second World War due to planting with conifers, gravel extraction, loss of grazing or conversion to golf and other recreational grounds.

2.2.3 Wetlands

Wetlands are characterised by the presence of permanent water at or very near the soil surface. In Hertfordshire such sites include: flowing and open water bodies, such as springs, rivers, ponds, lakes; as well as the more vegetation-covered types, such as marshes, swamps and wet woodland. Many of the open water bodies in Hertfordshire are recent land uses, such as flooded old gravel pits and watercress beds. As with our other habitats, even the more natural older wetland features have been shaped by a high level of human intervention.

Historically, wetlands were far more extensive than they are today. Over the millennia, wetland habitats, particularly swamps and marshes, were gradually drained to allow better access and increased productivity of the land. However, some of this would have been balanced by added wetland habitats in the drier areas of Hertfordshire, where the need to increase water storage would have been a critical factor.

Until the 20th century large areas of wetland remained in Hertfordshire. The wettest areas could not be adequately drained without modern technology and also the water table was higher due to less water abstraction. Wetlands were used for a variety of purposes, including grazing, which kept succession at bay. Extensive tracts of marsh and marshy grassland existed alongside many of our rivers. Today, water abstraction, river canalisation, drainage and flood defence mean that only a few ancient fragments remain intact, such as Thorley Wash. Many of these remaining sites are in danger

of turning into secondary woodland and consequently drying out through a cessation of grazing management.

Chalk rivers

The chalk rivers are Hertfordshire's most valuable and unique water systems. They are very rare globally, with a large proportion of the world's chalk river resource located in Hertfordshire. Nearly all of the county's upper river catchments are of a chalk river nature, with their origins in the chalk aquifer. Chalk rivers have a very different nature to other rivers and are characterised by a naturally consistent flow and temperature, all year-round, as well as a high mineral content in the water. These characteristics occur because chalk geology soaks up rainwater, stores a huge amount and releases it slowly and consistently, rather than the tendency of other soils to release rainwater quickly or run off the surface. The chalk river characteristics lead to rich, specialised ecosystems of high diversity and crystal-clear waters.

Hertfordshire's chalk rivers are under massive threat from over-abstraction of drinking water from the chalk aquifer. This has resulted in low flows, allowing silt and other pollutants to build up. Some, such as parts of the Beane, are now dry river beds.

Winterbourne rivers

Winterbourne rivers are a classic feature of the head waters of some chalk rivers. These occur highest up in the chalk catchments where water is released from the aquifer only at times of high rainfall, typically the winter months. These head waters usually flow in the winter and dry out naturally in the summer. Although these do not have the overall richness of main chalk rivers because of the lack of consistent conditions, their unique feature has led to a number specialist species that are found nowhere else. Following over-abstraction of the chalk aquifer in recent times, many of Hertfordshire's winterbournes now rarely flow or have lost much of their historical extent.

Clay and gravel rivers

Some of Hertfordshire's rivers originate in non-chalk soil conditions and are more typical of rivers found elsewhere in lowland England. Even the chalk rivers eventually lose their unique characteristics further down the catchment because they flow through non-chalk surface geology and become increasingly influenced by local run-off with increasing distance from their head waters.

These rivers tend to have much more variable flows, being more responsive to rainfall events, and experience higher erosion rates and natural flooding events. They often have tight meanders, providing a mixture of conditions for niche habitats and species. Because they are more liable to flooding than chalk rivers, they would naturally be associated with a greater amount of floodplain wetland habitats.

Gravel pits

Gravel pits are common in Hertfordshire's lower river valleys. They were dug in recent times for their gravel as an aggregates resource and have been allowed to fill with water to create large open water bodies. Prior to gravel extraction many of these may well have been arable fields of little ecological value, but previous to that, many of these areas would have been important hay meadows, which have now been irreversibly locked out of the landscape.

Fortunately, many of the gravel pits have instead become extremely important for water fowl and other birds, including dabbling ducks of shallower margins, such as gadwall and shoveler, and fish-eaters of deeper waters, such as common tern, smew and goosander. In places these birds are in such large numbers that they have resulted in gravel pit complexes receiving national and international protection designations. Parts of the Colne Valley are a site of Special Scientific Interest (SSSI) and parts of the Lea Valley are also a European Special Protected Area (SPA) and international Ramsar site.

Whilst the value of gravel pits for birds is undeniable, they cannot be considered to be a like-for-like replacement for Hertfordshire's important and endangered hay meadows. They can and have become a barrier to restoration of meadow networks in places.

Reedbed

Reedbeds were never historically a significant habitat in Hertfordshire. Few semi-natural wetland conditions existed to support reedbed and, as a result, it was never a traditional land management practice in this county. In recent times the advent of gravel pits in Hertfordshire has created conditions suitable for reedbed in places. These have become important habitats particularly for reedbed specialist species such as bittern, a key feature of interest behind the SPA designation in the Lea Valley.

Floodplain grassland , marshes, fen and swamp

Historically, many of the county's hay meadows existed in river floodplains and were seasonally damp or inundated. Hay meadows have been covered earlier under the neutral grassland section. In places where conditions were even wetter year-round, these neutral grasslands blend into other vegetation communities of marshy grassland, most of which were traditionally grazed.

In places with the wettest conditions, vegetation communities blend further into fen and swamp conditions, characterised by a shift from a dominance of grasses to a mixture of rushes, sedges and reeds of swamp.

In some areas, particularly the Stort Valley, a number of these habitats remain because the waterlogged ground conditions and proneness to flooding make them unsuitable for most modern land uses including arable farming and urban development. However, much of their extent throughout the county has been lost or severely degraded in recent times due to increased efficiency of land drainage and hard flood defences. Historically, these habitats served a purpose as

natural flood protection by working as 'sacrificial' areas where floodwaters would temporarily go and be released slowly and naturally back into the rivers.

Wet woodland

Wet woodland is characterised by permanently wet conditions at or near the soil surface. Trees suited to these conditions, such as willows, sallows and alder dominate these habitats. There is sometimes a rich characteristic groundflora made up of marsh, fen and swamp communities. Wet woodland can be considered part of a naturally component of the wider wetland complex and historically occurred where land was impractical or undesirable to graze livestock because of its extreme wetness. In recent times a lack of grazing industry in the county has meant that wet woodland is becoming more common on areas of land historically wet grassland, marsh and fen. This is shifting the balance between these habitats within the mosaic and is a modern threat to those other wetland habitats.

Wet seeps and flushes

These are an important and often overlooked component of wetland networks. They are naturally small and highly localised, according to specific geological and hydrological conditions. They occur mostly in river valleys but also elsewhere where sub-surface water wells up and emerges on a slope or in a dip, such that water is not pooled but flows over and through the surface soils. These create small but nonetheless highly important and specialised habitats, supporting a range of fen plant and invertebrate communities.

The extent of seeps and flushes has probably decreased in recent times due to increased land drainage, lowering of water tables and abstraction of the aquifer. As with other wetland habitats remaining patches have also been degraded through nutrification and diffuse pollution.

2.3 Summary of Hertfordshire's present natural environment

Despite the major losses and land use changes of the last 150 or so years, Hertfordshire has a number of remaining distinctive and important habitats and sites. Amongst other things, it holds a significant proportion of the world's chalk rivers, it has some sites of European importance for wetland birds and it has one of the highest densities of woodland of any county in this part of England. Towards the south of the county, wooded habitats are highly distinctive, characterised by the hornbeam tree and often a historically more open nature, containing important remnants of acid grassland and heathland habitats, reflecting our particular history and heritage in this area. Towards the north and the west of the county, we have some nationally rare and important chalk grassland sites.

However, we have clearly lost the vast majority of our areas of habitat, just in the last few hundred years. As a highly populated part of the country, and one that was heavily subject to the 18th century

enclosures, leading to later massive agricultural intensification, Hertfordshire has experienced even more than its fair share of recent habitat loss. As our latest habitat inventory shows we now have very few semi-natural habitats remaining. Biological Sites of Special Scientific Interest (SSSI) approximate only 1.5% of the county area, and roughly half of these are in unfavourable condition, despite being our most protected and monitored sites.

Hertfordshire habitats are still experiencing some of the greatest pressures anywhere in England. We are continuing to lose existing fragments and those remaining are becoming increasingly degraded, through pollution, land-use change and lack of conservation management. Hertfordshire has one of the highest population densities of any two-tier authority counties at over 1.1 million people (656 people per km^2), despite approximately two-thirds of the county being rural. Rural areas are dominated by intensive arable farming and the county is crossed in multiple places by major transport corridors, including three motorways and a number of trunk roads and railways. It is also one of the most water stressed counties in England, impacting on the quality and flow of its rivers and streams. Being a relatively affluent county and next to major urban centres, the importance of Hertfordshire's 'green and pleasant land' for recreation is reflected in its wealth of greenspaces and recreational areas, including over 70 golf courses.

So there are a number of challenges for Hertfordshire's natural environment but a number of opportunities also. We need to restore ecological networks and ecosystems, as outlined by the Lawton Review[3] and the Natural Environment White Paper[4]. This can only be achieved through partnership, involving landowners, local authorities, businesses, other organisations and local people. It is not practical to think we can turn the clock back to a time before roads were laid down, rivers were canalised, houses were built and farming intensified. But there is a huge amount we can do with the landscape we live in now, to improve and secure the future for our natural habitats and species. It will be good for wildlife and it will be good for local people too; our natural environment is essential to us. We need to recognise the value of our natural environment and understand what makes different parts of Hertfordshire distinctive and special. This way we can tailor our approach to align with the natural grain of our landscape in different parts of the county.

2.3.1 Hertfordshire's physical geography

Soils and hydrology profoundly affect where many habitats, and their characteristic vegetation communities, can exist. Particularly sensitive examples include wetlands and grasslands, although specific woodland stand types and ground flora communities can be equally affected. For example, chalk grassland can only occur on chalk, heathland can only occur on acidic sandy/gravely soils and acid grassland can only occur on acidic soils, either on drier sands/gravels or on damper London clay. River corridors and their floodplains not only determine where the majority of wetland habitats can exist but also provide the long-distance potential connectivity and strategic context to wetland habitat networks.

A simplified summary is briefly given here of the key physical features most affecting the distribution of natural habitats in Hertfordshire. A more detailed description of Hertfordshire's geology and soils is given on the Herts Geological Society website.

Geology and soils

Hertfordshire is part of the north of the London Basin, which slopes down over most of Hertfordshire towards London. Older chalk is close to the surface in the north but increasingly covered by younger rocks of Reading Beds and then London Clay towards the south. These solid formations, combined with later glacial superficial deposits, have resulted in a highly variable but general trend from alkaline chalk surface soils in the far north of the county through to contrasting acidic soils in the south.

In the far north and far south of the county, surface soils are almost exclusively chalk and acidic London clays respectively. However, there is a huge amount of variation in between. Towards the west, the soils are broadly acidic-neutral, with large areas classified as 'clay with flints'. Towards the east, the soils are broadly calcareous-neutral, with large areas classified as 'chalky boulder clay'. Much of the central and southern areas are more or less acidic with drier, freer-draining soils in the more central areas, giving way to damper, heavier soils in the south.

Many of the river valley beds are gravely, contrasting with exposed chalk on steeper upper valley slopes. The underlying chalk geology also comes to the surface in various scattered locations throughout and isolated patches of exposed chalk from quarries can be found even in the south of the county.

In summary, the far north of the county and the central/south are generally at opposite ends of the pH scale, with the north able to support chalk grassland and the south able to support acidic habitats. Beyond those broad generalisations, it is hard to predict exactly what habitats can exist where in Hertfordshire. This is because of the particular soil types present and the enormous variability within a given soil type of conditions pertinent to the distribution of vegetation communities (John Catt, *pers. comm*.). A given area within the Hertfordshire soil map can support a variety of very different habitats depending on local differences in conditions. For example, within an area in the soil map classified as 0571m, classified under Soilscape 7 ('freely draining slightly acid but base-rich soils'), two ecologically contrasting sites are found. Roughdown Common is designated as a SSSI for its chalk grassland. On the other hand, Nomansland Common is an important acid grassland and heathland site, with some of the last remaining fragments of heather in the county.

River corridors

Hertfordshire's river systems are shown in Figure 1. There are two main river catchments in Hertfordshire. These are the Colne towards the west and the Lea towards the east. Both of these flow southwards, between them draining nearly all of Hertfordshire into the Thames. There is a watershed in the far north of the county along the chalk escarpment, with the heads of the Anglian river catchments flowing northwards out of the county. The upper catchments of both the Colne and the Lea are predominantly groundwater fed from the chalk aquifer and are therefore characteristic chalk rivers. Chalk rivers are globally an extremely rare and unique habitat and therefore of very high conservation importance, described in more detail in section 2.2.3.

