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Locating new lowland woods

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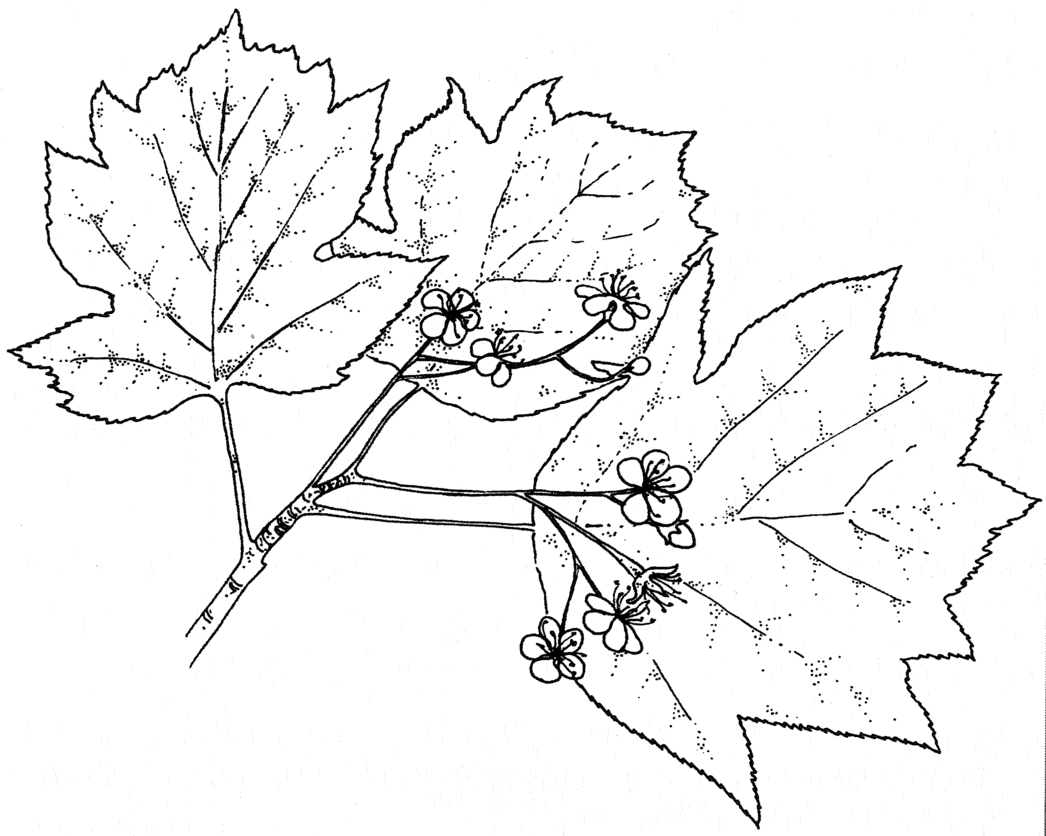

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Locating new lowland woods

G P Buckley & S Fraser
Environment Department
Wye College, University of London
Kent

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PE1 1UA.

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Preface

There is increasing interest in the expansion of woodland in lowland England to meet a variety of objectives. English Nature is keen to establish criteria and guidance for where this new woodland should best be placed. This report was commissioned as part of that process. The views expressed are those of the contractors, not necessarily those of English Nature. Nevertheless we consider that it is a valuable contribution to the debate.

Abstract

Four contrasting lowland regions of England were chosen in order to test their relative capacity to absorb new woodland planting. Representative 10x10km areas were selected from Natural Areas in the East Anglian Plain, Rockingham Forest, the Trent Valley and Rises and the Vale of Taunton and Quantock Fringes in which physical, biological, soils and land use data were collated. Field visits were made to three of the sample areas to obtain an overview of the local landscape and to add habitat detail at a finer scale.

Woodland information was then digitised on to base maps, and new small woodlands progressively 'added' as overlays in alternative spatial arrangements or 'planting scenarios' based on random, envelope, buffering and linking strategies. At the low levels of planting tested (1-2% cover), the constraints to new woodlands were relatively few, with only 12-22% of the land apparently unavailable for planting in the first instance. Existing semi-natural habitat other than woodland was rarely encountered, but the field surveys showed that linear habitat features were ubiquitous and would require careful integration with any new woodland planting. The planting strategy adopted had a significant influence on the agricultural land quality of the parcels selected, with the linking, buffering and envelope plantings associated with ancient woods generally picking out the poorer quality land. Envelope planting based on ancient woodland clusters also appeared to reduce the impact on other wildlife sites and to avoid urban areas.

Landscape fragmentation indices determined for each different planting scenario showed large contrasts in relative woodland isolation, patch size, core and edge area both within and between the different regions. The implications of these indices, when examined from the viewpoint of key species identified in the appropriate Natural Area Profiles, suggested that although there would inevitably be conflicts between species requirements, compromises between both generalist and specialist woodland species might be achieved by adapting the planting scenario to the landscape characteristics of the region. In well-wooded areas, such as Rockingham Forest, adding new woods had little effect on core woodland area, whereas the same area of woodland added via buffering and envelope scenarios effected a dramatic expansion of the woodland core in regions such as Trent and East Anglia, where woods were small and scattered.

The implications for conservation are that, up to a certain density of planting, strategies for Rockingham Forest might favour those scenarios which reduce interwood distances and create conditions likely to benefit edge species, while in poorly-wooded East Anglia, Taunton and Trent, buffering and envelope strategies which increase the core woodland area might be favoured initially. Although woodland planting incentives currently favour the random placement of woods in the landscape, significant gains for conservation might be achieved, depending on the region, by adopting simple targeting strategies such woodland buffering, or devising envelopes based on clusters of ancient woodland habitat.

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1.Introduction

1.1 *Aims and objectives*

New woodland can play a part in promoting nature conservation in most lowland landscapes, but the most desirable distribution and pattern that should be promoted will vary according to that landscape.
This pilot study was commissioned by English Nature (EN) to examine, for four contrasting lowland landscape types, the potential for optimising nature conservation benefits through the creation of new woodland areas. Specific objectives were:

- To assess the effects of new planting on landscape quality and on existing habitats of nature conservation importance,
- To investigate different locational scenarios, using more or less woodland, different patterns of placement (e.g. dispersed, concentrated or linking), on the potential species richness of woodland habitats, before and after planting, in each landscape type,
- To seek the views of other interested parties (Forestry Authority, Countryside Commission, Wildlife Trusts, local planning authorities) on possible planting proposals within each study area,
- To develop a rationale to guide planning, forestry and conservation interests in the formulation of new planting policies which specifically favour nature conservation objectives.

1.2 Literature review

The Countryside Commission's policy statement in which it advocated the doubling woodland cover in England to 15% by 2050 (Countryside Commission, 1993) has been debated vigorously, and especially since this target was endorsed in the former government's 1995 Rural White Paper (HMSO, 1995). Ironically, the positive tone of these statements is set against a context of nationally declining afforestation: although forestry expansion continues, current annual planting rates are only about half that of the government target set ten years previously, and only 25% of that required to achieve the government's 1995 target for England. These changes have come about for several reasons, but principally because of alterations to the tax regulations affecting forestry in the late 1980s, coupled with uncertainty over the future of the Common Agricultural Policy in Europe. The result has been poor uptake of the Farm Woodland Premium Scheme, which achieved less than 50% of available budget in its early years, and the slow progress of the Community and National Forestry programmes set up by the Countryside and Forestry Commissions (Countryside Commission & Forestry Commission, 1989).

Meanwhile the nature and composition of new forestry planting has changed notably, particularly as the shortfall in opportunity for upland planting has been matched by an increased scope for planting on lowland farmland. Broadleaved planting is a particular feature of the Farm Woodland Premium Scheme (Gasson and Hill, 1990) and since 1990 the proportion of new broadleaved planting has increased dramatically, reaching 36% in 1992, compared with <2% in 1980. In 1993 the new area of broadleaved trees planted exceeded that of conifers for the first time since 1920, with broadleaved planting outnumbering conifers by 3.5x in England. This type of planting seems set to continue and, in the right context, offers potential environmental benefits for nature conservation and landscape.

1.2.1 Planting scope

New planting initiatives must take into account the availability of land suitable for tree planting, the attitude of the planning agencies, and environmental and social concerns.

At current planting rates the prospect of doubling England's forest area is by 2050 is remote, barring considerable shifts in agricultural and forestry policy, possibly through the reform of the CAP or the development of a revised suite of agri-environmental schemes. Community Forestry and National Forest schemes, if they achieve their targets, might account for 95,000ha of new planting (<1% of England), leaving a considerable area to be found in the wider landscape, including already designated areas (National Parks, AONBs and Green Belts).

However, based on an economic analysis, Bunce *et al.* (1994) suggested that within England an average of 3% the land area was potentially transferable from agriculture to forestry in the short term. These figures increased significantly if assumptions were made that all woodland work was carried out by farm staff (5%) and if, in addition, current grants were maximised (10%) by planting broadleaved species in small-sized woodland blocks. Nevertheless, there was considerable regional variation and it was also conceded that the results might be less than forecast, since in practice farmers do not take decisions solely on the basis of gross margins between agriculture and forestry: other considerations, such as a farmer's perception of loss of land flexibility, are likely to be of major importance (Watkins *et al.*, 1996).

1.2.2 Planting location

Colin Price refers to the 'structural nihilism', aesthetically and environmentally, of landscapes formed by the untargeted planting efforts of many small landowners and farmers responding, piecemeal, to various grant incentives (Price, in press). This tendency for the random placement of new woodland may prove resistant to broad planning initiatives implied by Indicative Forestry Strategies (Price, 1993), or to landscape and wildlife designations such as Areas of Outstanding Natural Beauty, Natural Areas (English Nature, 1994) and Landscape Character Areas. At the level of the individual planting site there is a wealth of advice available from the Forestry Authority and other organisations dealing with how and where to plant trees or how to manage ancient woodland (e.g. Forestry Commission, 1991-2; Forestry Commission, 1994). Although these guidelines take into account landscape, recreation, conservation, archaeology and environmental pollution issues, they are difficult enough to apply within single land holdings, let alone multiple ownership at a landscape scale. This has been shown by a study of the Farm Woodland Scheme in Britain, based on 100 sample farms and 10 detailed case studies, which concluded that greater landscape benefits could have been achieved, citing in particular the predominantly small scale of plantings in relation to that of the landscape, and the angular boundaries of many of the planting sites themselves (Robertson Gould/CANOPY, 1991).

1.2.3 Conservation implications

Concern has been expressed not only about the loss, fragmentation and replanting of ancient, semi-natural and older woods (Peterken, 1996), but also the potential effects of new planting impinging on other land or habitats of wildlife importance. The latter concern was particularly evident at the time of major afforestation in the uplands (Nature Conservancy Council, 1986), but recently shifts in agricultural and forestry policy have enabled positive conservation measures to be put forward in the wider countryside (RSNC, 1994). These include conservation of existing linking features such as hedgerows, the enlargement of woodlands, and reversing the fragmentation process by providing new 'stepping stone' or corridor plantings between extant woodland or scrub habitats (Spellerberg and Gaywood, 1993; Kirby

1995). In practice, however, little empirical research has been carried out into the conservation benefits of woodland planting in Britain. The study by Robertson Gould of the Farm Woodland Premium Scheme indicated that although new planting had not compromised existing 'good' habitat, some poor choices in species mixtures used were identified and little or no account had been taken of linkages with neighbouring habitat features or the strengthening of the hedgerow network (Robertson Gould/CANOPY, 1991).

The ecological implications of new planting in different regions, represented by five Natural Areas in England, have been explored by Kirby and Thomas (1994). Their study identified the tendency of ancient woodland to survive in clusters, resulting in comparable distances between ancient woods almost irrespective of region: however, when random (planting) positions were chosen, there was wider variation in the distance of these positions from the nearest ancient wood, a result strongly influenced by the degree of woodland cover in each region. This geographical approach forms the basis from which planting strategies for conservation can be developed, but needs to be refined by taking into account a range of other factors, including suitability of site type; differing dispersal abilities of species; woodland size and gap formation rate; edge to interior ratio, etc. (Kirby, 1995).

1.3 *Future planting strategies*

Possible approaches include modelling alternative spatial strategies and differing habitat areas to fit a range of ecological objectives. This approach has been adopted in the Central Open Space project in the Netherlands (Harms et al., 1993), where different spatial scenarios were developed which promoted conditions for different key species of nature conservation importance: a) maintaining existing 'good' habitat patches ('godwit'), b) promoting habitat linkages, improving dispersal for species sensitive to habitat fragmentation ('otter'), c) wilderness formation through land abandonment ('elk') and d) planting up or abandoning selected large tracts of land to achieve maximum species diversity ('harrier'). Such an approach allows the prioritising of specific conservation objectives, particularly with regard to target species such as those identified in Biodiversity Action plans (HMSO, 1994;1995), enabling the success of future planting policies to be judged in these terms. At the same time the populations of more widespread species need to be considered, and more general biodiversity targets achieved, for example by basing the composition and management of the new plantings along the lines of potential semi-natural communities (Rodwell and Patterson, 1994).

A recent report by the Forestry and Countryside Commissions (1997) summarised the responses of organisations and individuals representing local planning, conservation, amenity, landscape and forestry interests to a discussion paper entitled *Woodland creation: needs and opportunities in the English countryside*. Out of 256 respondents, 75% were broadly in favour of new woodland creation initiatives, citing recreation and access, nature conservation and landscape as the major benefits which woodland could deliver (relegating timber production to sixth on the list). Although it was recognised that large-scale planting might be difficult to achieve, the following strategies were put forward:

- linking existing woods with shelterbelts;
- expanding out from existing woodland blocks which are former forest remnants;
- concentrating small-scale woodlands within specific areas to create a mosaics of forest cover.

The conservation implications of these planting strategies are discussed in detail within this report.

2.0 The Study Areas

Four contrasting study areas were chosen in which to explore the ecological and environmental implications of planting new areas of woodland cover. These areas were subjectively chosen from a number suggested by English Nature's local team staff, subject to the following criteria:

(a) a range of landscape types spread across the English lowlands (upland landscapes had been considered in a previous English Nature contract (Good *et al.*, 1997));

(b) very densely wooded regions such as south-east England were avoided. In such landscapes it could be argued that the location of new woodland is likely to be very constrained, its net conservation benefit is likely to be less, and the conservation emphasis is likely to be on managing what is there better.

Single, 10x10km squares were selected from four of English Nature's Natural Areas, as follows:

1. East Anglian Plain - an area of relatively small, isolated ancient woodland (particularly with the widespread removal of hedges). This situation might provide potential to link woodland sites together, or to build on existing woods to buffer them from adjacent arable spray drift, fertiliser etc.

2. Rockingham Forest - an area of scattered large ancient woods, many of them replanted. The focus here is likely to be whether adding to existing woods would be of greater net benefit than planting the landscape in between to create small 'stepping stone' wood patches or corridors.

3. Trent Valley and Rises - a landscape containing virtually no woodland at all. In this instance, one scenario could include planting a large, single new wood to create a significant feature, the shape of which (compact or linear) will have a significant impact over the surrounding area.

4. Vale of Taunton and Quantock Fringes - a landscape containing relatively little actual woodland, but good individual tree cover. Investigation of this situation might reveal whether it is 'better', in conservation terms, to strengthen such tree cover across a wide area, or concentrate on expanding the woodland area.

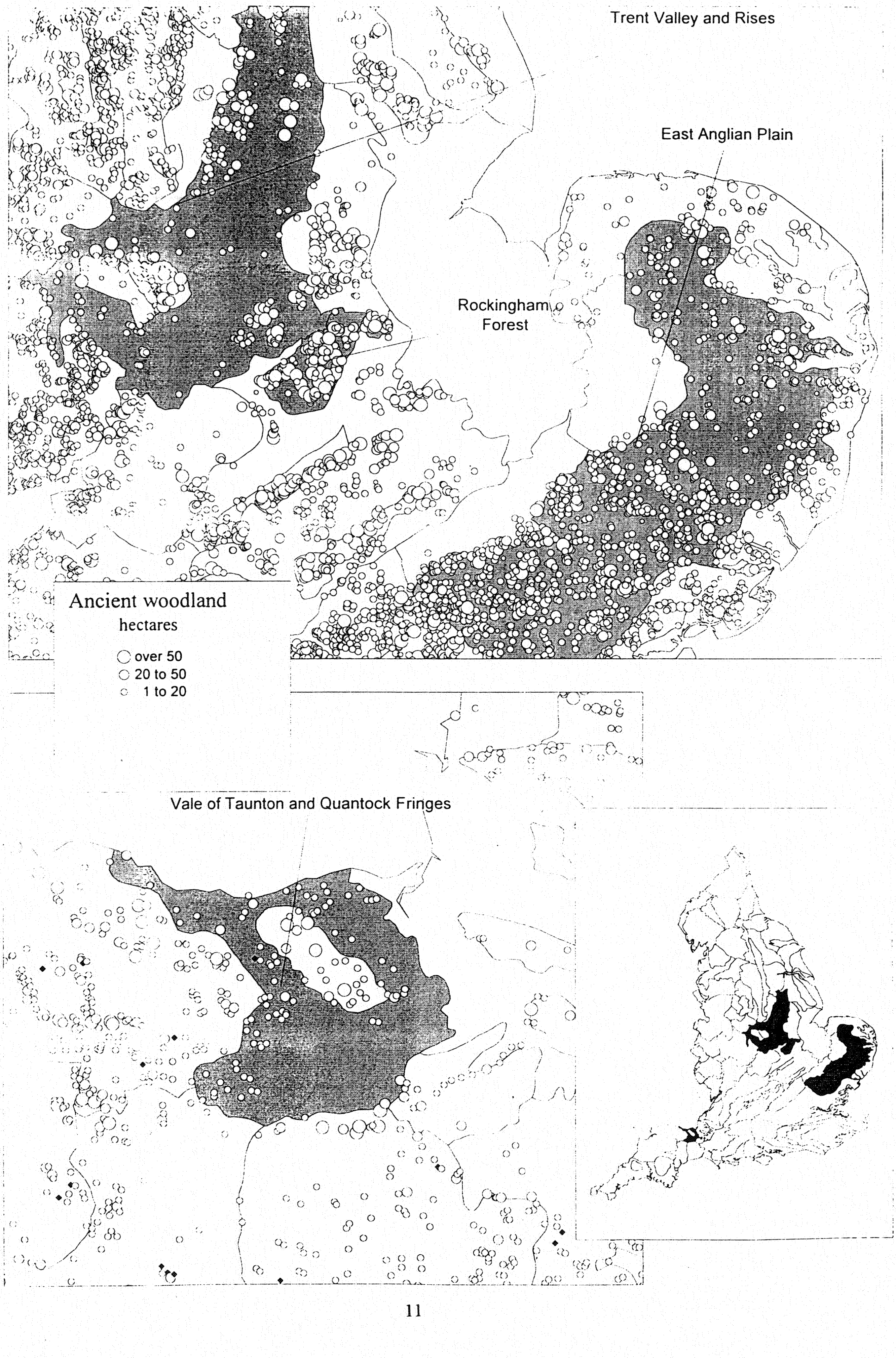
The location of the four Natural Areas with their pattern of ancient woodland cover is shown in Fig. 2.1. A general account of each of these study areas follows, with details of the agricultural background for each relevant county provided in Appendix 1.

2.1 *East Anglian Plain*

This area includes the Countryside Character Area described as the South Suffolk and North Essex Claylands, an undulating plateau dissected by small, steep-sided valleys. Much of the region is overlain by chalky boulder clay, giving rise to medium to good quality agricultural land (Grades 3-2). Small fields still survive in places, with associated hedges and copses, giving a wooded appearance to the landscape. Woods of ash, oak and field maple are common, with occasional hornbeam and small-leaved lime. Elsewhere modern arable field patterns, reinforced by losses of tree cover through Dutch elm disease, have created an open landscape providing habitat for grey partridge, corn bunting and quail. The focus of the study area is within Babergh District, where the broad valleys created by tributaries of the Stour contain pastures and fenland supporting wetland invertebrates, wading birds, snipe and barn owl. Livestock ponds and ditches, surrounded by trees and scrub, support the great crested newt and other amphibians.

The East Anglian Plain has high importance within England for its ancient woods in terms of the amount of cover and variation in stand types. There are about 1000 ancient woods more than one hectare in size (English Nature, 1997a) covering about 7,200ha. The South Suffolk and North Essex Claylands have

Figure 2.1 Natural Areas selected for the study, showing the pattern of ancient woodland



three times the density of woods, and also larger woods than either the Mid Norfolk and the South Norfolk and High Suffolk Claylands. These woods have a long tradition of coppice management and are amongst the richest in Britain for flowering plants, with oxlip, wood millet, wood sorrel and herb paris confined to ancient sites, together with trees such as wild pear, small-leaved lime and wild service. Typical stand types are of ash-field maple (W8) and oak-bramble (W10) woodland, the former being found on the chalky clay soils and often containing small-leaved lime in the east of the South Suffolk and North Essex Claylands.

Suffolk County Council recognises that the management of existing farm woodlands remains a concern, despite the success of the Anglian Woodland Project which for several years has promoted and developed new markets for small woods, especially charcoal. However, about 80% of woods less than 10ha in size remain neglected and many are overgrazed by roe, fallow or muntjac deer. One community woodland has been designated near Sudbury and other acquisition projects, notably the Woodland Trust *Woods on your doorstep* initiative, are receiving county council support. In the past the county council has tried to resist large scale plantings in river valleys, but it supports in general the objective of increasing tree, not just woodland cover (P. Holborn, pers. commn.). English Nature also includes within its Natural Area Profile document objectives for expanding the woodland resource, for example by planting bushy hedges and scrub to link ancient semi-natural woods with other woods to permit movement of species, or surrounding ancient woods with grassland or scrub to increase habitat diversity and reduce edge effects.

2.2 *Rockingham Forest*

An ancient royal hunting forest, Rockingham remained unsettled and heavily wooded until medieval times. This cover was gradually eroded, accelerating markedly after the loss of its royal status between 1796 and 1814, but today woodland still covers 11% of the region compared with 5% in the county as a whole. Rockingham is recognised as a distinctive landscape character unit within Northamptonshire (Northamptonshire County Council, 1997a; Cobham Resource Consultants, 1992). The area, which extends from Kettering to King's Cliffe in the north of the county, has a plateau-like landform dominated by large tracts of plantation woodland, much of which is former ancient woodland (Peterken, 1976). The 1980 County Structure Plan recognised the inherent attractiveness of the local landscape by designating Rockingham Forest and the Lower Nene Valley as one of ten Special Landscape Areas in the county.

Soils are generally heavy and poorly drained, being derived mainly from calcareous boulder clays over Jurassic limestone bedrock consisting of Inferior Oolite, Great Oolite and the Cornbrash. The Inferior Oolite and underlying Middle Lias strata include ironstone, which has been quarried in the region since the medieval period. Where the oolite outcrops the soils are well-drained, neutral to calcareous loams. Most of the area is classified as Grade 3 agricultural land and is predominantly arable (winter cereals), although in places supporting dairying on improved pasture.

The land is gently undulating with several smaller streams feeding the rivers Welland and Nene. Both maritime and continental climatic influences are important, with winds predominantly south-west to south-south west. Annual rainfall is typically 600-800mm, the east being drier than west. Views are constrained by woodland on all horizons, with some very large woodlands exceeding several square kilometres. In planning guidance provided by the local authority (Northamptonshire County Council, 1997a;b) there is a strong presumption that the woodland area should be expanded and even restored to the degree of cover (25%) thought to exist in the seventeenth century.

New planting opportunities have been identified by the local authority on farmland, where 1-3ha blocks, mostly broadleaved and mixed, currently typify the Farm Woodland Scheme and its successors, with natural regeneration and planting being suggested for old ironstone workings (where this does not conflict with limestone grassland habitat). It is recognised that the scale of the landscape demands that some new woodlands should be very large. To fulfil wildlife objectives, careful placement of new woods, locating them adjacent to existing woodland habitats (buffering), or linking them to other habitats is suggested. Restocking of the plantations on ancient sites with native, broadleaved trees is advocated, together with the restoration of parkland and wood pasture where this still exists. Lists of suitable native trees and shrubs are provided and are presented later.

The Rockingham Forest Natural Area profile (English Nature, 1997b) recognises ancient, semi-natural broadleaved woodland as the major habitat resource, consisting mainly of wet ash-maple woodland with elm (wych and English) and small-leaved lime occurring locally. Many of the woods were formerly coppiced and support notable butterflies, fungi, epiphytic lichens, deadwood beetles and other woodland invertebrates. The rich ground flora and shrub layer of these woods provide habitat for dormice and birds such as woodcock, nightingale and sparrowhawk. Other, non-woodland habitats of note include unimproved calcareous and mesotrophic grasslands, bryophyte-dominated springs, valley mires, swamps and marshes, watercourses and flood meadows. Lists of 'priority species' associated with all these habitats are included in the Natural Area profile, which also gives 'visionary objectives', including restoring coppice management to 20% of the remaining habitat, restoring coniferised ancient woodlands to broadleaved mixtures, and promoting the conversion of historic parkland from arable to grassland in order to benefit veteran trees and their associated species.

2.3 *Trent Valley and Rises*

The area concerned is that known as the South Nottinghamshire Farmlands or Trent and Belvoir Vales region (Nottinghamshire County Council (1997c) and English Nature (1997) respectively), a prosperous farming area with a simple rural character comprising large arable fields, village settlements and broad alluvial levels. To the south-east, the escarpment dips towards the flat claylands of the Vale of Belvoir, which has its own strong tradition of dairying, large-hedged fields and small rural villages. In the South Nottinghamshire farmlands, over 80% of the land is under arable cultivation and is regarded as some of the most productive agricultural land in the county.

South of the river Trent, the predominant geology is Triassic, consisting of Mercia mudstones with occasional bands of hard sandstone or 'skerries' which pass into shaley Rhaetic beds along the south-eastern boundary of the region. Alluvium is deposited into depressions between narrow mudstone ridges rising 5-10m above the surroundings, forming clayey and relatively poorly draining, sometimes peaty soils along watercourses such as the rivers Smite and Devon. In contrast, over the mudstones the soils are much better drained and good for ploughing, forming stony, sandy loam brown earths of agricultural grade 2-3.

The region has been extensively cultivated since before Domesday records, but field enclosures date mainly from the sixteenth to the eighteenth centuries. These have since been eroded by post -1945 agricultural practices, and the woodland cover also reduced to less than 2%. In the Village Farmlands sub-region the landscape is rolling, with large arable fields enclosed by low, gappy but neatly trimmed hawthorn hedges. There is a sparse distribution of hedgerow trees and scattered, straight-edged blocks of broadleaved trees, with occasional lines of willows along ditches. The Alluvial Levels are in contrast flat, uninhabited and open landscapes, with few remnant hedges and occasional geometrical plantations and game coverts. Most water courses have been canalised - the river Smite was brought under control to prevent flooding in the 1790s - and now have little distinctive riparian character.

The county landscape strategy recognises Mature Landscape Areas (MLAs), developed in 1990 and defined as 'areas of countryside least affected by intensive arable production, mineral extraction, commercial forestry, housing , industry and associated infrastructure' (Nottinghamshire County Council, 1993-4). These cover 13.5% of the county (9.5% outside the Dukeries/Sherwood Forest area) and contain one or more of the following: mature deciduous woodland, intact field patterns (including species-rich hedgerows), permanent grassland, heathland or parkland, and mature watercourses with riparian tree and shrub cover. In the South Nottinghamshire Farmlands the MLAs tend to fall on isolated areas of mature parkland and historic, small-scale pastoral landscapes adjacent to villages.

New tree planting within the South Farmlands region needs to be sensitive to the existing landscape pattern by strengthening enclosures and boundaries where they occur along existing hedgerows, parish boundaries, footpaths and bridleways (Nottinghamshire County Council, 1997). It is recommended that woodland blocks should not exceed the general enclosure scale or impede views into the medium distance. For the alluvial levels, similar restrictions apply, enhancing visual unity through small-scale woodland planting and strengthening the traditional pattern of hedged fields. Restoration of the riparian character of the watercourses can also be addressed by returning strips of arable to grassland and naturally regenerating or planting riparian trees and shrubs, or small-scale woodlands, along the river channel. Lists of suitable trees and shrubs are given in the county landscape guidelines.

Due to intensive arable production, only a few pockets of neutral and calcareous grassland remain in the region (English Nature, 1997c), the latter having developed on limestone or gypsum quarries, spoil heaps and railway cuttings. Woodland is extremely fragmented and ancient woodland is rare, but small game coverts planted in the 19th century and more recently provide some wildlife refuge from the surrounding agricultural land. The farm habitat itself is important for the brown hare and bird species such as lapwing, skylark, linnet and barn owl. The maintenance of hedgerow boundaries is vital to some birds, including grey partridge, turtle dove and tree sparrow, and butterflies such as the white letter, purple letter and black hairstreaks. Objectives for nature conservation within the Natural Area include restoring permanent grassland (especially adjacent to rivers and streams), encouraging mixed, traditional farming, restoring hedgerows and increasing the area of native broadleaved woodland.

2.4 *Vale of Taunton & Quantock Fringes*

The Natural Area occupies the low ground between the Quantock Hills, the Brendon Hills and Exmoor and the Blackdown Hills, extending east of the Quantocks to meet the Somerset Levels (English Nature, 1996). The countryside is gently undulating, mostly between 50 and 100m OD except in the lower-lying part of the River Tone floodplain and the Somerset Levels. The streams and tributaries of the Tone have narrow floodplains in small, winding valleys, accentuating the undulating nature of the land. The Natural Area has a very equitable climate, with rainfall fairly evenly distributed around the year and shelter being provided by the surrounding hills.

The geology of the area is extremely varied, consisting of Permo-Triassic pebble bed conglomerates (breccias and sandstones) in the south and west, with calcareous and silty mudstones and marls further east and north. Alluvium occurs along the Tone and its tributaries. Soils derived from these parent materials are highly fertile and typically form Grade 1 or 2 agricultural land, suitable for intensive dairy and beef cattle production, with sheep to a lesser degree. In parts of the area there has been a shift to winter cereals, but market garden crops and vegetables are grown in the richest soils on level ground. The overall pattern of land use has created a landscape predominantly of small fields with thick hedgerows, with hedgerow trees creating the illusion of a well-wooded region.

Much of the area south of the Quantock Hills falls into the jurisdiction of Taunton Deane Borough Council. Three main components of landscape character comprise the study area selected: Low Vale, High Vale and the River (Tone) Flood Plain (Taunton Deane Borough Council, 1997). Low Vale is a fertile agricultural zone with intensive arable production. Copses on higher ground accentuate the gently undulating ground, but existing tree cover is limited and is mainly present as hedgerows and small copses. Tree and hedgerow species are similar to the two other areas. In High Vale, existing tree cover is restricted to mid-sized copses and riverside areas (alder, willow) and hedgerow trees (ash, oak). Planning polices encourage planting on steep land. Hedges consist of field maple, silver birch rowan ,cherry, hazel, hawthorn, holly and blackthorn. Corridors of mixed shelterbelts and hedges which extend down slopes from ridge top woods to valley bottoms are emphasised as an important resource. The western and north-western part of High Vale is included as part of the Special Landscape Area designated in the County Structure Plan, covering the area between Exmoor National Park and the Quantocks.

Along the River Flood Plain, tree cover is described as fair along banks and includes grey poplar, black poplar, white willow, crack willow, ash and oak, but regeneration is poor and could usefully be supplemented by planting (subject to approval by the Environment Agency if closer than 7m from bank of the Tone). There is possible scope for biomass schemes due to the high water tables, but careful planning is needed to avoid wetland habitats. The River Tone is also being considered as a recreational and wildlife resource.

The Taunton Deane Nature Conservation Strategy (Taunton Deane Borough Council, 1997) and Biodiversity Action Plan (Somerset Environmental Records Centre, 1997) both provide detailed accounts of the wide variety of habitats within the district: 9.2% of the area consists of semi-natural habitat within SSSIs and County Wildlife Sites. The importance of the farmed landscape is emphasised (90% is indicated as farmed, notably higher than that given for the rest of the county, of which 65% is grassland and 3% farm woodlands). Key habitats within the Taunton Vale are wet woodlands, lowland wood pasture, ancient and species-rich hedges, lowland hay meadows, lowland heath, floodplain grazing marsh, fens, reedbeds and standing water. The river Tone supports a wide range of flora and fauna, including the greatest concentration of kingfishers in Somerset: other species mentioned are reed warbler, reed bunting, white-clawed crayfish, great-crested newt, otter, water vole, marsh fritillary butterfly, black poplar and southern marsh orchid.

