Woodland history and management in the Oxfordshire Chilterns: implications for the future.

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ABSTRACT

During the 20th century, woodland fragmentation and changes in composition have had an impact on the woodland ecology of lowland England. Government policy which initially focussed on softwood timber production, now aims to protect, enhance, restore and expand native deciduous woodland. These initiatives arguably will have the greatest ecological impact if they employ a landscape scale approach to ensure maximum woodland connectivity whilst retaining landscape character.

This research investigated woodland change over the last 160 years in the Oxfordshire Chilterns. The Chilterns, characterised by beech woodland, is one of the most wooded areas in lowland England. Digital analysis of two types of historic maps, combined with historic documentary evidence, enabled a quantitative analysis of woodland composition alongside comparison of change over time. The research investigated hypothetical future scenarios for both woodland creation, based on historically wooded sites identified by the research, and restoration of non-native plantations to native species. These scenarios were shown to improve woodland connectivity and to increase patch size in comparison with BAP targets. These methods allowed the retention of the characteristic mosaic Chiltern landscape.

Between 1840 and 1883, woodland extent reduced by only 4.6% but by 1883, 16.96% of native deciduous woodland had been converted to mixed woodland. In the 20th century, native woodland increased by 7.6%, still 12% less than in 1840, but mixed (26.13%) and coniferous woodlands (9.73%) increased markedly due to Government policy. These changes resulted in increased fragmentation of native deciduous woodland over time. Future restoration and creation scenarios improved woodland connectivity by increasing patch size and reducing near-neighbour distance; but to reach 30% woodland cover to create a habitat network, total woodland restoration combined with woodland creation is necessary, far exceeding BAP targets.

In this research, historic information identifies regional native woodland type and past management which needs to be recognised in policy and information dissemination. More importantly, it provides the information necessary to retain the local cultural landscape pattern while enhancing ecological connectivity and is therefore a valuable method which could be applied elsewhere.

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ABBREVIATIONS and ACRONYMS

AD	*Anno Domini* Year of Our Lord
AONB	Area of Outstanding Natural Beauty
ASNW	Ancient Semi Natural Woodland
BARS	Biodiversity Action Reporting System
BC	Before Christ
BEETLE	Biological and Environmental Evaluation Tools for Landscape Ecology
BAP	Biodiversity Action Plan
BP	Before Present
CFA	Core Forest Areas
CHLU	Chiltern Natural Area Land Use
CLFDP	Chiltern Landscape Forest Design Plan
CROW	Countryside and Rights of Way Act
CTA	Oxfordshire Conservation Target Area
DEFRA	Department for the Environment, Food and Rural Affairs
EC	European Community
ETWF	Strategy for England's Trees, Woods and Forests
FC	Forestry Commission
FDP	Forest Design Plans
FWPS	Farm Woodland Premium Scheme
GIS	Geographical Information System
HAP	Habitat Action Plans
HLC	Historic Landscape Characterisation
HLS	Higher Level Scheme
JIGSAW	Joining and Increasing Grant Scheme for Ancient Woodland
JCA	Joint Character Areas
JNCC	Joint Nature Conservation Committee
LARCH	Landscape Analysis and Rules for the Configuration of Habitat
LBAP	Local Biodiversity Action Plans
MM	MasterMap
NCC	Nature Conservancy Council
NNR	National Nature Reserve
NVC	National Vegetation Classification
OE	Old English
OHER	Oxfordshire Historic Environment Record
ONCF	Oxfordshire Nature Conservation Forum
ORO	Oxfordshire Record Office
OS	Ordnance Survey
OWLS	Oxfordshire Wildlife and Landscape Study
PAWS	Plantations on Ancient Woodland Sites
SAC	Special Areas of Conservation
SCI	Sites of Community Importance
SAP	Species Action Plan
SSSI	Sites of Special Scientific Interest
TVERC	Thames Valley Environmental Records Centre
UKBAP	United Kingdom Biodiversity Action Plan
WCG	Woodland Creation Grant
WGS	Woodland Grant Scheme

WIGS	Woodland Improvement Grant Scheme
WMG	Woodland Management Grant
WRG	Woodland Regeneration Grant
WPG	Woodland Planning Grant

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Chapter 1
Introduction

1.1 Introduction

The combined impact of forestry policy following the First World War and agricultural policy post-Second World War resulted in loss of natural habitat on a wide scale across lowland England during the 20th century. However, over the past two decades, steps have been taken to reduce and reverse this process. Government legislation and policy, partly driven by the EU Habitats Directive (1992), has resulted in formal requirements to maintain and enhance biodiversity in the UK. The United Kingdom Biodiversity Action Plan (UKBAP) published national objectives for habitat enhancement and maintenance which are translated into regional and local conservation targets for species (Species Action Plans SAPs) and habitats (Habitat Action Plans HAPs).

Similarly, the Forestry Commission (FC) reversed its policy of commercial forestry, focussing instead on woodland conservation, culminating in 2005 with the publication of "Keepers of Time: A Statement of Policy for England's Ancient and Native Woodland" in conjunction with DEFRA. This policy aims to increase the area of native woodland and maintain the area of Ancient Semi Natural Woodland (ASNW); to improve and maintain the ecological condition of ASNW; to improve the landscape context of woodland and conserve the cultural heritage associated with ancient woodland. Woodland Grant Schemes now have a similar emphasis on conservation rather than economic timber production.

It is generally recognised that a landscape scale approach is more widely beneficial to conservation objectives that a purely site or species approach (Selman, 2006). It should ensure that sites chosen for habitat creation or enhancement will operate in a functional way with other sites by enlarging, linking or reducing the distance between existing areas, thus providing the potential for species to expand their range or move more easily through the landscape (Forman, 1995; Peterken, 1992; McKernan, 2004; Quine and Watts, 2009). However, these initiatives provide little guidance on methods of identification of suitable sites for habitat expansion thus risking wasted effort and funding on randomly chosen sites

which may have no real ecological benefit in relation to existing sites (Davies and Pullin, 2006; Bailey, 2007). There is also a danger that generalised woodland targets or management may be inappropriate in certain situations where there is a strong local or regional character (Griffiths *et al.*, 2009). There have been several pilot projects and research studies to identify methods for targeting sites for habitat creation (Van Rooij *et al* 2004; Watts *et al.*, 2005; Griffiths *et al.*, 2009). However there is a risk that some may be too labour intensive or complicated to achieve when funding is reduced or for small local projects, for example at parish level.

The Chilterns Area of Outstanding Natural Beauty (AONB) was chosen as a study area because of its extensive woodland and its distinctive character. Although in many ways typical of woodland elsewhere in England, the Chilterns have other features which have had little investigation. The Oxfordshire Chilterns in particular were used as the study site; they remain the least developed area of the AONB with no major towns or roads, has a discrete shape and suitable extent and the research material was relatively easy to access.

The policies, initiatives and issues outlined above are highly relevant to the Chilterns which is famed for its expansive beech woods and characteristic mixed landscape. Lowland Beech *Fagus sylvatica* and Yew *Taxus baccata* woodland is one of several woodland related Habitat Action Plans (HAP) target for conservation and enhancement (UKBAP d, undated). There has been a loss of habitat over the past 60 years and existing beech and yew woodland is currently under threat of damage from a number of human and natural causes. The Chilterns is a key area for this habitat which is important for several priority species including rare and threatened fungi and mosses.

HAP requirements are to ensure that designated habitats should be brought into good condition by appropriate management, while non-designated sites should also be brought into favourable condition. It is aimed to increase the extent of beech and yew woodland by 1,500 ha, through colonisation or planting on unwooded sites or by conversion of non-native plantation sites by 2010, with a further 1,500 ha by 2015. A further 1,500 ha will be converted on planted ancient woodland sites by 2015 (UKBAP d, undated). However this national expansion and/or conversion target is only 15% of the current total habitat (estimated to be 30,000 ha) and therefore is limited in the benefits it can provide country wide.

Chiltern ASNW is protected by Forestry Commission policy and Planning Policy Statement 9: Biodiversity and Geological Conservation (2005), while the Ancient Woodland Inventory is to be updated imminently (John Morris, Chilterns Conservation Board, personal communication). The Chilterns AONB Management Plan (2008-13) encompasses these and other policies and initiatives; it also includes a reference to landscape scale initiatives for extending and connecting fragmented habitats. However it is also important that in implementing targets and identifying sites, the character of the Chilterns is also maintained.

The identifying 'character' of any area contains several components, both natural and anthropomorphic. The underlying geology has an influence on the topography and soils, which in turn relates to the natural and man-made environment. The importance of these factors were recognised in the designations of Landscape Character Areas and Natural Areas, which were combined into Joint Character Areas, now known as National Character Areas (Natural England, undated). The Chilterns is one of 159 National Character Areas in England. The historical aspects of the character are identified through the Chilterns Historic Landscape Characterisation project (HLC), again using a landscape approach, rather than focussing on specific sites and monuments, and provides an understanding of how the landscape developed over time as well as identifying historical patterns in today's landscape.

Chiltern beech woodland is different in composition, past management and use to that of other parts of England. Therefore, in order to apply national conservation or enhancement policies successfully, an understanding of these differences, how and why they developed in the past and their impact in the present day is important to ensure that the Chilterns retains its identity both natural and cultural and will assist in helping to achieve increased biodiversity as indicated in the Biodiversity Action Plan (BAP).

1.2 Aims and objectives

This research has a large interdisciplinary component as it comprises historical, ecological and social topics which are illustrated below in Figure 1.1.

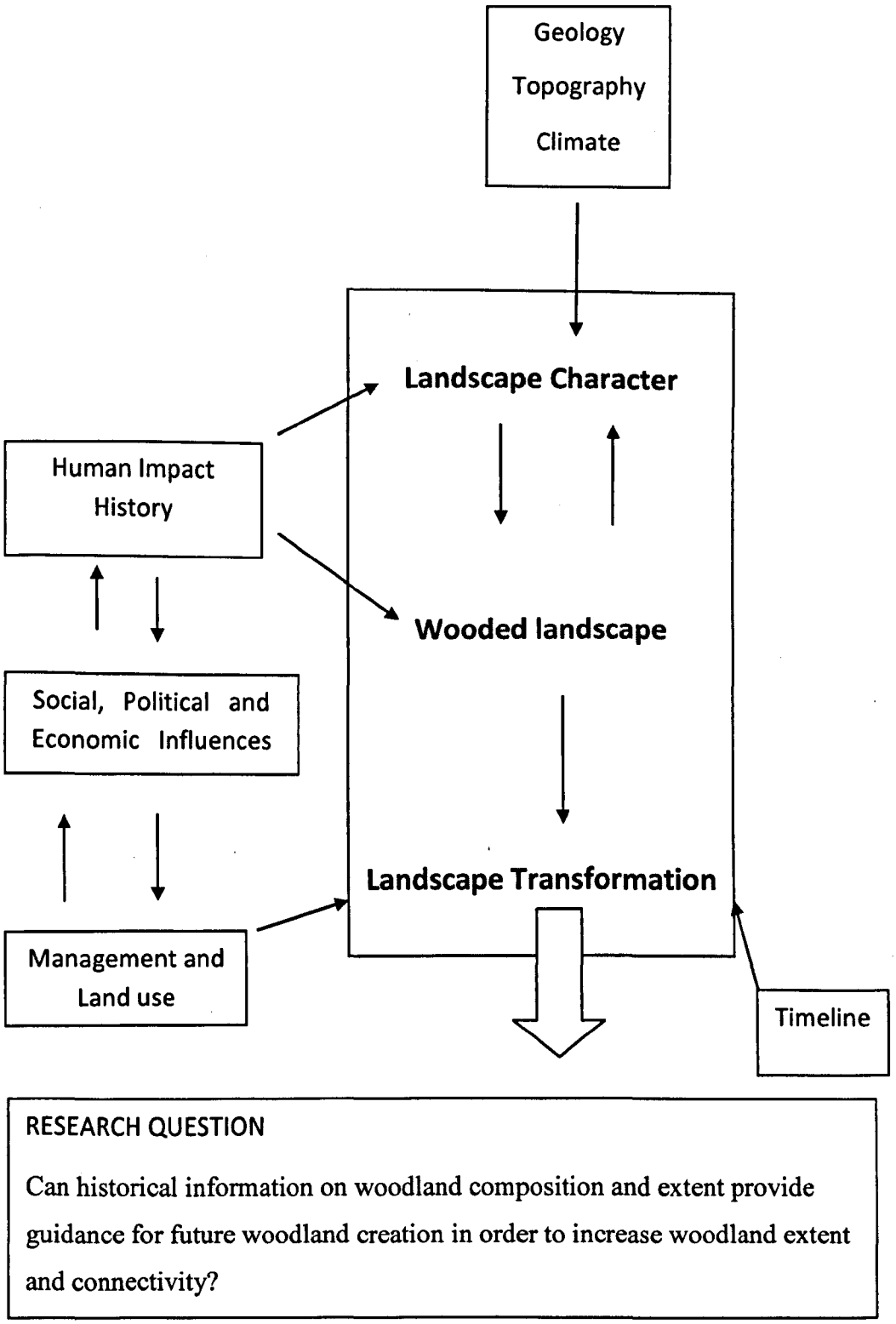

Figure 1.1 The range of subject matter included in this research

The aim of this research was to investigate the use of historical information in site selection for new woodland creation and the potential ecological benefits of such targeted woodland creation and restoration.

The research objectives were:

- To summarise topics and policies relevant to lowland English woodland and to the study area;
- To research a range of historical and documentary sources to ascertain the historical extent of *Fagus sylvatica* (beech) and its uses in the study area;
- To digitise and analyse historical maps from 1840 and 1883 to compare with Ordnance Survey MasterMap 2007. This will identify changes in woodland extent and composition over time.
- To use identified ex-woodland sites for selection in GIS for hypothetical woodland creation and to create hypothetical future scenarios of combinations of creation and restoration to native woodland. This will include investigation of the practical actions necessary to achieve an ideal woodland cover of 30% functioning as a Core Forest Area.
- To analyse the value of this method on reducing woodland habitat fragmentation by increasing area and decreasing inter-patch distances
- To evaluate the success of the data and methods used and the feasibility of their practical application and to indicate the potential for further work

The following chapter outlines in more detail the background to this research, describing the ecological issues and policies relevant to fragmented woodland in England and to the Chilterns in particular.

Chapter 2

Background to the Research

This chapter reviews topics and policies relevant to fragmented woodland in England and to the Chilterns in particular.

2.1 Changes in ancient and recent deciduous woodland

There has been a widespread reduction in natural or semi-natural habitats in lowland England in the 20th century, which accelerated after the end of the Second World War (Hopkins and Kirby, 2007). Prior to this, although causing great change over time to the original wild landscape, farming and forestry practices were of low intensity until the late 19th century, and were formative in the development of our semi-natural habitats e.g. chalk grassland, species-rich hedgerows and ancient woodland.

Ancient semi-natural woodland (ASNW) is woodland that can be dated by map or documentary evidence to have existed as continuous cover at least since 1600AD in England. It is not "wildwood" ie untouched by human interference, but has been managed and utilised by humans for many thousands of years. The use of long term management of woodland such as coppicing or pollarding, often but not always, in combination with standard trees, provided a constant supply of wood and timber products in the past; other uses for woodland materials include the removal of leaf litter (particularly beech) and bracken for bedding which seems to have had the effect of reducing the soil nutrient levels (Burgi and Gimmi, 2007). Ancient woodland as seen today is the result of this long-term management and the specialised flora and fauna which favour this habitat have adapted to such disturbance regimes.

However, ASNW has often developed on previously open or farmed land abandoned many centuries earlier (Day, 1993). It is clear that over time there have been many ebbs and flows in woodland cover, between woodland to agricultural land or settlements and back again. These land use changes have had an effect on ASNW and on more recent woodland.

Studies have shown that within ASNW, due to earlier land use, some dating from Roman occupation and agriculture 2000BP, soils (Verheyen *et al.*, 1999), seed banks, forest vegetation and diversity (Plue *et al.*, 2008) exhibit changes. These changes are also found in ASNW with different underlying geology and woodland types on former Roman sites (Dupouey *et al.*, 2002; Dambrine *et al.*, 2007). Prehistoric fields and common land in Denmark, now wooded for 2,000 years, still show the effects of this ancient land-use in the soil types (Kristiansen, 2001). The same effect has been noted in the United States, Mexico and Puerto Rico (Foster *et al.*, 2003) and in Ethiopia (Lemenih and Tektay, 2005). A similar picture appears in more recent woodland planted over the past 200 years on previously arable and pasture land, although with lesser impact on the latter (Koerner *et al.*, 1997) In the study area there are traces of past habitation, farming and other activities within the woodland, although to date no study of the effects of these have been undertaken (Morris, 2009). This pattern can also be seen in Ecclesall Woods, Sheffield, where over 1000 archaeological finds and features demonstrate the underlying history of many ASNW sites in the UK (Rotherham, 2007).

Late 19th and 20th century changes in woodland management, composition and extent had an effect on woodland biodiversity. The change from management for coppice-with-standards to high forest nationally is illustrated by Forestry Commission Census data dating from 1947 when coppice was still 21% of the total area of broadleaved woodland but by 2002 this was only 2.6% (Hopkins and Kirby, 2007). These changes have resulted in a reduction of the richness of woodland biodiversity (Goldberg *et al.*, 2007; Rackham, 2008) and of the quantity and species richness of the seed bank (Van Calster *et al.*, 2008). During the past 30 years there has been little management of broad leaved woodland and only about 30% of private woodland in England has either a felling licence or a woodland grant scheme (Hopkins and Kirby, 2007).

Conifers were planted in large numbers during the 20th century up to about 1980, particularly on sites which were previously deciduous, an estimated 37% of woodland, (Peterken, 2000), which has had a marked impact on the biodiversity and landscape in the study area and elsewhere in the UK. The effects of coniferisation include acidification and podzolization of soil, and in evergreen woods little seasonal variation affects ground flora (Peterken, 1993). Although European larch (*Larix decidua*) is deciduous, it has a similar

effect on the soil due to the slow decomposition of fallen needles (Grieve, 1978). However larch casts a less dense shade than other conifers and therefore allows more ground flora, which tends to be dominated by Blackberry (*Rubus*) species on fertile soils (Hill, 1979). Marked changes in composition have a similar effect to a reduction of woodland cover and leads to more fragmentation of ASNW and deciduous woodland in general. Coniferous plantations on previous agricultural land may have some biodiversity benefit for woodland species by acting as a more hospitable matrix than intensively farmed land e.g. by providing shelter or food, but conifer planting on previously wooded sites or on other lowland natural areas is generally agreed to be detrimental to biodiversity (Brockerhoff *et al.*, 2008). However, biodiversity quality is dependent on age of stand, upland or lowland sites and canopy density. Plantations on ancient woodland sites (PAWS) appear to have a higher diversity than plantations on previously unwooded ground (Quine and Humphrey, 2003).

In recent years there has been a move towards planting broad leaved trees, mainly as a result of recent Forestry Commission policy (see 2.4.1). Recent estimates from the Countryside Survey (2008) show that there has been a 6.9% increase (93,000 ha) in broadleaves between 1998 and 2007 in the UK which however has to be balanced by a loss of 15,000 ha between 1990 and 1998 so a net gain of 4.7% since 1990. The latest increase recorded in 2007 is on land previously recorded as neutral and improved grassland, coniferous woodland, arable and horticultural land (Countryside Survey 2008). It is suggested that coniferous plantations on previously wooded sites e.g. ASNW, can be more readily restored to native woodland than those on previous agricultural land, partly due to the possible survival of remnants of native vegetation or their propagules within the plantation (Eycott *et al.*, 2006). Research has shown that dormant seed banks survive under coniferous nurse-crops for 25-30 years although the majority are more typical of coppicing or post-clearance vegetation rather than woodland species. This is probably due to both deep shade and accumulation of humus and leaf litter (Pigott, 1990). In contrast, woodland planted on recently deforested agricultural land is unlikely to gain from woodland seed banks, due to their non-persistence (Hermy and Verheyen, 2007). However, there will be differences between woodland planted prior to World War II and that planted afterwards, due to the increased use of fertilisers in agricultural soil (Hopkins and Kirby, 2007).

2.1.1 A special case – the Chilterns beech woods

In the Chilterns, the woods have contained a greater proportion of beech than other species for many centuries and in order to utilise beech, a selection system was used for both coppice and timber (Plot, 1705; Roden, 1968; Peterken, 1993) which involves cutting individual stems or trees when they are the desired size, instead of the more usual hazel coppice with oak standards found in lowland England. Chiltern selection felling of timber is noted in several historic records (See Chapter 3) and became increasingly used during the 19th century when chair-making became a factory-based industry. Woodland resulting from this management was therefore uneven aged with small gaps in the canopy. This type of woodland is said to be diverse and of conservation interest probably due to its uneven age (Reilly, 2006). Due to the very local occurrence of this type of woodland management in England, very little literature relating to it has been found, although in the Appenine mountains of Italy and in France, a similar type of management was widespread (Coppini and Hermanin, 2007; Ciacio *et al.*, 2006). One of the current perceived problems of Chiltern beech woodland is that it is even aged and over-mature. However it has been demonstrated that this is not necessarily the case; Peterken (1993) found that beech felled in Hailey Wood in 1965 was a mixture of ages ranging from 80 to 250 years, although it all appeared to be even aged. This spread of ages is similar to that which would be found in a natural regenerating wood and reflects the past management of selection felling in the Chilterns (Clements, 2001).

The effects of historic management have been shown to affect beech woodland structure for many hundreds of years (von Oheimb *et al.*, 2004). The main impacts on beech woodland flora include gap size, light availability, and herbivory (Naaf and Wulf, 2007), therefore the general lack of management during the 20th century and especially post World War II may have had an adverse effect on flora whilst the increase in deer populations has a serious effect on both ground flora and regeneration (Peterken, 1999; Countryside Survey, 2008). It is difficult to assess whether changes in woodland management in the Chilterns, since the cessation of selection, have had an impact on woodland flora since there is no point of comparison; however this could possibly be demonstrated by an in-depth search and analysis of historical records of flora in the area.

Lack of natural regeneration is another concern in the beech woods of the Chilterns and may be due to several causes. Historically, beech either regenerated naturally in gaps

created by selection management or, if dense areas of regeneration occurred, seedlings were moved to fill gaps elsewhere (Young, 1813). In addition, regular soil disturbance during removal of timber or wood may have assisted in regeneration (See 3.12.2; Savill, 2001). As beech has been unmanaged for many years, the canopy is now dense with few gaps, although some gaps were caused during the storms of 1987 and 1991, as well as by other locally severe gales since then. Some regeneration has occurred in these gaps, but its success is then related to other factors, such as light levels, competition from brambles (*Rubus fruticosus agg*) and limited dispersal into open spaces (Mountford *et al.*, 2006). Regeneration needs a good supply of mast to allow for low levels of survival and to be successful. This depends on warm summer temperatures, which since the 1940's were comparatively rare in Britain.

Climate change in southern England may become a threat to beech survival, particularly on dry chalk soils and also because of low winter temperature requirements for germination (Savill, 2001). However, beech will tend to survive further north beyond its current natural range. In the Chilterns, north facing valley sides, the variety of soil types, as well as the elevation and therefore marginally lower temperatures, may enable beech to survive, if not in the current numbers (Kirby, 2001). Rackham (2008) suggests that there will not be a problem for beech nationally as it is not currently at its northern limit.

There are two immediate causes of damage to Chilterns woodland which have an effect not just on the present woodland but also on those of the future. The greatest current threat to the health of beech woodland in the Chilterns is the grey squirrel (*Sciurus carolinensis)*, introduced in 1876, which causes a huge amount of damage to beech trees, mainly those less than 50 years old, stripping bark at the base of branches so weakening them and causing breaks later. Up to 75% of younger trees are affected which has severe implications for the future (Rayden and Savill, 2004). Other species such as oak (*Quercus robur*), hornbeam (*Carpinus betulus*), birch (*Betula pendula*) and field maple (*Acer campestre*) are also affected, although ash (*Fraxinus excelsior*) and wild cherry (*Prunus avium*) are less often damaged. Young trees may never develop properly after a severe attack either growing in a stunted bushy form, often oak, or dying after being ring barked as often happens to young beech. Bark on smaller branches in the canopy of mature trees is often eaten on one side which can leave them liable to break when they have grown to about six inches in diameter. In some years damage can be very widespread, such as in

2008, when mature trees were damaged at ground level with long strips of bark up to 12 inches long being taken off. It is likely that an increase in grey squirrel populations, resulting from a preceding good mast year and a series of mild winters, results in extra pressure as dispersing young males are causing extra damage http://www.chilternsaonb.org/downloads/publications/notw39.pdf). Interestingly, in 1838, the "squirrel" presumably the red squirrel (*Sciurus vulgaris*) was also considered a pest of young beech trees, feeding on the lower bark. It also attacked larger beech and hornbeam stripping 3 to 6 inches of bark and eating the inner bark and soft wood. The remedy was to coat the trunk with tar and grease for 5 to 6 feet to deter them (Loudon, 1838).

Deer are another major problem in the Chilterns. Damage by fallow deer (*Dama dama*), muntjac (*Muntiacus reevesi*) and roe deer (*Capreolus capreolus*) is causing a reduction in natural regeneration and growth of young trees, many which are planted, with the result that land owners are increasingly wary of spending money on planting and managing woodland. The recent increase in deer populations (Countryside Survey, 2008), and therefore browsing, is having a detrimental effect on beech regeneration. In the study area, free roaming herds of fallow deer are a major problem along with muntjac and roe deer generally across the whole Chilterns. In Germany, areas of natural regeneration are fenced for about 15 years to reduce herbivory by deer i.e. until the fence collapses (Savill, 2001). Deer grazing adversely affects woodland regeneration and ground flora which is selectively grazed often leading to loss of rare woodland species. Control of both deer and squirrels is difficult although initiatives are underway for co-operative efforts (Chilterns AONB, 2008).

2.2 Spatial structure in woodland ecology

Adverse changes in spatial structure of woodland at the landscape scale have had negative effects on woodland biodiversity. Reduction in woodland size and number has resulted in loss of connectivity between woodland patches with a detrimental effect on colonization and spread of woodland specialist species (Grashof-Bokdam and Geertsema, 1998). Open areas within woodland are favoured by certain species and tend to be situated in large woodland patches, therefore smaller sized patches result in a loss of opportunity (Peterken, 2000). Smaller woods have a proportionally greater edge effect which increases the

likelihood of invasion by non-woodland species and more damage by wind and crop spray. Changes in woodland shape also relate to the edge effect, the core area and the surrounding matrix. All these factors brought about by a reduction in woodland extent and composition have had a marked impact on woodland biodiversity across the range of species, therefore it is important to recognise them in any planned woodland restoration or replanting initiatives.

2.2.1 Fragmentation

Woodland in lowland England is a fragmented habitat and has been for several thousands of years (Rackham, 1986). Woodland covered approximately 75% of the country during the post-glacial period (Peterken, 1993) until the impacts of human clearance started to take effect. Rackham (1986) estimated that broadleaved woodland had been reduced by 50% by the Iron Age and to 15% by 1086, compared to around 7.8% in England today (Countryside Survey, 2008) with many woods now small and physically isolated from each other. Woodland clearance was not a random event but focussed on the best sites for agriculture, leaving woodland on slopes, poor soil and on hillsides. Woodland fragmentation results in both habitat loss and smaller isolated remaining patches, therefore it is difficult to distinguish between these effects in terms of biodiversity loss (Laurance, 2008). Work by Peterken (2000) indicates that in a landscape with less than 30% woodland, ecological isolation between them is severe. When woodland has more than 30% landscape cover, isolation is reduced, woodland species are more resilient and can react more easily to change in woodland pattern. In long-term well wooded areas such as the Chilterns, colonisation of secondary woodland occurs more rapidly than in sparsely wooded areas, as identified by Verheyen *et al.* (2006). For this reason in the Chilterns it is often difficult to distinguish between deciduous PAWS and ancient woodland, to the extent that in the forthcoming update of the Ancient Woodland Inventory the PAWS designation will not be used (Patrick McKernan, English Nature personal communication, 2010).

2.2.2 Matrix

The reduction of linkage or connectivity between woods decreases the potential for species movement between woodlands (Peterken, 2002), although this depends on their dispersal mode and motility and the type of landscape they have to cross. Historically, the agricultural countryside in England between woodland patches was semi-natural, with no inorganic fertilizer input and no pesticide, but it has become an increasingly hostile

landscape post-Second World War with high inputs of fertilizer and pesticides on arable land and grassland to promote growth, at the expense of flowering plants and associated biodiversity (Opdam *et al.*, 1993). Isolation is therefore exacerbated by the surrounding intensive landscape or matrix (Watts *et al.*, 2005). There have been suggestions that an improvement of the matrix can aid transfer of species between fragments by "softening" the matrix and increasing its naturalness by, for example leaving wide strips of uncultivated land at field edges or by planting small areas of trees to act as stepping stones, although this provides the greatest benefit for more motile generalist species, rather than those with poor powers of dispersal (Donald and Evans, 2006; Uezu *et al.*, 2008). However, the matrix surrounding woodland is unlikely be uniform but varies across a wide range of landscape types, for example, across a gradient from natural grassland to urban buildings (Kupfer *et al.*, 2006), or in the case of PAWS patches of ancient woodland may survive, isolated amongst conifers, which form the matrix (Kirby and Thomas, 1994). It has been shown that, in small patches of woodland, the vegetation composition and diversity is positively related to a more natural adjacent land cover e.g. scrubland than heavily grazed grassland (Hersperger and Forman, 2003). The aim of matrix improvement may be achieved through the use of improved agri-environment schemes, currently the Environmental Stewardship Scheme in England. At the basic level these can fund the provision of specific features such as buffer strips or hedgerow management; the higher level scheme assists the management of entire farms for the benefit of biodiversity and the wider landscape (Natural England, Environmental Stewardship, undated).

2.2.3 Size (area) reduction

Island biogeography theory relates island size and isolation to immigration and extinction rates, resulting in equilibrium in turnover of species. It was predicted that extinction rates vary with the size of the island and with distance from the mainland (MacArthur and Wilson, 1963). Therefore, it was demonstrated that the best scenario for nature conservation is a large island close to the mainland (Shafer, 1990). Diamond (1975) based nature reserve design principles on island biogeography theory, suggesting that a large reserve is better than small and that small reserves should be clustered together rather than in a linear arrangement. This idea has been extrapolated and applied to "terrestrial islands" such as nature conservation sites in a "sea" of agricultural land. It is now recognised that the effects of fragmentation in the 'real' world, including natural and anthropogenic impacts, are important issues which were previously not considered (Laurance, 2008). Size

reduction of woodland patches leads to a decrease in available habitat area, a decrease in core area and shrinkage and isolation of populations, all of which lead to biodiversity loss. These factors are inter-related so it is difficult to understand which effects are causing the most impact (Laurance, 2008). In the case of woodland birds, it was found that woodland size best predicted species number and the probability of occurrence of the most species, although other factors were also involved to a lesser degree (van Dorp and Opdam, 1987). In an analysis of a series of Breeding Bird Atlases, it was found that persistence and colonisation of forest birds was more common with a greater amount of forest cover (Zuckerberg and Porter, 2010). Woodland plants in temperate regions are slow colonisers and therefore their ability to move through the landscape is limited. However, subdivision of woodland into smaller patches does not reduce total species richness, although patch age also plays an important role (Honnay *et al.*, 1999). Isolated small patches of ancient woodland have high conservation value which should be retained as sources of colonists for the future (Dolman and Fuller, 2003). Therefore, patch size, isolation and fragmentation have a relationship with colonisation, but this is dependent on the scale and size of the colonising organism under consideration (Kindlmann and Burel, 2008).

2.2.4 Core area

Reduction in patch size decreases the woodland core area and has the effect of altering the range of habitats within woodland. Continued size reduction will eventually result in the complete loss of woodland. Within larger woods, glades provide a significant habitat for open habitat flora, many of which are threatened elsewhere. Rides tend to support grassland and edge species, which are disappearing from the agricultural land around woods. The smaller the size of the wood (less than 3 ha), the less likely open un-shaded spaces, such as glades and management rides which host a significant amount of woodland flora, will occur. Therefore, reduction in size loses habitat variety within woodland (Peterken and Francis, 1999). These specialised areas are undergoing a significant loss of species, with an estimate of 18% loss since 1990 which may be due to increased shading (Countryside Survey, 2008).

2.2.5 Edge

A similar effect to core area reduction occurs with a decrease in the length of woodland edge. Due to the changes in vegetation and microclimatic conditions as trees and shrubs merge into open land habitats, woodland edge contains a different ranges of species

compared to the shade-loving species in the woodland centre. Adjacent agricultural management, such as fertilizer applications and spray drift can penetrate at least 4 metres into the wood with a long term adverse impact on woodland edge habitat (Gove *et al.*, 2004; Bateman *et al.*, 2004). Small and irregularly shaped woods are most at risk and show an alteration in herb species composition, with lower numbers of ancient woodland indicator species due to elevated levels of nitrogen and agro-chemical drift (Willi *et al.*, 2005) A larger wood, depending on its shape, may have a greater length of woodland edge available for species and a greater percentage of unaffected internal habitat. New planting to expand and buffer existing sites will reduce isolation and will protect ancient woodland from adverse local effects. It may also encourage colonisation of species into the new area, depending on the mobility and size of species (Peterken, 2000).

2.2.6 Shape

The shape of a patch has a major impact on ecological processes. It has a relationship with edge effect, interactions between the patch and the matrix and the efficiency of the core area although these attributes vary between different shapes. Assuming the shapes described below have the same area, a circle has the maximum core area, the minimum edge and less interaction with the matrix due to its compactness. An elongated, but smooth shape has more matrix interaction, although this may be dependent on other factors such as the direction of the prevailing wind or the direction of slope (Gutzwiller and Anderson, 1992). For example, one side may be sunnier than the other, or its position relative to a prevailing wind may allow migratory birds to find it more easily. An elongated shape allows species to find the patch more easily, for example a clearing within a wood (Forman and Godron, 1986; Forman, 1995). The core area is smaller, therefore the species diversity is less, but the edge is greater. This shape may also act as a corridor. A convoluted, lobed shape has a greater edge length than either of the above shapes, which increases with its complexity. This shape has the greatest interaction and exchange with the matrix. Lobes create microclimates and add to species opportunity as well as being entrance or exit points to and from the matrix; however the core area is greatly reduced (Hilty *et al.*, 2006). Therefore each shape type has benefits and disadvantages depending on the needs of any particular species.

In a real, as opposed to a theoretical landscape, the shape of woodland depends on how they have been formed and where they are situated. Woodland in England has been shaped

by humans, either gradually as agricultural land was cleared from a wooded landscape over a long period, or later by more rapid changes such as planting plantations or "tidying" older woodland edges to fit with modern agricultural needs. Surviving ancient woodland, especially in "ancient" landscapes, tends to have sinuous edges and an irregular outline, whereas more recent plantations are usually regular with straight edges. It is often possible to see the outline of now-disappeared woodland shown by sinuous hedges in an otherwise regular fieldscape.

2.2.7 Connectivity

In order to reduce threats to woodland caused by fragmentation, the creation of habitat networks or corridors between woodland patches to increase connectivity and thus biodiversity has been promoted. There is some discussion about the efficacy of such an approach as there has been little empirical evidence of their success (Davies and Pullin, 2006; Bailey, 2007). However the idea of "green corridors" has become widely accepted in conservation and land use policy as well as in the public imagination (Catchpole, 2004). The concept of ecological networks has frequently been applied to woodland, for example, an analysis and evaluation tool LARCH (Landscape Analysis and Rules for the Configuration of Habitat) has been developed by Van Rooij *et al.*, (2004). Results from the use of LARCH have been used to design sustainable ecological networks in Cheshire that fulfils the biodiversity objectives for Cheshire County Council. Another example of this approach is the focal species-based GIS tool BEETLE (Biological and Environmental Evaluation Tools for Landscape Ecology), developed by the Forestry Commission and the Countryside Council for Wales to model a woodland network habitat in Wales. The results indicate that this approach has potential for a large area such as Wales and will play a part in the implementation of the future sustainable development of Wales (Watts *et al.*, 2005). Subsequently, a spatial GIS model has been developed to identify sites for potential woodland expansion in Wales. It takes into account the natural aspects of landscape character (i.e. soil, geology and landform) and will be further developed to take account of cultural differences (Griffiths *et al.*, 2009).

A practical example of a fragmentation reduction initiative is the Joining and Increasing Grant Scheme for Ancient Woodland (JIGSAW) which uses spatial targeting and financial incentives, regulated by a scoring system aimed to improve connectivity between patches of ancient or long established woodland. On the Isle of Wight, between 2001-2006, 247 ha

of JIGSAW targeted planting and a similar area of non-targeted Woodland Grant Scheme (WGS) planting was compared using landscape metrics; total area, total number of patches, median patch size, mean core area, and mean Euclidean nearest neighbour distance. Six metrics gave more favourable results for the JIGSAW scheme in relation to de-fragmentation. Total woodland area was approximately equal, indicating the very similar area of woodland planted under the two schemes, and mean nearest neighbour distance was better for the WGS reflecting the creation of new small individual woodland areas. It was found that spatial targeting will have the potential to increase biodiversity benefits although further long term monitoring is necessary to evaluate the success of the scheme (Quine and Watts, 2009).

2.2.8 Land cover

A possible approach is to target already wooded areas to increase the land cover threshold, a concept derived from analysis models of random landscapes (Franklin and Forman, 1987). A large number of small isolated woods in a landscape with a woodland cover of less than 30% have a low level of connectivity, little edge habitat and virtually no core area. Over 30% cover, woodland starts to clump together, isolation is reduced and edge habitat is substantial. Over 60% the landscape becomes a wooded matrix which contains other habitats (Peterken, 2000). In designing habitat networks, 30% land cover is accepted as the optimum practical target as it provides enough habitat and connectivity to function as one large wooded landscape or Core Forest Areas (CFAs) (Peterken 2002). Ancient woodland is the most valuable woodland remaining as it has greater species richness than other woodland types (Peterken, 1996). Therefore in order to maximise their protection and enhance their biodiversity, new woodland planting should be adjacent to ASNW to increase patch size and reduce isolation (Peterken, 2002). This may not be practicable in sparsely wooded areas of England but in well wooded areas such as the Chilterns, planting can be targeted to achieve this (Lee *et al.*, 2002).

However, in the Chilterns the historic mosaic of woodland is one of its defining landscape characteristics, a fact recognised in several designations. Therefore it is important that this feature is not lost in the effort to increase biodiversity. One of the aims of this study is to identify potential sites for woodland creation, basing this on historically wooded sites which tend to occur adjacent to existing woodland and thus would emphasise rather than detract from the landscape pattern.

2.2.9 *Practical application of landscape metrics*

The descriptions in the above sections indicate that these metrics may be used in targeting woodland creation for optimum results, but in practice financial constraints limit choices. Biodiversity conservation operated on a species/site basis for many years, but there are now fears that this is failing to address wider biodiversity issues as outlined above. Therefore it is now generally seen that a wider landscape scale approach is more desirable. Woodland targets focus on three aspects; creation of new patches, restoration of degraded area and maintenance of existing woodland. Therefore funding and effort has to be divided between these priorities. Restoration and maintenance work occurs on existing sites which can be prioritised as to the urgency of the necessary work, but creation involves decision-making to identify the most appropriate sites for the greatest potential benefit. Decisions cannot be made on a 'one size fits all' basis; existing distribution of woodland within landscapes is an important factor in deciding how and where to target woodland creation, therefore local variation must be taken into account. Kirby (2004) applied a realistic approach to the problems of addressing conservation aims through the use of landscape ecology principles but emphasised that a generalised approach is not suitable for real sites in a varied landscape. In Kirby (2009), Oxfordshire was used to demonstrate a range of practical approaches for woodland creation on a fixed budget, depending on the needs and priorities of particular districts and the overall best outcomes for biodiversity. Both these papers indicate the value of landscape ecology principles in decision making but also illustrate the financial constraints for agencies and the compromises which have to be made in achieving targets.

2.3 Geographic Information Systems as a tool for landscape analysis

Geographic Information Systems (GIS) provide a means of investigating the landscape components described above by using map information with attributes relating to mapped land parcels (Lee *et al.*, 1999). While manual map interrogation can provide some assistance in issues such as targeted woodland planting, GIS and associated software are powerful tools to assess landscape pattern at least in a human perspective and to monitor the extent, rate and pattern of change (Quine and Watts, 2009). Using GIS, information can be manipulated, analysed and interrogated in different ways, for example, to target habitat creation such as sites for new woodland planting (Lee *et al.*, 2002; Griffiths *et al.*,

2004); to maximise natural capital benefits gained from state funding (Bailey *et al.*, 2006); and to identify sites suitable for management for key species (McKernan, 2004).

This study not only analyses woodland landscape components as they appear today but provides a comparison with the landscape of the 19th century with an indication of earlier landscapes. Although some of the historical resources (tithe maps and apportionments) used in this research do not appear to have been much used elsewhere in the UK, other sources and methods have been utilised used in various ways to understand land use change over time. In the UK, pre GIS, tithe maps and other resources were used to investigate landscape changes in Essex (Mason *et al.*, 1986). Mansfield (1952) studied historic maps of the Chilterns (but not tithe maps) to ascertain and compare change in woodland extent but the results now appear to be somewhat subjective and inaccurate, compared to that which can be obtained today. Historic GIS has developed over the past 12 years and is increasingly being used in other disciplines besides historical geography (Gregory and Healey, 2007) as shown in the examples below. A detailed historical and ecological reconstruction of a former extensive area of wetland in south Yorkshire used GIS to develop a series of maps showing the extent of wetland in the region from pre-Roman landscape to the present (Rotherham and Harrison, 2006). The time slice maps were used in conjunction with very detailed historical documentary evidence to build a picture of the former ecology of the area. The evidence produced from this work is being used to inform plans for reconstruction of wetland in areas of present day land diversification. An investigation into landscape stability of the pond network in the Wigan area used digitised historic and modern map data. Landscape change over time was demonstrated and an evaluation of likely future scenarios was developed (Boothby, 2006).

Change in forest cover was analysed in an area of Estonia, to assess the feasibility of using historic maps (Raet *et al.*, 2008), using a similar method to that of this research. A more complex GIS approach was taken by Käyhkö and Skånes (2006) which attempted to construct a landscape change trajectory to show continuous change rather than the snapshot approach used elsewhere, although this was hampered by the lack of enough suitable data showing the process of change.

In Europe, cadastral maps, equivalent to English tithe maps and apportionments, were more prevalent and used at different time periods. In Bavaria, Bender *et al.*, (2005) used a

range of data, mainly cadastral maps, covering four time periods to analyse the ecological structure and change of land use while Haase *et al.* (2005) used a variety of historic maps in Saxony, Central Germany, to understand change in land use and structure and to inform planning for the future. In conjunction with field surveys, aerial photos and topographic maps covering 200 years, a study of sunken roads in Belgium demonstrated their value as a habitat for woodland plants and illustrated the effects of age and isolation (Deckers *et al.*, 2005). In Sweden, work has been undertaken on semi-natural grassland; Lindborg and Eriksson (2004) used a combination of field work, aerial photographs, cadastral and historic maps and found that current species diversity was related to the historic landscape and Herben *et al.* (2006) used the same sources linked to population biology data modelling to understand how past land-use has affected the current distribution of Devil's-bit Scabious (*Succisa pratensis*). Other similar work has been carried out by Cousins (2002; 2003) who used historical data relating to Swedish grassland ecology to model and investigate change in species distribution. In Italy, historic data were used by Agnoletti (2007) to investigate changes in landscape quality since 1832 to the present in order to evaluate the effects of management by the Regional Park of the Apuane Alps; in both cultural and natural landscapes in the Northern Appenines, trends in vegetation change were analysed using information from cadastral maps from 1807 and aerial photographs (Pezzi, *et al.*, 2006). Across a smaller time scale, Jomaa *et al.* (2009) used GIS and FRAGSATS software (see 4.4.3.1) to investigate forest loss in the coastal area of Lebanon. However, Hermy and Verheyen (2007) offer a word of warning on the use of historical GIS and the production of seemingly accurate maps which "may... create an illusion of certainty". Therefore, it may be wise to use historical GIS as a good indication of the past rather than absolute fact.

2.4 Policies, designations and initiatives relating to Chilterns woodland and landscape

Traditional Chilterns woodland management evolved over centuries in tandem with local and regional conditions, needs and economics and, as apparent from its history, until the early 20th century these traditions continued without any national interference. However during the 20th century woodland management became more focussed upon providing timber at a national scale for national needs. Thus Chilterns woodland became subject to a

range of policies, firstly from the Forestry Commission focussing on timber production and woodland renewal then, in the 1960's, arising from the Chilterns new status as an AONB in recognition of its special landscape, and thirdly through the national biodiversity policies resulting from the Rio Summit in 1992.

At the present time, the three drivers of Chilterns policy i.e. woodland management, landscape and biodiversity, are now recognised as being inseparable and policies from the different organisations involved, both nationally and regionally reflect this. This section describes the development of policies on these three fronts, their effects on the Chilterns in general, and the study area where possible; there is some overlap between these themes.

2.4.1 The Forestry Commission

A general deterioration of the quality of woodland nationally was recognised in the early 20th century; management for timber production had declined everywhere and conifers were being planted mainly for amenity purposes, particularly as cover for pheasant shooting (Pakenham, 2001). This pattern of woodland management by private owners began in the 1840's in counties such as Oxfordshire and Berkshire, so allowing game shooting to become a weekend pastime for wealthy Londoners who could reach these areas by railway (Collins and Havinden, 2006). However in the study area this development took place later due to the value of the beech timber for the furniture trade. National statistics collected for England in 1905 and1913 showed that the rate of planting had fallen over the preceding 80 years and that the planting of softwoods, required for building, plywood, paper and telegraph poles, was becoming more prevalent than hard woods (MacGregor, 1953). These figures are generalised and were based on a sample with no detail on individual estates.

The impact of the First World War on timber reserves led to the formation of the Forestry Commission (FC) in 1919, which, on behalf of the government, had the remits of acquiring land for the establishment of state forestry to ensure a reserve of timber and of providing advice and encouragement to private owners. The shortage of imported softwoods during the war for uses such as plywood, pit props, railway sleepers, packaging, and many other purposes, meant that the main emphasis was on planting alien conifer species, the first time there had been a national forestry policy in the UK. However, the continuing parlous state

of UK forestry between the wars is demonstrated by the fact that 96% of timber was imported, mostly softwood (MacGregor, 1953).

By 1939 the FC had acquired 714,000 acres of suitable land nationally, of which 434,000 acres had been planted since 1919. Grants had been provided to private owners to plant a further 126,000 acres (Edlin, 1947), although it was 1927 before these were given any species-related incentive i.e. £5 per hectare for conifers and £10 per hectare for broadleaves (Pakenham, 2001). Although the grant for broadleaves was larger, the return on conifers was quicker. There were problems with planting on previous woodland due to the remains of coppice stools and shoots which often needed removal; however broadleaves grew better on the woodland soils, whereas conifers could be planted on poorer land. Beech was said to grow well on chalk downs with a conifer nurse crop (Edlin, 1947). It is clear that at this time there was no regard for wildlife or landscape in the species and style of planting chosen as the emphasis was purely on timber for the nation's needs. The national woodland census of 1938/9 showed that there was an equal amount of hardwoods and softwoods, and enough to supply needs during wartime, which was confirmed by a further survey in 1942 (Macgregor, 1953). During the Second World War, it is estimated that in England 10,300 hectares of usable timber had been felled, including much in the Chilterns (Pakenham, 2001).

During the Second World War, a draft Post-War Forest Policy was published which included a section on criteria and incentives for private woodland. In due course, these became the Dedication Scheme Basis 1 within the Forestry Act 1947. It placed a legal obligation on landowners who received grants to maintain woodland in perpetuity; there was no protection for biodiversity (Peterken and Pryor, 2001). The criteria for this first forestry scheme were; to use the land for timber production; to work to an FC approved plan of operations to be undertaken; to employ skilled supervision; and to keep proper accounts. This type of agreement has been used between private landowners and government ever since (Pakenham, 2001) (see 2.4.1.3 Grant Schemes).

2.4.1.1 The Chilterns Special Project

After the Second World War, a Census of Woodlands took place between 1947 and 1949 which itemised each wood throughout the country. The Chilterns were examined in 1947 and Mansfield (1952) summarised their findings for private woodland; 1,605 acres (5%)

of woodland was classified as "devastated" as a result of clear felling, the bulk of this being beech; 5.5 % of woodland was scrub and 1% coppice. Woodland felled annually before August 1939 was 0.5 % but after the outbreak of war this rose to 7.5%. By the time of the census, woodland in the study area and the Chilterns in general was not only devastated by wartime felling but also affected by the final end of the selection system, both of which had a deleterious effect on the wildlife and landscape value of the area.

Due to the poor condition of the Chilterns woodland, the area was made a Special Project by the Forestry Commission in 1951 aiming to restore the woodland. This and other legislation, including the Town and Country Planning Act (1947), Tree Preservation Orders (1949) and the Forestry Act (1951), ensured that the Chiltern woodland were saved from large scale clearance for housing and agriculture (Chilterns Standing Conference, 1988). However, the Chilterns Special Project, although rejuvenating many woodlands, also involved clear felling large areas of 'over-mature' woodland with large machinery and widespread planting of conifers to satisfy the policy for soft woods (Chilterns Standing Conference, 1988), which further adversely affected ecology and landscape value. Although not recognised at the time, these sites were often ASNW and so were later designated as PAWS. The landscape effects of large blocks of conifers caused much local controversy. However, it was not until the mid to late 1970's that national awareness of, and concern for, the ecological and historic value of woodland was raised by Rackham and Peterken (Pakenham, 2001).

2.4.1.2. Current Forestry Commission Strategy

The Rio Summit in 1992 and the landscape and biodiversity initiatives described below led to a change in policy by the Forestry Commission. Following extensive consultation, an England Forestry Strategy was published in 1998, which focuses on four strategic strands: rural development, economic regeneration, recreation, and environment and conservation. This last strategy recognises the importance of, amongst other things, local biodiversity and ecology linked to Natural Areas, landscape character and cultural aspects. This 1998 Strategy was reviewed in 2006 and is the foundation for the new "Strategy for England's Trees, Woods and Forests' (ETWF Strategy) published in June 2007. The ETWF Strategy Delivery Plan was launched in late 2008 (Forestry Commission, 2007a). The ETWF Strategy was developed by the Forestry Commission and Natural England and is delivered by both. It formulates national aims and strategy, providing guidance for work based on

regional and local collaborations as for example through the Regional Forestry Frameworks (see below).

In addition, the policy from the Department for the Environment, Food and Rural Affairs (DEFRA) "Working with the Grain of Nature – a biodiversity strategy for England" (2002, DEFRA, a) resulted in the formation of a Woodland and Forestry group, which monitors and reports on progress to the Secretary of State, which led directly to new policy on ancient woodland and native woodland (see Keepers of Time below).

Other Forestry Commission policies

The UK Indicators of Sustainable Forestry were published in 2002 (Forestry Commission, 2002b). They build on the previous strategic document and focus on: ancient woodland; native woodland area and condition; abundance of fauna; richness of flora; diversity of woodland; and natural regeneration. They work in partnership with other bodies and initiatives, for example, in the Chilterns, the Chilterns Conservation Board as well as English Nature's Natural Areas and the Historic Landscape Appraisal Project.

In 2004, after consultation and in light of the strategic strands mentioned above, a partnership of nine organisations produced a Forestry Framework for South East England entitled "Seeing the Wood for the Trees" Forestry Commission, 2004c). This has four themes which focus on: community wellbeing and recreation; enhanced environment and biodiversity with a priority for ancient woodland; economic contribution, the priority being renewable energy and associated jobs. The fourth theme is protection and sustainability of woodland through regional planning such as the Woodlands Policy included in the South-East Regional Plan. Similar Regional Forestry Frameworks have been developed across England.

Keepers of Time

A key policy is Keepers of Time: A Statement of Policy for England's Ancient and Native Woodland, produced jointly by the FC and DEFRA in 2005, which focuses on ancient woodland and veteran trees, recognising their value in terms of wildlife, historic, social and cultural resources (Forestry Commission, 2005d). This policy is highly relevant to the Chilterns with its high concentration of ASNW and PAWS. It is aimed at private landowners, of whom there are many in the Chilterns, rather than FC owned or leased

ASNW or PAWS which are undergoing their own transformation (see Forest Design Plans below).

There were several reasons for this new policy, but the most relevant are the new Government responsibilities for biodiversity and Sites of Special Scientific Interest (SSSI) resulting from the Countryside and Rights of Way Act (2000) (CROW); the Global Biodiversity Challenge resulting from the 2002 Johannesburg Earth Summit to halt the loss of biodiversity by 2010; and the utilization of advances in woodland ecology, not least those of landscape ecology, and woodland management. Keepers of Time aims to increase the area of native woodland along with maintaining existing areas of ASNW; to improve and maintain the ecological condition of ASNW; the improvement of landscape context of woodland and the improvement and conservation of the cultural heritage associated with AW. Ancient woodland should also be an example of sustainability and provide opportunities for employment and finally make an increasing contribution to quality of life, such as through recreation opportunities and its associated health and wellbeing. The Keepers of Time policy aims to deliver its objectives by 2020. A two year Action Plan to 2007 to begin implementation, worked in partnership with many other organisations including local authorities, Natural England, the Environment Agency, Wildlife Trusts, the Woodland Trust, RSPB and others.

One outcome of the Action Plan was a consultation draft (published early in 2008) of an England Practice Guide to the management of ASNW and native woodland to assist woodland managers to implement the policies of Keepers of Time. The draft England Practice Guide provides more practical advice and guidance than the previous prescriptive approach, although giving "explicit encouragement to restore PAWS" and emphasises the need to ensure that the management of each wood recognises its individual character, history and special features. Following the consultation process, the Guide is expected to be completed and launched in 2010. Funding for projects related to Keepers of Time will be through the English Woodland Grant Schemes (see 2.4.1.3). The draft Guide includes a section on woodland creation, which covers the location of new woodland in the landscape to improve functional linkage between areas of existing ASNW, as well as expanding and buffering existing woodland, whilst taking into account existing areas of non-woodland habitat. A suggestion for achieving this aim is that it may be beneficial to plant new woodland on sites of woodland loss and suggests using old maps for information on

possible sites, rather than planting at random elsewhere in the landscape, which reflects the focus of this research. It also explains the need to ensure that new woodland enhances landscape character and cultural heritage, and is designed to allow the development of a variety of habitats within the woodland (Currently (February, 2010) no reference is available from the Forestry Commission due to the hiatus between the consultation period and production of the final guide). A Guide to Restoration of Native Woodland on Ancient Woodland Sites (Forestry Commission, p) is aimed at woodland owners who wish to restore PAWS and provides good practice advice focussing on the biodiversity benefits to be gained (see Table 2.2).

Chilterns Landscape Forest Design Plan

A series of Forest Design Plans (FDP) have been drawn up for specific areas across the UK including in the South East Region. These demonstrate how woodland belonging to or leased by the Forestry Commission will be managed sustainably for biodiversity and landscape both now and in the future, as well as for the local economy by enhancing opportunities for tourism, recreation, and heritage.

A Chilterns Landscape FDP was produced for public consultation in 2005, in conjunction with the County Councils of Oxfordshire, Buckinghamshire and Hertfordshire, Wycombe District Council, the Chilterns Conservation Board, English Nature and the Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust (BBOWT) (Forestry Commission, e). The Forest Design Plan in the Chilterns shows the detailed management over the first 10 year with plans for felling and habitat creation, outline plans for the following 20 years and finally a description of the woodland at the end of the 30 year plan, along with the benefits for the local landscape and economy and the opportunities for biodiversity, recreation and heritage.

Five FC woodland complexes within the study area are included in the Chilterns FDP. From north to south in the study area they are Leygrove's; Cowlease; Queen, Fire and College; Burnt Platt, Greyhone, Ipsden and Boroughcourt; Crowsley Park (see Appendix 7). At present these contain conifer plantations, either pure stands or mixed with broadleaved trees, as well as some mature beech wood. All are PAWS, some are adjacent to SSSIs and one also contains small areas of ASNW. The plans aim to return these areas to broadleaved woodland, although some will retain scattered conifers, either as nesting

sites for raptors such as red kite *Milvus milvus* or buzzard *Buteo buteo*, or for aesthetic purposes as, for example, on a skyline. Some areas of mature woodland will become more open and there will be some small areas of non-intervention as in the Queen Wood area, Watlington. Some areas will be clear felled over a period of several years, others in one operation as at Leygroves Wood, Stokenchurch although generally there will be a Low Impact Silvicultural System with a maximum of 50% of canopy removed in any one operation.