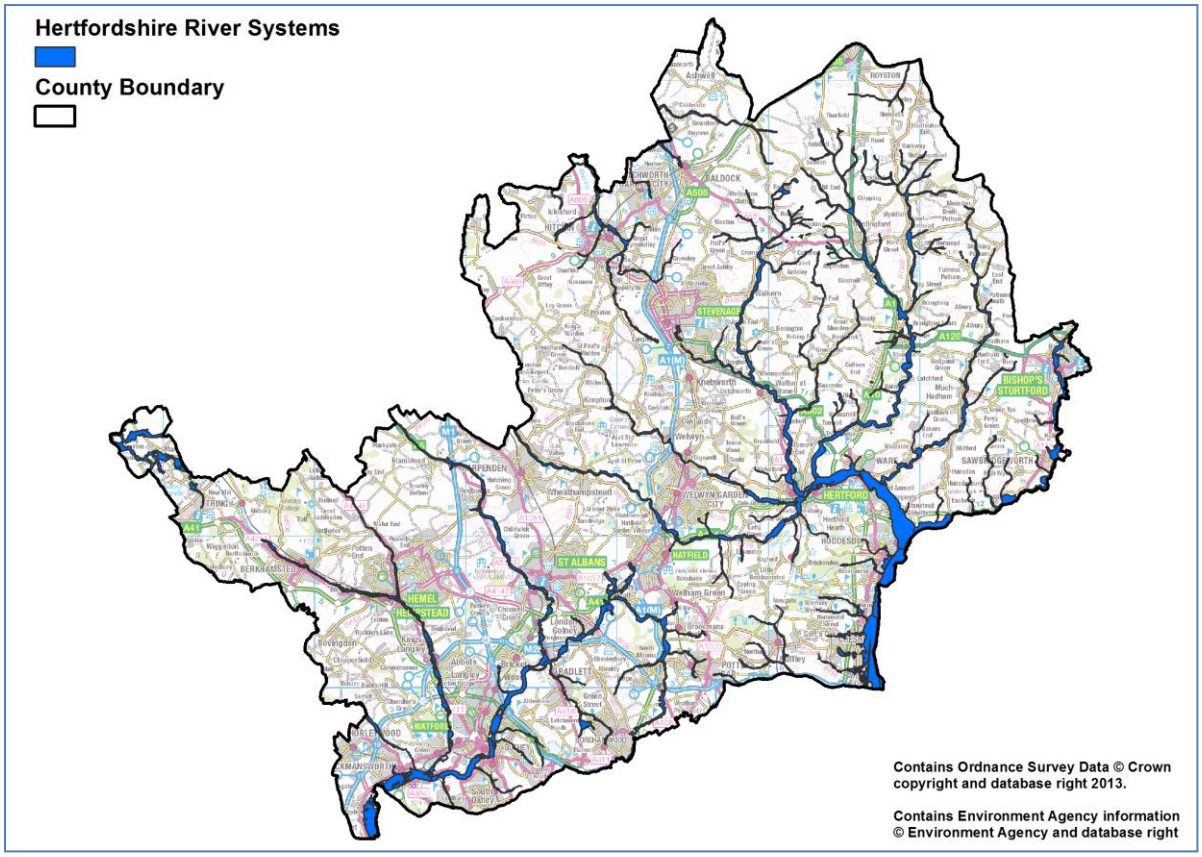

Figure 1. Map of Hertfordshire, showing river systems represented by the Environment Agency Flood Alert Areas map.

2.3.2 Hertfordshire in the context of National Character Areas (NCAs)

National Character Areas (NCAs), defined by Natural England, divide England into 159 distinct areas. Each is defined by a unique combination of landscape, biodiversity, geodiversity and cultural and economic activity. Their boundaries follow natural lines in the landscape rather than administrative boundaries, making them a good decision making framework for the natural environment.

NCA profiles, obtainable from the Natural England website, are guidance documents which will help to achieve a more sustainable future for individuals and communities. The profiles include a description of the key ecosystem services provided in each character area and how these benefit people, wildlife and the economy.

Each profile includes a description of the natural and cultural features that shape our landscapes, how the landscape has changed over time, the current key drivers for ongoing change, and a broad analysis of each area's characteristics and ecosystem services. Statements of Environmental Opportunity (SEOs) are suggested, which draw on this integrated information. The SEOs offer guidance on the critical issues, which could help to achieve sustainable growth and a more secure environmental future.

Six NCAs coincide with Hertfordshire, together describing the county's natural distinctiveness. These are the Chilterns (NCA 110), East Anglian Chalk (NCA 87), Thames Valley (NCA 115), Northern Thames Basin (NCA 111), South Suffolk & North Essex Clayland (NCA 86) and a very small area of the Bedfordshire Claylands (NCA 88).

Many NCAs are very large, spanning multiple counties. This is particularly true of some of those intersecting Hertfordshire, with their names reflecting places elsewhere. Therefore, a Hertfordshire-specific interpretation of each of its parts of the NCAs intersecting it are summarised here. These do not attempt to repeat the considerable volume of useful information within the NCA profiles; rather the descriptions below capture a high-level summary of Hertfordshire-specific local distinctiveness of each NCA. Hertfordshire parts of NCAs are interpreted here with a more locally-relevant name, appropriate within its own county context.

A closer look at the boundary between the London Basin and the Chilterns Natural Areas in Hertfordshire suggests that the boundary could be better represented slightly north of its current location. This better reflects Dony's[13] 'Botanical Districts', as well as new data on the distribution of the distinctive habitats and species making up the Hertfordshire part of the Northern Thames Basin. Natural England recognises that the boundaries between NCAs are more of a guideline than a strict boundary and should be treated as a transition zone. The transition zone, showing mixed characteristics of both NCAs is particularly large here. Locally interpreting Hertfordshire's NCAs with an adjusted guideline boundary, according to new data, is therefore within the limits of the intended purpose of the NCA framework. Figure 2 shows how Hertfordshire is split between the different NCAs, including the adjusted boundary and the Hertfordshire-specific naming.

Each of the areas is discussed in more detail in the following sections, informed by the latest mapping project, as well as the study by Dony[13] in 1967, which was a seminal piece of work and still reflects the latest data and thinking to date. The descriptions have also been informed by James[8] and Sawford[7].

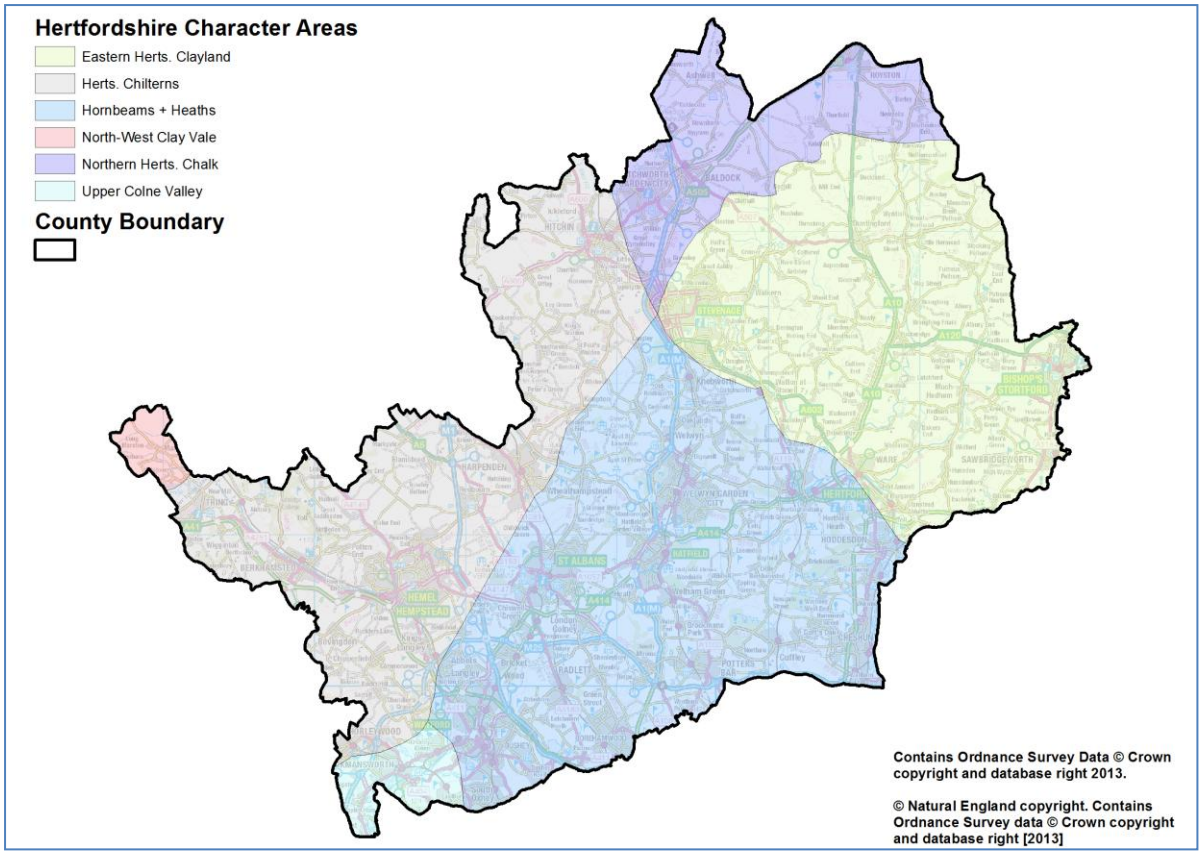

Figure 2. Map of Hertfordshire showing its constituent components of Natural England's National Character Areas. These are locally interpreted versions with Hertfordshire-specific names and boundary realignment, as detailed in the report.

2.3.3 Herts Chilterns (part of NCA 110 – Chilterns)

Summary of highest priorities for habitat network restoration for Herts Chilterns: Chalk grassland, chalk rivers.

This character area encompasses, but goes beyond the Chilterns designated Area of Outstanding Natural Beauty (AONB). This is because many of the geological and ecological characteristics that make the Chilterns special continue beyond the AONB boundary and dominate the distinctiveness of this whole area.

There is an interesting mix of geology and soils, which has a profound influence on the habitats found and their resulting diversity. Towards the north is the chalk escarpment, where the surface chalk is the key driver for the historical and present-day habitats found there. Elsewhere, particularly on the dip slopes of the Chilterns, clay-with-flints soils dominate, which vary in acidity, even over quite short distances. In places the chalk comes to the surface, and forms a patchwork with gravels. Hence, some places have an extraordinary mix of acid, neutral and calcareous habitats, resulting in a great diversity of species and habitat communities. Examples of this include areas around

Berkhamsted Common and Ashridge. In places, remnants can be seen of chalk, neutral and acid grassland, as well as heathland.

To the west of the Lea Valley it is better wooded than to the east. Beech woodlands towards the west and oak/hornbeam woodlands towards the east are the most common woodland types in this character area. Some of the less common stand types in Hertfordshire are also found, including birch/oak woods on the most acidic areas. Woodlands found around the Ashridge Estate and Berkhamsted common have more of a heathy groundflora and are mostly remnants of commons and parkland. Opening up parts of these and restoring grazing as appropriate would be of great benefit.

Chalk grassland is a key habitat within this character area. Important sites include Aldbury Nowers and Hexton Chalk Pit. The habitat is utterly dependent on the presence of surface chalk soils, which are found mostly in the north of the area, along the chalk escarpment. These almost completely connect with the chalk soils in the far north of Hertfordshire (Northern Herts Chalk) via southern Bedfordshire. Because of the rarity and the restricted distribution of chalk grassland in Hertfordshire, its creation and restoration is of the highest priority where chalk soils occur in this area.

Many of the chalk rivers within the Colne catchment originate in this character area. Great examples include the Chess and the Gade. These fragile and globally rare habitats are a high priority for restoration.

2.3.4 Northern Herts Chalk (part of NCA 87 – East Anglian Chalk)

Summary of highest priorities for habitat network restoration for Northern Herts Chalk: Chalk grassland.

The majority of this character area is dominated by surface chalk soils, particularly along the chalk escarpment. Apart from small breaks in the chalk around Hitchin, the result of periglacial features, the surface chalk is continuous through to the Chilterns via South Bedfordshire. This whole area would historically have been dominated by chalk downland, mostly grazed by sheep.

The major modern land use in this character area is arable farming, which has now replaced much of the historical chalk downland. Very few good sites remain, the most important of which is Therfield Heath SSSI, which is also one of the top two sites in England, and last site in Hertfordshire, for the pasque flower (our county flower). Other fragments of chalk grassland and representative plant communities do still exist within the landscape, along with some areas important for rare arable weeds. However, these are small and highly fragmented, mostly occurring on slivers of land between fields or along road verges or paths.

Chalk grassland is therefore the greatest habitat creation and restoration priority in this character area and it can be considered for most purposes to be part of a larger strategic network of chalk grassland into the neighbouring Chilterns. Best opportunities for restoration exist along road verges and around arable fields.

There is not much woodland in the chalk dominated areas, reflecting the long history of chalk downland as the main land use. Here, most existing woodlands are not of ancient origin and are the results of planting or secondary growth, following an abandonment of grazing. There are a few beech woodlands, such as Fox Covert. Further south within the character area, as the surface chalk gives way to more neutral boulder clay, woodlands become more common. Ancient woodland remnants here are mostly ash/maple/hazel, and there is a perceptible string of these along the southern boundary of the character area, where it joins the Eastern Herts Clayland character area.

2.3.5 Upper Colne Valley (part of NCA 115 – Thames Valley)

Summary of highest priorities for habitat network restoration for Upper Colne Valley: Mixed wetland habitats.