As already mentioned, woodland within the Vale is relatively sparse but the hill tops and ridges of the High Vale typically support oak and ash coppices which extend down to the valley bottoms dominated by willow, alder and aspen via a dense network of thick hedges. These woods support birds such as nightingale, wood warbler and redstart, and also the wood white butterfly and the dormouse. Hedges are considered an important extension of the woodland resource and some 35% (4,160km) are thought to be of significance in Taunton Deane, compared with 17.5% nationally (Somerset Environmental Records Centre, 1997). Dormouse, common shrew, brown hairstreak butterfly, old lady moth and double line moth are all associated with this habitat in the study area. Elsewhere, the agricultural land supports barn owl, skylark, brown hare and badger.

47 species are identified in the Natural Area draft report (English Nature, 1996), none of which is listed as depending exclusively on woodland habitat. The detail and accuracy of the habitats described might be questioned, but the information is useful in that it highlights combinations of habitats (such as woodland and grassy edges) which may be of importance for certain species and might therefore influence decisions about the locations of new woodlands. Habitat Action Plans for Taunton Deane indicate the expansion of broadleaved woodland in targeted areas to form links and buffers with existing broadleaved woodland SSSIs and CWSs. Other Borough Council literature generally encourages new planting, especially in High Vale in field corners and on steep land, and gives lists of suitable species for each landscape character area in woodland, woodland edge, hedgerow and riparian situations.

A total of 20 NVC records reveal the following types of woodland present in the Natural Area: W4, W6, W7, W8 and W10. No NVC types were recorded as being of national significance but W4, W7, W8, and W10 are mentioned as locally significant. English Nature gives 'medium priority' to coppice restoration and 'local priority' to both wet and mixed oak woods, with 'national priority' placed on upland oak woods. The potential for large scale woodland expansion is considered high.

2.5 *Conservation quality of Natural Area woodlands*

The conservation quality of woodlands within each Natural Area generally is summarised in Table 2.1. A combination of criteria, including the total amount of ancient woodland, its semi-natural status, cover and variation in stand-type have been used to compare each Natural Area (Kirby & Reid, 1997). On the basis of ancient woodland cover Rockingham and Trent Valley score highly, but Rockingham has a lower variety of stand types recorded in the National Vegetation Classification (NVC) compared with Trent. Overall, however, the conservation values of Trent and Rockingham are highly rated when all criteria are summed. As these are area-influenced assessments, in the case of small individual study areas (e.g. Trent) the overall quality of the habitat locally may be strongly at variance with the overall Natural Area assessment, as illustrated below.

Table 2.1 Overall conservation assessment of woodlands in the four Natural Areas (from Kirby & Reid, 1997)

Natural Area	Total area of ancient woodland	Area of ancient, semi-natural woodland	% cover of ancient woodland	NVC significance	Overall assessment
51 East Anglian Plain	<2,000ha	<1,000ha	<1.5%	low significance	some
45 Rockingham Forest	2,000-10,000ha	1,500-4,500ha	4.5-18.0%	low significance	high
33 Trent Valley & Rises	2,000-10,000ha	1,500-4,500ha	<1.5%	>5 NVC types	high
88 Taunton Vale & Quantock Fringes	<2,000ha	<1,000ha	<1.5%	low significance	some

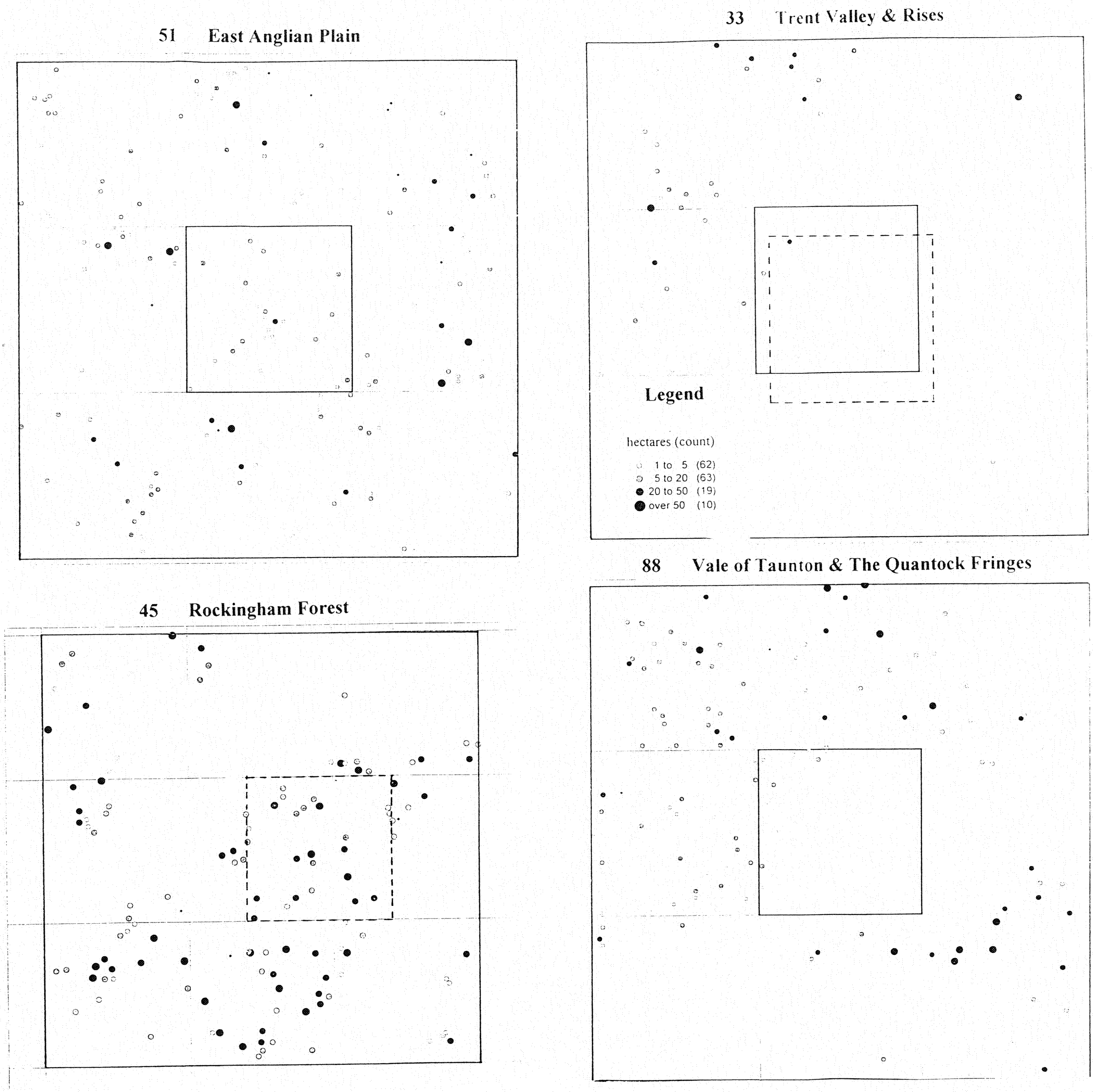
2.6 *Profiles of sample 10x10km squares*

Sample 10x10km squares were selected for detailed study from each Natural Area. The distribution of ancient woodland in the immediately surrounding area was fairly typical of that in the sample square itself for the East Anglian Plain, while that of the Trent Valley was situated in the relatively poorly wooded Trent and Belvoir Vales, south-east of the clay farmlands to the north and west of the Trent which have more woodland cover (Fig.2.2). The Rockingham Forest sample square fell well within the outline of the Natural Area shown by the block of dense ancient woodland running south west to north east, and the poorly wooded Vale of Taunton square picked out the sparsely wooded valley of the Tone, with some woodland on the High Vale shown to the north and west.

2.6.1 East Anglian Plain (TL 9004)

The sample area was situated north-west of Sudbury in south Suffolk. The landscape is undulating with broad valleys cut by tributaries of the Stour, notably the river Brett, which run diagonally from north-west to south-east across the 10x10km square. Although the woodlands are well-scattered over the area, ancient woodlands in particular tend to follow these valleys, forming local clusters. Agricultural quality of the region is relatively high, with at least on-third of the area consisting of calcareous pelosols and stagnogleyic argillic brown earth soils of the Hanslope and Ashley Association, yielding Grade 2 land.

Figure 2.2 Distribution of ancient woodland in and around the four study areas



2.6.2 Rockingham Forest (SP 9490)

The sample square falls entirely within the County Council's Rockingham Forest Landscape Character Area and is also included in the majority of the Rockingham Forest Lower Nene Valley Special Landscape Area. Its major feature is the very large area of ancient and ancient, replanted woodland, separated by large arable and grass fields and interspersed with minor settlements. Willow Brook rises in the south west, runs north to the mid-point of the study area, then flows towards the south east where it joins the River Nene. Woodland cover is distributed fairly evenly throughout, the notable exception being in the north east around Kings Cliffe (and the site of a former airfield), between significant blocks of ancient replanted woodland to the north west and south east. Smaller woodlands are scattered in two main bands running approximately north-south in the two halves of the sample square, with many to the west being associated with the Willow Brook and its tributaries.

There are no major settlements within the sample area (although there are several within 10km which are well served by the existing large woodlands within the Rockingham Forest area) but many small villages and hamlets are spread fairly evenly throughout the Study Area. The most significant transport corridor is the A43 (Corby to Stamford) running north - south in the east of the sample area. A disused railway is the only other major corridor, running east to west. Weldon Airfield to the south west is also of note since it could represent a constraint to new woodland planting.

2.6.3 Trent Valley and Rises (SK 7137)

Woodland is sparsely distributed, the only concentration being in the north west of the sample area, closest to the River Trent. Several minor clusters are found around the settlements, especially in the vicinity of churches and parkland areas. Shooting and game interests feature very strongly in the secondary woodland patches planted on farmland, but there are several blocks where no woodland exists over tracts of 4-6km^2. The woodlands are split fairly evenly between broadleaved and mixed, with the mixed woodlands tending to be around 1ha larger, and located on higher ground. Ancient woodland only occurs in the north west part of the study area (Shipmans wood), as a linear strip along the steep slopes flanking the flood plain of the Trent. This consists predominantly of ash-field maple with wych elm, the latter now largely defunct through Dutch Elm Disease.

2.6.4 Vale of Taunton & Quantock Fringes (ST 1020)

The area is located in the south west of both the Natural Area and the county of Somerset, to the west of Taunton and incorporating Wellington in the south. Running from the south-west to the east, with numerous tributaries bordered by moderately undulating land in the North west, the river Tone is the major feature. Soils are generally clay-rich with restricted drainage on flat and receiving slopes, but the pattern is complicated due to geology and relief. Grade 1 and 2 land is abundant on the upper parts of moderately steep slopes in the west and north-east, with grade 3 land dominating the south-east corner around the river Tone, with the exception of some grade 2 land. Grade 4 and 5 land is present but makes up only a small proportion of the total agricultural land, occurring on very steep slopes or on poorly drained land around the western Tone Valley and its tributaries to the north.

Wellington, to the south-west of the study area, is the largest single settlement, but numerous villages and hamlets are spread fairly evenly throughout the study area. Large urban areas in the vicinity of the study area include Taunton which is well served by the large areas of woodland in the Quantock Hills such as 'Great Wood' around 20km away. Major transport links tend to utilise the low ground in the river valley and tributaries (especially rail, some of which is now disused) and there is a convergence of powerlines in the eastern part of the study area, presenting a considerable constraint to any north - south corridor planting.

A broad band running from the south west to the north-west of the sample square is designated as a Special Landscape Area by the county, which 'merits special efforts to conserve its character'. This is to be achieved through tight development control and unspecified positive measures, which may include tree planting. Woodland cover is concentrated mainly in the west and the north east, with large groups of small woods forming a dominant feature. Very little woodland (only 7 blocks) is located in the south east and this corresponds with the low-lying river flood plain area. Larger woods tend to be associated with steep land or wetter streamside areas. The smaller woods comprise mainly simple geometric shapes located in field corners or intersections of boundaries, especially at valley bottoms and scattered in a random fashion within the broad groups identified above.

3.0 Methods

3.1 *Desk-top data collection*

3.1.1 Map information

Ordnance Survey pathfinder maps (1:25,000) were obtained for the four study areas. This scale provided convenient coverage of each 10x10km (40x40cm) sample area, giving sufficient detail of woodland and field patterns and indicating footpaths and bridleways for field survey purposes. Some maps, however, were up to ten years out of date, leading to minor discrepancies relating to rights of way, the removal of field boundaries, and the planting of new farm woodlands.

A series of overlays was prepared to show a range of features and information. All were drawn on to A2 clear acetate using permanent overhead pens, and every woodland on the map larger than 0.25ha numbered. Each woodland area and approximate perimeter was measured using an overlay grid noting the predominant woodland type (broadleaved, coniferous or mixed) and its origin, the latter by reference to the relevant county Ancient Woodland Inventory, and shaded to reflect the ancient, semi-natural or ancient, replanted status. The accuracy of this information was also checked by reference to English Nature GIS output of the sample area and the surrounding eight 10x10km squares. Some revision was needed, but this was mainly due to the sample areas straddling county boundaries or the placement of samples astride the national grid.

For three 10x10km sample areas, excluding the Vale of Taunton and Quantock Fringes, all woodland information was digitised at a scale of 1:25,000, using a raster (SPANS) GIS system. Adjacent land features within 500m of each woodland were noted, together with woodland shape and height above sea level. In many cases the adjacent land use was agriculture, but other features such as streams, ditches, other woodlands and churches were also noted. Height was taken to be that of the nearest contour available (in relatively flat landscapes) or the one in the approximate centre of the woodland (in undulating landscapes) or for large woodlands. The maximum and minimum height values were noted to provide a range to place the results in context. Woodland shape was recorded using standard or derived geometric outlines to describe some of the specialist shapes represented. This information not only enabled the main types of woodland to be characterised, but also allowed typical shape profiles to be used in building new woodland planting scenarios. Nearest neighbour distances were measured by hand using an overlay marked with the ancient woodland boundaries. All distances related to the nearest available woodland within the study area only (i.e. if one was outside the boundary it was not considered), recording the minimum edge-to-edge distance in kilometres.

Finally, Agricultural Land Classification (ALC) maps were reproduced by tracing and enlarging the appropriate section of the one inch map (HMSO 1960,1966 &1969) and redrawing onto the larger scale. Soil associations present in the study areas were also recorded from the relevant 1:250 000 sheet of the Soil Survey of England and Wales (1993).

3.1.2 Habitat, wildlife and planning data

Habitat and wildlife data were requested from several agencies, including English Nature, the relevant County Wildlife Trusts, local planning authorities and Biological Records Centres. Information received included the SSSI citations, Phase 1 maps at a scale of 1:10 000 and target notes, County Wildlife Site maps at 1:50 000 scale, and biological/ecological records held by the planning department plotted at a scale of 1:50 000. This mismatch between scales and levels points to the need for a consistent and reliable source of data in the application of any expert system. Planning information included designations of

AONBs, Special Landscape Areas and local and regional designations produced by the Local Authorities, together with descriptions of landscape character and proposed action plans.

3.2 *Constraints to, and opportunities for woodland planting*

From the information collected above it was possible to define a variety of constraints and opportunities relevant to new woodland planting initiatives in the four sample areas. These included the presence of good quality semi-natural habitat, high-yielding agricultural land, and positive planting opportunities recognised in planning proposals for some of the landscape character areas.

3.2.1 Agricultural land quality

The Agricultural Land Classification (ALC) provides a useful framework for the grading of land, according to its agricultural quality, into five grades reflecting the limitations imposed by chemical and physical characteristics (climate-rainfall, transpiration, temperature and exposure, slope, soil wetness, depth, texture and structure). These limitations may affect the yield, the consistency of the yield, the cost of obtaining it and the range of crops that can be grown (ALC, 1974). In the context of planning new woodlands the ALC grade gives an indication of the order of opportunity cost for planting at any particular point (although minor variations on the ground and availability of specialist equipment may affect this) and thus provides a useful 'economic constraint' that can be applied at a standard level across the study areas or relatively within one.

Information was also sought on the size of holdings, the type of crops grown and the amount of existing woodland on agricultural holdings for the relevant counties through the MAFF census (MAFF, 1995; see also Appendix 1). This supplemented the Agricultural Land Classification data and helped to develop profiles of those areas most likely, or otherwise, to enter any government planting scheme such as the Farm Woodland Premium Scheme. Factors such as the critical size of holding required before woodland is planted, and the main use of the land in determining what might be available or offered, were assessed with reference to previous studies on farmers behavioural patterns in response to planting incentives (e.g. Gasson & Hill, 1990)

3.2.2 Existing Wildlife Habitat

Use of the Natural Area Profiles provided by English Nature's local teams for each study area, depending on the extent to which the Natural Area and the sample 10x10km area conformed, provided a good overview and relevant listings of important species and habitats. Natural Area reports also provided information on the NVC types under threat or under-represented (Kirby & Reid, 1997). Phase 1 data and County Wildlife Site lists also indicated existing "good" habitat of high conservation value likely to be a constraint to tree planting (for example on unimproved grassland or heath), but also highlighted opportunities to build on complementary habitat features (e.g. woodland or grassland) which might combine to provide a habitat suitable for a particular species requirements.

3.2.3 Local Authority & Statutory Designations

Local authority designations and guidelines, often resulting from preconceived landscape character zones, might tend to discourage planting in certain parts of the sample area. On the other hand, positive initiatives for planting were highlighted in planning literature and lists of suitable native tree species for each area was provided. In some areas Community Woodland Supplement (CWS) is available from the

Forestry Authority to encourage the creation of new woodlands close to towns or cities for informal recreation. Grant rates are £950 per ha and there is also an additional locational supplement for targeted areas. There is no indication of the population level that might be required but sizes of nearby towns and villages are relevant. It is more likely that a planting application will be successful where the local authority has promoted a specific area, as for example in Suffolk where the County Council has prioritised the creation of community woodland around the site of a former airfield in the extreme west of the sample 10x10km area.

3.2.4 Pattern of land ownership

Land ownership profiles are critical to any discussion of land use change, but have not been considered in this study. An assumption is that most planting will be on agricultural holdings and therefore subject to a rational economic decision, although in the case of other types of owners this may not be so important, e.g. public bodies, private estates etc. The pattern of land ownership and the relative willingness of various groups of owners to plant is nevertheless a major constraint in the sympathetic positioning of new woodlands from a conservation point of view. This problem will be accentuated where desirable planting locations straddle several owners, and is more likely to occur in areas where there are many small holdings. On the other hand, if a single large land owner is unwilling to plant, the effect could be equally unbalanced.

3.2.5 Other factors

The reality of much of the lowland study areas, and perhaps the lowlands in general, is that even after disregarding land because of habitat or Agricultural Land Classification constraints there are still practical obstructions such as wayleaves for overhead powerlines to consider. In the Trent 10x10km sample, for example, several powerlines emanating from one point and running parallel to each other might hinder attempts to establish woodland corridors at right-angles, (although some scrub or coppice cover could be maintained where a corridor or buffer was essential). Approach paths to airfields and the non-agricultural use of land in mineral extraction fall into similar categories.

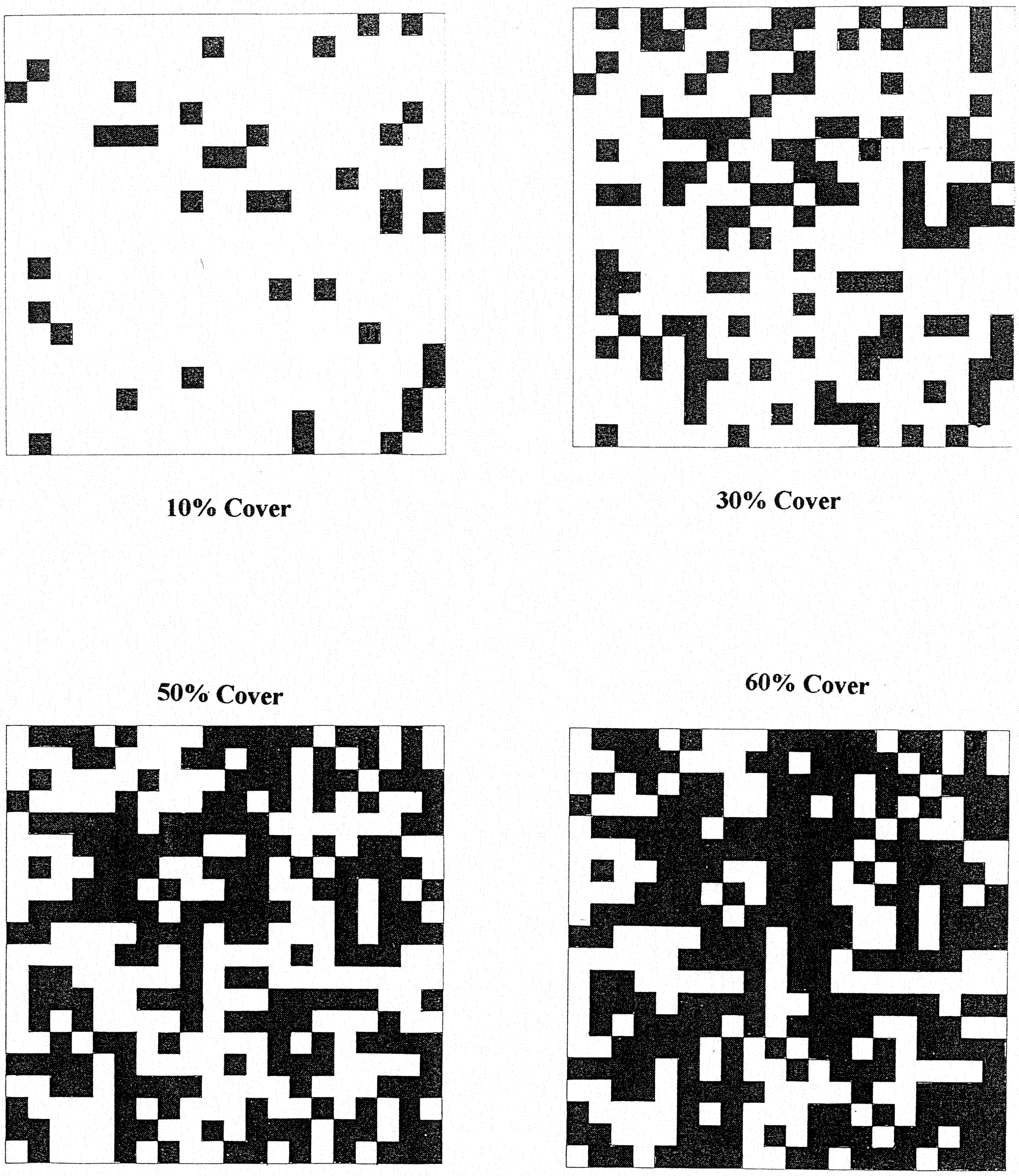
3.3 *Developing planting scenarios*

3.3.1 Planting density

A theoretical case in which woodland blocks are progressively and randomly added to an unplanted landscape is illustrated in Fig. 3.1. At low levels of cover up to 10%, few clusters of woodland form with the majority remaining as isolated, scattered blocks. However, at 30% cover the majority of woods coalesce into larger patches where their mean distance apart is dramatically lowered, leaving only about 10% of the original patches unjoined. Between 50 and 60% cover the patches fuse almost totally, giving virtually contiguous cover over the entire landscape. The full results of this exercise are presented in Section 4.4.

For the four 10x10km sample areas more modest planting targets of 1-2% were considered. As a starting point in the evaluation of different woodland planting strategies, 100-200ha of new planting was 'allocated' as 50-100 separate, 2ha blocks. Small block planting was chosen as it corresponds closely with the responses of landowners to the Woodland Grant and Farm Woodland Premium Schemes in many lowland counties of England. Using this basic strategy, a number of woodland planting scenarios were investigated in more detail using random, envelope, buffering and linking approaches described below.

Figure 3.1 The effect of progressivley adding single, one hectare woodland blocks (shown simply as squares) at random to an unplanted 2x2km landscape.



3.3.2 Random Planting

Planting sites of 2ha blocks were allocated randomly, to mimic a 'pepperpot' pattern of uncoordinated planting by local landowners. The shapes used were based on existing wood outlines within each sample area. This was done by listing all woodlands under 2ha in each study area, and using the main shapes (found in >20% of cases) in the approximate proportions that they occurred in the study area. For example in Rockingham the typical shapes were triangular, oval and square in equal proportions.

The Ordnance Survey grid was used to locate the main and subsquare for each potential planting point, based on random numbers. Using all four constraint overlays (ALC, wildlife sites, ancient woodland and administrative designations), points were allocated, noting whether the site was available for new woodland planting, or if some constraint, such as a road, existing semi-natural habitat or high quality agricultural land intervened. Random numbers were used until all the required planting positions had been allocated. Where applicable, the adjacent land use and ALC were also noted for each random point. Following allocation, the new woodland shapes were digitised at a scale of 1:25,000 as an overlay and added to the existing woodland GIS files.

3.3.3 Envelope, zone and stepping-stone planting

Envelopes were defined within sample areas as potential areas for targeted planting. The criteria for drawing these envelopes were existing woodland clusters, but designations based on other natural features or local planning authority strategies could have equally been used. In the case of Rockingham, envelopes were drawn around the extremities of ancient (semi-natural or replanted) woodland areas within 1km of each other, ignoring recent woodlands. This produced five separate envelopes or potential planting zones. A similar exercise for the East Anglian sample also produced five envelopes. The lack of ancient woodland in the Trent Valley sample square precluded using the same rationale, so clusters of existing secondary woodland were adopted as an alternative.

Planting positions within envelopes were allocated in a similar way to 'random' planting, except that the grid used and the number of points per envelope was tailored according to its size, allocating random points on a specially designed grid with random numbers generated to suit that grid. 50-100, 2ha woodlands were then allocated to the selected envelopes in proportion to the area occupied by each, and digitised as an overlay.

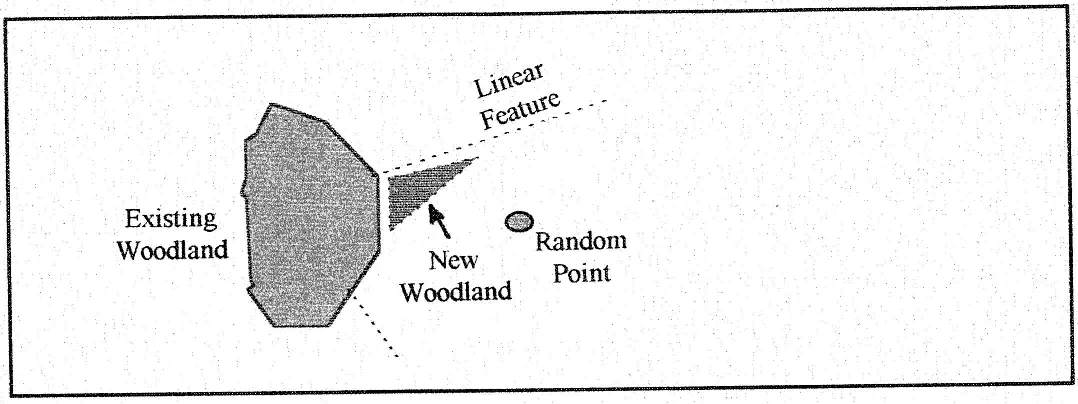
3.3.4 Linking or corridor Planting

In this scenario new woodland corridors connecting together existing woods were explored as the mode of woodland expansion. In the first instance planting "useful" corridors were defined as a width of 50m and added subjectively until a total of 2000m (100ha) of corridor had been allocated to the whole landscape. In the first approach, each ancient woodland in turn was located and linked to the nearest secondary woodland by the shortest feasible route, taking into account the need to follow field margins and to avoid crossing man-made features, such as roads. Any spare capacity was then used to add further linkages between ancient and secondary woodlands. A second method focused on linking together ancient woods, while in Trent a linkages were made between secondary woodlands only.

3.3.5 Buffer Planting

In this scenario, random points were used to locate new woods adjacent to the perimeter of the nearest existing wood, selecting the most obvious position to fit in with field corners or boundaries. 2ha blocks were added using the same ratio of shapes as in random and envelope planting, but attaching square, rectangle and triangle plantings to the existing woodland perimeter. A square was used in this case instead of oval in order to make full contact with the 'host' wood (Figure 3.2).

Figure 3.2 Allocation of a new, triangular woodland block to an existing 'host' woodland



Two scenarios were adopted: a) random buffering of any woodland, irrespective of size or origin, and b) random buffering of the smallest woods present in the 10x10km square. In the latter case, the 50 smallest woods were selected, adding to each in turn a new 2ha block to fit the existing field or land pattern, but randomly in terms of the orientation and position of the new extension.

3.3.6 Planting scenario analysis and interpretation

Digitised data for each planting scenario were analysed for three sample 10x10km squares: East Anglia, Rockingham and Trent, using the SPANS GIS package to create raster files for specialised spatial analysis. For practical purposes no distinction was made at this stage between woodland origin, mainly because of the low areas in each class and the difficulty of measuring the effect on the study area over several classes. Spatial analysis was carried out using the FRAGSTATS program (Oregon State University, 1994) which uses landcover data in raster form. This requires parameters to be set which relate to the form of the data, i.e. size of image, number of classes and so on, in addition to background and border options. Files are created for both class (the whole landscape as a summary) and patch statistics (each discrete woodland). A large amount of data is produced and a full list of all the statistics and their interpretation is beyond the scope of this report, but the main parameters used to assess the relative merits of each planting scenario are shown in Table 3.1.

3.4 Field survey

Three of the sample 10x10km areas were visited, allocating two person-days for Rockingham, Trent and the Taunton vale. Each area was traversed initially by car in order to obtain an overview of the landscape character, but due to the limited time available the detailed survey was concentrated to one or parts. These were chosen to reflect any small differences in land use patterns within the study area based on the information available at the time (generally the 1;25 000 OS map, Agricultural Land Classification and geology) and the impression gained by driving across most of the study area.

Where possible, existing woodlands and especially ancient woodlands were investigated to assess the National Vegetation Classification type, the existence of connecting habitat and surrounding land use and features. The areas selected were then traversed on foot using footpaths and other rights of way, covering at least five 1km squares either in one block (at Rockingham) or as two separate surveys (at Trent and

Table 3.1 Landcape parameters or metrics used in the interpretation of different planting scenarios

Landscape Metric	Abbreviation	Function & Interpretation
Total area	TA	Area of a patch type in the landscape
Number of patches	NP	Number of patches. Depending on landscape size, this may serve as fragmentation indicator
Largest patch index	LPI	Percentage of all total patch area composed of one block
Patch density	PD	Number of patches per 100ha
Mean patch size	MPS	Serves as a fragmentation indicator, as a progressive reduction in patch size corresponds to a more fragmented landscape
Total edge	TE	Total edge (metres) of each patch type
Edge density	ED	Metres of edge per hectare for each patch type
Landscape shape index	LSI	Provides a measure of the perimeter to area ratio for the whole landscape
Total core area	TCA	Core area (ha) of patch type
Number of core areas	NCA	Number of core areas in each patch type
Mean nearest neighbour	MNN	Average nearest neighbour distance for patch type

Taunton). The survey included a Phase 1 exercise (Nature Conservancy Council, 1990), adding any modifications to the OS map (extra woodland, loss of hedgerows, new development etc.) and recording linear habitat quality using a abbreviated hedgerow evaluation grading system (Clements and Tofts, 1992) to place the hedges in one of four main classes of conservation quality.

Using the data obtained in the field visits to the study areas, planting options were explored for the detailed areas covered on the ground. For consistency with the large-area proposals which allocated 1-2% of new woodland cover, around 1ha of woodland was allocated per 1km square covered in the survey, again using 2ha blocks of planting to fit the existing pattern of land use where possible.

3.5 *Consultation of expert opinion*

1:25 000 maps of part of two sample areas in Trent and Rockingham, showing alternative random, envelope, buffering and linking planting scenarios were sent to experts, representing planning, forestry and conservation organisations, for comment. Each was invited to discuss the pros and cons of each scenario as it might affect a particular taxonomic group or a keystone species, and to speculate on the overall effects on biodiversity, the density of planting, and any practical constraints foreseen. Unmarked maps were included in each respondent's pack to encourage them to sketch a preferred planting scenario (Appendix 3). Responses are summarised in Sections 5.2-5.3.

4.0 Results

4.1 *Woodland profiles of sample 10x10km areas*

Woodland cover was much higher in the Rockingham sample area (18%), while the areas selected from Trent, East Anglia and Taunton generally had less. In Rockingham, the proportion of ancient woodland was well above the county average as expected (79% compared with 60% in Northamptonshire) as was that for East Anglia (56% compared with 16% in Suffolk). The proportion of ancient woodland was lower than the county average both in Trent (3% compared with 7%, respectively) and Taunton (31% compared with 47%).

Ancient, replanted woodland dominated in the Rockingham sample, which also had the largest amounts of semi-natural, ancient and broadleaved and conifer woodland compared with the other sample areas (Fig. 4.1). In contrast there was almost no ancient woodland included in the Trent square, and relatively little ancient, semi-natural woodland compared with Rockingham and East Anglia. Ancient woodland in the Taunton Vale tended to occur on steep slopes, or as small blocks on or near to the tops of slopes in the north-west and south-west margins of the sample area. There was very little conifer woodland in any area, but mixed broadleaved-conifer plantations were common in Rockingham.