2.4.1.3 Grant Schemes

Post Rio 1992, Woodland Grant Schemes became more focused on multi-benefit woodlands, rather than purely on timber production. In the England Forestry Strategy, 1998, as well as timber related benefits, forestry was also aimed towards economic regeneration, environment and conservation of biodiversity and cultural heritage. These aims were to be delivered by the FC Woodland Grant Scheme (WGS) and Defra's Farm Woodland Premium Scheme (FWPS) for woodland planting on farm land. However, in the Chilterns at least, Bailey (2003) demonstrated that the aims of both timber production and biodiversity enhancement were not realised due to inappropriate site selection, a problem not identified through the grant application process. Woodland Improvement Grants (WIGS) are targeted grants for ancient woodland improvement; from 2011-13 they are available in the Chilterns for ecological improvement of PAWS (Personal communication Colin Finlay, Forestry Commission). Current grant schemes are outlined in Appendix 1.

The woodland area in the Chilterns is approximately 17,588 ha of which 9,830 ha are ASNW. At present across the Chilterns, approximately 75% of woodland is privately owned (CCB, 2008). Private owners may be reluctant to implement these ideas for restoration or woodland creation. However, figures from June 2009 show that the area of Chiltern woodland under Woodland Grant Schemes was 9,577 ha and the England Woodland Grant Schemes 3,585 ha, a total of 13,162 ha, although there is some overlap and inaccuracies in this data (*State of the Chilterns* Seminar, 2009). Nonetheless these figures imply that many owners are keen to manage their woodland in some way.

Table 2.1 Area of Chiltern woodland (ha) covered by Grant Schemes

	Woodland Grant Scheme ha	England Woodland Grant Scheme ha
Creation	284	21
Regeneration	2,197	1,088
Management	7,3325	1,640
Improvement	1,565	1,345
Planning		1,404
Total	**9,577 ha**	**3,585 ha**

Figures from the Forestry Commission (M. Render), *State of the Chilterns* Seminar, June 2009.

2.4.2 Chilterns Area of Outstanding Natural Beauty

The Chilterns are recognised as possessing a special quality and character in both landscape and cultural aspects. Hence 800km^2 were designated as an Area of Outstanding Natural Beauty (AONB) in 1964, enlarged to 833km^2 (324 sq miles) in 1990. The AONB stretches over parts of Bedfordshire, Hertfordshire, Buckinghamshire and Oxfordshire, the latter forming the study area for this research.

The AONB covers four county council and 11 district council areas so in order to ensure consistency in management and planning policy across such a wide area, the Chilterns Standing Conference was set up in 1969, later renamed the Chilterns Conference. The CROW Act (2000) placed a statutory duty on local authorities in an AONB to produce a management plan and to set up an AONB Conservation Board. This led to the formation of the Shadow Board for the Chilterns AONB in 2001, followed by the establishment of the Chilterns Conservation Board in 2004. The Board is comprised of 29 representatives of which 15 are appointed from local authorities, eight by the Secretary of State for Environment, Food and Rural Affairs and six represent parish councils. The remit of the Conservation Board is firstly to conserve and enhance the natural beauty of the AONB and secondly to increase the understanding and enjoyment by the public of the AONB, although if there is a conflict between these two aims, the first takes precedence. In addition the economic and social well being of the local communities are to be fostered but

in co-operation with local authorities and other bodies. The Management Plan is implemented by AONB Conservation Board staff. The Management Strategy Plan 'A Strategic Framework for Action 2002-2007' was reviewed in 2007/08 and resulted in Chilterns Conservation Board 'Management Plan 2008-2013: A Framework for Action' and its accompanying Action Plan published in 2008. Its aim is to ensure that the landscape and biodiversity of the Chilterns is protected and enhanced and is informed by the Natural England initiatives outlined in Section 2.4.5.

2.4.2.1 AONB Woodland policy

In 1971 the first Standing Conference agreed proposals for "A Plan for the Chilterns". It was acknowledged that, although the woods had been intensively managed for many centuries, this had been low impact in comparison with 20th century management in which felling in preparation for replanting was often on a large scale, sometimes even of entire woods. The Plan aimed to reduce some of the adverse landscape impacts of the Chilterns Project by reducing the area of woodland which could be felled in each cut; extending the replacement period for large woods to a period of 30 to 40 years; and ensuring that broadleaved woods (with the emphasis on beech) would be the end result (Chilterns Standing Conference, 1988).

However, although this Plan was implemented throughout the AONB, after some years it became obvious that some changes were necessary. One problem was that not enough attention had been given in the 1971 Plan to the woodland ecology and biodiversity of the area, resulting in fragmentation and loss. The natural mosaic of species related to the variation of soils, aspect and topography had been almost destroyed which caused a negative impact on biodiversity and landscape over large areas of the region. Felling together with replanting with conifers had further damaged those woods which had retained their semi-natural status. Therefore it was necessary for conservation issues to be included in the management policy and procedures. Other concerns arose about the slow rate of restocking amidst worries about the deterioration of over-mature woods and the barriers to renewal of the woods by planting or regeneration caused by grey squirrel, edible dormouse (*Glis glis*) and deer damage. There were some concerns that controlling these species was contrary to nature conservation, but it was pointed out that many of these were introduced species (Chilterns Standing Conference, 1988).

Therefore in 1985, the Chilterns Standing Conference produced a Revised Woodlands Policy which replaced the original woodland section of the 1971 "A Plan for the Chilterns". It coincided with the FC Broadleaves Policy 1985, which acknowledged that broadleaved woodland should be maintained and enhanced and started to reverse the habit of planting conifers on ASNW, and the Broadleaved Woodland Grant Scheme which paid a higher premium for planting broadleaves than for conifers. The AONB Revised Woodlands Policy included the aim of protecting biological diversity "in woodland identified as particularly sensitive for nature conservation" translating to a management principle in which "Heritage Woodlands should be managed in such a way as to support a rich variety of wildlife" (Chilterns Standing Conference, 1988). Other management principles were to ensure the continuity of the broadleaved landscape, emphasising the planting of beech where appropriate; to protect the total woodland area and increase it if possible; and to increase timber production.

Following the CROW Act (2000), which made it a statutory duty for an AONB to set up an independent conservation board, the Chilterns Conservation Board was formed in 2002. The Board has a legal duty to publish a management plan, so the Chilterns Management Strategy Plan "A Strategic Framework for Action 2002-2007" and Action Plan were published in 2002. A new five year Plan, which updates the 2002 Plan, was published in 2008 (Chilterns AONB Management Plan, 2008). Relevant sections for this study within this include Farming and Forestry, Biodiversity and Landscape. Climate Change and three social themes cross reference across all the sections of the plan.

Farming and Forestry

The figures for Chiltern beech woodland in the Management Plan are that 21% (17,588 ha) of landcover in the AONB is wooded. Of this, 50% (9,830ha) is ancient woodland, of which 5,754 ha is ASNW and 4,076 ha PAWS. Woodland ownership is mainly in private hands at 75%, with more than 10% owned by charities and local authorities and 9% by the Forestry Commission (CCCB, 2008).

Policies related to woodland (forestry) and farming include the promotion of co-operative approaches to woodland management and fragmented farmed landscapes to achieve landscape scale action. This policy is reiterated in the Biodiversity section where it

translates to action to "support and develop landscape scale initiatives which extend and connect fragmented habitats and sites".

The emphasis on developing landscape scale initiatives to link fragmented sites should produce significant benefits for biodiversity and likely important benefits to the conservation of landscape and the historic environment. However, one of the defining features of the Chilterns landscape is its mosaic of fields and woods, which must not be lost or weakened by linking fragmented sites in an inappropriate manner.

Other woodland policies include; support practices which assist adaptation to climate change; sustainable management for multiple benefits; resist fragmentation of woodland and farmland into small plots; encourage diversification and new business ventures such as the production of wood fuel, which is becoming more economically important in the Chilterns.

Actions resulting from the Management Plan are crucial. They include: work to update the 1990 Ancient Woodland Inventory to include all woodland under 2 ha (see Section 2.5.4.1); support provision of advice and training for woodland management; support management of ancient and semi natural woodlands and hedgerows; promote woodland management and environmental stewardship schemes; support woodland archaeological research and conservation. It is a priority to restore PAWS to a more natural condition (Chilterns Woodland Project, 2007).

Planning Policy Statement 9: Biodiversity and Geological Conservation 2005

Planning Policy Statement 9 (2005) is referred to in the Chilterns AONB Management Plan documentation and is seen as a useful tool to further their aims. It replaced *PPG9: Nature Conservation* 1994 and contains policy guidance for planning authorities at all levels on the importance of wildlife sites and habitats and how they should be addressed within the planning system. Included in the Statement are Ancient Woodlands and Other Important Natural Habitats, which should be identified and protected from development "unless the benefits of development outweigh the loss of habitat" although it is not apparent how this decision is to be made. Another section refers to Networks of Natural Habitats which local authorities should aim to retain, improve and protect through planning policies.

2.4.3 Chilterns Landscape Character Area

In 1992 the then Countryside Commission, now the Countryside Agency and part of Natural England, published a landscape assessment "The Chilterns Landscape" (Countryside Commission, 1992). It was commissioned as a study contributing to the 1994 Management Plan for the Chilterns AONB: The Framework for Action. It concentrates on what makes the Chilterns distinctive; the physical and human influences on the landscape; the features that contribute to the Chilterns character; description of the mosaic of landscape types within the Chilterns; current and future pressures and changes; and summarises the special quality which makes the Chilterns AONB of national importance. This was one of the early reports to take a landscape approach, looking at an area as a whole and incorporating historical and ecological principles, including physical attributes, landscape patterns and archaeology. Other Landscape Character Areas were later mapped throughout England.

2.4.4 European Habitats Directive – Special Areas for Conservation

The Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (1992) (EC Habitats Directive) (Joint Nature Conservation Committee, a.) aims to preserve and enhance threatened and degraded habitats across the region. Member states are required to put measures in place to protect habitats and species; to monitor progress and to produce a six-yearly report. Of the 189 European habitat types listed in the Directive, 78 occur in the UK while of the 788 European species, 43 are identified as native to the UK and require special protection. Each Member State is required to identify a list of national sites which will form a European network of Sites of Community Importance (SCI). After adoption, these are designated as Special Areas of Conservation (SACs) and form part of the network of protected areas making up Natura 2000. Landscape features should also be managed to enhance Natura 2000.

In the UK, these EC regulations are transposed into the Conservation (Natural Habitats, & c.,) Regulations 1994. Many but not all SACs are SSSIs which are protected in law, the reminder are managed by the promotion of wider countryside measures and protected by the Habitats Regulations. The Joint Nature Conservation Committee (JNCC undated, a.) advises the UK Government on the implementation of the Directive and on habitats and

species. It also produces the progress Reports on behalf of the Government and advises on suitable sites in the UK for consideration as SCI.

2.4.4.1 SACs in the study area

The Chilterns Beechwoods as a whole are designated as a SAC for *Asperulo-Fagetum* woodland (JNCC b.). This is a European designation which is is equivalent to NVC woodland classifications W12 (*Fagus-Mercuralis) W14 (Fagus-Rubus) and W15 (Fagus-Deschampsia)* (Clements and Mountford, 2001). These types are described below in Section 2.4.5.4. The SAC designation describes the Chilterns woodland as being vulnerable because of their uniformity due to past management practices, the low value of timber and its damage by grey squirrels, thus needing financial support to maintain suitable management for structural and species biodiversity, in particular to increase dead wood habitat. Juniper (*Juniperus communis*) populations are also mentioned in this context as being under threat due to their lack of natural regeneration and poor competitive ability against other scrub species.

There are two specific SACs in the study area. Aston Rowant National Nature Reserve (NNR) contains Juniper, the primary reason for its selection, and *Asperulo-Fagetum* woodland. The juniper present here is the best remaining example in the UK of lowland juniper on chalk (JNCC b.). Some of the juniper populations at Aston Rowant were threatened by the construction of the M40 cutting in 1972-74 which split the NNR in two. The contract for construction allowed funding for planting of natural plant species on the slopes above and bordering the cutting. On the south side above the cutting, the then Nature Conservancy Council (NCC) were granted access where experimental juniper cuttings were planted and successfully established (Motorway Archive Trust, undated). There is currently a joint initiative to improve the future prospects of juniper in the area between Natural England, local authorities and BBOWT (Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust). Juniper also occurs in small numbers on other similar sites in the study area such as Chinnor Hill. Hartslock Wood (SSSI) is a SAC due to its *Taxus baccata* woodland and chalk grassland which contains one of only three national populations of Monkey Orchids (*Orchis simia*) (JNCC, c.).

2.4.5 Biodiversity: policies and initiatives

Directives, laws, policy and designations relating to biodiversity in England come from both the UK Government and the European Community (EC). Only those with relevance to this study are described here.

2.4.5.1 *Inventory of Ancient Semi Natural Woodland and Heritage Woodland in the Chilterns*

In 1982 the NCC began a woodland survey in Oxfordshire, part of a national county-by-county programme to identify areas of ASNW which have had continuous woodland cover since 1600 with no clearing or extensive planting since that date. It was recognised that the variety of habitats, communities and species within these woods was of great ecological significance, as well as the soils, water and historical features contained within them, and the influence they had on the landscape. The results of this national survey were published in 1988 (Nature Conservancy Council, 1988).

However in the Chilterns woodland this was not as clear cut as in most other areas; as a result of centuries of management beech has become the dominant trees species, while in other previously non-wooded areas, woodland has developed through lack of grazing on common land and chalk downs on the escarpment. It is often difficult to distinguish between these woodlands of different histories due to the underlying natural flora of commons and the proximity of native woodland, thus allowing the spread of woodland ground flora. This difficulty led to an agreement between the Forestry Commission and the Nature Conservancy Council (NCC) together with the Chilterns Standing Conference that the majority of beech woodland could be regarded as PAWS and the richest sites were to be treated as ASNW. These latter were known as Chiltern Heritage Woods, classified as such by their rich flora and interesting structure, and a further survey was conducted in 1990 in the Oxfordshire and Buckinghamshire Chilterns to identify them (Nature Conservancy Council, 1990). However this unique designation is now no longer thought helpful as all ancient woods, either semi-natural, plantation or native, are considered important, although information from this survey is still used by the Chilterns AONB staff (John Morris, Chilterns Woodland Officer, Personal communication).

Update of the Ancient Woodland Inventory

The FC Keepers of Time focus on ASNW and its restoration and the Planning Policy Statement 9 (2005) requiring that local authorities should identify areas of ASNW which were not currently protected, have led to new developments in the Inventory of Ancient Woodland. A study in the High Weald ie Wealden, Mid Sussex and Tunbridge Wells District Councils, found that there had been an increase in ASNW, partly due to some errors in the first Inventory and also because areas under 2 ha had been omitted.

A pilot study in the Chilterns AONB took place in 2007 to assess whether a full scale study should be undertaken and also to provide information for the new Chilterns Management Plan (see above), (Chilterns Woodland Project, 2007). Twenty randomly chosen 1km squares, of which seven were in the study area, were surveyed across the Chilterns using 1st edition 6" OS maps and others, along with the original data from the previous surveys. Woods were identified as ASNW, PAWS or recent. Discrepancies in the original inventory were identified; some in digitising the original inventory on to the computerised version; some larger sites (including a SSSI) were omitted from the first survey; some woods were a complicated mixture of ASNW, PAWS and more recent planting, which was over simplified in the original data. In other cases, it seems that ASNW had been downgraded to PAWS if any planting had taken place at all. It was felt that all qualifying woods under two hectares should be added to the inventory, although this could sometimes be difficult as they are not always mapped on the smaller scale old maps (N.B. these appear on tithe maps for the study area). It was felt that the ancient nature of many high forest beech woods had been underestimated, as well as the woodland which had developed on earlier common land that had previously been either wooded or wood pasture in nature (Chilterns Woodland Project, 2007).

The pilot survey squares demonstrated an increase in ASNW of 53% and a reduction in PAWS of 19%, both figures resulting from a combination of subtracting misclassified woods and adding omissions. The results of the pilot have been extrapolated to show that, in the whole Chilterns AONB, the actual area of ASNW has increased to 14.2% compared to 11.7% of the original inventory, figures similar to those from the High Weald districts (Chilterns Woodland Project, 2007).

2.4.5.2 *The Chilterns Natural Area*

The Natural Areas concept was developed in 1993. Natural Areas are distinctive biogeographical areas, which combine natural and cultural characteristics, based on the underlying geology, ecology and wildlife, and form a framework for nature conservation planning (Tilzey, 1997). 120 unique Natural Areas have been identified nationwide, all different from each other, which cover the entire country. This was a new approach, moving away from the site focussed approach on Sites of Special Scientific Interest (SSSIs), to the wider landscape in which they are situated; however they are not official designations. Natural Areas form the basis for Local Biodiversity Action Plans (see below).

The Chilterns Natural Area is one of the most distinctive, with obvious and definitive boundaries, particularly on the scarp face, based on its geology (English Nature, 1997). Woodland is one of the features identified as a Nature Conservation Resource within the Chilterns Natural Area. Other habitats for conservation in the Chilterns are chalk grassland, commons, river valleys and chalk streams, the farmed landscape and geology.

2.4.5.3 *Joint Character Areas*

Both Landscape Character Areas (see 2.4.3) and Natural Areas produced very similar results so were combined to produce 159 Joint Character Areas (JCAs), now renamed as National Character Areas. The Countryside Commission and English Nature, with support from English Heritage, published these as "The Character of England Map". Each JCA describes the characteristic landscape and biodiversity of distinctive areas. Not surprisingly the Chilterns with its obvious geological boundary and associated topography, biodiversity and landscape form a discrete Chiltern Character Area, known as JCA 110 (Natural England, Joint Character Area).

2.4.5.4 *Biodiversity Action Plans relating to the Chilterns*

One of the results of the 1992 Earth Summit in Rio was the Convention on Biological Diversity, which was signed by over 150 countries, including the UK. The UK Government produced "Biodiversity: The UK Action Plan" in 1994, a broad 20-year strategy for conservation and enhancement of wildlife and habitats in the British Isles, which resulted in national priorities, targets and Biodiversity Action Plans (BAPs) for conservation and enhancement of 391 species and 45 habitats. Regular reports on progress

are produced (UKBAP, a). The England Biodiversity Group was formed to oversee development and delivery of the Strategy and to advise the Government on implementation of UKBAP (UKBAP, b).

Through Regional Development Agencies, each Region has a Biodiversity Forum e.g. the Oxfordshire Nature Conservation Forum (ONCF), which identifies the main habitats and sets biodiversity objectives, priorities and targets. Local Biodiversity Action Plans (LBAP) translate national strategy into effective local action, usually at county level (UKBAP, c). Priority habitats and species are identified, action plans prepared and implemented for their conservation and enhancement. Species Action Plans and Habitat Action Plans are the other means to ensure that Biodiversity Action Plans are translated into real action and results. Habitat Action Plans (HAP) identify 28 broad habitat types. These are further refined to 65 UK priority habitats, which include a range of upland, lowland, coastal and aquatic habitats (UKBAP, a)

Chiltern HAP and BAP

From a Chiltern woodland point of view, the priority HAP for lowland beech and yew woodland is of prime importance. There are three types of HAP beech and yew woodland which differ according to soil pH and are found in the Weald, the Cotswolds, Wye Valley and parts of the New Forest. Due to the varied geology, soils and topography of the Chilterns, all three types are present here and are described below (UKBAP, d).

1. Calcareous beech and yew woodland (National Vegetation Classification (NVC) W12) is present on the scarp slopes of the Chilterns where chalk is close to the surface. The woodland is predominantly beech (*Fagus sylvatica)* and may contain other species such as ash (*Fraxinus excelsior)*, whitebeam (*Sorbus aria)* and sycamore *(Acer pseudoplatanus)*. Oak (*Quercus robur)* is also present but in small quantities. Yew (*Taxus baccata)* can sometimes occur in pure stands.

2. On the Chilterns plateau, both neutral/slightly acid and acid soil can occur, often in places which were once common land, unsuitable for agriculture. Beech-yew woodland occurs on both but varies in composition and extent. On neutral/slightly acid soil, conditions tend to be damp with poor drainage. Here beech is found with

oak and an understorey of brambles *(Rubus fruticosus)* (NVC W14). Holly *(Ilex aquifolium)* or yew sometimes occurs, as does bracken *(Pteridum aquilinum).*

3. The more acidic soil (ph 3.5 to 4.5) tends to be well drained light gravels or sands. Beech and oak are the main canopy species with holly the main under-storey shrub (NVC W15).

The overall national targets for lowland beech yew woodland are to maintain existing areas (c30,000 ha) and to either restore 1500 ha of former beech woodland which are currently non-native plantations on ancient woodland sites or create beech yew woodland by colonisation or planting on non-wooded sites (UKBAP, e).

Biodiversity Action Plan targets for Beech and Yew woodland nationally have been amalgamated with six other woodland types into a general national woodland target. This also is the situation in Oxfordshire where the current target (2009) for all Native Woodland creation (i.e. Lowland Beech and Yew, Lowland Mixed Deciduous, Wet Woodlands, and Traditional Orchards) is 447 ha (10%) by 2015. The Chilterns contain 25.43% of targeted woodland in Oxfordshire where currently the extent of Native Woodland in Oxfordshire is 4,474 ha. The target for restoration of PAWS countywide is 600 ha but the extent of this resource is unknown both for the county and for Conservation Target Areas (CTA) (see 2.4.5.6 below) in the study area (UKBAP, f).

Targets for Oxfordshire woodland creation and restoration are currently under review and at present it is not clear how much will be situated in the Oxfordshire Chilterns and how much will be lowland beech and yew (Neil Rowntree, Biodiversity Project Officer, ONCF, personal communication, September 2009).

Table 2.2 Targets, plans and progress for Broadleaved Mixed and Yew woodland in Oxfordshire

Aim	Action Goal (ha) by 2010	Achieved (ha) no figure	Current (ha) as at 20.10.2008
WD 01a Maintain ASNW extent	Dip slope 60 Escarpment 460		
WD 02a Maintain native extent	Escarpment 400		
WD 03a Achieve good condition (favourable or recovering native broadleaved)	Dip slope 60 Escarpment 260		92 22.82
WD 04a Restore Conifer/Mixed Paws	Escarpment 24		

(Progress to date (March 2010) as shown on the BARS (Biodiversity Action Reporting System) website (UKBAP, g).

2.4.5.5 Oxfordshire Wildlife and Landscape Study (OWLS)

This three year pilot project by Oxfordshire County Council, with English Nature and the Countryside Agency (now both Natural England), produced a countywide picture of landscape character and its associated habitats based on a website with information available to all (OWLS, undated). OWLS provides a strategic framework for decision making by local authorities and other statutory bodies, as well as a source of information for the general public. It is the first such initiative at a local level to link landscape and biodiversity, as well as including a cultural element, thus reflecting national policy. Ten Regional Character Areas, including the Chilterns, were identified, divided into 240 Landscape Description Units (LDUs) based on geology, topography and soils as well as land cover and settlement patterns. LDUs were further subdivided into Land Cover Parcels to take account of variation in land use and enclosure patterns. 24 Landscape Types were identified, each with common features and visual appearance, as for example "Wooded

plateau" or "Wooded farmland". Biodiversity was mapped and graded according to its range of habitats. An interactive map of parishes within each local authority district provides information on the biodiversity and landscape character of each LCP within the parish.

2.4.5.6 Oxfordshire Conservation Target Area (CTA)

Based on Landscape Description Units identified by OWLS (above), CTAs containing designated sites, UKBAP priority habitats and other important areas for wildlife conservation have been identified and mapped by Thames Valley Environmental Records Centre (TVERC website). CTAs cover 85% of UKBAP priority habitat contained in Oxfordshire and are used in the implementation of national HAP and BAP targets. Some LDUs have been amalgamated, for example, Chiltern Dipslope and Chiltern Plateau are now one CTA; other CTAs are Chiltern Escarpment North; Central; South Central; South. These areas are amongst those where work has been targeted between 2006 and 2009. The table below shows areas within individual CTAs relating to the study area (ONCF).

Table 2.3 Chilterns data taken from: *Designated sites and UK BAP priority habitats associated with Oxfordshire Conservation Target Areas* (ONCF)

Chiltern Conservation Target Areas	**Area (ha)**	**Beech and Yew Woodland (ha)**	**SSSI (ha)**	**Local Wildlife Site (ha)**
Escarpment Central	952.48			6.74
Escarpment North	1,443.27	214.42	600.38	13.68
Escarpment South Central	453.90	0.51	4.67	15.93
Escarpment South	762.80	37.27	37.26	197.69
Dip slope and Plateau	5533.63	270.37	332.02	230.48
Total areas	9146.08	522.57	974.33	464.52

2.4.6 *Chilterns AONB Historic Landscape Characterisation*

The Historic Landscape Characterisation (HLC) for the Chilterns was a joint project between the Chilterns Conservation Board, Buckinghamshire County Council and English Heritage (Chilterns HLC). By comparison of 18th and 19th century maps with the present landscape, historic character types in the present day landscape were identified, such as patterns of enclosure and woodland, as well as roads and track-ways, the pattern of which pre-dates the Romans. The information was digitised using GIS. This allows information to be added, changed or annotated, as well as interrogated, thus providing a useful tool for many uses and applications. The long term use of the Chilterns HLC will be to help conserve the historic landscape of the AONB.

The Chilterns HLC is unusual in that it planned to "deepen" some of the landscape themes by researching further. The Chilterns AONB Board is also keen to link the historic landscape with the ecological features in the Chilterns. One such theme is woodland history, and it is hoped that this research will be able to feed into this process, possibly by supplying detail of woodland types in the 1840's from tithe maps (D. Green, personal communications, Buckinghamshire County Council 2005/2008).

2.5 SUMMARY

This chapter outlines:

- changes in ancient and recent deciduous woodland and the special case of the Chilterns beech woods;
- the spatial impacts of reduction in woodland extent over time;
- the use of GIS to analyse both the past and future scenarios;
- the development and implementation of policies, designations and initiatives in relation to the Chilterns which now include landscape, biodiversity and cultural and historical value.

This research incorporates these aspects into the final outcome which identifies suitable sites for woodland creation, demonstrating a method which could be applied elsewhere in England.

Chapter 3

Landscape and woodland history of the Oxfordshire Chilterns

The Chilterns stretch for 97 km (60 miles) from the Hitchin Gap in Hertfordshire in the north to the Goring Gap on the Thames in Oxfordshire to the south. The study area covers the Oxfordshire section of the AONB, approximately 25,500 ha in area. The Oxfordshire Chilterns were chosen as a study area for several reasons. They form a discrete geographical area; their proximity to Oxford; and the local knowledge already available. Although the general description of the Chilterns geology and topography is relevant to all areas, the Oxfordshire section has a distinct character of its own. There are no major towns within its boundary, except Henley-on-Thames, no major industry, no permanent river valleys except the Thames on its southern boundary, few A-roads and a very small stretch of the M40 crossing part of Lewknor and Stokenchurch, thus this is the least developed part of the Chilterns.

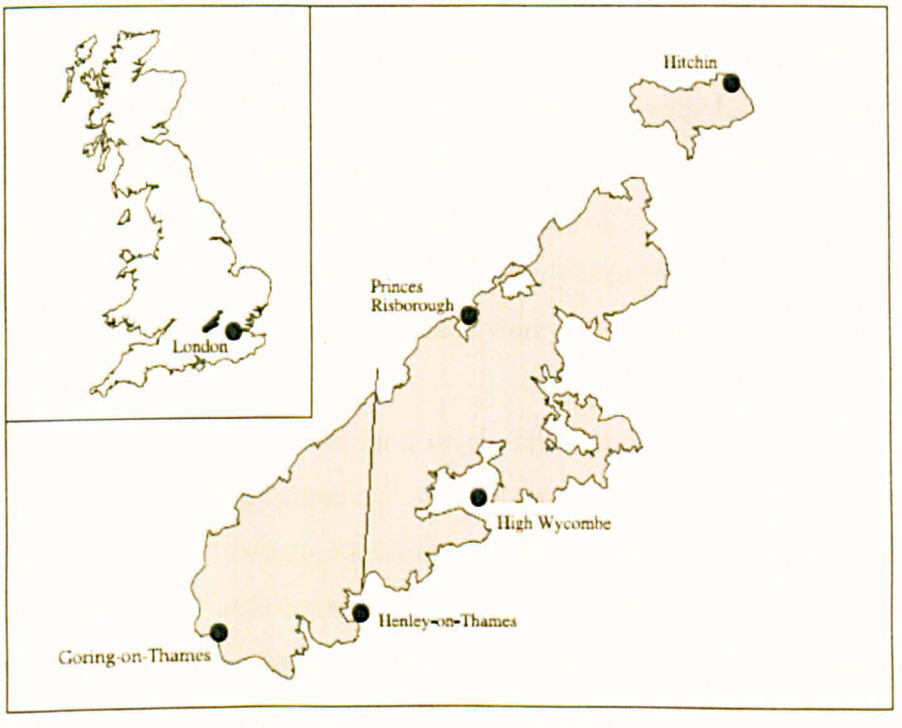

Figure 3.1 Chilterns AONB showing study area

3.1 Geology and Topography of the Chilterns

Although the Chilterns are described as "hills" they are actually a dissected plateau rising from the Oxfordshire plain and the Vale of Aylesbury. The steep north-west facing scarp slope rises 135m in places above the plain with a maximum altitude of 255m above sea level. The dip slope falls gently towards the south-east and is dissected by many dry valleys.

The Chilterns are composed of chalk, laid down during the Cretaceous Period 100 million years ago. There are three chalk strata in the Chilterns. Upper and Middle Chalk form the scarp while the Lower Chalk is found at the base of the escarpment. Upper and Middle Chalk also appears in valleys and in places on the hilltops (Countryside Commission, 1992). Lower Chalk is a mixture of chalk and clay, used in the manufacture of cement (as at Chinnor) and in the past as marl for improving poor agricultural land. Middle Chalk is a more pure white form, containing few flints. It is harder than Lower Chalk and more resistant to erosion. Upper Chalk is also white and pure but contains a high proportion of flint. There is some discussion as to the exact mechanism of flint formation; it is composed of silica which has separated out from chalk leaving almost pure calcium carbonate. It is a hard material which was used extensively for building in the study area (Smith, 1980)
During the Cretaceous period there were few earth movements, but about 65 million years ago at the start of the Tertiary Period, movement resumed. The chalk layers deposited during the Cretaceous Period were moved upward above water level and so were subject to erosion. As the continents drifted together, about 25 million years ago Africa joined Europe, the force of the meeting of the tectonic plates formed the Alps and buckled south-east England. A number of east-west folds were formed one of them being the Chilterns.

During the following millennia, land levels fell and rose again resulting in more deposits forming above the chalk about 55 million years ago. These deposits of clay, sand and gravel form the slightly acidic Reading Beds that overlie parts of the plateau (Smith, 1980) and often correspond with common land (or now ex-common land) as the ground was least suitable for agriculture. These materials were used in the past for brick, pottery and tile making where the clay was deep, and for glassmaking where the sand was suitable. During the Pleistocene glaciations, which occurred over a period of 2 million years ending about 10,000 BP, the final geological layer was formed. The Chilterns were never directly

affected by ice sheets, but experienced periglacial conditions with permafrost and intense cold. There would have been a brief thaw of the surface in the summer months, which resulted in solifluxion, the erosion of the chalk, leaving flints which mixed with the clay deposits. This formed Clay-with-flints which now covers the hill tops and provides a neutral to slightly acidic soil layer (Smith, 1980). It is these surface deposits which make the Chilterns distinctively different to other chalk landscapes.

Dry valleys are typical of chalk landscapes. These were formed during the Ice Age when surface thaw conditions caused numerous streams to flow across the plateau and erode ground that was still frozen and impermeable (Countryside Commission, 1992). The typical asymmetric valleys of the Chilterns landscape are thought to have formed as a result of this freezing and thawing cycle. South or west facing valleys are generally steeper than east or north facing valleys. It is thought that more weathering occurred on these steep valley sides due to greater temperature extremes on the slopes facing the sun (Smith, 1980).

Another feature of the Chilterns landscape is the general lack of surface water. Chalk is very permeable therefore rain water drains through it until it meets the water table just above an impermeable layer, in this case Upper Greensand and Gault clay. The water then emerges at this point, the "spring line" marked by a line of settlements below the Chiltern escarpment approximately along the line of the Icknield Way. Some of these settlements were the first basis for the long narrow "strip" parishes which extend up the escarpment and onto the dip slope. There are a few small streams within the Chilterns but these often have low flow rates in dry conditions or when local pumping stations extract water. Springs may also emerge in some dry valleys when the water table is high e.g. Stonor. These springs are now rare but in the past were often winterbournes or even permanent watercourses. All these factors have had a marked effect on settlement patterns and land use in the Chilterns.

3.2 Vegetation development post-glaciation: a brief overview for the study area

Due to the nature of the chalk landscape and the lack of areas of standing water in the Chilterns, it is not easy to reconstruct past regional vegetation patterns from pollen records. However, a variety of investigative techniques, using remains of wood, charcoal and seed, or snail shells, can construct a picture of the environment in chalk landscapes but this lacks information on species composition and density (Kerney *et al.,* 1963: Evans, 1972 in Smith, 1980). These techniques, although not providing as much information as pollen records, correspond well with them in terms of demonstrating changes in land cover indicating human influence from the first Neolithic clearances onwards. However with all these techniques it should be remembered that these provide fragmentary evidence only, both in time and place. New interdisciplinary developments in this field combine information from paleobotanical remains and genetic data from modern populations to assist understanding of changes in spatial distribution of species. It is possible to use large samples in this type of work which can provide a clearer picture of the evolution of the present day vegetation in Europe (Jackson, 2006).

A generalised picture can be made from pollen records for the development of woodland in southern England since the Devensian, the last ice age. The Devensian period was drier and colder than preceding glacial periods and resulted in obliteration of almost all vegetation. The vegetation seen today has colonised by a gradual movement north (Ingrouille, 1995). The present interglacial (post-glacial) period or Holocene, covering the past 10,000 years, is divided into different climatic periods associated with changes in vegetation. Until about 8,500 BP Britain was part of mainland Europe, but thawing ice and rising sea levels cut Britain off from the rest of Europe. Therefore, except for plants brought in by human intervention, the British flora is composed of those which crossed the land bridge prior to this time.

The earliest evidence for woodland vegetation is during the Pre-Boreal period approximately 10,500-9,500 BP when birch (*Betula*) and pine (*Pinus*) were the dominant species. A 1.4m section through peat in a stream adjacent to the Thames at Little Marlow, Buckinghamshire (east of the study area) found evidence of *Juniperus* and *Filipendula* at

the lowest level of the Late Devensian-Holocene period (10,000 BP), with pine and later hazel, the best early Holocene evidence in Buckinghamshire (Farley, 2008).

As the climate warmed the Boreal period 9,500-7,500 BP saw hazel *(Corylus)* and increasingly elm *(Ulmus)*, alder *(Alnus)* and oak *(Quercus)* in the south and west, while pine moved north into birch forests (Peterken, 1993). The Atlantic period was the warmest post glacial period to date (7,500 – 5,000 BP). Lime (*Tilia*) and later ash (*Fraxinus*) spread across southern England by 6,000bp (Rackham, 2006). Lime was a dominant woodland tree; it reached its peak around Oxford at about 6,800bp. It casts a deep shade and is thus a good competitor with other tree species, as its seedlings can survive in the shade (Ingrouille, 1995). However it is insect pollinated so pollen is under represented in the record.

The Sub-Boreal period (5,000 – 2,700 BP) is notable for the sudden decline in elm pollen which occurs in the centuries around 5,000 BP and which also appears across north-western Europe (Pennington, 1969). Archaeological evidence and pollen evidence relating to plants such as *Plantago* seemed to point to Neolithic activity as the cause for this decline (Pennington, 1969). However, more recent work indicates that the speed and form of the decline was more likely to have been caused by a pathogen similar to elm disease, possibly in tandem with far lower human activity than previously hypothesised (Peglar, 1993).

3.2.1 Lime and beech

Lime shows a marked decline in the pollen record; there is some dispute about the reasons for this. It was originally thought to have been climatically induced by cooler and wetter conditions. However, it is now agreed that the decline was due to human influence, spread over a long period in different areas from the Neolithic (6,500 – 4,300 BP), Bronze 4,300 – 3,600 BP) and Iron Ages, and even as late as the Anglo Saxon period (Baker *et al*, 1978). The peat deposits at Little Marlow, mentioned above, show evidence for the lime decline at this period which reflects woodland clearance (Farley, 2008).

Recent research on paleobotanical and genetic data indicates that beech (*Fagus sylvatica*) survived the last ice age and probably the previous glacial period, in sheltered refuges both on peninsulas around the Mediterranean and in central Europe. It seems that the beech present in south east England belongs to the central European group, rather than that from

the southern refugia as previously thought (Magri *et al.,* 2006). Using similar data, the current distribution of many beech woodland flora species appears to be dependent on post glacial dispersal rather than on their environmental needs (Willner *et al.*, 2009). Beech woodland in England has one of the lowest numbers of such species.

Beech pollen does not travel well in the wind so does not have a strong presence in the pollen record. In England, beech pollen appears in quantity only in the Sub-Atlantic period about 2,700 BP (i.e. c.500 BC) only in south east England. However, archaeological evidence of beech wood and charcoal dates from the Neolithic period (5,000 BP) indicating that it was present in England at this time (Pennington, 1969). Beech seems to have increased around 2,700 BP, taking over from lime which has a similar ecological position (Ingrouille, 1995). Beech pollen and fuel remains were found at Little Marlow and Taplow which could indicate that the Chiltern beech woods may date back to 3,000 BP (Kidd, 2008). The same pattern occurs in pollen diagrams from north Germany and Denmark (Pennington, 1969). It has been suggested by Godwin (1956) that this sudden increase in beech marked the beginning of the Iron Age, when stronger ploughs and axes allowed the clearance and cultivation of the heavier clay soils, thus allowing beech to spread on the lighter soils of the chalk region, which had previously been cleared and cultivated (Pennington, 1969). In the Weald the occurrence of beech pollen appears to be linked to human disturbance and use of woodland for pasturage, both in the Iron Age around 750 BC and during the Anglo Saxon period (Waller and Schofield, 2007).

A picture of the Chiltern escarpment at Pink Hill, Buckinghamshire (about five miles from the northernmost part of the study area), was created using snail shell fragments in soil samples down to a depth of 120 cm. It shows the transition from woodland to open arable during the Iron Age, with later grassland (Evans 1972). Earlier evidence comes from radio carbon dating of hillwash on the Chiltern scarp. This produced a date of 3,960 BP (early Bronze Age) and therefore suggests that clearance of primary forest took place resulting in soil erosion (Dimbleby, 1977). However there is no evidence of the type of woodland present at this date.

There are several theories as to how beech has become so firmly established across Europe, although in the UK it is occurs naturally only in the south east of England. There are two models for the migration of tree species; one that it spreads on a broad continuous

front and the other that it spreads across a discontinuous front, slowly from isolated outposts (Davis, 1987 in Bjorkman, 1999). Swedish data suggests that the second scenario is most likely (Bjorkman, 1999). This would imply that if beech was present in England in very small quantities before the closing of the land bridge between England and Europe, then it could have spread gradually in this way only reaching a large enough population size for pollen to occur in appreciable quantities after several thousand years. Another factor in beech establishment is suitable ground conditions for germination. Beech is dependent on disturbed ground for good germination and establishment. Natural disturbance and animal activity may have played a part, but it seems that the impact of humans on the landscape has played the most important role in the expansion of beech. Human impact in prehistoric times was minimal compared with today, however, early farming methods in the Neolithic and Bronze Age involved shifting cultivation, clearing land and using it for a few years, before moving to new sites, so leaving a mosaic of disturbed sites. This would have facilitated beech expansion (Bjorkman, 1999). However, there is disagreement between those who favour the above approach and those who argue that climatic effects are the driving force. On a continental scale, beech migration is compatible with climate models over the Holocene (Bjorkman, 1999). However, at a local level there are other factors which are also important for seed establishment. In the Swedish study it was found that there was no climate pattern to beech establishment at this scale (Bjorkman, 1999). It is argued that beech expansion is a natural process which would have happened without human influence, but which coincides with early agricultural activity (Gardner and Willis, 1999) whereas Kuster (1997) argues that because beech did not spread simultaneously in central Europe, the expansion of beech was due to shifting agriculture and colonisation. This process of expansion ended when settlements became permanent (Kuster, 1997).

3.2.2 The Vera discussion

The brief description above focuses on the expansion and contraction events of tree species since the end of glaciation and the formation of virgin forest or 'wildwood' untouched by human activity. This is generally taken to mean dense shady woodland with few open gaps which covered most of England except very wet, mountainous or coastal areas. However there is some disagreement with this view. Vera (2000) concluded that the landscape was far more open than this with wooded areas and large areas of grassland, grazed by large herbivores. The landscape was in a state of flux rather than climax

woodland. Thus the woodland would expand and decay in the centre so that over several thousand years before agriculture took hold, wooded and grassland areas would gradually move within the landscape. This hypothesis has been tested using palaeoecological data to compare the pollen record from Britain and Europe with that of Ireland, where there were no large grazing herbivores (Mitchell, 2005). This demonstrated that an open canopy was only ever maintained by human activity, although herbivores influenced tree species composition. However it is also acknowledged that pollen remains tend to be preserved in wetter areas, thus possibly influencing the conclusions. English Nature (now Natural England) reviewed the evidence for and against Vera's theory and concluded that it is likely that the woodland was more open than previously thought with wood pasture landscapes, but not to the degree of openness propounded by Vera (Hodder *et al.*, 2005).

3. 3 Early human impact

This and the following sections outline the general history of the woodland in the study area. Section 3.11 describes in detail the main uses for the wood produced in the study area.

Human activity began to influence the vegetation of England many thousands of years ago, although there is almost no direct evidence in the study area. Therefore this section aims to provide a brief overview of the prehistoric periods in the Chilterns to demonstrate that society was sufficiently organised to have had a marked impact on woodland and other natural habitats. This type of information is based on archaeological evidence and is highly dependent on chance finds for these early periods. Little archaeological information is available for the Oxfordshire Chilterns at this period, therefore much of the information below contains material from other parts of the Chilterns. All dates are approximate.
(Note: References for www.thehumanjourney.net refer to current archaeological work in the Solent Thames Research Framework, organised chronologically by time period. Material used in this study is mainly from the Buckinghamshire papers which contain most information relating to the Chilterns, rather than Oxfordshire.)

3.3.1.1 *Late Palaeolithic and Mesolithic periods (10,000bp - 6,500bp)*

The earliest south Chilterns evidence in the Holocene are signs of Palaeolithic and Mesolithic activity found in the gravels of the Thames valley, for example, in Gatehampton, Eye and Dunsden and in the Goring Gap area where "long-blades", flint tools for killing animals, have been found (Oxfordshire Historic Environment Record OHER PRN 15019). Mesolithic flint working sites at Nettlebed Common and Russell's Water also indicate hunting activities (Branigan, 1994). The Paleolithic was a hunter-gatherer culture to which the Mesolithic added skills in fishing. The latter population were semi-nomadic moving between summer and winter camps. Small scale woodland clearance for hunting and use of woodland materials would have had some effect on woodland composition and development. It has been suggested that the Chilterns plateau and valleys were quite heavily exploited at this time (Hepple and Doggett, 1992).

3.3.1.2 *Neolithic (6,500 to 4,300bp) and Bronze Age (4,300-3600bp)*

For many years it was thought that the major inheritance from the Neolithic period (in the study area and beyond) was the Icknield Way linking the major Neolithic centres of Salisbury Plain and East Anglia, which passed through the study area along and below the escarpment. However, Harrison (2003) has conclusively discounted this theory by using archaeological, documentary and theoretical approaches. The Icknield Way is not mentioned in documents until the 12th century as part of a fictional account. The modern existing "Icknield" tracks cross Iron Age and Saxon constructions and the previously held supposition that prehistoric sites were predominantly in chalk landscapes has been overturned by evidence for the widespread use of river valleys. The idea that items such as stone axes were transported from the north or west has been discarded for the theory that goods moved through the country by the exchange of gifts, so movement was slow. However, it seems that there was a post-Roman Icknield Way from Wanborough, near Swindon, to Princes Risborough. This runs at the foot of the escarpment but does not pass through any present day villages which are all situated on the spring line.

Some primitive farming took place during the Neolithic which became more established during the early Bronze Age, although at subsistence level. A possible field system has been identified at Cadmore End near Stokenchurch, with flint artefacts which indicate that the site was in use from the late Mesolithic to the Late Bronze Age, as were many sites. Hunting continued as demonstrated by bones of auroch, red deer, wild boar, roe deer,

badger, beaver and fox which have been found at various sites (Kidd, 2008). A scatter of flints from the Neolithic period has been found on Ewelme Downs, with others in the Goring Gap area (OHER PRN 15019). It is thought that a flint mine was situated at Peppard Common which would have produced better quality flint than surface flint. Stone axes, originating from the Lake District and Cornwall, have also been found, generally away from occupation evidence. They are often broken, suggesting that they were used for tree felling and either lost or abandoned. Pottery was in use by this time, a material which needs a good supply of wood fuel for firing.

Recent excavations of a Neolithic barrow on Whiteleaf Hill, about five miles from the study area, have found that it was constructed within woodland and that the body was held in a wooden structure under the barrow (Hey *et al.*, 2007). The presence of beech pollen both here and at Little Marlow and other sites in the Buckinghamshire Chilterns seems to indicate that the beech woods here originated during the 1st millennium BC (Kidd, 2008).

Metal working began in the early Bronze Age, when bronze was made as an alloy of copper and tin, again needing a plentiful wood supply for smelting. It was used for weapons and decorative purposes but later for tools as well. A defining feature of the early Bronze Age is their method of burial using round barrows and evidence of these has been recorded within the study area at Chinnor Hill, Stokenchurch and Pishill. The hamlet of Gatehampton on the Thames in the parish of Goring also has Bronze Age occupation; it was occupied from the Palaeolithic to the present day (OHER PRN 15019). During the Later Bronze Age, cremation became common, rather than burials in barrows and cremation urns have been found in Stokenchurch (Buckinghamshire County Council, HER 1737).

The site at Little Marlow (see 3.3 above), was part of an archaeological excavation of a feature known as a "burnt mound". These were late Neolithic or early Bronze Age systems for heating water using stones, which were heated in a fire and placed in a water container (English Heritage Thesaurus). The wood used for the fires included maple, hazel, oak, ash, beech, alder, holly, blackthorn, hawthorn, willow and pine.

3.3.1.3 Later Bronze Age and Iron Age (3,000bp – 2000bp)

During the Bronze Age, a land ownership system gradually developed which laid the foundation for today's landscape. By the end of the early Bronze Age, around 3600bp a good proportion of the Chilterns was farmed both for arable and animal husbandry in settled areas, with barrows possibly demarcating these areas. It is thought that the introduction of spelt wheat, which is more tolerant of wet ground, led to the farming of the clay plateau for the first time (Holgate, 1994). At an Iron Age site in Chinnor a distinctive type of pottery has been found which also appears in nearby settlements, for example at Lewknor further south along the bottom of the escarpment (Hepple and Doggett, 1992). Other studies below the escarpment at Chinnor, demonstrate that woodland was cleared, followed by open land (Evans, 1972).

During the late Bronze Age and early Iron Age, hillforts were constructed, mostly on the Chiltern scarp. Earlier thought to be defensive places but, following more excavation, they are now more strongly linked to agricultural produce storage and distribution (Bryant, 1994). Wyfold Castle hillfort in Checkenden is a slightly later Iron Age example. It is not situated on the scarp but on the plateau on fairly level ground which is now wooded (Castle Grove) and is partly destroyed by gravel digging and tree felling. The banks and ditches which surround it are still about 6 feet high or deep in places (OHER PRN 2016) and when first constructed had timber palisades. Hillforts are often in a loose pattern of pairs, which is apparent across the Chilterns and also in other areas; Wyfold Castle is paired with Boze Down Camp in Whitchurch to the south overlooking the Thames. This feature has been linked to a rise in tribal political development, which implies a well organised society (Barker *et al.*, 2003). Other notable features are the linear ditches which occur in several places across the Chilterns. These are all known as "Grim's Ditch" (as are others around England). The section in the study area is the Mongewell Grim's Ditch, which is traceable as earthworks, parish boundaries and bridleways from Wallingford to Henley, thus cutting off a large loop of the Thames. It predates the Icknield Way (see above) and is most likely to have been a territorial boundary. In the eastern Chilterns, holloways running down the escarpment have been linked to a pattern of roads and trackways which could be Bronze Age or even Neolithic (Bull, 1993). There are many such holloways within the study area, but it is not yet clear whether this pattern holds true here.

As the Iron Age progressed more contact was made with Europe and trading links may have occurred between the Thames Valley-Chilterns area and the Marne-Champagne region of France based on the similarity of metal and pottery finds (Bryant, 1994). During the middle Iron Age, society further developed with the likelihood of nucleated village settlements appearing in the Chilterns in a similar way to those found in Essex. The last 100 years of the Iron Age saw the Chilterns become one of the most highly developed regions of Britain, partly as a result of the expansion during the preceding period but also due to increasing contact with the Roman Empire. At this time there was intensive farming, with evidence from pollen grains, excavations of granaries and animal bones from cattle, pigs, horses and sheep.

Bryant (1994) stated that there is little archaeological evidence for iron working in the Chilterns woodland; however recent significant finds have been made dating from the Iron Age and the Romano-British period. Nine iron slag finds have been recorded in the Hertfordshire Chilterns and 35 in Buckinghamshire, mainly north and east of High Wycombe. To date no Oxfordshire sites have been found (Morris, 2009). Slag probably indicates sites where iron was smelted, using local charcoal to obtain the necessary high temperatures. Iron ore may have been obtained from the Greensand ridge, which runs parallel and north of the escarpment.

During this so-called Belgic period, a tribal group known as the Catuvellauni eventually controlled the whole of the Chilterns and eastwards into Essex and later most of the south-east. A Belgic burial near Watlington below the scarp indicates that wealthy aristocracy were living in the area (OHER PRN 2054). During the construction of the M40, finds were made below and above the escarpment near Lewknor. Amongst the finds were Iron Age structures on the Icknield Way which now passes under the M40. There was evidence of Iron Age occupation here and nearby in Hailey Wood a possible ritual site (Rowley and Davis, 1973). Finds have also been made along the line of a gas pipeline in Bix and Nuffield, showing the chance effect of such linear excavations. It is not clear how well populated the Chilterns were in the pre-Roman period and therefore any suppositions about landscape and land use are based on very little real knowledge. However as the preceding paragraph shows, archaeology is a chance event in most places and even more so in the hilly wooded Chilterns where clues are not easily visible.

3.4 Roman period AD 43 – AD 410

The previous section provided a brief overview of human activity in the study area of vicinity. The following sections increasingly provide more detail, the later periods including some unpublished primary sources.

A brief incursion by Julius Caesar in 55BC was followed by a full scale invasion in 43 AD resulting in Roman occupation of England until 410 AD. Vegetation identified for the earliest period of Roman occupation on the lower dip-slope north east of the study area include oak, beech, hazel and poplar (Branigan, 1969). It is likely that valley slope woodland clearance was underway at this time as late Iron Age sites are found in the valleys and on low ground. It seems that the non-Romanised people remained on the poorer soils on the hills (Branigan, 1969).

As Romanisation spread through the area, modest flint-and-brick villas were built in river valleys at Wycombe, Saunderton and Hambledon in south Buckinghamshire (Branigan, 1994). In the study area, two Roman villa sites, one with a bath house, have been identified at Harpsden (OHER PRN 2190; PRN 8784), both now in woodland, and another at Bix (OHER PRN 2866). These and other villa estates are estimated to be about 450-600 acres of pasture and arable with extensive woodland in addition, about half the size of a comparable villa in West Oxfordshire. It seems likely that the emphasis was on pasture with only enough grain grown for domestic use and winter feed for animals rather than for shipping elsewhere. The exception is the villa at Hambledon, east of the study area close to the river in a broad valley, where there is evidence of a large military presence and large scale cereal production possibly for the fort at Londinium (London) (Branigan, 1968). Lewknor seems to have been a Roman site for several centuries, with a farmstead there for at least 300 years, locally made pottery and a late or post-Roman cemetery containing 28 adults, five children and two new born babies (Rowley and Davis, 1970). Another long occupancy farmstead site was at Gatehampton on the Thames in the parish of Goring (OHER PRN 15019). Amongst animal bones found at various sites were those of sheep, horses, cattle, ox and pigs. Wool production was important with exports going to Roman Empire. Cattle were pastured in the damper valleys, while pigs were allowed to grub in the woods rather than fed with grain (Branigan, 1994).

Woodland was an important resource both for building and for firing hypocausts for heating, as well as in pottery making and iron working; therefore it is possible that coppicing took place. There is evidence of iron smelting in Common Wood, Penn, north of the study area. Woodworking tools have been found in some excavations. Wild animals hunted for food included deer, wild fowl and hare (Branigan, 1969). There is some evidence in the Buckinghamshire Chilterns that areas of open land were reforested through abandonment of Iron Age sites (Zeepvat and Radford, 2008). Evidence of tile production has been found in the east Chilterns but clay related work also took place in the study area. Pottery manufacturing sites have been identified at Watlington (OHER PRN1865), Sonning Common (OHER PRN16070) and possibly at Mongewell (OHER PRN2025). Locally made pottery has been found at Lewknor along the M40 route (Rowley and Davis, 1970).

Although the evidence for Roman occupation of the study area is sketchy, potential Roman sites have been found in the area, for example at Spring Wood, near Sonning Common (Morris, 2009). Other evidence has been found nearby such as a possible farmstead at Naphill Common, over the border in Buckinghamshire.

By the end of the 4th century AD, the Roman Empire was coming under increasing pressure as the economic system became overstretched and started to collapse. Early in the 5th century c410, Rome left Britain leaving the local population to survive alone. Chiltern villas had already been reduced in size in the previous century so Romanised society disappeared quickly, leaving the Romano-British farms to persist, although in a much reduced level, perhaps even reverting to a hunter-gatherer society. Within a short time all memory of Roman culture was lost even to the extent of coinage and the use of the potter's wheel (Hepple and Doggett, 1992).

3.5 Anglo Saxon period: 410 AD to 1066 AD

The first mention of the Chilterns as a distinct area is an entry in the Tribal Hidage, a late 7th century document which listed kingdoms linked to Mercia, a kingdom originating in what is now the Welsh Marches. By 670 Mercia was acknowledged as the overlord of the Ciltern Saxons. The entry states that "*Cilternsaetna landes is feowere thusend hyda*" (the land of the Chilterns is 4,000 hides) which amounts to about 160,000 hectares (Lobel,

1964). There have been suggestions that the Chilterns was a British (Celtic) enclave surrounded by Anglo Saxon settlement (Davis, 1982) and it is an interesting thought that, even in the 19th century, it could be claimed that there was a Chilterns Celtic "type" of appearance in the local people (Beddoe, 1885).

There is very little evidence of the Anglo Saxon period in the study area or elsewhere in the Chilterns. It is likely that settlement occurred mainly in valleys, particularly those with water, with burial sites occurring along the chalk escarpment. The population was probably sparse and scattered. It is thought that later medieval churches can possibly be used to indicate earlier Saxon settlement (Brannigan, 1994). In the excavations along the M40 route an Anglo Saxon cemetery was found at Lewknor (Rowley and Davis, 1973). Other sites are a burial site at Bix on top of a Roman wall (OHER PRN 2866), occupation at Gatehampton (OHER PRN 15019) and a cemetery at Shiplake (OHER PRN 2150).