This area shares some characteristics with bits of the Chilterns and also the neighbouring acid areas of the Hornbeams and Heaths character area. However, its most distinctive features are actually a result of modern land use and are within the river valley itself. The tributaries of the Colne converge either just above or within this character area. Whilst these are important chalk rivers, they have all but lost their chalk river characteristics by this point. Instead parts of the Colne are heavily canalised and the river valley is interlaced by a string of ex-gravel workings. These old gravel pits are filled with water and form a string of lakes.

The lakes in this area are important for waterfowl, and Broadwater Lake, in the far south of the character area, is part of the Mid Colne Valley SSSI, nationally important for its breeding and wintering wetland birds.

Although the majority of the wetland in this area is relatively recently man-made, a number of important habitats exist, including swamp, reedbeds, wet woodland, ponds and the large areas of open water. In many cases, the gravel pits are steep sided, limiting the amount of wetland habitats they are able to support. The river, canal and waterbodies are also disconnected from their natural floodplain. Much of the land around the gravel workings in particular is disturbed ground with poor structure, meaning that there are few opportunities for restoring marshes and wet grassland.

The best opportunities for enhancing wetlands and restoring their connectivity here is through re-profiling of lake margins and bringing more areas into active conservation management. The River Colne has potential to restore it to a more chalk river character.

2.3.6 Hornbeams and Heaths (part of NCA 111 – North Thames Basin)

Summary of highest priorities for habitat network restoration for Hornbeams & Heaths: Acid grassland, heathland, oak/hornbeam woodland, wood pasture, veteran trees.

The Hertfordshire part of the North Thames Basin, as well as the transition down into London itself, has a highly distinctive natural character, perhaps under-recognised in the context of the larger NCA. This is the most wooded part of Hertfordshire and also contains the majority of the county's remaining heathland and acid grassland.

The wooded habitats in this character area are an interesting mixture originating from a range of different historical backgrounds. These include ancient woodlands, wood-pasture, parkland (of both mediaeval and contemporary origins), commons and also recent plantations. Both ancient woodlands and wood-pasture were dominated by hornbeam trees, which is special to this part of the country. Hornbeam is considered native only to in the south east of England, and nowhere in the country does it characterise the landscape more than here.

The poor, acidic soils are the key to this area's distinctiveness, shaping its history and resulting land uses. The majority of the soils are more or less acidic, ranging from drier sands and gravels (towards the north and west) to damper London Clays (towards the south and east). However, there is of course some variation, resulting in more or less neutral patches interspersed throughout the whole area. There are also isolated patches of contrasting chalk soils, where the underlying chalk geology reaches the surface. Some are naturally occurring, such as along steep river valleys, or man-made, such as quarry exposures. Because of the isolated nature of these conditions, creating chalk grassland is of less strategic importance in this area.

It is the poor productivity of soil in the area that largely made it unsuitable for arable farming, resulting in livestock grazing driving the rural economy here for several millennia. For the same reasons, a great amount of this area escaped 18th century enclosures, resulting in much of the land becoming commons. These pastures and commons were the stronghold for acid grassland and heathland in the county until they were all but wiped out in the last 70 or so years through lack of grazing, leading to degeneration to secondary woodland.

When considering habitat restoration and creation priorities, this character area is not straightforward and requires careful thought. It is clearly a stronghold of wooded habitats in the county and so woodland creation and linkage would seem to be a high priority. However, there are very few ancient woodlands remaining. Where these do occur, a high priority clearly is to sensitively restore, expand and link them. Good examples include parts of Northaw Great Wood and Balls Wood. Many of the other wooded habitats are relatively recent plantations or secondary growth following a cessation of grazing. Where the land use was historically common, parkland, wood-pasture or acid grassland, recent woodlands may actually be detrimental in their current form to the ecological networks in this character area. Non-native conifers should be removed and areas thinned and opened up to allow grassland, heathland and ancient pollard trees to be restored, as applicable. For example, the wood-pasture heritage of parts of Northaw Great Wood can be clearly seen by the remaining hornbeam pollards. In places such as this, restoration could involve sensitively opening up areas, restoring heathland and acid grassland habitats and preventing the ancient pollards from

degenerating. New woodland creation should include a high proportion of open habitats and should avoid severing potential acid grassland and heathland networks.

Heathland is clearly a top priority, as our most threatened habitat in the county. Where the few patches remain, these should be restored and expanded. There will also be opportunities for restoration of heathland, or at least acid grassland, on historically common land through removal of trees and reinstatement of grazing. This part of the county is a stronghold for acid grassland, which is a priority for restoration and creation here. Because of the grazing heritage of this character area and the natural variation in soil conditions, a large proportion of the county's more neutral pasture is also holding on here and shouldn't be overlooked.

This area also holds some of the important rivers within the Lea Catchment, including part of the Lea Valley, an internationally important site for wetland birds, and the Lea and Mimram chalk river tributaries. These fragile and globally rare habitats are a high priority for restoration.

2.3.7 Eastern Herts Clayland (part of NCA 86 - South Suffolk & North Essex Clayland)

Summary of highest priorities for habitat network restoration for Eastern Herts Clayland: Chalk rivers, Ash/maple/hazel woodlands, mixed wetland habitats, neutral grassland.

This part of Hertfordshire sits mostly on the calcareous to neutral boulder clay. It was once the stronghold of neutral grassland, with hay meadows being a major land use for centuries. However, the relatively high soil productivity meant that most of this was turned to arable farming in recent centuries. A few large good meadows still remain such as Hunsdon Meads. There are also a number of smaller neutral grassland fragments spread throughout, reflecting the importance of this habitat within this character area.

This part of the county is characterised by its Ash/maple/hazel woodlands. These ancient woodlands have an interesting variety of different tree and ground flora communities, dependent on location and soil conditions. The woods in the Ash Valley are of special interest for their abundance of the only native populations in the county of wood forget-me-not *Myosotis sylvatica*. Many of the woodlands are botanically very rich, although they have lost a lot of their diversity in recent times through drainage of adjacent arable land drying them out, as well as nutrient enrichment from spray drift, and over-shading from a lack of traditional management.

Wetlands are an important part of this character area. A number of the important chalk river tributaries of the Lea catchment run through it, such as the Stort, Ash, Rib and Beane. The Stort Valley has some of the best and most connected wetland habitats in Hertfordshire, including a large proportion of the county's wet woodland. Some of the county's few remaining marshes and wet grasslands are here such as Thorley Wash. The Ash, Rib and Beane are important chalk rivers, not only in a Hertfordshire context but also from a national and even global perspective. These fragile and globally rare habitats are a high priority for restoration.

Because arable farming is such a large land use in this character area, the greatest opportunities for restoring and connecting habitats here is on farmland. Ancient woodland fragments need to be

restored and sensitively expanded to buffer the impacts of neighbouring land uses. Sites should be connected where possible. Neutral grassland restoration and creation is also a high priority. Second only to heathlands, it is one of our most beleaguered, once common habitats in the county. Wetland habitats can be restored alongside the rivers. Not only will this restore these specific habitats but it will also play a part in restoring the whole river ecosystem. For example, wetland habitats can help regulate flow and filter ground and surface water before it goes into the rivers.

2.3.8 North-West Clay Vale (part of NCA 88 - Bedfordshire and Cambridgeshire Claylands)

Summary of highest priorities for habitat network restoration for North-West Clay Vale: Neutral grassland.

In Hertfordshire this area is a very small part of the county, where the administrative boundary projects northwards from Tring. It is separated from the neighbouring Chilterns by a watershed, with the rivers here flowing northwards instead of southwards.

The key defining natural distinctiveness from a Hertfordshire perspective is the sudden absence of chalk habitats and a sparseness of woodlands, replaced instead by neutral grassland. The area is dominated by arable farming, similarly to the boulder clay in the east of the county, reflecting the easier to farm, more productive neutral soils. Neutral grassland is the highest priority for restoration and habitat linkage in this character area.

2.4 Project purpose

The introduction of this report summarised the history and description of Hertfordshire's natural environment and character areas. Whilst this information is important to understand broadly what needs to be done where in the county, on its own it is not detailed enough to understand where to prioritise within those broad character areas and where there is the greatest potential within them to create or restore habitats.

This has meant that local plans and policies have largely had to focus just on protecting existing known sites, rather than being able to plan for strategic ecological networks. A large number of local areas outside of Hertfordshire inform local plans with biodiversity opportunity maps or similar, such as neighbouring counties' Biodiversity Opportunity Areas (BOAs), within the previous South East England Region.

The purpose of the project was to address this deficit in Hertfordshire. Work was carried out between 2011 and 2013 to map Hertfordshire's existing habitat resources and to use computer models to predict where effort could best be prioritised to enhance ecological networks. This informs our work to restore ecosystems and their function, helping us to adapt to climate change and other pressures on the natural environment.

3 Methods

There were three main stages to the project. Firstly, an up-to-date habitat inventory was produced, showing the locations and extent of patches of existing habitat. These form the foundations and starting points for Hertfordshire's ecological networks. The next stage involved developing computer models to understand how the county's habitat networks fit together and where the priorities are for their restoration. Finally, specialist plant data were used to identify landscape-scale ecological units of particular strategic priority within the county.

3.1 Producing the habitat inventory

A standardised Phase 1 habitat mapping approach by JNCC[14] was used to classify habitats and produce the 2013 Hertfordshire habitat inventory. Phase 1 is a widely used standard UK approach for rapidly classifying and mapping semi-natural habitats over large areas.

The last attempt to produce a habitat inventory for Hertfordshire was done in 1995-97. This used a similar Phase 1 approach, although the two sets of results are not directly comparable due to some differences in how habitat classifications were interpreted and categorised between the two surveys. The 1997 inventory was updated by re-evaluating the old data against more recent survey data, as available. Recent aerial photographs, dating between (2008 and 2010) were also used to check accuracy, discrepancies and visible changes in habitat distribution since 1997.

Whilst useful for input into detailed data analysis later in the project, the Phase 1 classification is a bit too detailed and unwieldy on its own for displaying habitat distributions at a county scale. Therefore the Phase 1 classifications were grouped into broad habitat types relevant to Hertfordshire for the purposes of producing an easily interpretable habitat inventory.

3.2 Modelling ecological networks

An appraisal of previous ecological network modelling approaches from elsewhere in the country was carried out and an assessment made of their applicability to Hertfordshire and available data sets. Whilst a detailed review is not given here, it was concluded that there are many good examples of previous approaches, which fall broadly into two categories, each with their own strengths and weaknesses. The first of these general categories of approach is broadly to identify potential new areas for habitat creation based on physical parameters, such as existing land-use, soils, geology, slope and aspect. Expert judgement is used to determine suitability values and the process results in the identification of biodiversity opportunity areas. Examples of this include models from counties in the previous South-East England region, such as from Sussex[15]. The second category of approach is to model potential habitat networks through calculating theoretical maximum dispersal distances for species supported by a given habitat and making the assumption that networks can only exist within

dispersal distances of existing habitat patches. The most refined models, such as from Falkirk[16], take into account existing land-uses and assign each land-use a theoretical permeability score. This results in dispersal distances, and hence the modelled habitat networks themselves, being lessened where there are intensive land-uses.

The first general approach outlined above is good at defining broad areas to prioritise habitat creation projects, although it could benefit from being able to grade priorities further within these. It requires availability of detailed reliable data sets on physical parameters, such as soils. It also relies on a lot of expert judgement to value habitat suitability factors. Its biggest issue in a Hertfordshire context is that it downplays the potential contribution that urban areas and other intensive land-uses can make towards restoring habitat networks.

The second general approach outlined above is more aimed at defining where existing habitat networks occur, rather than identifying where the highest priorities exist for improving networks. It is good for understanding how habitat networks fit together, their condition and how species might disperse through the land. Its biggest issue is that it relies heavily on a number of theoretical parameters, particularly that of how far species can disperse between habitat patches.

For the project here, the best and most locally applicable principles of the above approaches were taken, whilst adapting them into a new approach that fulfilled four key principles important to the identified need and situation in Hertfordshire:

1. As well as needing to understand where ecological networks exist, a need was identified to indicate where habitat creation projects should be prioritised; i.e. where they have the greatest potential impact towards improving ecological networks.

2. The approach needed to model basic key principles of ecological networks; i.e. favouring areas near to or between existing habitat patches. It also needed to recognise that larger existing habitat patches are of greater value than smaller ones.

3. A simple model was preferred, with the lowest possible dependence on unreliable data or factors based on assumptions that are difficult to justify, such as representative dispersal distances.

4. Hertfordshire is a densely populated county, dominated by intensive land-uses. The modelling approach here needed to ensure that these land-uses were not excluded. Otherwise the view would need to be taken that there is almost no potential to restore ecological networks in Hertfordshire, which is incorrect. Herts & Middlesex Wildlife Trust's recent publication 'How to Build a Living Landscape'[2] demonstrates that ecological networks can be restored in all of the county's main land-uses.

In order to deliver against the four key principles above, a new modelling approach was developed based on an 'Inverse Distance-Weighted' (IDW) interpolation algorithm. A detailed description of IDW interpolation is given in the online ArcGIS Help Resources. A basic summary of the IDW method used is that for a point on a grid across the county, a score was calculated according to proximity, quality, number and size of patches of a given habitat within a search area. The highest scores would be assigned where a square was located closely between several existing habitat patches or adjacent to very large patches. The highest scoring areas in the results indicate where habitat restoration

would likely be of the greatest potential benefit to improving the ecological network for a given broad habitat type. This model reflects well the principles of ecological networks, in that the aim is to expand existing patches and connect them together with new habitat.