The density of individual woodland blocks was greatest in Rockingham and East Anglia and least in the Taunton Vale and the Trent Valley (Table 4.1). The mean size and range of the Rockingham woods was significantly greater than that of other sample squares, averaging nearly 15ha and extending to over 450ha (Fig. 4.2). Woodlands of ancient origin tended to be larger than other woods in all sample areas, but were over four times the average size of all woodlands in the case of Rockingham.

Table 4.1 Woodland density and size occurring within the 10x10km sample areas

Area in ha	East Anglian Plain	Rockingham	Trent Valley	Vale of Taunton
Number of woods >0.25ha	113	128	75	96
Mean size (ha) /SE	2.75 ± 0.38	14.8 ± 4.87	1.90 ± 0.19	2.0 ± 0.28
Size range (ha)	0.25 - 19.4	0.25 - 450	0.3 - 9.0	0.25 - 20
Number of **ancient** woods *	23	22	1	13
Mean size (ha) /SE	7.5 ± 1.39	68.1± 25.20	4	4.5 ± 0.73
Size range (ha)	2 - 19.4	3 - 450	n/a	1.6 - 12

*ancient, replanted woods are included in this category where applicable.

Woodlands within each study area were scattered, with mean nearest-neighbour distances averaging 0.22-0.37km apart (Fig.4.3; Table 4.2). However, when distances between ancient and other woods were taken into account, the figure increased from 0.6km in the Rockingham sample area to 5.5km in Trent, where a single fragment of ancient woodland occurred in the extreme north-west corner (Fig.2.2). Distances exclusively between ancient woodlands again emphasise the isolated situation in Trent (maximum nearest neighbour distance 10km), while the remaining areas show a smaller degree of scatter (0.4-0.7km) than the 'ancient to any woodland' scenario, indicating a tendency of the ancient woods to form clusters.

Figure 4.1 Woodland areas in the four 10x10km study areas by type and origin

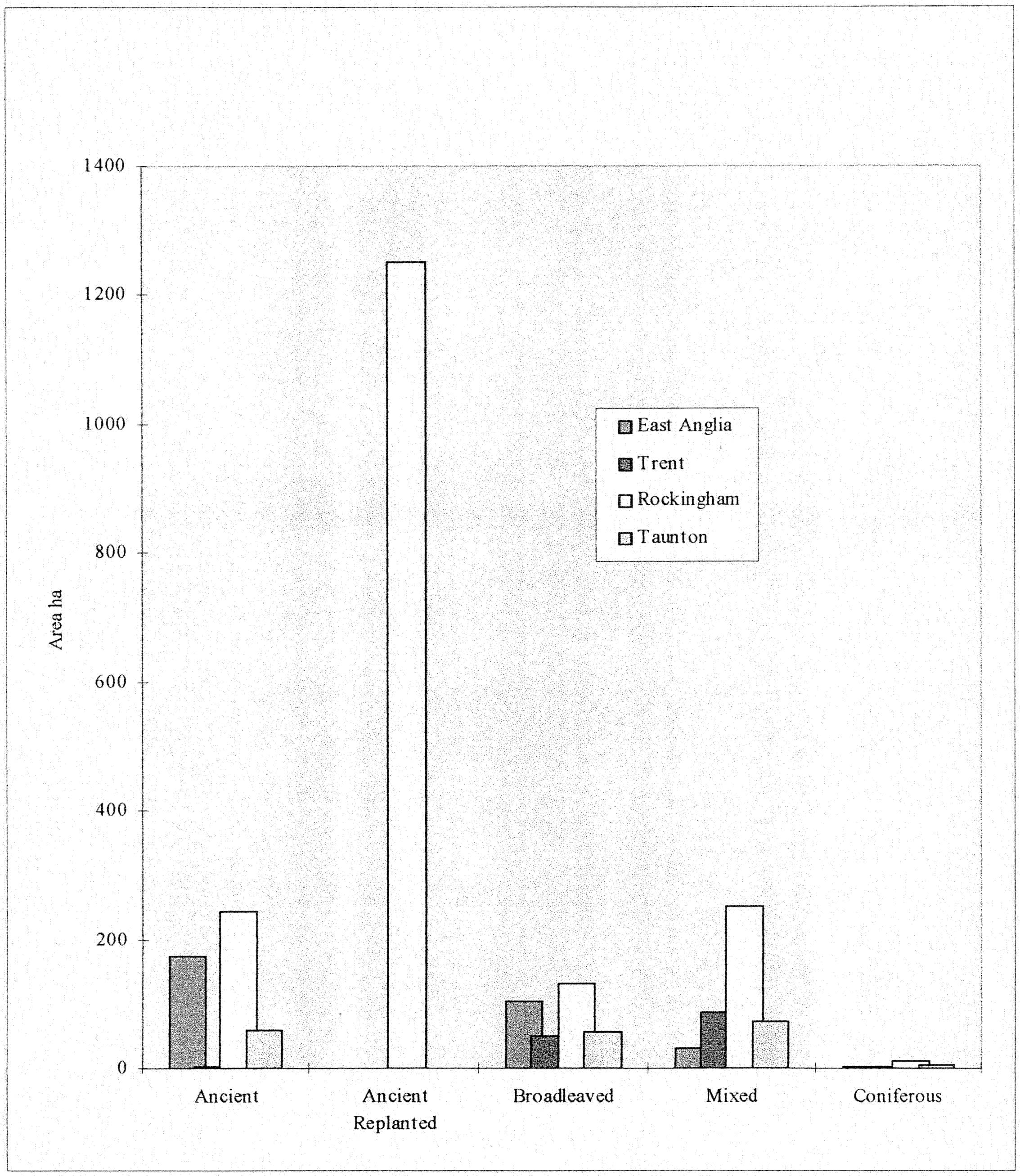


Figure 4.2 Woodland size class distribution in the four 10x10km sample areas

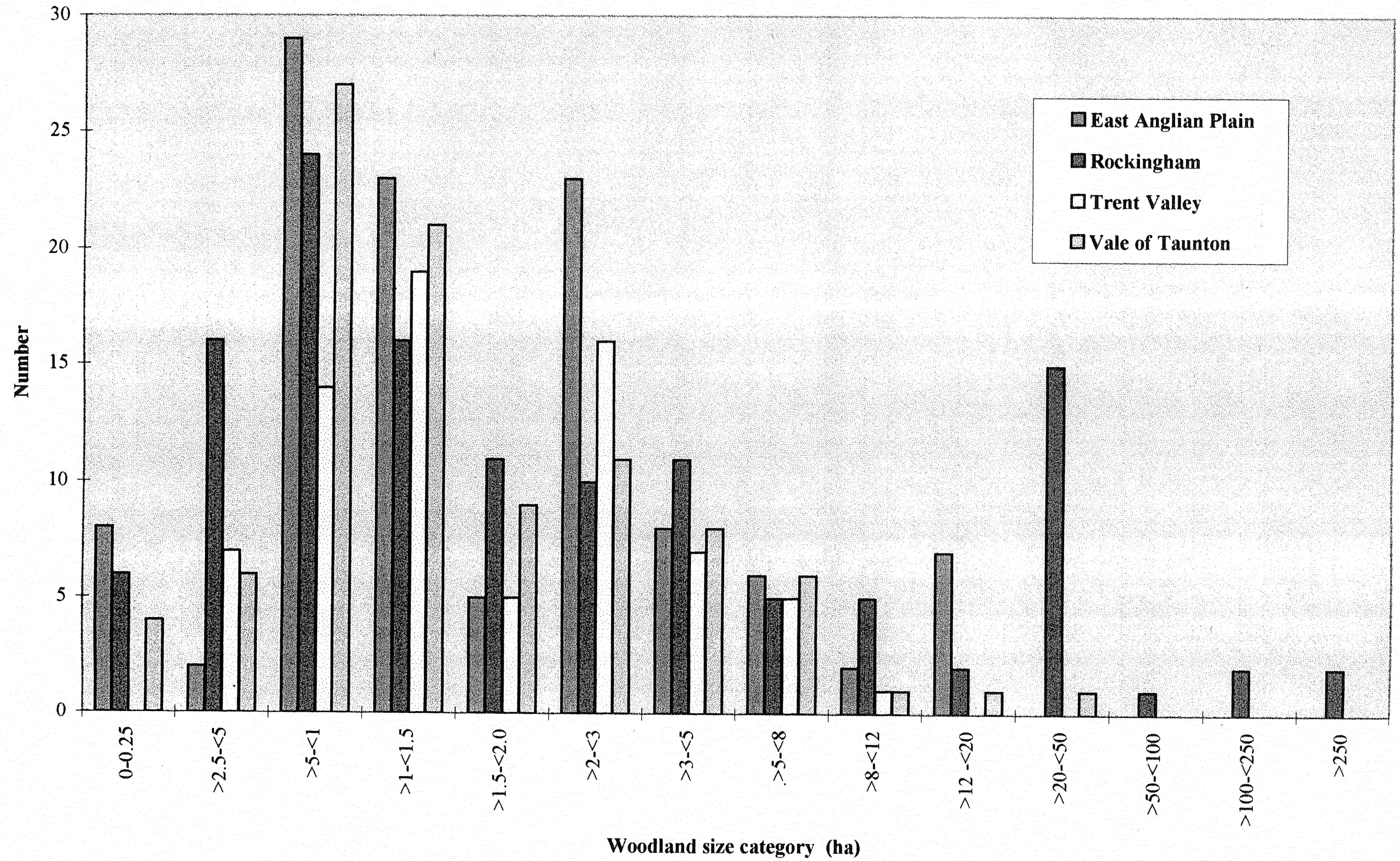
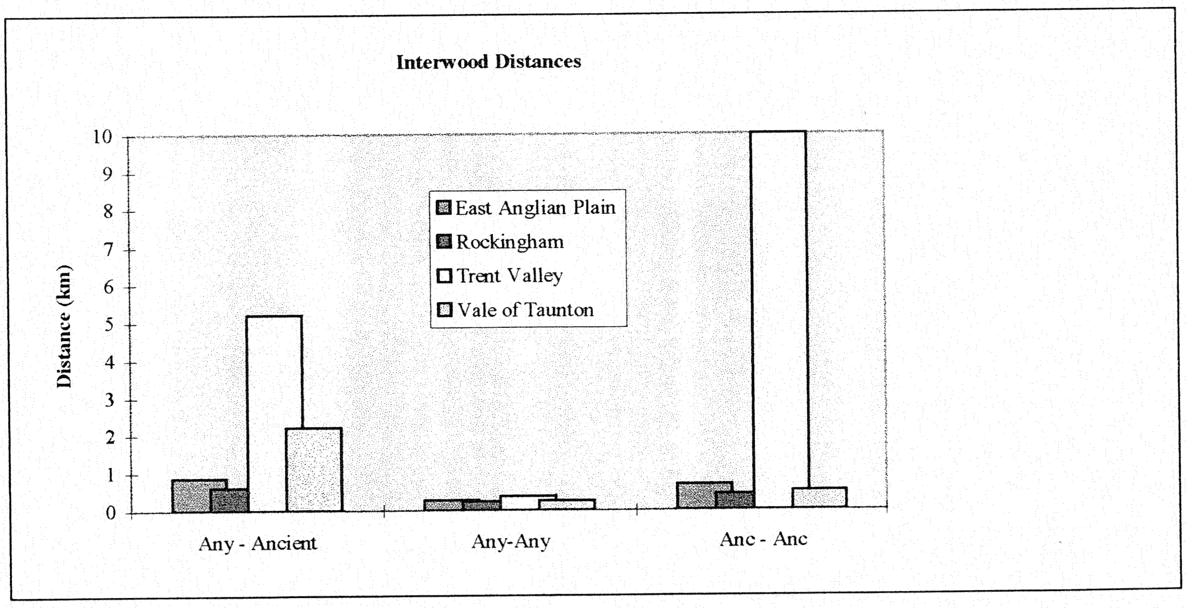


Table 4.2 Mean nearest-neighbour, inter-wood distances (km) measured between ancient and other woodland categories in each 10x10km sample area

Distance measured	East Anglian Plain	Rockingham	Trent	Vale of Taunton
Ancient-to-any wood				
Mean	0.99	0.62	5.51	2.2
Standard Error	0.07	0.04	0.36	0.21
Minimum	0.1	0.1	0.1	0.1
Maximum	2.6	2.4	10.2	8.1
Any-to-any wood				
Mean	0.28	0.22	0.37	0.24
Standard Error	0.02	0.02	0.04	0.02
Minimum	0.1	0.1	0.1	0.1
Maximum	1.2	1.0	1.4	1.2
Ancient-to-ancient wood				
Mean	0.68	0.42	N/A	0.49
Standard Error	0.12	0.09	N/A	0.18
Minimum	0.1	0.1	N/A	0.1
Maximum	2.3	1.0	N/A	2.6

Figure 4.3 Nearest neighbour, inter-wood distances between different woodland classes in the four 10x10km sample areas.



In both Rockingham and Taunton the average elevation of the ancient and larger woods was above that of the surrounding area, usually occurring on steep slopes or hilltops, but the flatter relief of the other sample showed no trends with elevation. Agricultural land was the most significant feature adjacent to the woodlands in all sample areas, emphasising their rural character and accounting for 39-58% of all adjacent categories (Table 4.3). As expected adjacent woods were the next most important category in Rockingham. Water features were often in close proximity to woodlands in all areas, particularly in East Anglia where several woods were associated with river and stream corridors. Ditches were common in Trent, ponds in the Vale of Taunton and parkland lakes in Rockingham Forest. Urban features were generally not found in close proximity to woods.

Table 4.3 Adjacent features and land within 500m of woodlands in the four 10 x 10 km study areas

Adjacent Land Use	East Anglian Plain		Rockingham Forest		Trent Valley		Vale of Taunton	
	Number	%	Number	%	Number	%	Number	%
Agricultural Land	66	58	57	45	41	55	37	39
Woodland	3	3	27	21	0	0	5	5
River	29	26	5	4	8	11	5	5
Stream	6	5	11	9	0	0	19	20
Ditch	0	0	0	0	18	24	0	0
Lake	0	0	15	12	0	0	0	0
Pond	0	0	2	2	3	4	15	16
Canal	0	0	0	0	0	0	1	1
Urban	1	1	0	0	0	0	1	1
Orchard	4	4	0	0	0	0	3	3
Park	4	4	8	6	2	3	9	9
Quarry	0	0	2	2	0	0	0	0
Rail	0	0	1	1	0	0	0	0
Church	0	0	0	0	2	3	0	0
Cemetery	0	0	0	0	1	1	1	1
Total	113	100	128	100	75	100	95	100

The range of woodland shapes recorded is illustrated in Fig. 4.4. The majority of woods were represented as simple geometric shapes such as rectangles, quadrilaterals, squares and triangles (Table 4.4). More complex organic shapes, although fewer in number, were more characteristic of the largest woods, particularly in Rockingham, and these had a significant landscape impact. There was no consistent influence to the shapes, but rather a variety of factors including the field pattern, landform and topography.

4.2 *Availability of wildlife and landscape data*

Requests for published data in each sample region met with a variable response (Table 4.5). County wildlife data was hardest to obtain, but in two instances were available for purchase. Several organisations commented disparagingly on the quality and age of the Phase 1 data, which was obtained only from English Nature's Suffolk Team. One local authority provided very comprehensive information on wildife habitats and species priorities in their Biodiversity Action Plan, commissioned from the county Biological Records Centre. English Nature's Natural Area Profiles, prepared by the local teams, were other useful sources. In general, descriptions of landscape character zones and landscape planning issues were readily available from the relevant county planning authorities.

Figure 4.4 Common woodland shapes found in the four 10x10km study areas

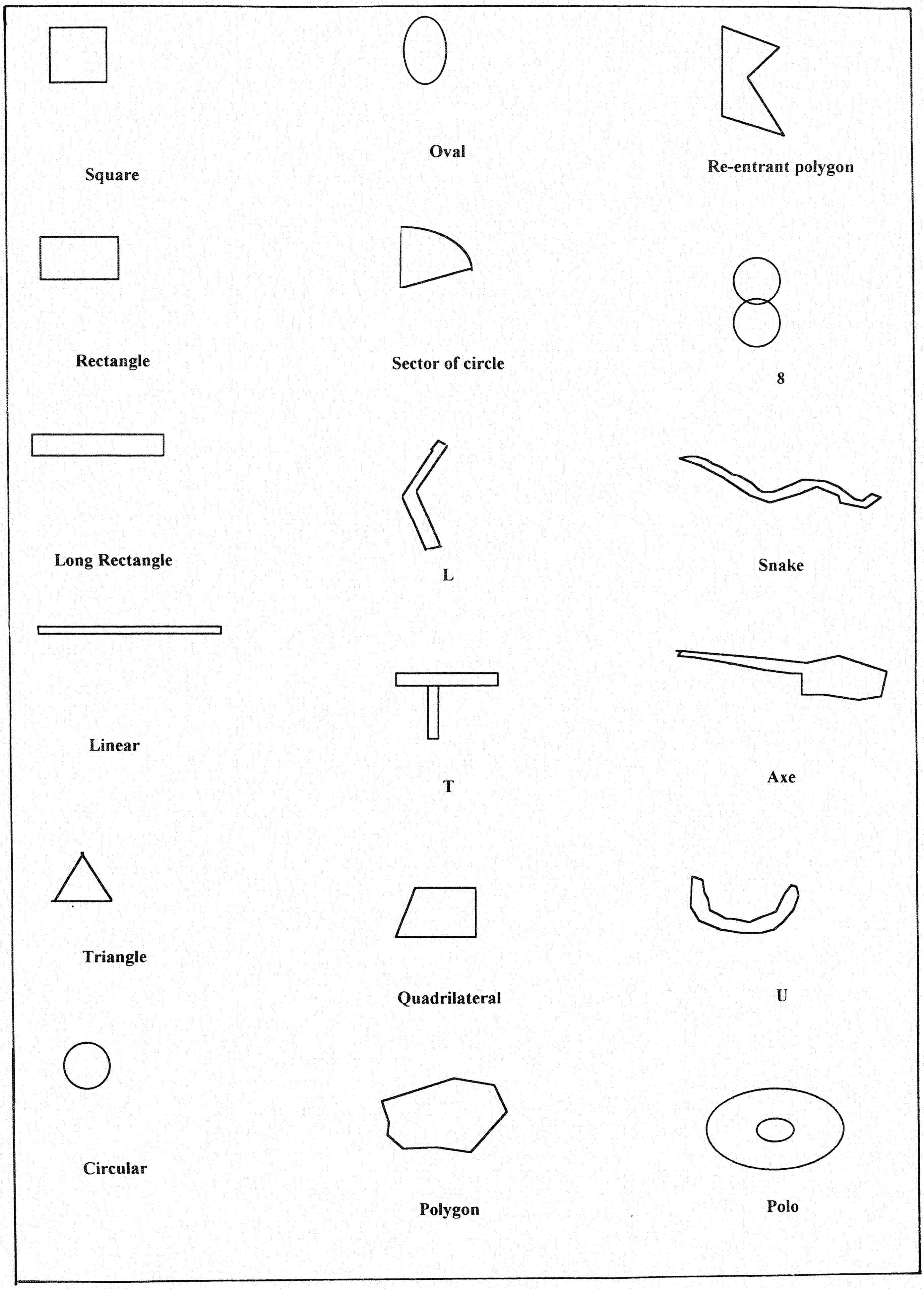


Table 4.4 Woodland shapes recorded in the four 10 x 10 km sample areas

Shape	East Anglian Plain		Rockingham		Trent Valley		Vale of Taunton	
	Number	%	Number	%	Number	%	Number	%
Axe	13	12	10	8	4	5	8	8
Circular	1	1	3	2	0	0	2	2
Eight-shaped	1	1	0	0	0	0	1	1
L-shape	9	8	11	9	4	5	7	7
Long rectangle	0	0	5	4	1	1	5	5
Linear	5	4	5	4	5	7	3	3
Oval	2	2	10	8	3	4	3	3
Polo-shaped	1	1	1	1	2	3	2	2
Polygon	10	9	20	16	4	5	10	10
Quadrilateral	11	10	12	9	9	12	13	14
Rectangle	29	26	24	19	17	23	17	18
Re-entrant polygon	1	1	1	1	5	7	3	3
Sector of circle	1	1	3	2	0	0	2	2
Snake	3	3	1	1	2	3	4	4
Square	11	10	5	4	9	12	4	4
T-shape	2	2	0	0	1	1	1	1
Triangle	11	10	13	10	7	9	8	8
U-shape	2	2	4	3	2	3	3	3
Total	**113**	**100**	**128**	**100**	**75**	**100**	**96**	**100**

Table 4.5 Sources of wildlife and landscape data obtained

Natural Area	Phase 1	County Wildlife Sites	Landscape Designations	Biodiversity Action Plans
East Anglian Plain	1;10,000 maps provided by English Nature	Wildlife Trust unable to respond (financial)	In preparation: some information provided by Suffolk County Council	NO
Rockingham Forest	Dates from 1979; not recommended by the County Wildlife Trust	Information provided by County Wildlife Trust	Information provided by Northamptonshire County Council	NO
Trent Valley & Rises	No response to request	Information provided by Notts County Council	Information provided by Nottinghamshire County Council	NO
Vale of Taunton & the Quantock Fringes	Not recommended by County Wildlife Trust	Data provided by Somerset Environmental Records Centre	Information provided by Taunton Deane Borough Council	YES

Table 4.6 **Features constraining the allocation of planting positions in the four sample 10x10km areas. Numbers are 'failed' allocations, made in the process of obtaining 100 'successful' planting positions, using random or envelope strategies.**

	EAST ANGLIAN PLAIN				**ROCKINGHAM FOREST**				**TRENT VALLEY**				**TAUNTON VALE**	
	Random		Envelope		Random		Envelope		Random		Envelope		Random only	
Woodland	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**
Ancient, semi-natural	5	(36)	11	(73)	2	(7)	15	(16)						
Ancient, replanted					8	(28)	75	(79)					1	(5)
Broadleaved			1	(7)	2	(7)	1	(1)	1	(7)	6	(33)	1	(5)
Coniferous														
Mixed			2	(13)	6	(21)								
Sub-total	**5**	**(36)**	**14**	**(93)**	**18**	**(62)**	**91**	**(96)**	**1**	**(7)**	**6**	**(33)**	**2**	**(9)**
Other Habitat														
County wildlife site	3		1	(7)	1	(3)			2	(13)	7	(39)	1	(5)
Stream					1	(3)								
River													3	(14)
Reservoir					1	(3)								
Pond					1	(3)							1	(5)
Sub-total	**3**	**(21)**	**1**	**(7)**	**4**	**(14)**	0	(0)	**2**	**(13)**	7	**(39)**	**5**	**(23)**
Built Landscape														
Urban and housing	5	(36)			5	(17)	3	(3)	9	(60)	1	(6)	11	(50)
Roads											1	(6)	1	(4)
Rail									1	(7)				
Mineral extraction.							1	(1)			1	(6)	2	(9)
Orchard	1	(7)											1	(4)
Airfield					2	(7)								
Powerlines									2	(13)	2	(11)		
Sub-total	6	**(43)**	0	**(0)**	7	**(24)**	4	**(4)**	12	**(80)**	5	**(28)**	15	**(68)**
TOTAL	**14**	**(100)**	**15**	**(100)**	**29**	**(100)**	**95**	**(100)**	**15**	**(100)**	**18**	**(100)**	**22**	**(100)**

The data assembled showed the Rockingham Forest sample square to be particularly rich in semi-natural wildlife sites, with no fewer than seven SSSIs contained within, or overlapping its boundaries. Four of these were woodlands, including part of Bedford Purlieus and two fragments of the former Royal Forest, most containing ash-maple woodland with elm, hazel and occasionally small-leaved lime. An additional scrub area, Glapthorn Cow Pasture, has dense blackthorn scrub supporting the largest colony of the black hairstreak butterfly (*Strymonidia pruni*) in Northamptonshire, and is one of the most important sites for the species in Britain. County wildlife sites were also dominated by woodland (28) and scrub (7). Calcareous grassland on oolitic limestone occurred at Kings Cliffe SSSI, along with 9 county sites, and marshy grassland at Bulwick Meadows on the floodplain of Willow Brook. Two neutral grassland areas were county wildlife sites, as were some open water and disturbed quarry habitat.

In the Vale of Taunton there were no specifically woodland SSSIs listed, but Langford Heath SSSI contains a variety of habitats including neutral, marshy grassland and ancient woodland. There were also a number of county wildlife sites citing ancient woodland (27), often associated with grassland, sometimes within rides, and mixed woodland (5). Neutral and marshy grassland were also recorded on a total of six sites which included an SSSI at Langs Farm. Several sections of the river Tone were scheduled as important riparian habitat. The East Anglian sample area also contained many county wildlife woodlands and one SSSI, Groton Wood, an ancient site on boulderclay containing a notable stand of small-leaved lime. Semi-natural grassland was also common in this area, with over 30 sites recorded on the Phase 1 map, including railways, verges and old track sides.

In contrast, there were relatively few wildlife features present in the intensively farmed Trent sample area. One SSSI, Orston Quarry contained calcareous grassland, together with 9 other sites listed by the county as Biological sites (grade 1 or grade 2). Only two woodlands were similarly listed, three scrub sites with associated grassland and some 3 pond and river features.

4.3 *Planting constraints and opportunities*

4.3.1 Non-agricultural features

The extent to which the various constraints affected the chance of locating a suitable point for new woodland was assessed by progressively picking random coordinates within the sample area until 100 suitable positions had been allocated (2% of the 10x10km square). For these purposes all agricultural land was considered suitable for planting, but existing woodland, other semi-natural habitat and urban features were all rejected as 'failed', i.e. unsuitable planting allocations. In the Rockingham sample area, for example, a total of 129 random allocations were needed to provide 100 suitable planting positions (a 22% failure rate). Almost two-thirds of these 'failed allocations' fell on existing woodland sites (62%; Table 4.6), but in other sample areas with less woodland cover the proportion was much lower, with 9% and 7% affecting woodlands in Taunton and Trent, respectively. Urban land was encountered on five occasions and an airfield on two. Of the remaining habitat, a limestone grassland verge was allocated on one occasion and wetland sites on three occasions.

In the Trent Valley and East Anglian sample areas the number of planting allocations required to meet the target was reduced owing to the paucity of other features, producing only 12-13% 'failed' allocations and thus allowing opportunities to plant in a wide range of locations. Of the few constraints encountered in Trent, 80% comprised urban land, powerlines and a railway, while 43% were affected by the built landscape features in East Anglia. Wellington in the Taunton Vale sample increased the proportion of unavailable urbanised land to 68%. County Wildlife sites, mainly consisting of grassland, scrub or old quarries, were encountered in all sample areas, with the river habitat intervening on three occasions in the Taunton Vale.

Table 4.7 Agricultural Land Classification grades of 100 tree-planting locations allocated to each 10x10km sample area, using random and envelope planting scenarios.

Agricultural Grade	East Anglian Plain						Rockingham Forest						Trent Valley and Rises					Taunton Vale					
	R	E	RB	SB	AA	AS	R	E	RB	SB	AA	AS	R	E	RB	SB	SS	R	E	RB	SB	AA	AS
1																		8	9	9	21	0	6
2	36	44	22	18	25	32							39	38	41	69	77	35	34	27	23	13	25
3	64	56	78	82	75	68	99	100	100	100	100	100	61	62	59	31	23	54	43	60	51	82	64
4							1											3	14	4	5	5	5

Key	**Planting scenario**
R	Random
E	Envelope
RB	Random buffer
SB	Small buffer
AA	Ancient to ancient woodland linkages
AS	Ancient to other woodland linkages
SS	Other to other woodland linkages (Trent Valley Only)

Note: no grade 5 land was encountered.

The effect of constraining the 'search' area by designating specific planting 'envelopes' around existing planting had a number of consequences. The first was to increase the number of 'failed' allocations due to the presence of existing woodlands which formed the basis of envelope selection. The overall failure rate was greatest at Rockingham (49%), of which most (96%) was due to woodland constraints, with high rates also for East Anglia (93%) and Trent (33%). In contrast the impact on other wildlife sites was reduced in these predominantly wooded areas, while their rural position also avoided the influence of urban development.

4.3.2 Agricultural land quality

The pattern of agricultural land quality in each sample area was reflected in the percentage of successful woodland allocations (Table 4.7). In Rockingham, all but one site was on grade 3 land which uniformly dominated the area. In the East Anglian and Trent sample areas random allocations showed the proportion of grade 3 land of about two-thirds, with the remainder all in grade 2. The Taunton Vale had the widest range of agricultural grades, but with a high proportion of grades 1 and 2 (43%) in the sample.

The planting pattern adopted had a significant effect on the balance of the grades. Compared with random allocations, planting envelopes included more grade 2 land in the East Anglian sample, possibly because the envelopes spread across pockets of good soils away from the existing woodlands, but in the Taunton Vale they incorporated a greater proportion of lower quality land. In Trent envelope planting made no difference to the balance of land quality. Buffering small woods, however, tended to increase the number of allocations on grade 2 land in Trent and Taunton, suggesting that these woods, many of them game spinneys surrounded by arable farming, were already on relatively good land. Linking these woods in Trent increased the 'take' of grade 2 land further, as the links tended to straddle better quality agricultural land than around existing woods. The situation was, however reversed in East Anglia and the Taunton Vale, where random buffering and linking strategies increased the number of planting allocations on poorer land, suggesting that in these cases the larger and ancient woods were associated with the poorer land.

4.4 *Analysis of planting scenarios*

4.4.1 Planting density

The impact of adding 100-200ha (1-2% cover) of new planting to existing woodland in each study area is shown in Table 4.8, together with the planting requirement to reach an arbitrary 30% cover. New woodland additions have to be seen in proportion to the current tree cover: in the case of Rockingham, where the total woodland cover is only 19%, a 200ha addition is only 10% of the resource, whereas it is 139% in Trent.

Theoretically, some level of woodland cover must exist which satisfies the requirements of a majority of species in any landscape, beyond which further additions are less effective, or where the marginal rate of return for increasing woodland level is reduced. This level and rate will vary in different landcape types, depending on the species under consideration, including those for which any increase in woodland cover may be detrimental. The simple model introduced earlier, which randomly and progressively allocates new blocks of woodland cover to an unplanted landscape (Section 3.3.1; Fig.3.1), can be used to demonstrate some of the important spatial relationships from which changes in habitat quality may be inferred.

Fig. 4.5 illustrates how the number of separate patches increases to reach a maximum at around 20% cover, but then falls steadily until, around 60% cover, almost all patches are effectively joined together at some point. The mean patch size, however, increases exponentially, so that patches average less than 10ha at 50% 'woodland' cover, but reach 50ha at 80% cover. Increase in the core area of the patches (assuming in this case that patches have internal or external 'edges' of 25m) follows a similar trend.