3.5.1 Parishes

At this period the people lived below the scarp but gradually moved into the hills, laying the foundation for today's modern county and parish pattern. It is thought that colonisation came from three different directions, that of the present-day Oxfordshire Chilterns from the Benson area. The three groups met and the frontiers between them formed the boundaries of the Aylesbury Hundred and the Chiltern Hundreds, still marked by many parish boundaries. There is also a boundary, similar to the Hundred boundary, between Buckinghamshire and Oxfordshire which is still obvious as a bank in wooded places today, e.g. between Crowell (Oxon) and Radnage (Bucks).

The layout of parishes developed in the late Anglo-Saxon period probably around the same time as the open strip field form of agriculture came into being. In the Oxfordshire Chilterns ancient parishes mainly follow the pattern of long narrow strips sometimes up to seven or eight miles long, which cover a variety of land types and therefore resources. In a typical parish along the escarpment there were two or three large open fields farmed communally in the low land, the settlement situated on the spring line with downland and commonable woodland on the scarp slope. On the dip slope were small hamlets or farms with enclosed fields and woods. This is a simplification but demonstrates the resources available in such a parish. In the study area this pattern has persisted in many instances except for some alterations during the later 19th and 20th century.

3.5.2 *Anglo Saxon landscape names*

Although there is little material evidence of the Anglo Saxon presence in the Oxfordshire Chilterns, their legacy can be found in the place names of the area. The Saxons used different names to indicate the subtleties of the landscape; they often relate to landscape features such as hills and valleys and can also indicate the type of vegetation present at that time.

Information in this section is from Gelling (1984). Her analysis was carried out using maps, but on the ground these names appear to be descriptive of the various places named here. Woodland and clearing names may be used to indicate land cover when Saxon settlement occurred. All the landscape feature names quoted are Old English (OE) (see Appendix 2).

The three wood-related names below do not occur in the study area as settlement names, presumably as there was so much woodland that it would have been meaningless. However they all occur frequently in wood names in the study area.

Wudu: a wood, a large stretch of woodland.

Graf: relates to a thicket, grove or copse. Rackham (1976) takes this to mean "a small, defined and possibly managed wood", distinctive in the landscape.

Hangra: sloping wood - is used frequently for narrow hillside woodland. The term "hanger" was used in the 18th century to denote a wood on a steep slope, which is so characteristic of the study area. However, in the Chilterns, "shaw" used between the 16th and 19th centuries is more commonly found

Tree names seem to signify a specific occurrence of a particular tree. In the study area Bix is derived from *byxe* – box tree or box wood; Mapledurham is named from *mapuldor* a maple tree; while Pyrton refers to a pear tree, *pirige.*

The following names occur in the study area and are described in the local context.

Leah is a confusing word whose earliest meaning was forest. However, it later referred to a glade or clearing and finally to a meadow or pasture. *Leah* is found in the study area in many field names (as Ley) and also in some minor names such as Horsleys Green and Studley Green, adjoining hamlets in Stokenchurch. It has been suggested that these hamlets were a clearing in a larger area of woodland (much of which still exists) and rough ground

(later commonland) where horse breeding possibly took place (Parker, 1992). Interestingly, there was a large annual horse fair in Stokenchurch, now an annual fun fair, which might be linked to these earlier activities. Linley was a now vanished hamlet of Aston Rowant; its name meant "the clearing when flax is grown". Wormsley is an ancient estate which originally included land in Stokenchurch and the Uphill detached portion of Lewknor. Its name suggests that it was a clearing belonging to Wudemund or Widmund (Leggat, 1992).

Feld means open country (in contrast to woodland) or an isolated place. This is an interesting name element as it describes specific areas, most of which remained more or less the same until the mid 19th century. Baines (1981) submits that the Saxons specifically used *feld* for the flatter plateau tops, where they were not wooded or cleared for agriculture. These areas have clay or gravel soil and are full of flints; they are also dry with no streams and very few springs. Many of these areas became common land, some of which has survived, although others were enclosed in the 19th century.

Rotherfield (Peppard) means open land of cattle, whilst Nuffield refers to "rough open ground". In both the places there is still a large area of open common land, although at Nuffield it is now a golf course. Binfield Heath is similar example. An interesting example is that of *Abbanfeld*, Abba's open country, later Abbefeld. This originally included a detached part of Lewknor on a large area of pebble gravel, as well as Stokenchurch Common which extended into what is now Cadmore End (now enclosed), and further into Buckinghamshire to Ditchfield Common in Lane End, Wheeler End, Moor End and Bolter End, all still with large areas of open land. The last reference to Abbefeld was in 1428. It never became a parish or a manor, the name always referring to the open, heathy land (Baines 1981). The remains of a large brick-making kiln are situated on part of what was Cadmore End Common, indicating the thick clay soil in that area, as well as The Brickmakers pub at Wheeler End. There was also a smaller brick kiln in Stokenchurch close to the present Kiln Farm, again on past common land.

There were several other large areas of common land, some as at Abbefeld, crossing the county boundaries, thus indicating they pre-dated this period. One covered the area from the escarpment downs leading up the escarpment from Watlington to Christmas Common, across the Buckinghamshire border to North End, Turville Heath (ie *thyrre* + *feld* - dry open land) and on to Summer Heath and Southend. Here, there is later evidence of drovers,

using this huge open space for grazing for cattle en route to London from Wales. Summer Heath probably also refers to the practice of transhumance, ie springline villages using uphill grazing in the summer. A large area of open common land, Russell's Water or Maidensgrove Common, linked in the past with the now enclosed common at Greenfield and maybe also on to Cookley Green, names which indicate *open land* and a *clearing* respectively. These large expanses of open land on the plateau tops would have been rough grass and heath with ponds in places on the clay. Settlement was no more than a few isolated farms or smallholdings on the margins.

3.5.3 Boundary Charters

Another legacy of the later Christianised Saxon period was written boundary charters. One, which covers Stonor and Pyrton in the study area, dates from AD774 with a second version dated circa AD1070. Baines (1981) translated and analysed this charter which can still be followed on the map and on the ground. It describes following the woodland verge, which is still present on the edge of Queens Wood. Later along the route there is reference to a boundary bank and woodland belonging to Stonor, a stony boundary bank, and a hollow boundary "lynch". These features form the county boundary and also the boundary of the large area of Turville Heath, mentioned above. Open land, likely to be agricultural fields in the Stonor valley is obvious from the reference to a small ash tree and a maple which acted as markers, obvious in an open landscape. As the route returns to the starting point it crosses a "clean down" which is likely to be sheep grazed grassland. Therefore a picture of the local landscape over a thousand years ago can be extrapolated from this charter, and in this area at least, there have been remarkably few major changes. The general pattern of settlements, fields and woodland as seen today was established by the end of the Anglo Saxon period in the 11th century. It was this landscape which was recorded in the Domesday Survey after the Norman Conquest in AD1066.

3.6 The Domesday Survey and Book 1086

Prior to the Norman invasion in 1066, five centuries of Anglo-Saxon presence and assimilation had established an "English" identity and language; England was a wealthy country, based on the wool trade. There was a unified culture with systems of taxation, written laws, coinage and chancery, and an Anglo Saxon civil service. Laws included the Laws of Ine, dating from the 7th century, some of which related to woodland management.

There were penalties for destroying a tree; if by fire the fine was 60 shillings, for felling by other means, 30 shillings for three trees (Hooke, 1989). Others governed the use of mast-bearing woods (Darby, 1950). If payment was taken for mast for swine, the mast owner received every third hog with three-finger- thick bacon, every fourth hog with two-finger-thick bacon and every fifth hog with thumb-thick bacon (Meritt, 1945).

Twenty years later, when the Domesday Survey was undertaken in 1086, the country had been devastated by war, disease and famine (Wood, 1987). The condition of land holdings in England both before and after the Conquest was recorded in the Domesday Book, which was compiled in 1086 from the Domesday survey. The main aim of the survey was to investigate land holdings on which tax could be charged. Through his conquest, William had acquired the right to levy a land tax (geld or danegeld) first mentioned in 991 (Maitland, 1897). Taxable land, held by lords and sub-tenants as *vills*, was listed rather than villages as recognised today, although many place names are still identifiable. The survey also obtained accurate information on the land holdings and income of feudal lords and tenants. The third reason was to obtain a record of the land and its worth in the days of Edward the Confessor and to legalise the changes in its ownership since the conquest (Wood, 1987). Domesday was not a census as it only recorded names of land holders, therefore no people of lower rank are named. It was the final proof of legal title to land and was used for this purpose in the courts for several centuries (National Archives Research Guides). The original survey was compiled in geographical terms of counties and their hundreds and manors, but when the information was rewritten in its "Book" form it was rearranged for each county in order of landholders, from the king downwards.

3.6.1 Method and terminology in the study area

The country was divided into areas for the survey, Oxfordshire being included with Warwickshire, Leicestershire, Staffordshire and Northamptonshire. This grouping is now known as Circuit 4 according to the style and structure of the entries. Commissioners from outside the area travelled round and asked a basic set of questions (See Appendix 1), although the methods of estimation and recording varied from area to area. A second set of commissioners were sent to check on the findings of the first survey. Such a detailed survey reflects the organisation and administration of the English society which William had inherited through conquest. It was unique in Europe for many centuries (Morris, 1978).

3.6.1.1 Domesday terms relevant to the study area or to woodland

A brief explanation of some of the terms used in the survey is given below and applied to the study area. Domesday Book Helpfile has been used in compiling much of the information below. More detail and other terms are described in Appendix 1.

Some of the Chiltern parishes in existence today were listed as vills (equivalent to villages) in the Domesday Book. However, one of the uncertainties of the Oxfordshire Domesday record is that the large vills held by the King or by the Bishop of Lincoln probably contained settlements not named or listed individually (Darby and Campbell, 1962). An example is Bensington, a large royal manor which extended from present day Benson across the hills to Henley, a settlement whose name is post-Domesday (Darby and Campbell, 1962). The same authors suggested that Stonor and other settlements were contained within the Benson entry. However, according to a boundary charter dating from 774, Offa granted 40 hides of land, called Radenore, to the Bishop of Worcester. This land formed a large detached uphill part of the parish of Pyrton which included Stonor and Pishill, both in existence by 1086. The charter bounds show this clearly and have been traced in the modern landscape by Arnold Baines (1981). Therefore the Domesday record for Pyrton is more likely to have included these two vills, rather than Bensington. Aston Rowant was large vill which extended to the then Buckinghamshire border at West Wycombe; Stokenchurch was a small settlement within this vill so not recorded individually. Woodcote was contained within the record for South Stoke vill.

A notable feature of the Oxfordshire Chilterns was the number of freemen recorded in 1086; the majority of freemen were recorded in the north and east of England. Across the county only 26 were listed (Darby and Campbell, 1962) of which 22 were in the Chilterns (15 in Aston Rowant, four in Pyrton and three in Goring). It is thought that these men were colonisers who had established freeholdings in the hills above the main settlements on the spring line. In 1279, the Hundred Rolls record high numbers of such men in the hamlets in the hills, such as Stokenchurch with almost 30 and Ackhamstead (a detached part of Lewknor) with nine (Hepple and Doggett, 1992.)

Waste was recorded once in the study area; in the majority of cases waste refers to areas laid low by the destruction of the Norman invasion, mainly in Yorkshire and on the Welsh border. However, in the Chilterns study area it is more likely to mean uncultivated or

unusable land such as heathland, or land that had fallen out of cultivation. The only site in the study area was *Vernefeld* which was recorded as half a hide of royal waste (about 60 acres). It is thought to have been situated on what is now Russell's Water Common, (Greening Lamborn, 1936). The name Verneveld comes from OE *fearn* - bracken, which would still relate to the vegetation in that area.

Woodland was generally recorded as "*silva*" across England. In the study area all woodland was recorded as *silva* with the exception of a record in Britwell of underwood, *silva minuta*, and *grava* or copse. These areas might actually be just outside the study area on the lower land. Amongst other woodland types was *silva pastilis*, wood pasture, but none was recorded in the study area. Lewknor woodland is recorded as worth 25s "when stocked". This is translated from "*cum oneratur*" which is taken to mean when it bore mast (Darby and Campbell, 1962). Newington woodland is another with this proviso, although again this may be situated outside the study area (Morris 1978).
Methods of woodland measurement varied between areas. In Buckinghamshire and Hertfordshire, further east along the Chilterns and other eastern counties (Circuit 3), the area was estimated as the number of swine the woodland would theoretically support e.g. *silva xxv porc* (woodland 25 pigs). In Oxfordshire and other midland and western counties, woodland was recorded by length and breadth i.e. miles, leagues or furlongs, with some smaller woods recorded by area as acres. The measurements given are woodland totals for each land-holding. The accuracy of the figures produced is likely to be approximate especially if several areas are being amalgamated in each manor, which is highly likely in the Chilterns and other well wooded areas (Darby, 1950). It is not known whether they were rough estimates, maximum diameters of irregular shaped woodland, or averages of diameters (Darby and Campbell, 1962). There was no information about individual woods, their names, site or composition. It is possible that the woodland recorded was demesne woodland or was being actively managed by coppicing (Victoria County History, 2007).

It has been suggested that the Chilterns were a mainly wood pasture economy, although none was recorded as such (see above); the area of arable recorded and the number of plough teams needed to cultivate the land show that the Chilterns was also an arable area, therefore very different to places such as the Forest of Dean or the Weald, based solely on a woodland economy (Hepple and Doggett, 1992). Although, in comparison with the

nearby lowlands, there were fewer plough teams, a smaller population and less wealth in the hills, when topography and soils are taken into account, the Chilterns were farmed quite extensively. This seems to be a contradiction to the status of the Chilterns as the second most wooded area in England. However, when the topography of valleys and steep hill sides is taken into account and the fact that woodland tends to occur on ridges and steeper valley sides, the lower valleys with better soil were very suitable for arable cultivation (Hepple and Doggett, 1992).

In some places the value of the vill had risen since the time of King Edward. In Pyrton the value was £16 in the time of King Edward; by 1086 it had risen to £30 (Lobel, 1964). Similarly in Aston (Rowant) and in Whitchurch the value had risen from £15 to £20, and in Rotherfield Peppard from 100s to £7 (Morris, 1978). It is suggested that this was due to woodland clearance (Salzman, 1939).

3.6.1.2 Domesday woodland analysis for the study area

A map of Domesday woodland across England produced by Rackham (1976) shows the Chilterns to be a well wooded area, second only to the Weald. In their maps of the South-eastern counties and of Oxfordshire, Darby and Campbell (1962) show the Chiltern woodland to be situated at the foot of the escarpment, where the main settlements lie on the spring line. However, in reality parishes extend up and over the Chiltern escarpment where most of the woodland was situated on the dip slope. Their Oxfordshire map does not include woodland recorded for Caversham, which was in Oxfordshire until 1911, when it was split between Berkshire and Oxfordshire. Instead it is shown on the Berkshire map, although it is more likely that the majority of woodland would have been in the Oxfordshire Chilterns rather than on the low lying land south of the river. Over most of Oxfordshire there is a fairly even spread of settlements names and population except for the apparently less populated Chilterns and the Wychwood area, already a royal forest at this date with large areas of wooded landscape (Darby and Campbell, 1962). However as mentioned above, not all settlements which must have been in existence by 1086 were recorded individually in Oxfordshire, so this assumption may be inaccurate.

The Oxfordshire part of the Chilterns was the most wooded area in 1086 (Roden, 1968). Of the 27 vills in the Oxfordshire Chilterns which appear in the Domesday Book, only five had no woodland recorded. These are places either close to the Thames such as

Gatehampton and Mapledurham, or on the escarpment such as Gangsdown (near Nuffield Common) and Swyncombe. The fifth, Verneveld, is a site which is now lost. It was mentioned in a grant of Aethelred II of 996 which would place it in the area of Nuffield and Swyncombe. However the lack of a record may not indicate that woodland was absent (Harvey, 1980). Bensington (Benson) belonged directly to the king and, in common with other royal manors in Oxfordshire, woodland was not recorded as a linear measurement. Instead, the monetary yield of the woodland is included with meadows, pastures and fisheries, so no details can be extrapolated. It is suggested that this refers to renders of money from pannage (Darby and Campbell, 1962).

Information has been collated on the Domesday woodland extent in the 27 Oxfordshire vills covered by the study area. These are now mainly parishes and/or villages with three exceptions: Badgemore is now on the outskirts of Henley; Bix Brand and Bix Gybwn are now combined forming Bix; and Gangsdown is now only the name of a hill within Nuffield parish.

For this research, indicative woodland areas have been calculated for each vill in the Oxfordshire Chilterns (Table 3.1 below). Using Domesday data to extrapolate a modern equivalent is fraught with problems. It is possible that not all the woodland present in a vill was recorded in the Domesday Book. Bix, for example, was listed with only a total of 20 acres, but it is very likely that there was far more at that date. Domesday measurements are probably estimates of the entire area of woodland within a vill, not accurate measurements. It must also be borne in mind that units of measurement were not statutory or standard, but were local or customary units until relatively recently (Maitland, 1897). When converted to modern measurements, the results are therefore an approximation. The figures used for conversions in these calculations have been taken from Darby (1950) and Rackham (1986). Darby and Campbell (1962) are very cautious about converting Domesday woodland figures into modern units. However, Rackham (1976) calculated the percentage of woodland cover for each county listed in the Domesday Book. In this research acres have been calculated and totalled for the entire study area using conversions shown below. The resulting figures were then converted to hectares.

Table 3.1 Domesday Woodland Areas calculated for the study area.

Vill	Woodland extent recorded	Hectares	Acres
Aston Rowant	1 league x ½ league	290	720
Badgemore	2 furlongs x 1 furlong	8	20
Bix Brand	12 acres	4	10
Bix Gibwyn	12 acres	4	10
Britwell (Salome)	3 furlongs x 1 furlong	12	30
Caversham	1 league 2 furlongs x 1 league	113	280
Checkendon	1 furlong x 1 furlong	4	10
Chinnor	5 furlong x 3 furlong	61	150
Crowell	2 furlong	48	120
Dunsden	1 league 4 furlong x ½ league	388	960
Gangsdown (Nuffield)	nil		
Goring	5 furlong x 5 furlong	101	250
Harpsden cum Bolney	nil		
Ipsden	1 ½ furlong x 1 furlong	6	15
North Stoke	4 furlong x 3 furlong	48	120
Lewknor	1 league 4 furlong x 1 league	776	1920
Mapledurham	nil		
Mongewell	1 ½ league x 4 furlong	291	720
Newnham Murren	6 furlong x 3 furlong	73	180
Pyrton	18 furlong x ½ league	437	1080
Rotherfield Greys	4 furlong x 4 furlong	64	160
Rotherfield Peppard	½ league x 3 furlong	73	180
Shirburn	6 furlong x 2 ½ furlong	30	95
Watlington	7 furlong x 3 furlong 1/12 league x ½ league	521	1290
Whitchurch	2 furlong x 2 furlong	16	40
	TOTAL	**3358**	**8360**

Note:

Bix: In both manors woodland was recorded in acres. Domesday acres are 1.2 modern acres (Rackham1986).

Britwell (Salome): Two landholders held two areas of woodland. Underwood is translated from *silva minuta*, while copse is *grove*. The grove was recorded in acres (see Bix).

Caversham was split between Oxfordshire and Berkshire. The woodland has been all been included in Oxfordshire figures.

Crowell: Woodland was recorded as one linear measurement, which is suggested equates to 120 acres (Darby, 1962).

Conversions used:

1 league (Domesday) = 1.5 miles (Rackham, 2006)

1 league = 12 furlongs (Darby 1950)

8 furlong =1 mile (Rackham, 2006)

1 furlong = 220 yards

1 acre (Domesday) = 1.2 acres (Modern) (Rackham, 1986)

2 furlongs = 120 hides (linear acre) (Darby 1962)

It can be seen that some places were far more wooded than others and in general this difference is still valid. Table 3.1 shows that Lewknor, Watlington and Pyrton had the greatest woodland extent. These three vills are situated to the north of the study area and extended from beyond the springline, up the escarpment and well over onto the dip slope.

Although attempts to produce maps and data from the Domesday Book can be made, nevertheless the Domesday Book provides as many problems as answers. However, for the purposes of this study, it indicates the woodland extent and landscape of the period, which even at this date demonstrates the mixed economy of the Oxfordshire Chilterns which was to survive until the 21st century.

3.7 The Middle Ages 1086-1600

After the enigmatic woodland records of the Domesday Book, the following centuries provide a little more information, mainly from the 13th century onwards. The woodland landscape in the Chilterns is inextricable from the fieldscape, so some explanation of field patterns and their development is necessary to place the woodland in context. As apparent from the Domesday records, the Chilterns was a wooded arable landscape. The arable land in a typical hill parish was a complex mixture of several open fields as well as other small closes which were owned by individuals (Hepple and Doggett, 1992). These open fields were smaller and more numerous than the large two or three open fields of the parishes on

the Oxfordshire plain and the Vale of Aylesbury. However, some parishes in the study area only had one common field because of the steepness of the valley sides (Roden 1973). The open fields were farmed in common in strips in a similar way to those on the plain, but the greater number of fields farmed in common in the hills meant that agriculture was more flexible than that on the lowlands. The smaller individual closes could grow crops which would complement those produced in common (Roden, 1969).

It has been shown that in 1086 there was still a large amount of woodland and heath in existence, much of this probably used in common for grazing and estovers (wood for fuel). However, during the two hundred years following the Norman Conquest, these uncultivated areas were reduced by more clearance, and at this time usually taken directly into individual ownership (Roden, 1969). Prior to this time there are some earlier references to woods in private ownership, as for example, Clacc's Wood mentioned in the 10th century boundary charter of Radenore, which may be west of the present day Queen Wood in Watlington parish (Baines, 1981). Many woods mentioned in documents dating from this period are still recognisable by name across the study area. Examples include Rumerhedge Wood (1153) in Checkendon; Hartslock Wood (1181) in Goring; Kingwood Common (1275) in Rotherfield Greys; Thirds Wood (1200) Aston Rowant (now Stokenchurch); Hailey Wood (1278) Lewknor (Gelling, 1953).

3.7.1 Landscape evolution

The arable landscape was created over several hundred years, and by the time of Domesday, much assarting or woodland clearance had already taken place, with more occurring over the next two hundred years. Some clearance was under the auspices of the lord of the manor who apportioned assart land between his tenants, whilst other assarts were formed by individuals or groups of people in more remote areas on the plateau or steep ridges in the study area (Roden 1969). Timber from assarting was sold and made a good profit (Roden, 1968).

The extensive charters in the Cartulary of Missenden Abbey in the central Chilterns were used by Vollans (1959) to study the evolution of arable land in the 12th and 13th century. The landscape there was similar to that of the study area, containing large areas of woodland and heath as well as arable fields. The charters contain much information about the process of clearance to extend arable land. Assarting took several forms. The actual

term "assart" was not used very often and when it was seems to have had a particular significance which is not now obvious (Vollans, 1959). There were intakes on the waste or heath which in time became new fields. Woodland was demarcated with signs to indicate new holdings, which were sometimes fenced before felling began and were gradually cleared in stages. These were usually "increments" to existing holdings and were described as such. They were probably in both a strip form or in a block. Fences were built with stakes and brushwood, often with a ditch, between the newly cleared land and the wood to prevent animals damaging crops. Fences with ditches were probably meant to be long standing and it is possible that these fences became hedges over a period of time. In the open fields, earlier fences were probably removed, but if they were left in place, the landscape became one of small enclosures. In Crowell, one of the last parishes to be inclosed in the country, some fields on the top of the escarpment were subdivided between owners, as well as some of the woodland (Oxford Record Office (ORO) s118).

Another method of clearing woodland for arable described in the Missenden Cartulary resulted in what was termed a 'grove'. In large areas of woodland, clearing took place selectively on patches of good soil, so that arable and small woods (possibly narrow strips now known as shaws) were intermixed. This seems to have occurred on the sides of large valleys and in or near smaller valleys. The topography, slope, aspect and soil are all very variable in these circumstances, so some areas would do better as arable, whilst other on poor soil were best left as woodland. The "grove" name referred to both the remaining wood and the arable associated with it (Vollans, 1959). The same pattern has been found in Checkenden parish where the Hundred Rolls entry for Wyfold records ten tenants with "crofts and groves" (Preece, 2005). Similarly at Goring Heath, hedged crofts and groves are mentioned in 1297 and 1334 (Preece, 2004).

One such assart may have been the hamlet of Linley or Lillee and its land within the parish of Aston (Rowant), uphill in the present day parish of Stokenchurch. There is no way of knowing when this settlement developed; it could have been in existence before Domesday and not listed, as was the case with Stokenchurch, or could be post Domesday. It was mentioned in 1200 when Geoffrey de la Mare was accused of taking pigs belonging to Samson which were feeding in Samson's common in Lillee (Lobel, 1964). There is no trace of this hamlet now although there was a field in the area called The Lillies, recorded on the Stokenchurch 1842 Tithe Apportionment (ORO 362).

There are references in the Hundred Rolls in 1279 to peasants with small amounts of assarted land such as Andrew ate Wode and others in Ipsden who held assarts of three acres (Preece, 1990). The remains of an assarted settlement were found in Sadlers Wood during the construction of the M40 above Lewknor. The farmstead was occupied from about 1250 until 1400 and is associated with field boundaries and a possible sunken track. There are no written records and there is no apparent reason for its desertion, as it does not fit with the usual dates of abandonment after the Black Death (Rowley and Davis, 1973). This is one of what may have been many small farmsteads now lost and covered with woodland.

3.7.2 Woodland composition

Beech was the most frequent tree species, particularly in the central and southern Chilterns. In 1310 there was an order to cut down 3,000 beeches in Bledlow Wood, just east of Chinnor, and in the 15th century at Greenfield, Sir William Stonor sold 500 beeches which were all to be taken from two named woods, so presumably sold standing (Roden, 1968). Wood was taken from Pyrton and Ibstone to Cuxham (both manors owned by Merton College). Where the type of wood was recorded it was always beech, which was sold either already felled or standing. It had a variety of uses; for building and carpentry and for firewood (Harvey, 1965). However, oak and ash were also common, more so than today. In Ibstone, close to Stokenchurch, during the winter of 1363-64, 100 beech and 400 oaks were blown down in one particular wood (Roden, 1966). In Bix, Bromsden manor had a wood containing oak saplings, ash and beech in 1593. Other trees were also present. Maple, withy (willow), aspen and whitebeam were listed in a lease of Kildridge wood near Stonor in 1525 (Lobel, 1964). Ash, willow and aspen were mentioned in 1483 when the growth of a coppice in Rotherfield Greys was sold by William Stonor (Victoria County History, 2006).

Management in demesne (i.e. land retained for the use of the lord of the manor) and private woodland was probably a mixture of high forest and coppice with standards. In the study area, due to the density of woodland, there seems to have been no systematic pattern of felling, which only occurred when needed, for example, if income from other sources was low or there were large bills to be paid. Small annual sales took place of fallen or dead wood, underwood and loppings, trimmings and bark from trees used on the manor appear to be typical of the study area in around 1250 (Lobel, 1964). However this must have been

for local consumption as by the 13th century large amounts of firewood was being sent by river to London (see 3.12). In some places, selective felling may have taken place as indicated by a sale in Stonor in 1482, when the purchaser had to agree not to fell trees unless they were more than 10 inches at breast height of a man, as well as ensuring that no young growth would be damaged. Another sale in 1525 in Pyrton stipulated that trees had to be 25 inches or more at breast height (Roden, 1968).

The wooded nature of the Chilterns was well described by John Leland, who was a scholar and librarian to Henry VIII. He was commissioned to search for documents from earlier periods and during his travels he recorded the landscape through which he travelled. His 'Itinery' was based on this information and covered the period between 1535 and 1543. He travelled from Caversham to Ewelme and remarked that he travelled through 'great wooddes' and elsewhere described the landscape 'Thens by Chiltern-hilles and baren, woody and fern ground for the most part...'. Around Henley the landscape contained 'plenty of wood and corne', whilst at Stonor there was 'a fayre parke and warren of connes and fayre woods' (Smith, 1907).

3.7.3 Common Woodland

Common woodland could be either a wood used in common or wood-pasture common (i.e. wooded/open common); these types often merged into each other. The term "waste" probably referred to wooded heathy common. Even as recently as 1842, the Stokenchurch tithe map, in which common woodland and open commons were illustrated graphically, shows this gradation from one type of vegetation to the other.
See Figure 3.2 below.

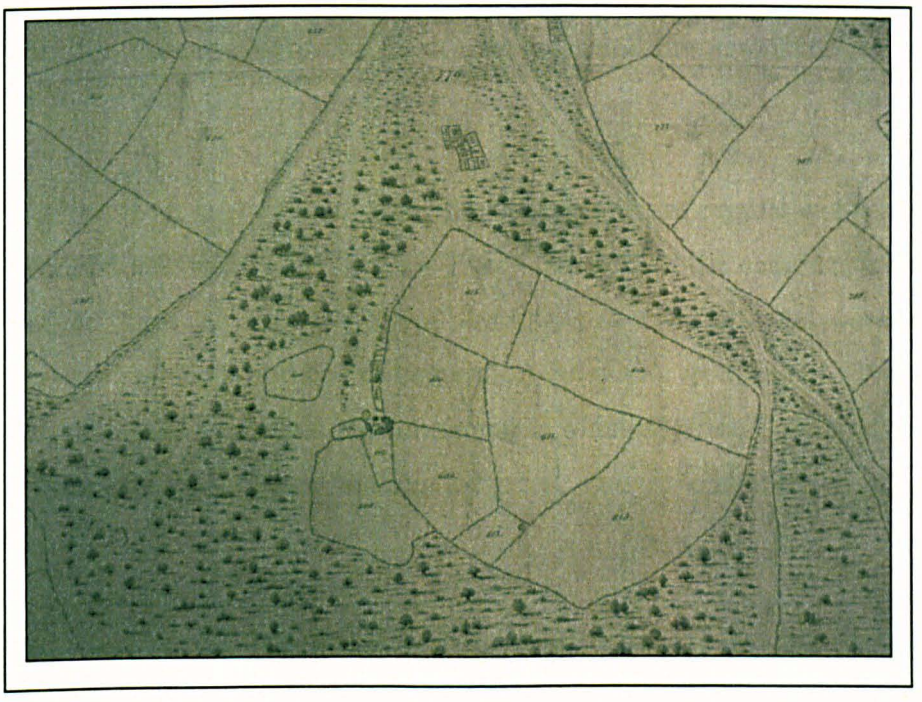

Figure 3.2 Stokenchurch tithe map (1842) Detail showing vegetation patterns on common land (ORO, 362).

Note: Eastwood Farm surrounded by common land, possibly created as an early assart. Common woodland (Eastwood) is situated to the east of the farm.

Common woodland would have initially had much the same composition as described above. Rights to wood were strictly regulated to prevent over-cutting, and grazing was also controlled. Most common woods were more open in this period with little or no underwood and more ground flora; wood pasture was a more extreme version of this. However, some common woods were quite densely wooded such as around Bretons Heath in Bix in the 12th century (Roden, 1968). Scrubby semi-heath commons evolved by the 17th century, although in the early 19th century there is a mention of trees growing into large timber on Stokenchurch Common (ORO C26/4).

There were large areas of common woodland and waste in the study area and although some was taken into private ownership or cleared for farming, large areas remained up to the 19th century as is evident from tithe maps. Rights in common woodland were usually attached to tenancies and could be sold with the landholding. Some rights may have been open to all in the manor. They were a valuable asset for small tenants who could use wood for building (housebote) and for fuel (firebote). These rights were tightly governed so as to

protect the woodland from over exploitation; for example, at Shirburn tenants could cut trees for firewood only one week each year and the amount taken was tightly regulated (Roden, 1968).

In Minigrove, part of Bix parish, there were a list of regulations relating to cutting wood. Records date from 1715, but are likely to reiterate the same rules that were used in the Middle Ages. In Bishops Wood, cutting was only allowed between Michaelmas and Mayday and the wood had to be used on the manor or a fine of 10 shillings was imposed. The same rule applied on the common (i.e. Maidensgrove Common, with an additional fine of sixpence for anyone cutting a "green stub or chuck at any time of year" (ORO, VorII/i/1).

Estovers were the right to collect fallen wood which again was limited to those with rights, but probably not in the amount which could be taken. It was sometimes allowed to use "hook or crook" to reach loose wood in the trees themselves. At Cowleaze in Lewknor, tenants could each claim 1½ loads of bushes as estovers from the common for firewood, as well as plough-bote, cart-bote and stake-bote for their farming needs. House-bote for repairs for their homes was directed by the lord of the manor and given out by him (Lobel, 1964). The right of pannage (feeding pigs on mast) was also regulated in the same way and dues were charged when mast (beech nuts or acorns) was available. As beech mast does not occur every year, it must have been an irregular occurrence. At Woodcote in 1279 in the Hundred Rolls, dues were payable for rights of pannage "when the wood carries it" (Preece, 1990). In Ibstone, which belonged to Merton College, pigs were brought from Cuxham, another of their holdings, to feed in the Ibstone woods (Harvey, 1965). However, most common woodland was available to all the tenants for grazing of other animals such as sheep. Haybote, (taking wood for repairing fences and hedges ie an enclosure or *hay)* could also be taken by all in most places (Roden, 1968).

Not all commons belonged to one manor. In some places several parishes inter-commoned. The common woodland at Wyfold was used by Rotherfield Peppard, Harpsden and Wyfold, and Exlade Wood was shared between Stoke (South Stoke), Woodcote and the monks from Caversham (Roden 1973). Another wood used in common was Eastwood in Stokenchurch (see Figure 3.2) but then partly situated in Abbefeld, a detached portion of Lewknor Uphill, before boundary changes took place. There are records in 1206 of a

dispute between Laurence de Scaccario who claimed that Alan FitzRonand had disposed him of common pasture in Estwode which he held by virtue of his smallholding in Abbefeld. In 1240 another dispute on the same issue took place between Roger de Scaccario and Rewald FitzAlan. In 1279, the Hundred Rolls contain a reference to services rendered including care of the lord's swine in East Wood (Parker, 1971). In about 1680, the Vicar of Aston Rowant claimed that, before the Civil War, he used to receive six loads of the largest billets from the woods known as Eastwoods as tithes (Lobel, 1964). Eastwood was not enclosed until 1861.

Hillwork

A particular aspect of common woodland was apparently concentrated in the north- west corner of the study area around Chinnor, Aston Rowant with Kingston Blount and Crowell. Known as "hillwork" it involved the taking and carting wood as estover from the woods on the escarpment and at the top of the dip slope (Hassall, 1951). In 1241 six cartloads of wood were taken from Chinnor to Kingston Blount as estovers and were recorded as "hillwork". A similar number of loads occurs over several centuries and is often called hillwork or a variation e.g. hegginwood. In time, hillwork came to mean both the common rights in taking wood and the woodland itself. In 1717 it occurs in a reference to the 'Common wood or Hillwork' belonging to Chinnor. Its usage was strictly governed and in the 18th and 19 centuries there were orders forbidding cutting 'our hillwork in the Hillwork' in the spring. It was open to all parishioners to use, although it was stressed that it was mainly for the poor who were 'not to meddle' in other woodland (Lobel, 1964). Later the word became Hillock. In Kingston Blount, the 'Poors Hillock' which contained 'brushwood or fuel for cutting and taking' was finally exchanged for allotment land in the village by the Lord of the Manor in 1864 (Hassall, 1951). There is another example further north on the Buckinghamshire escarpment near a hamlet called Parslows Hillock. An area of earlier common woodland was shown on a sale map of 1847 as the 'Hillocks or Scrubbs'. Juniper can still be found there today.

In Stokenchurch, once part of Aston Rowant, the 1842 Tithe Map and Apportionment records a piece of common land known as Lot's Hillock next to Lots Wood, just over on to the dip slope, in the same possible vicinity as Linley (see above). The wood may have been taken down to Aston Rowant as "hillwork" or used in Stokenchurch in the same way, using the same local word for the operation. The name "Lot" would imply that there may have

been a system of drawing lots for the use of both pieces of woodland, although no other reference to these woods has been found either in original documents or references. In Crowell all the tenants had common rights attached to their dwelling to take wood from Hill Wood. This is comparable to hillwork (Lobel, 1964). In neighbouring Radnage, across the border in Buckinghamshire, at a court held in 1549, the tenants of the manor claimed the right of common in Croull (Crowell) Wodd (sic) (Page, 1925).

Other rights were also given in common woodland, for example, the extraction of chalk, sand and clay for making pots, bricks and tiles. These minerals occurred more frequently in common land areas, which were usually on areas of poorer soil.

3.7.4 Private Woodland

Private woodland varied from large areas to small groves, often on land which was unsuitable for cultivation. Large woods were sometimes subdivided as a result of enclosure by several men or later when plots of woodland were sold or leased to tenants. In 1387, "Harlyngrugge wode" in Pyrton parish, near present day Hollandridge Farm, was said to contain hedges and *hays* (any type of enclosure or a hedge) (Lobel, 1964). In time, scattered woodland holdings were consolidated by buying or exchanging holdings (Roden, 1968).

Areas of woodland were taken from common woodland into private hands, sometimes with agreement as at Wyfold, which was held by Thame Abbey from 1153. At the beginning of the 13th century, this area was woodland and heath with only a small amount of cultivated land. In a complicated set of exchanges and agreements, woodland became enclosed by hedges and was in private ownership while other areas were held in common by neighbouring manors (Roden, 1968). The legal processes of taking over common woodland into private ownership were complicated and long drawn out.

The timber was valuable so was protected in private woods. Pannage was allowed but not grazing by sheep or cattle, although there would have been little forage in the shade cast by the trees (Roden, 1973). Coppiced areas were enclosed for at least seven years; grazing was allowed after this period. A record of a sale of wood (ie for cutting) by Sir William Stonor to William Fullard of Watlington in 1482 stipulates that no tree could be cut unless it was above 20 inches at breast height. The young saplings were to be protected:

'specially that no colyers nor others destroy not the young spring with stopping of their *sattes* (slips or suckers). The wood shall be *ryd* (cleared up) at draw so the young copyse be not hurt'.

(Kingsford, 1919).

N.B. Colyers were charcoal makers.

3.7.4.1 Deer Parks

Some woodland was enclosed for use as deer parks for hunting, for meat as well as for sport. Parks were probably a form of wood pasture both for grazing and for cover for breeding deer. Trees may have been pollarded to allow regrowth without deer damage. Parks were usually roughly circular or oval in shape and can sometimes be traced in today's landscape in woodland and/or field patterns, as well as by place, field and wood names. Secure fences (pales) made of cleft oak stakes were at least six feet high; within this was a ditch, designed to keep the animals inside the park and poachers out (Hepple and Doggett,1992).

In the study area there were several small parks; these included Stonor, Shirburn, Rotherfield Greys, Nuffield, Watlington, and Mapledurham. There may also have been parks at Elvedon (Goring), Elmore near Woodcote, Hardwick (Whitchurch) and Wyfold (Preece, 1990). Sometime prior to 1272, the park at Watlington was taken from commons above the escarpment by Richard, Earl of Cornwall. This caused some resentment amongst local freemen who had been able to hunt and use the assets of the common. In 1279 the park was 40 acres. It was fenced in 1296 (Lobel, 1964; Hepple and Doggett, 1992). At Rotherfield Greys, in 1240 the Grey family had a royal grant or licence to free warren on their demesne. 'Free warren' meant they had sole right to hunting "beasts of the warren" such as rabbits, hares, wild cats, pole cats, pine marten and others (Langton and Jones, 2008). They had a park by 1290, which surrounded the house and can still be seen. There were two other parks which extended into Highmoor by 1294 (Victoria County History, Rotherfield Greys, 2006). The park at Stonor was originally on the opposite side of the valley to the present day ornamental deer park. Its past presence can be traced in wood names e.g. Park Wood, field names and others such as Lodge Farm. It supplied much venison and other meat, both to the house at Stonor and to their residence in London.

When deer parks fell out of favour for hunting, many became landscaped grounds, often preserving some of the appearance of a park in the landscape and sometimes containing ancient pollard trees.

3.8 Post medieval: 1600-1800

By the 16th century, increasing population and economic growth led to a greater demand for food, grain and other consumables, such as firewood. The Chilterns was in an ideal position to supply both corn and wood to London, although, in reality, this was an expansion of trade which dated back to at least the 13th century. The study area, in particular, located close to the Thames, was able to participate fully in this expansion. Apart from the period of the Civil War in the 17th century, this trend continued until the late 18th century.

There were some major changes to the fortunes of some of the large landowners in the area due the Rescusancy fines payable by those who remained Catholic after the Reformation and which continued until 1829. The south Chilterns was a stronghold for Catholics who owned at least 12 manors in the study area but it is not clear if this had a major impact on woodland and land use (Hadland, 2001). The Stonors were a notable example; by 1650 most of their estates in other regions had been sold to help pay fines and much of their remaining land in the Oxfordshire Chilterns was woodland. However, the county commissioners, responsible for letting the estate on behalf of the government, could not find a tenant who could be trusted not to clear the woodland for a profit, so it remained in the hands of the Stonors.

3.8.1 Woodland clearance

Many smaller woods and parts of larger ones were cleared for more arable production. Roden (1969) states that, throughout the Chilterns, references to closes (ie small enclosed fields) on sites of recently cleared woodland occur in almost every detailed survey made after 1550. These tended to be situated on better land, more suited to agriculture. Within the study area, several documents demonstrate this. The earliest dates from 1707 and 1711 and was an article of agreement for part of Lambridge Wood in Henley parish to be cleared. William Brooks and Phillip Seale were to grub up *starks* (stocks) and roots and cut

to size (3'7" by 3' wide) 'when made fit for the collier' ie for charcoal making, as well as lay the hearth and carry wood and charcoal. They were not to sell or dispose of any roots or rounds of wood, this presumably being taken by the owner. This work was to continue 'until the whole shall be grubbed' and appeared to take place over a period of time (ORO, PAR 209/13/9D/4 1658-1884).
A lease for Pages Farm dated 1744, in Bix parish, included an agreement that the landlord would grub up two areas of wood, one of 10 acres and the other 30 acres for cultivation within five years of the date of the lease. From the Tithe Map of 1841, it can be deduced that the smaller area was cleared, but probably not the larger area (ORO, 44S).

Around the same time in 1747, part of Upper Shirburn Wood was cleared in a very similar arrangement. The owners of 52 acres of the wood made an agreement with Daniel West, who was to clear the woodland to make four arable fields which he would then rent (Hepple and Doggett, 1992).

In 1753, a sale by the Stonor family of their Watlington Estate includes "grubbed ground called Cames Hangers (ORO E31/1D/34). Deeds of an estate at Russell's Water and Swyncombe in 1792 mentions several areas which had been cleared including a "piece of ground formerly a wood called Blanches Wood, Swyncombe" and another, "formerly part of woodlands called Halls Hill Wood" (ORO, Vor XX/i/1). A lease of 1758 in Checkendon mentions that the chief part of Horsehill Wood had lately been cut down, but also that it had not been separated by any fence whatsoever from the remaining woodland (ORO, SL/146/2/D/2). It is difficult to date the exact year of felling as many legal documents recite earlier ones, particularly leases and sales so that "lately" might refer to something that had occurred in the past.

In contrast, woodland was also being created, as well as being allowed to develop on areas of heath (Roden, 1969). A lease related to a farm at Greenfield dated 1746 mentions a field, Scars Close, to be planted with four acres of wood (ORO, Vor/I/vii/2); in 1783 the same closes were now planted with wood as well as a further 16 acres at 'Stonish' in Bix (ORO, Vor/I/vii/5). The Metes and Bounds of Minigrove Manor dated 1782 include a reference to a "new plantation", although it cannot be said for certain that this was still "new" as it is likely that these were a recitation of previous boundary perambulations (ORO, Vor/II/viii/2).

3.8.2. Woodland composition

The woodland was a mixture of high forest and coppice with or without standards. A wood in South Stoke was described as "now being inclosed and copsed" in 1536 and according to Roden (1968) this was the first time that coppicing (of beech) had been mentioned in the study area and central Chilterns. However, this seems a sweeping statement, as there is evidence of beech coppice from the 14th century and earlier (Victoria County History, 2007), used mainly for firewood. A medieval account from Eynsham Abbey of wood sold in South Stoke includes sales of large amounts of underwood called 'bechenwood' (Preece, 1990). In 1661, a survey of Greenfield Coppice describes pollard beeches, young hazel and 'sellable' oaks but it was said to 'be much abused by the browse of cattell and unfavourable felling' (Lobel, 1964). In 1657, beech in Oxfordshire is described as 'it delighteth to grow in some places and not in others, for as in the Chilterns country no wood is more familiar...' (Cole, (1657) in Druce, (1886)). In the 1720's, Daniel Defoe described the huge amount of beech wood which was shipped down the Thames from Marlow. It was also sent from wharves at Henley, Whitchurch and Mapledurham in the study area. The wood was used for 'fellies' (wheel rims for carts and other vehicles), for fire wood and fuel for glass making, and for turning items such bowls, cups and plates. He remarks that the quantity is "almost incredible and yet so is the country overgrown with beech in those parts, that it is bought very reasonable, nor is there likely to be any scarcity of it for time to come" (Defoe, 1724). There is a record dating from 1667 of "800 longe beechen velleyes" (sic) waiting on a wharf in Henley to go to London (Preece, 2004) (see 3.12).

An analysis by Mansfield (1952) of 17th century papers from West Wycombe and Great Hampden Estates, outside the study area, has demonstrated that the majority of coppice was beech. It was always acknowledged that the most dominant tree in the Chilterns was beech, but in most wood books and other records it was hardly ever mentioned by name, although other trees, such as oak, ash and cherry, were named in wood sales and accounts. It is generally thought that beech was so common that it did not warrant being named in these local records. A 'History of Stokenchurch' written in the mid 1700's by Rev Thomas Delafield, the schoolmaster, said that 'beech is of such plenty in this country that it is the common furniture of the woods and the ordinary growth of every hedge and common' (Delafield, c1744). As mentioned above, the woods contained a range of species besides beech. It has been widely suggested that much oak was removed over the 17th and 18th centuries for use in naval shipbuilding but Rackham (1986) disputes the extent to which

this affected the distribution of oak nationally. Oak was surveyed in Stokenchurch in 1696 by John Bowyer, Purveyor at Deptford, but was found to be too small and 'not fitting' (National Archives Catalogue). Evidently there were 'large oak' at Stoke (South Stoke), suitable for gun deck beams. William Ellis (1744) observed that when oak is removed beech grows up in its place and Richard Mabey (2007) has suggested that it was the increased use and hence removal of oak for house and ship building that led to the dominance of beech in the Chilterns, although as briefly described above it was widespread earlier than this period.

3.8.3 Woodland management

The Chilterns woodland seems to have a variable rotation and management at this period. The underwood coppices were felled at eight or nine year's growth, so young in comparison to the 20 years growth around the Wychwood Forest area in west Oxfordshire. In the Chilterns the "tall-wood or Copices" was felled at no certain time. This wood was used for large Shids and Billets, which were 4' and 3'4" inches respectively, in accordance with the Statutes of 1542. These latter woods were not felled all together but they were "drawn out" almost every year, some when the wood "comes to be of a fit Scantling for tall Shid or Billet" Robert Plot (1705). Scantling is the size to which wood is to be cut (Fowler and Fowler, 1970). This appears to be a description of selective coppicing. Beech does not coppice well but responds to selective coppicing, when one or more stems are retained (Peterken, 1993). Arthur Young, the agricultural improver, describes the "perpetual woods of beech" which were "little better than underwood" (Young, 1768) which is probably a good description of selection coppice with stems of mixed sizes, thus appearing like overgrown coppice.

In 1794, a report by Richard Davis to the Board of Agriculture describes the beech woods of Oxfordshire, only found in the Chilterns. They were described as "trees growing on their own stems, produced by the falling of the beech-mast". Very little was permitted to grow from old stools, which were usually grubbed up. The woods were never felled all at once but "drawn" or thinned occasionally unless for converting the land to tillage, "which has been much in practice of recent years". This description implies selection woodland. The wood was sold in long lengths called poles or cut into shorter billet and sold for fuel (Davis, 1794). It was a skilful operation to thin the woods, so that the remaining trees did not shade the young seedlings; and on the south facing hillsides, the soil might be too

exposed to the sun. He observed that there is a "better growth of beech" on the north side of a hill. This is confirmed by Clements (2001) who used environmental variables to produce an Ecological Site Classification to estimate potential yields and regeneration in the Chilterns.

The succession of young trees was damaged by grazing animals, mainly sheep. Davis suggested that an improvement could be made by transplanting young seedlings from areas where they are too thick to places where they are sparse. There were also oaks and ash in the woods but they were not very numerous. He also mentioned that in most unenclosed parishes in the county, which at this date were all in the study area, there were large or small "tracts of wastes or down-land" which were grazed by sheep; in the Chilterns this was because in many places it was too steep to plough (Davis, 1794).

At the same time, Humphrey Repton who was employed to redesign the park at West Wycombe, close to the study area, described the woods in 1803 as having 'more the appearance of copses, than of woods; .....few of the trees are suffered to arrive at great height..... These woods are evidently considered rather as objects of profit than picturesque beauty...' (Hepple and Doggett,1992). This description infers that they were neither coppice nor typical woods, so possibly either selection coppice or selection woodland.

At Greenfield in Watlington parish, the woodman, John Heath, sent in his bills for 'wood fellin and work don' each March for a year's work, often in Greenfield Wood; those from 1798 to 1806 have survived. Each year, he felled over a hundred loads of beech poles and made about 1,000 faggots, which were bound with withies, also cut by him. He also made poles for hedging and charged for several days work mending hedges. He also charged for measuring loads of beech and sometimes ash. From 1798 to 1800 he also cut two loads of billets annually. In 1800 there is a record of stripping 20 yards of oak bark and making 15 oak faggots. A note on the reverse of the bill for 1799 records that poles were sold for 11/6 a load (ie 57 pence) and faggots at £1.10 shillings (ORO, Parrott II 78a-x). In 1788 beech poles were 10 shillings a load and faggots 22 shillings (ORO, Parrott II/69).

3.8.4. Chilterns selection management

The Chilterns is the only area in England where selection coppicing or selection felling took place (Peterken, 1993). From the descriptions above and others at later dates, it is

clear that a form of selection coppicing took place in the Chilterns for many centuries. Beech is weak as clear cut rotation coppice therefore it is highly likely that selection coppicing was taking place.

It has traditionally been widely used for beech on the continent. In the mountains of France it was known as *furetage*, a cut which only takes larger shoots, leaving smaller ones to grow on; in mountainous parts of Italy, there were complicated rotation systems with two or three ages of cut ranging up to 24 years. Selection beech coppice was also common in the Pyrenees (Coppini and Hermanin, 2007). It can also be seen in the western Ligurian mountains, where, in some areas, it appears to be undergoing restoration (Figure 3.3).

Figure 3.3 Selection coppicing of beech, Liguria, Italy (M. Webb, September 2009)

This method has also been used during a trial of re-coppicing at Maidensgrove Scrubbs, an area of old common coppice now in the Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust (BBOWT) Warburg Reserve (Nigel Phillips, BBOWT personal communication) (See Figure 3.4 below.)

Figure 3.4 Restored selective beech coppice in Maidensgrove Scrubs, Warburg Reserve, Bix. (M. Webb, January 2008)

It seems that this system has been used in cooler altitudes; it is possible that the combination of the Chilterns being situated at higher latitude and at a slightly higher altitude with cooler temperatures than the surrounding area, led to the use of selective coppice.

Selection forestry is widely practised on the continent but, apart from the Chilterns, seems not to have been practised elsewhere in England (Stamp, 1962). This practice takes out trees scattered throughout the wood rather than either clear felling the whole or part of a wood or a small group of trees within a wood. Gaps are left in the canopy following felling which allows a scattering of regular regeneration throughout the woodland. In pre-19th century France, selection was common in mountainous areas (Pyrenees, Jura, Vosges) particularly in mixed deciduous and coniferous forests, where more usual coppice with standards could not be used. There were two types; furetage (informal selection) took out scattered best trees while jardinage (selection management) took a mix of sizes and also removed damaged trees. A third type reduced the numbers of deciduous trees as conifer was more valuable (Rochel, 2006).

References to these practices in the study area date back for centuries and also surprisingly into the 20th century. On a map of All Souls College land holdings in Lewknor, made in 1598 by Thomas Langdon, it was noted that "They fell not the wood together but at every

fall do glean and draw out only that which is about the growth of 21 years" (Lobel, 1964), although this may refer to selection coppice. In an "Account of Woods" written in 1811 the best ways to manage enclosed beech woods are described as:

> 'to cut all trees ....when the tree contains about 5 feet and that will be when a yard above the ground the tree is about 5inches in diameter.'
>
> Mss dd Clerke Brown papers

It was also noted that since a change in the poor rates, woods were no longer rateable so therefore more valuable than underwood or coppice (ORO, C26/5). In 1911, an article on the beechwood industry of the Chilterns described the felling system. Despite the common assumption that most beech was planted, this was not the case at this date. Each wood was gone through periodically and a number of larger trees removed as well as badly sited trees. The resulting gaps allowed natural regeneration as a constant process. If an occasional clear felling took place, larch tended to be planted, occasionally with beech (Dallimore, 1911). In 1921 a report on rural industries included information from a local resident in Stokenchurch on woodland management (Woods 1921). Evidently timber merchants preferred wood grown naturally from seed rather than planted, although some planting had been carried out recently. It was usual to thin out saleable timber in rotation once every seven years. The small trees were bought by the chair leg turners, who fetched the timber as they wanted it and paid as they took it. Old stumps used to be grubbed up which helped to cultivate the soil for mast germination and helped get rid of pests. However this practice was dying out as it was hard work and the machinery which could help was too heavy for the situation in which it was needed.

A comment on one reason for poor regeneration in beech woods, made in 1991 by a descendent of Richard Clerke, the 19th century lord of the manor whose papers have been used above, described how machinery used in extracting timber from the woods squashed the mast too far into the soil. When logs were moved out by horses, the load was spread better and the mast was protected by the soil, but was not too deep (Colonel Clerke Brown, Personal communication, 1991).

3.9 19th century

3.9.1 Background

There was a boom in agriculture during the late 18th and early 19th centuries, caused partly by the general improvement of agricultural techniques with new crops and better fertilisers. The Napoleonic Wars (1799 -1815) added to this effect by raising the price of corn. Therefore, at the beginning of the 19th century, woodland was still being cleared as it was more cost effective to grub up the woods and sell the timber, getting interest on the income and rent for the cleared land now in arable production. An example is Dark Wood, now in Swyncombe, which may have been cleared in the early 19th century. It is marked by six field names in the Tithe Apportionment; Little Dark Wood, divided into two with different owners, Further Dark Wood, Hither Dark Wood, The Grubbing and Little Grubbing, amounting to 16.3 ha (ORO, Vor/VIII/i/4). Another similar sized area of field name clearance relating to College Wood was situated on the parish boundary between Nettlebed and Nuffield.

Mansfield (1952) suggested that the many new estate owners in the Chilterns area needed to raise cash to pay off their debts therefore were clearing woodland and selling timber. A comment in the Agricultural Report of 1809 illustrates both a new crop and woodland clearance; it was said that sainfoin was widely grown in the Chilterns, although it did not do so well upon "freshly grubbed woodlands" (Young, 1813). However, the reduction in woodland extent meant that the value of the produce of woodland was 40% higher than 20 years previously ie about 1790 (see 3.8.3) (Young, 1813).

After the War ended, corn prices fell, the level of debt was high and an increase in cheap imports caused a period of depression. The Corn Laws of 1815 assured protection for farmers by keeping corn prices high and reducing the volume of imports. However, this caused resentment both amongst the general population, because of the high price of bread, and amongst industrialists, who wanted free trade for their products; as a consequence the Corn Laws were repealed in 1846. Conifers may also have been planted during this time, as 143 ha were recorded in tithe documents in the study area in the 1840's. An example from the High Wycombe area of the increase in conifers is demonstrated by a sale by auction of '3,786 larch and scotch fir poles with the felling faggots' in February 1857, advertised for several weeks in the South Bucks Free Press.