Ecological networks were modelled separately for broad habitat types, relevant in a Hertfordshire context. These were Woodland, Chalk Grassland, Neutral Grassland, Acid Open Habitats (including acid grassland, heathland and bracken) and Wetland (including open water, swamp, fen, wet woodland and marshy habitats).

The Phase 1 habitat inventory was the main dataset used to model the ecological networks. Each Phase 1 habitat category was assigned to its relevant broad habitat type and given a weighting appropriate to its qualitative contribution to that habitat. For example, Unimproved Neutral Grassland includes the best examples of the Neutral Grassland broad habitat type, and accordingly received a high weighting. On the other hand, Semi-improved Neutral Grassland is generally of lower quality, and hence received a lower weighting. Weightings were based on local expert judgement by the partnership steering group.

In addition to the Phase 1 habitat data, botanical data were used of particularly indicative species of the best habitat conditions in a Hertfordshire context. This is because not all fragments of existing quality habitats were able to be identified from aerial photographs or existing habitat data. By including plant records of particularly strong indicators of habitat quality, it ensured that the most complete dataset possible was used to inform the computer models.

The county was then divided into 50m x 50m squares, with each square assigned its coinciding habitat or nothing if no habitat was present. Adding in specialist plant data allowed the inclusion of important habitat fragments that were otherwise too small, hidden or narrow to be picked up by the grid. An IDW algorithm was then used on this input data, separately for each broad habitat type, to model potential ecological networks between patches of similar habitat.

The model made no assumption as to how far species can disperse between habitat patches across different land uses. Instead, scores are relative and on a continuous scale, with higher values indicating areas where there is theoretically a better chance of improving an ecological network than lower value areas. The model also made no assumptions as to the relative ease with which habitats can be restored or created within different land uses.

3.3 Identifying landscape-scale ecological units

Most habitat network studies in other parts of the country include soil characteristics in the models, particularly pH, delimiting where habitats sensitive to various soil conditions are predicted to be able to exist. For example, theoretical opportunities for creating chalk grassland are only shown where surface chalk soils occur, whereas heathland creation opportunities would only be shown where acidic sands and gravels occur.

This was not able to be achieved using Hertfordshire soil data. As described in section 2.3.1, there were two main reasons for this. Firstly, some of Hertfordshire's classified soil types are highly

variable, within themselves, in their suitability for different vegetation communities. Secondly, soil types in the county are highly variable over short distances, perhaps in part due to the repeated glacial and periglacial disturbances during the ice age. The soil sampling points that were used to create a map of Hertfordshire's soils were perhaps not of a high enough resolution to detect much of this variability. Therefore the potential habitat network models did not take soil data into account directly.

However, in order to develop an understanding of landscape-scale ecologically-coherent units, an appraisal of at least the broad-scale relevant physical geography is required. Two types of physical factors were taken into account. These were ground wetness and soil pH.

For ground wetness, the best readily available datasets are flood alert maps. However, there is enormous variation in degree and frequency of wetness both within and outside flood alert areas and so they weren't used to definitely determine the location and extent of wetland potential networks. Instead they were used to represent existing river corridors and indicate the most likely extent of wetland potential networks. This project recognises that not all components of wetlands were able to be modelled at this stage due to lack of readily available datasets. Rivers are obvious physical long distance wetland features in themselves, which largely define wetland potential networks and whole river systems should be considered part of the wetland potential network, even where the models do not predict high priority for wetland restoration.

To take into account the other critical physical factors, that of soil pH, distribution data were collated at the tetrad scale (2km x 2km squares) of two separate suites of specialist plant species, considered to be particularly strong indicators of acid conditions and chalk conditions respectively. These were smoothed using a similar IDW algorithm as for the habitat data. The result was an interpolated map as a proxy of the soil factors throughout the county that directly control the distribution of both acid and chalk habitats.

At a county-scale, the results corroborated what is known about the general trends in soil conditions affecting chalk and acidic habitats. From these outputs, strategic core areas, generally suitable for each of chalk grassland and acid open habitats respectively, were defined. These boundaries roughly delimit landscape-scale, ecologically-coherent units. These not only provide strategic core areas but also help interpret how Hertfordshire's natural habitats fit together, along with the physical and historical human factors that have shaped them.

Neutral strategic core areas were not similarly modelled. This is partly because there were not enough records for specialist plant species in Hertfordshire that reliably occur exclusively on neutral habitats. Linked to this, it is also a result of Hertfordshire's soils outside of wet areas being dominated by more or less either acidic or alkaline (chalk) characteristics. Dry neutral soils do occur in the county but these appear to be patchy, and over short distances can quickly blend into a more chalky or acidic nature. This project accepts that there are no clearly definable strategic core areas for dry neutral grassland in Hertfordshire and recognises that there is a patchy distribution of suitable more-or-less neutral conditions throughout the county, even within the modelled acidic and chalk strategic core areas. Outside of the chalk and the acid strategic core areas the probability of habitats tending towards neutral is increased.

3.4 Combining all the outputs into a single GIS dataset

Because networks for different groups of habitats were modelled separately, it is hard to interpret all the individual outputs in one go to understand which habitats to focus on where and what to do in areas of overlap. It is also hard to identify where habitats already exist in relation to priorities for creation of new habitats.

To address this, a further GIS analysis was performed on the individual project outputs to combine them into a single GIS dataset. The aim was to simplify everything into a single product that could be more easily interpreted by non-ecologists.

The habitat inventory, each of the modelled ecological networks and the identified landscape-scale ecological units were combined. This ensured that the single combined dataset recognised location and type of existing habitats, did not propose creating new habitats over existing ones and took all affected habitats into account for a given location. It also recognised different levels of priority for habitat creation across the county.

4 Results

The minimum number of maps and computer model outputs to illustrate the project results has been included here. A more comprehensive set of map outputs is available separately from Herts & Middlesex Wildlife Trust on request.

4.1 Habitat inventory

There was a total of 359 km^2 (35,900 ha) of habitat identified, equating to approximately 22% of the total county area. Not all of this was included in the ecological network models because some of the Phase 1 categories fall outside the main broad habitat types included in this study or represent unacceptably low quality habitat, such as 'Poor semi-improved grassland'.

Table 1 summarises the areas of habitats included in the ecological network models, against the broad habitat types modelled.

Woodland is clearly the most common habitat in Hertfordshire, comprising 10% of the land cover. However, less than half of this is able to be classed as semi-natural and only 3,876 ha (less than one-quarter of Hertfordshire's woodland) is ancient.

Neutral grassland is the next most common habitat, totalling approximately half of the woodland cover. However, of this only 280 ha are of known decent quality. The semi-improved neutral grassland category should be treated cautiously. This is probably a mixture of genuinely reasonable quality sites and poorer quality sites. It also potentially contains a large number of semi-improved acid or chalk grassland sites that are not of high enough quality to distinguish between them. The results therefore show an overly optimistic picture of the total neutral grassland resource.

Heathland is the rarest of Hertfordshire's important habitats, and is now all but wiped out, with just 13 ha remaining. The reason it was included together with other open acid habitats was because the heathland model on its own would have been meaningless.

Chalk grassland is the next rarest and most threatened habitat, with just 148 ha of high quality sites remaining.

Table 1. Results of the 2013 Hertfordshire habitat inventory. Areas of broad habitat types and further broken down by their constituent Phase 1 categories.

Broad habitat types	Phase 1 categories included (Phase 1 codes)	Phase 1 categories included (descriptions)	Area of habitat (ha)
Woodland	A1.1.1	Broadleaved woodland - semi-natural *	8,406
	A1.1.2, A1.2.2, A1.3.2, A2.1, A4	Other wooded habitats	7,954
		Total	**16,360**
Chalk grassland	B3.1	Calcareous grassland - unimproved	148
	B3.2	Calcareous grassland - semi-improved	218
		Total	**366**
Neutral dry grassland	B2.1	Neutral grassland - unimproved	280
	B2.2	Neutral grassland - semi-improved	7973
		Total	**8,253**
Acid open habitats	D1, D1.1, D5	Heathland	13
	C1.1, C1.2	Bracken	91
	B1.1	Acid grassland - unimproved	188
	B1.2	Acid grassland - semi-improved	429
		Total	**721**
Wetland **	E2.1, E2.2, E3.1, E3.2, E3.3	Flushes and fens	9
	F1, F2.1, F2.2	Swamp and inundation	129
	B5	Marshy grassland	278
	G1	Standing water	882
		Total	**1,298**
Total			**26,998**

* This Phase 1 category does not distinguish between ancient woodland and more recent secondary broadleaved woodland. The amount of remaining ancient woodland in Hertfordshire is actually only 3,876 ha.
** The current Hertfordshire wet woodland inventory also contributed to the wetland habitat model but the area is not itemised here because it is part of the woodland category area total in this table.

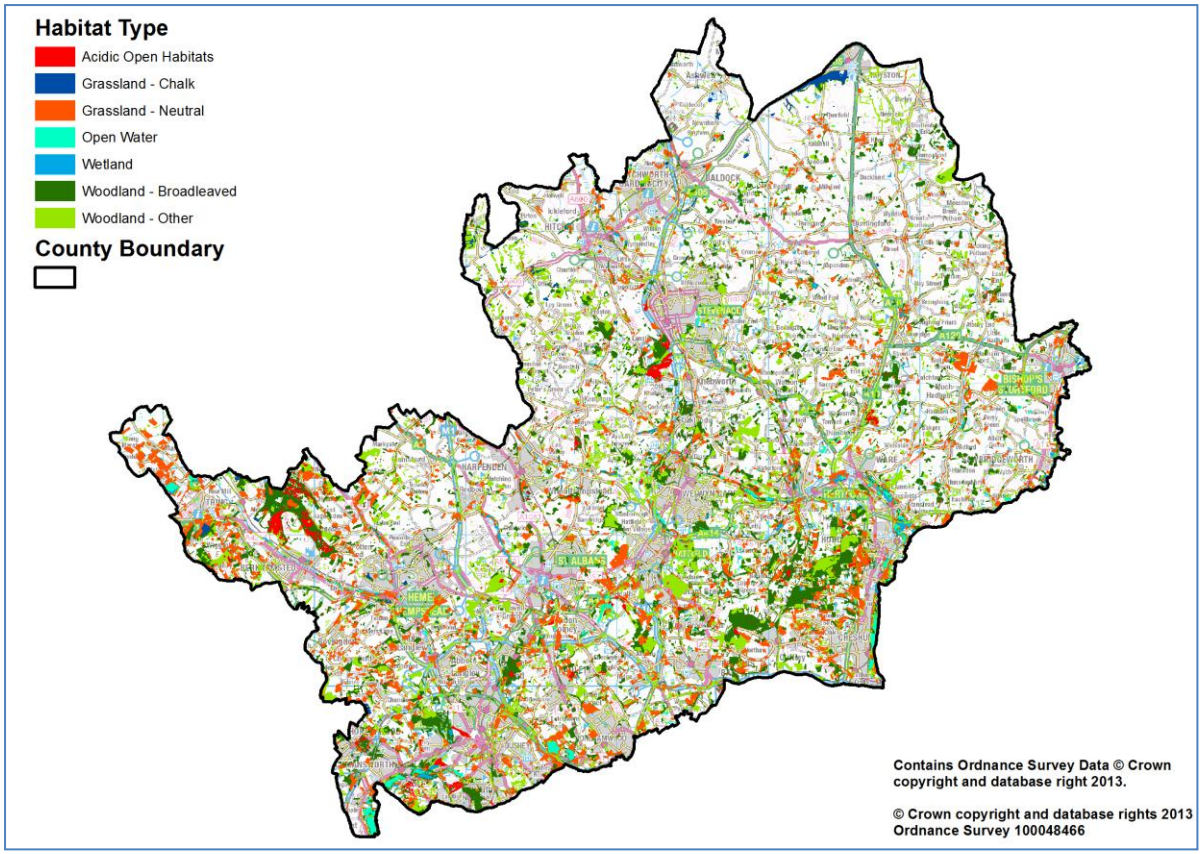

Figure 3. Map of Hertfordshire showing locations and distributions of different habitats in the 2013 inventory.

Figure 3 shows where the different habitat types are found in the county. Wooded habitats have a scattered distribution throughout the whole county but are particularly concentrated within the Hornbeams & Heaths area in the central and south. Chalk grasslands are highly restricted to the chalk escarpment in the north between Royston and Tring, although outliers occur elsewhere where the underlying chalk geology reaches the surface, either through outcrops or more commonly through quarrying or road cuttings. Acid open habitats are concentrated across much of the Hornbeams and Heaths character area. Other notable areas are around Berkhamsted and Ashridge in the north-west and Patmore Heath in the east. Wetland habitats are found throughout the river valleys but are notably most concentrated along the Stort in the east and parts of the Lea and Mimram. Old gravel pits in the Lea and the Colne are very important sites for wetland birds.

4.2 Ecological networks

Woodland

This is the most widespread and common suite of habitats in the county, giving it the strongest potential for network connectivity. However, part of the reason for this is the inclusion of a lot of suboptimal woodland habitat in the model. A number of patches have not been surveyed and were difficult to distinguish between good and poor quality.