Figure 4.5 The effects of increasing random planting cover on woodland landscape metrics (1ha woodlands were added progressively within a 2x2km planting area)

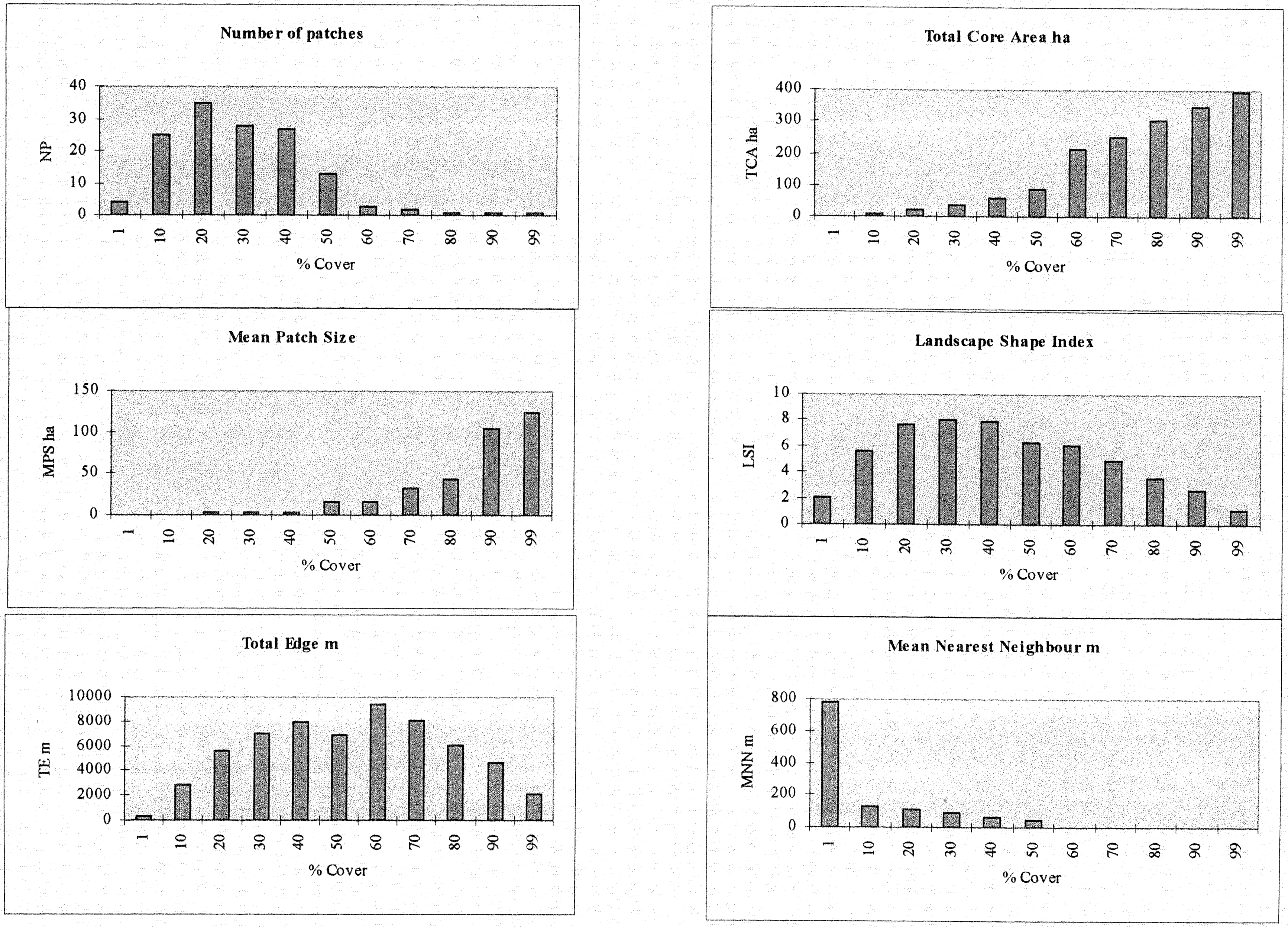


Table 4.8 The effect of adding successive amounts of new woodland planting on existing woodland in each 10x10km sample area

Natural Area	Existing woodland cover	Adding 100ha	Adding 200ha	Planting area needed to reach 30% cover
Trent Valley & Rises	144ha 1.4%	70% of existing woodland 2.4% cover	139% of existing woodland 3.4% cover	2860ha
Rockingham Forest	1891ha 18.9%	5% of existing woodland 20% cover	10% of existing woodland 21% cover	1100ha
East Anglian Plain	311ha 3.1%	32% of existing woodland 4.1% cover	64% of existing woodland 5.1% cover	2690ha
Vale of Taunton & The Quantock Fringes	192ha 1.9%	50% of existing woodland 2.9% cover	104% of existing woodland 3.9% cover	2810ha

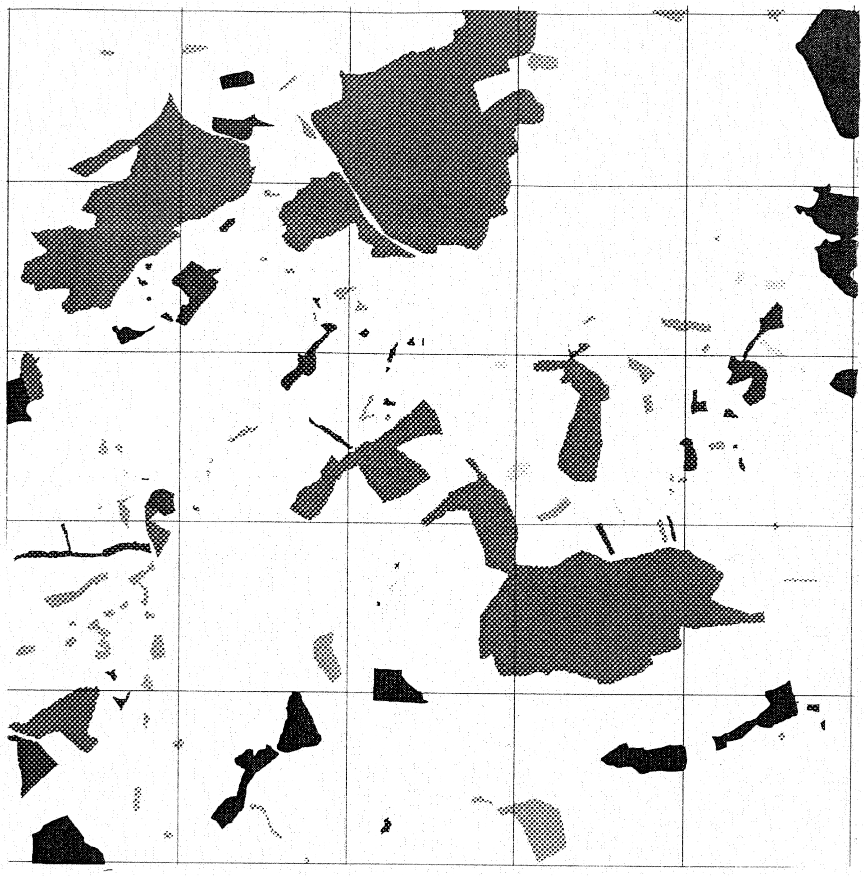
Total woodland perimeter (total edge) again increases gradually, reaching a maximum at 60% cover, after which successive infilling reduces the *internal* edge. Shape complexity (Landscape Shape Index, LSI) reaches a maximum at 30% cover, but as the patches increase in mass through infilling they become progressively less complex. Isolation also changes rapidly with increasing cover: at about 1% the mean nearest neighbour distance is around 800m, but this falls exponentially to 180m at 10% cover until, at about 60%, most woods are effectively connected. Interestingly, this point also corresponds with the maximum perimeter of the planted area, when about half of it is present as 'core' area.

This theoretical approach allows us to speculate about the likely ecological effects of new planting initiatives, but also challenges our knowledge and interpretation of individual species ecology. However, in reality landscapes are much more complex. More sophisticated models are needed to increase our understanding of how a range of woodland size classes and planting distributions affect the basic spatial patterns of the landscape. The following section examines the influence of different planting scenarios on landscape metrics in the real landscapes of East Anglia, Rockingham and Trent.

4.4.2 Planting pattern

A selection of landscape metrics derived from the FRAGSTATS output for the various scenarios in Rockingham, Trent and Suffolk is presented below as the *class output* for each sample area as a whole, ignoring *individual patch* statistics. There are minor anomalies in the exact areas of the landscape due to small digitising errors in both the original landscape and the subsequent additions marked on photocopied maps. Errors also result from the conversion of the files to raster format, and from the scale of resolution used (in this case 12.5m cells). What is intended here is to begin to quantify the effects of each scenario, using the important metrics, the exact values of which are less important than the direction and order of change. At this stage no distinction has been made between the different types of woodland (ancient, recent etc.) as the overall effect of the changes is of more interest at this stage. Maps 4.6a-g show the effect of the full range of scenarios on the landscape for Rockingham only (figures for East Anglia and Trent are presented in Appendices A4 and A5, respectively).

When comparing the scenarios it is important to consider the original woodland extent and distribution. For linking strategies only 100ha has been added, whereas the other options add 200 ha (2ha x 100 woods).

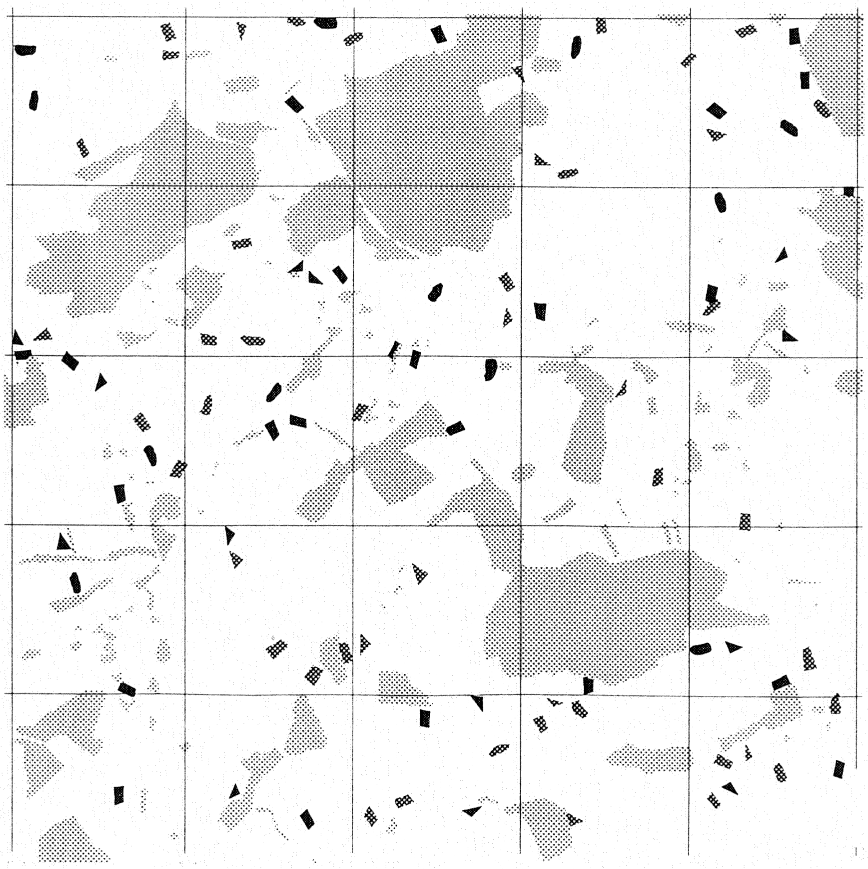


Map 4.6a Rockingham

Existing Resource

Ancient Replanted
Coniferous
Broadleaved
Ancient
Mixed

Scale 1: 100 000

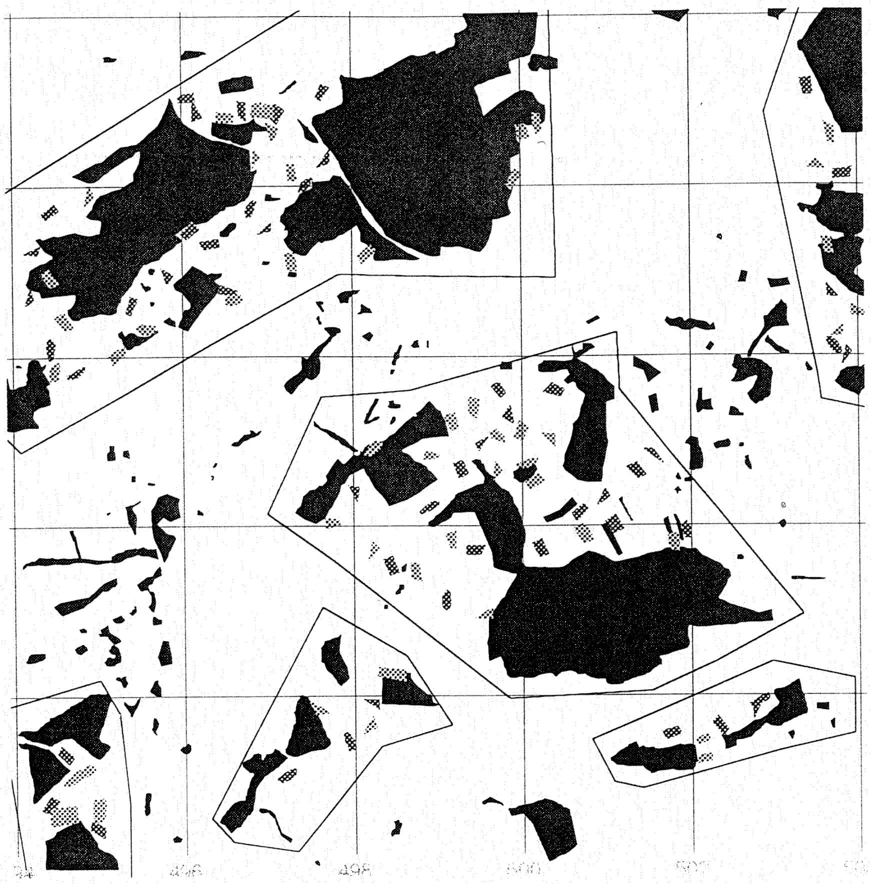


Map 4.6b Rockingham

Random Scenario

Existing Woodland
New Woods 1-50
New Woods 51-100

Scale 1: 100 000

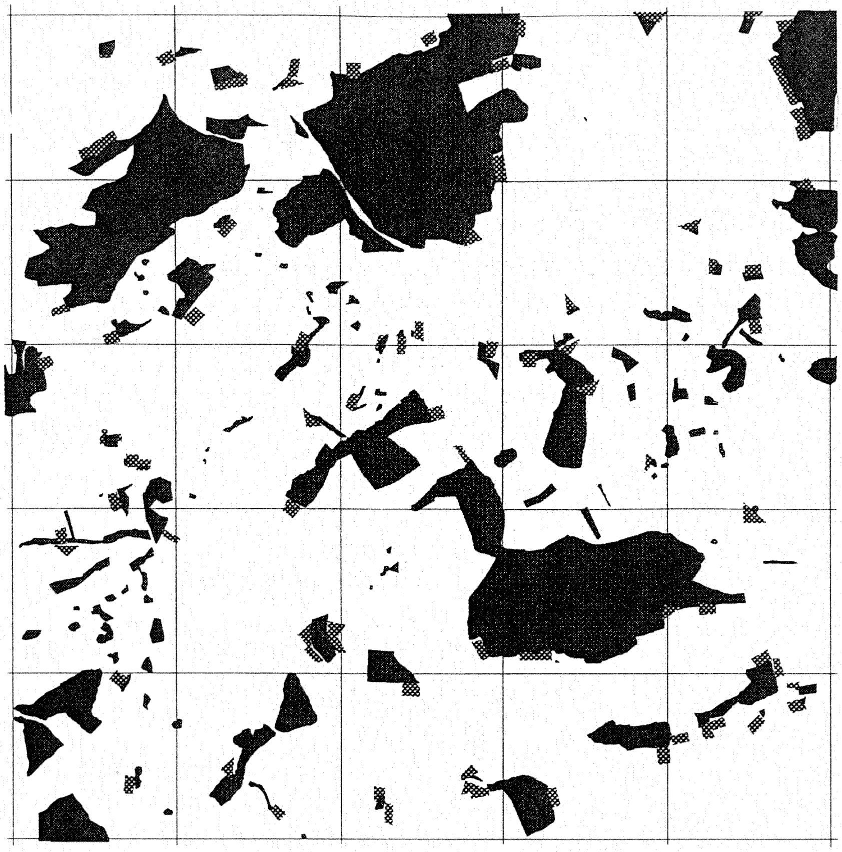


Map 4.6c Rockingham

Envelope Scenario

- Existing Woodland
- New Woods 1-50
- New Woods 51-100

Scale 1: 100 000

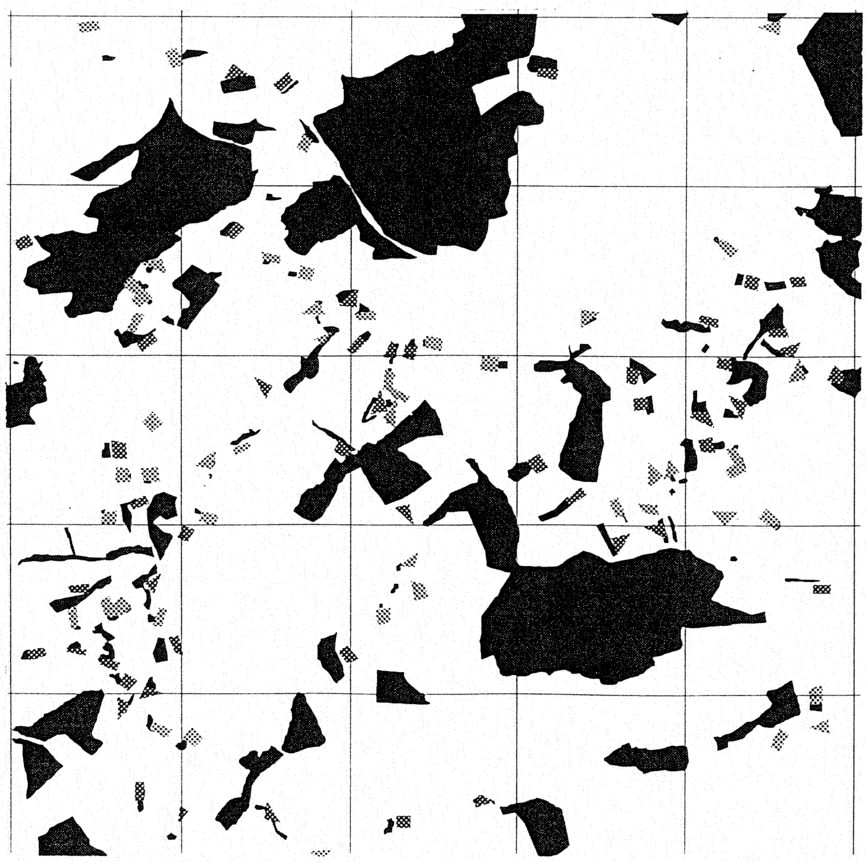


Map 4.6d Rockingham

Random Buffer Scenario

Existing Woodland
New Woods 1-50
New Woods 51-100

Scale 1: 100 000

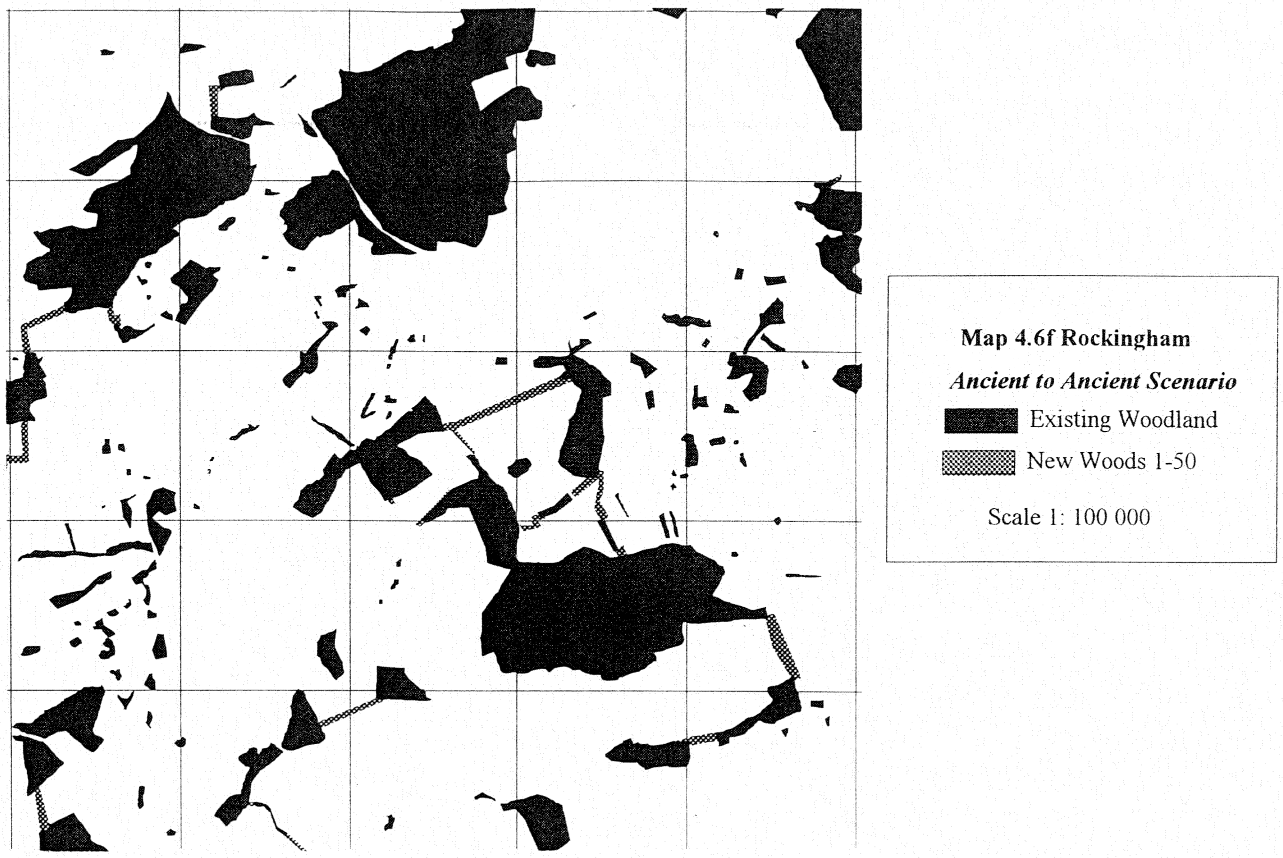


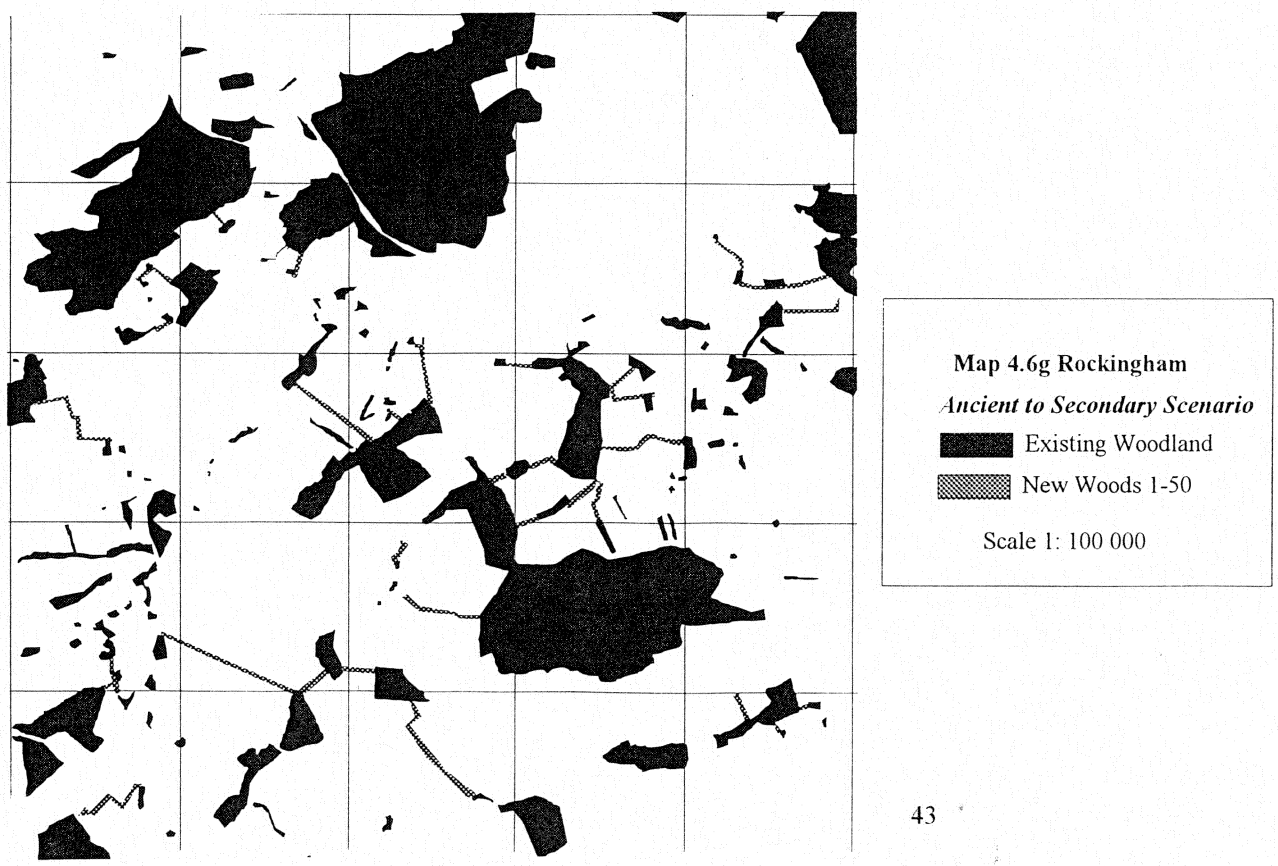
Map 4.6e Rockingham

Small Buffer Scenario

Existing Woodland
New Woods 1-50
New Woods 51-100

Scale 1: 100 000


Map 4.6f Rockingham
Ancient to Ancient Scenario
Existing Woodland
New Woods 1-50
Scale 1: 100 000


Map 4.6g Rockingham
Ancient to Secondary Scenario
Existing Woodland
New Woods 1-50
Scale 1: 100 000

Mean nearest neighbour distance (MNN)

Table 4.9 shows high mean distances for Trent (344m) and East Anglia (202m) compared with Rockingham (159m), reflecting the greater concentration of woods within the latter area and the sparse but clustered groupings of woods in the former. High standard deviations and coefficients of variation further emphasise the uneven distribution in all sample areas. Nearly all scenarios had the effect of reducing the original MNN distance, which decreased more or less according to the planting strategy and the area planted. In general, envelopes were more effective than random planting in reducing distance as new woods were placed within limited areas defining by existing woods, bringing them into proximity with original woods as well as each other. However, in the East Anglian sample the addition of 50 woods caused an increase in the MNN distance, due to position of these new woods away from the existing ones and mainly outside their well-defined clusters.

Buffering had a similar effect to envelope planting, the small woodland buffering scenario for Rockingham in particular reducing neighbour distances because, as the new plantings significantly extended these woods towards each other and joined up small woodland clusters, this also reduced the total number of woods present (Map 4.6d,e).

Linking scenarios at Rockingham connected woods that were already close to each other, so that once linked they were treated as one and were no nearer to their adjacent woods than before, the total interwood distance being divided by fewer woods. Only longer and more complex links were effective by joining together otherwise remote clusters of woods, causing a dramatic 43% reduction in the MNN distance for the 'ancient to other' linking scenario in the East Anglian sample area. In contrast, the 'ancient to ancient' distance was less affected due to the already clustered distribution of these woods.

Table 4.9 Mean nearest neighbour (MNN) distances calculated for the three 10x10km sample areas

Planting Scenario	**Rockingham Forest**			**Trent Valley & Rises***			**East Anglian Plain**		
	MNN (m)	% change	SD	MNN (m)	% change	SD	MNN (m)	% change	SD
Original	158.90	0	161.71	344.21	0	327.41	201.93	0	199.83
Random 50	147.26	-7	158.01	302.75	-12	252.73	221.19	10	199.16
Random 100	126.43	-20	108.77	260.02	-24	196.29	197.75	-2	174.57
Envelope 50	136.95	-14	146.5	244.02	-29	252.41	168.48	-17	162.8
Envelope 100	110.81	-30	134.18	184.35	-46	207.75	135.47	-33	148.94
Random buffer 50	151.27	-5	164.15	295.94	-14	293.13	188.37	-7	195.71
Random buff 100	143.43	-10	167.78	278.81	-19	274.63	179.38	-11	205.74
Small buffer 50	138.40	-13	155.41	273.49	-21	307.29	181.85	-10	204.19
Small buffer 100	97.25	-39	114.7	245.15	-29	282.62	169.54	-16	203.99
Linking anc-anc+	148.32	-7	179.99	339.75	-1	405.44	173.44	-14	199.01
Link anc-other +	153.52	-3	163.39				114.57	-43	178.01

* For Trent the linking strategy was limited to recent, not ancient woods

\+ Linking strategies only added 100ha, similar to the '50' separate or buffering scenarios

Area metrics

The number of discrete woodland patches (NP) was much smaller in the sparsely-wooded Trent sample compared with Rockingham and East Anglia (Table 4.10). Patch numbers broadly matched the intended new additions, but were underestimated due to their amalgamation by rasterization of the image, especially noticeable in envelope scenarios where small woods were placed in close proximity to each other and to existing woods. Little change in number resulted, as would be expected, in the buffering scenarios, but linking woods showed an appreciable reduction as woods were joined. The effect of adding separate woodlands in a more or less wooded landscape is well illustrated by comparing Rockingham with the Trent Valley, where in the former a 63% increase was achieved with the random addition of 100 woods in envelopes, compared with 120% in Trent with more new woodlands remaining separate because of lower woodland coverage.

Table 4.10 Numbers of discrete woodland patches (NP) calculated for the three 10x10km sample areas

Planting scenario	Rockingham Forest		Trent Valley & Rises*		East Anglian Plain	
	no.	% change	no.	% change	no.	% change
Original	128	0	70	0	111	0
Random 50	167	30	113	61	155	40
Random 100	209	63	154	120	198	78
Envelope 50	149	16	108	54	149	34
Envelope 100	189	48	141	101	183	65
Random buffer 50	129	1	69	-1	111	0
Random buff 100	129	1	69	-1	110	-1
Small buffer 50	125	-2	70	0	111	0
Small buffer 100	128	0	67	-4	110	-1
Linking anc-anc+	101	-21	55	-21	94	-15
Link anc-other +	116	-9			99	-11

* For Trent the linking strategy was limited to recent, not ancient woods
\+ Linking strategies only added 100ha, similar to the '50' separate or buffering scenarios

Mean patch size (MPS) serves as a fragmentation indicator since a progressive reduction in patch size corresponds to a more fragmented landscape. For all sample areas there was a very wide variation in the range of patch sizes in both absolute and relative terms, indicated by the standard deviations and coefficients of variation. At Rockingham the random 100 scenario produced a coefficient of variation of 468%), while for East Anglia it was 270% in the ancient-ancient linking scenario, but less in Trent, where the linking scenario produced the lowest coefficient of 123%.

Owing to the large average woodland size in Rockingham, the addition of 'new', 2ha patches to the landscape as random or envelope scenarios resulted in a significant reductions in mean patch size (Table 4.11). The change was less for the smaller woods of East Anglia but for Trent it was hardly noticeable, due to the much lower original MPS of 2.2ha. Conversely, the addition of woodland areas as buffers to existing woodland affected Rockingham least and Trent the most, where the MPS more than doubled to 5.7ha in the random buffering scenario. Linking scenarios also significantly increased the MPS in all three sample areas, the greatest effect occurring where the somewhat larger ancient woods were joined to other ancient woods in East Anglia and Rockingham, whereas in Trent linkages between the predominantly small (recent) achieved an approximate doubling of the original MPS.

Table 4.11 Mean patch size (MPS) of woodlands in the three 10x10km sample areas

Scenario	Rockingham Forest			Trent Valley & Rises*			East Anglian Plain		
	(ha)	% change	SD	(ha)	% change	SD	(ha)	% change	SD
Original	16.85	0	6.33	2.20	0	2.87	3.07	0	5.03
Random 50	13.51	-20	5.86	2.53	15	2.41	2.77	-10	4.30
Random 100	11.25	-33	5.27	2.63	20	2.24	2.62	-15	3.83
Envelope 50	15.06	-11	6.25	2.57	17	2.53	2.83	-8	4.55
Envelope 100	12.33	-27	5.60	2.72	24	2.41	2.76	-10	4.41
Random buffer 50	17.47	4	6.70	3.91	78	3.78	3.84	25	5.29
Random buff 100	18.13	8	6.76	5.66	157	5.17	4.43	44	5.47
Small buffer 50	17.96	7	6.71	3.49	59	2.90	3.88	26	4.78
Small buffer 100	18.36	9	6.65	4.94	125	3.89	4.70	53	4.83
Link anc-anc +	22.23	32	8.06	4.06	85	5	4.78	56	13.02
Link anc-other +	19.35	15	8.50				4.31	40	7.97

* For Trent the linking strategy was limited to recent, not ancient woods
+ Linking strategies only added 100ha, similar to the '50' separate or buffering scenarios

The area of woodland 'core' was assessed on the basis that the woodlands had 'edges' effectively 25m wide. Adding new woodlands therefore increased the total core area (TCA) in all planting scenarios (Table 4.12), but predictably this was most pronounced in Trent, where most woodlands were already small and consequently contained little core. In contrast TCA in Rockingham was relatively unaffected by new planting additions since this landscape had a large woodland areas consisting also of large patch sizes. The effect on the East Anglia was intermediate between these two extremes.