3.9.2 *Impact on woodland*

The period from 1850 until the late 1870's is known as the Golden Age of Agriculture or High Farming, with good prices for agricultural products, new methods and more land being taken from woodland. This led to renewed clearing generally across England (Rackham, 1986); it is estimated that the area of ploughed land in the Chilterns in 1879 was the highest at any date in history (Coppock, 1961). This is a generalised statement covering the entire Chilterns, but in the study area where the wood products were used for chair making (see 3.12.2) and prices for wood were high, there appears to have been little woodland clearance (see Chapter 5 and Appendix 4.). However, Stokenchurch, although an important centre for chair making, was an exception to this trend with 133.42 ha cleared, almost half of all clearance in the study area between 1840 and 1883. One landowner, Phillip Wroughton, owned 118 ha of woodland here in 1840. He died in 1860 and around this time some of this land was sold by his son, both in Stokenchurch and in a neighbouring parish outside the study area; some of his woodland was cleared at this time, a total of 21.76 ha by 1883. Several owners cleared a further 14.21 ha of recently enclosed wooded common. A further large area, Ivy Copse (16.35 ha) had been allotted to a new owner at Enclosure in 1862 (see 3.10.3) but was cleared by 1883.

These events are similar to those in the Weald where, for almost 2,000 years, coppice wood was used for charcoal in the iron industry. However new methods required the use of coke rather than charcoal and by the early 19th century the industry had moved to the north of England closer to supplies of coke (Hodgkinson, 1993; Straker, 1931). This coincided with the expansion of the hop growing industry where poles were needed to support the hop vines (Straker, 1931). Hops were grown for the London breweries and to supply breweries in Chatham for the ship yards (Tann, 2005). This trade resulted in woodland being retained rather than cleared and the Weald is now the most wooded area in England.

Similarly, in the West Midlands and the Lake District, coppice products also had other specialised uses. These industries included making hoops for barrels, bobbins for spinning, crates for transporting pottery, brooms, baskets and domestic turnery ware. All these products were reliant on specific types of wood, for example, birch and alder for broom and bobbin making. Like chair making in the Wycombe area, these industries continued and prospered due to the demand from the industrialised north, London and other areas of

growing population, and in a similar way, began to decline in the late 19th century, as cheap wood and competition from abroad reduced local demand (Mingay, 1989).

3.9.3 Parliamentary Enclosure and its effect on woodland

During the mid 19th century many parishes in the study area were enclosed by Public Act of Parliament. Most of the parishes concerned were strip parishes situated on both the land below the hills, the scarp and the land above the hills. Probably the main objective was to enclose the open fields on the lowland, but also the common land in the hills. In some other parishes situated completely within the hills only the commons were enclosed. Six parishes in the study area did not undergo any 19th century enclosure. These parishes were all adjacent and were situated in the centre of the study area (see Appendix 3B).

Changes to commonland, either by Parliamentary enclosure or through a gradual reduction in use, had an effect on the woodland extent in the study area. Prior to enclosure, many commons were at least partly wooded, although probably by this time much of it was of poor quality with stunted trees and shrubs resulting from longstanding grazing and wood cutting. There were also areas of heath with heather and furze (gorse); in some places furze was sown to be used as fuel as at Minigrove, where it was used for the poor of Watlington (Lobel, 1964). Furze was mentioned on Stokenchurch common: it was used for faggots (ORO, C27/19) and in 1838 two men were paid for putting out a fire in the furze (ORO, C26/4). Freedom Scrubbs, in Bix, was recorded as 22 acres of common on the Tithe Apportionment of 1841, but was never enclosed (ORO, 44S) and is now part of the BBOWT Warburg Reserve. The multiple areas of common in Ipsden are recorded on the Tithe Apportionment as wood and pasture, and only parts of this parish were enclosed in 1856 (ORO, 230S). However, timber trees on commons were mentioned in some documents such as in 1819 when: "The beech trees upon the common, if they grow handsome, are better kept for large timber" (ORO, C26/5). Prior to enclosure in Stokenchurch in 1861, parts of the common were sold in 20 lots to raise money to pay for expenses incurred in implementing enclosure. The conditions of sale allowed the purchasers to take the timber and wood growing on the lots (ORO, Stokenchurch Bk52). In Aston Rowant and Kingston Blount, enclosure allotments to major landowners were distinguished between "commons and waste lands chiefly covered with trees" and other land (ORO, QSD/A Bk 4).

Post enclosure, some land was used for agriculture, the fields being easily identifiable by their regular pattern, which contrasts with the irregular shaped fields of most of the study area. However in many places, the poor ground made agriculture unprofitable, so often this land was gradually used for housing as at Woodcote, Sonning Common and Stokenchurch, where the outlines of the later housing fits the shape of all or part of the old common land. Goring Heath was a large area of common which now contains the hamlet of Whitchurch Hill as well as farms and fields.

Where the commons were not enclosed, they gradually fell out of use as grazing and other uses ceased, and heath or grazing land became overgrown with trees and shrubs. An example is Russell's Water Common at Maidensgrove or Minigrove, as it was previously known. Here some areas are still covered with trees, bracken and gorse, but a large area is open grassland which was ploughed for crops during the Second World War and has remained open ever since by cutting for hay. In contrast, Kingwood Common has very few remnants of heath left and is mostly tree covered. Other examples are the escarpment slopes of Crowell and Chinnor, some of which were open land in the 1840's and were not inclosed, are now wooded. In Crowell, the wood is now part of Crowell Wood and contains old beech coppice on an area shown as rough ground in Crowell Hill in 1883 (Ordnance Survey (OS) County Series).

3.9.4 Agricultural Depression and its effects on woodland

In the late 1870's, a series of bad harvests, combined with falling agricultural prices as competition from cheap imports increased, caused a depression which lasted until 1940, with a brief respite during the First World War. Again the study area seems to have escaped some of the worst effects with much of the arable land being laid to grass for cattle which provided milk for an increasingly urban population in places like Reading and London which was easily accessible by rail (Coppock, 1961). Little arable land in the study area "tumbled down" to rough grass and scrub, although there was some increase in tree planting, often in the form of larch plantations. These were grown on previous agricultural land, usually those on poorer soil, as a cash crop for pit props. These are identifiable as they are often called "plantation". In Bix, for example, around the area of what is now the BBOWT Warburg Reserve, five conifer plantations on previously arable land were planted between 1877 and 1898 (Webb, 1987). The Land Tax Valuation Survey made in 1909 records these trees as being 20 and 30 feet tall so it is likely they were planted in the mid

1890's (ORO, DV1X 145/152). Another example is Lot's Hillock wood in Stokenchurch (see Section 3.8). It was cleared between 1844 and 1880 and known as The Grubbing. At some point after this it was planted with conifers shown on a map of 1920, and later felled in the Second World War.

In some places, beech woodland was interplanted with conifers as blocks in areas of clear felling (Dallimore, 1911). This process was described by Thomas Hardy in "The Woodlanders" in which "a thousand young fir trees" were planted on land "which had been cleared by the woodcutters" (Hardy, 1887). Conifers were also planted amongst existing deciduous trees. Rackham (2006) is unclear as to how this was successful, but it is likely that in the Chilterns woods, where selective felling took place, conifers could be planted in gaps where wood was taken out for chair making, and would survive as mixed woodland. This change in woodland composition in the study area is noticeable in a comparison of woodland types between the 1840's and 1880's, with a 15% increase in mixed woodland (from zero in 1840) and with an increase to 3% from 1% of conifer plantations (see 5.3).

3.10 20th century

The general history of the woodland in the study area during the 20th century follows a similar pattern as in the rest of England. Statistics collected for England in 1905 and 1913 showed that the rate of planting had reduced over the preceding 80 years and softwoods were becoming more prevalent than hard woods (MacGregor, 1953). Softwood was required for building, plywood, paper and telegraph poles. These figures are very general; they were based on a sample and have no detail on individual estates. However the pattern of woodland management by private owners reflects this, with more attention paid to sport, such as pheasant shooting and other amenity uses, than timber production, a trend that began in the 1840's in counties such as Oxfordshire and Berkshire, within easy reach of London (Collins and Havinden, 2006). With the increase in imported timber for the furniture industry, this trend is likely to have been similar, if perhaps later in the study area.

Mansfield (1952) collated data from the 1947-49 Census of Woodland for private woodland in the Southern Chilterns (the actual location is not clear). For beech, 16,071

acres were classified as uneven aged, i.e. selectively managed, compared with 719 acres for oak. In single aged stands, a total of 4,101 acres of beech ranged in age from 1-10 years to over 120 years, ie prior to 1820 (105 acres). Oak was the only other species with trees over 120 years of age (40 acres). Evidence of selective management of standard trees at this time can be seen in photographs of this period in the late 19th and early 20th century, where woodland is composed of a range of sizes and ages (Figure 3.5).

Figure 3.5 Selection felling in Chiltern woodland April 1908.

Exact location unknown (Buckinghamshire County Council, SWOP, undated)

By the end of the 19th century, local beech was being superseded by imported timber for chair and furniture making; by 1899 75% of it came from North America (Hepple and Doggett, 1992). This resulted in a gradual reduction in selective felling, which only took the best tall timber for the factories, leaving the small or poor quality trees which were not being thinned to encourage growth. Finally, by the 1940's, selective felling and management had ceased altogether (Edlin, 1956). In time, this led to beech becoming more even aged, rather than mixed in age as under the selection system (Chilterns Standing Conference, 1988), although this assertion seems to be contradicted by the data from the post-war Woodland Census. This sequence of events is illustrated by an investigation of

tree rings in beech and oak clear-felled in Hailey Wood (an Ancient Semi Natural Woodland) in 1965. It showed that, before about 1851, the trees had been lightly thinned and beech regeneration had taken place in the gaps. The wood had been managed by selection felling with mature trees growing within groups of younger trees. In 1851 their ages had been approximately 29-41, *c*42 and 51-85 years old. In 1851 there was major thinning which allowed more regeneration of beech and oak, lasting until about 1876. After this time the canopy was too dense to allow any further new growth. The wood was untouched until another major thinning in 1940, after which there was renewed growth of ash, birch and beech (Peterken, 1993). The thinning in 1940 was probably part of the large-scale felling which took place during the Second World War when good quality beech was taken for making rifle butts and plywood for the construction of aircraft in High Wycombe. Round trunks were necessary for rotary peeling for plywood manufacture, so these had to be free of all defects.

Post war, much woodland in the study area was defined as 'devastated' in the post-war Census, i.e. areas from which the best timber had been removed (Watkins, 1984) and was also affected by the final end of the selection system. Therefore in 1951 the Chilterns were made a special project by the Forestry Commission which aimed to restore the woodland (Chilterns Standing Conference, 1988). Further policies and designations relating to the Chilterns over the latter 20th century are previously described in Chapter 2.4.

3.11 Wood uses in the study area

Apart from the usual local rural uses for wood around the home and farm for fuel, tools, utensils and internal construction materials, the Chilterns area was a source of wood products based on beech on an almost industrial scale for several centuries.

3.11.1 Fuel

During the Middle Ages, firewood and charcoal was regularly taken to manors on the Oxford plain, to Oxford, and also to London by river. The study area is bounded by the Thames on three sides so had good access to London. The large loop in the river upstream from Henley made it more efficient to carry loads overland to and from Henley and Wallingford, where they were loaded back on to the river to carry upstream to Oxford (Victoria County History, Henley, 2006). Henley was major centre for trans-shipment of

goods, both from the immediate area and further afield. Records of firewood going down river from Henley and Marlow date from the early 1200's. For example, 14,000 bundles, probably faggots, were sent from West Wycombe to London via Marlow in 1218 (Roden, 1968). The Stonors regularly sent firewood (as well as many other goods) to their London household from Henley.

The accounts of Thomas West, a Thames trader, drawn up after he died in 1573, show that he carried mainly firewood and corn to London from Wallingford, bringing back coal, fish and consumer products (Prior, 1981) An example of his loads at different times includes:

40 loade talle wood

1,000 billets

12 loades of billets

44 loades of talle wode

20 loades of talle woode and 10 loades of billets.

Both these types of logs were used for firewood, talle wood being thicker than billet.

Large quantities of fuel was needed in London, not just for heating but for baking bread, brewing, and for industries such as iron working, brick- and tile-making and cloth dying (Galloway, Keene, Murphy, 1996). The wood required for these industries was of 20-25 years growth (Crossley, 2005). Another type of fuel was charcoal which was made across the Chilterns and again was sent to London and the Vale (Mansfield, 1952), as well as being used locally. It is now being realised that traces of charcoal hearths can be found in the woods, appearing as a flat circular area about five to six metres across. If the leaf litter is removed, the soil beneath is black and often contains small pieces of burnt wood and blackened flints (Morris, 2003; personal observation). The wood used for this process was smaller than that used for direct firing, about 8-14 years of growth (Crossley, 2005).

Coal began to be easily available from the mid 18th century onwards, especially in larger centres such as London. In 1791 an inquiry by the Crown Commissioners asked whether the improvement of roads and canals had introduced coal into the parts of the country where wood had previously been used for fuel and whether this had had an impact on the demand and value of underwood (Hepple and Doggett, 1992). In 1794, a report of the agriculture of Buckinghamshire stated that beech "afforded an abundance of fuel to that

part of the county where coals are scarce" (James and Malcolm, 1794). However the main market for beech in London had gone and soon the local market in the vale shrank.

3.11.1.1 Fuel uses

Locally, firewood also had industrial uses. Glass was made in the study area on a small scale. There is a record of it being made in Bensington, Stockyngchurch and Henley in 1498 (Pearman, 1896). Robert Plot (1705) mentions glass being made at Henley by Mr Ravenscroft, using white sand from Nettlebed; he later moved his manufacture to London.

A larger and longer lasting industry was that of tile and brick making, as well as pottery. This probably began during the Roman period, and continued during the Saxon period, but on a small scale for local and family use. Tiles were made first in the area, probably in the early 14th century. In 1365, 35,000 tiles were made for Wallingford Castle, with many more orders over the next hundred years. The first record of brick making was in 1416, when 200,000 bricks were made for Stonor House at Croker End, although bricks were used in the building of Shirburn Castle around 1377, possibly from the Nettlebed area. Many large houses in the area were brick built or brick faced, and later most ordinary houses as well (Bond, Gosling, Rhodes, 1980). The most important centre in the study area was Nettlebed, which was to remain in production until 1938, by which time there was a tramway and numerous claypits, waterpools and brickyards. There were many other kilns scattered throughout the study area, mainly on or near areas of common land where suitable clay was found, as at Croker End near Nettlebed, Russell's Water, Stokenchurch and Woodcote, plus at least another 14 (Chilterns Conservation Board, 2006). Water is a necessary prerequisite for brick or pottery making and many ponds in the study area are probably linked to this industry. An example is the pond at Russell's Water, a hamlet which was named after the Russell family who were working there in 1690 (Hepple and Doggett, 1992).

The number of known kilns and the volume of bricks produced indicate the huge volume of wood which must have been necessary to fire the kilns. Attempts to ascertain an indication of the quantity of wood needed for these processes has been unsuccessful, but as an indication, data relating to early pottery kiln firing has been investigated. A re-enactment of a early Roman pottery kiln holding 86 pots required 203 kg of wood for firing at 880°C (Woods, 1974) while 150 kg was required for a similar exercise

(Bryant,1973, cited in Killick *et al.*, 1998). Therefore the volume for larger brick or tile production would be vastly greater. In the medieval period and even up to the 19th century in some places, sun-dried bricks were layered with brushwood in temporary clamps which were up to 12 feet high. The brushwood was probably in the form of faggots. From a description in 1784 of a clamp in the north Chilterns, flues were made of burnt bricks and contained fires, first burning large pieces of wood to bring the clamp to a high temperature, then kept going by twigs for two or three days. Other fuels used included charcoal, turf, bracken or furze. Lime was often burnt at the same time in the bottom of the clamp. When the contents had cooled slightly, the flues were stopped with moss and furze. Updraught kilns used a similar process but were permanent structures. The bottle kiln at Nettlebed (which still exists) was built by the 18th century and could hold 12,000 bricks. Three flues used wood fires to heat the kiln, which fired the bricks for two or three days. In the 19th century, coal was used when transport by canal or railway made it more accessible. At Nettlebed, wood was still used for the initial firing to dry the bricks, then coal was used for the higher temperature phase (Bond, Gosling, Rhodes, 1980).

Pottery was also made in Nettlebed, the earliest record from the 9th century (Lewis, 2004). Checkenden, Stoke Row and Highmoor were other centres, with potters, brick and tile makers listed in 19th century censuses, although by 1901 there were only four men in this trade, with chair part making having taken over.

3.11.2 Chair making

Chairs, as recognised today, only belonged to the most important people, even in a wealthy household; for the general population stools or benches were used until the 18th century. Beech was sent to London for chair-making as noted by Daniel Defoe in 1724, probably in the form of billets. It is likely that there was a wood turning trade for up to 300 years in the Chilterns, using pole lathes to make bowls, spoons, wheel spokes and other small items. Research into craftsmen in forest areas in the 13th and early 14th centuries found occupational surname evidence of turning in 1297, and there is no reason to suppose that this did not occur in the Chilterns at the same time (Birrell, 1969).

The reasons for the development of chair making in the Chilterns are twofold. As has been described, the market for fire wood for London and the vale was dwindling as coal became easily and cheaply available. At the same time, the Industrial Revolution was increasing

the spending power of the general population, particularly in the Midlands and the north of England, which provided a market for simple chairs. Beech is a good wood for turning due to its fine, even grain, strength and hardness and its capability to be turned "in the green" ie without prior seasoning as it does not warp when dry. Therefore, the rapid development of chair making in the south Chilterns was the utilisation of a traditional material, which was in plentiful supply, for a new industry which could function in a system of individual craftsmen and small units, similar to that which must have existed in the production of firewood.

It is likely that in the early days of wood turning, coppice wood was used because of its size and availability. However, as a selection system of coppice had been used as described in Section 3.9.4, stems were larger and more suitable for turning. Alongside coppice, the selection system for "tall wood" in the Chilterns, as described by Robert Plot in 1705, could also be utilized for chair parts. It is likely that turned chair parts were being made in the area in the 18th century and sent by river to London for assembly (Sparkes, 1975). By the late 18th century chair-making on a larger scale was beginning to develop around the High Wycombe area. There was a good market for church and chapel chairs which formed the basis of the early industry. In 1784, Baileys Directory for High Wycombe notes three chair-makers, the Treacher family (Baileys, 1798). In 1798, the *Posse Comitatus*, a census of men aged between 15 and 60 available for conscription was compiled, in preparation for a possible invasion by Napoleon; the Buckinghamshire record is the only one surviving. The men's trades were recorded; in the High Wycombe area there were 76 chair-makers and 79 wood turners (Hepple and Doggett, 1992).

The Windsor chair was best suited to the wood resources and skills of the area. These are not made as a stool with extended back legs like other styles, but have a seat into which both the legs, back (and arms if used) are inserted. Typical chairs made in the High Wycombe area were composed of a variety of woods, all locally available. The seat was elm, the curved bow back was ash or yew, which was boiled, bent and tied into shape round a shaping block. The legs, stretchers (and arms if used) and sticks (back) were turned from beech.

Figure 3.6 Windsor chair made by Samuel Rockall, the last of the bodgers
(Photograph S.King)

The process was essentially hand crafted from start to finish until mechanisation gradually took over from craftsmen in the late 19th century, although even into the 20th century up to the Second World War, the best chairs were still made by hand (Sparkes, 1975).

Wood sales took place in the autumn and winter. In Stokenchurch, sales took place annually at the King's Arms, the sellers alternating each year between the two main land owners, the Fanes at Wormsley and the Clerke-Browns at Aston Rowant. The areas or falls (Dutton, 1992) or drifts (Bourne, 1929) within the woods containing the trees selected for sale were operated on a rotation basis of about seven years (Dutton, 1992). The timber was sold standing, the bidders having previously inspected it in situ. The trees marked for sale were scattered through the woods and prospective buyers needed the help of the woodman in charge of each wood to find them. It was sold by the load (25 cubic feet) (Dutton, 1992). The purchaser was responsible for felling the timber, sometimes using the vendor's woodman or, in the case of the turners or "bodgers", doing it themselves. Timber could also be sold felled and in this case it probably seems to have been sold in loads of 40 cubic feet. In both scenarios the wood had to be removed within a year. Small and medium size trees, available through the selection system, were preferred by the bodgers (Bourne, 1929). The name "bodger" has a variety of suggested derivations. One is that is Cockney back slang for jobbers or outworkers, used by London chair makers for the suppliers of turned parts. Another is a derogatory name given by papermakers in Wycombe who

referred to turners "bodging about" in the woods (Mayes, 1960). A third idea is that it is a corruption of "badger" a travelling pedlar, as bodgers travelled around the woods and took their finished work into the town. Bodgers were sometimes seasonal workers, employed on farms in the summer and turning during the autumn and winter.

After the trees were felled, the timber remained in the woods until the larger trunks had been cut into planks or the smaller ones cut, split and turned as it was easier to remove smaller loads of finished parts than large trunks. If logs were taken out of the woods, they were drawn out by horses using a timber "bob" (Sparkes 1973) This consisted of two large wheels (up to 8' diameter) on an arched axle, with the log slung under the arch at balance point to clear the ground. This caused very little damage to the ground in comparison to later heavy machinery.

In order to cut large logs into planks, the log was placed over a saw pit. Sawing was done by two men, a "top-man" (top dog) and the "second man" or pit sawyer. The "second" man was responsible for digging the saw pit which was about 15 x 8 feet oblong and 6 feet deep. Pits were lined with planks where the soil was soft and were often constructed close to a track for easy access. Remains of these pits are common in the present day Chiltern woods, although Oliver Rackham claims to have never seen a convincing one (Rackham, 1986). Pits are usually smaller now as soil and leaves have gradually fallen in over the years. They may also be seen on fields as slight hollows. For example, Ivy Copse in Stokenchurch was cleared between 1861 and 1880 and the remains of three pits can be seen when the sun is low (personal observation).

Figure 3.7 Old sawpit, outlined in moss.

Thirds Wood, Stokenchurch. (Photograph January 2009. M. Webb).

Using a seven foot long saw which tapered from ten to three inches, cutting started from the centre of the trunk, planks being cut in turn until the entire log was converted. Hand sawing continued after mechanisation replaced other aspects of the chair making process. This was partly a function of the difficulty in getting timber out of the woods or of taking heavy machinery into woods which were often on steep slopes in inaccessible places. The other reason was the limitation of circular saws which only cut half their diameter so could not cut a thick trunk. This problem was not solved until the invention of band saws (Sparkes, 1973). Planks were used for making seats and arms of chairs, parts which were not turned.

For turned parts, smaller trunks were cut crossways into lengths (butts) and then split (or rived) into halves and quarters with a beetle and wedge. These were then split further into triangular shaped billets using a beetle and hatchet (a wedge on a wooden handle). Split wood followed the line of the grain and was far superior to sawn billets which could split easily. The billets were the correct size for the required turned article ie. leg, stretcher (between front and back legs), or sticks or spindles (the back supports under the curved back). The billets were first shaped roughly with a small axe with a chisel edge, then shaped more exactly with a draw shave. The leg or other part was then turned on a pole lathe. Beech was turned "in the green" ie not seasoned and dried out later. The lathe was

made from a young ash or larch tree of the right size. The bark was peeled off and the pole left to season for a while. It was shaved on the underside to make it more flexible. The pole lathes were so efficient that it was said that four legs could be made in the time it would take to make three on a modern lathe. Hence pole lathes were used well into the era of mechanisation. These turned parts usually had patterns of rings and grooves, which can indicate where they were made. From a 12" (30 cm) section of trunk it was possible to make 24 legs. The turned chair parts were made either in small workshops attached to houses or in the woods by bodgers who lived in temporary huts, first made from branches covered with wood shavings, later with corrugated iron.

Turned parts were taken to the workshops in High Wycombe and Stokenchurch and other villages. They were paid for by the 'gross' which actually meant a gross (144) of legs plus 108 stretchers. Before 1914 the price for a gross was 5 shillings (25p). A man, working for 12 hours a day for 5 ½ days, would make 2 ½ gross, thus earning about 12 shillings. When the parts were delivered, men would count and stack them. They were passed to the stacker in sixes called 'hands' (ie three per hand) and counted up to 24 hands, making a gross. One leg would go on to a special pile to represent a counted gross. At the end of the process the bodger, who had obviously watched the counting process, was paid for his legs. There was no paperwork or invoices for these transactions. All chair parts were treated in the same way hence the lack of any accounts or records (Mayes 1960).

Seats were made by bottomers from planks cut about two inches thick. Traditionally, elm taken from farms and parkland, was used but beech was also used (Stuart King, personal communication). They were cut into squares and shaped by an adze which made the curved saddle shape of these traditional seats (Dutton, 1992). The chairs were assembled by a framer in a workshop, another skilled job which involved drilling angled holes in the seat for the back and legs, which themselves were joined to the stretchers. The back bow and arms (if any) were also drilled for the sticks and finally the chair was glued and assembled. This use of different workers making specific chair parts must be one of the earliest examples of a mass production system.

As mechanisation on farms reduced available agricultural work, so the chair making trade expanded during the 19th century. It centred on High Wycombe in Buckinghamshire, which although just outside this study area, used wood from across the region. From the

small beginnings in the late 18th century, by 1877 there were almost 100 factories in High Wycombe making 4,700 chairs a day (Mayes, 1960). In 1911, when mechanisation was taking over, 2 million chairs were made annually (Dallimore, 1911).

Stokenchurch (in Oxfordshire until 1896) was the second most important centre and in 1807 there were at least five chairmakers, according to details of rents taken at Christmas that year (ORO, C26/5). The 1851 census shows the impact of the chair making across the area. In Stokenchurch there were 86 chairmakers in the village centre with more in the outlying hamlets in the parish. In addition, there were allied trades such as bottomers and French polishers. There were 15 people employed in other wood related jobs such as woodman and sawyers. By 1891 the number of chairmakers had reached 178 in the village centre alone.

The surrounding villages and hamlets were also major contributors in both materials and labour. The 1851 census showed that in Chinnor, 43 men were working at chair turning, the parts going to High Wycombe by carrier. There was a pub in the village called the Chairmaker's Arms (Lobel, 1964) In Crowell at the same time there were 3 chair-turners and a chair-bottomer (Lobel, 1964).

As far away as Stoke Row and Highmoor, villages approximately 33km (20 miles) from High Wycombe and 24km (15 miles) from Stokenchurch, the development of chair making can also be seen. In 1851 there were four woodmen, two sawyers and two firewood dealers in Stoke Row. In Highmoor at the same date there were four sawyers, seven woodmen, and one faggot maker. The firewood emphasis in this area might be related to the brick, tile and pottery manufacture. By 1891 this had changed. In Stoke Row there were seven men employed in brickmaking activities, but 19 in wood related trades. Of these, nine were turners; in Highmoor 22 were employed in wood trades, including eight turners (Spencer-Harper, undated). Interestingly many turners were not local to these villages but came from further north around High Wycombe and Stokenchurch. In 1916 men around Checkenden combined work on their small holdings with making chair parts for High Wycombe (Orr, 1916).

In 1885, a report from the Chief Inspector of Factories and Workshops said of Stokenchurch that there was only one proper factory, but steam sawmills were "constantly

employed in cutting up lengths of chair stuff which is turned by hand in the little workshops attached to the cottages." These parts were sent to the "numerous manufacturers in Wycombe" (Mansfield, 1952). This method of making chairs continued for many years until finally, by the end of the 19th century and into the 20th century, machines gradually took over from hand crafting.

A "Report on Rural Industries round Oxfordshire" made in 1921 used Stokenchurch as an example of industrial development in a village ideally situated for its raw materials. At this time there were six turners sending legs into High Wycombe, It is not clear whether the turners were working by hand or not at this date. Twelve workshops were making chair parts, much of which was sent to the north of England (Lancashire in particular) where the chairs were assembled. It was better to transport parts rather than finished chairs which were liable to get damaged in transit. (It is not known whether assembly instructions were provided!) There were seven chair factories making chairs using steam driven mechanisation, and five sawmills (Woods, 1921).

The Report also describes the woodland management at this time, the information being supplied by a local resident. Evidently the timber merchants preferred beech which grew from naturally germinated mast rather than planted, although some planting had been done recently. The saleable timber was thinned in rotation about every seven years, although the time of growth (ie the age) varied because of differences in aspect. Some damage was inevitable when felling took place because of the variation in tree size; some merchants preferred smaller trees, which were bought by the chair leg turners, who often took the timber out of the woods with horses, or used it *in situ* when it was needed and paid for it then. Earlier, the old stumps had been grubbed up which helped to cultivate the soil for beech mast germination, but this operation had ceased as woodmen thought the work was too hard and machinery would be too heavy and impractical (Woods, 1921).

Mass production on a large mechanised scale meant that the local wood could not compete with imported wood in quantity and price. By 1899, 75% of timber used in Wycombe came from North America and Canadian birch was less than half the price of local beech (Hepple and Doggett 1992). This loss of a market for timber led to the demise of wood management in the area. The cessation of selection felling by bodgers meant that there were few gaps for regeneration to occur and the woods gradually became more even aged.

However, some hand working still survived, in places such as Stoke Row, even after the Second World War. Some companies used local timber until quite recently, Parker-Knoll used beech from the study area until at least 1994, and Hunts in Stokenchurch continued to make traditional chairs and other furniture with local wood into the 21st century (Ingram, 2001). Although large scale chair making has ceased, several small local furniture makers still use local timber; Stewart Linford Furniture, a small company in High Wycombe, uses local timber, often making a feature of "burrs" in a range of woods. Phillip Koomen Furniture is known for its craftsmanship and makes one-off pieces in local wood in a workshop in Checkendon.

Other uses for beech

Cleft beech was used to make tent pegs, especially during the First and Second World Wars (Edlin, 1949), as well as ammunition boxes and wooden rifles for training (Wycombe Chair Museum). During the Second World War, beech was used to make rifle butts during 1940-41 instead of using imported American walnut (Mansfield, 1952). However, a shortage of plywood for aircraft led to the felling of good quality beech for this purpose. The timber had to be free of defects and cylindrical to allow rotary peeling. In the war effort 2,300 acres of beech was clear felled in the south Chilterns between 1939 and 1947 (Mansfield, 1952). The ply was used in the manufacture of the de Havilland Mosquito and parts for other aeroplanes including the Tiger Moth, which were made in High Wycombe (Scott and Simmons, 2007).

SUMMARY

This chapter summarises the natural and human influences which have created the present Chilterns landscape;

- the characteristic Chilterns geology of chalk, with overlying deposits of clay with flint, sand and gravels, and its topography of the dissected plateau and asymmetric dry valleys;
- an overview of the post-glacial development of vegetation, in particular beech, in the study area;

- a general outline of woodland history and management related to human impact from pre-history to the 21st century in the study area;
- the past uses for wood, particularly beech, as fuel and in chair making and the impact on these of external events or changing needs.

Chapter 4
SOURCES AND METHODS

Historic maps and their associated information provide a valuable resource for the study of landscape change and using GIS for digitisation, data manipulation and interrogation, allow comparison with present day landscapes. In this research data obtained from historic maps will be used to inform potential future woodland creation to increase woodland extent and improve connectivity. Both future woodland restoration and creation scenarios can be created in GIS and therefore will enable an understanding of the steps necessary to increase woodland area and connectivity within the study area.

This chapter is in five parts which describe the following:

4.1 historical and modern map sources used in this research;

4.2 methods of data compilation and digitisation for five types of maps to produce GIS shapefiles;

4.3 method of data manipulation to identify change over time;

4.4 creation and manipulation of future woodland restoration and creation scenarios in GIS;

4.5 analysis of landscape metrics both over time and for future scenarios.

4.1 Map sources and data compilation

4.1.1 Historic maps accessed at Oxfordshire and Berkshire County Archives

4.1.1.1 Tithe Maps and Apportionments - 1840's

The most useful 19th century data sources, in terms of details on land use and land ownership, are the Tithe Maps and Apportionments. They were produced in the 1840's for

the Tithe Commissioners, acting for the Government, in order to implement the 1836 Commutation Tithe Act (see below). Maps and Apportionments covered about 75% of England and Wales, on a parish by parish basis. Tithe and Enclosure Maps (see below) are cadastral maps, meaning that they contain additional information on the area and ownership of the land in a separate associated document, so are an invaluable data resource.

Tithes were originally a payment in kind of crops (e.g. oats, wheat) or produce (e.g. milk, wool) made by parishioners to the clergy of the parish. In time payments in kind became monetary payments: in some parishes tithes were gradually extinguished or commuted on enclosure into corn rent payments that varied from place to place. However, by 1836 monetary tithes were still payable on farmland in most parishes in England, even though many people were either no longer members of the established church and therefore resented supporting the church or were working in industry and so exempt (Delano-Smith and Kain, 1999). By the early 19th century, the whole system was in disarray and after several years of discussion, the Government decided to commute all tithes through the 1836 Tithe Commutation Act. This Act replaced tithes with a rent charge related to the average price for wheat, barley and oats, adjusted annually. The total rent charge for each parish or Tithe District was to be apportioned between the various lands related to its quality and use.

In order to obtain the information needed for this process, a survey and valuation of each parish was undertaken. The Tithe Commissioners had pressed for high quality standardised maps at a large scale of one inch to three chains (1:2376) which would have formed the basis for a full cadastral survey of the British Isles, but this argument was overturned by the Government who preferred a cheaper option (Delano-Smith and Kain, 1999). As a result of this decision, tithe maps are of varying quality; landowners had to pay for the cost of the survey, and tithe maps were sometimes based on existing parish maps. The scale of the maps is given in chains to the inch, a chain being 22 yards (20.32 metres). In the study area, scales of three chains (nine parishes), four chains (ten parishes) and six chains (eight parishe) were used (Kain and Oliver, 1995).

The equivalent modern scales are:

3 chains	1:2376
4 chains	1:3168
6 chains	1:4752

The maps were not always an accurate survey but were intended to show the boundaries of all areas for which tithes were payable. Scale and compass points are shown but north is not always at the top of the map. Maps were classified as First-class or Second-class depending on their accuracy. First-class maps were those made specifically for tithe commutation, checked by the Commissioners and deemed to be accurate enough for use as legal evidence; however across England and Wales only 11% were first class, none of which were in the study area. Second-class maps were those compiled from existing surveys and not submitted for examination by the Commissioners or which had a smaller scale than three chains (Delano-Smith and Kain, 1999).

The parish was the usual map unit but where portions of a parish were detached these were mapped separately e.g. Lewknor Uphill comprised three areas amongst other parishes in the hills while the parent village Lewknor was below the escarpment on the spring line. Surveys were undertaken in most parishes, the most important purpose being to obtain an accurate measurement of the acreage of each parcel of tithable land and to record its current state of cultivation (Kain, 1985). The detail of the variations between arable and permanent pasture are not relevant to this study, except to remember that at this time agriculture was non-intensive and essentially "organic", so a more sympathetic landscape for biodiversity than that of the present day.

Tithe maps in the study area vary in appearance from simple outlines of fields, woodland and other land areas, eg the Lewknor Uphill Tithe Map (ORO, 252), to descriptive drawing showing detail such as hedges and the density of trees in woods and on commons as in the Stokenchurch Tithe Map (ORO, 362S) (see Figure 4.1 below). Many, but not all maps, indicated woodland by simple tree symbols. Each discrete tithe area (field, wood, dwelling or plot of land) is numbered on the map.

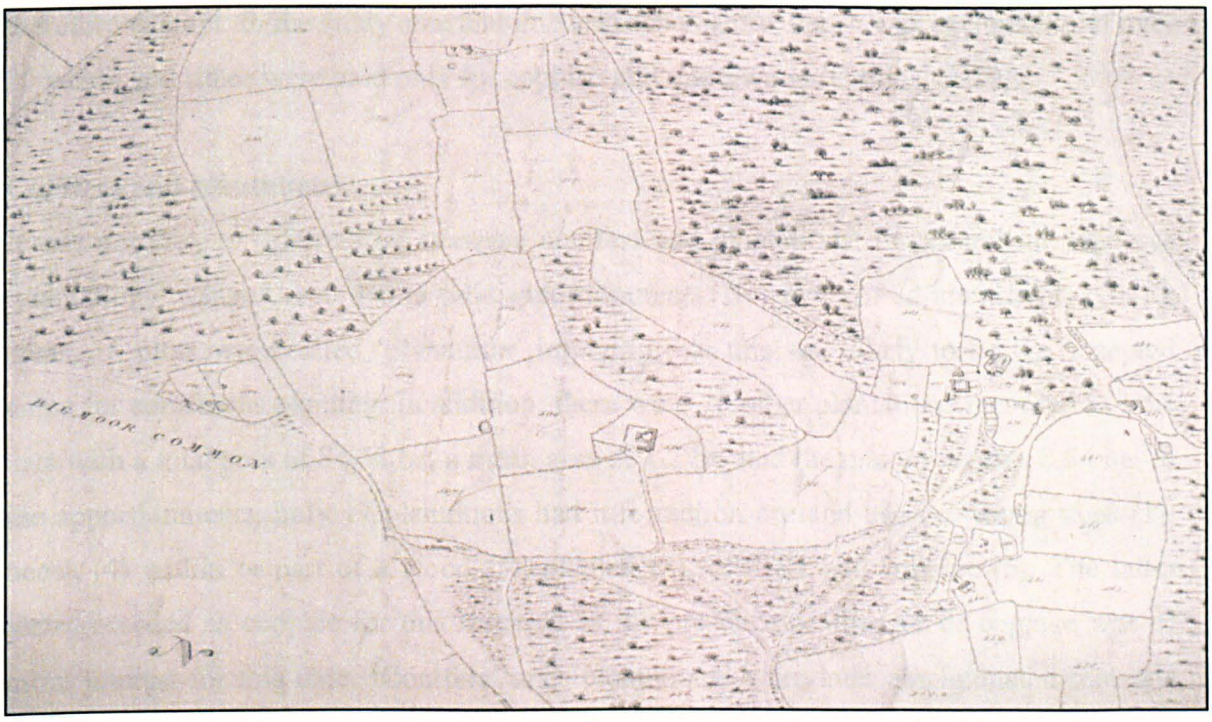

Figure 4.1 Portion of Stokenchurch Tithe Map 1842 (ORO, 362S) showing areas of common land, woodland, plantation and farmland.

Apportionments are made up of a roll of parchment sheets ($21^{1}/_{3}$ inches by $19^{3}/_{4}$ inches or 54cm by 50cm) printed with a blank *pro forma* of headings and columns hence they are of uniform quality in comparison to the Maps. The first section records agreements for commutation of tithes with the names of commissioners, surveyors and owners of tithes, the date of the apportionment and an estimate of the area of titheable land (Kain and Prince, 1985). The second part of the apportionment contains the information relating to each numbered plot on the map. The following information was recorded; land owners, listed in alphabetical order; the occupier of each plot; plot number (as shown on the map); plot name; state of cultivation i.e. land use; acreage; rentcharge payable; name of tithe owner .

Woodland information from apportionments

Some apportionments give more detail than others on woodland type. These vary between regions and from parish to parish, but in the Oxfordshire Chilterns they included: wood; beech or beech wood; underwood; coppice; plantation (which could be either deciduous or conifer and was not always specified); fir or conifer. Not all woodland was tithable. Under the General Law of England oak, ash and elm over 20 years old were classed as timber and

therefore exempt. In the study area and in Buckinghamshire, beech was exempt (i.e. if over 20 years) and tithes were paid only for coppice and underwood (Collins, 1989).

Conifers and plantations

It was not easy to differentiate between conifers and plantations; in general the land use 'plantations' was not recorded in tithe apportionments. However, of 24 identifiable conifer areas, 16 plots were called 'plantation' implying that this was likely to be the accepted name for coniferous planting. In addition, there were 70 other plantations recorded in tithe data with a total area of 84.53 ha, a mean area of 1.2 ha, and the maximum size 8.54 ha. In the apportionments, only 17 plantations had information on land use i.e. young trees (1); beech (4) within or part of a wood (5), planted (2), conifers and coppice (5). The latter were recorded as coppice for this research as the presence or absence of coppice was of more interest for this date. 'Conifers' and 'plantations' were later amalgamated into one 'conifer' shapefile. The rationale for this was the fact that 'plantations' were more likely to be coniferous than deciduous at this date ; they pre-dated the period of high demand by the chair making industry, so were less likely to be planted with 'wood' or 'beech' by this date. Beech is more likely to have mentioned as the landuse because of tithe payment implications. The designation of "beech" is important in this study, hence this method of recording. In retrospect, it would have been more effective to have coded by landuse when possible i.e. either conifer or deciduous as in 1883 (see 4.2.1) however this would have still resulted in a shapefile containing 'plantation' with no known land use designation.

Osiers or withies (products of willow coppiced or pollarded for materials for basket making) were also mentioned on the fringe of meadows alongside the River Thames mainly outside the study area. Other non-agricultural land uses recorded on the apportionments include furze, wood-and-pasture, orchard, common, common woodland, pits, ponds and road verges.

Field Names

The major landscape component recorded in the tithe apportionments were arable and pasture fields. Field names and sites taken from Tithe Apportionments for use in this research were confined to those with a link with woodland, parkland, commons or heaths, although the latter two were not used in the final analysis. However, without in-depth

research within parishes, it is difficult to trace the age of these fields and their names. Although most names have either Old English (pre–Conquest) or Middle English (medieval) roots, this may not definitively date the origin of the fields as many of these words were in use for a long time. It is possible that some names have changed over time, so these taken from the tithe documents still retain their original name in some form relating to their previous land use. Other similar names may have been lost through time and now, for example, allude to a farm, owner, event or use.

For more information on etymology and detailed information on field names used in this research see **Appendix 2**.

4.1.1.2 Enclosure Maps and Awards

Below the Chiltern escarpment on the flatter land, open field agriculture was traditionally the norm. During the enclosure process communally farmed large open fields were split into smaller units, their ownership being awarded to individuals; this process took place over several centuries in different ways. In parishes where enclosure took place prior to 1840, tithes were usually commuted during the enclosure process, so tithe maps and apportionments are not available.

Enclosure maps have been used for four parishes in the study area; Aston Rowant, Watlington, Goring Heath and Whitchurch. These enclosures were made under the Public General Enclosure Acts passed from 1801 to 1845 (National Archives Research Guide 86). After 1845 the General Enclosure Act allowed enclosure without approval by Parliament. This Act was used for later enclosures, which took place after tithes were commuted. When Chiltern hilltop parishes were enclosed, usually only common land was affected as little or no arable was held in common. Common land in the study area was used by parishioners with the appropriate rights, for grazing, extracting clay, sand and gravel and for collecting firewood. After enclosure this land tended to become agricultural, a change illustrated by the 1st Edition 6" O.S. maps (1880's), or sometimes fell into disuse. Enclosure maps do not have the land use detail recorded in the Tithe documents but may demonstrate the position and extent of woodland. However, only land which was to be enclosed was usually mapped so care has to be taken when extrapolating from these maps in case woodland was present but not recorded at that date.

4.1.1.3 Recording method for Tithe and Enclosure Maps (1840's)

Working in both the Oxfordshire and Berkshire County Archives, 31 original maps were used of which 27 were tithe maps and the remaining four, enclosure maps (See Appendix 3A and 3B). Maps ranged in size, the largest used being about 3 metres long and 2 metres wide.

Black and white prints of modern OS 1:10,000 maps were created from Ordnance Survey tiles covering the study area (Figure 4.2 below).

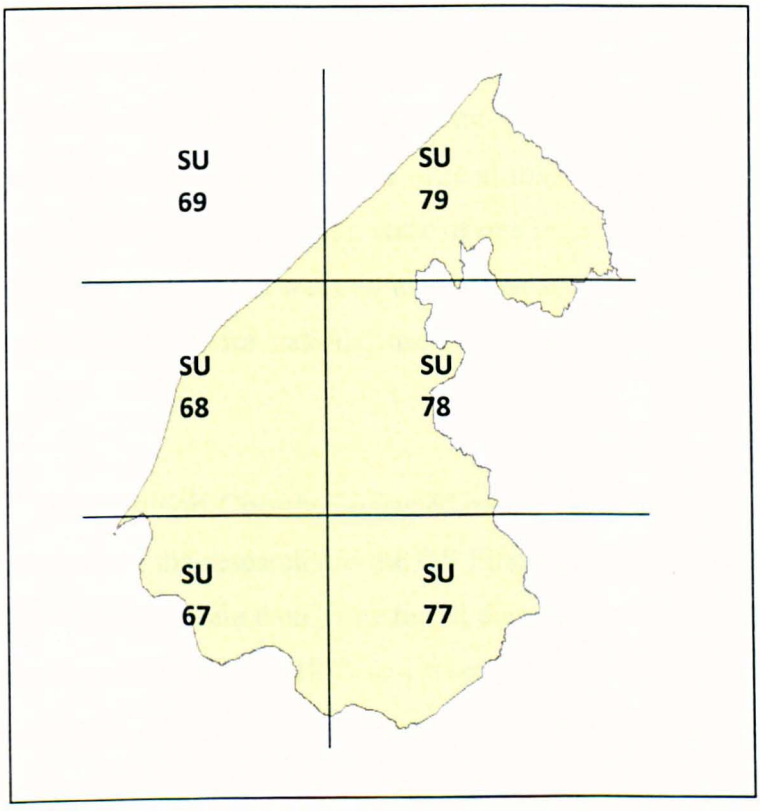

Figure 4.2 Ordnance Survey tiles used for the Oxfordshire Chilterns Study Area.

Information was copied from each Tithe Map and Apportionment using the following method. The plot numbers for woodland shown on the Tithe Maps were recorded in the corresponding area on the printed OS maps. The shape and extent of woodland and other features such as commons were copied by hand on to the printed maps; often the shape was unchanged Sections were traced if the detail was complex. The Tithe Apportionment was searched for information on all woodland and commons including name, type, owner, size and any other comments and full details were recorded. Owner and occupier names were

included for use in further research. From the Apportionment, relevant field names, as described in 4.1.1.1, with plot number and other details were recorded. Their position on the Tithe map was found using the plot number. The field was then mapped on to the modern map copy. In some parishes the same procedure was used for woodland if it was not shown by symbols on the maps.

Using Enclosure maps, woodland and other relevant features were transcribed as above, but they lacked the extra details of the Tithe Apportionment.

4.1.2 Ordnance Survey maps

Ordnance Survey (OS) originated from the need for accurate military maps in the Scottish Highlands between 1747 and 1755; the first survey in England in 1784 was of the south-east, again for military use. The first official map surveyed by the Ordnance Survey and published in 1801 was of Kent at a scale of one inch to the mile. Ordnance Survey became a separate entity in 1841and went on to produce accurate maps at different scales including the 6" scale (1:10560) for national use ever since (National Archive Records Guide No 70).

4.1.2.1 First Edition County Series 6" maps (1880's)

The maps used in the research are the OS First Edition County Series six inch to the mile (1:10560), a smaller scale than Tithe maps, dated from between 1849 to 1899. Those in the study area date from c.1880-1883 and were made pre-National Grid, which did not come into use until the 1950's. Maps in this series were made for each county and, at the time the maps in the study area were made, were produced by direct photo-reduction of the larger scale 25" to the mile (1:2,500) maps, with some re-numbering and re-written place names (Edina Digimap Help). For this research the symbols for different vegetation types are essential; the County Series illustrated deciduous, conifers, mixed woods and brushwood (i.e. underwood or coppice) (Watkins, 1985). However during the research it was not possible to identify brushwood, although this could infer that there was none left in the study area at this time; comparisons with printed copies were equally difficult to distinguish. Printed copies of 25" to the mile maps were consulted and showed that coppice only remained on some areas of unenclosed commonland eg Maidensgrove Scrubs and part of Russell's Water Common.

A case study of a small part of the study area was conducted early in the research using the maps described above as well as OS 1:10560 maps for 1904 and 1920. However woodland changes were found to be small in the 20th century (or at least in the pilot area) so it was decided that these would not be used. There were also queries associated with the information to be gained from these later maps. Since the late 19th century there has been a simplification of woodland information on the maps and the revisions which have taken place over the years do not always include an update of woodland vegetation information, including that of felled woodland (Watkins, 1985).

4.1.2.2 Recording method - 1880's Ordnance Survey maps

County Series First edition 6" (1:10560) maps were accessed from two on-line sources. Data from Old Maps accessed from (http://www.old-maps.co.uk/index.htm) was used for seventeen parishes in the north of the study area. These maps were scanned from OS historic map sources by Ordnance Survey and Landmark Information Group Ltd and the project completed in 2003 (Roper, 2003). There were some problems relating to the scanning of the original maps which resulted in gaps in the coverage; however, as the study area is adjacent to Buckinghamshire and Berkshire, in all cases any part missing in the Oxfordshire map could be seen on another. This meant that occasionally there was a small difference in publication dates for the maps, although the original ground surveys had slight overlaps into adjacent counties so in fact were part of the same survey for the study areas. The format of the Old Map website when used in the research was such that it allowed maps to be seen in a large format with easy manipulation (ie scrolling in all directions and zooming). The current website is now in a different format so would have been unsuitable for this use (http://www.old-maps.co.uk).

The remaining sixteen parishes used data accessed through Edina Digimap using Historic Digimap, available through Higher Education institutional subscription (Edina Digimap, undated). This source was not fully available when digitisation of this layer started. As with Old Maps, the maps used in Historic Digimap were First Edition County Series 6" to the mile (1:10, 650). The Landmark Group assign an "epoch" name for each layer which has been created, linked to map series, edition or scale, therefore these are Epoch 1 (Edina Historic Digimap Help). The reason for this change in data source was a computer problem resulting in the loss of 1880's data for the southern sixteen parishes. Therefore, these had

to be re- digitised using the more accessible and user friendly Edina Historic Digimap, which allows County Series map tiles of the required date and scale to be downloaded, which had not been accessible at the start of this research.

4.1.3 Ordnance Survey MasterMap (2007)

MasterMap is a digital map containing themed layers, one of which is OS MasterMap Topography Layer, available through Edina Digimap. The Topography Layer contains nine themes relating to land cover, of which the "land theme" includes features relevant to this study. The data is in the form of polygons for each land cover parcel which is identified by a unique 6-digit code number known as a topographic identifier or TOID, as well as a series of attributes. For land cover types, one or more descriptive term is used as for example Coniferous;Non-Coniferous;Scrub;Grassland in an area of mixed semi-open woodland (Edina 2006a). MasterMap is not arranged in tiles as in a traditional map series but in a seamless database so eliminating artificial breaks such as tile boundaries (Edina, 2006 b).

MasterMap was chosen in preference to Land Cover Map (LCM) 2000 as it is more up to date, more accurate and is spatially aligned to the base OS maps used for the previous layers. This last point was important as it allowed a reasonable comparison between 1880 and the modern period which would have been problematic using LCM 2000. However, during the later analysis stage of the research, MasterMap caused some problems with the greater amount of detail it contains compared with the created historic shape file layers. This resulted in large numbers of polygon slivers being created during data manipulation between time periods which had to be eliminated.

4.1.4 Chiltern Natural Area Land Use map

The Chiltern Natural Area Land Use (CHLU) digital map was created in 2002 for research purposes in the Spatial Ecology and Land Use Unit at Oxford Brookes University. Land use was identified from aerial photographs held by Oxfordshire, Buckinghamshire, Hertfordshire and Bedfordshire County Councils, with further information obtained from the University of Reading, all dating from the 1990's. The Oxfordshire data was filmed in 1991. The identified land parcels were head-up digitised over 1:10,000 OS maps and given a code number based on one of 45 land uses. The spatial accuracy is good and the input

accuracy 96%, but there were some errors in identification of land use which were quantified by a ground truthing exercise. The reliability of the accuracy of woodland identification proved to be 64% for deciduous and 87% for mixed/conifer. The overall accuracy was deemed to be 80% (Bailey, 2003). CHLU covers the entire Chilterns, from which the study area was clipped for this research.

In order to assess percentage of woodland cover within the landscape of the study area, information was needed on other land use. As it was not possible to use MasterMap for this purpose, data from this research was used in conjunction with CHLU to provide a complete landscape of the study area. A shapefile was created which incorporated MasterMap woodland information with other land use based on the CHLU map. CHLU was appended with the MasterMap shapefiles for deciduous, conifer and mixed woodland, which had been created, refined and used during this research. Where necessary, the resulting attribute information was further refined to ensure that woodland polygons were correctly identified. Other land use information was also changed if necessary, for example if a previous CHLU polygon was identified as woodland which did not correspond to the MasterMap information and *vice versa*.

4.1.5 Ancient Woodland Inventory of England

The Ancient Woodland Inventory identified over 22,000 sites of ancient woodland, although it omitted sites under 2 ha in size. For Oxfordshire and Buckinghamshire the Inventory was published in 1982. The digital version has been partly updated but is still felt to be inaccurate both in terms of area included and data boundaries. The national Inventory is being gradually updated by county or area based on 0.25ha as the smallest area. The Weald and the Kent updates are completed and completion of Surrey and West Sussex is due in early 2010. The Chilterns update is a two year project and was due to commence in spring 2010, but was delayed. During this process a range of historical maps will be used: the 25" OS map (1:2500) *circa*1870, OS Surveyors drawings and any available earlier estate maps. During the recent updates of the Surrey and West Sussex, the value of tithe maps was realised. Tithe maps were photographed, but as the method used did not include information from apportionments, those maps without woodland symbols could not have been informative.

AWI data had previously been made available to the research team; for this research it was clipped (cut) to show the study area only. Two shapefiles were created, one of ASNW and one of PAWS. These plantations may be deciduous, mixed or conifer, so the PAWS shapefile was clipped in turn with these wood type shapefiles to ascertain the composition of each polygon. In this research, information on ancient woodland and PAWS was used in future scenario analysis.

4.1.6 Parishes Boundaries

It may be reasonable to assume that parish boundaries would have been used in this research for mapping and analysis. However boundaries changed radically over the study period and therefore such information would have been confusing. Tithe and Enclosure Maps were made parish by parish and data for this study included the name of the parish in order to manage and identify the information more easily. Figure 4.3 shows parish boundaries in the study area at 1851 (Edina UK Borders, undated). In the 1880's layer parish names from 1840 were retained, although some boundaries in the south of the study area had changed by this time. The 2007 MasterMap layer did not use parish names. Modern parishes in the Oxfordshire Chilterns are in many cases very different in shape and even name to those recorded during historical research as shown in Figure 4.4 (Edina UK Borders). For example, Stokenchurch and parts of Lewknor Uphill are now in Buckinghamshire; Pyrton once included Stonor which is now amalgamated with Pishill; and many other parishes in the south of the study area, which were originally long narrow strip parishes, have been amalgamated, split and renamed e.g. Highmoor and Stoke Row.

As a result of these confusing changes, this research used the original parish boundaries obtained from 1840's tithe maps which allowed straightforward clear referencing of sites.

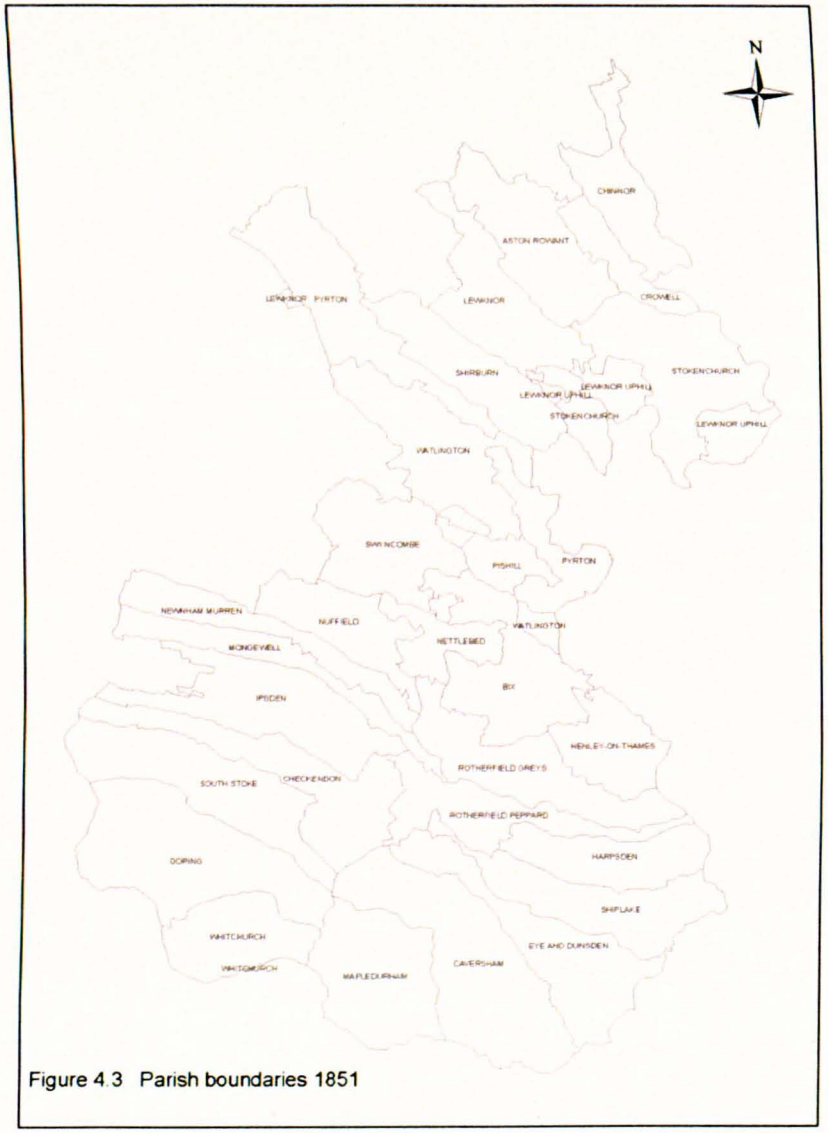

Figure 4.3 Parish boundaries 1851

Figure 4.4 Parish boundaries 1991

4.2 Changes over time: GIS creation and analysis

As described above, four types of maps were used to supply information at different time periods, which led to the methods of digitisation differing slightly for each type. These are described below in relation to the maps used. Some woodland areas are cut at the study boundary, regardless of their natural extent. On tithe maps this occurred at parish boundaries so for consistency this method has been used across all time layers.