Figure 4 shows the modelled potential woodland network, with the strongest components shown in red through to the weakest in blue. Highest priority areas appear to be in the Hornbeams & Heaths character area, a long distance potential network north-south through the middle of the county and another east-west along the boundary between the North Herts Chalk and the Eastern Herts Clayland character areas.

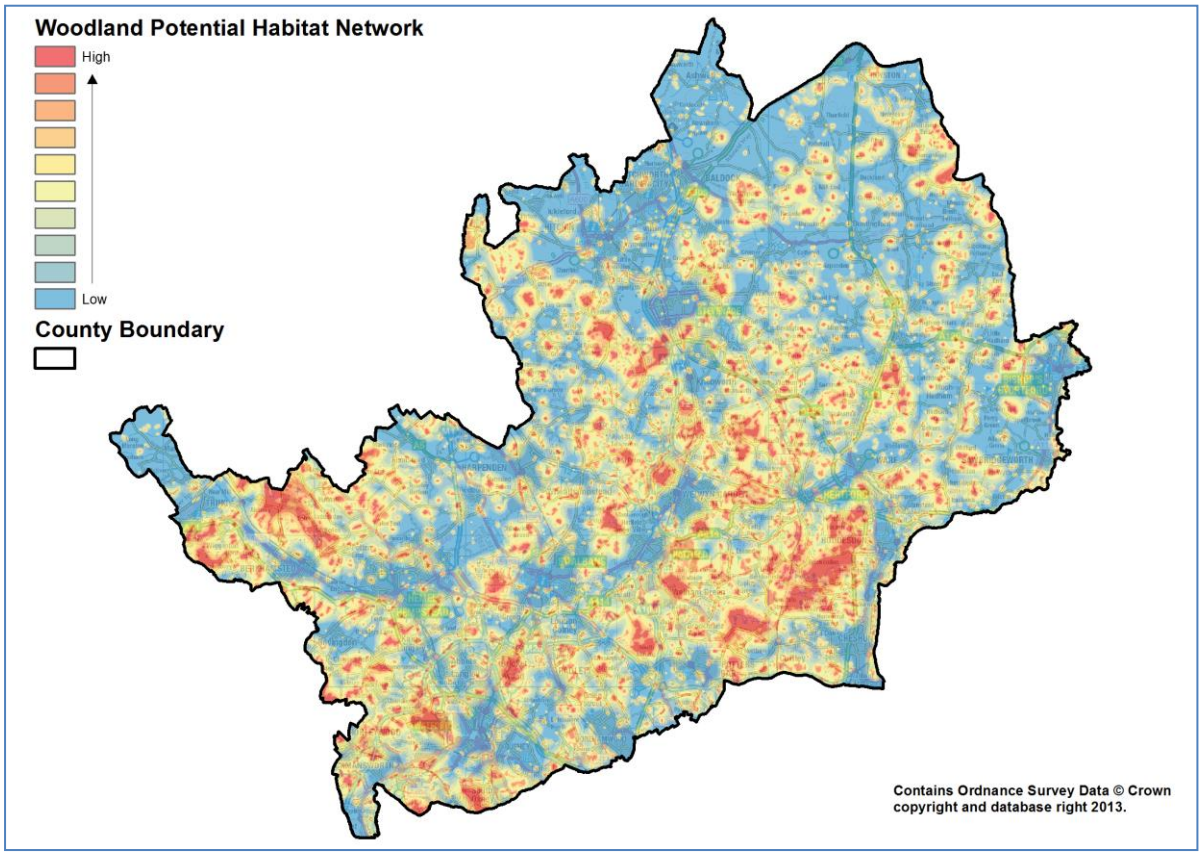

Figure 4. Map of Hertfordshire showing the results of the modelled potential woodland network. Strongest components are shown in red through to weakest in blue. The strongest components show the highest modelled priorities for habitat creation.

Chalk grassland

This is the most vulnerable and poorly connected habitat of those modelled. Figure 5 shows the modelled potential chalk grassland network, with the strongest components shown in red through to the weakest in blue. There are only a handful of good sized patches left, the most significant being Therfield Heath. The majority of sites and the best potential for connectivity is along the chalk escarpment, with a particular priority around the Therfield Heath vicinity. The presence of chalk exposures on road verges, the Icknield Way and some small patches of chalk grassland within farmland shows up as a potential string of fragments, which should be a priority to connect.

Chalk grassland elsewhere is generally rare, of small patch size and extremely isolated from other patches. Whilst these are an important natural resource in their own right, there is little potential to connect them as part of a chalk grassland network.

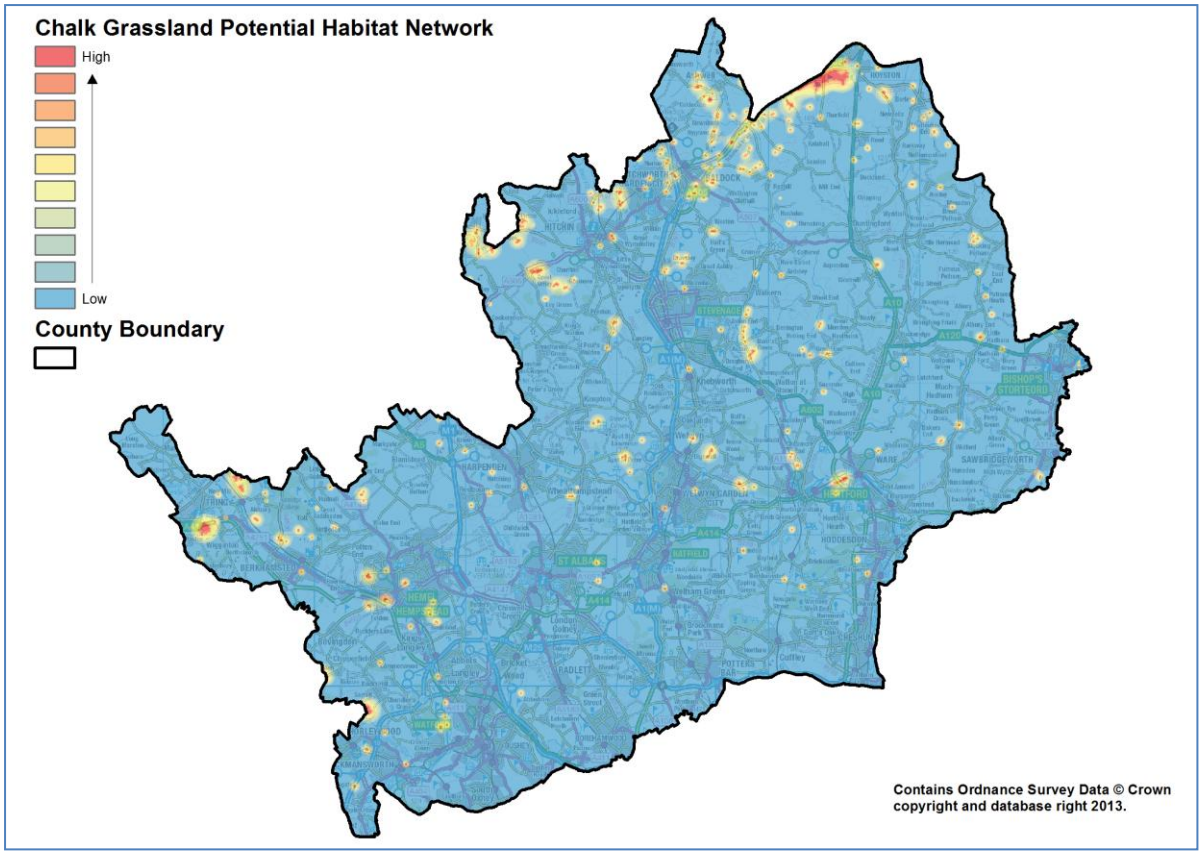

Figure 5. Map of Hertfordshire showing the results of the modelled potential chalk grassland network. Strongest components are shown in red through to weakest in blue. The strongest components show the highest modelled priorities for habitat creation.

Neutral grassland

Figure 6 shows the modelled potential neutral grassland network, with the strongest components shown in red through to the weakest in blue. This was the second most common and widespread habitat modelled, after woodland. Even more so than woodland, much of this is an artefact of not always being able to distinguish between good and poor habitats. Not only is it likely to represent neutral grassland but also degraded examples of acid and chalk grassland. This is because as grasslands degrade, they lose their distinctive character that allows them to be recognised as either a chalk, neutral or acid grassland. As they become less recognisable, they give the appearance of a more neutral character in the species they support. Therefore this particular habitat potential network model should be treated with the most caution because it is likely to also predict where some of the other grassland types might be able to be created instead.

The biggest concentration is in the Hornbeams & Heaths character area. This is partly because it includes some potential acid grassland potential but also because this area historically had a greater proportion of pastures than elsewhere because of the general poor soils, unsuitable for arable. There is likely to be genuinely some high potential in the Hornbeams & Heaths area for neutral grassland creation.

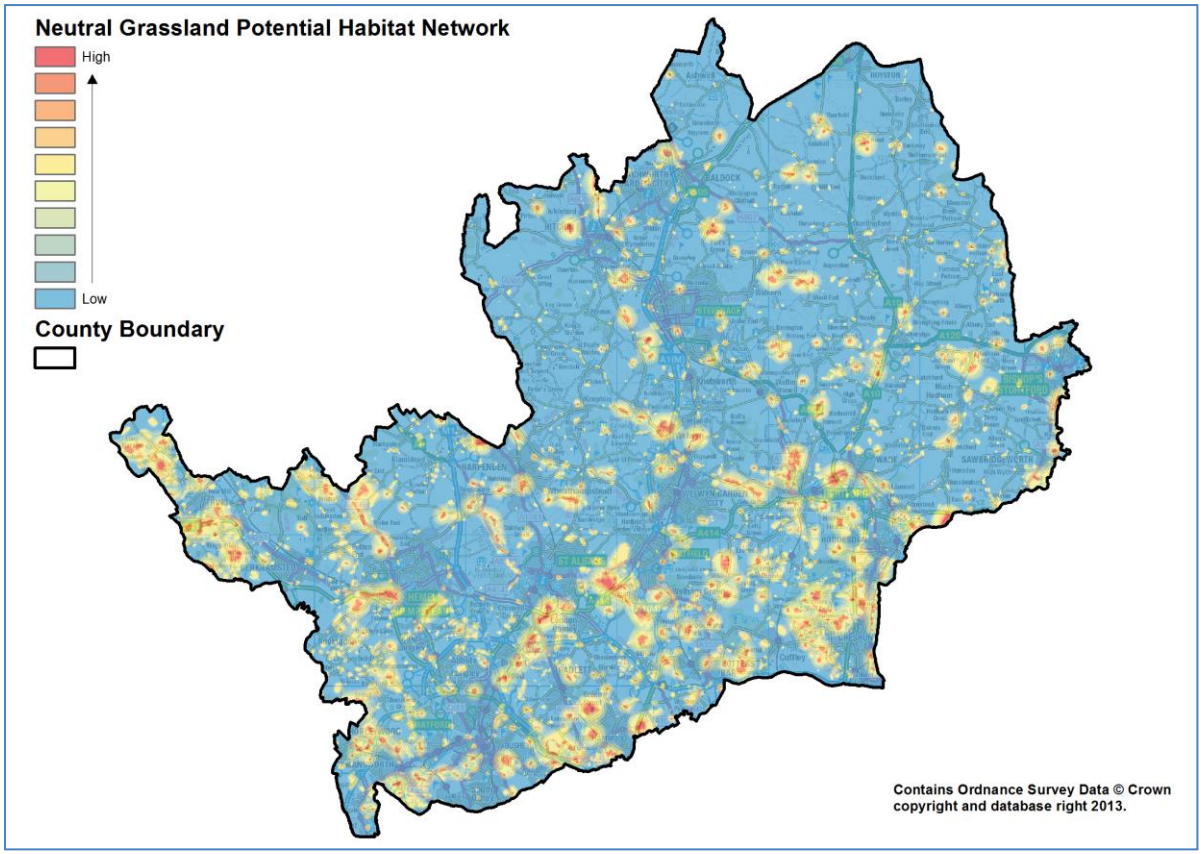

Figure 6. Map of Hertfordshire showing the results of the modelled potential neutral grassland network. Strongest components are shown in red through to weakest in blue. The strongest components show the highest modelled priorities for habitat creation.

Acid open habitats

Figure 7 shows the modelled potential open acid habitats network, with the strongest components shown in red through to the weakest in blue. This is the second most vulnerable and poorly connected habitat of those modelled, after chalk grassland. This is despite merging heathland with acid grassland. Modelling heathland on its own would have been pointless because it is now almost extinct from the county, with the model showing no more than a simple buffer around existing patches.

The distribution of acid grassland is patchy within the county but clearly concentrated in the Hornbeams & Heaths area. The area around the Ashridge Estate and Berkhamsted Common is also particularly important, with lots of potential for improving network connectivity. Because of its suitable soils and particular history of a more open nature in the past, much of the wooded area around the Ashridge Estate still supports fragments of acid open habitats and rare species associated with them. It is a high priority to restore open acid habitats within this area.