Table 4.12 The effect of new planting scenarios on total woodland core area (TCA) in the three 10x10km sample areas

Scenario	Rockingham Forest		Trent Valley & Rises*		East Anglian Plain	
	(ha)	% Change	(ha)	% Change	(ha)	% Change
Original	1905.2	0	84.2	0	221.5	0
Random 50	1962.3	3	169.4	101	269.5	22
Random 100	2017.1	6	242.5	188	318.5	44
Envelope 50	1957.4	3	163.4	94	265.5	20
Envelope 100	2005.3	5	228.6	172	311.7	41
Random buffer 50	1977.7	4	176.8	110	285.1	29
Random buff 100	2038.1	7	262.3	211	340.8	54
Small buffer 50	1966.8	3	149.0	77	281.4	27
Small buffer 100	2033.5	7	209.9	149	343.5	55
Link anc-anc +	1939.2	2	113.9	35	260.9	18
Link anc-other +	1963.5	3			251.7	14

* For Trent the linking strategy was limited to recent, not ancient woods
+ Linking strategies only added 100ha, similar to the '50' separate or buffering scenarios

In Trent the random buffer scenario produced the greatest increase (211%) in TCA, but the comparable small wood buffering scenario was less effective, probably because random buffer plantings tended to congregate on a few woods, whereas small wood buffering by definition was restricted to one buffer per existing wood, with fewer connections made to other existing woods. At the other sample sites buffering was also the most effective general strategy compared with random and envelope planting. Linking had least impact, but did increase the core area even though the width of the links (50m) allowed no core. The operative factor in this case was the number of connections, where the extra woodland increased the core area at the point where it met the existing wood.

Edge metrics

All scenarios increased the length of the woodland perimeter (total woodland edge, TE). Rockingham maintained the largest perimeter in its original landscape, double that of East Anglia and over three times that of Trent (Table 4.13), so that additions of woodland had the greatest impact on TE in the least wooded landscapes of Trent and East Anglia. In all landscapes the addition of 50 and 100 separate woods produced similar relative increases in edge in both the random and envelope scenarios. Large TE increases in the random scenarios in Trent and East Anglia were due to the new woods being located on their own, the whole of their edge contributing to the increase. In envelopes, slightly lower edge figures were obtained since more new woods were placed adjacent to existing woods, absorbing some of each other's 'edge'.

Buffering scenarios added less edge in all three areas, due to the incorporation of part of each new wood's edge at the joining point. Buffering small woods also tended to add more edge than random buffering, as the slimmer contact points and overlap with the smaller 'host' woods often produced lengths of unabsorbed perimeter. Overall, linking scenarios were responsible for the greatest relative increases in woodland perimeter (compared with other, 50-wood scenarios) except in Trent, where many short links between woodlands were made (Appendix A5f). Differences in linkage type were also seen in the larger TE values for the longer, ancient-to-other woodland links used in Rockingham compared with the shorter ones used in ancient-to-ancient scenarios. The position was reversed in East Anglia where ancient-to-other links were longer than between exclusively ancient woodlands.

Table 4.13 The effect of different planting scenarios on total woodland perimeter (total woodland edge, TE) in the three 10x10km sample areas.

Scenario	Rockingham Forest		Trent Valley & Rises*		East Anglian Plain	
	(m)	% change	(m)	% change	(m)	% change
Original	203082	0	62543	0	100245	0
Random 50	220546	9	102531	64	135405	35
Random 100	222989	10	142556	128	170674	70
Envelope 50	225031	11	100788	61	131260	31
Envelope 100	229844	13	135800	117	162893	62
Random buffer 50	237099	17	87095	39	117734	17
Random buff 100	239870	18	109251	75	136168	36
Small buffer 50	244501	20	84081	34	124169	24
Small buffer 100	252923	25	104856	68	143149	43
Link anc-anc +	264116	30	94868	52	155221	55
Link anc-other +	271445	34			145404	45

* For Trent the linking strategy was limited to recent, not ancient woods
\+ Linking strategies only added 100ha, similar to the '50' separate or buffering scenarios

Shape metrics

The landscape shape index (LSI) provides a measure of the perimeter to area ratio for the whole landscape, quantifying the amount of edge relative to that which would be present in a landscape of the same size but with a simple geometric shape (i.e. a square in a raster image) and no internal edge. The ratio gives the divergence from the simple shape baseline of 1, so that the figures for all three landscapes are directly comparable.

The addition of new planting patches increased the shape index for all landscapes as would be expected from the small, irregular (mainly rectangular) blocks used (Table 4.14). LSI was lowest for Rockingham and remained so throughout all the scenarios, due to the very large, compact woodlands comprising this landscape. Buffering scenarios tended to have least effect on LSI as this strategy maintained basic woodland shapes, although overlap with 'host' woodlands in small woodland buffering gave somewhat larger LSI values. Linking produced elongated shapes which gave the greatest relative increases in LSI compared with the 50-wood additions in other planting .

Table 4.14 The effect of planting scenario on Landscape Shape Index (LSI) in the three 10x10km sample areas

Scenario	Rockingham Forest		Trent Valley & Rises*		East Anglian Plain	
	LSI	% change	LSI	% change	LSI	% change
Original	10.9	0	12.6	0	13.6	0
Random 50	12.5	14	15.2	20	16.3	20
Random 100	14.0	28	17.7	41	18.7	38
Envelope 50	12.1	11	15.1	20	16.0	18
Envelope 100	13.7	25	17.3	38	18.1	34
Random buffer 50	11.6	6	13.1	4	14.3	5
Random buff 100	12.4	13	13.8	10	15.2	12
Small buffer 50	11.8	8	13.4	7	15.0	10
Small buffer 100	13.0	19	14.4	14	15.7	16
Link anc-anc +	12.9	18	15.9	26	18.3	35
Link anc-other +	11.9	9			17.6	30

* For Trent the linking strategy was limited to recent, not ancient woods
+ Linking strategies only added 100ha, similar to the '50' separate or buffering scenarios

Double log fractal dimension (DLFD) measures the divergence from simple Euclidean geometry and showed similar changes to the shape index (LSI). The measure had less sensitivity than LSI to the changes produced by the addition of woods. Buffering small woodlands and linking strategies produced the most complex shapes and is reflected in DLFD values (Table 4.15).

Table 4.15 The effect of planting scenario on double log fractal dimension (DLFD) values calculated for the three 10x10km sample areas

Scenario	Rockingham Forest		Trent Valley & Rises*		East Anglian Plain	
	DLFD	% change	DLFD	% change	DLFD	% change
Original	1.19	0	1.41	0	1.25	0
Random 50	1.2	1	1.38	-2	1.27	2
Random 100	1.2	1	1.43	1	1.28	2
Envelope 50	1.21	2	1.41	0	1.27	2
Envelope 100	1.22	3	1.45	3	1.3	4
Random buffer 50	1.21	2	1.39	-1	1.24	-1
Random buff 100	1.22	3	1.43	1	1.26	1
Small buff 50	1.21	2	1.59	13	1.27	2
Small buff 100	1.23	3	1.87	33	1.35	8
Link anc-anc +	1.29	8	1.66	18	1.52	22
Link anc-other +	1.26	6			1.46	17

* For Trent the linking strategy was limited to recent, not ancient woods
\+ Linking strategies only added 100ha, similar to the '50' separate or buffering scenarios

4.5 *Field surveys*

The site maps below show a range of alternative planting options and the captions outline the strategy followed or rationale for each block proposed (Maps 4.1,4.2 & 4.3).

4.5.1 Rockingham sample area (Map 4.1)

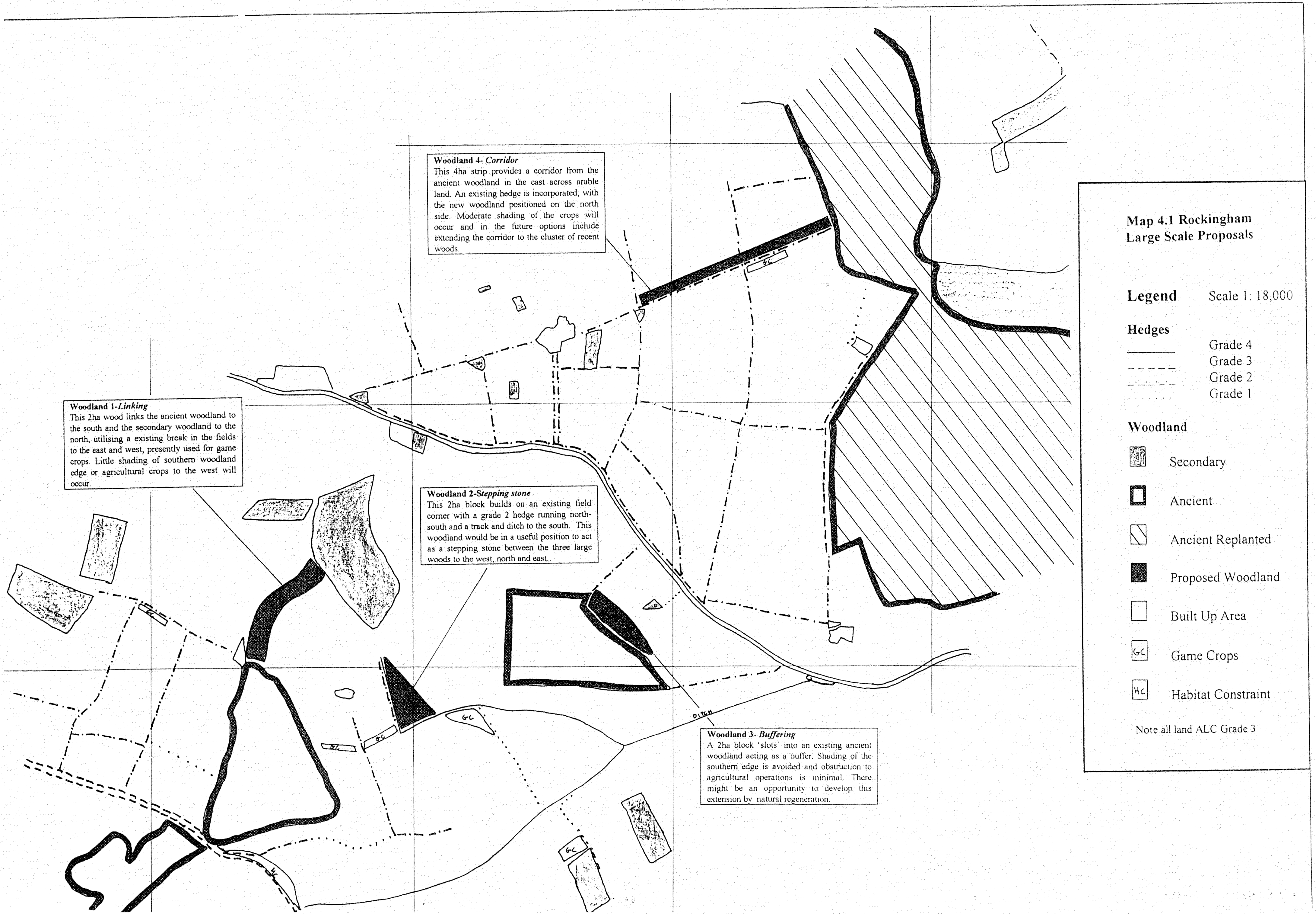
The landscape of this area is dominated by large open fields and substantial woodland blocks. Some hedges are of reasonable conservation value but many large fields are open with no boundary at all.

The main constraints in this area include a roadside verge of neutral grassland to the south, and an airfield to the south-west. All agricultural land is classed as 3 so the main agricultural constraints lie in the positioning of new woodlands to fit in with the existing pattern of land use or to minimise disruption of agricultural operations. There are some areas of recent woodland planting (mixed broadleaved, probably Farm Woodland Premium Scheme with trees spaced at 1000/ha planted around 4-5 years ago) obviously not shown on the Ordnance Survey map.

Since the approximate area of the survey was 10km^2 there is around 10ha to allocate, based on the initial proposal of planting 100ha throughout the sample area. There may be a case for this level to be increased moderately, especially if the area in question was viewed as an ancient woodland envelope (as part of it has been in the small scale proposals) or dramatically, if the rate of planting was increased over the whole study area.

New woodland 1-*Linking*

This 2ha wood provides a useful link between the ancient woodland to the south and the secondary woodland to the north, utilising a existing break in the fields to the east and west. At present there is a small triangular extension to the north of the ancient woodland and some game crops along a rough


Map 4.1 Rockingham
Large Scale Proposals
Legend
Scale 1: 18,000
Hedges
Grade 4
Grade 3
Grade 2
Grade 1
Woodland
Secondary
Ancient
Ancient Replanted
Proposed Woodland
Built Up Area
Game Crops
Habitat Constraint
Note all land ALC Grade 3
Woodland 1-*Linking*
This 2ha wood links the ancient woodland to the south and the secondary woodland to the north, utilising a existing break in the fields to the east and west, presently used for game crops. Little shading of southern woodland edge or agricultural crops to the west will occur.
Woodland 2-*Stepping stone*
This 2ha block builds on an existing field corner with a grade 2 hedge running north-south and a track and ditch to the south. This woodland would be in a useful position to act as a stepping stone between the three large woods to the west, north and east..
Woodland 3- *Buffering*
A 2ha block 'slots' into an existing ancient woodland acting as a buffer. Shading of the southern edge is avoided and obstruction to agricultural operations is minimal. There might be an opportunity to develop this extension by natural regeneration.
Woodland 4- *Corridor*
This 4ha strip provides a corridor from the ancient woodland in the east across arable land. An existing hedge is incorporated, with the new woodland positioned on the north side. Moderate shading of the crops will occur and in the future options include extending the corridor to the cluster of recent woods.
DITCH
GC
HC

boundary leading to a poor hedgerow (grade 1) in the north. Little shading of southern woodland edge or agricultural crops to the west will occur and in the future this could be part of a set of links to the west incorporating the other areas of new woodland.

New woodland 2-*Stepping stone*

This 2ha block builds on an existing field corner with a grade 2 hedge running north-south and a track and ditch to the south. This woodland would be in a useful position to act as a stepping stone between the three large woods to the west, north and east. Shading of crops will be minimal and little alteration to the pattern of cultivation should be necessary. Future extensions of this wood could join it to the recent woodland in the north, or to those in the east and west using corridors.

New woodland 3- *Buffering*

Another 2ha block can be fitted into an existing ancient woodland acting as a buffer. Shading of the southern edge is avoided and obstruction to agricultural operations is minimal. There might be an opportunity to develop this extension by natural regeneration, provided suitable provision for fencing and management is made. The small triangle to the east might be incorporated in the future, perhaps as part of the existing game planting, providing a corridor out of the ancient woodland.

New woodland 4- *Corridor*

This 4ha strip (around 50m wide) provides a corridor running from the ancient woodland in the east across hostile arable land. An existing hedge of good quality (grade3) is incorporated, with the new woodland positioned on the north side. Moderate shading of the crops will occur and in the future options include extending the corridor to the cluster of recent woods and perhaps building on them. This theme could easily have been followed to the east, joining a larger section of recent woodland to the ancient, replanted one.

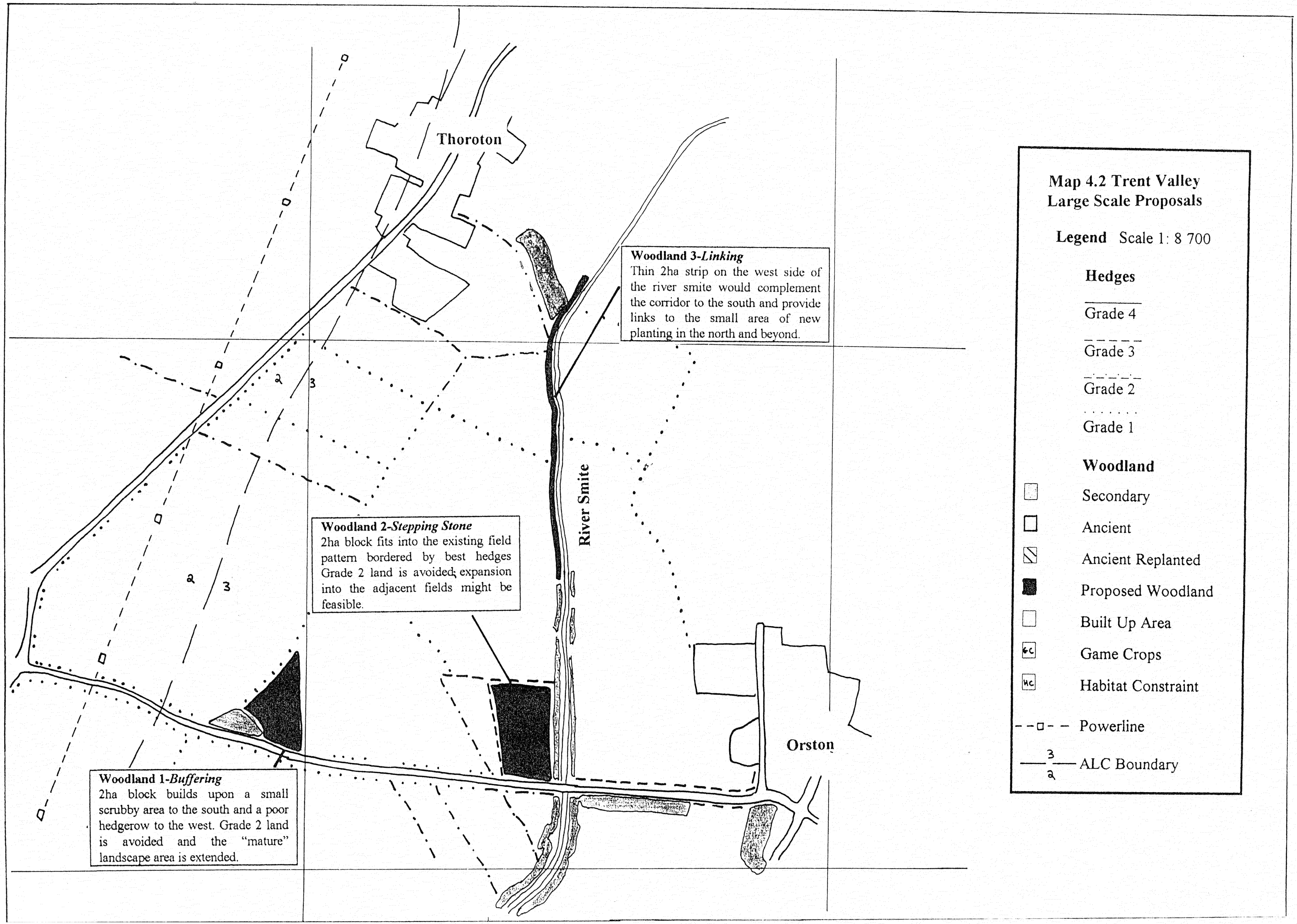
Other Options

- Consolidate or build on other new woods in the west, to create large stepping stones.
- Link ancient woods with a corridor along the existing ditch or track.

4.5.2 Trent Valley sample area (Map 4.2)

The landscape is characterised by medium sized open fields and small blocks of woodland the latter often associated with settlements. Some hedges are of reasonable conservation value, but many fields have been enlarged and have boundaries of poor and gappy hedges. The river Smite a is major feature of this area, with considerable woodland edge to the south and is designated a grade 2 biological site. The main constraints in the vicinity include the river (which should not be overplanted), a powerline to the west running north-south, and the belt of grade 2 agricultural land also to the west.

A small amount of new planting was recorded in the north alongside a hedge and ditch towards the river Smite. All options below extend or consolidate the Mature Landscape Area designation of the local authority. Since the approximate area of the survey was 3km^2 there is around 3ha to allocate, based on the initial proposal of planting 100ha throughout the sample area. There may be a case for this level to be increased moderately, if perhaps the area in question was viewed as a envelope or dramatically if the rate of planting was increased over the whole study area.


Map 4.2 Trent Valley
Large Scale Proposals
Legend Scale 1: 8 700
Hedges
Grade 4
Grade 3
Grade 2
Grade 1
Woodland
Secondary
Ancient
Ancient Replanted
Proposed Woodland
Built Up Area
Game Crops
Habitat Constraint
Powerline
ALC Boundary
Thoroton
Orston
River Smite
Woodland 1-*Buffering*
2ha block builds upon a small scrubby area to the south and a poor hedgerow to the west. Grade 2 land is avoided and the "mature" landscape area is extended.
Woodland 2-*Stepping Stone*
2ha block fits into the existing field pattern bordered by best hedges Grade 2 land is avoided; expansion into the adjacent fields might be feasible.
Woodland 3-*Linking*
Thin 2ha strip on the west side of the river smite would complement the corridor to the south and provide links to the small area of new planting in the north and beyond.

New woodland 1-*Buffering*

This 2ha block builds upon a small scrubby area to the south and a poor hedgerow to the west. Grade 2 land is avoided and disruption to agricultural operations is minimal. The Mature Landscape Area is extended, and options in the future might include the linking up of roadside woods and hedgerows.

New woodland 2 *Stepping Stone*

Another 2ha block fits into the existing field pattern bordered by some of the best hedges encountered in the area. Grade 2 land is avoided and disruption to agricultural operations is minimal. Future expansion into the adjacent fields might be feasible (although their status as unimproved grass would need to be checked).

New woodland 3-*Linking*

A thin strip of new planting on the west side of the upper part of the river smite of around 2ha would complement the corridor to the south and provides links to the small area of new planting in the north and between the wooded fringes of the villages. Grade 2 land is avoided and disruption to agricultural operations is minimal although care would be needed to ensure compliance with Environment Agency regulations.

Other Options

- Build on the existing riverside woodland/tree cover, but avoid overplanting on both sides.
- Expand roadside shelterbelts.

4.5.3 Vale of Taunton sample area (Map 4.3)

This is an intricate landscape, characterised by small enclosed fields and groups of trees at the corners of fields and also at low points where the land is steep or wet. Many hedges are of good conservation value. Land use reflects the topography and the tops of slopes are frequently cultivated, with the steeper and smaller fields reserved for grass, often near settlements or farms. The main constraint in this area is the high proportion of grade 1 and 2 agricultural land, grade 3 being confined to the steeper slopes and valley bottoms.

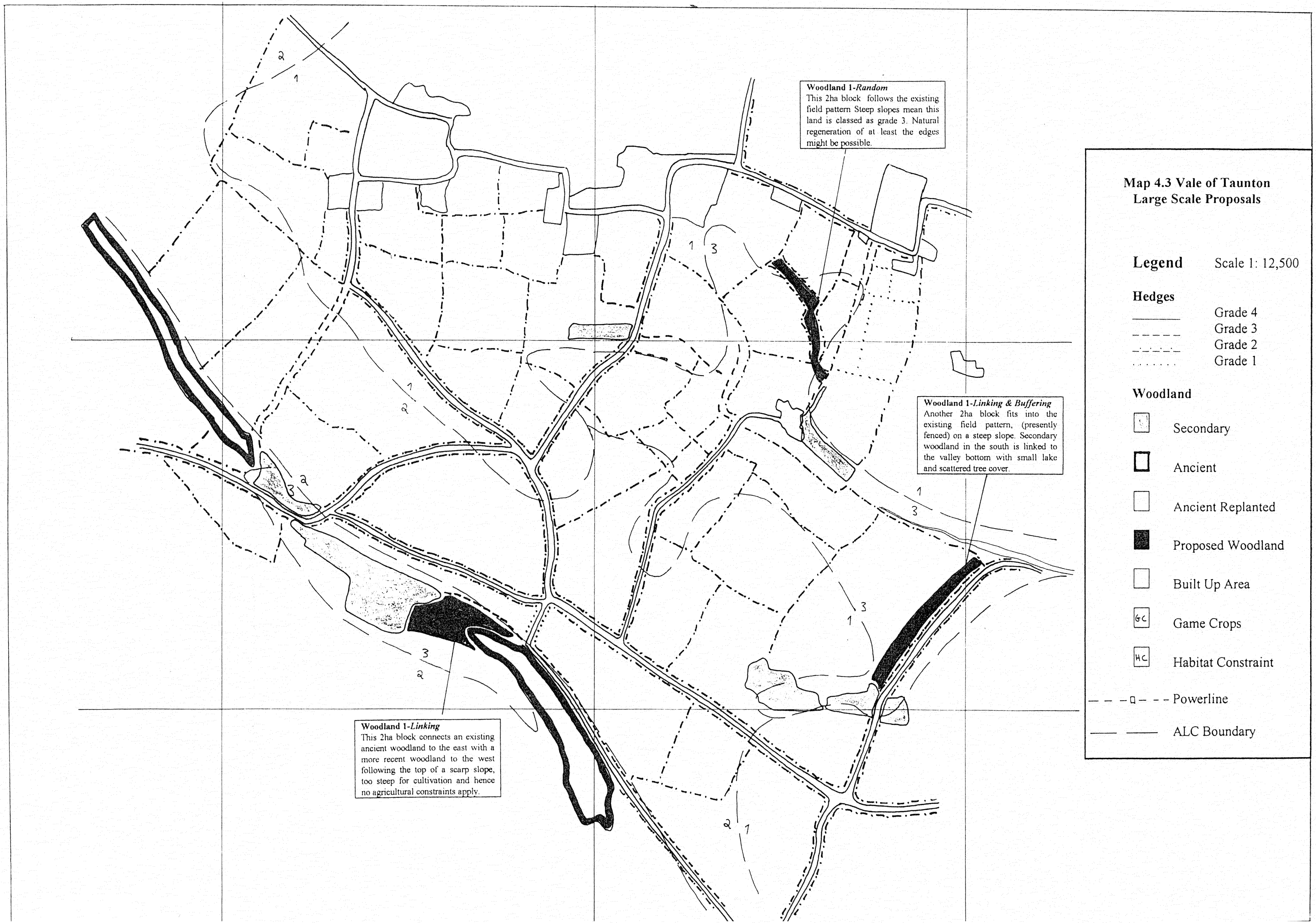
The approximate area of the field survey was 5km^2, giving around 5ha to allocate in line with the initial approach. There may be a case for this level to be increased moderately, if perhaps the area of the field survey was viewed as a envelope, or dramatically if the rate of planting was increased over the whole study area.

New woodland 1-*Linking*

This 2ha block connects an existing ancient woodland to the east with a more recent woodland to the west following the top of a scarp slope, too steep for cultivation and hence no agricultural constraints apply. The present land use is rough pasture and a grade 3 hedge is incorporated to the north, which will be shaded, unless a buffer strip is left, and natural regeneration of the edges might be possible. Future expansion of this linear belt along the steep slope is a possibility since it already extends for around 2km.

New woodland 2- *Linking & Buffering*

Another 2ha block fits into the existing field pattern, presently fenced off to the west, on a steep slope with a small lane below. As well as incorporating the lane side hedge the secondary woodland in the


Woodland 1-*Random*
This 2ha block follows the existing field pattern Steep slopes mean this land is classed as grade 3. Natural regeneration of at least the edges might be possible.
Woodland 1-*Linking & Buffering*
Another 2ha block fits into the existing field pattern, (presently fenced) on a steep slope. Secondary woodland in the south is linked to the valley bottom with small lake and scattered tree cover.
Woodland 1-*Linking*
This 2ha block connects an existing ancient woodland to the east with a more recent woodland to the west following the top of a scarp slope, too steep for cultivation and hence no agricultural constraints apply.
Map 4.3 Vale of Taunton
Large Scale Proposals
Legend
Scale 1: 12,500
Hedges
Grade 4
Grade 3
Grade 2
Grade 1
Woodland
Secondary
Ancient
Ancient Replanted
Proposed Woodland
Built Up Area
GC
Game Crops
HC
Habitat Constraint
Powerline
ALC Boundary

south is linked to the valley bottom where there is a small lake and some scattered tree cover. This type of planting is actively encouraged by Taunton Deane Borough Council. Grade 2 land is avoided and disruption to agricultural operations is minimal, although the loss of improved pasture might be a constraint. Future expansion into the adjacent fields is unlikely but further connections utilising the river valley might be feasible.

<u>New woodland 3- *Random*</u>

- Another 2ha block follows the existing field pattern, filling in the entire field (one of the smaller ones). The low point and with fairly steep slopes this land is classed as grade 3. Impedance of agricultural operations might be a constraint if access to the surrounding fields is via this land. Grade 2 hedges surround this field and natural regeneration of at least the edges might be possible. There is a link to a very good quality hedge in the east and this might be extended in the future. Constraints of grade 1 and 2 agricultural quality mean that only a little more woodland planting would effectively 'saturate' the landscape.

<u>Other Options</u>

- Build on the existing riverside woodland/tree cover
- Consolidate existing recent woodland blocks .

5.0 Discussion

5.1 *Limitations of the scenarios*

Any approach to the problem of assessing the nature conservation potential of an area or region using landscape metrics for a single habitat type, woodland, are clearly limited. Habitat 'quality', both of the woods themselves and their juxtaposition with other habitat types, is equally important in determining the number of species they can support. In particular, the presence of significant features such as hedges, ditches, verges and ponds, highlighted in the field-by-field surveys (Section 4.5), had to be excluded through lack of data. Such information is rarely available from county wildlife trusts or local authorities, as small-scale features are more difficult to integrate into GIS databases. Nevertheless, to take only one example, good information on hedgerow 'quality', connectivity and length is clearly critical to an appraisal of the wildlife benefits of new woodland planting in the Vale of Taunton. There is also a good case for examining the inverse effect of woodland planting scenarios on other categories of land type (arable, unimproved grassland, etc.) in order to model the potential ecological effects on species of open habitats.

A major limitation of the modelling approach adopted is that, while woodland density, size and dispersal have all been considered, less account has been taken of woodland 'quality' factors such as semi-natural status, National Vegetation Classification variety, structure and management. Technically it would be possible to re-visit the spatial analysis of each planting scenario and to consider each woodland category separately (ancient, secondary, broadleaved, conifer, mixed, etc.) both in relation to themselves and each other, but this is beyond the scope of this report. Equally, the investigation could be broadened to examine in more detail the positional relationship of woods to other landscape categories such as grassland, arable, settlement, riparian corridors and so on.

The vehicle of using a single layout of planting (1-2ha blocks) to increase the area of woodland cover can be criticised as it is based on *current* planting behaviour of landowners in response to existing government incentives. Other approaches might have included establishing single, 100ha blocks of woodland in the sample areas, or a number of woods added in a wider range of different size classes. However, some of the scenarios did approximate to other strategies: envelope and buffering planting, for example, effectively increased woodland size and minimised fragmentation. Further modifications could involve varying the shape and size of new woodlands, or combining or splitting allocations to create fewer, or more stepping stones.

All the planting scenarios presented here are capable of further refinement. For envelope planting, the size of the envelopes can readily be modified by re-setting the minimum interwood distance between clusters, or by targeting particular woodland types such as semi-natural, ancient woodland). Envelope scenarios also need to be viewed at a wider landscape perspective in order to determine their biological and administrative usefulness. In the sample 10x10km sample units, several designated envelopes overlapped the perimeter, suggesting that a more informed picture of 'viable' woodland groupings might be obtained over larger landscape units, allowing these to be prioritised as potential planting areas. In an extreme case, such as Rockingham Forest, potentially the whole Natural Area might be considered a valid 'envelope'. Other types of envelopes could be defined on totally different criteria, not necessarily related to existing woodland, such as the selection of riparian corridors or steeply-sloping land.

Buffering scenarios can also be approached in different ways, for example by adding the permitted new planting area as a constant perimeter width to each separate woodland, either equally or in proportion to size. Allocating only a few percent of woodland to a landscape is, however, unlikely to achieve much ecologically, since in a moderately wooded landscape only a few metres (at most) would be added to each wood perimeter. The relative effect would be greater if only the smallest woods were targeted, as was demonstrated by the 'small buffer' scenario used in different sample areas.

5.2 *Linking landscape metrics to species requirements*

5.2.1 Generalist and specialist species

The implications of different planting scenarios for wildlife conservation can be viewed in two main ways. In the first case, new planting may be expected to benefit the relatively common, more generalist species requiring cover, foraging or breeding habitat provided by the woodland edge. At the same time, species requiring open habitat and avoiding woodland edges may be disadvantaged, although the balance is likely to remain positive at modest planting scales in intensively farmed landscapes. Secondly, for more specialist woodland (often Biodiversity Action Plan) species identified as being important by the local English Nature teams for their respective Natural Areas, the situation is less straightforward. It is less likely, in these cases, that planting *per se* will attract key species into the area unless they already occur locally, but appropriate planting strategies can be developed if the prospects are considered favourable.

In general terms, the quantification of woodland parameters through GIS provides a tool to generate hypotheses concerning likely species responses to increases in woodland habitat. At this level the main trends of the landscape metrics, based on three sample 10x10km areas, can be used to examine the effects on various species and taxonomic groups (Table 5.1). Broadly, random and envelope plantings which increase woodland cover by up to 2% reduce isolation between blocks, increase patch number, woodland perimeter and to a lesser extent core area, while the effect on average patch size depends upon the pattern and extent of existing woodland cover. Buffering strategies predictably emphasise patch size and core area, but with little concomitant increase in the woodland perimeter. Linking strategies increase edge effects markedly, while less obviously increasing patch size as woodlands are joined together.

Besides the key species, common species also have a range of susceptibilities to new woodland planting. Several experts consulted were concerned to point out the effects of different landscape scenarios on a range of generalist, as well as the specialist species listed by the English Nature local teams (Appendix 6). For example, a number of studies have shown that certain bird species are 'specialists', virtually confined to woodlands (e.g. nuthatch, nightingale, tree creeper, willow tit, blackcap (Fuller, 1995, Bellamy *et al.*, 1996) and moreover require large patch sizes of mature woodland habitat. Others are essentially woodland 'edge' species, capable of breeding in and utilising small woods and hedgerows (e.g. whitethroat, yellowhammer, dunnock), as are some more ubiquitous species (e.g. blackbird, chaffinch, blue-tit, robin, wren).