An attribute table (database) was created concurrently for each layer within the GIS. Each land parcel (or polygon) with its associated identifying information (attributes) was recorded on the attribute table. Unique attributes codes are attributed to each land use type within the GIS. They can be interrogated to highlight or analyse land use patterns and to demonstrate and measure change. Information linked to map features can be recorded and expanded as necessary. Areas in hectares can be calculated in GIS and used to demonstrate woodland extent over different time periods. Table 4.1 below shows the attribute codes and land use types to which they refer, as identified from the maps and data used in this research.

Table 4.1 Land use types and related attribute codes for maps used in GIS

Attribute codes	Tithe maps 1840s Enclosure maps pre 1840s	OS County Series 1st edition 6" 1880s	MasterMap 2007
100	Woodland	Deciduous (all)	Deciduous (all)
101	Beech		
800	Bulk deciduous		
102	Underwood Coppice		
103	Plantation		
105	Conifer	Conifer	Coniferous
106		Mixed woodland	Mixed
107	Scrub	Scrub	
109	Furze		
110		Ex-woodland	Ex-woodland
111		New deciduous	New deciduous
112		New conifer	New conifer
113		New mixed	New mixed
200	Common	Common	
201	Wooded common Common woodland Wood and pasture		
202		Ex-common	
203		Wooded ex-common	
500	Field name – wood related		
600	Field name – common related		
700	Park land		

4.2.1 Tithe and enclosure maps – 1840's

Using the data recorded at the Record Offices, tithe and enclosure maps were manually head-up digitised using GIS (ESRI ArcMap9.0). The outlines of the land parcels were digitised as polygons into the GIS on screen over geo-referenced modern 1:10,000 Ordnance Survey maps tifs by visually copying the paper maps. The historic map information is indicative of area rather than absolutely accurate in scale, partly because tithe maps vary in their scale and accuracy and because inaccuracies were inevitable in the transcribing process, therefore this study assesses trends rather than absolute measurements. A shape file, *tithe_1840,* was created for tithe and enclosure data. Land use codes were chosen and assigned to each different woodland type or relevant land use as identified from tithe apportionments.

Attributes recorded from tithe data are: the polygon unique identifier number; land use code (see Table 4.1 above); wood name; field name; parish name; owner; acres; roods; perches; date; plus space for any additional information. As tithe maps recorded deciduous woodland as *beech*, *woodland, wooded common* or *coppice* this nomenclature was used in producing the tithe shapefile attributes. However, in order to compare tithe deciduous woodland with deciduous in other time periods, this data was later copied and amalgamated to create a separate shapefile of deciduous tithe woodland (*tithe_decid*). Enclosure attributes were limited to wood name, acreage and owner.

4.2.1.1 Pre-1840's information

A further shapefile was created using relevant field names in the same way as described above. This file was appended (joined) to *tithe_decid* to form *pre_tithe* shapefile. It shows possible woodland cover at a hypothetical time consisting of deciduous tithe woodland *circa* 1840 plus woodland previously cleared as identified by field names. Clearly there may have been other clearances not recorded in field names but Pre-tithe provides an attempt in this research to demonstrate a past landscape beyond the scope of data shown on available historic maps.

4.2.2 OS 1st edition County Series 6" maps – 1880's

Two methods were used for this data due to the different sources used.

For the seventeen northern parishes only, the *tithe_1840* shapefile was copied and renamed as a new *1883* shapefile. The information from Old Maps was input into GIS by head-up digitising and editing of the copied tithe data over geo-referenced **modern** 1:10,000 Ordnance Survey map tifs.

For the sixteen southern parishes, Edina Historic Digimap data was downloaded as derived National Grid tiles in Georeferenced TIFF format for use in ArcGIS. As mentioned above, these maps were originally made pre-National Grid but were converted to National Grid tiles by the OS and Landmark Information Group Ltd. The *tithe_1840* data was copied over the geo-referenced 1:10,000 Ordnance Survey **historic** map tifs and saved as *1883* shapefile. The data from the OS 6" maps was manually head-up digitised over this in the same way as above.

Digitising and editing the new *1883*shapefile from the copied *tithe_1840* shapefile for both types of OS historic data ensured continuity for unchanged polygons. Attributes which had changed between 1840 and 1880 such as land-use were taken from the vegetation symbols; changed wood names from the text on the 1883 maps. If woodland shape had altered, changes to polygon shape could be made by editing rather than by new digitising and in the process new or ex woodland was identified and mapped. Other new woodland was mapped as new polygons with the appropriate attribute code for its composition. Other changes, such as small areas of new planting, which may otherwise have been missed given the complexity of the landscape, were more obvious using the second 1883 method.

4.2.3 MasterMap: Creating a MasterMap shapefile

A boundary for the study area was created using a combination of Lower Super Output Area (LSOA) boundaries, extracted from the national dataset provided by Neighbourhood Statistics, and clipped by the Joint Character Area (JCA) boundary for the Chilterns to arrive at the boundary for the Oxfordshire Chilterns. The LSOA within this boundary were merged into one polygon and saved.

MasterMap shapefiles were downloaded and converted from GZIP files. The study area shapefiles were selected and extracted rather than clipped (cut) to include polygons which fell on and over the study area boundary. As the study area was in fact smaller than the original JCA boundary (see above) a map of parish boundaries was used to delete the

woodland patches which were not within the study area (see Figure 4.4 above). This map was obtained from Edina UK Borders by downloading individual parishes in the study area from English Civil Parishes, 1991 (http://borders.edina.ac.uk/ukborders/action/restricted/textgeosearch).

However to ensure that the same general woodland areas were analysed, any polygon which fell outside the actual study area ie that bounded by the Icknield Way below the escarpment, but inside the boundary outline was deleted. Similarly, polygons around the north–east of the boundary were treated in the same way. Those falling on the study area boundary were edited manually to follow the same pattern as the historic maps, ie cut at the study boundary. Nineteen fields were displayed in each MasterMap shapefile; these were reduced by removing ten fields which contained data not relevant to the research. A single shapefile containing all the MasterMap data for the study area was created by selecting data and exporting it all to a new file; this prevents any confusion with the attributes table which can occur from unioning.

The attributes of the MasterMap data contain many subdivisions of woodland and other land cover type, for example there are 23 types associated with coniferous tree ranging from *ConiferousTrees* to *ConiferousTreesScatteredNonconiferousTreesScrub* and similarly nine for Nonconiferous trees. In order to simplify analysis, these types were reduced to those which most resembled the vegetation described by tithe maps or found on the 1883 Ordnance Survey maps i.e. to woodland cover only so not including those which did not fall into this type of category, for example "scattered". These chosen types were then amalgamated and saved as new shapefiles of *Deciduous*, *Conifer* and *Mixed*. The Tithe maps did not show divisions in woodland, unless there was a change of ownership or wood name and only major roads and tracks. Therefore, as the tithe maps formed the basis for the 1883 maps, this format was retained. However a feature of Master Map, which is inconsistent with the other time layers, is the subdivision of woodland areas by forestry tracks, so resulting in many more polygons. This resulted in some difficulties in data comparison between time periods and in landscape metrics analysis.

4.2.4 Data size issues

In order to use GIS to provide meaningful results in terms of ecological benefit, decisions had to be taken on the smallest useful size of polygon to include. Recent FC Woodland

Grant Schemes advice (Forestry Commission, q) gives no recommendation as to the size of the site although in the recent past, WGS sites were to be no less than 1.0 ha. Recent pilot work in the Chilterns AONB to refine and update the Ancient Woodland Inventory has observed that ancient woodlands under 2 ha need to be identified and added with a cut off point of 0.25 ha (Chilterns Woodland Project, 2007). Initially it was decided to delete polygons under 0.5 ha in size in the 1840 and 1883 shapefiles. However on further investigation it became apparent that these small woodland areas demonstrate the woodland pattern of the past and had a variety of origins and uses which can provide further historic information (see Table 4.3 below), therefore these small polygons were retained.

Table 4.2 Woodland types and numbers under 0.5 ha in 1840 and 1883

Woodland Type	**Tithe 1840**	**OS 6" 1883**
Wood *Some were parts of a larger wood but in different ownership*	42	100
Underwood *Some were part of larger woods*	26	-
Plantation or nursery garden	47	1
Shaw *Some called "remainder of..... (wood name)"; others "shaw in breach ground" Both indicate remnants of clearance*	80	-
Ex-woodland *By comparison with 1840. This figure represents approx 50% of all ex-woodland at this period*		119
Orchards *Likely to be cherry orchards*		141
Conifers		24
Mixed		21
New deciduous *Approximately 60% of new deciduous in 1883 was less than 0.5 ha*		22
New conifer		8
Scrub		1

In MasterMap (MM) there are numerous small polygons as a consequence of the detailed information provided by this data. Problems occurred when data was manipulated between historic data and MM, which often resulted in ambivalent polygons and slivers being created. Using ET GeoWizard Eliminate tool to either delete or merge very small polygons or slivers into adjoining polygons after identification, some of these extraneous polygons were removed.

4.3 GIS analysis of change in woodland extent and composition

Woodland change over a period of 167 years using snapshot information at three dates, 1840, 1883 and 2007, was investigated within the GIS. There are many possible combinations of change; for example, woodland types (eg deciduous; mixed; conifer) could remain the same; could have become another type; or become non-woodland. In the 1840 period, small areas of coppice still remained, but disappeared over the next 40 years. There were also small areas of conifer, and of plantation. It was not apparent whether "plantation" was coniferous or deciduous so plantation and conifer were amalgamated to create one shapefile. In the 1880 period, mixed woodland was present which had not been mentioned in the Tithe documents. Agricultural land could become wooded (any of the three types) or remain as agricultural. Therefore all possible combinations of change (or no change) had to be identified.

However in order to quantify how the woodland extent and composition has changed and the effect this had on the landscape ecology of the area, further analysis of the data is necessary. GIS data was used in two ways in this part of the research. Firstly to show woodland extent and composition at different times and to show changes to these over time (see 4.3.1 below) and secondly to analyse landscape metrics to ascertain changes in ecological and landscape function using FRAGSTATS analysis software (McGarigal, *et al*, 2002) (See 4.5 below).

4.3.1 Data manipulation to assess change over time

In order to identify these changes, map and attribute data from the three time periods (1840; 1880; 2007) was compared to show where and how change occurred between these

time periods. Therefore comparisons between 1840 and 1883 and between 1883 and 2007 were made. At the end of this process, the area in hectares of all these wood types and cleared areas were calculated in GIS and then used in Excel to produce bar-charts showing change in land-use over time.

Six GIS procedures, using the *clipping* or *erasing* tools in various combinations, were used to identify all possible change in woodland over time (see below). The same procedures of GIS data manipulation described below were used for each time period. Flow diagrams illustrate this process; see Appendix 4.

NOTE:
Clipping extracts features that overlay the clip feature. In this research, clipping identified change from an earlier wood type to a different type at a later date.
Erasing removes parts of polygons which coincide with the erase feature polygons. In this research it was used to ascertain new or cleared woodland depending on the order in which earlier or later shapefiles were used.
Export is the process by which new shapfiles are created from identified polygons. New shapefiles were created for the data resulting from these processes by using *export.*
Appending is the process of joining two or more shapefiles to create a new shapefile which contains all the data from the contributory shapefiles.

i. For each time period, each woodland type was identified and exported to create the type shapefiles below:
1840deciduous; 1840conifer (which included plantation); 1840coppice;
1883deciduous; 1883mixed; 1883conifer;
2007deciduous; 2007mixed; 2007conifer.

ii. To ascertain if changes from one type to another had occurred over time, each earlier type was ***clipped*** in turn by all types of the later date. This process identified polygons which had changed from deciduous to the other types (or had remained deciduous). These identified polygons were exported to create three new shapefiles for each resulting wood type.

EXAMPLE: In order to identify changes to deciduous between 1840 and 1883, the *1840deciduous* shapefile was ***clipped*** in turn by:
1883deciduous to identify unchanged deciduous;
1883mixed to identify deciduous which was now mixed;
1883conifer to identify deciduous which was now conifer
This procedure was repeated for each type to identify change between 1883 and 2007.

iii. To ascertain the total new of each woodland type at each date, the later shapefile was ***erased*** by the earlier shapefile of the same type. This identifies total new woodland which is comprised of both that changed other wood types and from agricultural land.
EXAMPLE: In order to ascertain the total new deciduous between 1883 and 2007, *1883deciduous* ***erased*** *MMdeciduous* resulting in *TOTAL_NEW,* which was exported to create a new shapefile. This is comprised of deciduous which was previously either conifer (*con_decid*) or mixed (*mix_decid*) and also new deciduous on agricultural land.

iv. To ascertain new woodland planted on agricultural land (ie un-wooded at an earlier date), the *TOTAL_NEW* shapefile of any type was cumulatively ***erased*** in turn by the other types that comprised the total new shapefile. This process eliminates all polygons relating to changed woodland and thus identifies new woodland on agricultural land.
EXAMPLE: In order to ascertain new planting on agricultural land between 1883 and 2007:
TOTAL_NEW was ***erased*** by *con_decid* resulting in ERASE1 which was *exported* to create a new shapefile.
ERASE1 was ***erased*** by *mix_decid* – ERASE 2 which was *exported* to create *agric_decid* (i.e. new deciduous on previously unwooded land.

v. In order to identify woodland which had been cleared, the earlier type is erased cumulatively by the later three types. If it was no longer woodland of any type, it had become ex-woodland.
EXAMPLE: In order to ascertain deciduous cleared between 1840 and 1883: *1840_deciduous* was ***erased*** by *1883_deciduous* resulting in ERASE_1 which was *exported* to create a new shapefile.

ERASE_1 was ***erased*** by *1883_conifer* resulting in ERASE_2 which was *exported* to create a new shapefile.
ERASE_2 was ***erased*** by *1883_mixed* resulting in ERASE_3 which was *exported* to create *tdecid_agric* (i.e. earlier deciduous now ex-woodland).

vi. In order to create a shapefile containing all identified ex-woodland, all ex-deciduous shapefiles, ex-coppice shapefiles and ex-woodland in 1883 (identified in v. above) were *appended* to a shapefile of wood-related field names to create an ex-woodland shapefile which contained all cleared woodland identified in the study area.
It became apparent that some of these sites are now again wooded therefore in order to ensure that these were not included, the ex-woodland file was erased with all MM types. In order to identify the type of woodland which had been created on these re-wooded sites, the ex-wood shape file was clipped by all MM types.
The final ex-woodland shapefile represented the total woodland clearance from before 1840 to the present day.

Table 4.3 GIS Shapefiles resulting from changes between (A) 1840 and 1883 and (B) 1883 and 2007.

	A 1840 to 1883 **B** 1883 to 2007	**Original Deciduous**	**Original Mixed** (1880 only)	**Original Conifer**	**Original Agriculture**	**Original Coppice** (1840)
New Deciduous	**A**	tdecid_decid	--	tcon_plt_decid	tagric_decid	cop_decid
	B	decid_decid	mix_decid	con_decid	agric_decid	--
New Mixed	**A**	tdecid_mix	--	tcon_plt_mix	--	cop_mix
	B	decid_mix	mix_mix	con_mix	agric _mix	--
New Conifer	**A**	tdecid_con	--	tcon_plt_con	tagric_con	--
	B	decid_con	mix_con	con_con	agric_con	
Ex-woodland	**A**	ex_tdecid	--	ex_tcon_plt		ex_cop
	B	ex_decid	ex_mix	ex_con		--

4.4 Creation and analysis of future scenarios

A total of eight future scenarios, either deciduous restoration or creation, were identified. One, the Chiltern Landscape Forest Design Plan, is a restoration project which is in the process of being implemented on land owned and managed by the Forestry Commission (FC) (Forestry Commission, 2005) and is due to be completed by 2030.

Five further potential restoration scenarios and two potential woodland creation scenarios were created in this research in GIS for analysis to assess their benefit. The aim of these scenarios was to ascertain the improvements in landscape metrics, such as total woodland and patch areas, nearest neighbour distance and connectivity, which could be achieved by these measures.

4.4.1 Chiltern Landscape Forest Design Plan

The Chiltern Landscape Forest Design Plan (CLFDP) is working to replace FC owned and managed coniferous and mixed woodland in the Chilterns with native deciduous woodland, whilst retaining some small appropriate areas of conifer and creating some open space. There are five such areas in the study area. These areas are currently a mixture of woodland types but, in this GIS future scenario, they have been converted to the planned land uses described in the CLFDP to allow assessment of their benefit in relation to improved connectivity and an increase in deciduous woodland size and area.

These changes are relatively small scale, but nevertheless are physically taking place. The other future scenarios explored below in this research aim to demonstrate the changes necessary at a landscape scale to restore or create deciduous woodland to provide a functioning woodland network. Thus, unlike the CLFDP, they are not based in reality but are examples of the potential change which could be achieved long-term.

4.4.2 Future GIS scenarios for deciduous restoration and creation

Eight alternative future scenarios were created in the GIS in this research, including the CLFDP described above, based on woodland restoration or woodland creation to link with existing deciduous and/or ASNW. They indicate possible ways to increase the area of native deciduous woodland in the study area and improve the ecological connectivity for woodland species.

However, in reality, these would be dependent on land owners being aware of possibilities on their land and woodland grants being targeted accordingly, thus these scenarios are theoretical only.

4.4.2.1 Restoration scenarios

The premise of this scenario is that mixed woodland could all be converted to deciduous in future which would be both ecologically beneficial and economically viable through the use of the removed conifers for fuel production.

The conversion of mixed woodland to deciduous and the conversion of coniferous PAWS are currently targeted in the Chilterns by the F.C. Woodland Improvement Grant Scheme. Oxfordshire HAP targets include a small area of coniferous or mixed PAWS woodland for

restoration (24 ha) in the Oxfordshire Chilterns (Oxfordshire Nature Conservation Forum). In these scenarios, landscape character would either be unchanged or improved by the removal of alien conifers, although, as in the CLFDP, some could be retained where they are beneficial. The Deciduous/CLFDP scenario is actually in progress and is due to be completed by 2030.

Restoration scenarios are to replace each woodland type below with deciduous:

i. CLFDP
ii. Replace mixed with deciduous;
iii. Replace conifers with deciduous;
iv. Replace mixed PAWS with deciduous;
v. Replace coniferous PAWS with deciduous;
vi. Replace mixed and coniferous PAWS with deciduous.

For each woodland restoration scenario listed above the method was identical. The deciduous shape file was appended with the target restoration shapefile, (i.e CLFDP; mixed; conifer; mixed PAWS; conifer PAWS). The new shapefile represented total deciduous cover resulting from restoration.

The composition of PAWS was identified by using the PAWS shapefile to clip each type of MM woodland. This resulted in a total of 580 PAWS polygons, of which 137 were deciduous, 188 mixed and 255 coniferous. The deciduous PAWS were not used, as in many cases they are now difficult to distinguish from native deciduous woodland (Hornby and Welsh, 1990).
The final shapefiles were used for analysis with FRAGSTATS.

4.4.2.2 Creation scenarios

This approach is based on the selection of ex-woodland either identified from field names or through GIS analysis between time periods. Woodland creation on previously wooded sites can be successful as it is likely to appeal to both land owners and local people. This form of targeting would improve woodland connectivity as well as retaining landscape character through the use of previously wooded areas. It could have the added benefit of incorporating remnant woodland vegetation which may have survived; for example,

several hedges bordering known sites of ex-woodland, cleared between 1840 and 1883, have been found to contain species such as dog's mercury (*Mercuralis perennis)*, wood anemone (*Anemone nemoralis*), bluebell (*Hyacinthoides non-scripta*) and archangel (*Lamiastrum galeobdolon)* (personal observations).

Creation scenarios are:

i. Deciduous planting or regeneration on suitable fields identified as ex-woodland and selected in relation to existing deciduous woodland.

ii. Planting on suitable fields identified as ex-woodland, selected in relation to ASNW.

For use in woodland creation, ex-wood shapefiles were first refined by removing polygons under 0.2 ha to reduce the effect of MasterMap as described above.

In each creation scenario, the *Select by Location* tool was used to identify ex-wood polygons within 1.0m (i.e. adjacent to existing deciduous woodland) of each target type (i.e. deciduous and ASNW). This distance ensured that both types of polygons were directly adjacent to each other. This process was repeated using 200m as the target distance. At 200m it was more likely that some of the selected polygons would not be suitable for inclusion, if for example they were separated by a road or other barrier from the target. These polygons were identified by eye using the Chilterns Natural Areas Land Use map, to identify barriers and were deleted.

The selected polygons were then exported to make a new shapefile for each target distance. This was then appended with the target type to create future creation shapefiles to be used for analysis with FRAGSTATS.

4.4.2.3 Combination scenario

A further scenario which combined both woodland restoration and woodland creation was created in order to maximise the woodland extent in the study area, with the aim of reaching a figure of over 30% of woodland cover, the minimum identified by Peterken (2000) necessary for a woodland network. This would have the effect of returning woodland extent to that of an earlier time period, although it would not be possible to identify a specific time or date.

The combined scenario was achieved in GIS by first replacing all conifer and mixed woodland with deciduous, which was saved as new shapefile representing the greatest deciduous extent. This shapefile was then used in woodland creation by selecting using the *Select by Location* tool, as described above in 4. 4.2.2. The selected polygons were then exported to make a new shapefile for each target distance. This was then appended with the restored deciduous target shapefile to create a future combination shapefile to be used for analysis with FRAGSTATS.

4.4.2.3 Data size issues in future scenarios

For use in future restoration scenarios, it was decided that only MM conifers and MM mixed would have the smallest polygons (less than 0.1 ha) deleted to remove possible sources of error which could affect the outcome. As MM deciduous is the "target" land-use, in this case it was decided to retain the entire data set, as by deleting small polygons there was a danger of including those which represented "wood and scrub" on woodland edges. However, in the case of creation scenarios, polygons of less than 0.5 ha were removed from deciduous and mixed shapefiles to reduce selection of ex-wood polygons by small isolated patches of deciduous or mixed which would confuse the final outcome. Ex-woodland polygons less than 0.2ha often resulted from the manipulation of different time layer shapefiles so were deleted to avoid irrelevant results in FRAGSTATS. Data from the Ancient Woodland Inventory was also used in the future scenarios in the form of shapefiles for Ancient Semi-Natural Woodland (ASNW) and Plantations on Ancient Woodland Sites (PAWS).

4.5 Changes in spatial metrics over time and in future scenarios

In order to quantify how wooded landscapes have changed in the past and may change in future, woodland cover at the hypothetical Pre-tithe period, at 1840, 1883 and 2007, and for future scenarios, was analysed using FRAGSTATS Version 3 to compute woodland spatial metrics as shown in Table 4.5 below. In order to compare like with like, the 1840 and 1883 shapefiles were refined to produce shapefiles which showed only the woodland types i.e. deciduous, mixed and conifer as applicable to each time period. This allowed a

more accurate comparison with Master Map. Data was converted to raster data with a cell size of 5m in ASCII files for processing.

Table 4.4 Woodland types and future scenarios analysed by FRAGSTATS

Woodland cover type	PreTithe	1840 Tithe	1883 OS	2007 MM	Future scenarios
All wooded areas	*	*	*	*	
Total deciduous		*	*	*	
Deciduous + CDP[1] *Restoration*					*
Deciduous + mixed *Restoration*					*
Deciduous + conifers *Restoration*					*
Deciduous + PAWS mixed *Restoration*					*
Deciduous + PAWS conifer *Restoration*					*
ASNW + con/mix PAWS *Restoration*					*
Deciduous + ex-woodland *Creation*					*
ASNW + ex-woodland *Creation*					*
Deciduous + mixed + conifer + ex-woodland					*
Complete landscape (MM and CHLU)				*	

[1] CDP Chilterns Design Plan

4.5.1 Woodland spatial metrics and their analysis

FRAGSTATS computes metrics for mosaic landscapes at three scales: each patch; each type of patch ie class; and landscape as a whole. The scale used is relative to the phenomenon under investigation; in this study types of woodland and their spatial pattern is under investigation, rather than species in patches of habitat, therefore a large grain or scale (ie at class and landscape level) is appropriate; patches were not used for analysis, although class metrics include indices quantifying the number and size of patches of each woodland type within the landscape. The absence of a digitised matrix (i.e. the external background in this case agricultural land) has no effect of the metric calculations as the background is assumed to be outside the landscape under analysis (McGarigal *et al.*, 2002).

The following metrics were analysed for both class and landscape and demonstrate changes in woodland type and distribution in the study area:

Class area: the area of each type as a component of landscape composition. In this study it will demonstrate changes in composition and extent at different time periods.

Patch number: the number of patches of each type (not individual polygons).

Patch density: the number of patches of a type per unit area.

These metrics have the same measure if the landscape does not change, but in this study the landscape is likely to have changed and so they provide a useful comparison between time periods.

Patch shape: measures the complexity of shapes in comparison with a square.

Isolation/Proximity: measures the distance between patches of the same type in a landscape, therefore, in the context of this study, will show what effect changes have had on the distribution of any particular type of woodland.

Contagion/Interspersion and *Interspersion/Juxtaposition* analyses the heterogeneity or texture of the landscape i.e. how mixed the patch types are in the landscape. Contagion measures the aggregation of patch types, while Interspersion refers to the mixture of patch types within the landscape. Juxtaposition measures the intermixing of patch types.

Connectivity: measures the percentage of maximum possible connectance per number of patches at a distance range set at 5000m for this study.

Diversity (landscape only): measures richness and evenness of patches in a landscape. In the case of the Complete Landscape metrics, as well as analysis of the woodland and

landscape, the areas and percentage areas of woodland from the analysis were used to extrapolate percentage woodland cover for historical time periods and for future scenarios.

4.6 SUMMARY

This chapter describes the use of a range of data sources and methods to investigate woodland change over time:

- primary data are obtained from Tithe Maps and Apportionments (1840's), 1st edition 6" Ordnance Survey maps (1883) and MasterMap data (2007);
- the methods devised to compile and digitise the data from these different sources;
- comparison of data and analysis within GIS to identify change in woodland extent and composition over time;
- a pre-1840 GIS layer, using field names identified from Tithe Apportionments, is created to indicate the approximate extent of earlier woodland;
- Chiltern Natural Area Land Use data is used to allow analysis of woodland within a complete landscape and to extrapolate the percentage of woodland at earlier dates.
- the Ancient Woodland Inventory allows identification of PAWS.

These data are then selectively applied to target woodland creation scenarios which, with restoration scenarios, are analysed to identify the best outcome for woodland spatial ecology:

- previously wooded sites, identified in GIS by comparison of woodland extent over time and from Tithe field names, are used to target woodland creation in GIS;
- hypothetical conversion of mixed, conifer and PAWS in GIS to deciduous identifies the extent and combinations of possible woodland restoration;
- FRAGSTATS is used to analyse changes to woodland spatial metrics over historical time and, in future scenarios, to identify the best combination of woodland creation and restoration for improved habitat linkage and extent.

Chapter 5

Results

5.1 Introduction

Map data, the range of information obtained from their digitised format and the processes used to identify change and to create future scenarios was described in the previous chapter. Historical maps in a digitised form show the extent and type of woodland in 1840 and 1883, as well as providing an indication of earlier woodland extent. This digitised format allows comparison with modern woodland. Woodland change was interrogated using manipulated GIS data and compared with modern areas calculated from map data. Landscape metrics were analysed to gain an understanding of how the landscape of the study area has changed over time. Future scenarios demonstrate possible woodland change through woodland restoration and creation, the latter based on historic information. Landscape metrics were analysed to ascertain the potential benefits which could result from these hypothetical initiatives.

Here the results of these approaches are described with a brief comment of their implications for the woodland of the study area.

5.2 Historical maps – illustration of past woodland types and extent

Figure 5.1 shows woodland types taken from the 1840's tithe maps and apportionments. 'Wood' and 'beech' may be synonymous; here they are shown in different shades of green, the lighter representing beech. The extent of this is clear to see. Underwood or coppice is shown in red; it can be seen that this was scattered throughout the study area, some areas being very small. Several woods were called "-- Coppice" but were recorded as "wood" or "beech" therefore it was not clear whether or not they were being coppiced at this period.

It is possible that they were selective coppice over 20 years old and therefore exempt from tithes. The other feature of note is the large areas of common land shown in pale orange. Although not necessarily wooded, some of these areas were to become wooded as commons fell into disuse, so it is useful to understand their earlier extent and position.

Figure 5.2 shows woodland types taken from the 1st edition 6" Ordnance Survey maps dating from the 1880's. This figure demonstrates that coppice has disappeared or at least was not indicated as such by map symbols. Some areas of old coppice still currently exist (2010), for example, at Maidensgrove Scrubs but are not apparent on the earlier maps. The most striking feature is the large increase in conifers, either inter-planted into pre-existing deciduous to form mixed woodland (dark pink) or as pure conifer stands (pink). The areas of new deciduous (red) or conifer (black) are sparse and small in size. Another feature are areas of ex-woodland (purple), the majority in the north of the study area are in one parish, Stokenchurch. It can be seen that certain areas of ex-commonland have become wooded (brown) while some commons were not enclosed in the centre of the study area (light brown). There are also areas of scrub (pale green) on the escarpment edge which resulted from a reduction in grazing on open commons.

Figure 5.3 shows woodland types (deciduous, mixed and conifer) in 2007. The largest areas of deciduous are towards the north of the study area, with more widespread mixed woodland and conifer in the southern part of the study area.

Figure 5.4 indicates the position and number of all wood-related named fields taken from the tithe apportionments in relation to 1840 woodland. Many of these fields abut still existing woodland. Some groups of fields clearly show where entire woods previously existed such as Dark Wood in Swyncombe parish and College Wood in Nettlebed.

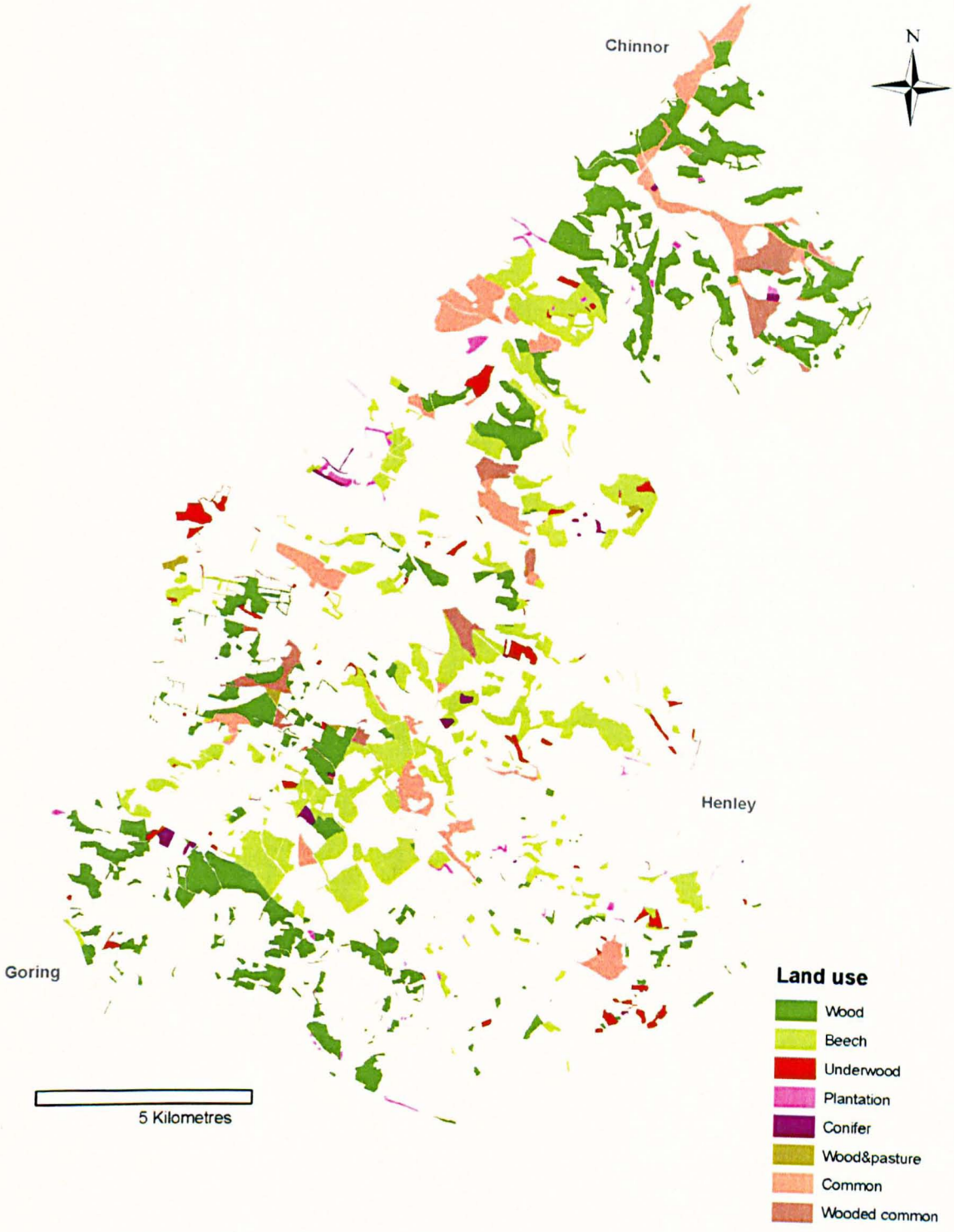

Figure 5.1 Oxfordshire Chilterns 1840 Tithe and Enclosure data

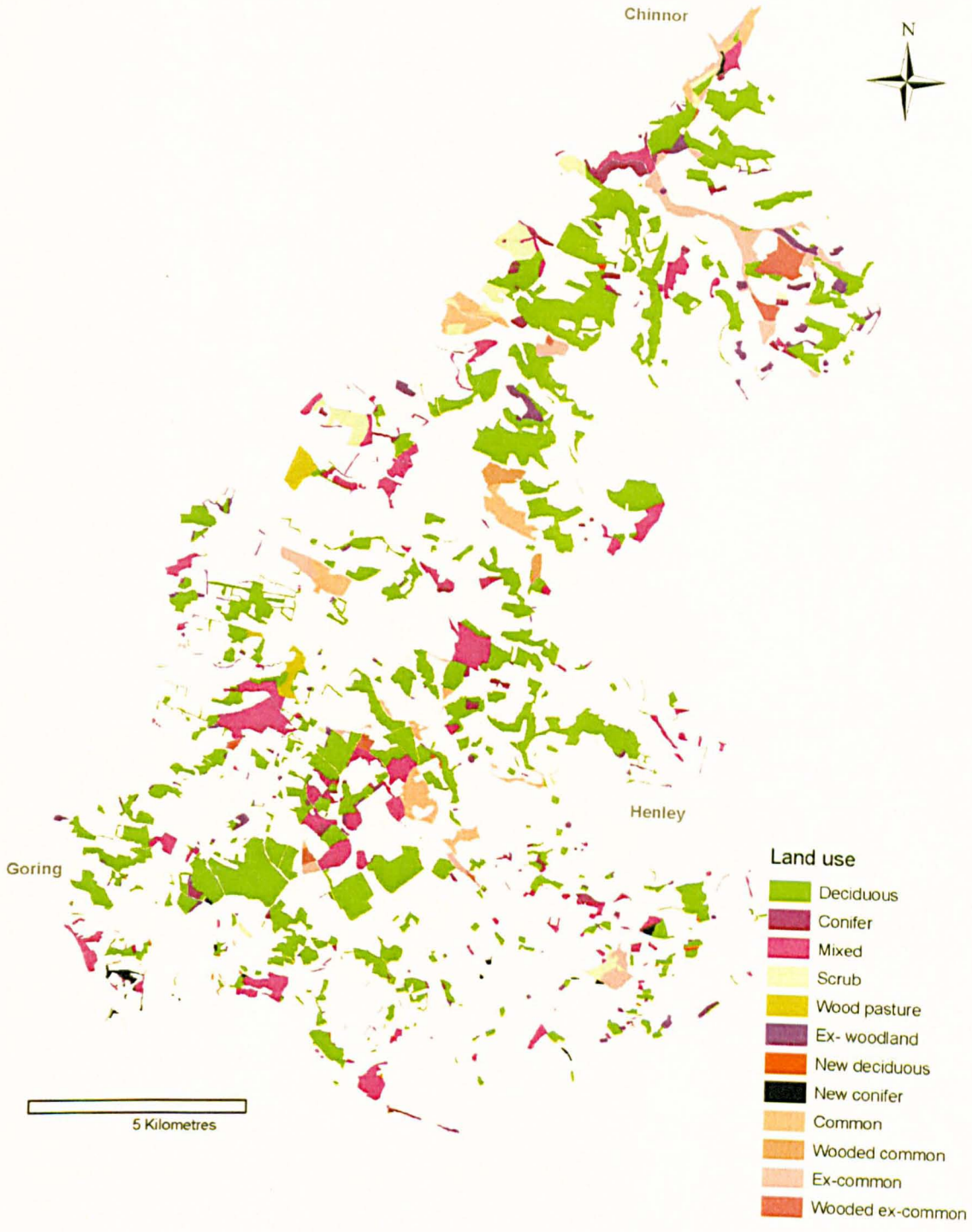

Figure 5.2 Oxfordshire Chilterns 1883 1st edition 6" Ordnance Survey data

Figure 5.3 Oxfordshire Chilterns 2007 OS MasterMap

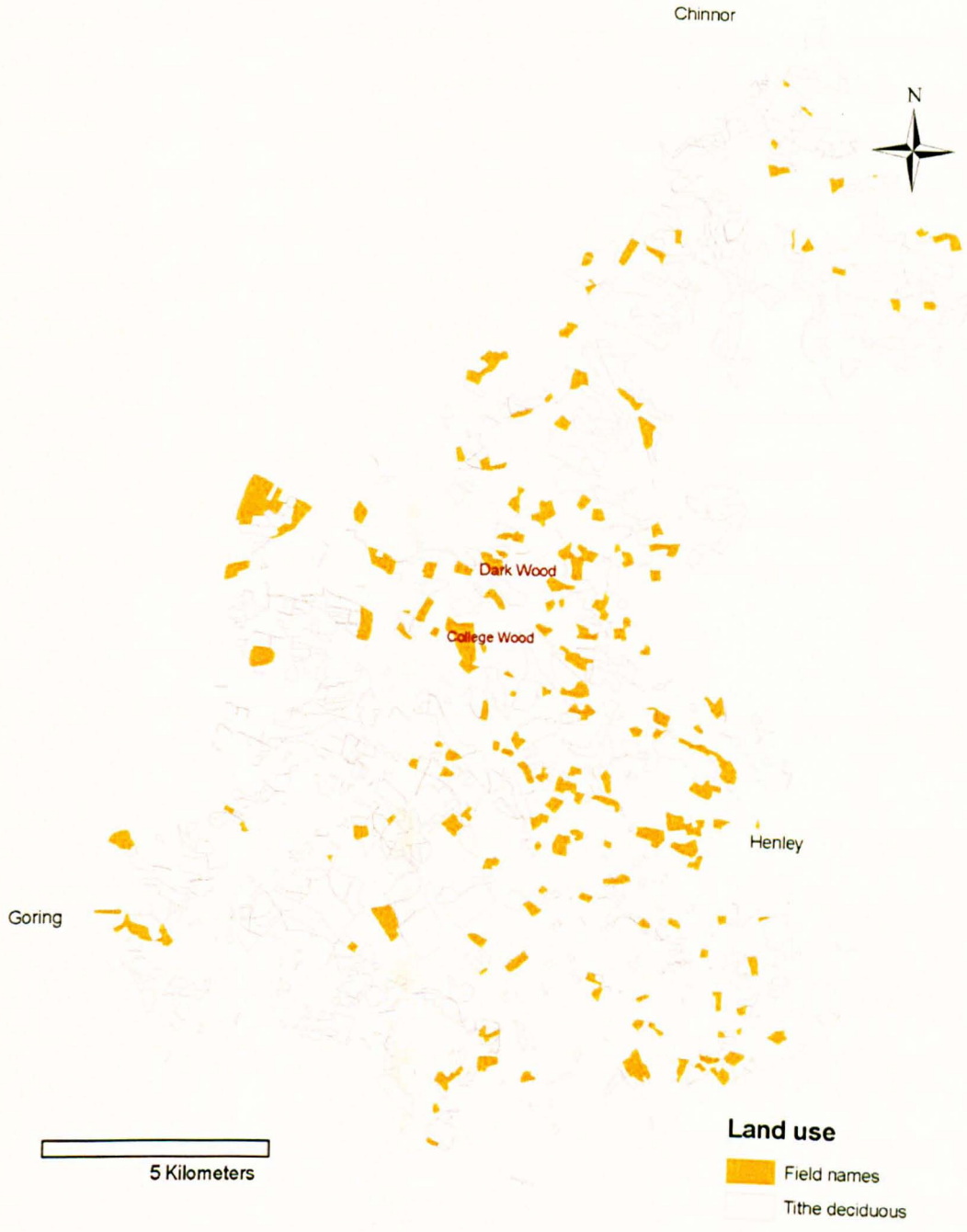

Figure 5.4 Woodland-related field names pre-1840

5.3 Analysis of change to woodland area and composition over time

Although the woodland areas taken from the tithe apportionments were recorded in acres, roods and perches, there were no measurements available from the 1st edition 6" map. Therefore, in order to compare changes in woodland area between time layers, it is more accurate to use GIS to calculate areas in hectares. In all the following scenarios, "wood", "beech", "coppice", "wooded common" recorded from Tithe Maps were amalgamated to 'deciduous' so as to make a meaningful comparison between 1840 and later maps when it was impossible to ascertain the type of deciduous woodland.

GIS shapefiles from pre-1840, 1840, 1883 and 2007 were compared between time periods to ascertain woodland extent and change over time. Changes occurred between dates both in area and composition as shown below in Tables 5.1 to 5.4. Areas are shown in hectares. The tables below show how the area of woodland types has changed since 1840.

Table 5.1 Changes in extent of woodland type (ha) between pre-1840 and 2007 (Figures taken from GIS)

	Deciduous	**Conifer**	**Mixed**	**TOTAL**
Pre-1840	6125.05[1]	n/a	n/a	6125.05
1840	5081.76[2]	143.32[3]	n/a	5228.50
1883	4074.54	179.24	898.25	5152.03
2007	4384.31	665.43	1786.55	6836.29

1. An extrapolated figure using 1840 deciduous extent and wood-related field-name areas
2. Amalgamated beech, wood, wooded common and coppice.
3. Conifers and plantations of unknown type

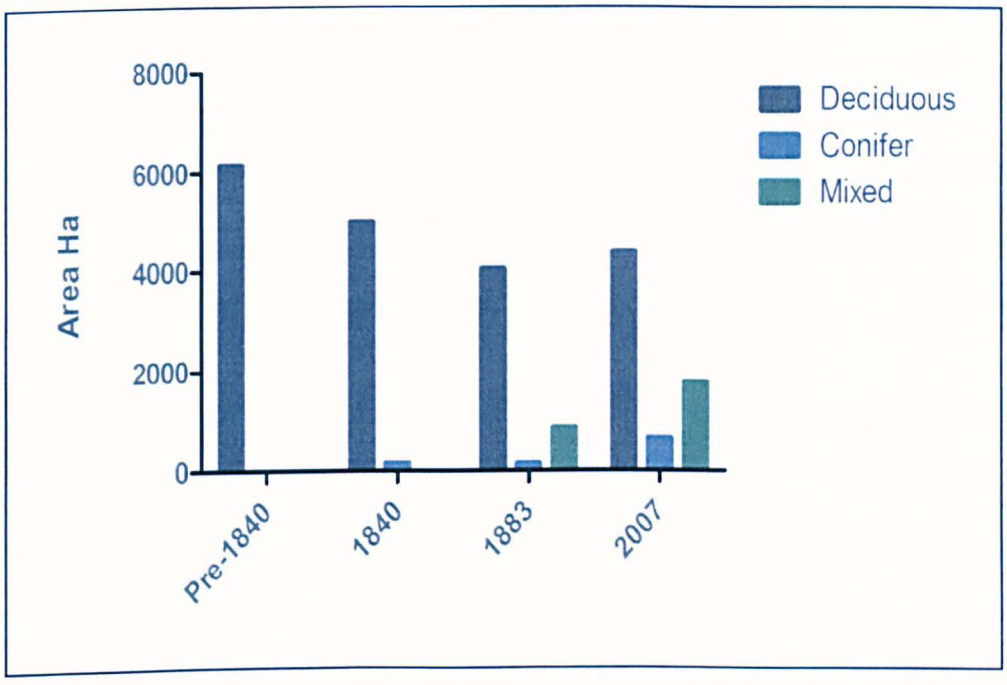

Figure 5.5 Changes in extent of woodland type (ha) between pre-1840 and 2007

Table 5.1 and Figure 5.5 illustrate the overall change in woodland type and area over the past 170 years. Discounting the pre-1840 figures which are hypothetical only, deciduous declined by 19.75 by 1883 but by 2007 recovered to 93% of the 1840 total. A marked change is the increase in mixed woodland which more than doubled between 1883 and 2007. More detail about these changes is shown below in Tables 5.3, 5.4 and 5.5.

Coppice was included within the total figure for deciduous in 1840; however it is useful to demonstrate the changes which occurred to this type of woodland in the study area.

Table 5.2 Changes to Coppice (ha) between 1843 and 1880

	Original Coppice	Remains Coppice	Becomes Deciduous	Becomes Conifer	Becomes Mixed	Cleared
1840-1883	204.97	None	156.38	none	31.41	17.18

Table 5.2 demonstrates that coppice disappeared between 1840 and 1883, the majority being converted to deciduous, with 15.32% becoming mixed woodland and 8.38% being cleared for agricultural land.

Table 5.3 Change to Deciduous (ha) between 1840, 1883 and 2007 from GIS

	Deciduous at start date	Remains Deciduous	Becomes Conifer	Becomes Mixed	Cleared	New Deciduous
1840	5081.76					
1883		4022.2	69.54	660.00	290.64	391.22*
1883	4105.83					
2007		2617.41	285.58	721.45	328.66	1766.46**
2007	4384.31					

* Change from Coppice (199.74); Conifer (55.53); Agricultural or Common (135.95).

** Change from Conifer (63.46); Mixed (429.92); Agricultural or Common (1456.66)

Table 5.3 shows that there was a 20% decrease in deciduous woodland between 1840 and 1883, with 13.2% becoming mixed woodland, 5.7 % cleared and 1.39% replanted with conifers, although part of this loss was balanced by new deciduous.

Between 1883 and 2007, there was a 35.76 decrease in existing deciduous of which 17.7% became mixed, 7.0% conifer and 8.06% was cleared. By 2007, 44.47% of deciduous was either newly planted or developed on ex-commonland.

The increase in mixed and conifer woodland during the earlier time period could be due to the onset of the agricultural depression which led landowners to want a quicker return for their woodland so turning to faster growing conifers and inter-planting them into existing

woodland. Conifers were also in demand for industrial use such as pit props and telegraph poles. In the late 19th century, it reflects the increasing mechanisation of the chair making industry in High Wycombe and the import of timber, and in the 20th century, the widespread felling during the two World Wars, followed by replanting (see Table 5.4 below). Despite this, there was a marked increase in new deciduous planting. However, given that this time period covers 124 years, it is difficult to pinpoint when this took place. Comparisons with the 1883 map showed that 118.26 ha of deciduous had developed on disused ex-common land, whilst in the later 20th century and up to 2007, financial encouragement in the form of grants for landowners to plant woodland has been available.

Table 5.4 (below) indicates that conifers had a low impact on the study area until the late 19th century as described above. The major increase took place during the 20th century; the Forestry Commission was set up post World War I and encouraged the planting of conifers, resulting in their quadrupling in the study area.

Table 5.4 Changes to Conifers (ha) between 1840 and 2007 (From GIS)

	Original Conifer	**Remains Conifer**	**Becomes Deciduous**	**Becomes Mixed**	**Cleared**	**New Conifer**
1840	143.32					
1883		44.76	26.43	76.92	20.35	120.56*
1883	179.23					
2007		39.00	63.46	49.40	27.33	620.92**
2007	665.43					

* Change from Deciduous (69.54), Agriculture (51.02)

** Change from Deciduous (285.58), Mixed (96.84), Agriculture (238.5)

As explained in 4.1.1.1, 1840 Conifers, as used in this research, are a combination of known coniferous woodland (24) and assumed coniferous plantations (75), 92 patches in

all. Table 5.5 shows the area of each as shown by GIS codes both in 1840 and, following changes, in 1883. No 'plantations' were recorded as such from the 1883map; land use codes for deciduous or conifers were used for the eight polygons which appeared to be plantations.

Table 5.5 Areas of 'Conifer' 1840 and after subsequent changes in 1883.

Date	Landuse / change of use	Conifer	Plantation	Total
1840	*'Conifer'*	*56.12*	*87.20*	*143.32*
1883	Remains conifer (identified by map symbol)	14.00 *25.0%*	15.10 *17.3%*	29.10
1883	Becomes deciduous	8.08 *14.4%*	17.58 *20.1%*	25.66
1883	Becomes mixed	36.97 *65.8%*	39.95 *45.8%*	76.92
1883	Cleared	2.36 *4.0%*	17.99 *20.6%*	20.35
	TOTAL	61.41	90.62	152.03

A greater percentage of 1840 conifers or plantations appear in mixed woodland in 1883 than in any other land use change. However, the figures in Table 5.5 above show that the composition of '1840 plantation' remains unclear after analysis of changes by 1883. This uncertainty probably explains the discrepancies in Table 5.3 for deciduous change between 1840 and 1883 in tandem with some GIS inaccuracies when digitising 1840 data.

Table 5.6 shows that mixed woodland in the study area has been more prevalent since 1883 than pure conifer stands. It has more than doubled in area since 1883, with equivalent areas being created on both deciduous and agricultural land. This may be

explained by the use of conifers as nurse crop for deciduous planting; 81% of the change from mixed was to deciduous which would support this explanation.

Table 5.6 Changes to Mixed (ha) between 1883 and 2007 (From GIS).

	Original Mixed	Remains Mixed	Becomes Deciduous	Becomes Conifer	Cleared	New Mixed*
1883	898.25					
2007		277.65	429.92	96.84	97.28	1517.98
2007	1786.55					

Note: No mixed woodland was identified in 1840.

* Change from Deciduous (721.45), from Conifer (49.40), from Agriculture (747.13)

5.4 Analysis and comparison of spatial metrics over time periods

Changes in woodland extent and composition over time are reflected in landscape metric analysis. Table 5.7 provides an analysis of the spatial patterns of woodland and their changes at different time periods using Fragstats.

Table 5.7 Spatial Statistics for woodland types at four dates (Fragstats).

Abbreviations:

NoP - Number of Patches; MPA - Mean Patch Area; SI – Mean Shape; ENNMN - Mean Nearest-Neighbour Distance; MNNSD - Mean Nearest-Neighbour Distance Standard Deviation; IJI - Interspersion and Juxtaposition Index; CON - Connectivity; CONT – Contagion

(at landscape level for each time period).

Data in square brackets and italics is taken from Lee (2000) for comparison.

Date	Land Use	NoP	Area (Ha)	% of wooded landscape	MPA	SI	ENNMN (ENNSD)	IJI	CON	CONT
Pre-1840	Deciduous	420	6108.9	n/a	14.54	1.84	94.80 (121.10)	n/a	28.02	100
TOTAL		**420**	**6108.9**							
1840	Deciduous	386	4912.8	97.17	12.73	1.91	110.35 (132.11)	n/a	27.30	90.43
	Conifer	78	143.24	2.83	1.84	1.76	457.86 (581.48)	n/a	25.07	

TOTAL		**464**	**5056.04**	-	-	-	-	-	-	-
1883	Deciduous	345	4064.36	79.08	11.78	1.91	133.25 (158.07)	94.43	27.90	71.68
	Mixed	132	895.70	17.43	6.17	1.84	330.69 (424.19)	73.07	25.17	
	Conifer	64	179.13	3.48	2.01	1.67	355.23 (406.00)	89.51	20.81	
TOTAL		**541**	**5139.19**	-	-	-	-	-	-	-
2007	Deciduous	2064	4347.48	65.29	2.10	1.76	49.00 (66.45) *[190.11 (264.31)]*	94.95	24.54	59.01
	Mixed	849	1699.79	25.52	2.00	1.79	90.59	68.70	25.04	

							(138.80) *[390.16 (517.7)]*			
	Conifer	457	610.82	9.17	1.33	1.63	177.16 (228.83) *[610.91 (1025.68)]*	85.21	26.60	
TOTAL		**3370**	**6658.09**							

NOTE. In all subsequent tables of results, there are discrepancies in figures for area between those taken from GIS and those from FRAGSTATS due to the different formats of data, ie vector and raster. The source of the data is shown for each table.