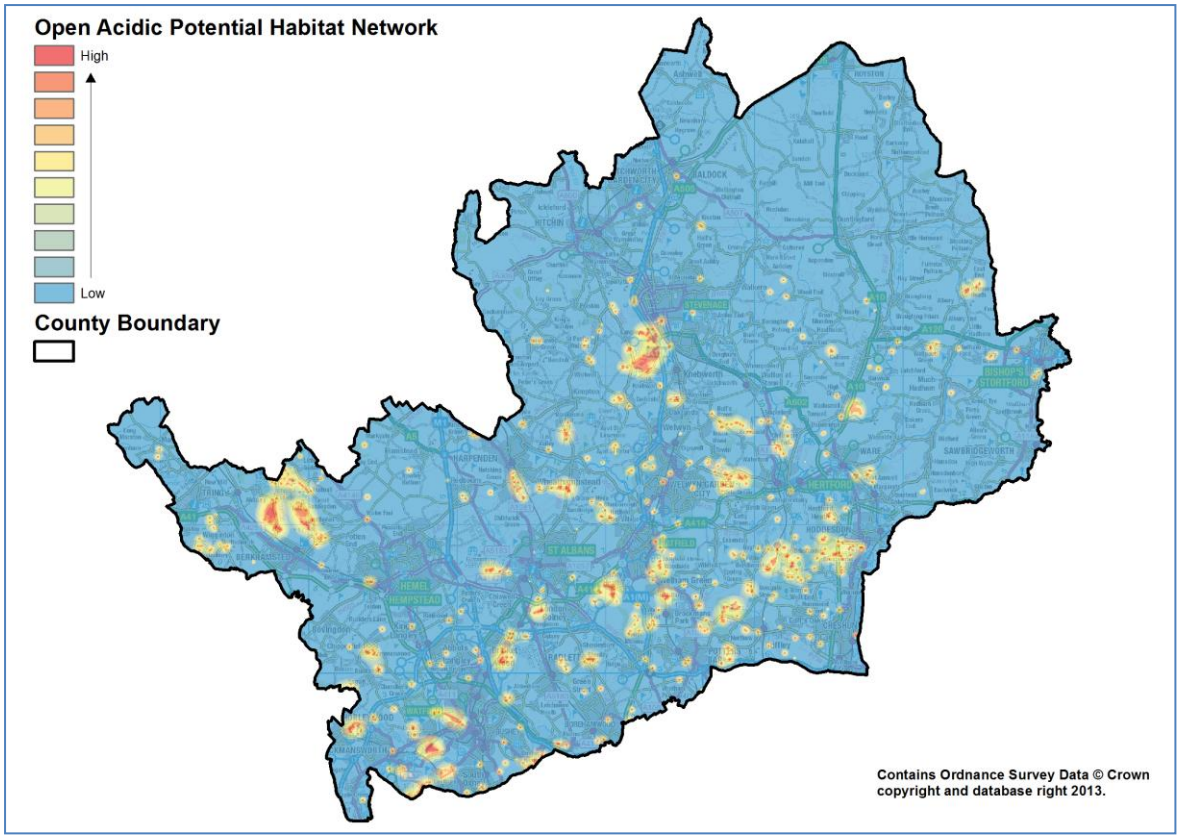

Figure 7. Map of Hertfordshire showing the results of the modelled potential open acid habitats network. Strongest components are shown in red through to weakest in blue. The strongest components show the highest modelled priorities for habitat creation.

Wetland

Figure 8 shows the modelled potential wetland habitats network, with the strongest components shown in red through to the weakest in blue. Wetland habitats are naturally highly restricted but where they do occur in river corridors they potentially have a greater potential for long distance connectivity due to the linear nature of the geography as well as the often unsuitability of floodplain land for modern land uses. It was recognised in the methods section that rivers themselves were not modelled because their presence is clearly map-able, and datasets distinguishing between high and low quality rivers from an ecological networks perspective was not readily available. In the absence of these data in the models, river corridors are shown underneath the wetland model outputs in figure 8 to show the full range of map-able wetland components and where the network could be improved outside of the modelled high priority areas.

The nationally and internationally important open water bodies at Tring and in the Colne and Lea Valleys are particularly obvious and show a good deal of connectivity due to their large size and concentration in those areas. The most impressive network connectivity however is in the Stort Valley where there is a relatively continuous corridor alongside the river and the model shows a lot of high priority potential between these patches.

Conversely, apart from small parts of the Mimram and a few others, there is generally very little current or modelled potential wetland habitat connectivity along the important chalk river tributaries of the Lea or Colne. This highlights one of the reasons why chalk river ecosystems in Hertfordshire are failing. Without significant habitat creation alongside these rivers, they will continue to be highly vulnerable to erosion and diffuse pollution, as well as being unable to support their full range of flora and fauna.

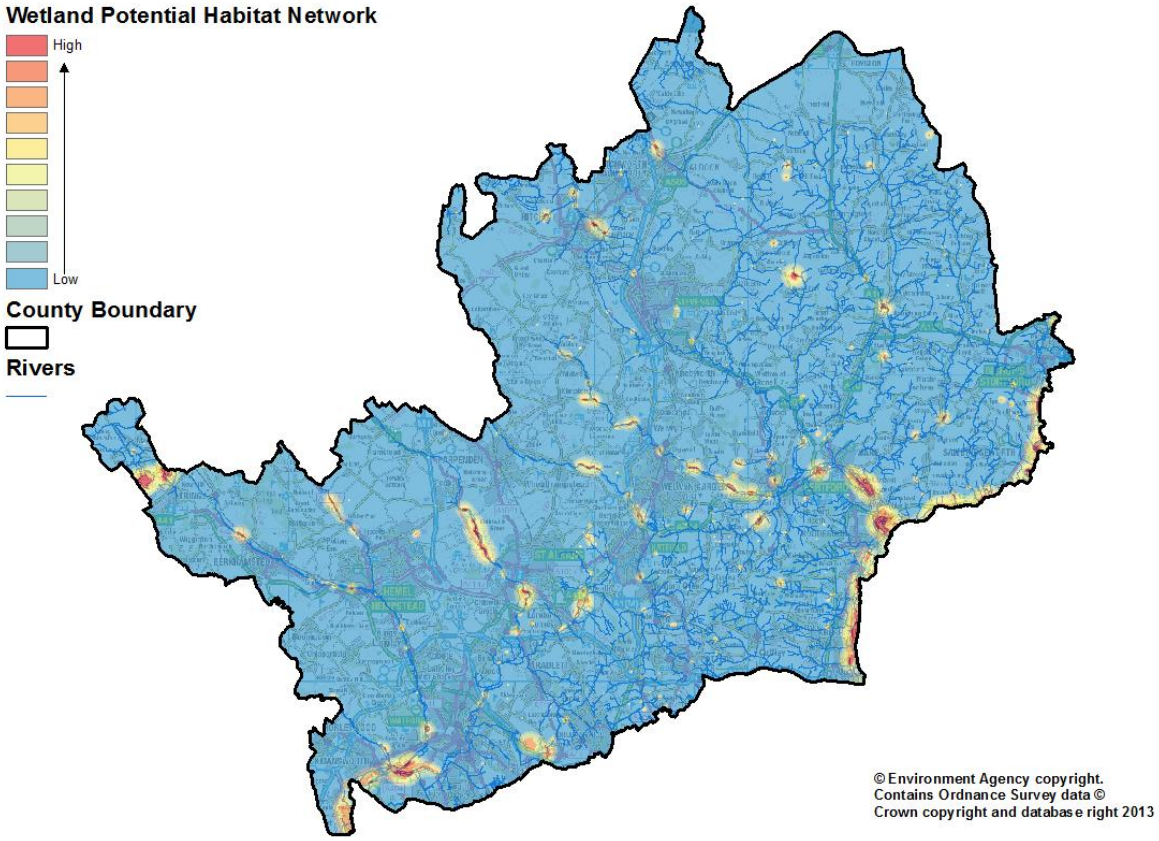

Figure 8. Map of Hertfordshire showing the results of the modelled potential wetland habitats network. Strongest components are shown in red through to weakest in blue. The strongest components show the highest modelled priorities for habitat creation. River corridors show where strategic wetland network existing and potential components occur between high priority modelled areas.

Overlaps between different habitat networks

Figure 9 shows the overlaps between the different modelled individual potential habitat networks, with the most number of overlaps for a given location shown in red through to the least number of overlaps (two habitats) in blue. For the purposes of defining overlaps, the two weakest categories from the outputs of each potential habitat network model were excluded from the analysis.

Much of the county showed an overlap in the potential networks between two or more habitats. This is not surprising because many of the conditions that make an area suitable or a hot spot for one habitat will be similar for another habitat. There is also a wide distribution of some habitats,

such as woodland, increasing the chances of it overlapping with others. Lots of overlaps between habitat networks correspond with some of the most diverse areas are in the county but also where the most thought needs to be applied as to what habitats to restore and create there so as not to unintentionally sever one potential network for another. The most common overlaps are between acid open habitats and woodland, particularly in the wider Ashridge and Hornbeams & Heaths areas. This is perhaps not surprising considering that many acid open habitats have been gradually lost or degraded to scrub or secondary woodland.

Another interesting pattern in the results of the overlaps analysis is that a broadly north-south line is visible between approximately Broxbourne and Hitchin. This follows the transition zone between several of the NCA boundaries, showing that these transition zones can be particularly diverse in a county context.

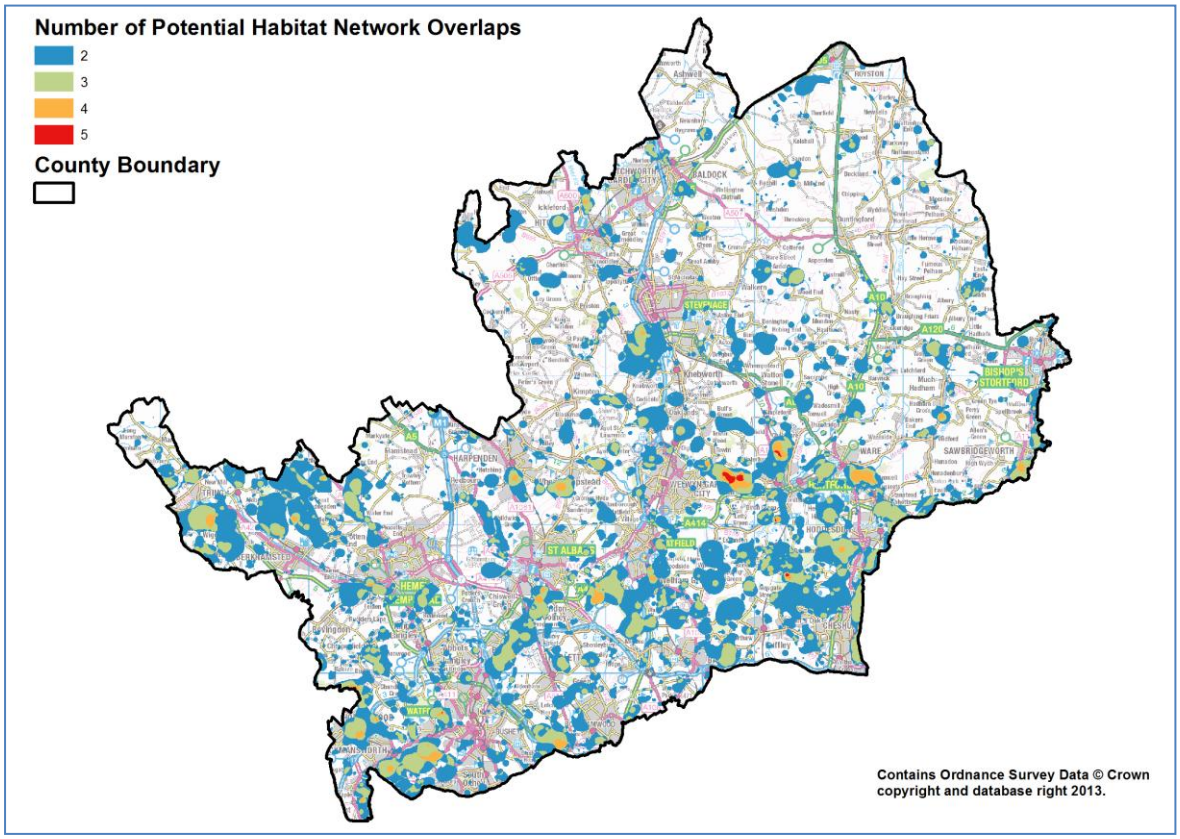

Figure 9. Map of Hertfordshire showing overlaps between the different modelled individual potential habitat networks. These range from the maximum possible of five overlapping potential networks coloured in red through to the minimum possible of two overlapping potential networks in blue.

4.3 Landscape-scale ecological units

Whilst it has already been recognised that soil conditions vary greatly across the county, even within a single soil category, clear strategic core areas can be seen. Similarly the two main river catchments of the Colne and the Lea define the majority of strategic core wetland habitat networks.