At the levels of planting proposed, together with the amounts of background woodland cover in the three sample areas, all generalist species using woodland edges, and to a greater or lesser extent those using the 'core', will probably be benefited by an increase in woodland cover. Table 5.1 suggests that random, envelope and especially linking strategies which optimise the woodland perimeter and produce more complicated shapes, should particularly favour the 'edge' species, for example leading to population increases in small mammals such as field vole, harvest mouse, wood mouse and bank vole (Flowerdew & Trout, 1995; Fitzgibbon, 1997) but possibly also deer species such as roe, muntjac and fallow (Gill, 1992).

On the other hand, buffering strategies which increase woodland core area and patch size may be expected to benefit and sustain some specialist species which require larger areas for foraging and breeding, (e.g. yellow-necked mouse or dormouse) or may be vulnerable to large population swings in unbuffered, smaller woods. Buffering may also be the best option for plant species which tend to be confined to, or are 'indicators' of, ancient woodland (Peterken, 1974) as they can expand into the new woodland areas without encountering hostile or unshaded terrain. 'Ubiquitous' species of all taxa which can also utilise woodland edges and open habitat should also increase with buffering. However, buffering also has the disadvantage, shared with linking strategies, that potentially invasive species may be present in, or will be attracted to, the expanded wood, with deleterious effects on species already present, which hitherto have enjoyed little competition. This is clearly important in the case of tree and shrub species used in adjacent planting, but may also apply to other species groups, such as birds or mammals. Buffering could also result in a decrease in diversity if the generalist species of scrub and open country are lost by overplanting the original perimeter.

Table 5.1 Summary of the effects of the planting scenarios on woodland landscape metrics

Scenario	mean NN distance	patch no.	patch size	core area	edge length	shape index	fractal dimension
random	--	++	+/-	+	++	+	
envelope	---	++	+/-	+	++	+	
random buffer	-	o	++	+++	o	o	
small buffer	-- **effective for <u>small</u> woods**	o	++	++	+	+	++
linking anc-anc	-	--	+++	o	+++	+++	++
linking anc-other	-- **effective for long, complex links**	--	+	o	+++	+++	+

\- reduced quantity o little effect
\+ increased quantity +/- positive or negative, depending on existing woodland scale

Two antagonistic effects operate here which relate to woodland size and number. Buffering small woods may bring them up to a critical size which enables them to support metapopulations of some specialist species such as jay and treecreeper (Hinsley, 1994). Usher *et al.* (1992) also found that the area of recent farm woods was a good predictor of plant species richness and that 'typical' woodland species tended not to occur in woods <1.5ha, leading them to suggest that new planting should be larger than this threshold. On the other hand, expanding a woodland through buffering will tend to occur within similar terrain, taking into account soils and topography, than if the planting had been carried out elsewhere. If, as the Single Large or Several Small patches (SLOSS) debate in island biogeography suggests, several smaller plantings are likely to encourage a greater variety of species than a single, expanded site, random planting would be the preferred strategy. In ancient woodlands this has been shown to operate for vascular plant species in Lincolnshire (Game and Peterken, 1984), but it is uncertain whether this would hold true for recent woods. At a very small scale of planting, however (say <2ha), bird species biodiversity might be expected to be lower as the position of the specialist species is more precarious unless they have larger, existing woods to support them (Fuller *et al.*, 1995).

Envelope planting and linking scenarios, which reduce inter-wood isolation while providing 'stepping stones' for colonisation, should benefit sedentary species which are unable to disperse over large distances (for example some fritillary butterflies (Thomas, 1995), or nuthatch and tree-creeper). However, although linking plantings extend the habitat, it is considered unlikely that narrow links significantly aid bird dispersal, although the increase in edge will benefit several 'hedgerow' species.

Linking also tends to divide up habitats and to form barriers against the dispersal of non-woodland species. There was some disagreement between experts as to whether linking plantings of 50m would provide useful habitat for woodland specialists, one expert considering that 100m was probably the minimum for woodland birds. An entomological view was that structural linkages which connected existing woodlands should be planted as a deliberate framework which could then, a some time in the distant future, be infilled by new planting to increase the structural diversity of the landscape while allowing new veteran trees to develop at the edges.

5.2.2'Keystone' species

All the key species set out in the Natural Area Profile documents were listed and their broad habitat requirements ranked in an attempt to determine local conservation issues and to anticipate possible conflicts between habitats and species preferences. As some species were listed as occurring in a number of habitats, a judgement had to be taken as to which was the primary habitat in the results presented below. A summary of the main species groups identified by the local English Nature teams is shown in Table 5.2. Birds, invertebrates and plants together accounted for nearly 80% of all species citations and showed a reasonable division between groups, with birds predominating, while a smaller number of mammals and amphibians was noted. Overall, the East Anglian Plain received the fewest species citations and Rockingham the most.

Table 5.2 Species cited as being of key importance by English Nature staff in the four Natural Area Profiles

Species group	East Anglian Plain		Rockingham Forest		Trent Valley and Rises		Vale of Taunton		Total	
	no.	%	no.	%	no.	%	no.	%	no.	%
Invertebrates	6	**24**	21	**32**	6	**13**	10	**21**	43	**23**
Mammals	4	**16**	6	**9**	3	**7**	11	**23**	24	**13**
Birds	10	**40**	14	**21**	21	**47**	12	**26**	57	**31**
Reptiles/ Amphibians	1	**4**	3	**5**	1	**2**	8	**17**	13	**7**
Plants	4	**16**	22	**33**	14	**31**	6	**13**	46	**25**
Totals	25	**100**	66	**100**	45	**100**	47	**100**	183	**100**

Of the habitats associated with these species, woodland and wetland categories were most frequently cited, but grassland, especially calcareous grassland and meadows, featured strongly in Rockingham and the Trent Valley respectively (Table 5.3). Wetland habitats supported more listed key species in the Vale of Taunton and Trent, while urban and other habitats were reported more frequently in Rockingham and again in Trent. In Rockingham, where much ancient pasture woodland is present, it was perhaps surprising that only one species associated with dead wood habitats was listed. The relative importance of wetland and grassland indicates the importance of avoiding these habitats when considering further tree planting. Table 5.3 also draws attention to the need to plan new woodlands sensitively with respect to existing scrub and hedgerow habitat.

An illustration of potential difficulty of balancing several different key species' requirements is given below. Table 5.4 attempts to summarise some habitat profiles of nine selected species listed in the Natural Area reports, taking account of bird, mammal, insect and plant taxa which, where possible, occurred in more than one region. Although the information is inadequate to make accurate predictions for most, broad responses to radically different planting scenarios can be inferred and predictions made as to whether a given species will benefit more or less from new tree planting in one landscape configuration or another.

Table 5.5 summarises the possible responses of nine species to different woodland landscape parameters discussed in the previous section. Of these, it seems likely that the dormouse, together with woodland interior plants such as bluebell and yellow archangel, all of which would tend to be favoured by large patch size, core area and minimum isolation of woods, might be expected to respond most favourably to buffering and envelope strategies, particularly where the locating woodland elements are predominantly ancient. On the other hand, species which use edges, such as pipistrelle, great-crested newt, brown hairstreak butterfly and linnet might respond more strongly to linking or envelope strategies, although random strategies also tend to emphasise the scrub edges used by the linnet, while the linking of woodlands in small buffering strategies might be advantageous to pipistrelles. Skylark habitat would be best maintained by maintaining a compact woodland layout promoted by buffering scenarios, or by no planting at all.

Table 5.3 Summary of habitats associated with the key species cited in the four Natural Area Profiles

Habitat	East Anglian Plain		Rockingham Forest		Trent Valley and Rises		Vale of Taunton	
	no.	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**
Woodland	9	43	16	31	10	27	7	16
Scrub	1	5	0	0	0	0	2	4
Dead wood	1	5	1	2	0	0	0	0
Old trees	0	0	0	0	0	0	2	4
Hedgerows	1	5	1	2	0	0	1	2
Total	**12**	**57**	**18**	**35**	**10**	**27**	**12**	**27**
Grassland	0	0	1	2	0	0	4	9
Calc. grass	0	0	16	31	0	0	4	9
Meadow	2	10	1	2	12	32	1	2
Total	**2**	**10**	**18**	**35**	**12**	**32**	**9**	**20**
Wetland	1	5	5	10	0	0	1	2
Rivers	2	10	4	8	2	5	10	22
Standing water	1	5	2	4	12	32	5	11
Valley fen	2	10	0	0	0	0	0	0
Total	**6**	**29**	**11**	**21**	**14**	**38**	**16**	**36**
Buildings	0	0	0	0	0	0	2	4
Specialist	0	0	0	0	0	0	4	9
Various	1	5	5	10	1	3	2	4
Total	**1**	**5**	**5**	**10**	**1**	**3**	**8**	**18**
Grand Total	**21**	**100**	**52**	**100**	**37**	**100**	**45**	**100**

The debate as to whether the species cited in Table 5.5 are indicator, flagship, umbrella or keystone species is somewhat academic (Simberloff, 1997), but what is clear is that there are potential conflicts between their requirements. For the nine subjects examined here, buffering was the best 'average' planting scenario, followed by envelope and linking planting, but this would not necessarily be true if all other key species listed in the four Natural Areas, or elsewhere, were brought into the equation.

Table 5.4 Requirements of some key species listed as present within one or more of the four Natural Areas.

Dormouse (***Muscardinus avellanarius***) Dormice are more frequently found in larger ancient woods, despite high quality of habitat in some recent woods. Area and isolation are complimentary factors, smaller woodlands being more likely to have dormice if close to other woodlands. A minimum patch size of 6ha has been suggested for new introductions in Species Recovery Programmes, but 10-20ha for viable indigenous populations (Bright and Morris, 1989). However, a later study of 229 woods in Herefordshire using gnawed hazel nut shells as indicators of dormouse presence suggested that ancient woodlands less than 20ha are unlikely to support viable dormouse populations in the long term (250 years), while in recent woods dormice are too scarce to make any estimate on their minimum area requirements (Bright *et al.*, 1992). Minimum areas are likely to be considerably higher in isolated or low quality woodlands. Across all size classes dormouse incidence was lower in more isolated woods with interchange more important for smaller woods. If the hedgerow network is good, dormice might colonise up to 1.7km but are unlikely to travel far along the ground, even across wide woodland rides. Where there is a clustered distribution of woodlands dormice are unlikely to disperse further than the nearest woods, subdividing the population into more vulnerable metapopulations whose units have little genetic or demographic interchange.

Pipistrelle bat (***Pipistrellus pipistrellus***) Foraging activity of pipistrelles was significantly higher over lakes & rivers, with 70% of all bat passes recorded over water in a survey by Vaughn *et al.* (1997). Activity was also high in both the woodland interior and along edges, but there was more activity in sheltered transects, following insect distribution. Previous surveys which have indicated preference for edges may be biased due to ease of identification compared to interior. Pipistrelles did not, unlike other species of bat, avoid open habitats and rides, glades and deciduous cover are likely to be of benefit due to the increased foraging opportunities. Although treelines and hedgerows are selected as foraging habitat., in some arable areas hedgerows are avoided (Walt and Harris, 1996). In a fragmented landscape hedges and treelines are important links and provide cover between roosting sites, as well as additional feeding areas.

Great crested newt (*Titurus cristatus*) The great crested newt has both terrestrial and aquatic phases during its annual life cycle, ponds being used for courtship, breeding and larval development and land used for feeding and overwintering. The majority of the breeding population travelled no more than 250m from the pond with a small proportion recorded at distances in excess of 350m (Latham *et al.*, 1996). Undisturbed deciduous woodland with dead wood was found to be important for overwintering, with coppice and coniferous woodland being used less frequently. Scrub and grass also provided cover. Observed adult density appeared lower in fragmented landscapes, with the lower limit of suitable adjacent habitat was 0.4ha within 500m.

Skylark (*Alauda arvensis*) The skylark is considered a species of open habitat , breeding in a wide variety of habitats including saltmarsh, rough grassland, pasture and cereals (Dodds *et al.*, 1995). It avoids tall structures such as hedgerows and trees. Over 65% of the population nests on farmland (Wilson and Evans, 1995). Birds nest on the ground, preferring sparsely-vegetated areas in open fields, optimum sward height 20-50cm.

Linnet (*Carduelis cannabina*) The linnet is a bird of scrub (Lack, 1992), generally avoiding large areas of tall trees and using scrub and hedges consisting of blackthorn and hawthorn (Dodds *et al.*, 1995). Birds occur in cultivated farmland, stubbles and fallow fields, preferring stubbles as a foraging habitat in winter (Wilson *et al.*, 1996). Tall hedges (>1.2m) and hedges with standard trees are avoided and Nests are usually found from ground level to 2m in dense vegetation, especially thorny trees, scrub, hedges and young conifer plantations (Green *et al.*, 1994; Dodds *et al.*, 1995).

Brown Hairstreak (*Thecla betulae*) The habitat of this butterfly species is deciduous forests, open woodland, scrub and hedgerows. Adults congregate on woodland edges in order to mate, but the larvae feed on blackthorn (*Prunus spinosa*), usually in nearby hedgerows (Warren, 1991). Thomas (1995) estimates the minimum area required by metapopulations to be in the region of 50-250ha.

Wood White (*Lepidea sinapis*) This butterfly prefers lightly shaded conditions in grassland with <20% direct shade, using rides and permanent glades (Warren and Thomas, 1992). It is a classic edge species but in Britain does not breed outside the woodland environment (Warren, 1991). The approximate minimum area of habitat required by metapopulations of species is in the region of 5-10ha (Thomas, 1995).

Bluebell (*Hyacinthoides non-scripta*) Bluebell tends to be restricted to mesic, but reasonably well-drained sites. A frequent coloniser of plantations in the uplands of northern Britain, but tends to be restricted to ancient woodlands in the south (Rackham, 1980). Spread is mainly by seed but is slow, such that the species to regarded as an ancient woodland indicator in the south and east. Bluebell tends to be more frequent in the woodland interior than at the edge, although it responds well to temporary clearances of the canopy (Buckley *et al.*, 1997).

Yellow archangel (*Lamiastrum galeobdolon*) Like bluebell, yellow archangel is also tolerant of deep shade and heavy litter. It spreads readily by seed and stolons within woods, but dispersal along hedgerow corridors appears to be limited, even where there are good adjacent connections to woodland (MacCoss, 1996) and spread from gardens into woodlands is also poor (Grime *et al.*, 1988). Yellow archangel is regarded as an ancient woodland indicator species in much of lowland Britain.

Another problem is that the finer-grained habitat requirements of each species, relating to the condition of existing woods (such as vertical and horizontal structure, age and canopy composition), or the 'quality' of other habitat in the surrounding countryside (e.g. the presence of hedgerows, ponds, grassland, stubble, etc.), has been neglected at this wider landscape scale. For a narrow approach, GIS may be valuable when modelling the effect of planting on individual species with well-known requirements, especially as customised landscape and habitat parameters can fed in as GIS overlays, or the edge or core area settings adjusted to optimum values for that species. Alternatively, the broad approach taken above may be to used to predict the effects of landscape change on wider species groups, such as those preferring edge, core woodland or open habitat.

Table 5.5 Projected responses of selected species to different woodland parameters

Landscape metric	dor-mouse	pipis-trelle bat	great crested newt	skylark	linnet	brown hairstreak	wood white	bluebell/ yellow archangel
MNN distance	--	-	---	+++	+	-	---	---
patch number	+	?+	+	---	+	++	+	+
patch size	++	+	+	---	--	+	++	++
core area	+++	+	?+	---	---	?+	+++	+++
edge length	-	++	?+	--	++	+++	+	-
shape index	--	++	?+	--	++	++	+	-
preferred scenario	buffering envelope random	linking buffering envelope	linking envelope random	buffering	linking random envelope	linking envelope random	buffering envelope linking	buffering envelope random

+++ strong positive species response — --- strong negative species response
++ moderate species response — -- moderate species response
\+ slight species response — - slight species response
? response uncertain

5.3 *Practical limitations and planning*

5.3.1 Planting density

The assumptions made hitherto must been seen in the context of relatively modest additional areas of woodland planting, but conservation strategies must take account of any possible scope for much larger-scale tree cover in the future. In the case of Rockingham Forest, large amounts of existing woodland meant that 1-2% of additional cover made little difference to the 'core' woodland area potentially suitable for specialist woodland species, whereas the total woodland edge was increased significantly by several different planting scenarios. This same effect is also shown in the theoretical relationship between increasing woodland cover and 'core' and 'edge' woodland up to around 50% cover (Section 4.4.1; Fig.4.5). Therefore in Rockingham, where there is already a substantial core area of woodland, the conservation priority might rather be emphasise small buffer and envelope scenarios, which here increased the habitat for woodland edge species, while at the same time improving prospects for dispersal of woodland specialists by bringing woods closer together. Linking plantings might also be considered, unless important open-field species are known to be present.

In contrast, in East Anglia and Trent, small additions of woodland significantly increased the woodland 'core' of the small, scattered woodlands present in these areas. If, as in East Anglia, some of these woodlands are ancient and may contain some specialist woodland species, buffering of the larger woods or envelope planting could achieve the greatest gains for conservation compared with random or linking scenarios. The same may be true of the Trent 10x10km sample, even in the absence of ancient woodland, if it is anticipated that a key species present in the vicinity has the potential to colonise. As the woodland area is increased and the woodland 'core' is gradually expanded, planting strategies which increase the woodland edge may eventually become more acceptable as a means of increasing local biodiversity.

In either case, substantially larger areas of woodland cover, perhaps of the order of 40-60%, may be required to create an optimum balance between woodland edge and core (Fig.4.5). Again, this would severely restrict open country species, but such densities are unlikely to be achieved unless a conscious decision is made to create 'woodland districts' of continuous forest (Kirby and Reid, 1997) in which the interests of woodland and woodland edge species are considered overriding.

5.3.2 Planning and economic considerations

Within the context of the essentially rural and fairly intensively farmed landscapes examined here, constraints to new tree planting posed respectively by the built landscape, open semi-natural habitats and existing woodland, were relatively minor. Taken at random, the apparent unavailability of suitable land was 12-22% on a total area basis, but, at these low planting densities, could be largely circumnavigated. Envelope scenarios, for example, were shown to be successful in reducing the risk of coincidence between new planting positions and urban, semi-natural and other constraints, although at the same time they severely restricted the 'search area' to the available space left between existing woodlands. Buffering or linking strategies might be expected to behave similarly.

The apparent availability of planting land may however be deceptive, as this takes no account either of agricultural land quality or of existing habitat fragments. In the former case, landowners will be tempted to choose land for tree planting which is the poorest in agricultural terms, perhaps coinciding with permanent grassland or other land of conservation significance. In the Taunton Vale, envelope planting around existing ancient woods, often located on steep hillsides, tended to take less agriculturally valuable land and might therefore be considered a feasible and cost-effective strategy provided that no losses of semi-natural habitat result. In East Anglia and the Taunton Vale, random buffering and linking were also more effective than random planting in targeting the poorer land. While no universal generalisations concerning the local characteristics of woodland size, distribution and origin and their relation to soil type can be made to guide general policy, at a local level the planting strategy which avoids the most fertile farmland could be adopted.

The field survey work also illustrates a greater complexity on the ground which tree planting needs to avoid or take into account, especially the presence of linear habitats such as hedgerows, verges, ponds and ditches. Overplanting of these features will usually be undesirable and some modification of planting will be often be necessary, such as leaving buffer zones between the planting and the habitat feature (Kirby, 1995). In practice this reduces the available planting land further, so that in the Taunton Vale the presence of high quality hedgerow corridors observed in the field restricted planting potential considerably.

Analogous to evaluating different planting scenarios for conservation, selected landscape parameters can be used as GIS overlays to test the practical implications of planting on agricultural value, landscape character and ownership pattern. The same approach could be used to identify associations of landscape features (topography, soils, etc.) adjacent or related to existing woodland in the area, using GIS to interrogate similar situations where new planting might be expected to have least impact on landscape character. Such an approach effectively mirrors that adopted by indicative forestry strategies, but the level of detail and objectivity provided by GIS is potentially greater. Conservation criteria might also be entered with the landscape background information in order to refine the process. Another, totally different approach would be to take an historical perspective, in which information from historical maps and documents is used to digitise the outline of former woodland cover on to overlays. New planting scenarios showing a strong correlation to the former distribution of woodland might then receive a higher priority, resulting in a reversal the fragmentation process and taking remnants of modified habitat currently isolated from its original setting.

From a planning point of view, area designations have considerable advantages over other strategies in targeting the areas considered to deliver the maximum landscape or conservation benefits.

Nottinghamshire County Council, for example, recognises Mature Landscape Areas or small envelopes which are frequently based on already wooded areas and village envelopes. In the sample 10x10km square in Trent, nine such areas occupied 6.5% of the area, averaging 73ha each. This contrasted with our envelope planting scenarios in the three sample areas of East Anglia, Rockingham and Trent (which occupied much larger areas of 14-35% (Table 5.6). If an area had to be fixed on the grounds of practical feasibility, this could be achieved relatively easily by adjusting the minimum distance between woods. In East Anglia, for example, increasing the distance qualifying for an ancient woodland cluster to 2km would have had the effect of designating as much as 50% of the land within planting envelopes.

Table 5.6 Areas of planting envelopes based on existing ancient woodland in the four sample 10x10km areas of East Anglia, Rockingham, Trent and Taunton.

Envelope Number	**East Anglian Plain**		**Rockingham Forest**		**Trent Valley & Rises**		**Taunton Vale**	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
1	388	3.9	1400	14	1000	10	750	7.5
2	375	3.8	240	2.4	1200	12	300	3.0
3	600	6	1250	12.5	350	3.5	350	3.5
4	500	5	212	2.1	700	7	n/a	n/a
5	300	3	200	2	250	2.5	n/a	n/a
6	n/a	n/a	140	1.4	n/a	n/a	n/a	n/a
Total	**2163**	**21.7**	**3442**	**34.4**	**3500**	**35**	**1400**	**14.0**

Any imposed planting strategy will carry its share of difficulty in persuading or encouraging landowners to establish new lowland woodlands. Envelope strategies, for example, are vulnerable to failure if the areas designated are so small as to cover the holdings of, say, a handful of large landowners who are unwilling to plant. Linking strategies may also be compromised if the links to adjacent woodlands traverse into other ownerships where the planting initiative is not supported. Random and buffering plantings have a greater chance of success as they can applied anywhere, although in the case of buffering this will discriminate against landowners who have no woodland to build on.

On the evidence presented here, buffering and envelope planting scenarios seem to be the most effective compromise in conservation terms because they appear to offer the most to those specialist species confined to the woodland habitats, and in particular to the woodland interior, while at the same time increasing the available edge habitat used by other groups. Both strategies were also well rated by the expert panel, although it was pointed out that wide, linking plantings might also have special significance for some insects and birds. Because envelope and buffering scenarios also tend to complement and reinforce the existing woodland pattern and size distribution, they should fit more easily with visual and landscape character designations, while in practical terms they offer a convenient means of identifying and designating new planting areas.

Small buffer planting and envelopes in particular achieved significant gains compared with random scenarios and could be relatively easily implemented without major changes in the current grant aid regulations, depending on a landowner's willingness to plant on productive agricultural land in the first place. Buffering and envelope planting may also be more 'natural' than random or linking scenarios if they correspond closely to the pattern of historical woodland cover and any extant remnants. Ideally, however, to give the widest species benefits the planting strategy adopted should be based on the existing pattern and layout of woods within the particular locality.

Finally, a problem arises if there is little or no existing woodland within the area. In such cases, where few specialised woodland species are likely survive or have little prospect of dispersing to other woods, there may be little point in planting to enhance conservation. If, however, planting is considered desirable for landscape purposes, or on the basis that some common species will become more abundant, the pattern may still be of little significance to the local wildlife. Broader targets might equally be established, for example by planting according to topographic features, such as river corridors or tracts of steep land. If large enough landscape features in their own right, they may in time begin to attract a specialist species portfolio.

5.3.1 Towards a decision support system

1. Define objectives:

In practice decisions to plant lowland areas will be determined by a mixture of political, planning, forestry and conservation motives. From a wildlife viewpoint, the fundamental question is: how much woodland cover is desirable to safeguard key species and to maximise species diversity? To make the necessary subjective decision, the following points need to be considered:

- Does the area already support important open-field species, and is it a traditionally open landscape?
- What is the 'carrying capacity' of woodland in the area which does not significantly compromise the local landscape character?
- If the region is already well wooded, is further planting justified?
- Will woodland species benefit if further large tracts of woodland are planted, and what level of planting will deliver an acceptable balance between woodland specialists, 'edge' and open-field species?

While it is probable that increases in general biodiversity resulting from new planting will be small at a Natural Area level, significant increases could be achieved at the level of the wood, or the area of agricultural land which it replaces.

2. Review sources of information

The next stage is to assemble practical information which can be used to appraise 'conservation value' of potential woodland planting. The pattern of woodland within the region can be displayed as maps or GIS overlays showing woodland type, origin and historic distribution. Other information on habitats and species can also be added as overlays, using Phase One information, NVC data, county wildlife records, Natural Area Profiles and local Biodiversity Action Plans. If necessary buffer zones can be added as constraints to planting adjacent to certain habitat types or known distributions of open country species.

It is clearly important at this stage to highlight 'keystone' woodland species, although the experts we consulted were wary of Natural Area Profile lists, pointing to instances where species were 'missing' from area lists or were actually absent from the sample location under consideration. The selection of species listed in Natural Area Profiles was also questioned *a priori*, or criticised for the neglect of the commoner species. Subjective decisions on the relative importance of species would appear to be unavoidable, especially where their habitat requirements conflict, but at a practical level it is important to come to a consensus on the actual ranges of 'keystone' species within the area or their potential colonising ability in relation to each planting site.

3. Take account of existing woodland character

If already well wooded (e.g. as in Rockingham Forest), a logical aim would be to develop planting strategies which benefit specialist woodland species associated with semi-natural and replanted ancient woodland. New planting will reduce inter-wood distances and increase the available 'core area' for these species, but some account also needs to be taken of open country or 'edge' species, either by putting an overall ceiling on the amount of new planting, or planning its distribution so as to minimise the impact.

For poorly wooded regions such as Trent and Taunton, one approach would be to concentrate on the species typical of the habitats already present, for example by planting small, linear woods, or even to favour the restoration and planting of new hedgerows as an alternative to tree-planting. The creation of very small woodlands may be questioned if they fail to achieve a critical size threshold which allows them to accommodate few, if any restricted or specialist species.

An extreme strategy in a poorly wooded area might be to concentrate the planting into a few, large tracts of woodland. This might be done exclusively for landscape reasons, to minimise impact on open-country species, or again if there is some prospect of the new woodland reinforcing the diversity of other habitat features or attracting 'keystone' species to the new area. Natural landform might be used as the basis for siting, such as watercourses and ponds where woodland will provide some buffering. In Trent this might improve habitat potential for restricted species such as the water vole and otter, while restoring some riparian woodland in the area.

4. Select the planting strategy/scenario

An analysis of species requirements, based on steps 2 and 3 above, is then be used to examine the present carrying capacity of the landscape. An objective method would be to model alternative new planting scenarios, setting different planting levels on a range of the 'front-runner' strategies in order to identify those which appear to deliver the best compromise between species requirements.

In Rockingham Forest, for example, it might be decided that sufficient woodland 'core' already exists to satisfy the requirements of several key woodland specialist species, in which case alternative planting strategies such as small buffering may be given priority in order to favour a higher ratio of 'edge' species (Section 5.3.1). However, if still more 'core' is thought desirable, opportunities to join the largest woodland blocks together can be explored. In contrast, in the poorly wooded Trent Rises, buffering existing (recent) woodlands would be one option, giving large relative increases in woodland 'core', but creating no really large woods. Alternatively it might be decided that the potential benefits to specialist species justify the creation of a relatively concentrated area of woodland, for example along the corridor of the river Smite, in association with permanent grassland areas created to buffer and enrich the habitat.

5. Select planting sites

Within the adopted planting strategy, potential new planting locations can be identified using GIS associations of existing woodlands with adjacent landscape features such as topography, underlying geology, soils, agricultural land quality and drainage, etc. Provisional planting regions can then be shown on overlays and checked both for constraints and opportunities (e.g. agricultural land quality, other wildlife interests, urban intrusions, historic woodland cover). One approach might be to deliberately target the most productive farming land in order to avoid potentially good habitat such as permanent grassland, or more realistically to avoid substantial areas of Grade 2 or better land.

Having narrowed down potential planting areas using map or GIS overlays, the actual sites need to be adjusted in the field, 'ground-truthing' for habitat features which do not appear on maps and which may need to be avoided, such as hedgelines, streamsides and road verges.

6. Plant and manage new planting sites

Guidelines are already provided by local authorities, English Nature and wildlife organisations which specify a) the appropriate tree species to plant and b) methods of locating the new woodland relative to existing woodland or other, semi-natural habitat features. Selection of species can be refined by basing the planting on the composition of nearby woods, or on local conservation knowledge of key species distributions. The black hairstreak butterfly at the Rockingham site may, for example, benefit from the planting of blackthorn amongst new plantings in the vicinity of the main colony. The planting layout may also reflect keystone species interests. In Rockingham, mixtures of closed-canopy and pasture woodland (the latter at very wide spacing) may eventually benefit both woodland species and tree invertebrates present.

Finally, appropriate management, not just of the newly planted areas, but more critically of existing woodland, is key to the success of all conservation initiatives . If edge species are wanted, scrub areas will need to be managed as such, glades and rides will need to be maintained. and coppicing carried out in certain areas. Indeed, it is arguable that resources put into managing existing woodlands appropriately may be at least as good an investment, in wildlife terms, as the effort of establishing new ones.

5.3.2 Further work

The limited scope of this report has meant that there has been little opportunity to develop a number avenues suggested by the GIS approach. In particular, the following refinements would add insights to the process of locating new woodlands:

- exploring mechanisms for defining woodland aggregation and cluster size at scales beyond the 10x10km template in order to further evaluate the use of envelope and buffering scenarios;

- examining the effect of increasing woodland density in landscapes with contrasting woodland cover and distribution in an attempt to determine contrasts in 'saturation' level of woodland cover for different planting scenarios;

- applying different parent planting scenarios to larger and more exhaustive inventories of 'key' species in order to evaluate the extent of conflict/complementarity between them, taking account of both woodland and non-woodland species.

- differentiating between woodland type and condition in planting scenarios

- investigating which new planting scenarios are most likely to coincide with former, historic woodland cover and extant remnants.

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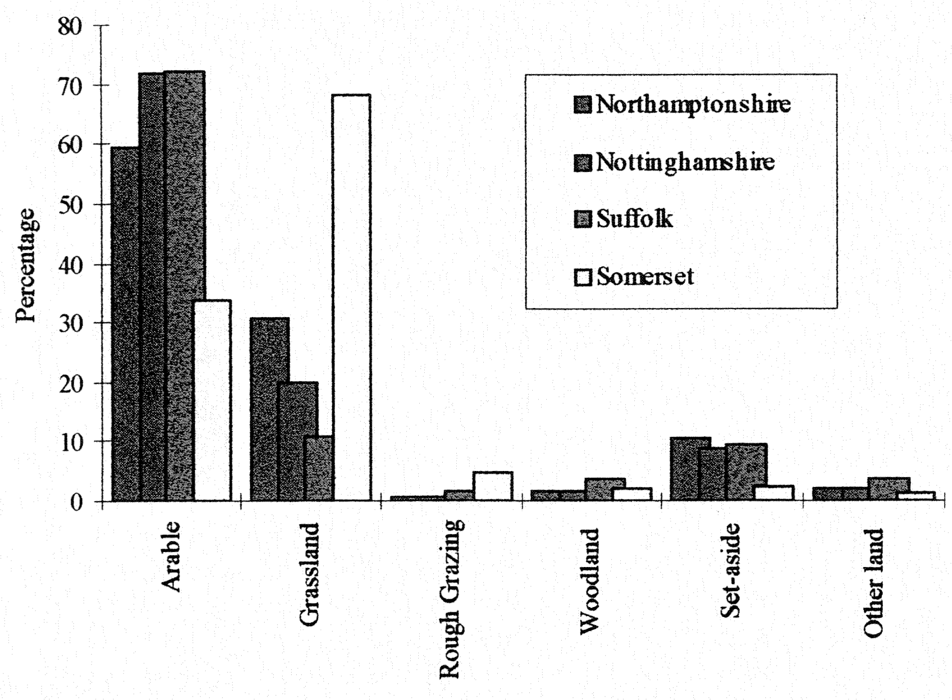
Appendix 1

Agricultural statistics published by the Ministry of Agriculture give a good introduction to the land use pattern within each county (MAFF, 1996). These show a large proportion of arable land, covering 60-70% of the county, in Northamptonshire, Nottinghamshire and Suffolk, but only about 30% in Somerset where the proportion of grassland and rough grazing land is much higher, and that of set-aside land correspondingly less (Fig. A1). Woodland covers about 2-3% on agricultural holdings in all four counties and is highest in Suffolk.