5.5 Analysis of total landscape in the study area

The land use map of the study area shown in Figure 5.6 below is a composite of the woodland from Master Map (2007) and the Chilterns Natural Areas Land-use map (CHLU) (2000) which used 1991 data for the study area. Although likely to contain inaccuracies due to both the original data and the process of compiling the map, it nevertheless demonstrates the variety of land use types in the study area. The large amount of arable land is a traditional feature in the Chilterns (Roden, 1965). Notice the golf courses present in the area, some of which were created on ex-commonland. This data was also analysed in Fragstats (Table 5.8 below)

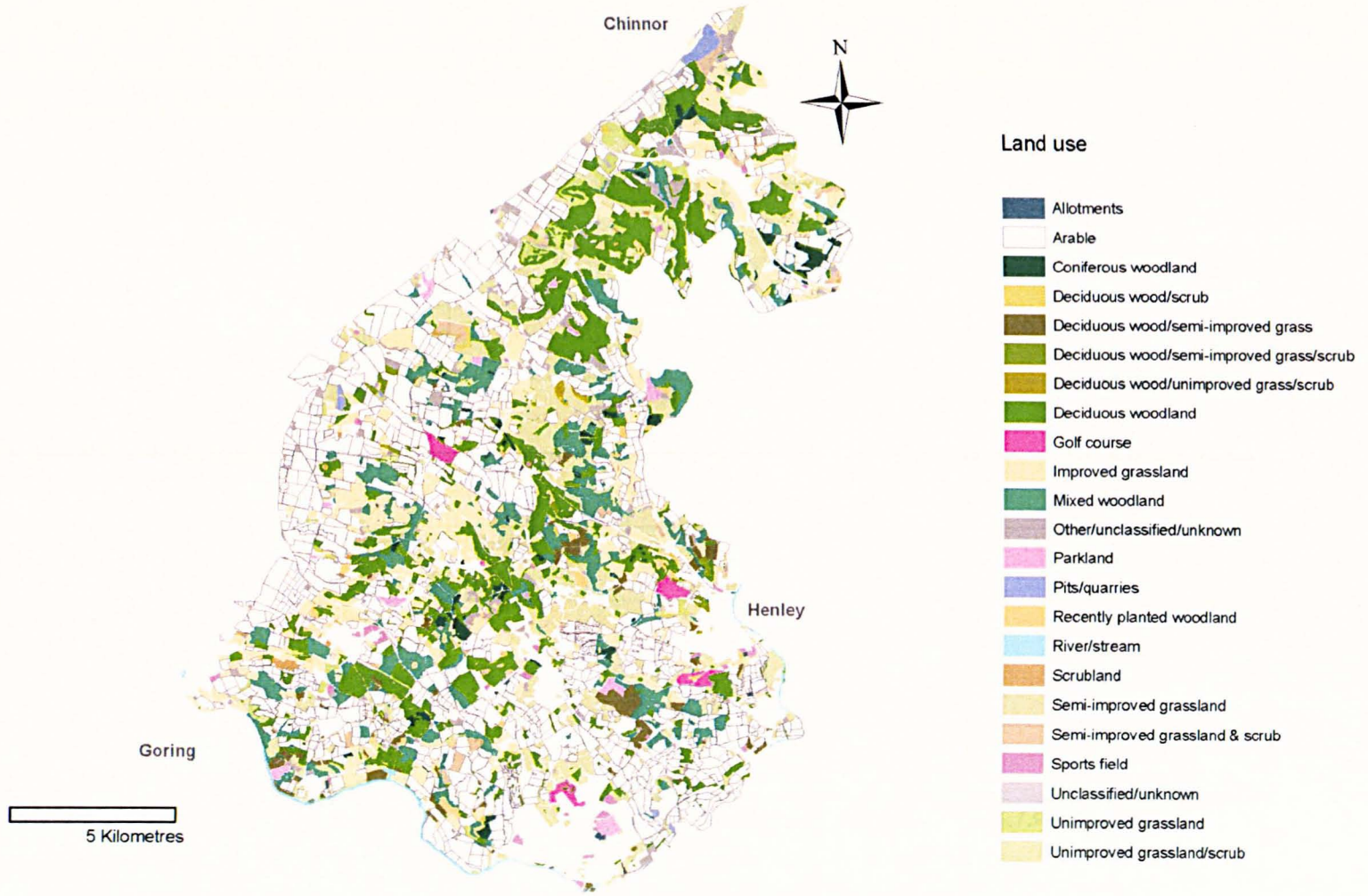

Figure 5.6 Complete landscape of Oxfordshire Chilterns

Table 5.8 Spatial Metrics for total landscape of study area (Fragstats)

Abbreviations:

NoP - Number of Patches; MPA - Mean Patch Area; SI - Mean Shape; ENNMN - Mean Nearest-Neighbour Distance; IJI - Interspersion and Juxtaposition Index; CON - Connectivity.

Land Use	NoP	Area (ha)	% of landscape	MPA	SI	ENNMN	IJI	CON
Woodland								
Deciduous	819	4259.25	17.9	4.69	1.92	78.97	74.26	25.57
Mixed	438	1755.9	7.38	3.43	1.79	116.93	69.18	25.39
Conifer	222	585.6	2.46	2.49	1.66	233.45	67.31	27.75
TOTAL woodland		**6600.03**	**27.74**					
Grassland/Scrub								
Common (one area)	38	12.61	0.05	0.33	1.25	13.39	28.73	100.0

Parkland	40	146.91	0.62	3.67	1.37	421.55	67.33	37.43
Scrubland	102	48.65	0.20	0.47	1.43	271.32	73.62	26.30
Unimproved grassland	168	245.84	1.03	1.46	1.49	151.48	67.51	42.38
Unimproved grass/scrub	53	18.33	0.07	0.34	1.52	163.17	45.12	55.15
Semi-improved grass/scrub	87	145.61	0.61	1.67	1.45	197.46	75.61	21.41
Farmland/Other								
Semi-improved grass	640	3362.25	14.14	5.25	1.56	90.76	73.46	26.30
Improved grassland	236	2198.90	9.24	9.31	1.57	151.48	68.36	26.66
Arable	625	9524.97	40.06	15.24	1.52	38.18	72.45	22.16
Allotments	14	38.83	0.16	2.77	1.53	2015.3	63.48	12.08

Golf courses	27	150.40	0.63	5.57	1.53	175.55	34.98	47.57
Pits, rivers, streams	49	240.97	1.01	4.91	2.13	156.07	57.83	22.95
Unclassified[1]	11	16.97	0.07	1.54	1.45	2703.13	58.88	50.90
Unknown[2]	709	834.10	3.50	1.17	1.73	109.12	65.04	22.20

1. Unclassified: data from CHLU map;

2. Unknown: includes land uses likely to have changed since 1991 e.g. headlands, field margins; unidentified areas created during GIS appending process.

The data shown in Table 5.8 can be compared both with that of Lee (2000) and with figures from the Chilterns Management Plan (2008).

Table 5.8 shows that the percentage total (i.e. Deciduous; Mixed; Conifer) of woodland area in the study area is 27.74% compared to approximately 21% for the Chilterns AONB as a whole (Chilterns Management Plan, 2008) although there may be some discrepancies due to the nature of the data used here. The percentage of woodland types in the landscape is higher in the study area than in the Chilterns as a whole. A comparison with Lee (2000) shows the percentage of deciduous was 13.32% in the Chilterns AONB compared with 17.9% in the study area, mixed was 4.02% compared to 7.38%, and conifer was 1.72% compared to 2.46%. These figures indicate the greater density of woodland in the study area. As before, woodland data is skewed for MPA and ENNMN due to the complexity of MasterMap data; data from Lee (2000) in comparison shows MPA to be about double for deciduous and conifer and three times larger for mixed than shown in here. Woodland has a higher shape complexity in comparison to other land use types, although there are also complex field shapes.

Arable land is the main land use type, with the greatest percentage area and closest nearest neighbour, reflecting the figure of approximately 60% for the Chilterns as a whole (Chilterns Management Plan, 2008). Connectance and interspersion of most land use types is fairly similar to Lee (2000), showing the mosaic landscape typical of the Chilterns.

The large area of 'unknown' land use noted in Table 5.8 has two causes. One is the format of woodland data in MasterMap as described previously, which when appended with CHLU results in small areas of unidentifiable land. The other source is land such as field margins and headlands which have changed since the CHLU map was created. The 'unclassified' land is data from the original CHLU map.

Figure 5.7 illustrates woodland types in the study area landscape; woodland is generally clustered along the length of the study area and the more open land to the south-east slopes towards the Thames, while that to the west is lying below the escarpment.

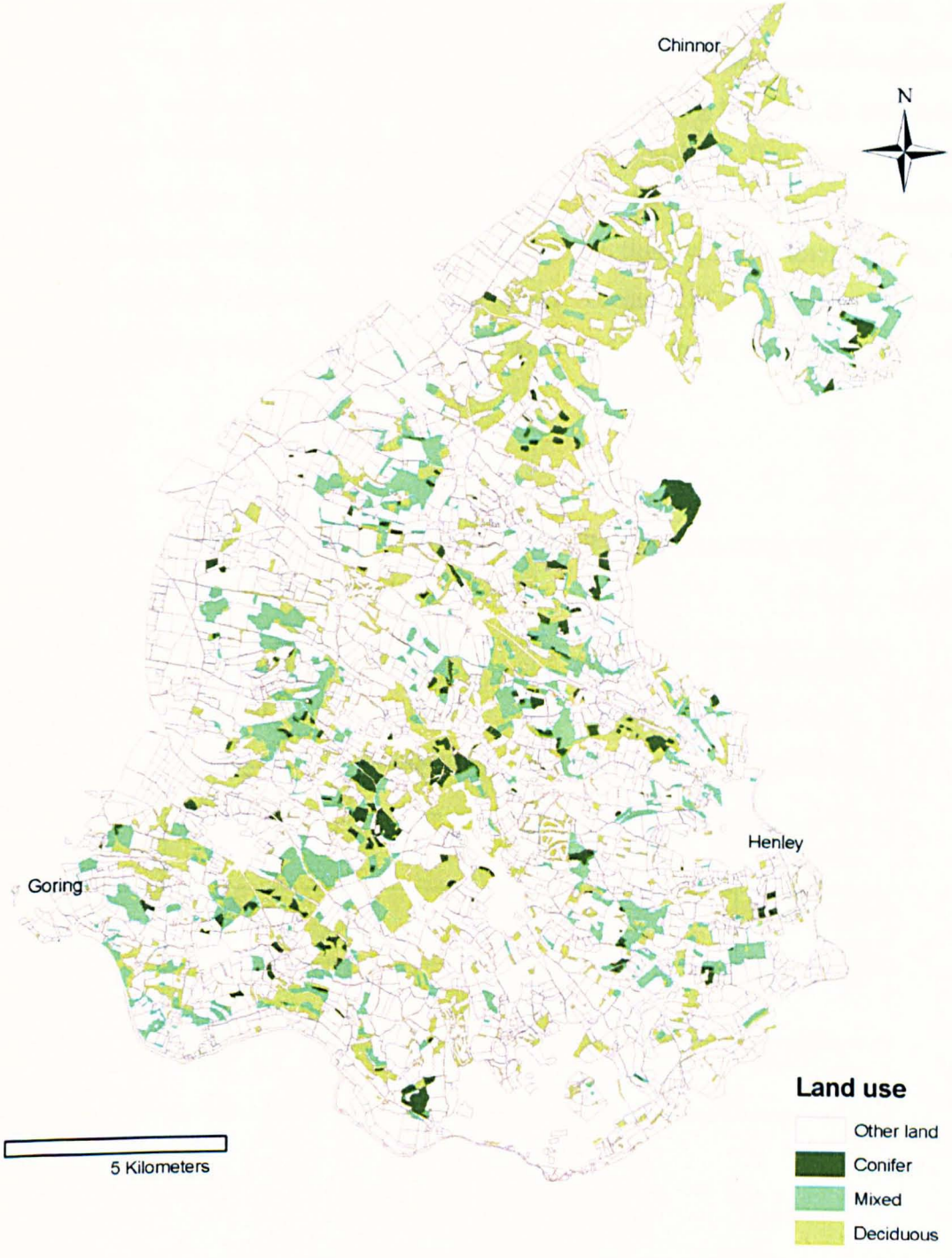

Figure 5.7 Woodland types in complete landscape of Oxfordshire Chilterns

5.5.1 Extrapolation of woodland extent in historic landscape

Areas and percentage of woodland in the total landscape in the study area were used to extrapolate the percentage of woodland in the total study area landscape for 1883, 1840 and pre-Tithe. The total landscape data shown in Table 5.8 above has some discrepancies in area totals for woodland types, due to the method of compiling the map, in comparison to those shown for woodland analysis (Table 5.7), although in fact there was little difference between them. As the latter figures are likely to be more accurate for woodland percentage woodland cover, these were used in conjunction with the total area for the landscape to calculate percentage woodland cover; because of the refinements made during the creation of CHLU this approach was felt to be more consistent with other results.

Table 5.9 Extrapolated percentage of the total landscape in the study area of woodland types at four dates (Fragstats)

	Deciduous % total landscape	**Mixed % total landscape**	**Conifer % total landscape**	**All wood % total landscape**
Pre-1840	25.69%	_	_	25.69
1840	20.24	*	0.61	21.86
1883	17.1	3.61	0.61	21.32
2007	18.29	7.15	2.57	28.01

*Mixed was not recorded in 1840

The figures shown in Table 5.9 above reflect changes in composition of woodland in the study area since 1840 (and an indication of that at a hypothetical earlier date). It corresponds to the data in Table 5.1 and reflects the changes in woodland composition and the fluctuations in area since 1840. The overall picture of change was caused by external

influences; first the agricultural boom drawing to an end by 1883, as reflected in the increased planting of conifers in existing woodland; and secondly the increase in conifers both in plantations and in mixed woodland, some resulting from the aftermath of the Second World War and also for economic reasons in the 20th century. The slight increase in deciduous is likely to relate to natural regeneration of woodland on areas of ex-common land in the 19th century and to recent planting funded by grant schemes.

5.6 Future Scenarios

5.6.1 Woodland Restoration

Shapefiles for future scenarios were created to demonstrate possible combinations of woodland restoration and the resulting increase in native deciduous woodland. Spatial metrics were applied to these scenarios to ascertain how effective these changes would be in improving the ecological function of the woodland.

Table 5.10 Spatial statistics for Woodland Restoration (Fragstats)

Land Use	NoP	Total Area (Ha)	MPA	S I	ENNMN	CON
Original Deciduous	2232	4383.31	1.96	1.77	45.39	24.80
Decid + CDP	2207	4631.41	2.10	1.77	44.74	24.67
Decid + Mixed	2109	6074.27	2.88	1.83	41.66	24.37
Decid + Conifer	2273	4989.20	2.19	1.77	45.44	24.51
Decid + allPAWS	2147	5386.40	2.5	1.76	45.56	24.68
Decid + MPAWS	2194	4889.11	2.22	1.78	44.83	24.92
Decid + CPAWS	2211	4693.58	2.12	1.77	45.04	24.71

Original ASNW	225	2622.51	11.95	1.95	168.17	25.89
ASNW + MPAWS	268	3128.01	11.67	1.89	140.31	25.13
ASNW + CPAWS	253	2932.82	11.59	1.92	152.55	25.43

NoP - Number of Patches; MPA - Mean Patch Area; SI – Shape Index; ENNMN - Mean Nearest-Neighbour Distance; CON - Connectivity.

Table 5.10 demonstrates that in restoration scenarios, the best combinations with increased area, larger mean area of patches, closest near neighbour are clearly those with either restored mixed woodland or mixed PAWS in combination with either deciduous woodland or ASNW. Connectivity remains very similar across all combinations, again reflecting the mosaic landscape of the study area.

Figure 5.8 below illustrates the location and extent of existing deciduous in relation to mixed which could potentially be restored to deciduous.

Figure 5.9 below illustrates the location and extent of existing deciduous in relation to mixed and conifer PAWS which could potentially be restored to deciduous.

Figure 5.8 Deciduous with mixed woodland for restoration to deciduous

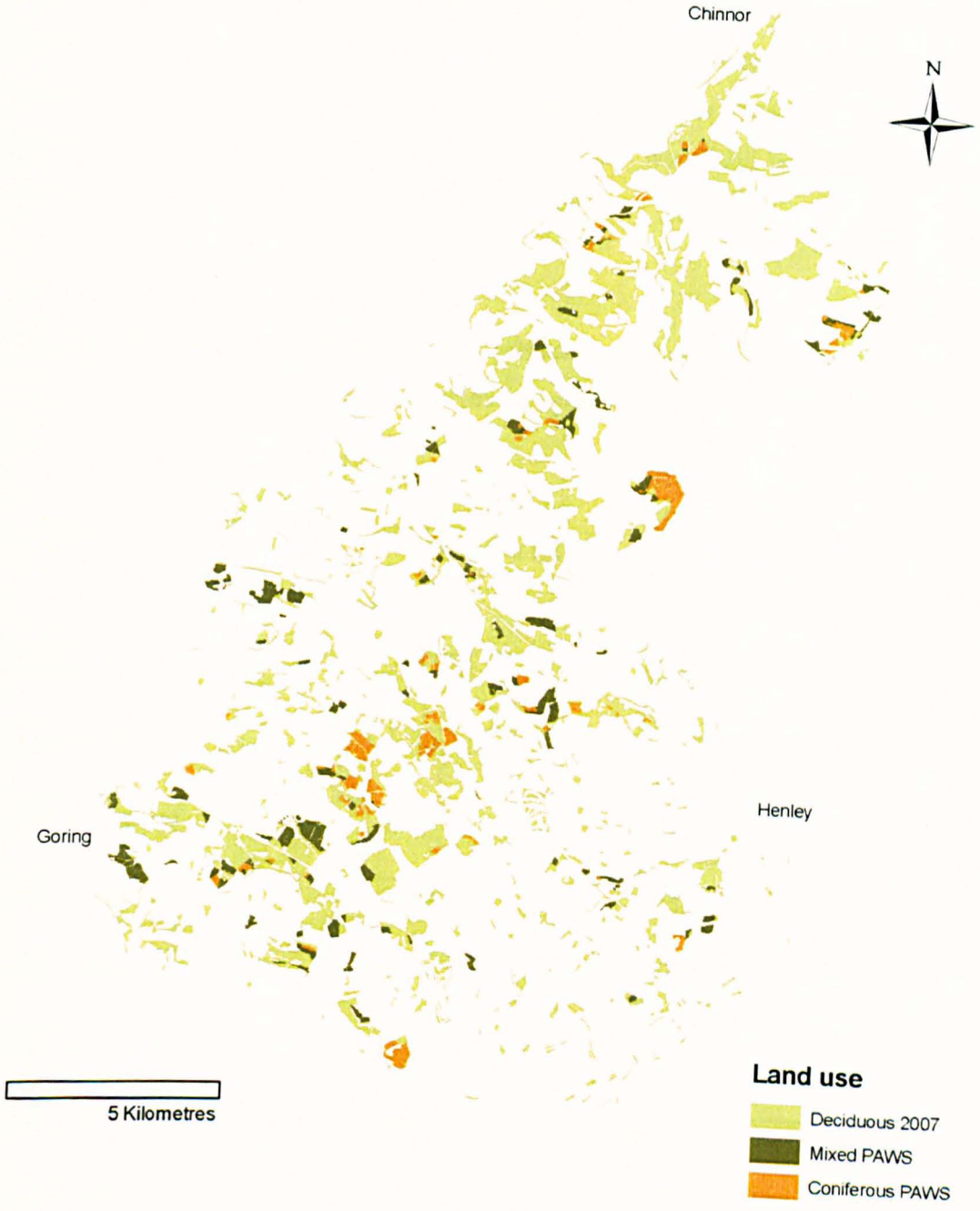

Figure 5.9 Deciduous with PAWS for restoration to deciduous

Table 5.11 below shows how the restoration of non-native woodland to native deciduous woodland would increase deciduous woodland extent. The percentage of woodland in the landscape approaches the 30% level suggested by Peterken (2000) as the desirable figure to achieve throughout the country to provide a woodland network. However, the complete landscape (Figure 5.6 above) shows that the woodland is concentrated along the length of the study area with areas alongside which are mainly arable or grassland. Therefore taking these specific wooded areas only the percentage of the woodland in the landscape would be greater than the maximum of 28.65% shown above.

Table 5.11 Percentage of Deciduous Woodland in the landscape following Future Restoration Scenarios (Fragstats).

Land Use	Total Area (Ha)	Woodland % in total landscape
Original Deciduous	4383.31	18.42
Decid + CDP	4631.41	19.46
Decid + Conifer	4989.20	20.09
Decid + Mixed	6074.27	25.53
Decid + Mixed + Conifer	6818.14	28.65
Decid + CPAWS	4693.58	19.72
Decid + MPAWS	4889.11	20.54
Decid + allPAWS	5386.40	22.64

5.6.2 *Deciduous Woodland Creation*

Sites for potential woodland creation were based on ex-woodland sites (deciduous) which date from pre-1840 to 2007. An ex-woodland shape file was created, composed of ex-woodland identified from map comparisons, data manipulations between time periods (see 4.2.1.1) and of wood related field names, identified from Tithe Apportionments (see 4.1.1.1). Appendix 4 provides details of deciduous clearance between 1840 and 1883, listed by parish. Table 5.12 below shows the origin of ex-woodland data and Table 5.13 shows the proportion of each source data.

Table 5.12 Sources of data for ex-woodland used in woodland creation scenarios.

Source	Number of polygons	Attribute code
Field Names (pre-1840) from tithe apportionments*	219	500
Ex-wood indentified from 1883 map*	144	110
Wood (ex-1840 and ex-1883)	83	100
Beech (ex-1840)	10	101
Underwood/coppice (ex-1840)	10	102
Wooded common (ex-1840)	10	201
Wooded ex-common (ex-1840)	1	203
Total	**476**	–

*Source not created through data manipulation.

Table 5.13 Areas of ex-woodland from map data, GIS manipulation and field names

Source	Number of polygons	Area (ha)
Map data and GIS manipulation	257	456.38
Field names	219	1043.28
Total	**476**	**1499.66**

Figure 5.10 below shows all identified ex-woodland (blue) in relation to 2007deciduous, showing that ex-woodland sites are generally small in size, with the least density in the northern part of the study area.

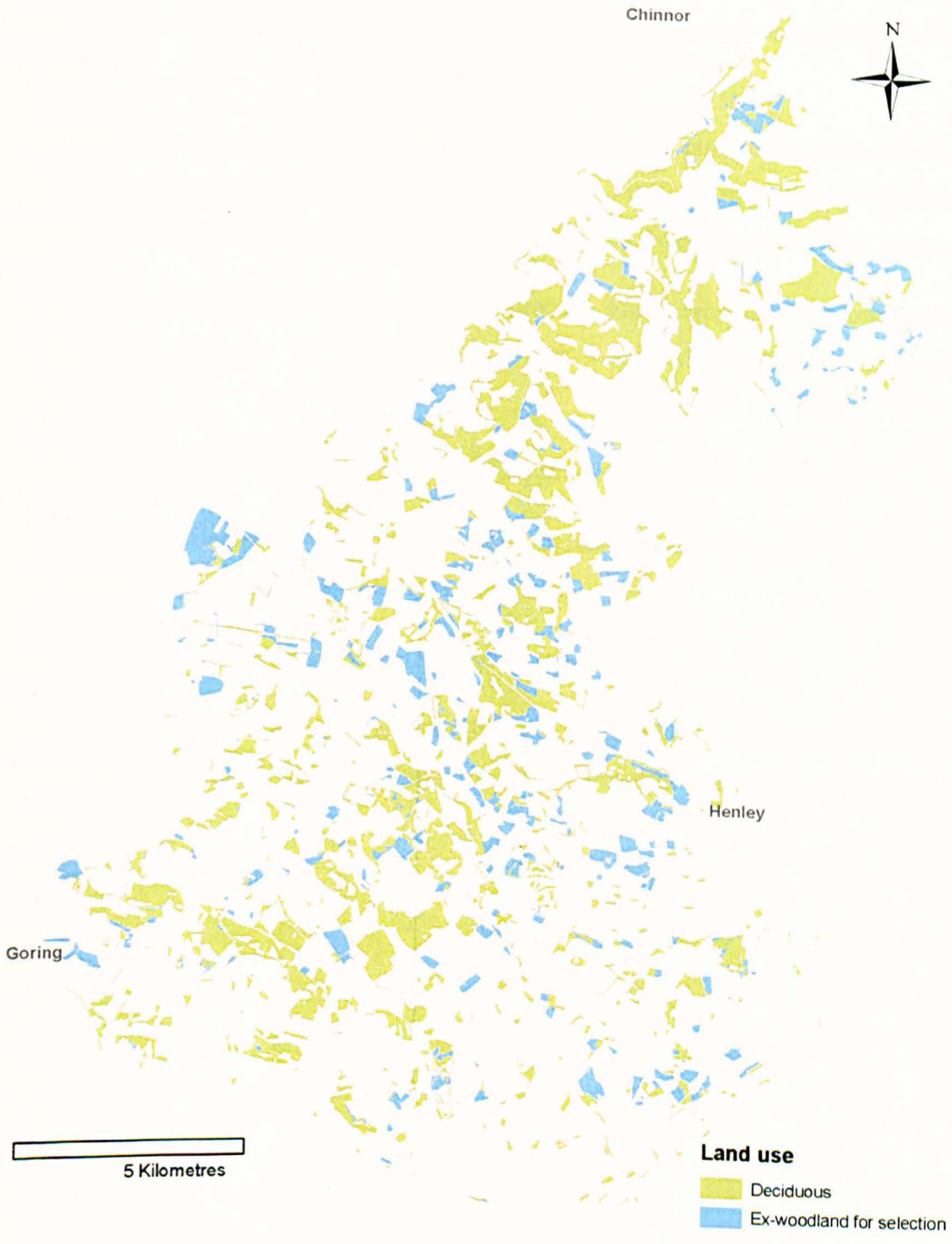

Figure 5.10 Deciduous and ex-woodland for selection for deciduous creation

In GIS, ex-woodland polygons were selected at 1.0m range (directly adjacent to the target deciduous polygons) and at 200m to increase the possibility of creating larger woodland patches by linking more patches together. This process was repeated using ASNW as the target shapefile.

The MasterMap deciduous shapefile was refined to exclude any polygons less than 0.5 ha in order to eliminate any slivers which could have affected the outcome. Post-selection any unsuitable selected polygons were removed e.g. if separated from target polygons by roads.

Ten versions of this scenario resulted from this process. Four scenarios are shown in map form below and illustrate the varying areas of ex-woodland selected in the various scenarios.

Figure 5.11 shows selected ex-wood at 1.0m (blue) in relation to 2007 deciduous.

Figure 5.12 shows selected ex-wood at 1.0m (blue) in relation to deciduous, composed of 2007 deciduous and restored conifer and mixed PAWS.

Figure 5.13 shows selected ex-wood at 1.0m (blue) in relation to ASNW.

Figure 5.14 shows selected ex-wood at 1.0m (blue) in relation to all possible restored deciduous; this is composed of 2007 deciduous and 2007 conifer and mixed, converted to deciduous.

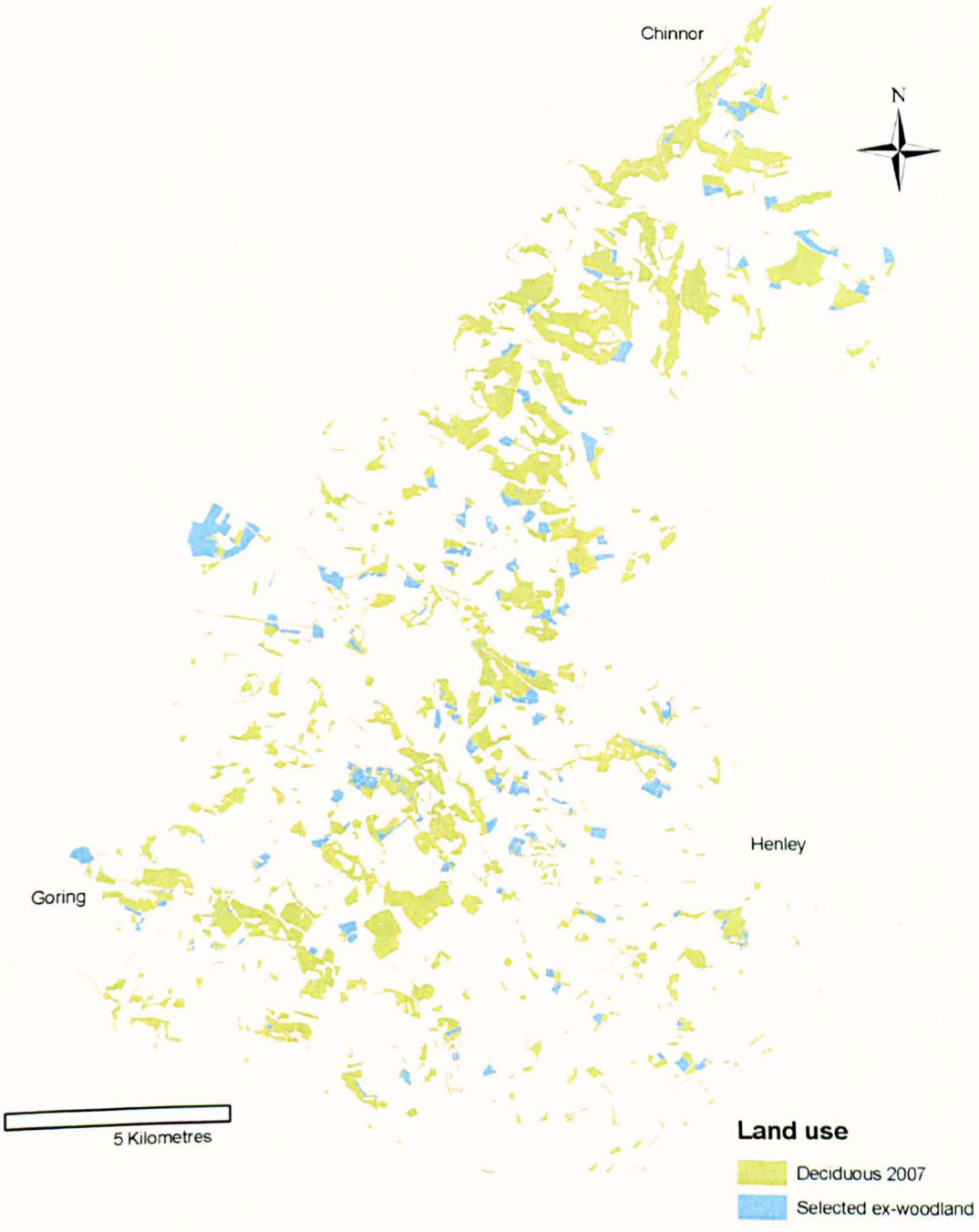

Figure 5.11 Deciduous with ex-wood selected at 1.0m for deciduous creation

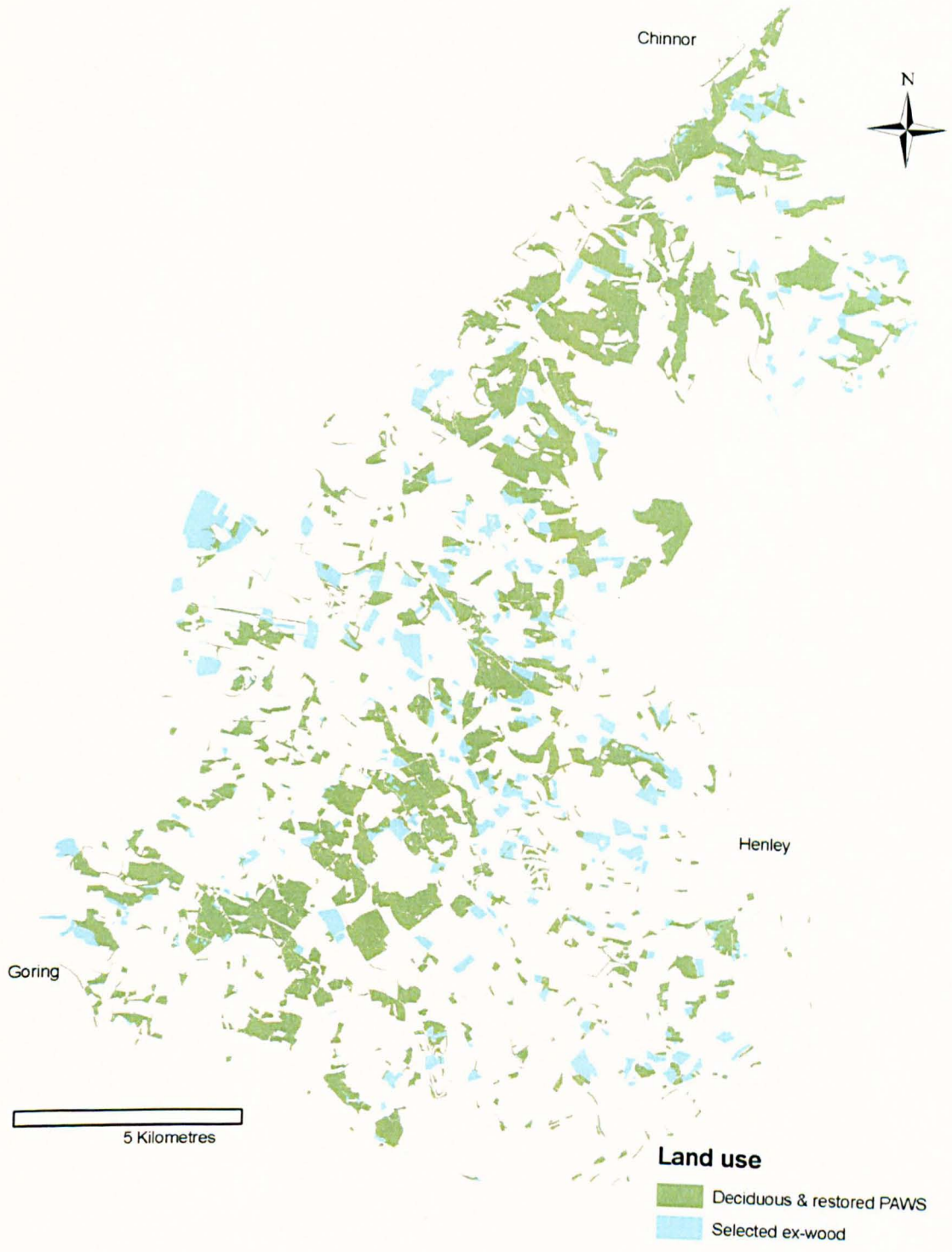

Figure 5. 12 Deciduous and restored PAWS with selected ex-wood at 1.0m for deciduous creation

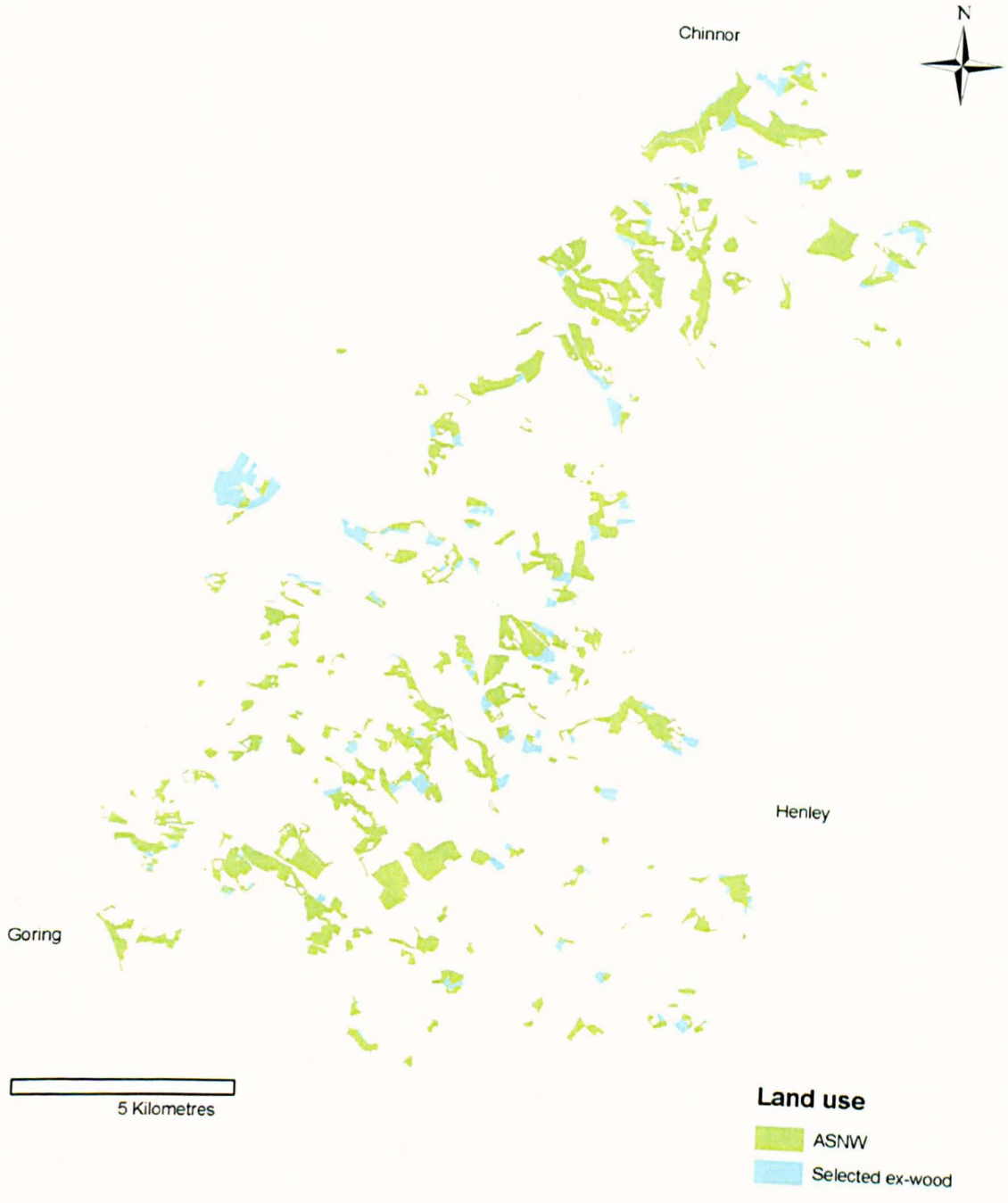

Figure 5.13 Ancient woodland with selected ex-wood at 1.0m for deciduous creation

Figure 5.14 All restored deciduous with selected ex-wood at 1.0m for deciduous creation

In each case, following selection, a new shapefile of the resulting selected ex-wood was created and appended to the original target shapefile for all combinations of range and type. Spatial statistics were then used to investigate the best woodland creation scenario for both deciduous woodland and ASNW. Results are shown in Table 5.14 below.

Table 5.14 Spatial statistics for four woodland creation scenarios on selected ex-woodland (Fragstats)

Wood combination created	**NoP**	**Area ha**	**MPA ha**	**SI**	**ENNMN (m)**	**CON**
Original Deciduous	2064	4347.48	2.10	1.76	49.00	24.54
+ 1.0m SEL ex-wood	818	4665.09	5.70	1.82	59.23	25.65
+ 200m SEL ex-wood	920	5232.70	5.68	1.80	52.53	25.30
Original Deciduous and all PAWS	2147	5386.40	2.5	1.76	45.56	24.68
+ 1.0m SEL ex-wood	798	5652.86	7.08	1.81	58.0	25.25
+ 200m SEL ex-wood	888	6243.35	7.03	1.81	52.96	25.44
Original ASNW	225	2622.51	11.95	1.95	168.17	25.89
+ ex-wood at 1.0m	247	3103.21	12.56	1.89	129.87	27.49
+ ex-wood at 200m	404	3547.23	8.78	1.74	68.67	25.44
All restored woodland	923	6194.30	6.71	1.91	51.44	24.28
All restored woodland *+ ex-wood at 1.00m*	1179	7185.46	6.09	1.93	47.56	23.96

NoP - Number of Patches; MPA - Mean Patch Area; SI – Shape Index;
ENNMN - Mean Nearest-Neighbour Distance; CON - Connectivity.

Table 5.14 shows that, in woodland creation scenarios, the new deciduous scenario at 1.00m range shows the best increase in mean patch area, shape complexity and connectivity. The 200m selection has a higher total area, number of patches and nearest neighbour distance. However the latter is to be expected as the selected polygons are close to the existing woodland, but not linked. The same pattern is repeated for the second scenario, deciduous and all PAWS, showing a greater improvement in patch size and connectivity at 1.00m range, although the shape complexity is the same at both ranges. For both these deciduous scenarios, nearest neighbour distance ENN is also affected by the format of the Master Map data as described earlier.

The ASNW scenarios are not affected by Master Map data, therefore are more likely to display the clearest results. Again the 1.00m selection shows largest mean area and connectivity. Patch number, total area, and nearest neighbour distance are highest at 200m range. Patch complexity reduces from the original ASNW through the range size, being least at 200.0m. It is likely that ASNW is complex in shape as it is least likely to have been altered in shape over time; the addition of ex-woodland patches appears to have the effect of reducing this complexity slightly because they are more regular in shape. However, ASNW and ex-wood at the 1.00m range show the most complex shape for any of the creation scenarios, probably because the selected shapes are 'infilling' woodland lost at some point earlier, so returning these areas to an earlier shape.

In the final combined scenario, all non-native woodland was first converted to deciduous then combined with ex-woodland selected at 1.00m range. This produced the greatest total area but fewer patches than original deciduous, thus indicating that patches are larger in the combination scenario. The shape is more complex as the figure for ASNW creation.

Table 5.15 below shows the potential increase in the percentage of woodland in the total landscape of the study area, using the range of different combinations for deciduous woodland creation.

Table 5.15 Extrapolated percentage of deciduous woodland in the landscape in future creation scenarios (Fragstats)

Wood combination created	**Area ha**	**Woodland % in total landscape***
Original Deciduous	4347.48	18.27
+ 1.0m SEL ex-wood	4665.09	19.6
+ 200m SEL ex-wood	5232.70	22.0
Original Deciduous + all PAWS	5386.40	22.63
+ 1.0m SEL ex-wood	5652.86	23.37
+ 200m SEL ex-wood	6243.35	26.23
Original ASNW	2622.51	11.02
+ 1.00 m SEL ex-wood	3103.21	13.04
+ 200m SEL ex-wood	3547.23	15.0
All restored woodland	6194.30	27.98
All restored woodland ***+ 1.00 m SEL ex-wood***	7550.57	31.73

*Percentage Landscape was extrapolated from Total landscape figures (see 5.6).

Table 5.15 shows that, in order to reach a woodland cover of more than 30%, to ensure a woodland habitat network, it would be necessary to convert all existing non-native woodland to deciduous and, in addition, create new woodland on selected ex-woodland at 1.0m range. The study area is the most wooded part of the Chilterns therefore for this target to be reached throughout the Chilterns, an even larger restoration and creation programme would be necessary.

5.7 SUMMARY

This chapter reports and illustrates the results obtained from the processes described previously. These provide detail of historical woodland change and demonstrate the potential ecological benefits of future scenarios. The findings are discussed in more detail in Chapter 6.

- A series of digitised maps illustrate the wooded landscape at three dates and the extent of wood-related field names in relation to deciduous in 1840. They also illustrated future restoration and creation scenarios.
- GIS analysis of woodland extent and composition at three dates and pre-1840 shows a reduction in deciduous until 2007 when there was a slight increase, with a corresponding increase in mixed and to a lesser extent in conifer. Coppice woodland was not identified post-1840. The composition of plantations recorded in 1840 was unclear.
- The analysis of spatial metrics over time confirms and quantifies the effects of changes in extent and composition identified in GIS.
- Map and data analysis of the total landscape shows its mosaic nature and the setting of woodland mainly on higher ground and amongst other land uses, arable being predominant. These data are extrapolated to provide percentage figures for woodland within the landscape at past dates.
- FRAGSTATS analysis shows that restoration of mixed or mixed PAWS results in the greatest improved deciduous area and closest near neighbour distance.
- Woodland creation targeted at 1.0m to existing deciduous results in best increase in patch size, complexity and connectivity compared to that targeted at 200m. ASNW scenarios show the same result except that complexity is reduced, although still higher than other types.
- To reach woodland cover of more than 30%, conversion of all non-native woodland and woodland creation targeted at 1.0m would be necessary in the study area, but more elsewhere in the Chilterns.

CHAPTER 6

Discussion

6.1 Introduction

In the previous chapter, the results of the GIS analysis of historical map data were reported. The analysis demonstrated changes to woodland composition and extent since 1840 which can be related to the impact of external influences on Chiltern woodland. For future scenarios, information gained from both historical map data and GIS analysis provided the basis for selection of ex-woodland sites for future woodland creation. Combinations of potential deciduous creation and restoration were investigated to ascertain the best result for the future in relation to landscape metrics, BAP targets and the Chilterns mosaic pattern of woodland. Analysis of woodland spatial statistics provided additional information for comparison of the past woodland pattern with that of the present and future.

The results are now discussed in relation to the historical background of Chiltern woodland; future scenarios based on these historical findings; the national policies for woodland at different times; and the data used.

6.2 Results of historic map analysis

6.2.1 Changes in woodland extent over time

There has been an assumption that deciduous woodland loss has been widespread across the whole of England in recent times. This research set out to ascertain whether this scenario was true of the Chilterns and investigated woodland extent and composition at three time periods to discover where and how change occurred. Documentary evidence

provided detail on management and utilization of woodland over a longer time period than that of extent and composition.

The extent of different woodland types at 1840, 1883 and 2007 found by this research demonstrate that the overall pattern and extent of woodland in the study area changed over a period of 167 years, as reported in Section 5.3, Table 5.1. Between 1840 and 1883 the percentage fall in total woodland area was only 4.6%, a figure that is markedly different to that of other parts of England over the same time period. According to Rackham (2006), there was a general loss of woodland in the 1860's and 1870's related to changing industrial needs. This period was also a time of high agricultural prosperity, so-called High Farming, when agricultural land was worth more than low priced wood or timber, which encouraged woodland clearance. However, in the Chilterns, especially in the study area, this effect was not so apparent, as shown by the results obtained by this study. Due to the success of the chair making industry in the High Wycombe area (Section 3.12.2), woodland was still valuable in the 19th century, so there was not widespread clearance as occurred elsewhere.

The total area of woodland in 1840 and 1883 was very similar but there was a marked increase by 2007, although the composition is different. The area of mixed woodland in 2007 is double that of 1883. Conifer woodland increased slightly between 1840 and 1883 but substantially so by 2007. Nationally, woodland extent was at its lowest in the early 20th century post-First World War, but has increased since then (UK Indicators of Sustainable Forestry). In this research, the lowest extent was in 1883; no data was available from the early 1900's for use in this research. However national changes in emphasis from conifer to deciduous planting during the latter part of this period (UK Indicators of Sustainable Forestry) is reflected in the findings of this research, which shows a similar increase in deciduous by 2007, although the high point of conifer density is not apparent again due to the long period between the data used.

6.2.1.1 Change in extent between 1840 and 1883 identified by GIS

Apart from changes in composition (see 6.2.2 below) analysis shows that, between 1840 and 1883, there was 135.95 ha of new deciduous on previously un-wooded sites. 51.27 ha were situated on previous commons which had been enclosed between 1835 and 1862. The

remainder was often situated alongside existing woodland, sometimes to fill a gap, create a shaw or on previously wooded sites such as Little Chalk Wood, which in 1840 was a field named Upper Grubbed Wood.

However, woodland clearance also took place in the study area at this time. In 29 parishes a total of 291.54 ha were cleared; only two parishes had no clearance (see Appendix 4). Three parishes had obvious larger areas of clearance than the others. Stokenchurch had the greatest area of woodland clearance (91.36 ha). Lewknor Uphill, a parish in three parts all adjoining Stokenchurch, lost 26.97 ha of woodland. Stokenchurch was a major centre for chair making so it is likely the timber was used there, but it is unusual for such a large amount of clearance to take place at that time in the study area. Some cleared areas are on fairly level ground, the rest is on steep slopes and two are now wooded again. There is no obvious reason why so much woodland was cleared in this particular area but its loss may coincide with the Parliamentary Enclosure of Stokenchurch Common in 1862, therefore it could be linked to this process and the general sense of change amongst the larger land owners. Watlington (25.25 ha) was the other exception where the major clearance was Lambourn Wood (20.88 ha) which by 1883 was shown as open ground with scattered trees; it is now wooded again. In most other parishes, clearance was very small scale usually affecting small areas less than a hectare in size.

None of the coppice recorded in 1840 was apparent in 1883, although small remnants have remained on some areas of commonland. GIS analysis showed that by 1883 it was either deciduous, i.e. allowed to become high forest through conversion, or mixed, having been inter-planted with conifers. Only 17.18 ha (8.38%) had been cleared in the study area. Outside the study area in south Buckinghamshire, an area of beech coppice on previous commonland at Low Scrubbs still exists, although it is now over grown and is undergoing gradual restoration. It is thought to have been used by local people for fuel during the Second World War and in the 1970's and 1980's during the miner's strikes. Nationally most coppice-with-standards gradually declined during the 20th century, the last actively managed remaining in Kent and Sussex until the 1960's (Fuller and Warren, 1993).

Pre-1840

The Pre-1840 woodland extent is based on names of fields created from cleared woodland as identified in Tithe Apportionments and combined with 1840 deciduous. These field names probably date mainly from the two main periods of clearance i.e. the Middle Ages

and the 18th century (see Section 4.1.1.1). Although their use in this context is completely hypothetical, nevertheless these names indicate the extent of earlier woodland. A detailed study of parish or estate papers would be helpful to follow the course of clearance, regeneration and planting over an extended time period but this was outside the scope of this research.

The GIS shows that the figure for Pre-1840 woodland extent is 61.46% greater in area compared with the 2007 deciduous coverage, but is 11.2% less than the current total woodland area. Although landscape metrics are shown for Pre-1840 (Table 5.7) they cannot be accurately compared to other dates as the data in this shapefile is hypothetical. Nevertheless, they indicate a greater area of woodland, with a larger mean patch size and a lesser degree of fragmentation in comparison to the later periods. Shape metrics show patches to be slightly more regular than in 1840, by which date more clearance had taken place. This may either demonstrate the effect of small-scale clearances, for example taking out a corner of woodland so resulting in more irregularly shaped woodland patches, or that cleared fields (upon which this data is based) have more regular shapes than the remaining woodland, but are less regular than Parliamentary Enclosure fields. In Lee (2000) arable fields were found to be irregular in shape and remarked upon as being unexpected. However, given the history of piecemeal clearance in the Chilterns, this should not be surprising and thus demonstrates the usefulness of an understanding of land use history in ecological studies.

6.2.1.2. Change in extent between 1883 and 2007 identified by GIS

Nationally there has been an increase in woodland over the past 25 years, mainly in the form of small deciduous areas planted on farmland, rather than the expansion of commercial forestry. These have doubled in number since the 1980's, funded by subsidies and grants described in 2.4.1.3, in fact there has been more new woodland than new housing created on previous agricultural land (Bibby, 2009).

In the study area, between 1883 and 2007, deciduous increased by 7.6%, although this was still 12.2% less than in 1840 (Table 5.1). This increase is partly due to the gradual change of disused common land to woodland. However the land cover of commons were not always recorded on tithe documents (e.g. whether wooded or not) and varied from parish to

parish, therefore it is not always clear what the starting point was for change. In the study area, enclosure took place mainly in the 1850's and 60's (see Appendix 1B), so by the time the 1883 maps were surveyed, resulting changes in land use to agriculture had probably taken place. The change of unenclosed commons into woodland occurred over several decades well into the 20th century so not all were apparent as woodland in 1883.

However, these changes appear to have been quite varied and were identified in this research by a comparison of historic and modern maps. For example in Chinnor, common rights on the escarpment were extinguished in 1854 but no physical enclosure took place (Lobel, 1964). By 1883, part of the previously open common was deciduous and another area conifer but by 2007 the majority of the old common was deciduous. In Checkendon, White Wood Heath, previously open, was enclosed in 1864 (Appendix 1B), in 1883 was scrub and is now mixed woodland. Kingwood Common in Rotherfield Peppard was not enclosed and was still open in 1883 but is now deciduous as its use by local people declined. By contrast, although not enclosed in the 19th century, part of Nuffield Common became a golf course in 1901 and remains so; the un-mown areas still exhibit heath land vegetation (personal observation).

6.2.2 Changes in woodland composition identified by GIS analysis

Rather than woodland loss, this research found that the major change in the study area over 160 years was in woodland composition, with a general reduction in deciduous and increase in mixed and conifer.

When changes to deciduous were examined, it was clear that deciduous woodland declined in area between 1840 and 1883, not only due to clearance (5%) but primarily because of its conversion (18.3%) to either mixed woodland by inter-planting with conifers or into conifer plantations (see below). Between 1883 and 2007, deciduous increased by 7.6%, although was still 12.2% less than in 1840 (see 5.3).

Conifers and mixed figures follow the national trend. Nationally, conifers were planted during the 19th century as forestry techniques from the continent developed in England (Rackham, 1990) and for increased industrial use. The area of conifers in the study area remained almost static in the 19th century at 143.32 ha in 1840 (2.85% of total woodland)

and 179.23 ha in 1883, but by 2007 had increased to 665.43 ha (9.73 % of total woodland). In contrast, the first identification of conifers in the Rockingham forest area was in 1885 using 6"OS maps (Peterken, 1976). However, as this was compared to 1st edition OS maps rather than tithe data, it is not possible to compare like with like. In the study area, early conifers were probably planted for game cover, for example 13 small fir plantations in Nettlebed parish, recorded in 1842, each less than 1 rood (0.25 acre) in area, but, post-1918, as a consequence of Forestry Commission policy.

In this research, no mixed woodland was recorded in the tithe documents, but by 1883, mixed woodland covered an area of 861.91ha (16.96% of total woodland). It had also been created on some wooded commons, for example at Bix, which, although not enclosed, was mixed by 1883. By 2007, mixed woodland was 26.13% of the total woodland. At both periods some may have been in the form of nurse conifers amongst new deciduous planting, to be removed in due course.

Between 1930 and the early 1980's, almost 40% of ASNW in England was either clear felled and replanted with conifers or inter-planted, mainly but not always with conifers (Thompson, *et al*, 2003). In the study area, the percentage of ASNW converted to PAWS was 33.17%; FC-owned Queens Wood and Leygrove Wood are examples of this policy.

The map data analysed in this research reflects these national issues which impacted on English woodland in general, for example, the post-war national policies described in Chapter 2.4, which focussed on increasing conifer plantations at the expense of native woodland, as well as the more local emphasis of the FC "Chilterns Special Project" which, although conserving woodland from development, was also was instrumental in widespread clearing and coniferisation across the area.

However it also clearly demonstrates local differences to the generally accepted pattern of woodland history in England. This local difference would not be apparent without the use of tithe maps and apportionments, which provided the detail necessary to identify local patterns of later change, for example, the designation of "beech" in tithe apportionments. This would not have been possible using the 1st edition 1" Ordnance Survey maps or surveyors drawings. Natural England now recognises the value of tithe maps, which are now "central" in the process of updating the Ancient Woodland Inventory (Patrick

McKernon, Natural England, personal communication). However, if apportionments are not being used in cases where maps do not show tree symbols for woodland, data will be missed.

6.3 The effect of change on spatial metrics

The area of deciduous woodland shows a decline from 1840 to 1880, followed by an increase by 2007 (see Table 5.7). However the percentage of deciduous in the wooded landscape has declined between all time periods from 97.167% in 1840 to 65.29 % in 2007 due to the increase in conifers and mixed woodland. Deciduous woodland has the greatest area and number of patches in all time periods, with a marked increase in patch number in 2007, mainly due to the format of the imported MasterMap data which showed all subdivisions of woodland, not identified or digitised in previous layers. This is reiterated in the mean patch area, which are noticeably smaller in 2007, and in the nearest neighbour distance, again less in 2007 than that at the earlier dates (see below).

Shape metrics show irregular shaped patches particularly for deciduous woodland at 1840 and 1883. Conversely, conifers which were planted, show a lower figure, and thus are more regular in shape, particularly in 2007. Mixed was mainly created within existing deciduous woodland; in 1883 it is less irregular than deciduous, but by 2007 is similar to deciduous.

Deciduous woodland fragmentation increased between 1840 and 1880, as shown by the comparative figures for nearest neighbour distance (ENND), mainly due to conversion to mixed rather than by clearing. Due to the detailed format of the 2007 data with so many adjacent patches of sub-divided wood, fragmentation now shows a marked decrease. Figures taken from other work in the Buckinghamshire Chilterns which used the Chilterns Natural Area Land Use map (Lee *et al.*, 2001), also show a high figure for ENND and thus in fragmentation in 1991, the date of data collection; the same was true of conifer and less so of mixed. However, it should be remembered that these figures do not cover the study area, so are used for illustrative purposes only.

Metrics to analyse the distribution of patches of different types show that the connectance of patches, i.e. whether patches of the same type are joined or not, was slightly greater for deciduous woodland in 1883, possibly because of new woodland on previously open commons, but with very little change from 1840. There was very little difference between all woodland types in 2007. As fragmentation increases, the contagion figure decreases and this trend is shown clearly between time periods. Interspersion measures the heterogeneity of the landscape; the higher the number, the more the land use type is adjacent to all other patch types. Thus, for 1883 and 2007, deciduous is most widespread and has a greater number of adjacent different patch types, thus indicating a mosaic landscape. This measurement is not affected by the format of MasterMap in the 2007 data.

6.4 Management history from documentary historical sources

The third change, not apparent from map data, is that of management. For many centuries English woodland was utilised in various ways, managed most commonly as coppice-with standards. In the Chilterns, as has been described in Section 3.9.4, there was a selection management system, both for coppice and for standard trees. These management techniques resulted in a more constant woodland cover and shadier, more stable conditions compared to that of rotation coppice with standards which was widespread elsewhere in England. As this management method is so unusual in England it is difficult to assess how this affected woodland flora. When trees were selected within a specific area of woodland, it would have resulted in small open areas and some ground disturbance when logs were removed by horses. This disturbance was less than today, when machinery is used, and therefore could be said to be equivalent to natural disturbance. It is suggested that selection felling, depending on its severity, may be a way to conserve woodland plant diversity while at the same time allowing an economic benefit from woodland (Oheimb and Hardtle, 2009).