4.3.1 Chalk strategic core areas

Figure 10 shows a map of Hertfordshire, identifying concentrations of chalk plants. These areas indicate where suitable physical conditions exist, such as surface chalk soils. Using both Hertfordshire and Bedfordshire plant data, an almost continuous band of surface chalk can be recognised along the chalk escarpment along the northern boundary of the county. With the small exception of the Hitchin Gap, a periglacial feature, this can be considered one coherent ecological unit. It is of high strategic importance in a Hertfordshire context and should be the focus of chalk grassland network enhancement in the county. Although chalk and associated habitats do occur elsewhere in the county, they are much patchier and with less potential for restoring landscape-scale units. Within the chalk strategic core area, chalk grassland is the highest priority habitat.

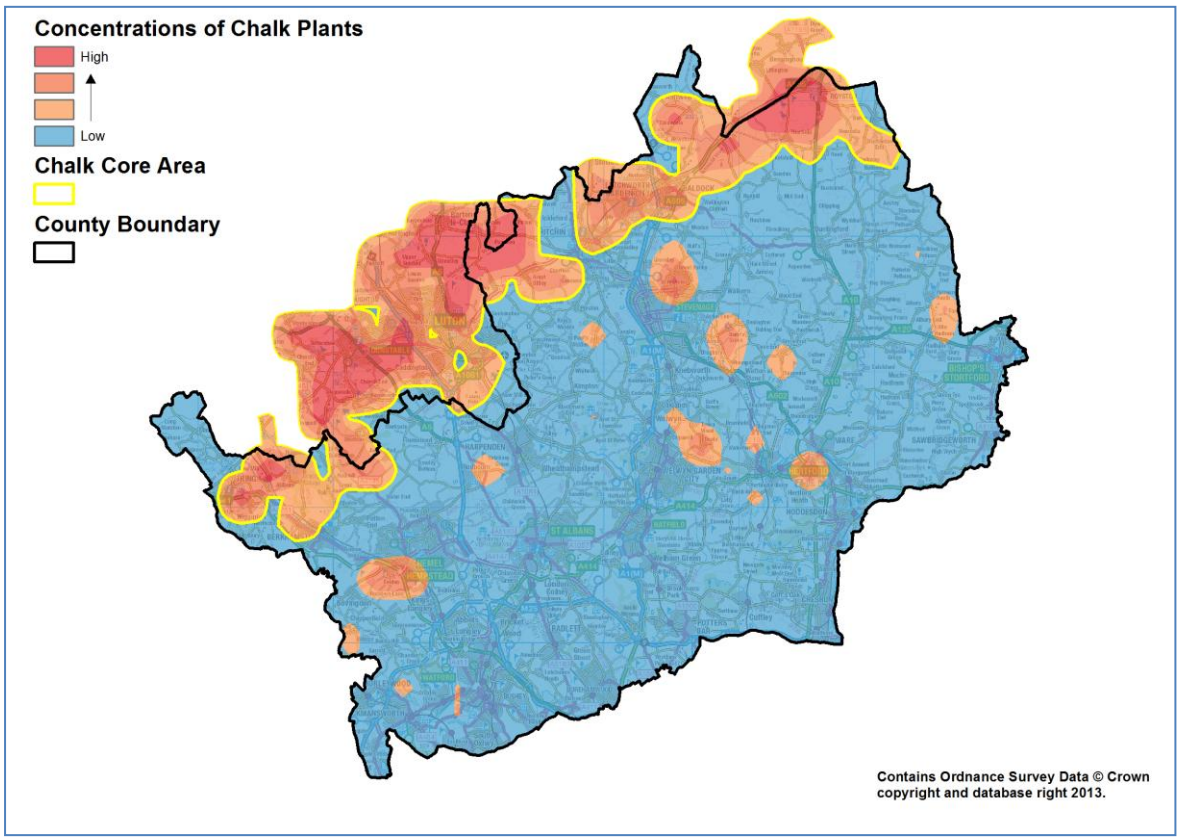

Figure 10. Map of Hertfordshire showing concentrations of specialist chalk grassland plants per tetrad (2km x 2km squares). High concentrations are shown in red through to areas where there are none present shown in blue. Relevant plant data from neighbouring Bedfordshire and Cambridgeshire was also used. A combined strategic chalk core area was identified, represented by the yellow outline.

4.3.2 Acidic strategic core areas

Figure 11 shows a map of Hertfordshire with the results of the processed acidic habitat plant data, identifying concentrations of these plants. These areas indicate where suitable physical conditions exist, such as acidic soils. Similarly to the chalk, acidic habitats occur over much of the county but are mostly found within a single strategic core area. This fits extremely well with the identified Hornbeams & Heaths character area and covers much of the central and southern part of the county, within one coherent ecological unit. This is of high strategic importance in a Hertfordshire context and should be the focus of heathland, acid grassland, oak-hornbeam woodlands, wood-pasture and parkland. Similarly, a second smaller area around Ashridge and Berkhamsted could also be considered a strategic core area with similar priorities.

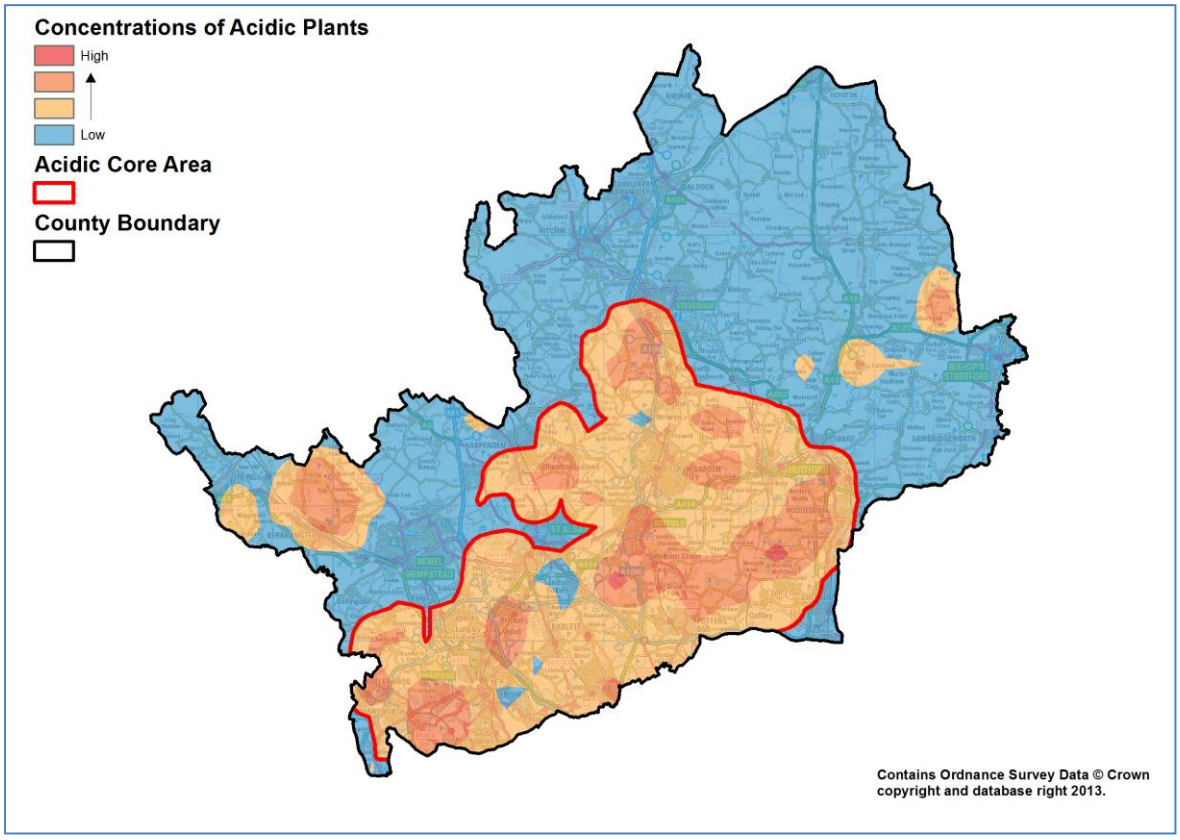

Figure 11. Map of Hertfordshire showing concentrations of specialist acid habitat plants per tetrad (2km x 2km squares). High concentrations are shown in red through to areas where there are none present shown in blue. An acid strategic core area was identified, represented by the red outline.

4.3.3 Wetland strategic core areas

Wetlands are not limited to river corridors but it is within these that the greatest strategic opportunities exist for the creation of wetland ecological networks. Hertfordshire's river systems were previously shown in Figure 1. The two key catchments are the Colne and the Lea, each of which is clearly an ecologically coherent unit. Both are extremely important for their chalk rivers, which are of the highest ecological priority for restoration work in these strategic core areas. Open water bodies, such as gravel pits are very important in their own right and contribute to wider wetland ecological networks and their features need to be protected. However, they are not a priority for expansion. Other wetland habitats, such as wet grassland, wet woodland, fen, swamp and marsh communities naturally occur in a mosaic, dependent on hydrological and other soil conditions. It is a mosaic of these habitats alongside the rivers, appropriate to local conditions, that is the priority for wetland habitat expansion and linkage.

4.3.4 Strategic core areas in relation to National Character areas

Figure 12 summarises the four key landscape-scale strategic core areas for specialist habitats. These are the chalk, the acid and the two river catchments of the Lea and the Colne. The acidic habitats strategic core area fits extremely closely with the Hornbeams & Heaths character area. The chalk strategic core area follows the chalk escarpment across northern Hertfordshire to the Chilterns and is within both the Northern Herts Chalk and the Herts Chilterns character areas. The Colne catchment spans three character areas with its chalk river tributaries arising from the Herts Chilterns character area. The part within the Upper Colne Valley character area is of a different nature than much of the rest in that it is dominated by open water gravel pits here. The Lea catchment covers a large area and many of its tributaries fit well with the Eastern Herts Clayland. The Lea changes nature from Hertford southwards, where it is dominated by open water gravel pits. This part of the catchment marks the boundary between the two character areas of Eastern Herts Clayland and Hornbeams & Heaths.

There were a number of patterns that emerged from the new data and modelled outputs. There were clearly strong fits between specific habitat concentrations, their networks and the NCAs. This is not surprising given that the NCAs were heavily influenced by defining areas of particular habitat distinctiveness, alongside other interlinked factors, such as landscape and soil characteristics. However, new interesting patterns also emerged from the results, particularly along boundaries and transition zones between NCAs. It has already been mentioned in the introduction sections that Hertfordshire is surprisingly variable from one part of the county to the next because it lies across a number of different NCAs. The new patterns that emerge from the results, which are visible in figures 4-9 are the concentrations and diversity of habitats within the transition zones between NCAs. Of particular note is the approximate north-south line from the Broxbourne Woods area, past Knebworth Park and alongside the Hitchin Gap. This broadly follows the transition zone between Hornbeams & Heaths and Eastern Herts Clayland, continuing up to the transition zone between the Herts Chilterns and the Northern Herts Chalk. This is the main north-south mixed habitat network

through the county, of particular note in the context of allowing species to move broadly northwards in response to climate change.

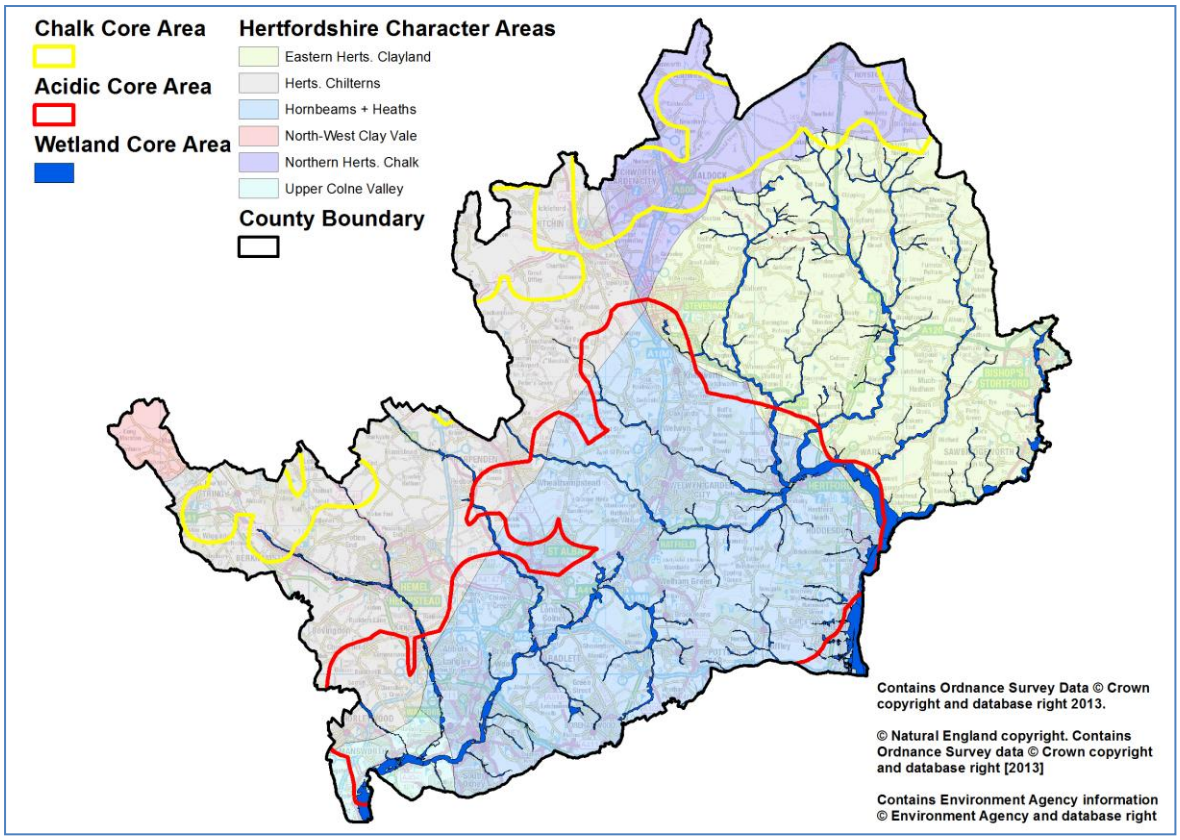

Figure 12. Map of Hertfordshire with identified strategic core areas for focus of specialist habitat network enhancements drawn over the locally interpreted National Character Areas. The chalk area is outlined in yellow, the acidic core area is outlined in red and the two main river catchments of the Lea and the Colne are shown in blue.