Taking the entire county area into consideration, the proportion of all land covered by woodland is similarly low, ranging from 3% in Somerset to 7% in Suffolk (Fig. A2). Ancient woodland sites comprise a significant proportion of this woodland resource in Northamptonshire (60%) and Somerset (47%), but relatively little of Suffolk (16%) and Nottinghamshire (14%). The proportion of all woodland cover present on farm holdings varies considerably between counties, ranging from 16% in Nottinghamshire and 44% in Suffolk. Unfortunately the data has not been collected in such a way to allow the calculation of the proportion of ancient woodland on farmland relative to that in the county.

Figure A1 Agricultural Land Use In The Four Counties



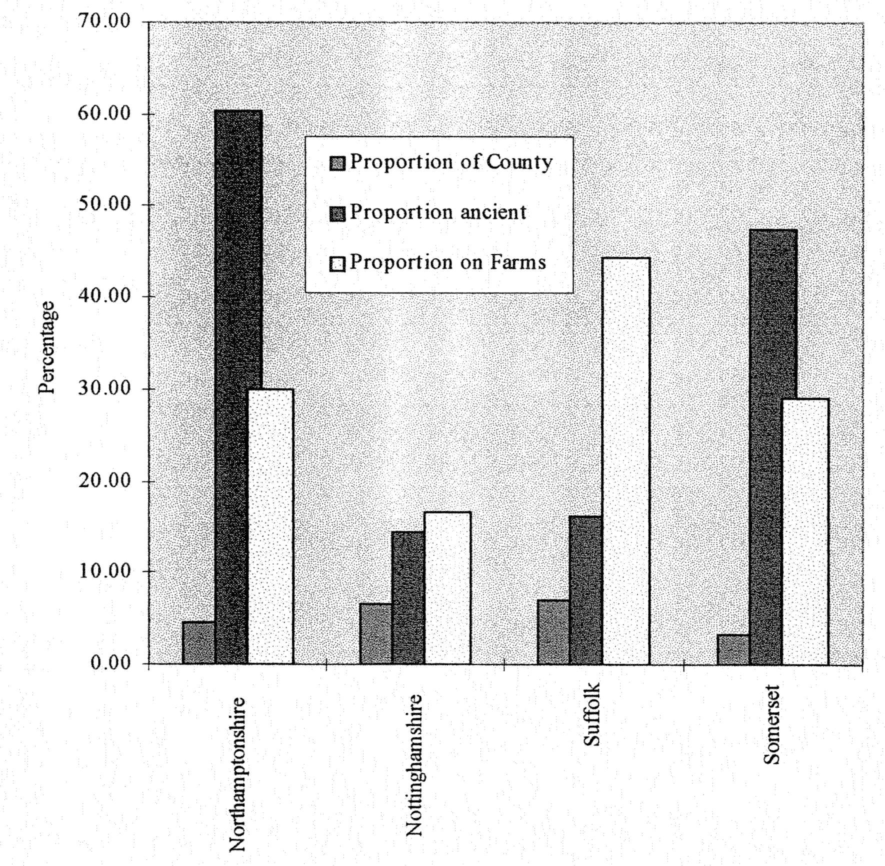
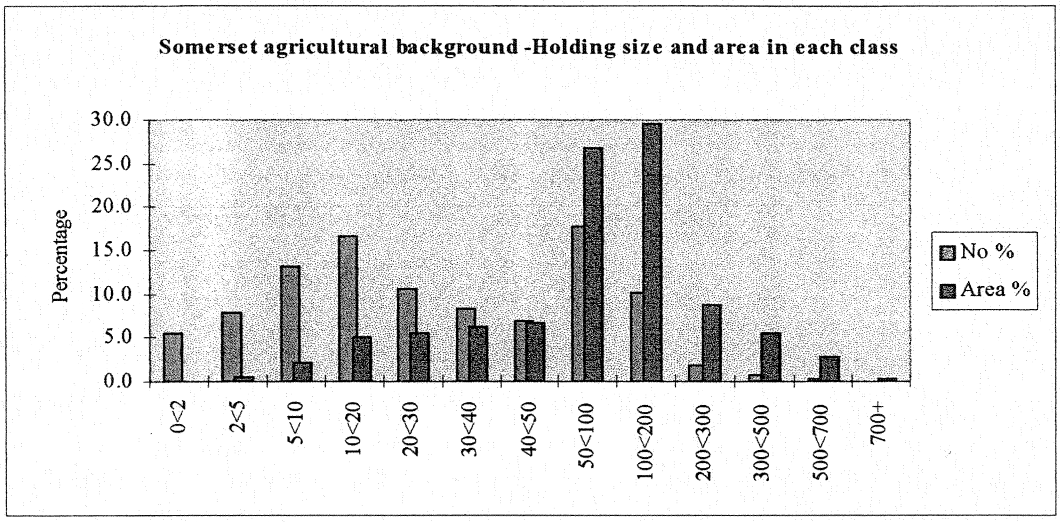


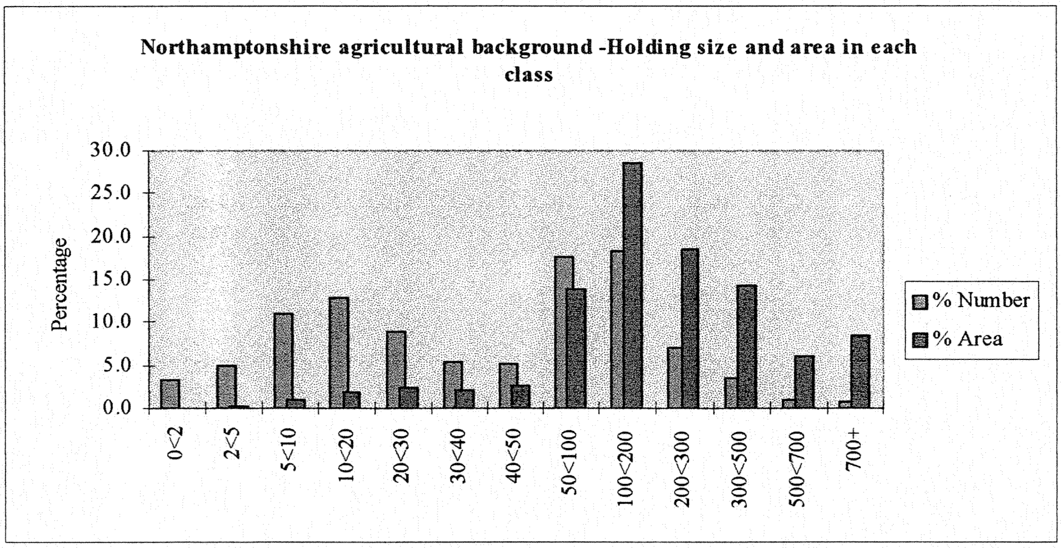
Figure A2 County Woodland Data

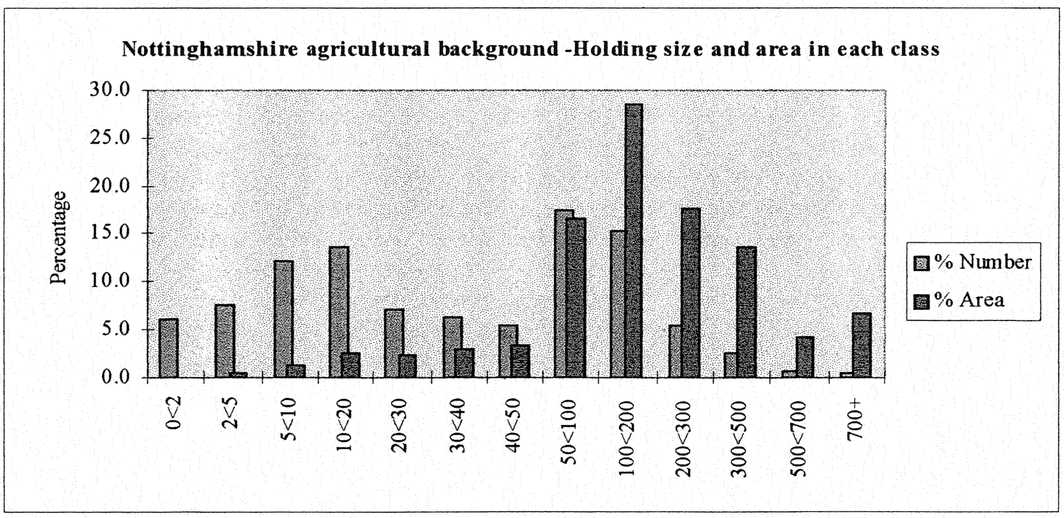
Table A1 Number of Holdings in county and % of land in agriculture for all four counties

Number ofHoldings in county and % of land in agriculture	County area ha	Number Of Farms	Total area in agriculture (ha)	%
Suffolk	379663	3443	304486	80 %
Northamptonshire	236 734	2014	184241	78 %
Nottinghamshire	216365	1987	149672	69%
Somerset	345094	5794	272248	79%

Figures A3a, b, c & d Agricultural holding size and area distributions for each county







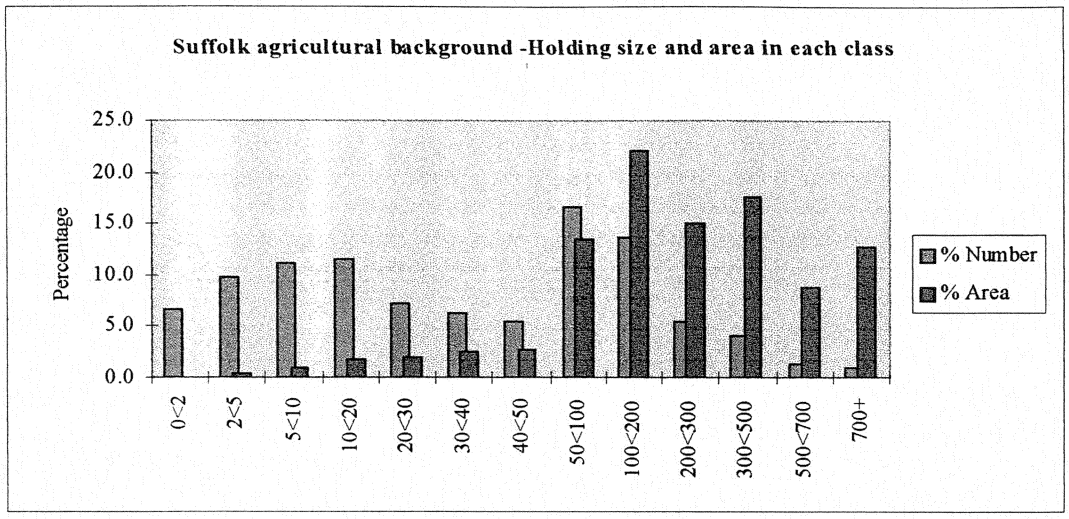
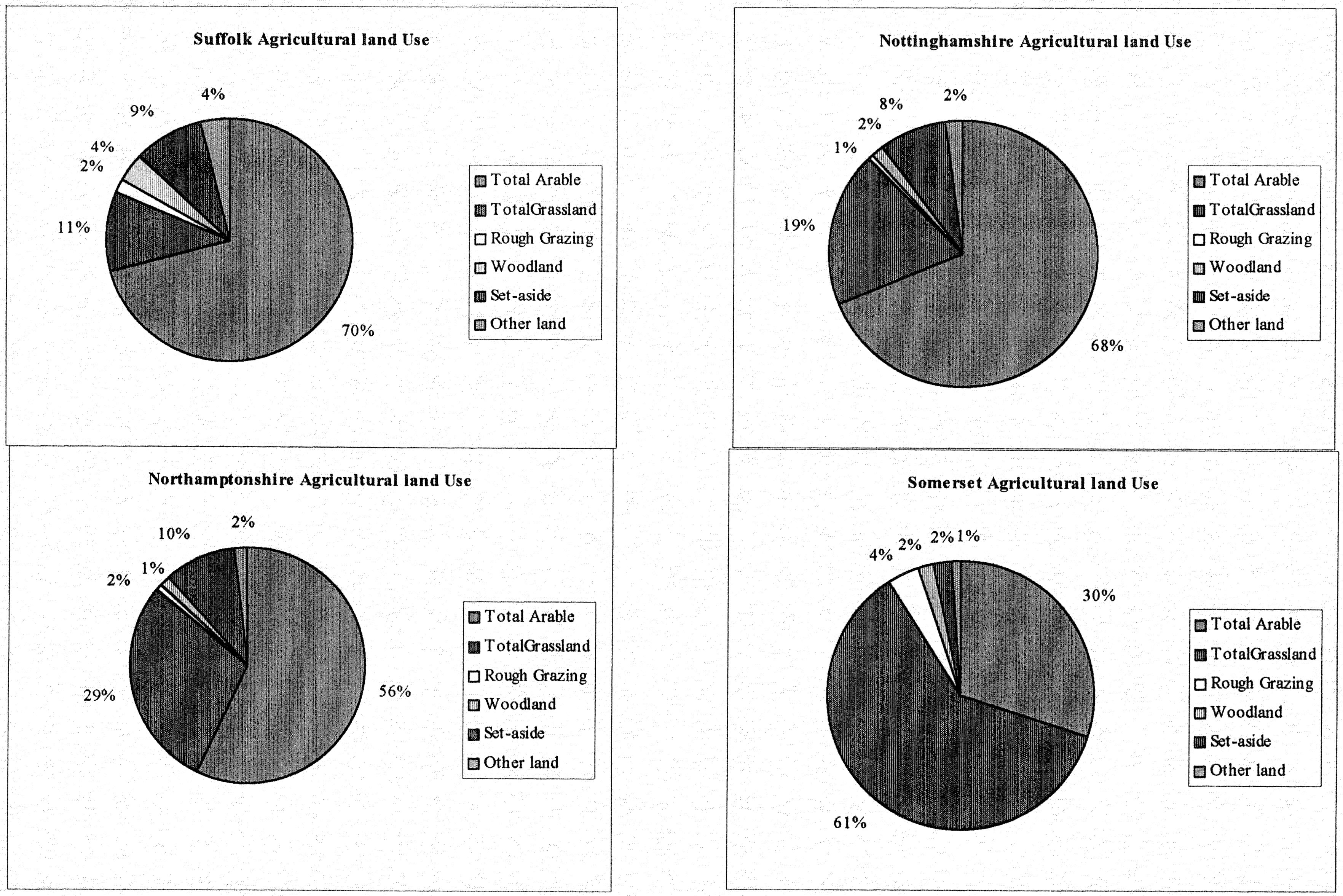

Suffolk agricultural background -Holding size and area in each class
Percentage
25.0
20.0
15.0
10.0
5.0
0.0
0<2
2<5
5<10
10<20
20<30
30<40
40<50
50<100
100<200
200<300
300<500
500<700
700+
% Number
% Area

Figure A4 Agricultural land use in the four counties



Appendix 3

Open questionnaire sent to wildlife, forestry, landscape and planning 'experts'

Appendix 3

Open questionnaire sent to wildlife, forestry, landscape and planning 'experts'.

Respondent	Organisation
Keith Alexander	Biological Survey Team, National Trust
Steve Clifton	Conservation Officer, English Nature East Midlands Team
David Denman	Conservation Officer, English Nature Bedfordshire, Cambridgeshire and Northamptonshire Team
Robert Fuller	British Trust for Ornithology
Peter Kirby	Independent invertebrate ecologist, Peterborough
Shelley Hinsley	Institute of Terrestrial Ecology, Monks Wood
Richard Smithers	The Woodland Trust
Martin Warren	Butterfly Conservation

Wye College

University of London

Wye, Ashford, Kent
TN25 5AH UK

THE QUEEN'S ANNIVERSARY PRIZES
FOR HIGHER AND FURTHER EDUCATION
1994

Tel:01233 812401 Fax: 01233 812855 e-mail: P.Buckley@wye.ac.uk

Dear

English Nature Contract - Locating New Lowland Woods

We are currently working on an English Nature contract which aims to examine issues relating to the most appropriate siting of new lowland woods. Four, 10 x 10km study areas in contrasting Natural Areas have been chosen. A range of new (theoretical) woodland planting options are being investigated in each, in an attempt to predict the likely overall effects on wildlife. Part of the remit is to solicit expert opinion and we are hoping that you can be persuaded to contribute to the discussion.

Copies of part of one or two of the study areas are enclosed as 1:25 000 maps, illustrating a range of experimental planting scenarios and their relation to existing woodland. At this stage each new planting scenario adds around 200ha to the study area (2%).

We invite you to comment (briefly!) on one or more of the following:

- the pros and cons of each scenario as it might affect a particular taxonomic group (e.g. birds, plants, insects, mamals, etc.)
- which keystone species (see attached list) might be affected (plus others you may be aware of)?
- what is the likely overall effect biodiversity (e.g. which options are 'best' or 'worst')?
- what practical constraints, other than wildlife considerations, do you forsee?
- how much more (or less) planting could the area stand, yet still deliver further positive wildlife benefits?

An unmarked map is enclosed for you to sketch your own alternative, preferred planting scenario. You will also find enclosed an extract for each relevant EN Natural Area Profile.

Many thanks for your cooperation.

Yours sincerely

Dr G P Buckley

2. NATURE CONSERVATION FEATURES

Earth Science

Much of the Natural Area is situated on a bedrock of limestone of Jurassic age. However, it is rare for this limestone to be naturally near the surface as the area has be blanketed by thick glacial deposits which resulted in heavy clay soils of a generally calcareous nature being fairly typical. Since the Medieval period and before 'ironstone' (an iron rich form of limestone) and limestone have been quarried producing artificial limestone exposures which became colonised by the plants and animals of limestone derived soils. In more recent times commercial limestone and ironstone extraction has been carried out on a reasonably large scale and many of the typical 'gullets' produced by opencast mining operations were to be found. Today many of the quarries have been filled in, but a number of important geological exposures remain. Tufa formation is characteristic of the area. This is a soft rock produced when springs emerge from the limestone and precipitate dissolved calcium carbonate. Very localised acid deposits are found in the form of decalcified limestone, where leaching has removed the calcium carbonate content to leave a sandy substrate.

Key Habitats

Wildlife occurs throughout the Natural Area in a wide range of habitats found in both rural and urban areas. Farmed land is an important habitat and in common with much of lowland England, arable land and agriculturally improved pasture comprise a major proportion of the habitats now present within the Natural Area. Such widespread habitats include important features such as hedgerows and mature trees, ponds and small watercourses and rough grassland such as is found alongside tracks and on road verges. These habitats give much of the character to the Natural Area and support a wide range of species, including some that have undergone dramatic recent

declines such as skylark and grey partridge. There are also a number of other important habitats of more restricted distribution within the Natural Area and these are described below.

Ancient, semi-natural broadleaved woodland; is the major habitat resource of the area. Most of the woods stand on ill-drained calcareous clays and their characteristic tree and shrub species are ash, pedunculate oak, field maple, hazel, hawthorn, midland hawthorn and wild service tree with local concentrations of wych elm, small-leaved lime and English elm. The typical ground flora dominants on the wet clay are tufted hair-grass, dog's mercury, bluebell, meadowsweet, enchanter's-nightshade and wood anemone with many other herbs, including many orchids, sedges and grasses, some of them locally important. Pockets of acid sands occur locally, giving rise to woodland in which sessile oak, small-leaved lime, silver birch and hazel figure strongly over a ground flora typified by creeping soft-grass, bracken, wood sorrel and lily-of-the-valley. Further diversity is provided in some areas by varied ride grasslands.

Unimproved calcareous grassland; found on old (sometimes very old) quarries, such as Barnack, or on a few sites where the turf is original. Upright brome and tor-grass are the dominant plants but there is a rich herb flora including nationally rare and scarce plants, many orchids and others of local importance.

Unimproved mesotrophic grasslands; on calcareous clay soils with ridge and furrow topography These are characterised by cowslip and green-winged orchid with betony and devil's-bit scabious on more acid and/or leached soils, and with salad burnet, golden oat-grass and lady's bedstraw where it becomes more strongly calcareous.

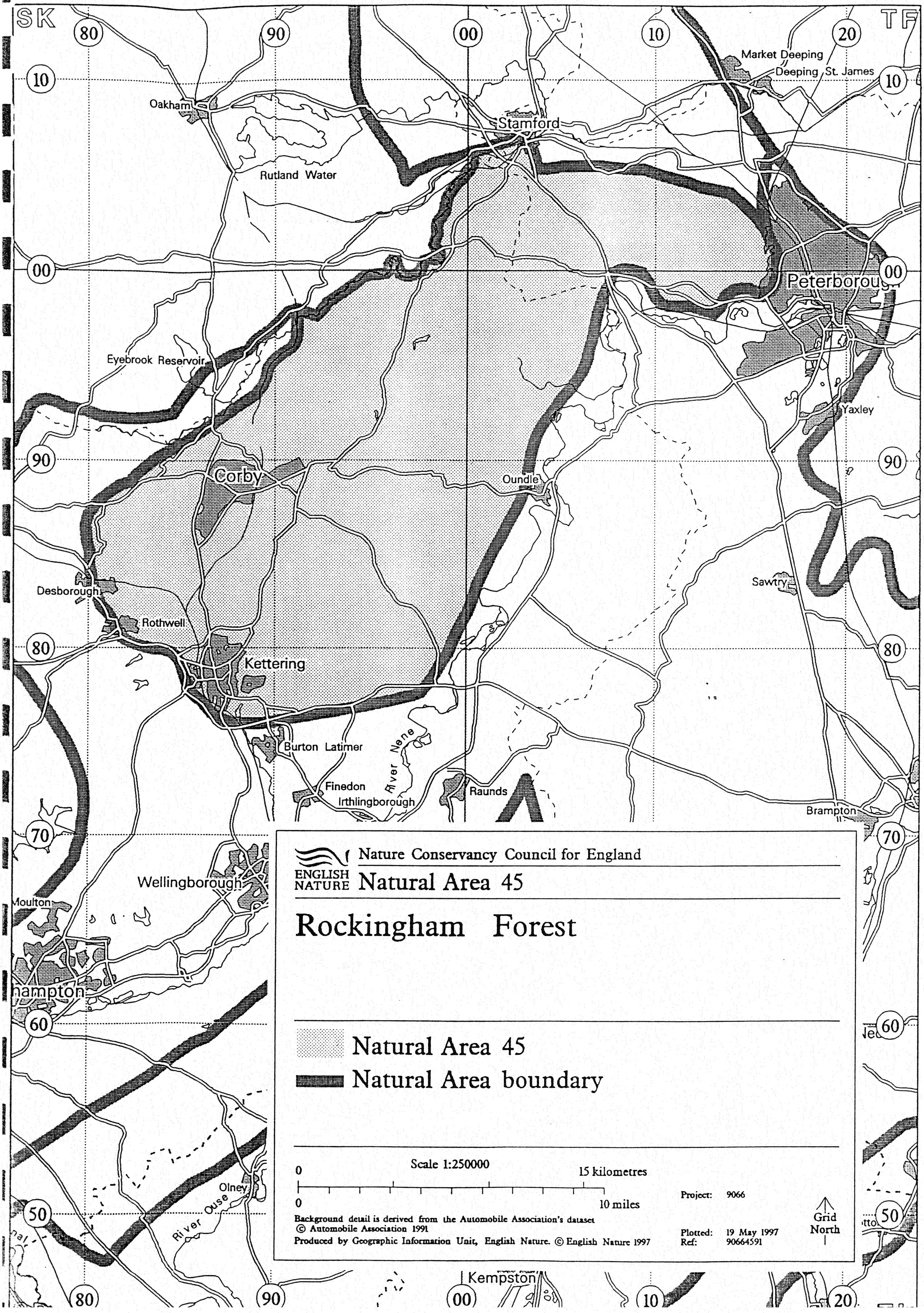
Bryophyte dominated springs; have formed where ground water issues strongly from the junctions of permeable and impermeable strata. The bryophytes which includes such species as *Cratoneuron commutatum* which mediate tufa formation.

Marshes and swamps; on wet ground and beside rivers. The characteristic vegetation on the mineral soils includes hard rush, lesser pond-sedge and reed sweet-grass.

Valley mires; formed in hollows where springs and seepages release calcareous water and there has been the formation of alkaline fen peat. Characteristic plants are purple moor-grass and blunt-flowered rush associated with a number of other sedges and rushes, and herbs such as marsh valerian, black bog-rush, tormentil, bogbean and marsh pennywort.

Flowing waters; with a substrate of clay and base-rich waters. Watercourses which are large tend to have been over-managed. Watercourses with a natural structure are scarce in the area and are best represented by the River Ise, a tributary of the River Nene which has a characteristic 'Clay River' flora including yellow water-lily, branched bur-reed, unbranched bur-reed, arrowhead, common club-rush and greater pond-sedge.

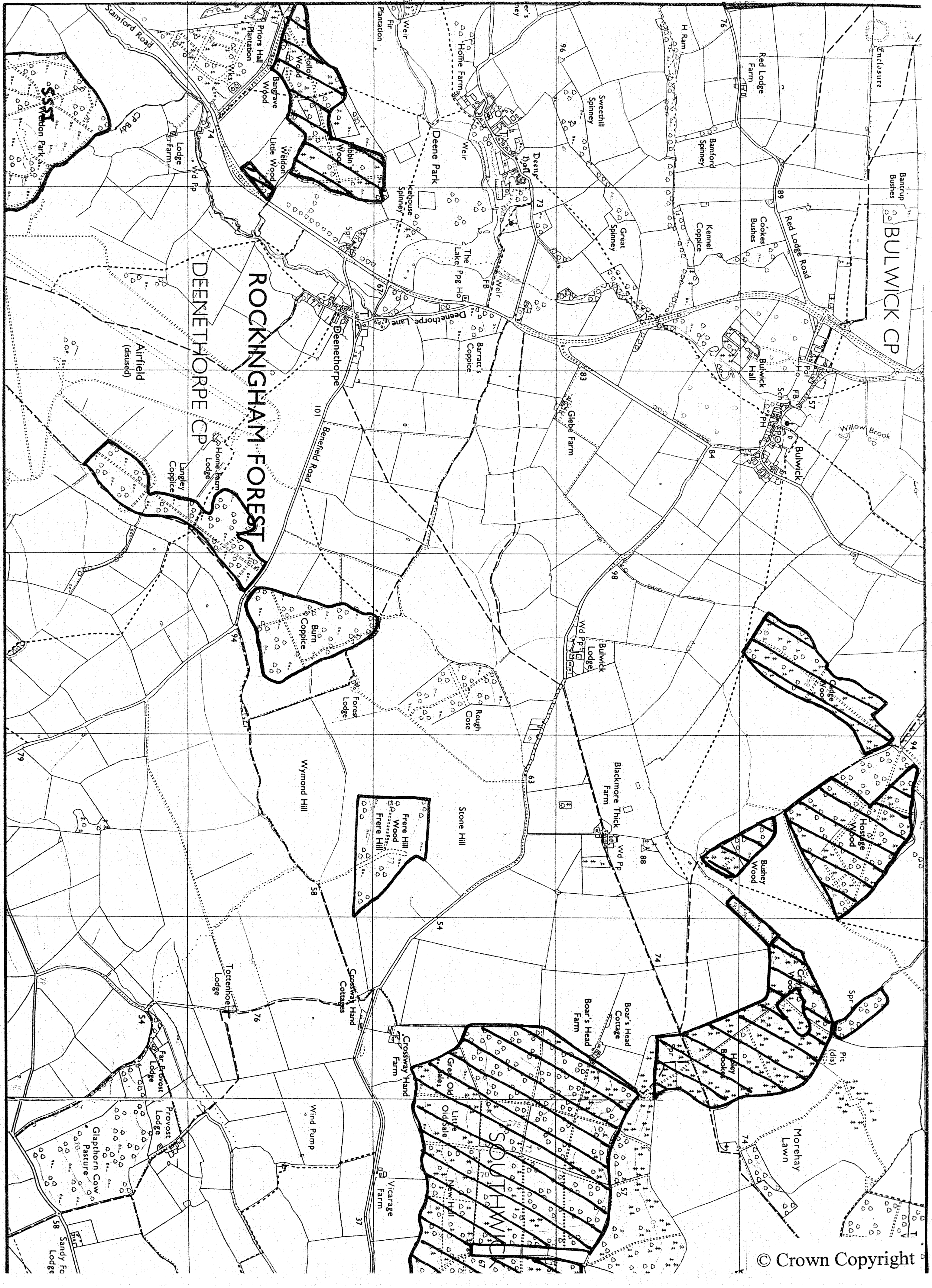
Unimproved flood meadows; in the valley of the River Ise as it passes through the area, characterised by great burnet and meadow foxtail.