The cessation of most management during the 20th century has led to the development of a dense tree cover and deeper shade conditions. Although this may be a detrimental to some species, the lack of disturbance allows shade loving woodland plants to survive rather than those which flourish through a rotation coppice regime and which rely on periods of open conditions. Druce (1886) describes 'myriads of primroses' in the Oxfordshire Chiltern

woods, but today they are not common in the study area. However while woodland plant species such as Bluebell (*Hyacinthoides non-scripta*) are found in large numbers, others are less showy shade-loving Chiltern specialities. Rare characteristic Chiltern plants still found, especially on the chalk escarpment, include Yellow bird's-nest (*Monotropa hypopitys*), Mezereon (*Daphne mezereon*), Ghost orchid (*Epipogium aphyllum*), Violet helleborine (*Epipactis purpurata*), Narrow-lipped helleborine (*Epipactis leptochila*) and Green-flowered helleborine (*E. phyllanthes*) (Hornby and Welsh, 1990). Although not present in the study area, Coral-root (*Cardamine bulbifera*) is so localised that is said to be found only between High Wycombe and Wendover in Buckinghamshire. Detailed research of historic plant records could indicate whether these species have always been present or have flourished as a result of a lack of management and whether there has been a general decline in woodland flora in the Chilterns, perhaps compared to woodland elsewhere. It would be interesting to link this type of data with changes in composition and management over time to assess their impact.

6.4.1 Beech - planted or not?

There are several misconceptions about the woodland history of the Chilterns. The most widely accepted are the assertions that beech was a minor component of woodland prior to chair making and that woodland was planted with beech in the 18th or 19th century. The exemption of beech woodland from tithe payments "since time immemorial", as described in the tithe records used in this research, confirms its long term existence.

Historic documentary records show that beech was present in high numbers at least by the early 14th century with further evidence from the early 18th century, almost a century before the development of large scale chair making. Mansfield (1952) demonstrated the high numbers of beech in the Chilterns by analysis of wood books and other documents from two estates in the Buckinghamshire Chilterns. Many other local records prior to the chair making industry show beech as the most felled, commonly by volume of wood produced. However what is beyond dispute is that the Chiltern woods were highly managed for many centuries until the early 20th century when, apart from areas of clear felling during the First and Second World Wars and planting with conifers, much management ceased.

Map and documentary investigation in the study area during this research found no mention of beech planting on a large scale or of nurseries for beech. A very low number of very small nursery gardens were recorded in tithe documents, usually as conifer, hence their amalgamation with conifers in the 1840 data analysis. These sites may have been producing conifers which were later inter-planted in deciduous woodland to create mixed woodland, although their small size would make this unlikely. This is a contrast to other areas where replanting with nursery grown stock was widespread by the early 19th century (Harmer, 1994). However, areas within woodland were improved when necessary by thinning young saplings which regenerated naturally and replanting nearby in gaps created by the selection system (Young, 1803). Harmer (1994) implies that natural regeneration was not mentioned by early writers. However, Selby (1842) described the use of natural regeneration in the Buckinghamshire Chilterns, although Ellis (1745), while describing natural regeneration in woods and suggesting that it could be possible on adjacent fields, recommended planting or sowing instead.

In Tithe documents, 71 plantations were recorded, of which only 19 were given a landuse. Four were beech and these appeared to be ornamental strips in country estates; two were conifer, five were 'fir and coppice'; five were 'within or part of ..... wood' so not clear; two were 'planted' and one was 'young trees'. However, as so few were specified as beech, and as such exempt from tithe payments, it is more likely that those not specified were conifer. In this research (as described in 4.1.1.1) unspecified plantations were assumed to be coniferous rather than deciduous. Map analysis for the study area does not show large scale "new beech plantations created here in the 19th century" as expounded by English Nature (1997) and others. Plantations of any types tended to be small with a mean area of 1.16 ha; 59 plantations were less than 2.00ha. These figures demonstrate clearly that these plantations would have been of little benefit for a demanding chair making industry. If beech plantations had been planted in large numbers during the 19th century, they would have reached a useful size towards the end of large scale chair making. Planting in the 18th century "for chair making" (English Nature, 1997) is also very unlikely since at that time agriculture was profitable, chair making was relatively small scale until the early 19th century.

Historical information, such as field names which record earlier woodland names, demonstrates that the Chilterns must have had a "mosaic" landscape for many centuries, due in part to the varied topography and the mixed underlying geology which resulted in a

range of different land uses for people in the area over time. Fragmentation of woodland is not a new phenomenon in this area and aiming to restore full woodland connectivity would result in a landscape similar to that prior to Domesday, well over a thousand years ago and probably much earlier. Total woodland of all types in the landscape of the study area in 2007 has a woodland cover of 28.65%, which is a close match to the 30% cover described by Peterken (2000) as a realistic target for a functioning woodland resource (see 2.2.1).

Therefore, historical information is important to identify local exceptions, such those in the Chilterns, to widely accepted standard woodland information. Each woodland area is affected by its unique physical situation, the local economic and social patterns and the impact or not of external events (Peterken, 1976). Not only can historical information explain developments in woodland composition but it can inform on past management, woodland uses and traditions, which are not necessarily the same in different localities even within the same region, for example the Chilterns and the Weald in the South East of England.

6.5 Results of future scenarios investigation

The second part of this research was based on the premise that historical information could inform future woodland creation and restoration in the Chilterns. Other approaches for site selection have been based on a variety of criteria; for example, natural capital predictors (timber quality, public benefit, biodiversity and carbon sequestration) for woodland expansion funded by Woodland Grant Schemes (Bailey, 2003); site selection using specific indicators for expansion of ancient woodland (Lee, 2000). The Forestry Commission have used the Joining and Increasing Grant Scheme for Ancient Woodland Challenge (JIGSAW) Fund (2005) which aimed to link or extend areas of semi-natural woodland in order to reduce fragmentation and to protect biodiversity (Forestry Commission l) These new woodland areas were allowed to naturally regenerate where there were nearby seed sources, or planted with locally sourced trees. When this approach was evaluated in comparison with non-targeted WGS, it was found to have been effective both in reducing fragmentation and increasing woodland size (Forestry Commission m).

In this research, the selection process for new woodland creation utilised ex-woodland sites, identified from two sources i.e. field names that indicate where woodland had existed

before 1840 and GIS manipulation which identified sites cleared since the 1840's. It is also likely that the soils and other physical factors on these selected sites are suitable for tree planting or natural regeneration having been previously wooded. As Chiltern woodland has not been continuous for many centuries, this approach maintains the mosaic pattern typical of the Chilterns within which local woodland flora and fauna have developed. The Forestry Commission (2008) produced a draft version of guidance for management and enhancement of ancient woodland. It contains a similar approach to this research for new planting based on sites where woodland has been cleared, suggesting that this can be identified by a comparison of 6" Ordnance Survey maps, the earliest dating from the 1880's. However, the Forestry Commission had no specific reason for this suggestion (Rebecca Isted, Forestry Commission Biodiversity Advisor for England, Personal communication, 2008).

Using an historical approach such as that outlined in this research is likely to be very appealing to local communities and land owners who are often more interested in their local history than biodiversity. Peterken (2000) made similar comments in relation to potential woodland re-creation in Lincolnshire. This interest is demonstrated locally by the Chiltern "Special Trees and Woods" project, a very successful four and half year initiative linking notable trees and woodland with local history and people, relying on volunteers to identify and record these (Chilterns Special Trees and Woods project). Another is The Wychwood Project in West Oxfordshire which uses the location of the ancient Royal Forest of Wychwood as a foundation for conservation and enhancement of the area (The Wychwood Project, undated).

A feature of the Chilterns is the pattern of small hedged fields, most of which can still be indentified from tithe maps and most of the fields used in the selection process are still in existence. It has been found that the presence of hedges is important in lowering isolation effects on AWI in woodland patches, due to the presence of such species in an agricultural landscape (Petit *et al*, 2004). Similar effects were found where the vegetation of secondary woodland on fields abandoned over 100 years ago and monitored ever since, was found to contain woodland plants present in hedges around the sites (Harmer *et al.*, 2001). Although previous land use may have an effect on colonisation success of woodland plants, there seems to be no real consensus on this factor, other than the less intensive the previous use, the more successful the outcome (Grashof-Bokdam and Geertsema, 1998;

Wulf, 2004; Brunet, 2007). Based on this evidence, woodland flora should be able to colonise this type of site for new woodland, not only from adjacent woodland, but also from remnants contained within the surrounding hedges, thus more likely to become richer than those without this source (Peterken, 2000). This evidence is therefore particularly relevant for the study area as, except for those planted during Parliamentary Enclosure, most hedges in the Chilterns were created from woodland remnants during clearance and as such are composed of a variety of shrub and tree species. Although cleared woodland is now arable or grassland and has been for many years, there may be remnants of woodland flora in hedges. These tend to occur in areas where the presence of ASNW is high (McCollin, 2000) and is certainly apparent in the study area. The effect of using ex-woodland sites is successful because the chances of adjacency is high as woodland tends to be cleared from the edge towards the centre and resulting fields cluster around the remaining core woodland.

The selection process for woodland creation was based on ranges within 1.0m and within 200.0m. The sites selected at 1.0m were directly adjacent to existing woods and in some cases joined woodland areas together, for example, some of the areas described in 3.10.2 relating to land cleared by Phillip Wroughton. Sites at 200m captured both these adjacent sites and others further away, but in reality many of these more distant ex-woodland sites were isolated from existing patches of woodland. However these sites could act as stepping stones between other woodland patches with the added benefit that they may have colonisation potential from adjacent hedges. In two places, entire woods appear to have been cleared; these fields form a cluster of potential sites, but in both cases, these sites have not been selected as they are too isolated from existing woodland.

The selection process of 1.00m has more chance of being successful in terms of plant colonisation than those further away as it has been found that new woodland should be contiguous with existing woodland in order to facilitate colonisation by typical woodland flora (Brunet, 2007). Bossuyt and Hermy (2000) analysed the time taken for successful colonisation in new woodland adjacent to ancient woodland and found that many species were able to colonise in less than 90 years, although others with low dispersal rates require more than 100 years. However, while recent woods adjacent to ancient woodland are richer in plant species than isolated recent woods, they are significantly poorer than ancient woods (Peterken and Game, 1984). However, the questionable success rate and the time period necessary for plant colonisation should not affect the decision to expand woodland

in this way, as it would appear to be the best method available. In historical terms, the effects of previous habitation and land use, dating from many centuries ago, can still be identified in woodland that is classified as ancient, so given time, woodland created in the 21st century will eventually become "ancient", its previous land use insignificant in a natural time frame, so concerns about the current land use of selected sites should be put into this long-term context.

This type of approach has been examined elsewhere, for example in Lincolnshire, based on planting areas which were wooded in the past (Peterken and Game, 1984). However, due to the low density of existing woodland in that area, from a woodland network point of view the outcomes from this approach were not thought encouraging; several woods would remain under 25ha and woodland still occupies only 10% of the landscape. In the study area, the percentage of deciduous woodland in the landscape at 18.29% is already much greater than that in the Lincolnshire study and it increases slightly to 19.6% when adjacent ex-woodland fields are selected for habitat creation. However, woodland size in the study area appears to be generally smaller in comparison than those in Lincolnshire, the majority here less than 25 ha, which follows the general pattern for the whole of the Chilterns.

In a combined scenario created in this research by which restored PAWS and existing deciduous are further increased in area by adjacent woodland creation, the woodland percentage of the landscape increased to over 23%. PAWS restoration is a current (2010 onwards) target specifically funded by the Woodland Improvement Grant Scheme (WIGS). A positive outcome of this targeted funding is crucial as it would be a high profile success story for the Chilterns and could lead to further similar funding opportunities. The combined restoration/creation scenario, which converts all existing non-native woodland to deciduous with adjacent woodland creation, results in a woodland cover of 31.73%. This demonstrates the substantial extent to which woodland would need to be expanded to reach Peterken's suggested 30% land cover target (see Figure 5.17). However, in practice this target is unlikely to ever be reached due to cost and difficulty in involving all landowners. This outcome is highly unlikely to be achieved unless encouraged by the development of a thriving high profile wood fuel industry in the Chilterns (see below).

Woodland restoration by removal of conifers or non-native trees in mixed woodland could be more likely to succeed ecologically as a method of expansion of native woodland than woodland creation. It has been found that remnants of woodland ground flora can survive

as vegetation and in the soil seed bank in coniferous stands adjacent to deciduous woodland, particularly in mature stands; it is possible that up to 86% of native woodland plants could be restored on conversion (Augusto, *et al*, 2001). As mentioned previously, this approach is already taking place in the study area in the FC Chilterns Design Plan project. To further inform this approach, historic information could be used to ascertain the history and previous management of the site.

Although it could be argued that the Chilterns is very well wooded already and that funding should be focused elsewhere, the ecological success rate of planting in already wooded areas is greater than in less wooded sites due to the proximity of existing woodland to aid colonisation and improve connectivity. In addition, sympathetic new planting and management will protect and enhance existing Chiltern woodland which is recognised as a unique resource. Therefore, ideas for improving woodland connectivity depend greatly on the landscape in which they are situated and there is no single solution which can be used universally, especially when landscape character has also to be taken into account, as is paramount in the study area.

Whatever approach is used to target new woodland, it has to be remembered that woodland will take many centuries to develop the characteristics of "ancient woodland", although this in the future might differ to that seen now. Funding and public awareness should stress that woodland expansion, and to a lesser extent restoration, is a very long term event. It needs to be thought of in a natural time frame rather than a human one and is therefore a legacy to the future.

6.5.1 Wood fuel

Development of the wood fuel industry in England is currently underway with a move to promote the sale of local firewood for local people and the manufacture of chippings and pellets for large scale boilers. The Forestry Commission is actively promoting the production and use of wood biofuel (Forestry Commission, Woodfuel in England). It is estimated by the Forestry Commission that 500,000 tonnes of fuel could be produced in the South East region annually while in the Chilterns this figure is approximately 60,000 tonnes (Chilterns Conservation Board, Management Plan, Farming and Forestry). Restoration processes linked to the removal of conifers could utilise this wood for fuel for

many years, so providing an economic rationale for woodland restoration whilst at the same time enhancing biodiversity. This approach is currently being used by the Forestry Commission in the Great Trossacks Forest around Loch Katrine where non-native trees are being removed and utilised as fuel as part of replanting and woodland linkage scheme (FC Field Trip, 3.9.09).

Woodland management in the study area could return to the traditional selection methods, particularly if an economic return is needed for privately owned woodland, with the added benefit of rural employment and sustainable energy generation. In Italy, where there was widespread selective beech coppice until the early 20th century, the idea of restoring a system of selection coppice for fuel has been evaluated and tested as part of a multifunctional approach to beech woodland management (Coppini and Hermani, 2007).

6.6 Policy implications

The adverse impact of early Forestry Commission policies and the current focus of policies such as Keepers of Time (2005) with a wider remit than purely timber production ie incorporating biodiversity, historic, cultural and social values, have been described in Chapter 2. The value of ASNW has been recognised and efforts are being made to restore this to a good state, with further plans for the future, although the FC guidance document on management of ASNW and restoration of PAWS due in 2008 does not yet appear to have been published. In relation to the study area, this is a welcome development as long as funding continues for private owners as for example the Woodland Improvement Grant which is applied to specific regions, currently (2009) just available in the Chilterns for the first time. Restoration of FC owned land in the Chilterns through Forest Design Plans is already underway and may well act as an inspiration for private landowners to follow suit.

The Chilterns Conservation Board (CCB) is also following this route, but is dependent on co-operative working with a wide range of other organisations to fulfil its aims. However these organisations are also dependent on state funding and/or donations so in effect financial issues will be the deciding factor in the success of the CCB Management Plan 2008-2013. The Delivery Plan lists key indicators which, in relation, to woodland are the area of woodland covered by England WGS agreements and the area of SSSIs in

favourable condition. Under the general heading of 'Conserve and Enhance Natural Beauty', the sub- headings of 'Farming & Forestry' and 'Biodiversity' contain 31 actions, together with their outcomes and participating organisations (see Appendix 6). They include aims for sustainable timber production especially when it will achieve multiple benefits i.e. linked to restoration of PAWS, implementation of BAPs and landscape plans. The results of this research indicate the impact of some of these measures. For example, the potential changes to landscape metrics by restoration of all PAWS (i.e. mixed and conifer) demonstrated a 4.22% increase in deciduous woodland, although if all mixed woodland was restored to deciduous this would increase by 7.11% from present.

Oxfordshire BAP targets for the study area are shown in Chapter 2 Table 2.2. PAWS restoration of 24 ha is targeted on the escarpment, with only 1.48% of the total area of mixed and conifer PAWS in the study area of 1620.51 ha (taken from Ancient Woodland Inventory data). This may improve small local areas but in the broader picture is almost irrelevant and would have no effect on landscape scale measurements such as connectivity and patch area which are crucial to maintain calcareous beech and yew woodland (NVC W12). According to figures taken from the Oxfordshire Conservation Target Areas data, the total area of the Escarpment CTA is 3,612.45 ha therefore the PAWS target restoration area is 0.66% of this. This research identified 7550.57 ha which could potentially be either created or restored. However, the national BAP target for beech and yew creation, colonisation or PAWS restoration is 4,500 ha which, in theory, could be targeted in the Oxfordshire Chilterns alone and still not achieve complete creation or restoration of these sites, thus demonstrating the ineffectiveness of these target figures.

CCB and Planning Policy Statement 9 (2005) aim to link fragmented habitats, but where Chiltern woodland is involved, sites should be chosen with care. There may be a danger that the long term mosaic pattern of woodland, as described throughout this research, could be altered by inappropriate siting of new woodland, thus resulting in loss of irreplaceable local character. Therefore targeting new planting in relation to its end purpose (for example, for biodiversity and connectivity or for timber) needs to be developed to ensure this does not occur. Another way to reduce fragmentation would be to site new woodland alongside existing ancient hedges to form shaws linking two areas of woodland as suggested by Kirby (2009). This would reflect traditional landscape patterns rather than creating larger wooded links where none have existed for many hundreds of years. The CCB plan also aims to buffer and extend habitats and sites, which would have less impact

on the landscape and would be as beneficial from a biodiversity point of view, given the slow rate of expansion of the range of woodland plants and the larger core area which would result. This would be an ideal use for the site selection methods as identified in this research to ensure that landscape character is retained by the re-use of ex-woodland sites. Targets are mainly achieved by voluntary efforts by land owners through a range of FC grant schemes described in Chapter 2.

If the implementation of BAP targets is ultimately in the hands of land owners, then they need information, income and inspiration to undertake the projects necessary to achieve a positive end result. It is clear that information is being disseminated by bodies such as CCB, the Chilterns Woodland Project, the Woodland Trust, the Forestry Commission and others such as Confor (Confederation of Forest Industries), while income is available from grant schemes of various types. However, landowners may also need to feel that in some way they are contributing to a larger project which will provide more than purely financial short term gain. It is possible that historical information, such as that described in this research which not only demonstrates how woodland was in the past but also how it could be in the future, could provide a human link to biodiversity and ecological issues encompassed by BAP targets and thus an extra stimulus for woodland restoration or creation. This wider knowledge in tandem with the woodland archaeological work currently being developed could be an exciting and interesting spur to encourage land owners to understand more about their woodland and the importance of safeguarding it for the future by management, restoration and creation.

6.7 Data sources used

6.7.1 Map data

Although the Chilterns AONB as a whole is a well wooded area, there is little information available relating to changes over time in situation, composition and extent of woodland. The decision to use Tithe Maps and Apportionments rather than 1st edition 1" OS maps was based on the additional detail contained within the tithe documents on woodland type, area and field names. As mentioned previously, they do not appear to be often used for historical comparison, although recently a decision has been made to use maps only (not apportionments) in the process of update the AWI. 1st edition 1" OS maps or the original

OS surveyors drawing are not always clear as hatching to denote hills can render woodland difficult to see, as discovered by Peterken in his study of changes in Rockingham Forest (1976). In this research they were used in some instances to clarify data from Inclosure Maps, but were not useful because of this problem.

The 1st edition 6" OS map (1:10,560) for the 1883 data contained good graphics which allowed clear identification of wood types, although there is a slight question over the presence or absence of coppice which was either not shown or found in the study area. This was checked on printed copies but again was not clear from map symbols. Some selected areas were further checked on printed 1:2,500 maps (25" to one mile) dating from a similar period which showed that coppice only seemed to have survived on common land such as Maidensgrove Scrubs where remains can still be seen.

There was a large gap between the 1883 maps and the 2007 MasterMap, which is not ideal for identifying change. However, there was also a gap between new editions of OS maps as the First World War and later economic cutbacks brought planned new editions of the 6" map to a halt until the late 1940's. These editions concentrated on urban areas and transport routes rather than natural landscapes while later versions do not delineate woodland extent clearly so were not suitable for use in this study (Harley, 1975). One option would have been to examine the 1911 Land Valuation maps in the Oxford Archives, resulting from surveys carried out for the Finance (1909-1910) Act. These are OS maps but have occasional notes on written on them relating to land use. However, these would have been unlikely to have provided a full coverage of the study area.

The use of OS Master Map 2007 resulted in some problems relating both to its use and its effect on the results. The main adverse effect was caused by the large number of polygons representing woodland divided by paths (both Rights of Way and others), tracks and boundary banks as described earlier. The large number of MM polygons affected FRAGSTATS results particularly for mean patch area and nearest neighbour. Tithe maps showed woodland and divisions (of name and/or ownership) which often correlated to boundary banks shown on modern 1:25,000 maps. Paths and roads through woods were shown but were digitised only if wood name changed. 1883 OS maps showed paths, boundary banks, tracks or roads but the woodland (except perhaps in composition) was generally very similar to the previously digitised version of the tithe maps and so paths,

woodland tracks and boundary banks were retained if they had continuity between the time periods.

Maps by their nature cannot be completely accurate, mainly because of the time lapse between the ground survey and publication, as well as possible human error in both survey and reproduction, for example, tithe maps and apportionments were copied by hand and several copies were produced. Modern maps such as Master Map are created from both ground survey and aerial photography so errors in polygon description are still possible, and slight differences in boundaries and scale between the two OS maps (ie 1880's and 2007) can also have an effect, however Master Map is said to be 80-90% accurate (Harrison, 2002).

The Ancient Woodland Inventory has inaccuracies resulting from under-recording which may have affected results. Nationally, areas under 2 ha were not recorded whilst in the Chilterns there is the additional problem of the distinction between PAWS and ASNW, as mentioned in 2.4.5.1.

The Chiltern Natural Area Land Use Map was used in order to provide a "landscape" within which woodland data could be analysed. The GIS "fit" with digitised historic maps was accurate with no overlapping boundaries so it also provided a background for identification of suitable ex-woodland for creation scenarios by showing sites which were not suitable or available for new planting. The overall accuracy of 80% is in line with MasterMap, although the photographic base data for the study areas is now 18 years old.

In Chapter 5, figures taken from GIS (vector data) and FRAGSTATS (raster data) show differences in woodland extents, due to the different data format of each. However the results in both demonstrate the same trends for each time period so do not directly affect the outcome.

Errors may have occurred during this study during the process of transferring tithe map and apportionment data to paper, and in the following digitising processes. In the case of 1883 data, approximately 50% required copying by eye from a web page to the GIS, rather than digitising over map tifs, the process used for the remaining data from this date. The latter method was more accurate as it was much clearer to identify changes in landuse. When manipulating data between time periods to identify changes in landuse, any slight discrepancy between polygon outlines may have skewed results by small amounts.

Table 6.1 Summary of map data sources, uses, benefits and problems

Date	Data type and source	How used	Benefits of content or use	Problems in content or use
*c*1840	Tithe Maps & Apportionments (Archives)	Identification of woodland type and area	Detailed information and maps	Compilation and digitisation process cumbersome
*c*1820's	Enclosure maps (Archives)	Indication of woodland areas	Used because no Tithe data available.	May not show all woodland. Compilation and digitisation process cumbersome
*c*1883	Ordnance Survey 1st edition 6" map (Online and digital versions)	Identification of woodland type and area	Edina Historic Map downloads easy to use for digitisation	Old Maps online source not easy to use for digitisation
2007	O.S. MasterMap (Digital data)	Identification of woodland type and area	No digitisation necessary (but see problems)	Needed simplification/ amalgamation of wood types to match earlier data. Division into small polygons relating to internal woodland divisions affected FRAGSTATS
*c*1988	Ancient Woodland Inventory (Digital data)	Identification of ASNW and PAWS	Easy to download and use	
1990's	Chilterns Natural Area Land Use map (Digital data)	Allowed 2007 woodland data within landscape; extrapolation of percentage woodland at different dates.	Available in house. Gave an indication of wider landscape	Amalgamation of data sets not entirely accurate

6.7.2 *Documentary historic data*

A wide ranging compilation of published material relating to the study area and nearby parts of the Buckinghamshire Chilterns has resulted in a picture of woodland, its management and uses covering many centuries. However due to the everyday nature of such woodland activities, they were not often recorded in detail. People from outside the area, such as Loudon, Repton and Defoe found practices here different to those elsewhere and were more likely to comment on them, but often information is scanty and has had to be pieced together from a variety of sources. Original documentary material mainly provided information on, for example, local management or clearance which was probably typical of events throughout the area. It would be a large research project on its own to search all the available documentation for more detail, which due to time taken by the digitisation process in this research, was not feasible.

6.8 SUMMARY

This chapter discusses the results previously described in Chapter 5.

- Changes to woodland extent in the study area were affected by local and national influences. There was less clearance in the 19th century in the study area than elsewhere in England due to the local chair making industry and growth on disused commons. In the 20th century, woodland was cleared during both World Wars and post-war programmes of coniferisation took place to increase timber stocks through the Forestry Commission and the "Chilterns Special Project".
- Changes to woodland composition were affected by the same events. In recent years a change of FC policy has led to an increase in deciduous planting through woodland grant schemes. From 2010, PAWS restoration in the Chilterns is being funded by the Woodland Improvement Grant.
- These changes are reflected in spatial metrics which show that deciduous patches have more irregular shapes than planted conifers and mixed. Fragmentation has increased over time, mainly because of changes in composition rather than clearance and this trend is reflected in figures for contagion and interspersion.
- Documentary evidence shows that beech was present in large numbers for many centuries. It does not coppice well and, in order to produce wood for fuel and chair

parts, selective coppice and felling was used; this appears to be unique in England. This management results in more stable woodland conditions and therefore in a different type of flora than that in rotation coppice. Historical information demonstrates that the study area has had a mosaic landscape for many centuries so the importance of local differences must be recognised to inform planting patterns.

- Woodland creation on previously wooded sites, identified from historical sources, and adjacent to existing woodland, will retain landscape patterns. The historical input will appeal to land owners and local communities. Woodland restoration to deciduous can be effective in improving biodiversity and could have an economic benefit for wood fuel, which in time could also be developed to use beech once more. A combination of creation and restoration is necessary to reach a land cover of 30%.
- FC and Chilterns Conservation Board policy incorporates interacting biodiversity, historic, cultural and social values; this approach has been achieved to a broad extent by this research. However national BAP targets for beech and yew restoration are low and could all be used in the study area alone.

Key Findings

Information from historic data shows distinct local differences to the standard national assumptions on woodland distribution, composition, management and change. It demonstrates that, due to stronger local influences, some national events did not have the same impacts as elsewhere. Analysis in GIS quantified historic woodland distribution and identified how change occurred. Measurement of landscape metrics demonstrates the impact of change on woodland connectivity, patch size and shape and thus ecology.

The results are used to target planting strategies which not only benefit woodland connectivity and ecology but also reflect local landscape patterns. Other methods target only the ecological factor and take no account of local landscape character.

The combination of historical data, GIS and landscape metrics presents a successful and appealing new method to investigate temporal and spatial change in wooded landscapes. In a simpler format, using historical data only, this combination of methods could easily be used by local communities and land owners to identify previously wooded sites to target

for woodland creation, thus resulting in local improvement in woodland connectivity and biodiversity.

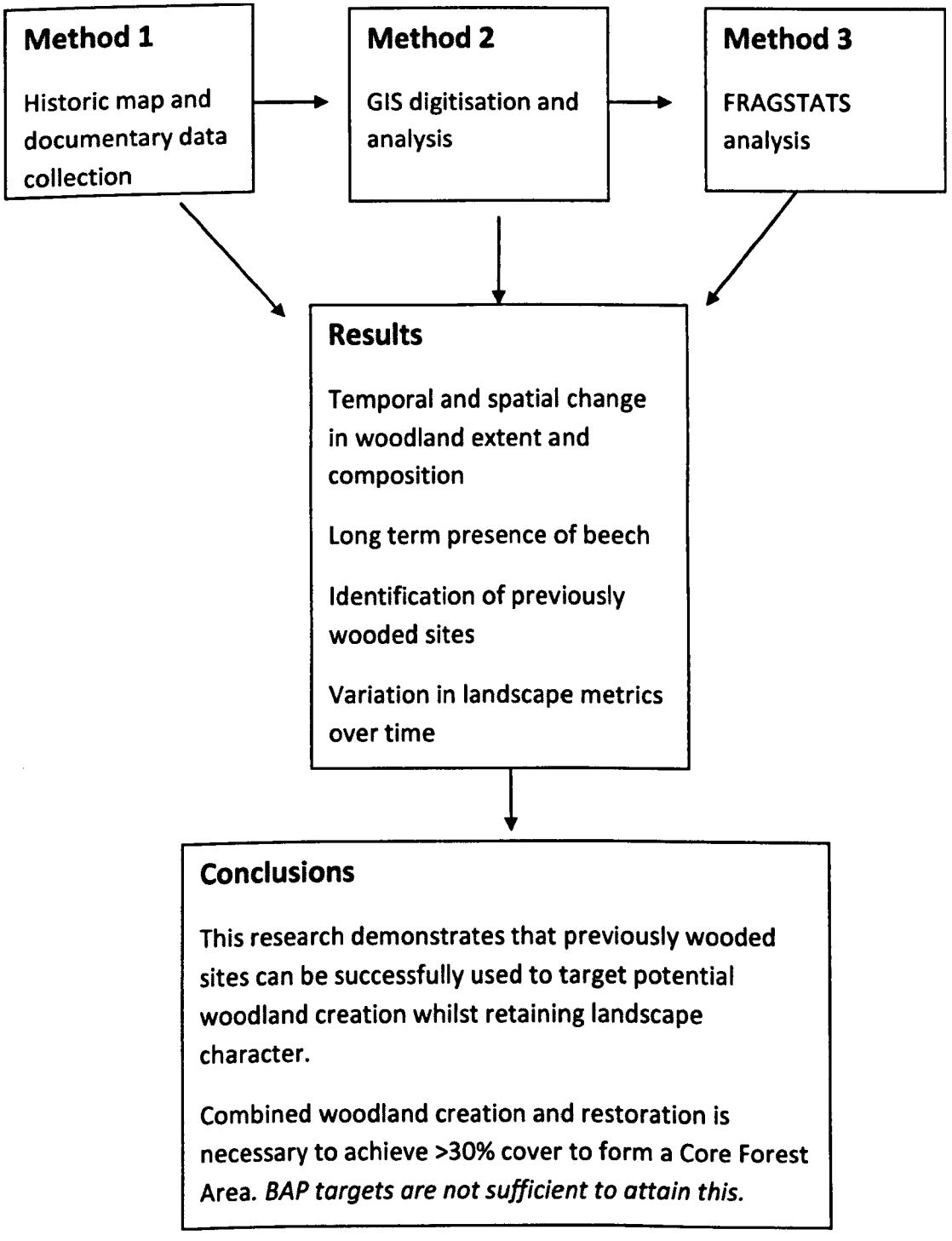

Figure 6.1 Summary of methods, results and final conclusions

Chapter 7

Conclusions

A widespread and general loss of natural or semi-natural habitat has occurred throughout England over the past 100 years, intensifying since the 1940's. Woodland, although managed for many centuries, has undergone marked changes over this period due to clearance and changes in composition and management, resulting in fragmentation and loss of biodiversity. In order to redress some of these losses in habitat, the Government has instigated changes in policy and funding to encourage general woodland restoration, creation and improved management through the Forestry Commission and an increased focus on biodiversity including habitat action plans for key habitats including lowland beech and yew, administered by Natural England working at local levels.

7.1 Research Aims

This research focused on the Oxfordshire portion of the Chilterns AONB and had two aims. The first aim was to investigate the history of the woodland in the area using map and documentary evidence. Using historical map data from 1840 to the present day, changes in extent and composition were ascertained using GIS. This demonstrated that changes in composition had occurred by 1883, when mixed woodland had been created by inter-planting within existing woodland and by 2007 when mixed and conifers comprised about 30% of the wooded landscape. Changes in extent were less marked with little change during the 19th century and a small increase by 2007, probably as a result of grant schemes. This data also provided information on sites of ex-woodland, either cleared prior to 1840 using field names, or post-1840 as identified through GIS manipulation. Documentary research was more limited due to time constraints but nevertheless, using both primary and secondary data, succeeded in compiling a picture of the development, management and uses of Chiltern woodland over more than two thousand years. It illustrated the use of selection management for beech coppice and woodland, a system used widely on the continent but probably nowhere else in England. This selective coppice system which

produced numerous beech stems allowed a relatively rapid change of use from fuel to chair making while a further change from selective coppice to selectively managed high forest provided more materials as chair making became mechanised. Therefore the flexibility of management and its economic value resulted in less woodland loss than in many other areas of England. These findings emphasise the need for an understanding of regional and historical woodland management and usage rather than the assumption that all woodland in lowland England was managed and used in the same way, a generalised view which tends to be taken by many national organisations.

The second aim of the research to identify sites for future deciduous restoration and creation. Restoration scenarios were based on restoration to deciduous of conifer or mixed woodland, including PAWS. This hypothetical approach resulted in an increase in mean patch size and a decrease in the nearest neighbour distance. Restoration of mixed woodland showed the best results with the highest increase in patch size and a reduction in near neighbour distance, thus beneficial for habitat improvement and ecological linkage. This type of restoration is now a funding target in the Chilterns and would therefore result in a successful outcome if widely achieved.

In the case of woodland creation scenarios, ex-woodland sites were used as targets for woodland creation. Sites were selected either directly adjacent (1.00m) to existing deciduous woodland to facilitate plant colonisation or at 200m in order to capture more potential sites or linkages between woodland. The same selection method was used to investigate a larger area of deciduous which included all converted PAWS. Analysis of these results showed that at 1.00m range the resulting mean patch area was larger, the number of patches decreased and therefore the nearest neighbour distance increased, so this approach increased habitat extent and reduced fragmentation. In choosing to use these ex-woodland sites, the culturally and ecologically important Chilterns landscape is retained and the character of the study area is reinforced rather than diluted, which may happen with sites targeted for other reasons. This method demonstrates the importance of taking regional history and character into account when national policies are implemented at a local or regional level.

7.2 Further work and recommendations

Further work in certain aspects of the research would be of benefit, particularly in relation to the historical aims and the use of GIS.

7.2.1 Historical research

More documentary historical research may provide data on volumes of wood felled or sold; information on planting during the 19th century; changes to woodland over a longer time period if access could be found to estate records. Research into historic biological records would provide an insight into the species present in the past which are now either depleted or extinct. It would also help in the understanding of the impact of large scale selective woodland management on biodiversity compared with that of the more common coppice-with-standards regimes.

7.2.2 Map resources

The use of tithe maps rather than early Ordnance Survey maps, although very labour intensive, was worthwhile and successful in producing a far wider range of information than would otherwise have been available. Later availability of digital 1883 OS maps was beneficial in terms of detail clarity and ease of GIS creation, but the use of Master Map often proved problematic. In retrospect it may have been more effective to use the same method as for 1883, editing and digitising changes based on the most up to date available OS data. This process, although labour intensive, would have ensured easier analysis and data manipulation.

If tithe maps and apportionments were recorded in full, a greater understanding of the Chiltern landscape would be obtained. Field names used in this research were only related to woodland, but mapping and recording all fields and their names would provide much information about the development of the Chiltern landscape. Recording small features such as ponds, orchards and road verges could provide useful information for the understanding of changes since 1840.

Earlier maps could be systematically compared to Tithe Maps. An example is that made of Oxfordshire by Richard Davis (1797). Although the Davis map showed the landscape

graphically it was not entirely accurate. Although it illustrates some woodland areas different to those in 1840 and so could add to the knowledge of the area, it would not be useful to digitise this type of map.

A further historical resource is the District Valuation Records, created around 1910/11 under the Finance Act 1910. These contain field books and maps of land surveys which valued land for taxation purposes. The surveys used existing O.S. maps but were sometime annotated to describe the land use, which may show woodland types at this date. However, these records are not always easy to access and use, although in Oxfordshire some are currently in the process of being digitised.

The use of soil maps may have the potential to clarify whether decisions made by land owners were influenced by local conditions or for economic or fashionable reasons; for example, the choices to plant conifers in deciduous woodland or to clear certain areas during the 19th century.

7.2.3 GIS issues

Several discrepancies were found in the GIS data over the course of data analysis, although they did not adversely affect the outcome of the research.

An example is the differences between the mapped figures obtained from the GIS for the area of woodland types compared to the sum of figures obtained by data manipulation between time periods. In Table 5.3, for example, 1883 deciduous was composed of that remaining from 1840 (4022.20 ha) and new deciduous (391.22 ha) obtained by data manipulation, a total of 4413.42 ha, in comparison to 4074.51 ha taken from the GIS 1883 map. Similarly, in 2007, there is a difference in deciduous of 183.14 ha between these methods of calculation. There are other discrepancies between the total type at the start of a time period and the sum of the various changes which occurred (i.e. remained deciduous, became conifer, became mixed, cleared). For example, the area of 1840 deciduous was 5081.76 ha but the sum of the changes was 5042.38 ha, a difference of 39.38 ha, with a difference of 91.41 for changes to 1883 deciduous. Nevertheless the trends in woodland change have been demonstrated clearly by this data and reflect the woodland history as described in Chapter 3.

These discrepancies may be due to errors or omissions in digitising, differences in GIS, for example overlap of shapefiles between 1840, 1883 and Master Map, and errors in recording source maps. These are issues which could be resolved in future work of this type by ensuring that the primary digitisation process is completely accurate but, more importantly, resolving the problems encountered with the use of MasterMap by reconfiguring the data to eliminate the problems caused by its detailed format.

7.2.4 Field work

One reason for using ex-woodland sites for woodland creation was the likelihood of woodland remnant flora remaining in hedges and thus acting as potential sources for colonisation. Although a few sites were identified, a thorough investigation of this potential would confirm the validity and scope of this possibility.

The methods and outcomes from this research could be usefully applied elsewhere, particularly in other similar areas where tithe maps are available as a basis for information and where parliamentary enclosure was late or non-existent. The Forestry Commission already suggest using ex-woodland sites for woodland creation, but only suggest using OS maps as a basis. The 1st edition 6" OS maps date from the 1880's but tithe maps are earlier, were made on a larger scale and provide more local information and interest. In the current work to revise the AWI, tithe maps have recently been used in Kent and Sussex for the first time and will be used in the Chiltern AWI revision. However to make full use of this resource, apportionments must also be used because of the additional information they contain, in comparison with either 1st edition 1" OS maps or OS surveyor's drawings.

7.3 Climate change

Climate change has not been mentioned previously in this research. However, it is clear that any future scenarios as described in this research would be affected by changes in future conditions. Rising temperatures, changing rainfall patterns of either higher precipitation or drought, warmer winters, stronger winds and more storms are widely predicted in the future, all of which will affect woodland in varying degrees, depending on their location within the British Isles. However, the wide range of possible combinations

and interactions in climatic conditions make it impossible to predict their impact on woodland with any accuracy (FC, r). Models of the effect of climate change on habitats and species show a variety of responses; however beech in southern England is predicted to fare badly and is likely to be replaced by ash and pedunculate oak (FC, r) (Berry, Dawson *et al.*, 2002), although by 2005, no adverse effects were apparent. Beech is predicted to be able to survive further west and north in the UK. However, beech is currently widespread on the continent, covering 12 million hectares, in areas that are currently warmer and drier than south east England (Kramer *et al.*, 2010).

In the Chilterns, the majority of beech is mainly of longstanding local origin and thus has genetic variability within the population, which may allow some adaptation to changing conditions to take place (Broadmeadow *et al., 2005*). It is also thought that management regimes, similar to the selection system used historically in the Chilterns could increase genetic variability, thus having some further potential for adaptation to climate change (Vendramin *et al.*, 2007). In addition, the physical conditions in the area are complex, with varied topography, aspect, a range of soil types and related ground conditions, all of which may provide the variability in physical conditions which could allow at least some beech to survive in this area. Beech woodland on both calcareous and acidic soils, as in the Chilterns, is also present in Cumbria and Derbyshire, outside its present native range but within a future climatic range. These could provide a focus for future conservation objectives for beech woodland (Wesche *et al.*, 2006).

Woodland restoration or creation is a long term project and therefore planning for climate change has to be part of this process, regardless of the lack of definitive knowledge currently available. Future planting could involve the use of the same species as present, but from more southerly provenance, as well as non-native species. However, in order to retain the features of native semi-natural woodland, in southern England, non-native provenance of native species could be used, as long as they can withstand the present conditions (FC, s). In order to retain the genetic resource, these could be obtained from the central European genetic group to which English beech belongs (Magri *et al.*, 2006) (see 3.3.1); distinct genetic differences are still apparent between the various post glacial groups (Buiteveld *et al.*, 2007).

This brief outline demonstrates the complexity and uncertainty which surrounds the effect of climate change on beech woodland. Beech woodland is intrinsic to the Chilterns in both its landscape and ecological impact, as well as in its cultural legacy. Therefore hard decisions are necessary to either attempt conservation to retain the *status quo* or to allow natural processes take their course, leading to a new chapter for the Chilterns landscape and biodiversity.

7.4 SUMMARY

- The research set out to ascertain the history of the Oxfordshire Chilterns woodland, its extent, composition and uses since 1840 using historic maps, original documents and secondary sources. The findings succeeded in illustrating the importance for an understanding of regional and local differences in woodland management and uses.
- The second aim of the research was to investigate future scenarios for both woodland creation, based on historically wooded sites, and restoration of non-native plantations to native species. These scenarios were shown to improve woodland connectivity and to increase patch size. These methods allowed the retention of the characteristic mosaic Chiltern landscape.
- Further historic map and documentary research would be beneficial in supplying more detail than could be achieved in this research. Field work could usefully support findings related to previously wooded sites.
- Climate change is likely to play a complex role in any future scenarios, although the form that this may take is difficult to predict. Attempts to retain the *status quo* or to apply *laissez faire* management will determine the future appearance and ecology of the study area whatever that may be.

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PRN 2190 Monument Roman Villa and Finds Harpsden Wood
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APPENDICES

Appendix 1 Additional Domesday Information

1. Survey Questions

The questions asked follow the format below:

1. What is the name of the place?
2. Who held it in the time of King Edward?
3. Who holds it now?
4. How many hides are there? (ie what is its assessment for geld tax)
5. How many plough teams, in demesne (on the lord's land) and among the men?
6. How many villains, cottars, slave and freemen?
7. How much wood, meadow, pasture? How many mills, fisheries?
8. How much has been added or taken away?
9. How much was it and is it worth?
10. How much had or has each freeman?

2. Domesday terms

Vill: the smallest administrative unit, equivalent to a parish. It might be equivalent to a manor, be part of a manor or contain several manors. In the latter case, because information was recorded under the heading of land holders, information relating to one vill is spread across several entries. Village is an equivalent modern translation for vill.

Manors: units of ownership and the smallest element recorded.

Hides: originally this was the amount of land which could support one peasant family (about 120 acres). By the time of the Domesday survey it had become an abstract fiscal rating which could be adjusted for taxation purposes (Wood, 1987).

Ploughland or land for ploughs: the most disputed term in the Domesday Book.

In many places it is clear in its meaning of the amount of arable land which can be cultivated over a year. However in other areas it is not so clear giving rise to the suggestion that plough land was another form of tax assessment. Roffe (2000) has hypothesised that it was a way to tax previously tax exempt holdings of the tenant-in-chief who held their land directly from the king. It is often taken to be equal to the old hide equivalent of 120 acres. Rackham (1976) and others have used this figure as a basis for estimating the amount of arable land available. Many parishes in the study area had fields situated on the more fertile low land (outside the study area) with more fields in the hills (Roden, 1969). Therefore it is impossible to assign a particular area of cultivated land to one area or another.

Ploughs: a standard plough team at that time was eight oxen.

Lordship: this term indicates a title to a holding. Land in lordship or in demesne was land farmed by the peasants for the lord's profit.

Villeins: Villeins or villagers worked for the lord but also held land and resources for themselves, which averaged 30 acres and two ploughs.

Smallholders: on average smallholders possessed five acres of land or less and might have a share in the villagers plough team.

Slaves: were the lowest ranking peasants who owned no land or resources. They worked for the lord and it is thought were often ploughmen.

Freemen: were personally free but owed rent or obligation to the lord (Wood 1987). Their land holding was an average of 30 acres with two ploughs. The majority of freemen were recorded in the north and east of England.

Meadow: grassland mown for hay for winter fodder. There was very little recorded in the Chilterns, with the exception of Pyrton which recorded 200 acres, although this is likely to have been situated on the lower part of the estate.

Appendix 2 Etymology and detail of field names

(The numbering below relates to columns in Table A.1)

1. **Wood** field names usually refer to a neighbouring wood; this is the most numerous type of name in the study area. Without in-depth research it is not possible to tell whether or not these names merely refer to the wood itself or refer to parts of a once larger wood which have been cleared for agriculture. For example in Henley, there is a reference in 1721 to "woods and coppices now cut down and converted to three closes or pasture", all of which were named after Lambridge Wood (ORO Bladon PC III/ii/1). These names often occur in groups such as Little, Further and Hither Dark Wood and Little, Upper and Middle Breach (Swyncombe)

There was much woodland clearance in the late 18th century instigated by landowners wanting a quick profit due to high corn prices resulting from the Napoleonic war, therefore the frequency of this type of name may well reflect a relatively recent occurrence. This is sometimes apparent on maps, where the earlier shape of the woodland can often be seen in the pattern of these fields.

2. **Coppice** may fall into the "wood" names but was made into a separate category to indicate its occurrence.

3. **Tree** field names contain the name of a specific tree. In this study the following types were found: ash, beech (3), cherry tree, crab apple, crab tree, hazel, holly (4), juniper (2), nut tree, oak (9), sloe, walnut, yew tree. An unusual name is that of "Slagger Tree Close" in a cluster of fields with tree related names ie "Apple Tree Close", "Cherry Tree Close" "Beech Tree Close" in the parish of Rotherfield Greys. "Slagger" is an old Oxfordshire dialect name for sloe (Wright, 1905). Another field is named "Woodwax" which may refer to a fungus.

4. **Woodland clearance** names include *stocking* and *grubbing* which may indicate two or three periods of clearances. *Stocking* is an early name so may date from clearances during the Anglo-Saxon period and later, whilst *grubbing* may have been used later and certainly appears in 18th century documents. However there is one instance of "Old Grubbing" in Lewknor Uphill, so presumably older than other "grubbings. "*Park*" names refer to medieval hunting parks rather than the later landscaped pleasure parks. Medieval parks often contained both woodland and open spaces, *launds*, which are still apparent in field names in this study; deer browsing was often responsible for woodland loss in parks (Rackham, 1986). There were often multiple uses in parkland so fields with *park* names may have been contained within the park itself or may be named after a now disappeared park, as is likely to be the situation in the Stonor area. Here the old park was later converted to farm land and a new landscaped park constructed around the house across the valley on the opposite hillside. *Grove* refers to the small areas of woodland and field as described by Vollans (1959), see Chapter 3.8.1. Therefore these names may well be the original fields formed during this clearing process. "Rid Wood" field (Mapledurham) indicates a cleared woodland and is close by others with wood names relating to a (then) still existing wood, indicating that this area was once more densely wooded than at the date of the Tithe Apportionment.

Assart names are usually thought to be the quintessential clearance name but it is interesting to note that no such names have been found in the Tithe documents for the study area,

although they are frequently found in West Oxfordshire especially in the Wychwood Forest area. This study confirms the suspicion that these do not exist in the Oxfordshire Chilterns, as mentioned by Bond (1982), although he wrote at a time when field names in Oxfordshire had only been partially recorded. However some assart names occur in the Buckinghamshire Chilterns, including one at Ibstone which borders Oxfordshire on the north-east edge and others mentioned in the Great Missenden area (Vollans, 1959). It was also thought by Bond that "*breach*" also did not occur in the Chilterns but three examples have been found in this research, although they might also refer to the change of use from grassland to arable (Field, 1993).

5. Names referring to the **enclosure of rough ground** are more difficult to differentiate between woodland and open land clearance and enclosure, as commons were often partly wooded. However, they are useful to include as they indicate the extent of this type of landscape and habitat. *Common* field names refer to land either used in common or enclosed from rough common grazing. However there are three field names in the area which are less obvious. "Common Halfridge" in Bix is a field next to Halfridge Wood; in Lewknor Uphill, two fields named Common Field occur next to each other and close to one named Lotts, which are not far from Stokenchurch Common so may have had a link with this wider land use at some point in the distant past *cf* Baines (1981). *Lots* is another commons – related name reflecting the practice of drawing lots for the use of land. "New Common" in Checkenden is adjacent to a field called White Wood Heath so again this area may have been once heathy commonland; now both these fields are woodland, perhaps indicating their poor quality soil for agriculture. *Furze* and *Fern* names clearly relate to scrubby rough ground and are often close to common or heath areas. These names are scattered across the study area. *New* names also relate to fields directly taken from either woodland or rough ground; there are four in the Nettlebed Common area, and another not far from Stoke Row Common. *Innings* has a similar meaning and again appears close to areas which were common land such near Dell's Common and Cowlease, once a cow common (both Lewknor Uphill). In Nettlebed, Upper and Lower Nimmins are situated next to a field called Newlands, on the edge of the common, whilst the fourth example is near Christmas Common opposite Watlington Park which was made into a hunting park from part of the commons there in around 1270 (Hepple, 1992).

Table A.1 Field Names relating to woodland taken from Tithe Apportionments

Name Category *	Field name element	Number Recorded	Meaning and example
1.Wood		109	Refers to adjacent wood or is part of a cleared wood *School Wood* (Nettlebed)
2. Coppice (ME)		22	Land by or containing a thicket *Coppice Ground* (Eye and Dunsden)
3. Tree		39	Refers to specific tree or shrub *Beech Ground* (Nuffield)
4. Woodland clearance			
	Grubbing (ME)	31	Land from which trees and shrubs have been cleared *Grub Hill* (Pyrton)
	Park (ME)	23	Land enclosed for hunting or pleasure *Great Park* (Checkenden)
	Stocking (OE)	18	Land cleared of tree stumps *Stockings* (Bix) *Stokenchurch* (place name)
	Grove (OE)	8	A small wood *Coxes Grove* (Nettlebed) (Also see Vollans E. C. 1959)
	Smock	1	Land on which the rendering of tithe wood was replaced by the payment of money *Smock Hill* (Pyrton)
	Rid (OE)	1	Cleared land *Rid Wood* (Mapledurham)
5. Enclosure of rough ground	Common	21	Land enclosed from commonland or held in common *Common Field* (Lewknor Uphill)
	Furze (OE) Moor (OE)	10	Land on which gorse grew Barren waste land *Furze Moor Hill* (Goring)
	New (OE)*	9	Land newly taken into cultivation or enclosed *Newlands* (Ipsden)
	Lots (OE)	8	Land allocated by annual ballot *Great Lots* (Crowell)

	Heath (OE)	8	Uncultivated, unproductive land covered with scrub and heather *Heathy Close* (Pishill)
	Brake (OE)*	6	Wasteland covered with brushwood *New Field on the Brake* (Shirburn)
	Innings (OE)	5	Land taken in and enclosed *Innings* (Lewknor Uphill)
	Breach (OE)*	3	Land (newly) broken by ploughing *Lower Breach* (Swyncombe)
	Fern (OE)	3	Land covered in fern *Ferney Shaw* (Rotherfield Peppard)
	Bake (EMnE)	1	Land prepared by paring and burning *Burn Bake* (Bensington)
TOTAL		**329**	

Abbreviations: OE Old English; ME Middle English; EMnE Early Modern English (from Field, 1989).

Appendix 3A

Tithe Maps and Apportionments.

Listed by: Parish name; date; reference numbers; scale in chains.

Comments recorded from Maps or Apportionments in *italic.*

1. Documents from the Oxfordshire Archives

Bensington 1841 (Ref PC III 1a, 1b) 4ch
Largest concentration of underwood, possibly because of proximity to the River Thames.

Bix 1841 (Ref 44S) 4ch
Beech wood and plantations exempt from tithes.

Checkendon 1841 (Ref 87S) 3ch
Woodland being entirely beech timber without any underwood is exempt from tithes.
Underwood subject to tithes.

Chinnor 1844 (Ref 95S) 3ch
Woodland exempt from tithes.

Crowell 1839 (Ref s118) 3ch
Woodland consisting of timber and not underwood is by prescription exempt from tithes.

Ewelme 1840 (Ref 159) 4ch

Eye and Dunsden in the liberty of Sonning 1842 (Ref D/D1 113D) 3ch

Harpsden cum Bolney 1842 (Ref 203S) 3ch
Beech wood exempt by immemorial custom.
Quantity of land cultivated as coppice wood was titheable.

Henley on Thames 1843 (Ref 210S) 4ch
Beech woods by prescription not subject to tithes.

Ipsden and North Stoke 1848 (Ref 230S) 6ch
Tithes had already been commuted to rentcharges.

Lewknor and Lewknor Uphill 1844 (Ref 252) 3ch
Lewknor Uphill is now forms part of Stokenchurch and of Cadmore End (Bucks).
Lewknor was enclosed in 1815 but no woodland was awarded

Mapledurham 1842 (Ref 258S) 6ch
Land subject to tithes cultivated as woodland 21 acres. This consisted of osiers or orchards only.

Mongwell 1841 (Ref s276) 4ch
Only the Beech woods are exempt from tithes. The whole quantity of land subject or liable to tithes within the parish now cultivated as woodland is by estimation 20 acres being underwood.

Nettlebed 1842 (Ref 282S) 3ch
Exempt from tithes – beechwood and plantation.

Newnham Murren 1846 (Ref 285) 4ch

Nuffield 1839 (Ref 291) 4ch
Beechwood exempt from tithes.

Pishill 1849 (Ref306S) 3ch

Pyrton 1850 (Ref 311) 4ch
At this date Pyrton was still in two parts. Assenden was a large detached area, now united with Pishill forming Pishill-with-Stonor

Rotherfield Greys 1844 (Ref 325(s)) 6ch
All the beech wood above 20 years growth exempt from tithe of wood.

Rotherfield Peppard 1840 (Ref 326S) 3ch
Beechwood exempt.

Shiplake 1841 (Ref 341S) 6ch
While appropriated to the growth of beech, wood and timber are by prescription or other lawful means absolutely exempt from payment of tithes both great and small.

Shirburn 1841 (Ref 343) 4ch
The whole quantity of the land of the parish which are growing beechwood are by prescription exempt from both great and small tithes.
These areas were shown in outline but not numbered on the map or recorded on the apportionment.

South Stoke cum Woodcote 1853 (Ref 364S) 6ch
Lands known as beechwood... are exempt from tithes.

Stokenchurch 1842 (Ref 362) 6ch
Woods exempt

Swyncombe 1840 (Ref 378S) 4ch
Plantations were charged with tithes and recorded as wood. Other woodland was recorded as beech and was exempt.

2. Documents from Berkshire Record Office

Caversham 1844 (Ref D/D1 162/1A and 1/B) 6ch
Some areas were not recorded as it now very built up and was difficult to relate to the Tithe map.

Goring 1848 (Ref 183) 6ch
Beech wood exempt by prescription.
Goring was enclosed in 1812 so tithes were reorganised then with payments to the various landowners. A very few small areas were listed on the tithe award although all features were shown on the map. More information was gained from a map produced for Goring Charity in 1826 (**Ref P402/1/M/1**), which gives acreage details of several woods in their ownership.