4.4 A single combined GIS dataset

Figure 13 shows a map of Hertfordshire with all the project outputs combined into a single GIS dataset. This shows at a glance where habitats already exist and where resources for creation of new habitats should be prioritised. The tabular information accompanying the map data identifies the type(s) of habitat present or to be restored or created in any given location. The single combined dataset is described in much more detail in the publication produced in partnership with the Herts LNP Planning Task Group 'Guidance on applying Hertfordshire's Ecological Networks within the planning system'[17]. This publication was aimed primarily at supporting the planning system (both for plan-making and development management functions). However, its description of the dataset and many of the principles in the guidance on how to apply it are equally applicable to any other use of

the dataset, such as informing strategies, land management, grants and individual projects on the ground.

Much of the detail within this dataset is not readily visible at the county scale, where only strategic patterns are evident. Instead this dataset is best used and interpreted by zooming in to a more local area, where the detail becomes apparent.

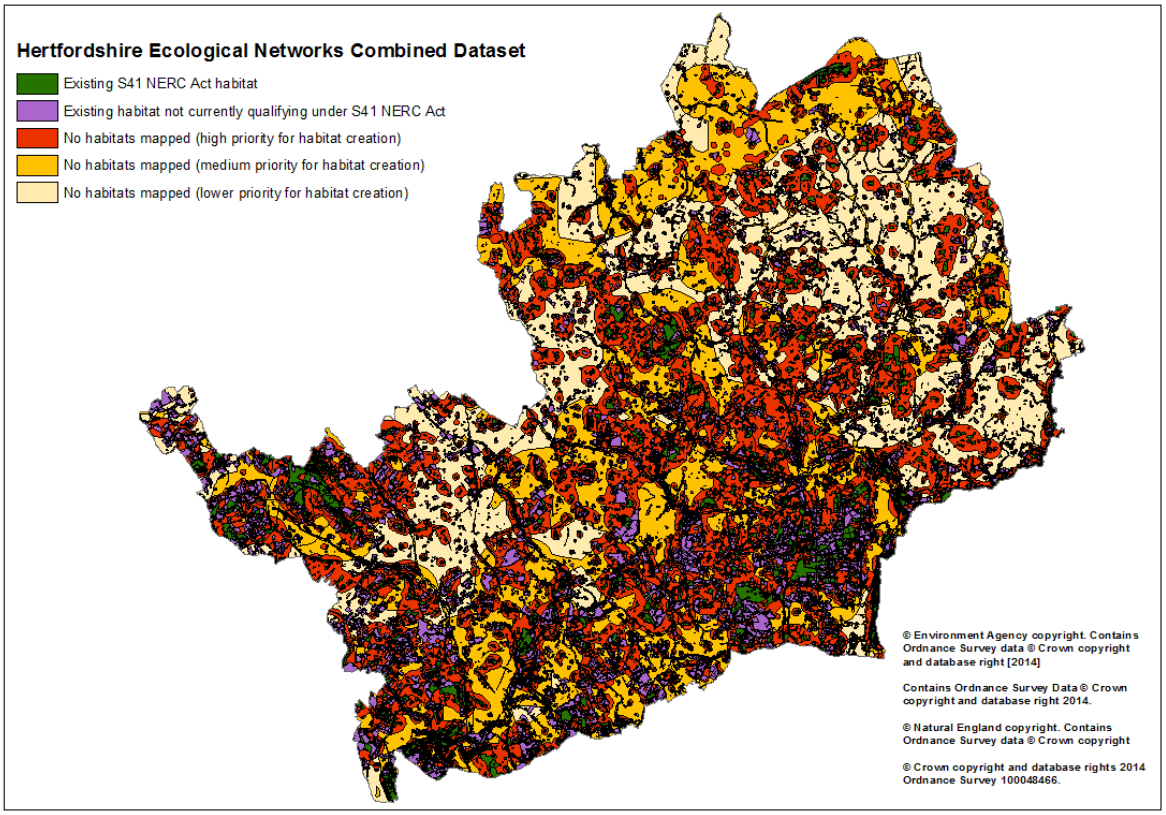

Figure 13. Map of Hertfordshire with all the project outputs combined into a single GIS layer. Existing NERC Act habitats are shown in green; existing poorer quality habitats are shown in purple; the other colours show where no habitats were mapped (orange= high priority for habitat creation, yellow = medium priority for habitat creation, yellow = lower priority for habitat creation).

5 Conclusions and further remarks

5.1 The state of Hertfordshire's ecological networks

Overall habitat network connectivity, and therefore ecosystem integrity and resilience, is currently very poor in Hertfordshire. The general small size of remaining fragments and their relatively large distances from each other means that many areas directly between habitat patches are not recognised as high potential network connectivity by the computer model. The closer and the more clustered the habitat patches, the more likely the model will recognise the importance of the bits of land between them. This is certainly true in the best areas, where good potential connectivity is identified. Elsewhere, over much of the county, complete connectivity between adjacent habitat patches doesn't occur until the lowest values.

The two lowest categories from each habitat potential network model (blue colours) do not contribute meaningfully to the interpretation of potential ecological networks because they cover the whole county. All the other categories show where priorities can be predicted for habitat creation projects, with the blue categories representing the areas where no meaningful priority can be predicted.

5.2 Where to prioritise efforts

Greatest habitat creation effort clearly needs to be put into the highest priority potential connections around and between existing habitat patches, as predicted by the computer model output maps. However, because of the poor starting point of Hertfordshire's habitat connectivity, many apparently low priority areas might actually be very important in practice. If a potential connection looks intuitively important by eye, or there is a physical opportunity on the ground, it should not be disregarded even if it is not prioritised by the model. **The model outputs are not definitive and can only be used as a guide, with decisions also needing to be informed by available practical opportunities and professional judgement.** For example, a road verge in need of restoration could present an opportunity where something could realistically be achieved. A long stretch of new linear habitat through an area the model is currently predicting as low priority could actually be of huge benefit and link up part of a network that may have previously not been apparent.

The four strategic core areas of the chalk, the acid, the Lea catchment and the Colne catchment identified by the project represent landscape-scale strategic priorities, each with distinct objectives. They complement prior existing knowledge, whilst providing new evidence and understanding. The acid and chalk strategic core areas are an extremely close match with Dony's[13] 'botanical districts'. They fit well with National Character Areas and reflect previous or existing partnership aspirations in and around Hertfordshire. All four strategic core areas identified (chalk, Hornbeams & Heaths, Colne and Lea Catchment) were put forward in some shape or form to the

Nature Improvement Area competition. Of these the Lea Catchment made it through to the final round of the competition and has since been endorsed by the Hertfordshire Local Nature Partnership and received national funding. The Lea Catchment also aligns with catchment management plans, of which the ones in the Lea Catchment are, in effect, the main delivery mechanism and plan for the NIA.

5.3 Choosing between different habitats to create

The single combined GIS dataset indicates the most appropriate habitats to create for any spot in the county. **However, habitats occur in mosaics across the county and there are a number of overlaps between potential individual habitat networks.** The models therefore cannot always define a single priority habitat for a given location and it is important to ensure that the needs of one habitat are not sacrificed for another when designing habitat creation projects. **Areas of overlap were identified within the project results and within these areas particular care needs to be taken when choosing which habitat or mixture of habitats to create.** No hard rules for making such decisions are proposed here, and it is recommended that ecological advice is sought for projects in areas where more than one habitat is indicated by the dataset. In more general terms, landscape-scale ecological principles clearly apply. For example, a location immediately adjacent to a high-quality existing habitat (e.g. SSSI, ancient woodland, unimproved grassland) would favour the creation of the same habitat type as the adjacent one. Strategic core areas were identified for the most physically restricted habitats (e.g. the chalk and acidic strategic core areas and river corridors), and within these areas the corresponding identified habitats (chalk grassland, acid open habitats and wetlands respectively) would normally be prioritised. Given that heathland and grasslands in Hertfordshire are its most threatened and rare habitats, it is important to protect or restore existing patches of these, depending on condition, rather than creating a wooded habitat over the top of them. Beyond these principles, Natural England has identified priorities for each NCA, and this has been taken further here to provide additional Hertfordshire-specific detail. For more information refer to Natural England's NCA profiles on their website and to sections 2.3.3 to 2.3.8 of this report.

5.4 Interpreting general patterns in ecological networks

A number of patterns can be interpreted from the results of both the individual potential habitat network maps and the map of overlaps between these. **In some cases, patterns evident in the data may help inform strategic priorities for both local and landscape-scale restoration of ecological networks**. Some of the patterns have been described in this report, namely the fit of newly identified strategic core areas with NCAs and the new information on the importance of transition zones between NCAs, often being where the greatest diversity of different habitats occur together. Of particular note is the broadly north-south mixed habitat network between Broxbourne and Hitchin.

5.5 Uses of the habitat network maps

There are a number of uses for the potential habitat networks maps. They can inform where the greatest benefits are likely to be achievable through **strategic landscape-scale projects** and partnerships such as Nature Improvement Areas. **They can inform landowners or individual conservation projects** as to what the habitat restoration and creation priorities may be in a given location. They can inform **green space management strategies**. They can help provide evidence of priority or need in relation to **land management grants** or project grants. **They can inform local plans**, identifying where the best opportunities are likely to be for delivering the new objectives on enhancing ecological networks in national planning guidance. **They can alert developers and planning authorities to where the greatest sensitivities are likely to be in relation to the protection and enhancement of ecological networks, as well as where there is greatest potential for biodiversity gains from development**. Potential habitat network maps on their own should not be considered a barrier to development. Indeed, sensitively planned new development can contribute positively to ecological networks. This is reinforced by the new emphasis on the promotion of ecological networks in the national planning guidance. The potential habitat network maps are **a local tool for informing masterplan design, principles of sustainability, and pointing developer contributions and biodiversity offsets (as appropriate) to where they can be of most benefit.**

5.6 Limitations in relation to soil and hydrological data

Soil and hydrological factors affecting the exact distribution of sensitive habitat types were only able to be interpolated, meaning very local variations occur, not able to be predicted by the computer models. If more reliable soil data became available, or if this modelling approach were to be adapted to other parts of the country where such reliable data may exist, it would be possible to use GIS to further rationalise the modelled potential habitat networks by using soil data as a 'cookie-cutter'. This would ensure that modelled networks for those habitats sensitive to particular soil conditions were completely limited to just the relevant soil types. In absence of such data, **individual habitat restoration or creation projects coming forward for habitat types sensitive to soil conditions will need to be further informed on a case-by-case basis by a site-specific survey of the soil and physical geography**.

5.7 Using this report in conjunction with other reports

The potential habitat network maps and guidance within this report should be used in conjunction with guidance in the Hertfordshire Biodiversity Action Plan[1]. That document details priority actions, and their rationale, for each habitat type. Much of the spatial guidance in the Biodiversity Action Plan has now been superseded by the new potential habitat network maps and updated Hertfordshire character area descriptions but the detail of habitat-specific actions, and suggestions for unlocking some of these within today's economic drivers, are still highly relevant and are not

therefore repeated here. Likewise, Natural England's NCA profiles contain complementary Statements of Environmental Opportunity.

Herts & Middlesex Wildlife Trust recently produced a guidance document on 'How to Build a Living Landscape'[2]. This document identifies four of the main land uses in Hertfordshire and suggests how each of these can contribute to restoring ecological networks. That publication should be used in conjunction with this project report to help inform which habitats to build into the land use for a given location.

It is important to recognise that **this project created a spatial framework in order to inform decision-making and spatial priorities, rather than a detailed action plan**. Such a plan requires a very detailed knowledge of opportunities on the ground and a scoping of potential projects. It would be unrealistic to try and achieve this level of detail over the area of the whole county. Therefore, it is important that future partnerships within a defined spatial area, such as Nature Improvement Area (NIA) proposals, take the new evidence-base a step further. It needs to be used, in conjunction with real opportunities on the ground, to inform and prioritise projects with the buy-in of all stakeholders.

Once habitat improvement or creation projects have been delivered it is important to notify the Hertfordshire Environmental Records Centre (HERC) so that it can be used to monitor cumulative progress towards the LNP's vision of a resilient natural environment. It will also inform future iterations of the computer models to take into account the improved network and the resulting new priority areas.

6 References

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