Appendix 3 B

Enclosure Maps and Awards

Listed by: Parish name; date; reference number.

1. Documents from Oxfordshire Record Office

Aston Rowant & Kingston Blount 1835 (Ref QSD/A Bk 4) 6 ch
Woods mapped and named

Goring Heath 1812
Woods shown and named; some pre-enclosure field names; part of Whitchurch shown.

Lewknor 1815 (Ref QSD/A Vol D) 6ch
No woods awarded in enclosure, therefore tithe map made for woods, which were situated mainly in Lewknor Uphill.

Watlington 1815 (Ref QSD/A Vol F) 6ch
Woods named and mapped.
Field names recorded

Whitchurch 1806 (Ref QSD/A Vol C) 6ch
Wood mapped but no names.

2. Enclosure dates for other parishes in study area (Maps not used)

Taken from: Oxford County Council (1975) *A Handlist of Inclosure Acts and Awards relating to the County of Oxford*

Checkendon	1864 and part of Ipsden and North Stoke
Chinnor	1854 Hill Common not enclosed, rights extinguished.
Crowell	1882 Hill area ancient enclosure
Ewelme	1863
Goring	1788; 1812 Both dates included parts of Goring Heath
Harpsden	1837 included part of Shiplake
Henley	1860 open fields only
Ipsden and N. Stoke	1856 part with Checkendon 1864

Kidmore End	1834 part with Caversham and Eye& Dunsden
Kidmore End	1865 with Gallowstree and Cane End commons, Emmer Green, parts of Caversham, Sonning Common, Mapledurham
Mapledurham	1792 Green Dean Wood;1799 Newney Green
Pyrton	1851
Rotherfield Peppard	1867 part
Shiplake	1837 with part Harpsden; 1867 with Binfield Heath, Sonning Common, Rotherfield Peppard
Shirburn	1806
Stokenchurch	1861
South Stoke/Woodcote	1853
Whitchurch	1806 includes part Goring Heath

3. Parishes in study area not enclosed.

Extrapolated from: Oxfordshire County Council, (1975). *A Handlist of Inclosure Acts and Awards relating to the County of Oxford.* Record Publication No 2. 2nd Edition.

Bix

Harpsden (part)

Pishill and Stonor

Nettlebed

Nuffield

Rotherfield Greys

Rotherfield Peppard (part)

Swyncombe

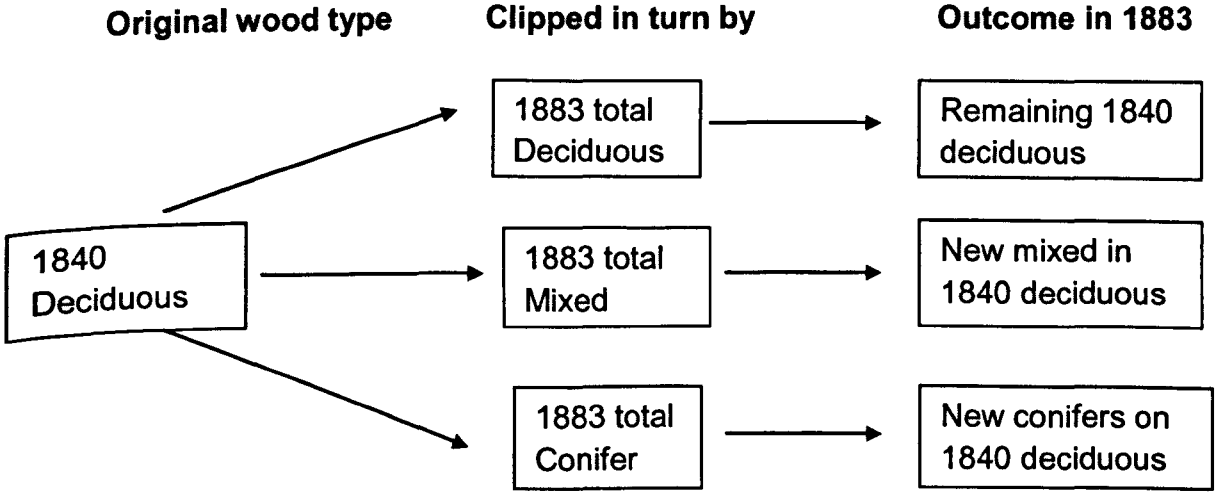
Appendix 4

Flow Diagrams relating to Section 4.4.2

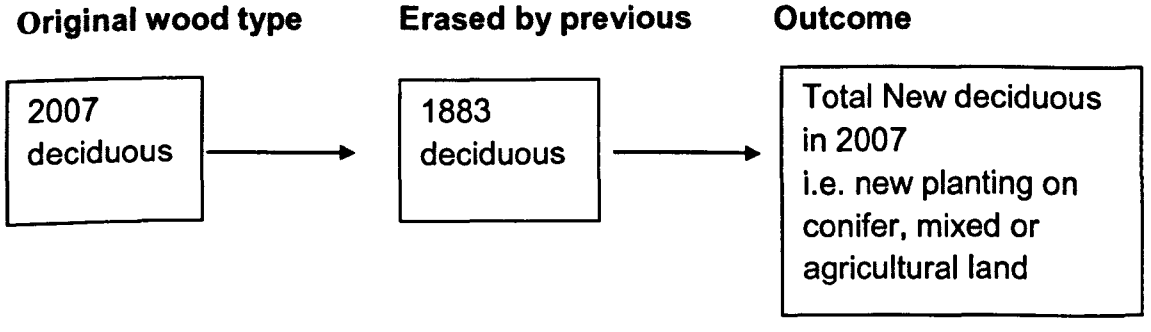
GIS manipulation of map and attribute data to ascertain changes in composition of woodland between 1840 and 2007

a. No flow diagram.

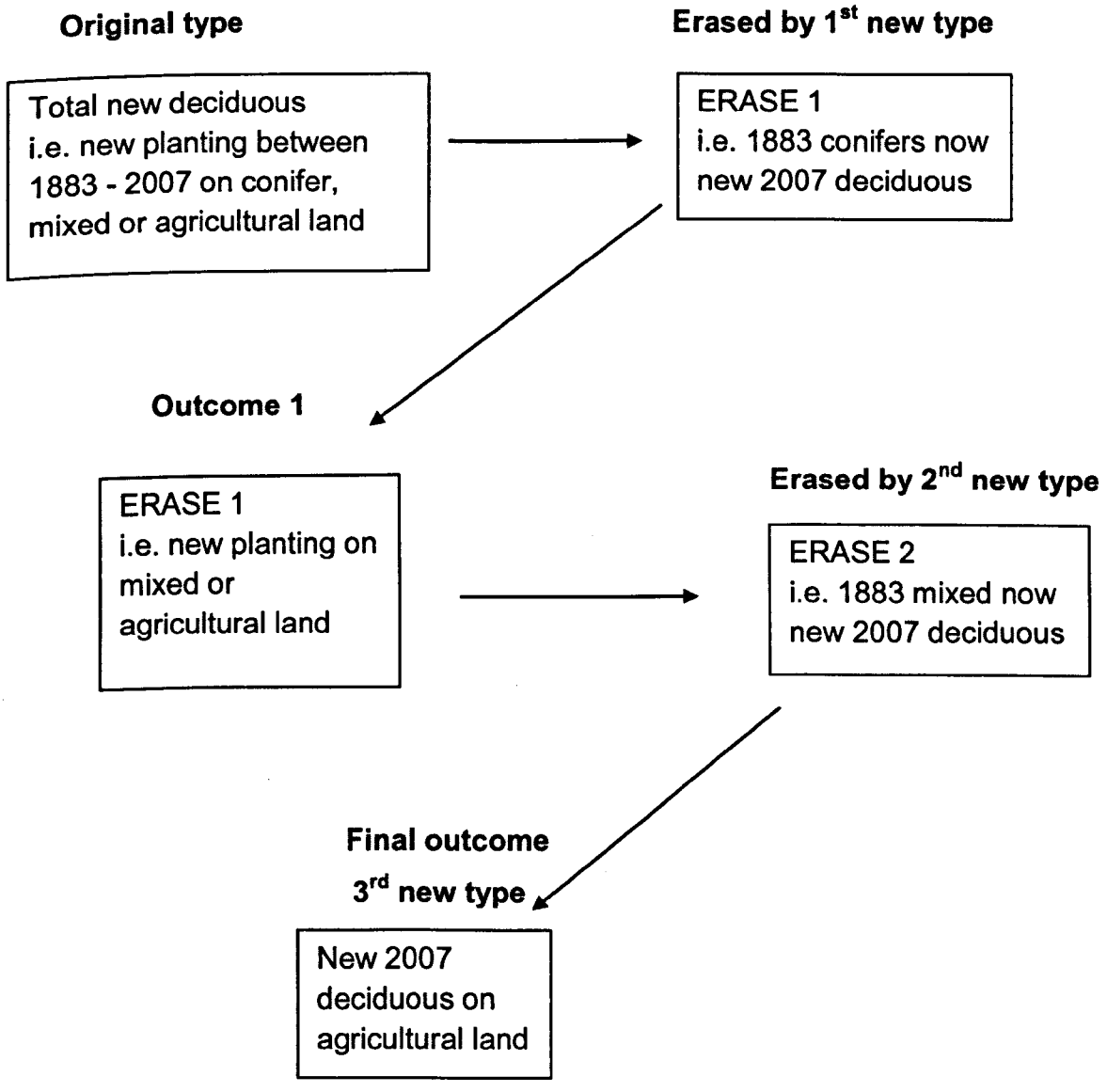
b. To ascertain if changes from one type to another had occurred, all previous types were individually clipped by all types of the later date.



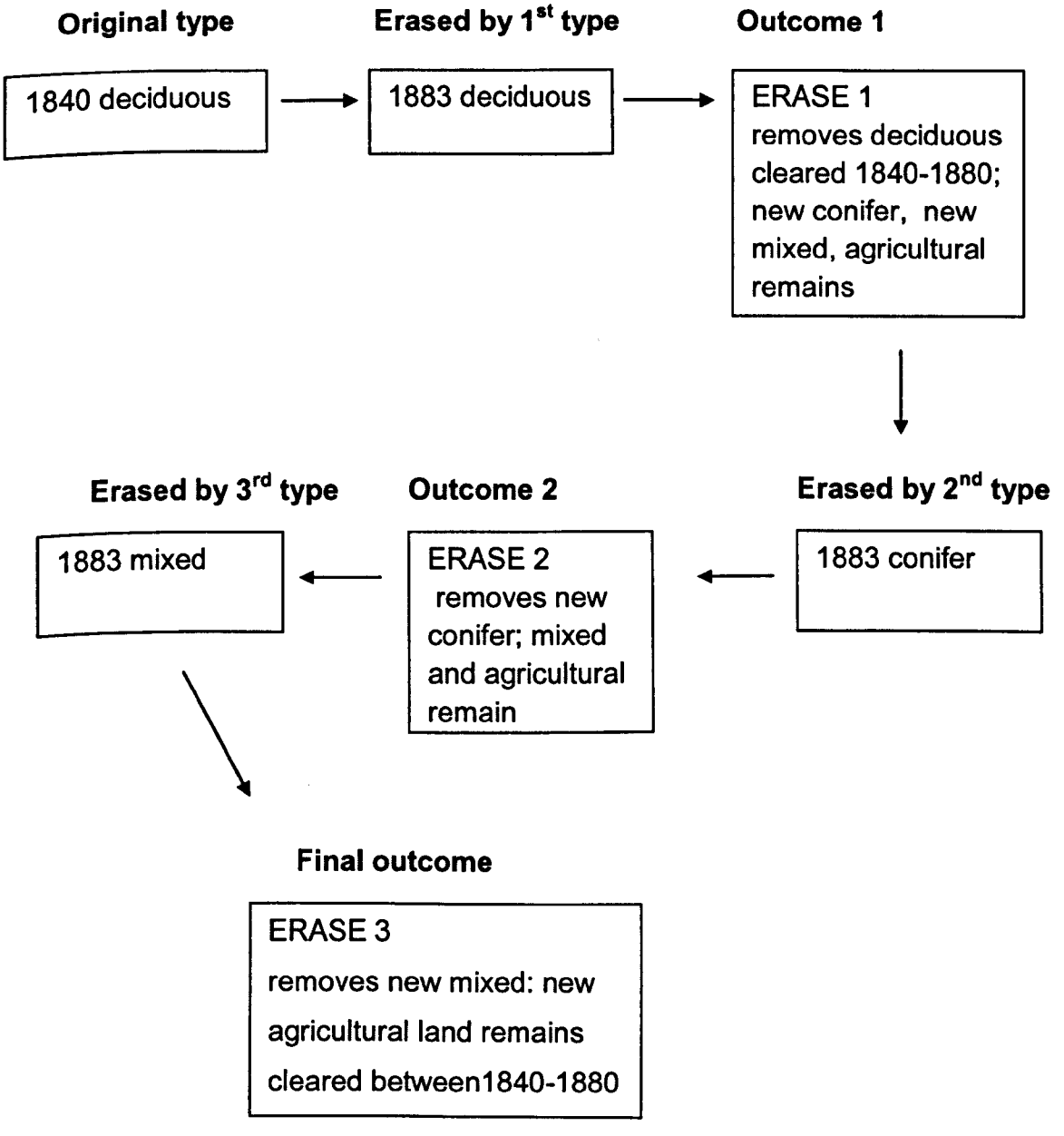
c. To ascertain the total new of each woodland type, the later shapefile was erased by the previous shapefile of the same type. The total new type is comprised of changed landuse from other types and from agricultural land.



d. To ascertain new woodland planted on agricultural land (ie previously un-wooded), the total new of any type was cumulatively erased by the other types which comprised the total new.

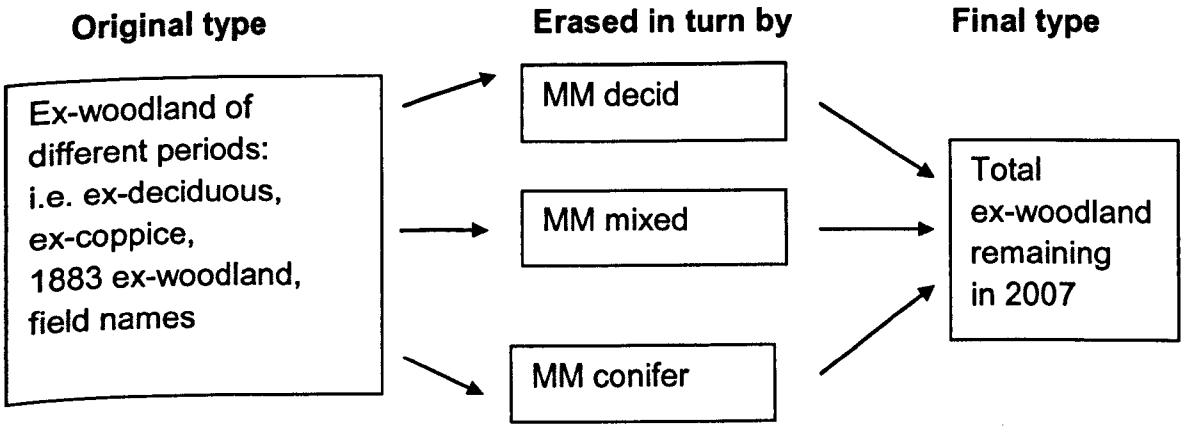


e. To find woodland which had been cleared, the earlier type is erased cumulatively by the later three types. In addition, there were some areas of cleared woodland identified by comparison with the 1840 Tithe map whilst digitising the 1883 map layer (ex-woodland 1883).

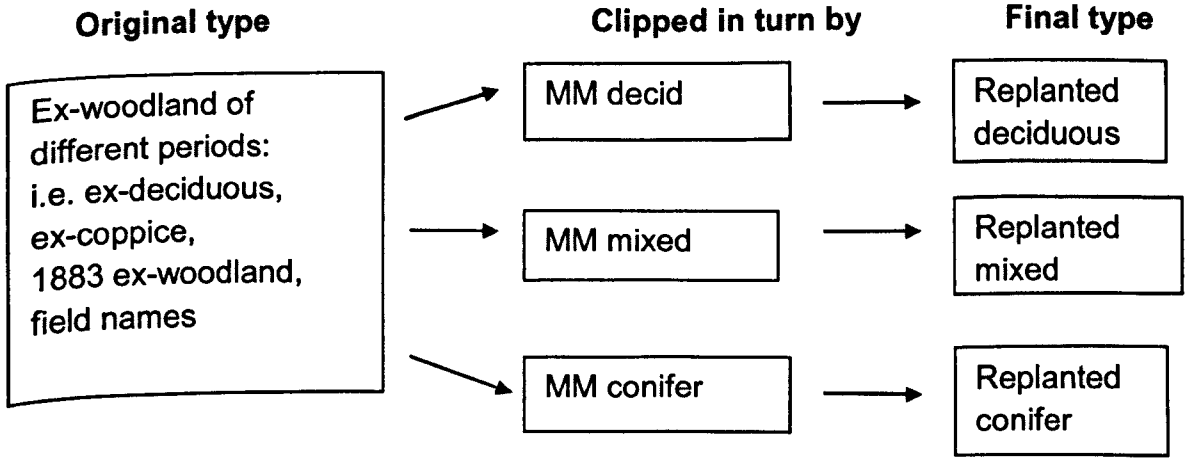


f. All ex-deciduous shapefiles, ex-coppice shapefiles and ex_woodland1883 (identified during map digitisation), were appended to a shapefile of wood-related field names to create an ex-woodland shapefile which provided a complete picture of cleared woodland over the study time period.

It became apparent that some of these sites had been replanted so to ensure that these were not included, this file was erased with all MM types. The final shapefile represented the total woodland clearance from prior to 1840 to the present day.



In order to identify the type of woodland which had been created on these re-wooded sites, the ex-wood shape file was clipped by all MM types.



Appendix 5

Woodland clearance between 1840 and 1883 by parish

Parish	Area cleared (ha)	Number of plots
Aston Rowant	9.83	3
Bensington	5.56	7
Bix	2.65	7
Britwell Prior	5.22	1
Caversham	4.35	7
Checkendon	9.89	9
Chinnor	5.67	3
Crowell	5.88	13
Eye and Dunsden	10.77	17
Goring	5.0	12
Harpsden	2.47	9
Henley	5.75	9
Ipsden	11.36	17
Lewknor Uphill	26.97	11
Lewknor	1.40	2
Mapledurham	2.14	9
Mongewell	4.40	6
Nettlebed	4.73	1
Newnham Murren	2.30	5
Nuffield	5.06	6
Pyrton	0.82	3
Rotherfield Greys	2.75	4
Rotherfield Peppard	2.45	5
Shiplake	6.55	10
South Stoke/Woodcote	8.61	7
Stokenchurch*	91.36	24
Swyncombe	8.95	7
Watlington	25.25	3
Whitchurch	3.26	7
TOTAL	**291.54**	**224**

*included part of Lewknor Uphill at this date

No clearance in Pishill or Shirburn.

Appendix 6 CCB Management Plan *Delivery Plan: Farming and Forestry; Biodiversity*

CONSERVE AND ENHANCE NATURAL BEAUTY Farming and Forestry		
Action	**Key Agencies**	**Outcomes**
1. Undertake and publish a regular survey of land use and analysis of land use change.	CCB	Identification of changes in land use and associated landscapes, assisting with monitoring of landscape condition.
2. Update the 1990 Ancient Woodland Inventory by undertaking a new survey to include all woodlands under two hectares.	FC, NE, CWP, CCB, LAs	All ancient woodland is identified and recorded for protection and management purposes
3. Support the provision of advice and training to promote management of woodlands especially those in public ownership and under 20 hectares	FC, CWP, LAs, NE, CCB, WdT, WTs, ConFor	Woods have management plans and relevant management is in place
4. Promote uptake of environmental stewardship and woodland management schemes particularly where they contribute to landscape and biodiversity gain.	CCB, NE, FWAG, LAs, FC, Confor	Improved management of land in line with objectives for the AONB.
5. Promote the sustainable production of timber and other woodland products especially where this helps achieve multiple objectives e.g. PAWS, Biodiversity Action Plan, local landscape design plans.	FC, CWP, WdT, Confor, LAs, WTs, CCB	Where appropriate sustainable production of timber and other products are an objective of management.
6. Organise regular fora on issues of concern and interest to farmers and foresters	CCB, FC, NFU, LAs, CLBA, CWP	Promote networking, cooperation and information sharing between land managers.
7. Support the survey, identification and conservation of archaeology in woodland, including provision of training for owners and managers.	FC, CWP, WdT, LAs, EH, CCB	Archaeology in woodland is identified and appropriate management is in place.
8. Publish regular information on climate change and how it could	CCB, FC, NE, LAs, WTs	Land managers have information to help

affect the landscape in the Chilterrs.		them cope with climate change and measures can be put in place to maintain the quality of landscape character
9. Organise, support and coordinate activities which help the public to understand better and appreciate the impact of farming and forestry.	CCB, LAs, CSoc, FWAG, NFU, FC, WdT, CWP, NT	Increase public awareness of the importance of traditional land management to the landscape.
10. Encourage appropriate management of landscape features and habitats, in particular chalk grassland, chalk streams, ponds, ancient and semi natural woodlands and hedgerows.	NE, FC, FWAG, LAs, CCB, WdT, CWP, WTs	Landscape features and types are well managed.
11. Encourage appropriate management of commons especially by grazing and other beneficial farming and forestry activity.	CCB, LAs, NT, WTs	Commons continue to offer biodiversity landscape, recreational and community benefits.
12. Support the identification, celebration and management of special trees and woods.	CWP, WdT, FC, LAs, CCB	Trees and woods valued by the public are identified, recorded and celbrated
13. Promote the development of appropriate infrastructure to support traditional land management practices, for example local abattoirs and sawmills.	CCB, LAs, NFU, CLBA, NE, C Soc, FC, WdT,	Fragmentation into small, unmanageable plots is avoided.
14. Scope the likely impact of biofuels in the Chilterns and develop an action plan to ensure they are produced in a way consistent with the AONB's landscape and biodiversity objectives.	CCB, FC, NE	The production of biofuels does not damage the AONB's landscape and biodiversity.
15. Encourage collaboration and networking between farm and woodland enterprises to maintain viable businesses particularly those contributing to habitat management.	SEEDA, EEDA, CCB, LAs, NFU, CLBA, FC, CWP	Habitats are managed by viable farm and woodland businesses.
16. Actively discourage owners and agents from sub-dividing farmland and woodlands into smal plots	NE, FC, FWAG, LAs, CCB, WdT, CWP, CSoc	Fragmentation into small, unmanageable plots is avoided.
17. Support the identification, management and planting of new hedgerow and in-field trees.	CCB, FWAG, LAs, CWP	Important landscape and biodiversity features are maintained.

CONSERVE AND ENHANCE NATURAL BEAUTY		
Biodiversity		
Actions	**Key Agencies**	**Outcomes**
1. Develop projects to implement Biodiversity Action Plans, and ensure continuity across county boundaries.	LBPs, CCB, ERCs, Farmers and other land managers,	Biodiversity Targets achieved, in particular in relation to habitats and species of significance in the Chilterns.
2. Support and develop landscape scale initiatives and green infrastructure projects which extend and connect fragmented habitats and sites.	LBPs, CCB, Green Infrastructure Groups	Fragmented habitats and sites are linked, buffered and extended.
3. Support and promote expansion of the area of chalk grassland in appropriate management.	NE, NT, LAs, WTs, CCB, FWAG, Farmers and other land managers.	Existing chalk grassland sites are in good conservation management.
4. Support and promote efforts to conserve farmland birds and rare arable flora.	RSPB, NE, WTs, CCB, Farmers and other land managers, ERCs	Farmland birds and rare arable flora populations are conserved and enhanced.
5. Conserve and enhance biodiversity on common land through development of a Chilterns Commons Project.	CCB, CCN, WTs, NT, LAs, NE, CSoc, landowners, common rights holders, ERCs, local groups	Funding is secured for a commons project with a dedicated officer; common land is restored and enhanced for wildlife and people.
6. Develop training programmes and disseminate best practice to land managers.	CCB, WTs, NE, LAs, NT, FWAG, Farmers and other land managers, RSPB, BC	Improved management of land in line with objectives for the AONB
7. Obtain and collate information on extent, condition and management of key habitats and species so that baseline data is available across the AONB.	ERCs, LBPs, CCB	Improved baseline data assists with setting priorities for management of key habitats and species.

8. Monitor and develop actions to prevent any further losses of priority habitats or species.	ERCs, LBPs, CCB	Priority habitats and species are monitored and conserved.
9. Monitor the spread of pest species and invasive non-native species and develop strategies for control where appropriate to minimise negative impacts.	NE, EA, Defra, CCB, ERCs, landowners/managers.	Adverse impacts of non-native and pest species are minimised.
10. Develop and support initiatives to involve more local people in wildlife conservation in the Chilterns and support existing community environmental activity.	CCB, CSoc, LAs, NT, WTs, local groups	More local people are involved in and supportive of wildlife conservation in the Chilterns.
11. Identify relevant climate change indicators for the Chilterns and develop a monitoring programme.	CCB, ERCs, LBPs	Local impacts of climate change on Chilterns wildlife are tracked, and used to inform future habitat management planning and public awareness campaigns.
12. Develop approaches to monitor visitor impacts on sensitive habitats and support initiatives to relieve pressure on the most sensitive sites and wildlife habitats.	LBPs, CCB, NT, ERCs	Sensitive habitats and sites are not significantly affected by impacts of visitors.
13. Work with urban communities adjacent to the AONB to raise awareness and understanding of the management needs of wildlife in the Chilterns.	NT, Groundwork Trust, LAs, CCB	Increased awareness of Chilterns wildlife amongst urban populations adjacent to the AONB.
14. Improve interpretation of Chilterns wildlife and countryside management.	CCB, CSoc, site managers	Increased public support for countryside management in the Chilterns.

Climate Change: assessment of possible impacts and the role of the Chilterns Conservation Board

						Improve site linkages to enable species migration	
Special Features and Qualities of Chilterns AONB	**Relevant Aspects of Climate Change**	**Nature of Impacts**	**Timescale** **Short Term**	**Long Term**	**Response** **Mitigation**	**Adaptation**	**CCB role**
Woodland	Earlier spring Hotter and drier summers Fewer frosts (liming) More frequent gales Wetter winters Increased CO2 in atmosphere.	Drought stress/soil moisture deficits Periodic water logging Windblow Reduced growth rates/crown and root die back More disease/pests Change in species composition - reduced suitability for beech in particular Changing associated flora and fauna – both losses and gains Increased risk of scrub fires	Low	High	Woodland creation	More careful species selection. Promote demand for wood fuel Link woods to facilitate species migration	Information (e.g. potential impacts according to soil types) Monitoring Promote and assist with preparation of long term management plans Promote adherence to the Forestry Commission's guidance on managing ancient and native woodland

Appendix 7
Chilterns Landscape Forest Design Plan 2006-2036

List of woods to be restored

1. **Leygrove's.**
2. **Cowleaze Wood**
3. **Queen, Fire and College Woods**
4. **Burnt Platt, Greyhone, Ipsden and Boroughcourt**
5. **Crowsley Park**

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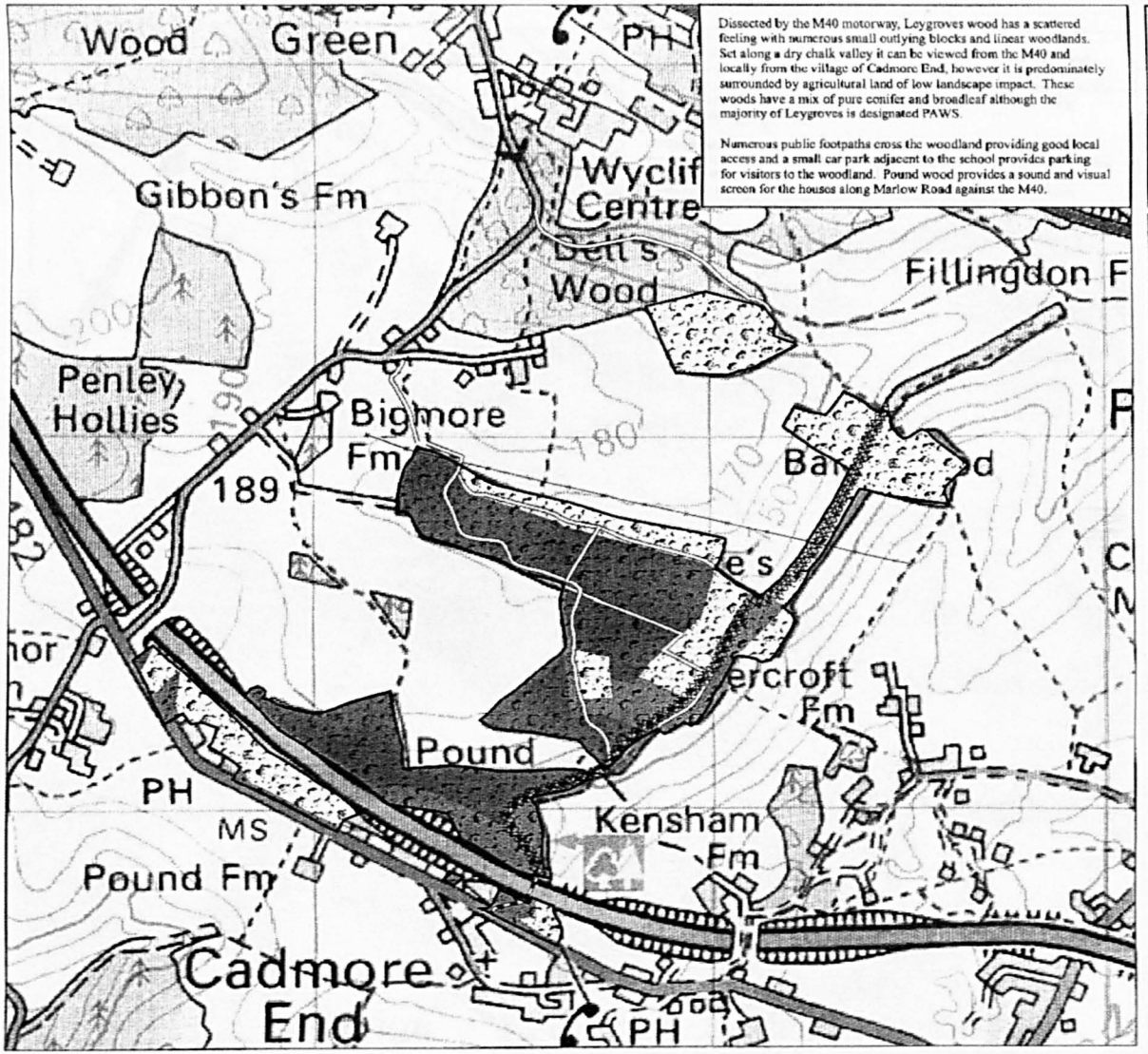

Dissected by the M40 motorway, Leygroves wood has a scattered feeling with numerous small outlying blocks and linear woodlands. Set along a dry chalk valley it can be viewed from the M40 and locally from the village of Cadmore End, however it is predominately surrounded by agricultural land of low landscape impact. These woods have a mix of pure conifer and broadleaf although the majority of Leygroves is designated PAWS.

Numerous public footpaths cross the woodland providing good local access and a small car park adjacent to the school provides parking for visitors to the woodland. Pound wood provides a sound and visual screen for the houses along Marlow Road against the M40.

Forestry Commission England

South East England Forest District

Leygrove's

Design Concept

Restored to broadleaf woodland with scattered conifers for conservation and diversity. Open ride network and age class mixture to ensure continuous cover forestry, thus retaining the woodland landscape character.

- Conifer woodland managed to provide a diversity of habitats, landscape interest and marketable timber.
- Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly conifer species at present: >60% of tree canopy cover at 2006).
- Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly broadleaf species at present: >60% of tree canopy cover at 2006).
- Broadleaf woodland managed to create a diversity of species and age classes.
- Mature broadleaf woodland retained for biodiversity and aesthetic value.
- Area managed for special conservation interest.
- Area of permanent open space managed for biodiversity or amenity value.
- Open water
- Watercourse
- Forest road
- Rides and tracks
- Overhead wayleave
- Managed open space and edge habitat alongside roads and rides.

Produced by the Planning Team August 2006

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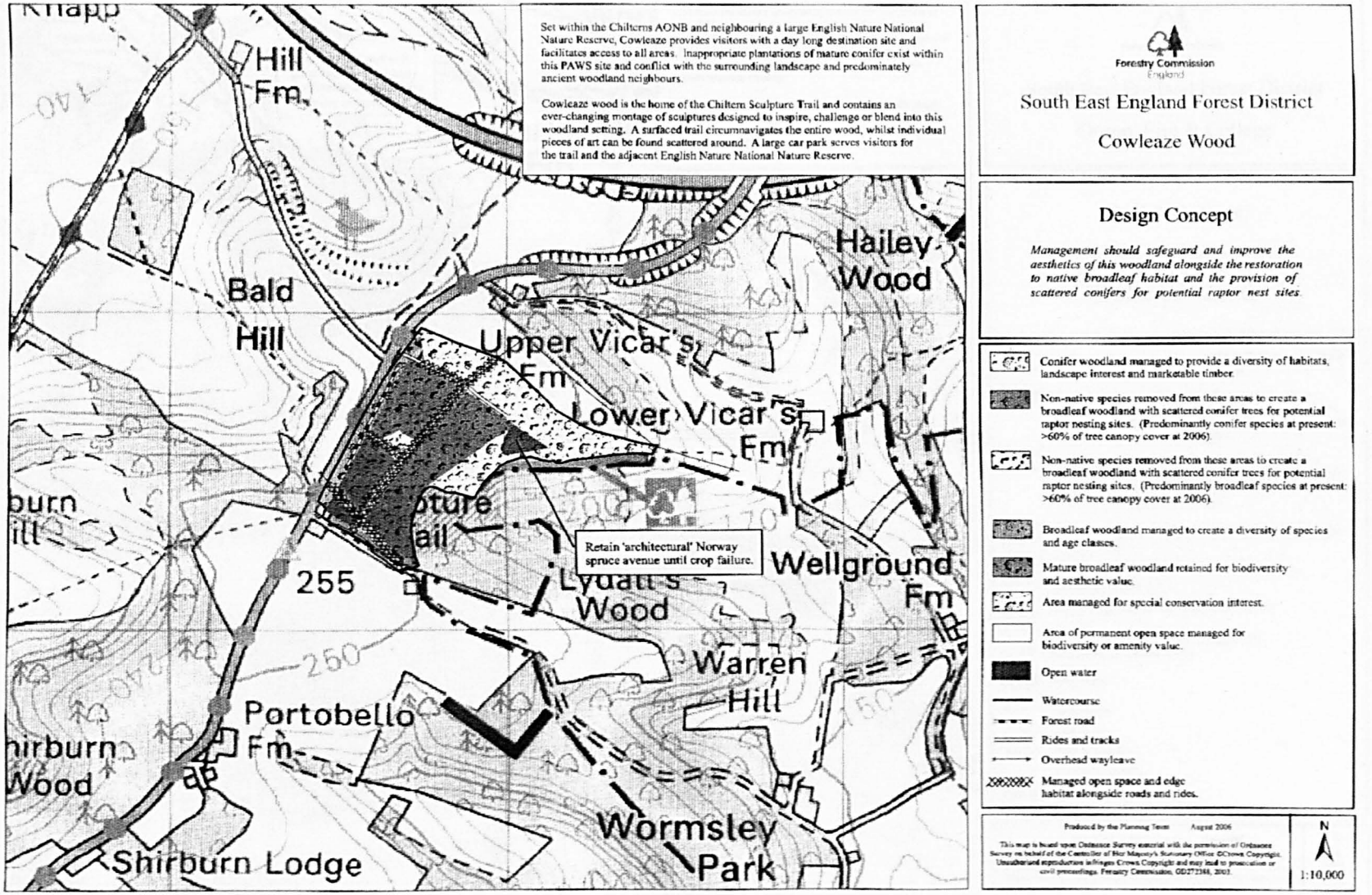
Set within the Chilterns AONB and neighbouring a large English Nature National Nature Reserve, Cowleaze provides visitors with a day long destination site and facilitates access to all areas. Inappropriate plantations of mature conifer exist within this PAWS site and conflict with the surrounding landscape and predominately ancient woodland neighbours.
Cowleaze wood is the home of the Chiltern Sculpture Trail and contains an ever-changing montage of sculptures designed to inspire, challenge or blend into this woodland setting. A surfaced trail circumnavigates the entire wood, whilst individual pieces of art can be found scattered around. A large car park serves visitors for the trail and the adjacent English Nature National Nature Reserve.
Forestry Commission England
South East England Forest District
Cowleaze Wood
Design Concept
Management should safeguard and improve the aesthetics of this woodland alongside the restoration to native broadleaf habitat and the provision of scattered conifers for potential raptor nest sites.
Conifer woodland managed to provide a diversity of habitats, landscape interest and marketable timber.
Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly conifer species at present: >60% of tree canopy cover at 2006).
Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly broadleaf species at present: >60% of tree canopy cover at 2006).
Broadleaf woodland managed to create a diversity of species and age classes.
Mature broadleaf woodland retained for biodiversity and aesthetic value.
Area managed for special conservation interest.
Area of permanent open space managed for biodiversity or amenity value.
Open water
Watercourse
Forest road
Rides and tracks
Overhead wayleave
Managed open space and edge habitat alongside roads and rides.
Retain 'architectural' Norway spruce avenue until crop failure.
Hill Fm
Bald Hill
Upper Vicar's Fm
Lower Vicar's Fm
Hailey Wood
Wellground Fm
Lydall's Wood
Warren Hill
Portobello Fm
Wormsley Park
Shirburn Lodge
255
250
Produced by the Planning Team August 2006
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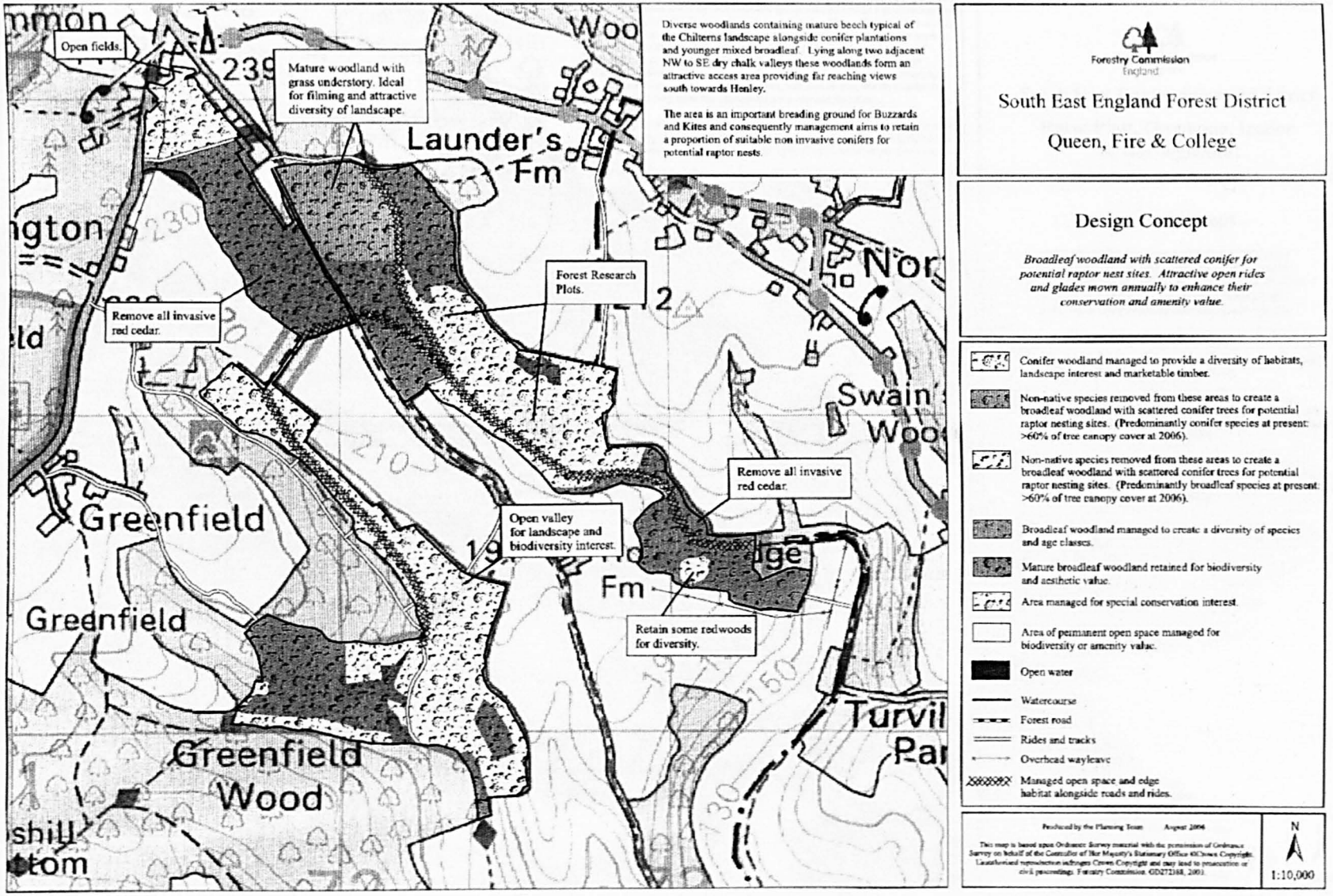
Diverse woodlands containing mature beech typical of the Chilterns landscape alongside conifer plantations and younger mixed broadleaf. Lying along two adjacent NW to SE dry chalk valleys these woodlands form an attractive access area providing far reaching views south towards Henley.
The area is an important breading ground for Buzzards and Kites and consequently management aims to retain a proportion of suitable non invasive conifers for potential raptor nests.
Forestry Commission England
South East England Forest District
Queen, Fire & College
Design Concept
Broadleaf woodland with scattered conifer for potential raptor nest sites. Attractive open rides and glades mown annually to enhance their conservation and amenity value.
Open fields.
Mature woodland with grass understory. Ideal for filming and attractive diversity of landscape.
Launder's Fm
Forest Research Plots.
Remove all invasive red cedar.
Remove all invasive red cedar.
Open valley for landscape and biodiversity interest.
Retain some redwoods for diversity.
Greenfield
Greenfield
Greenfield Wood
Fm
Conifer woodland managed to provide a diversity of habitats, landscape interest and marketable timber.
Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly conifer species at present: >60% of tree canopy cover at 2006).
Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly broadleaf species at present: >60% of tree canopy cover at 2006).
Broadleaf woodland managed to create a diversity of species and age classes.
Mature broadleaf woodland retained for biodiversity and aesthetic value.
Area managed for special conservation interest.
Area of permanent open space managed for biodiversity or amenity value.
Open water
Watercourse
Forest road
Rides and tracks
Overhead wayleave
Managed open space and edge habitat alongside roads and rides.
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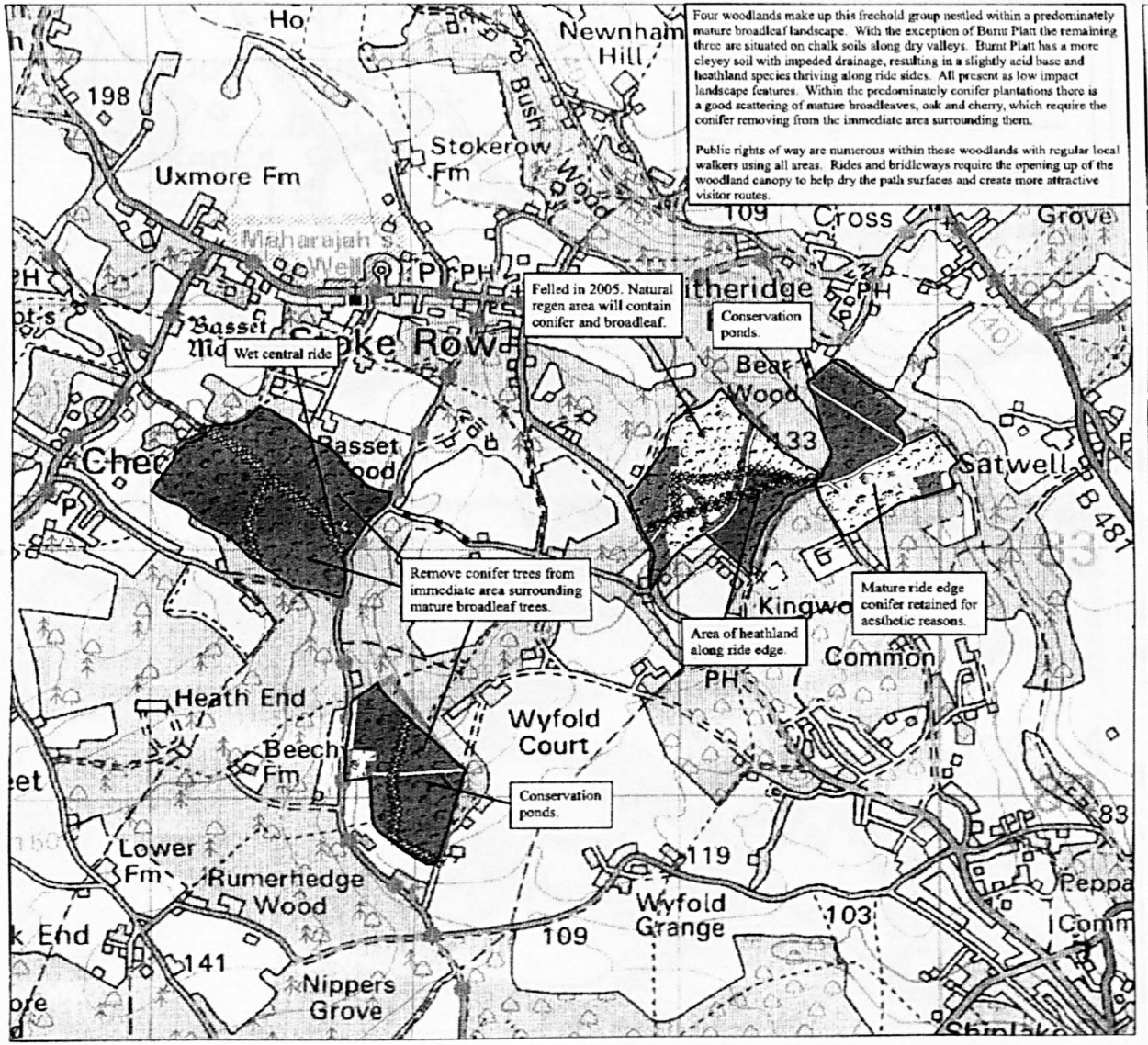

Forestry Commission
England

South East England Forest District

Burnt Platt, Greyhone, Ipsden & Boroughcourt

Design Concept

In keeping with its surrounding landscape these woodlands should revert back to predominately broadleaf with occastional conifer groups for diversity. Open conservation / public access rides with sensitive management around the various ponds.

- Conifer woodland managed to provide a diversity of habitats, landscape interest and marketable timber.
- Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly conifer species at present: >60% of tree canopy cover at 2006).
- Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly broadleaf species at present: >60% of tree canopy cover at 2006).
- Broadleaf woodland managed to create a diversity of species and age classes.
- Mature broadleaf woodland retained for biodiversity and aesthetic value.
- Area managed for special conservation interest.
- Area of permanent open space managed for biodiversity or amenity value.
- Open water
- Watercourse
- Forest road
- Rides and tracks
- Overhead wayleave
- Managed open space and edge habitat alongside roads and rides.

Produced by the Planning Team August 2006

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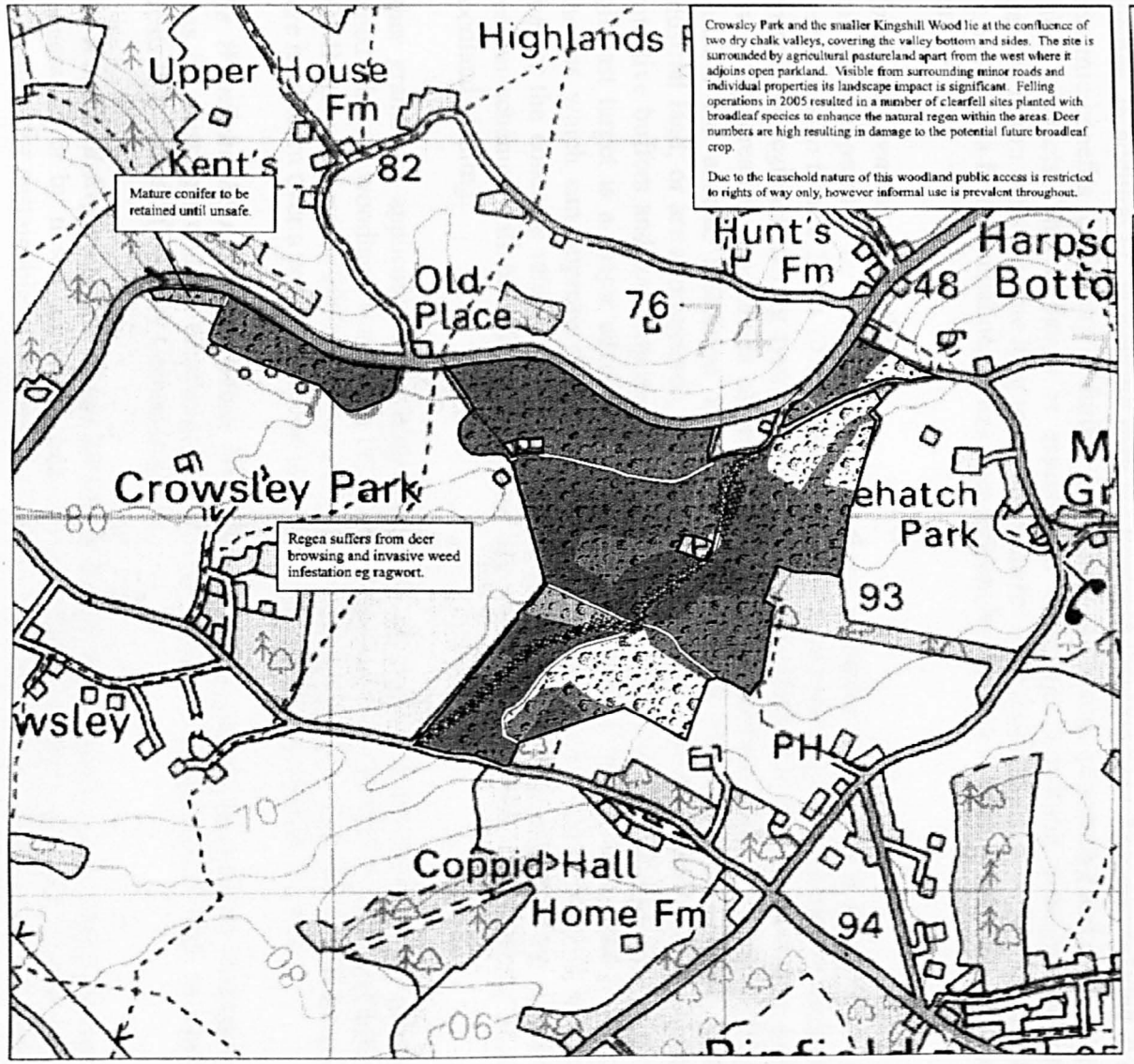

Crowsley Park and the smaller Kingshill Wood lie at the confluence of two dry chalk valleys, covering the valley bottom and sides. The site is surrounded by agricultural pastureland apart from the west where it adjoins open parkland. Visible from surrounding minor roads and individual properties its landscape impact is significant. Felling operations in 2005 resulted in a number of clearfell sites planted with broadleaf species to enhance the natural regen within the areas. Deer numbers are high resulting in damage to the potential future broadleaf crop.

Due to the leasehold nature of this woodland public access is restricted to rights of way only, however informal use is prevalent throughout.

Forestry Commission England

South East England Forest District

Crowsley Park

Design Concept

Broadleaf woodland of mixed species and age structure with open rides and glades. Occasional conifers for potential raptor nest sites.

- Conifer woodland managed to provide a diversity of habitats, landscape interest and marketable timber.
- Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly conifer species at present: >60% of tree canopy cover at 2006).
- Non-native species removed from these areas to create a broadleaf woodland with scattered conifer trees for potential raptor nesting sites. (Predominantly broadleaf species at present: >60% of tree canopy cover at 2006).
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- Area managed for special conservation interest.
- Area of permanent open space managed for biodiversity or amenity value.
- Open water
- Watercourse
- Forest road
- Rides and tracks
- Overhead wayleave
- Managed open space and edge habitat alongside roads and rides.

Produced by the Planning Team July 2006

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Appendix 8 English Woodland Grant Schemes (EWGS)

The EWGS is aligned with Defra's Agri-environment Environmental Stewardship Higher Level Scheme (HLS) within the Rural Development Programme 2007-2013 and at least £190 million is available for EWG schemes and their immediate predecessors (Forestry Commission, f; DEFRA b). There are a range of grants which are covered by this scheme which apply to both creation of new woodland and to various aspects of existing woodland. The overarching aims are to sustain and increase the public benefits derived from existing woodlands and to invest in the creation of new woodlands of a size, type and location that will effectively deliver public benefits.

Another £41 million is for woodland regeneration, SSSI target delivery and partnership schemes. In addition FC is working with the Regional Development Agencies looking at the economic benefits for forestry of further investment in training, processing and marketing of timber products. This initiative is essential to encourage woodland management for a financial return otherwise the long term prospects for large wooded areas as the Chilterns are not based on a firm foundation, as has been evident by the lack of management over the past century.

Woodland Creation Grant (WCG)
This grant appears to be more targeted than those in earlier schemes as it is aimed at land greater in size than 0.25 ha (0.6 acres) (Forestry Commission, g). It is available through a competitive regional scoring system, selecting schemes which will provide maximum public benefit by creating woodlands close to habitation, particularly within the urban fringe; available for access, recreation and sport; will enhance the landscape, restore former industrial land; or are appropriately designed for wildlife, particularly where they can act as protective buffers and link important woodland habitats and other associated natural areas. This last target is a major advance on previous biodiversity targets by expressly funding schemes which can improve the ecology of wooded landscapes. However it is not clear whether the concerns raised by Bailey (2003), who identified poor results from woodland creation schemes will be addressed by the new scheme in relation to the siting of new woodland planting.

Other grants are applicable to existing woodland. In 2007/8, 6,500 hectares of privately owned Chiltern woodland were in an FC grant scheme out of a total of 16,500 ha (Chilterns AONB Annual Review 2007/8). New grants are more competitive and at reduced levels so there is concern over a possible decline in actively managed woodland in the area

The Woodland Management Grant (WMG) provides payments to produce management plans for existing woods to encourage low key sustainable management as well as identify threats to woodland (Forestry Commission, h).

The Woodland Regeneration Grant (WRG) enhances felled areas of woodland by natural regeneration or by new planting, to improve its capacity to deliver public benefit and its opportunity for sustainable management (Forestry Commission, i). This grant will assist in

changing the composition of a wood eg from conifers to broadleaf, but does not allow the inclusion of conifers or exotic shrubs.

The above grants are not for timber production, a change from previous grant provision. They could make a difference in ecological benefits to English woodland.

The Woodland Planning Grant (WPG) has an emphasis on sustainable forestry for timber production, which takes account of biodiversity and landscape (Forestry Commission, j). It is for woodlands which meet the requirements of the UK Woodland Assurance scheme which provides a common standard for UK certification schemes such as the Forest Stewardship Council (FCS). Funding contributes to the cost of producing management plans, thus encouraging those woodlands used for timber production to join the scheme and so ensuring that timber production comes from sustainable woodland.

Woodland Improvement Grant Scheme (WIGS)
These are targeted grants for ancient woodland which pay 80% of standard costs for certain operations and are available in certain areas only (Forestry Commission, k). They were piloted in 2006 and since then have targeted biodiversity issues such as habitat improvement for threatened woodland butterflies or removal of invasive species such as Himalayan balsam (*Impatiens glandulifera*) or rhododendron (*Rhododendron ponticum*) from ancient woodland. In the South East Region they have been available in specific regions and from 2010 are available in the Chilterns.