SK
TF
80
90
00
10
20
Market Deeping
Deeping St. James
Oakham
Stamford
Rutland Water
Peterborough
Eyebrook Reservoir
Yaxley
Corby
Oundle
Desborough
Sawtry
Rothwell
Kettering
Burton Latimer
River Nene
Finedon
Irthlingborough
Raunds
Brampton
Wellingborough
Moulton
hampton
Olney
River Ouse
Kempston
70
60
50
Nature Conservancy Council for England
ENGLISH NATURE
Natural Area 45
Rockingham Forest
Natural Area 45
Natural Area boundary
Scale 1:250000
0
15 kilometres
0
10 miles
Background detail is derived from the Automobile Association's dataset
© Automobile Association 1991
Produced by Geographic Information Unit, English Nature. © English Nature 1997
Project: 9066
Plotted: 19 May 1997
Ref: 90664591
Grid North

Rockingham Forest - Existing Woodland Resource

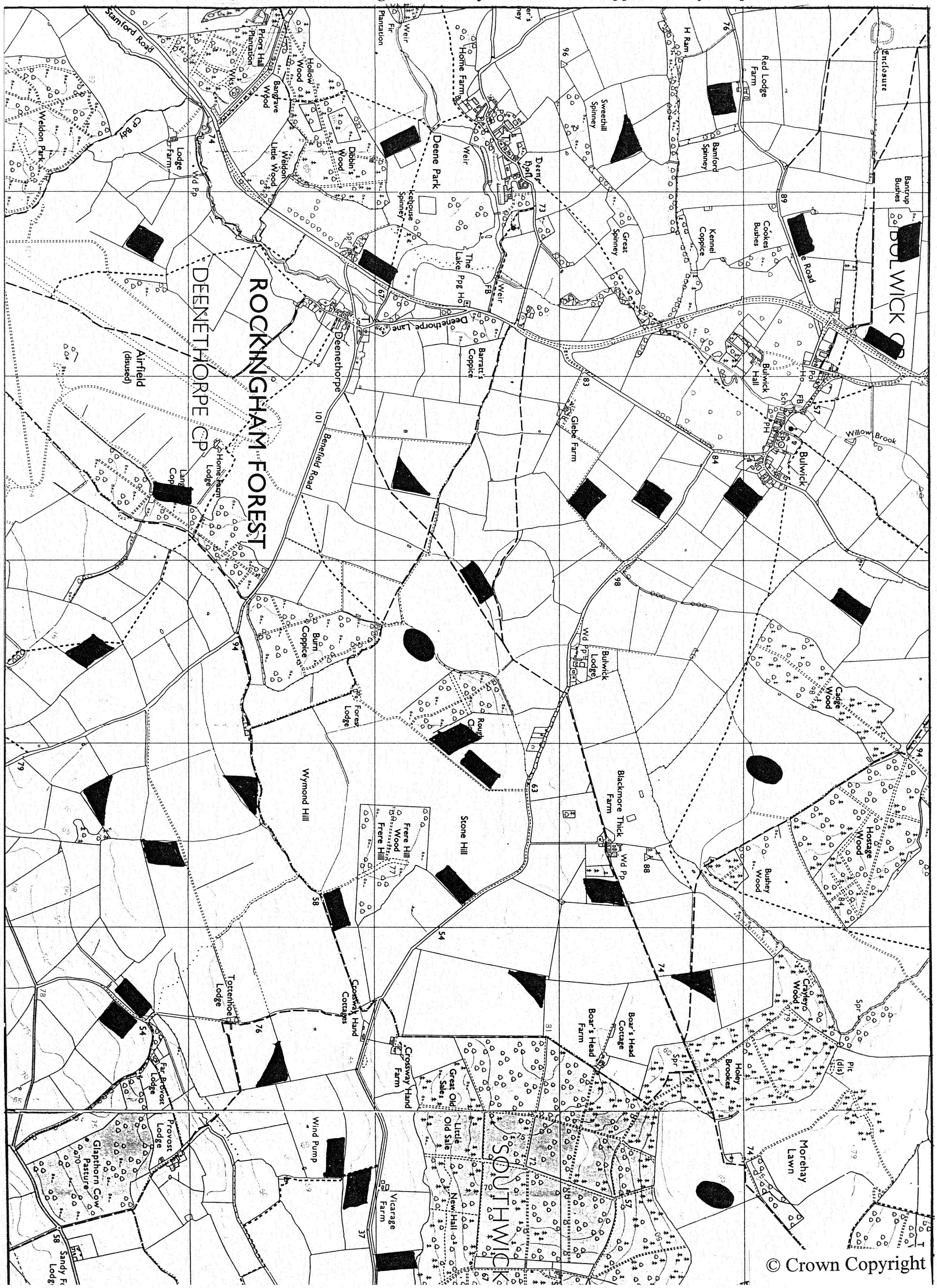
Ancient

Ancient Replanted

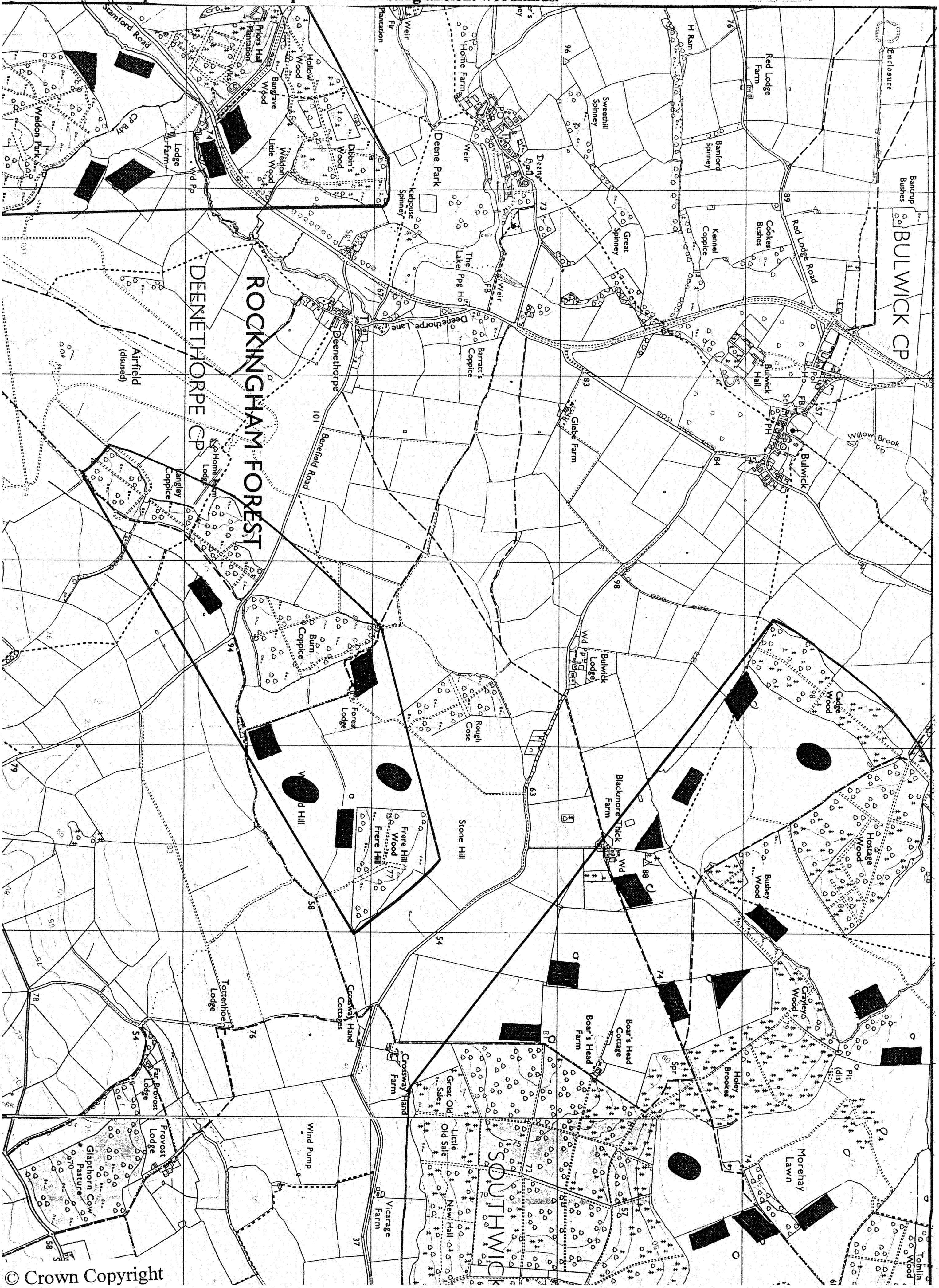


5

Rockingham Forest - Scenario 1
Random planting of 2ha blocks throughout the study area at a rate of approximately 1ha per km

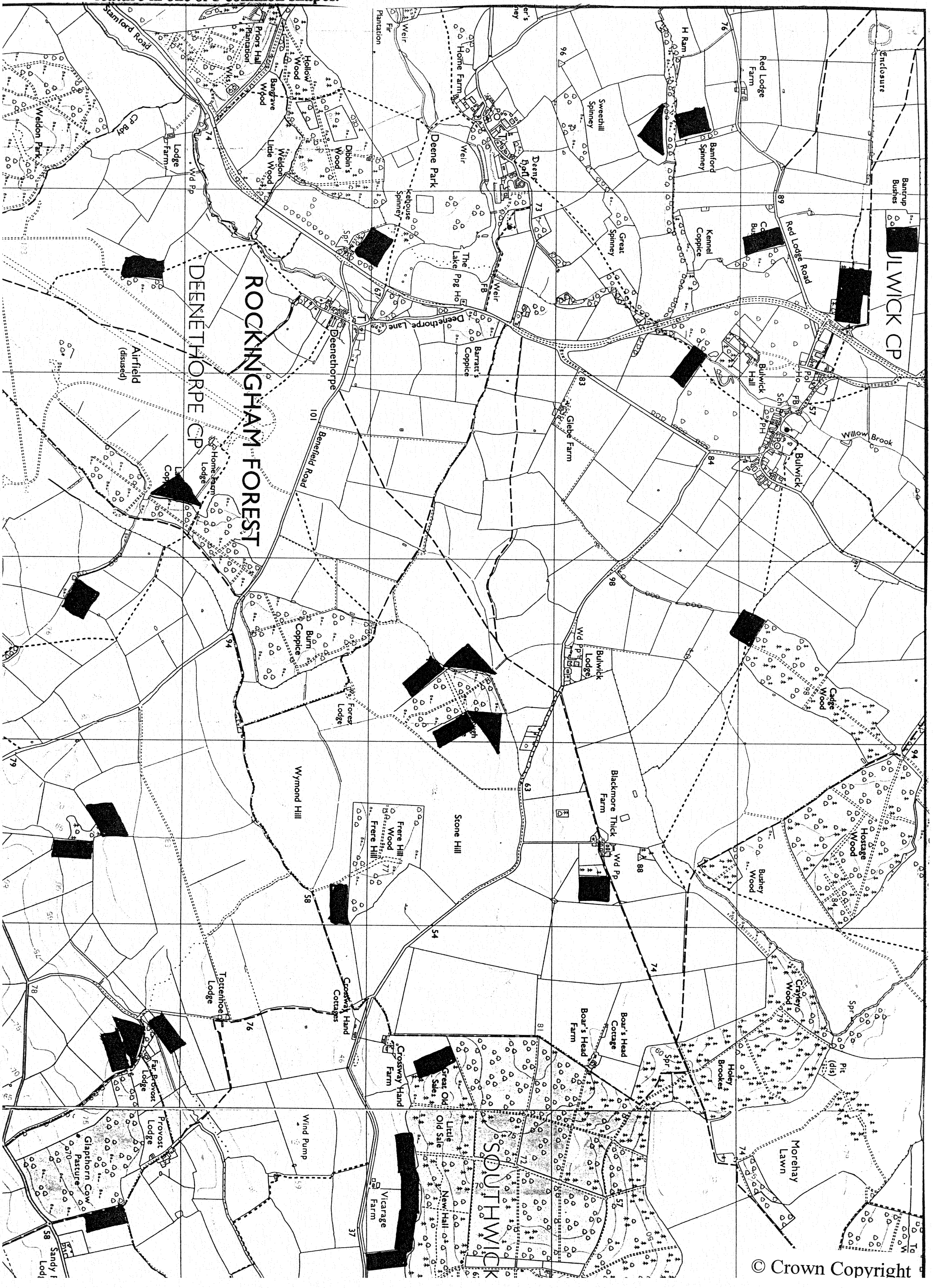


Rockingham Forest - Scenario 2
Random planting of 2ha blocks in 'envelopes' based on the pattern of existing ancient woodland.
Envelopes are based on the pattern of existing ancient woodlands.



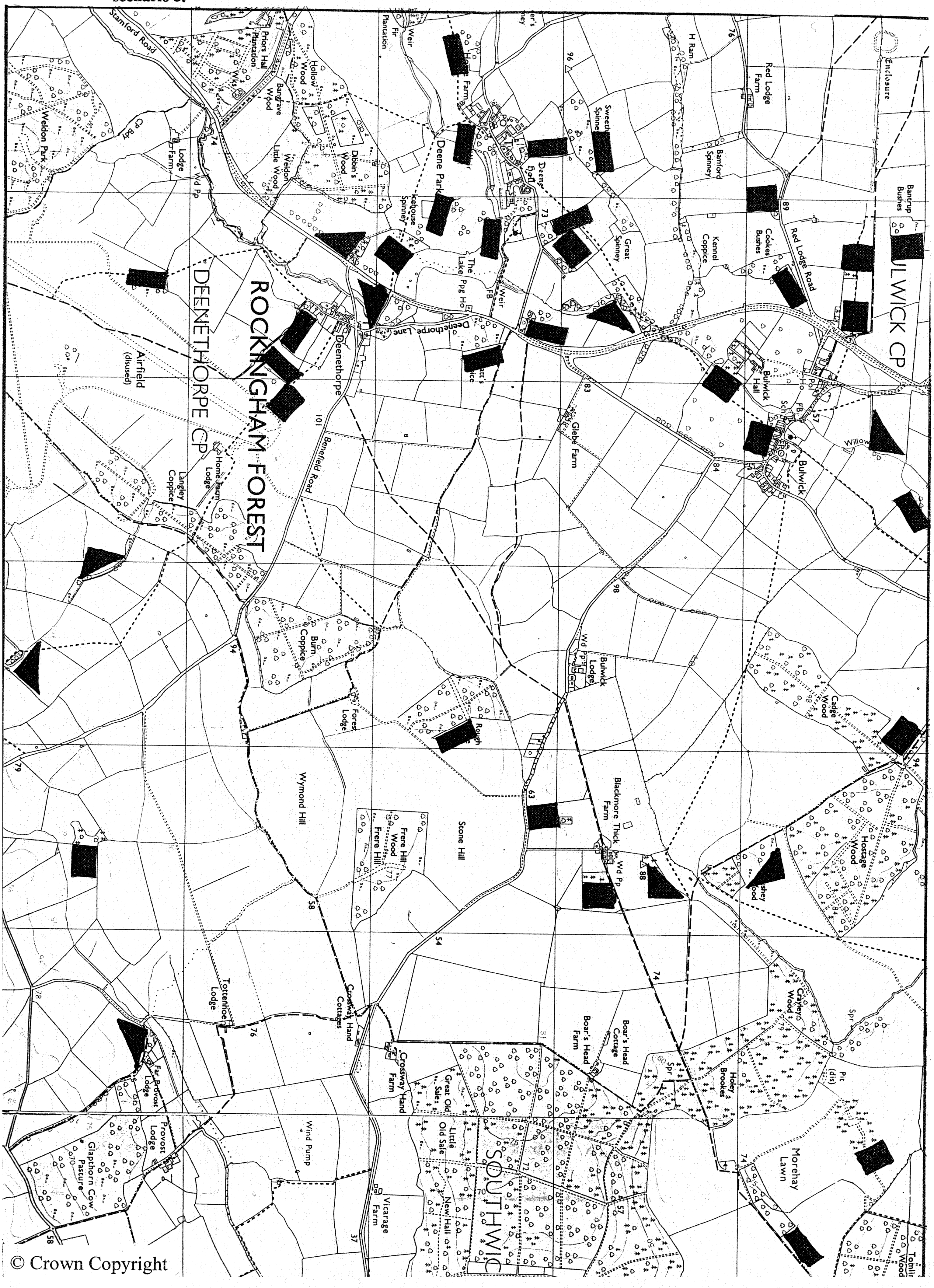
Rockingham Forest - Scenario 3
Random buffering of existing woods, a 2ha block has been added in the nearest field corner or other feature in one of 5 common shapes.

7



Rockingham Forest - Scenario 4
Preferential buffering of the smallest woodlands using the same criteria and range of shapes as in scenario 3.

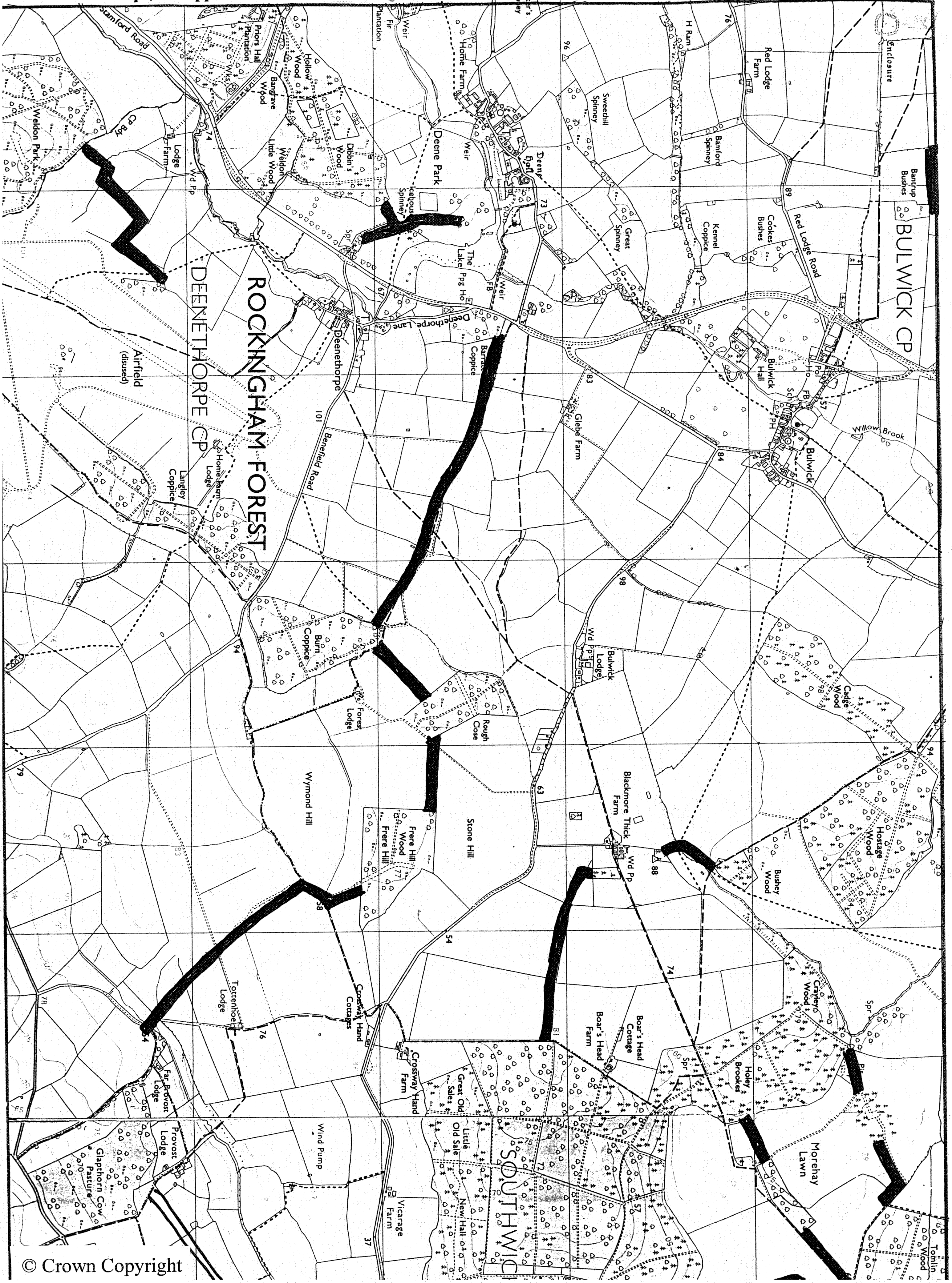
8



Rockingham Forest - Scenario 5

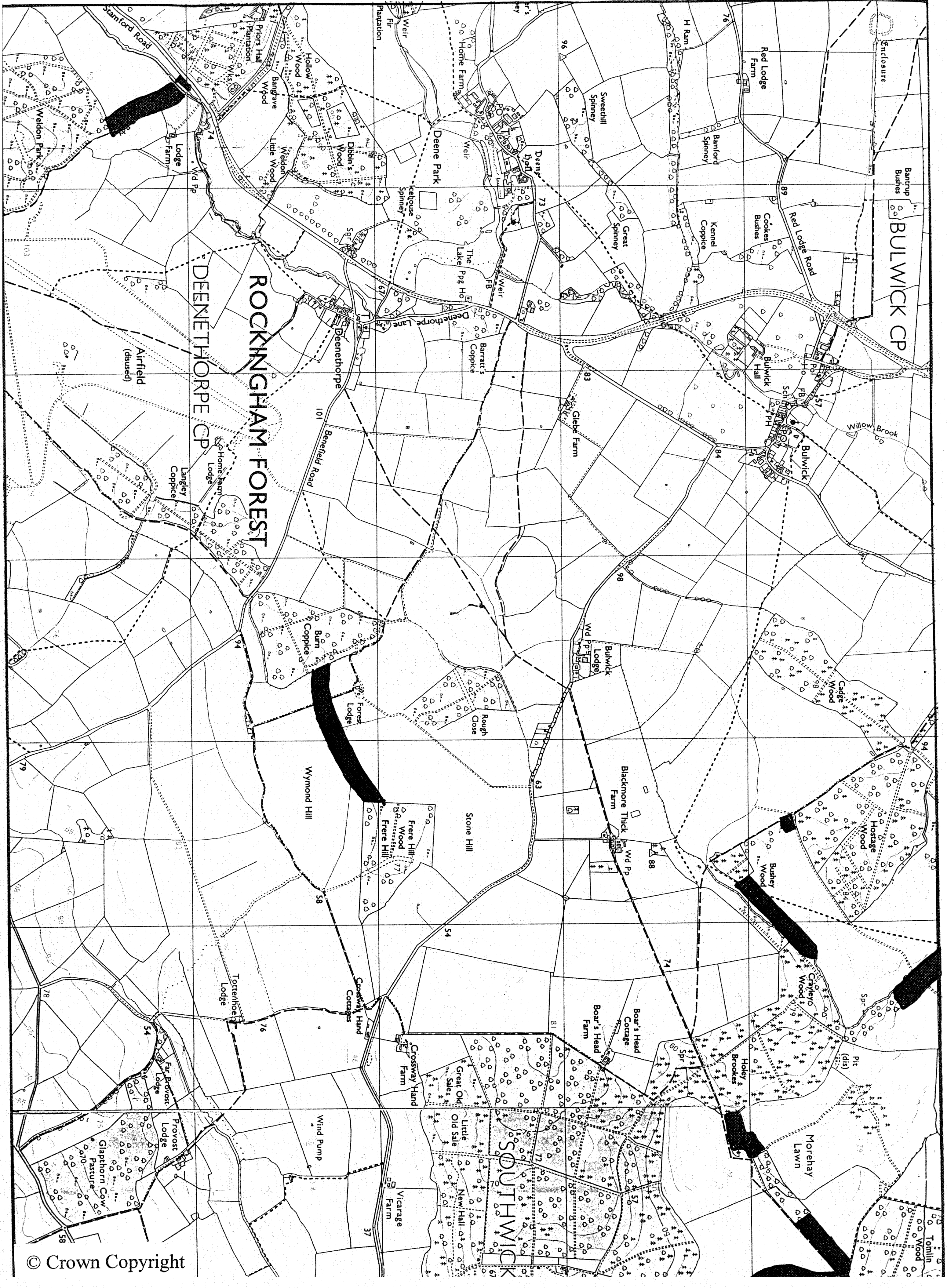
Linking of ancient woodlands with secondary woodlands around 100ha has been added as 50m strips, few opportunities existed for further links of this type.

9



Rockingham Forest - Scenario 6

Linking of ancient woodlands with other ancient woodlands. Fewer of these links were possible, requiring a 100m strip to allocate 100ha.



Summary

What are Natural Areas?

The whole of England has been divided up into Natural Areas. Their borders do not follow existing administrative boundaries, but are defined by their wildlife, natural features, land use and human history. In many cases they also share similar landscapes. Natural Areas provide the framework for much of English Nature's work and form the context of national and local Biodiversity Action Plan targets.

Purpose of this document

Our long term goal is to maintain, enhance and restore the natural wildlife and geology of each Natural Area. This document provides clear objectives to this end. The purpose of the document is to be visionary, unconstrained by current restrictions. This profile briefly describes and evaluates the wildlife and geological features of the Trent Valley and Rises Natural Area. It summarises the issues which affect the nature conservation resource and concludes with the long-term visionary objectives through which the nature conservation interest could be preserved and enriched.

Trent Valley and Rises

Most of the Natural Area comprises a geology that produces a fertile soil ideal for agriculture. Despite a large part of the area being under intensive agriculture there are a number of important habitats remaining. These include neutral grasslands, wet meadows, parkland, wet woodlands, restored gravel pits, reservoirs, rivers and streams. The habitats support a vast range of characteristic and rare species, for example the white-clawed crayfish is of international importance . The recent decline in farmland birds such as the linnet and grey partridge is of serious concern. There are important geological sites including evidence of ancient volcanic activity.

Nature conservation features

Physical features
The geology is fairly simple, dominated by a broad expanse of mudstone and clay. Glacial and river deposits provide the Trent Valley with rich fertile soil and a considerable source of gravel that is extensively quarried. The highest ground is in the south east just west of Oakham. There are a number of important geological sites, most of which show evidence of volcanic activity during the Caledonian orogeny. One geological site is internationally important for minerals and has provided examples to almost every major collection in Britain and many throughout the World.

Meadow and pasture grasslands
Neutral grassland is the most common, and there are a number of acidic and calcareous grassland sites associated with local differences of geology. Flood meadows along the Soar and Trent support some of the richest wildlife and are important for many breeding birds such as the redshank. Many grasslands are under threat from ploughing and flood prevention schemes.

Woodlands and parklands
The Natural Area is very poorly wooded, with areas of concentration around the south east of the NA known as Leighfield Forest, and south west of Lincoln. Important woodlands present include ancient semi-natural, wet woodland and parkland. Surviving medieval hunting parks have ancient trees that support vast number of insects and birds. Over 250 species of beetle have been found at Calke Abbey alone.

Standing water
Standing water habitats of particular wildlife interest are restored gravel pits, reservoirs and canals, there are no natural large standing waters. There are many gravel pits along the River Trent and its main tributaries, some have been restored to provide habitat for breeding and wintering birds such as reed warblers. Gravel pits and reservoirs have a diversity of habitats including marsh, reed beds, wet woodland, mud flats and open water. Rutland Water reservoir supports such a large number of wintering wildfowl that it is considered to be of international importance.

Running water
Rivers, streams and their associated habitats are a significant feature and include the River Trent. Water quality varies from the Erewash of poor quality to the Soar of relatively good quality. Dumbles; ravines carved out of the Mudstone by streams, are important local features. Their micro-climate is able to support varied flora such as ferns. Important species include the nationally important narrow-leaved water-dropwort and white-clawed crayfish.

Farmland
Farming is the principle land use of the Natural Area. Traditional farming supported a range of habitats and species. Important habitats on farms include 'unimproved' grasslands, hedges, streams, ponds and woodland copses. Lapwings, skylarks, corn buntings, linnet and barn owls and brown hares were once common sights on farms. These birds have declined in numbers by as much as half this century because of modern farming methods.

Objectives for nature conservation for the Trent Valley and Rises Natural Area

Objective: **To prevent further loss of, and maintain, the characteristic semi-natural habitats in the Natural Area, particularly the meadow and pasture grasslands, freshwater and woodland habitats.**

Meadow and pasture grassland
- Protect and restore current extent of permanent grassland and field boundaries.
- Encourage traditional mixed farming.
- Restore semi-natural grassland to optimal condition.
- Increase area of flood meadows

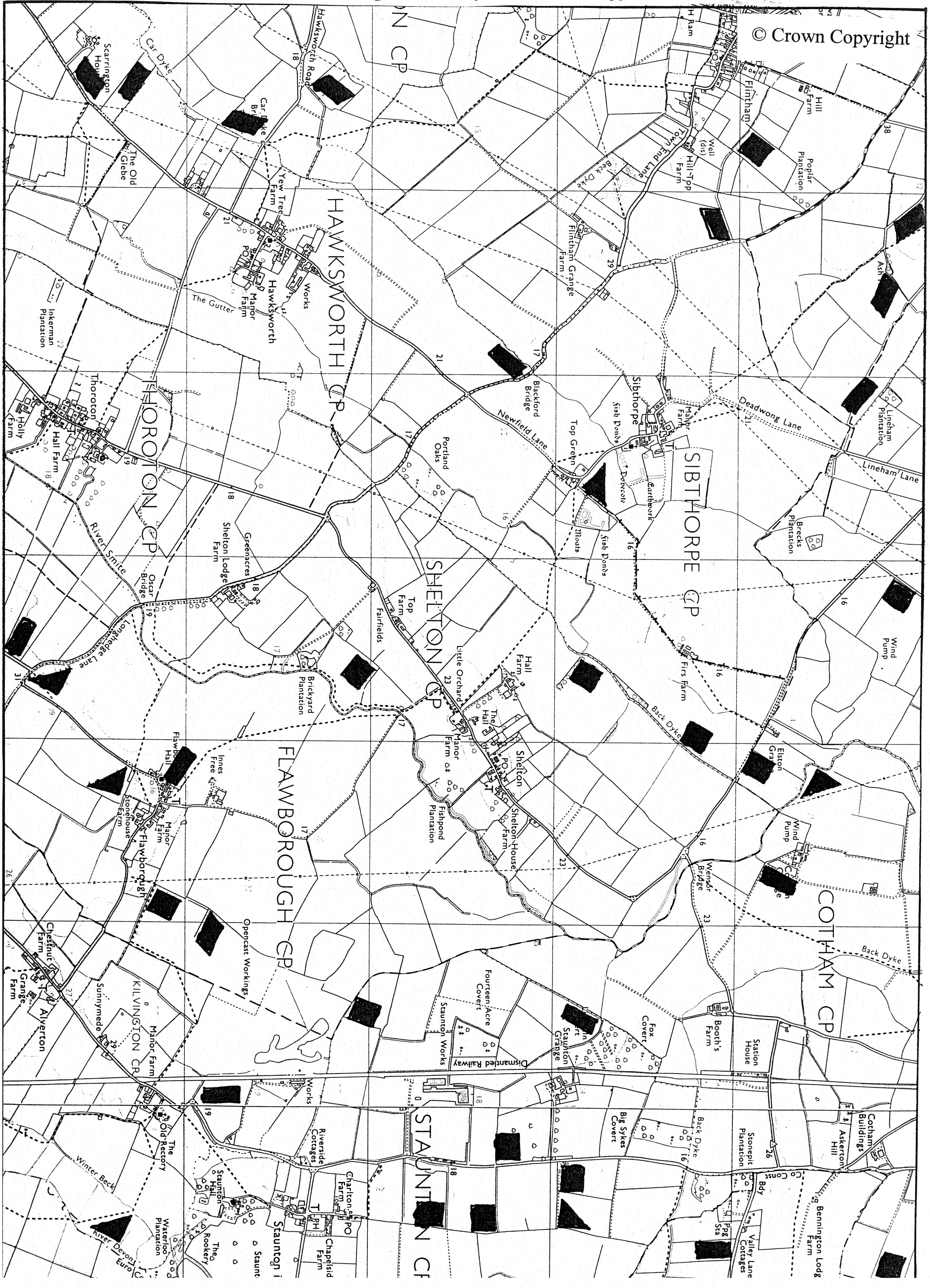
Woodland and parklands
- Protect, manage and extend existing semi-natural woodlands, particularly wet alder woodlands.
- Re-introduce a variety of management in suitable sites to increase the diversity of habitats and species within the woodlands.
- Establish grass to woodland transition zones.
- Maintain and encourage appropriate management of wooded dumbles.

Freshwater habitats
- Improve water quality.
- Reduce water abstraction.
- Encourage grassland creation adjacent to rivers and streams.

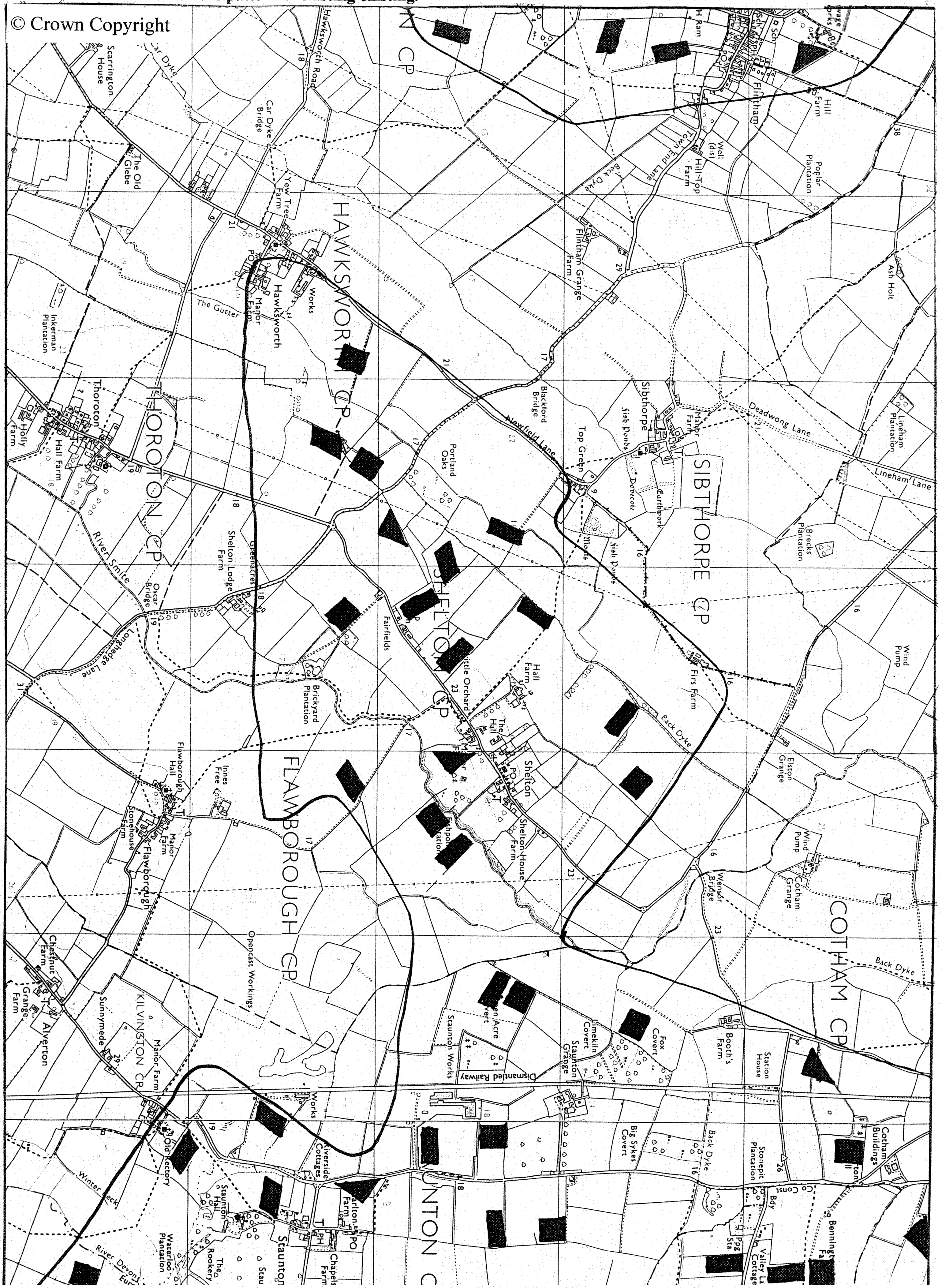
Farmland
- Increase permanent set-aside and improve management for wildlife.
- Return to traditional management of hedges.
- Encourage grass strip along hedges in arable fields, incorporate this with set-aside.
- Reform National and European agricultural policy to meet conservation needs.

Trent Valley & Rises - Scenario 1

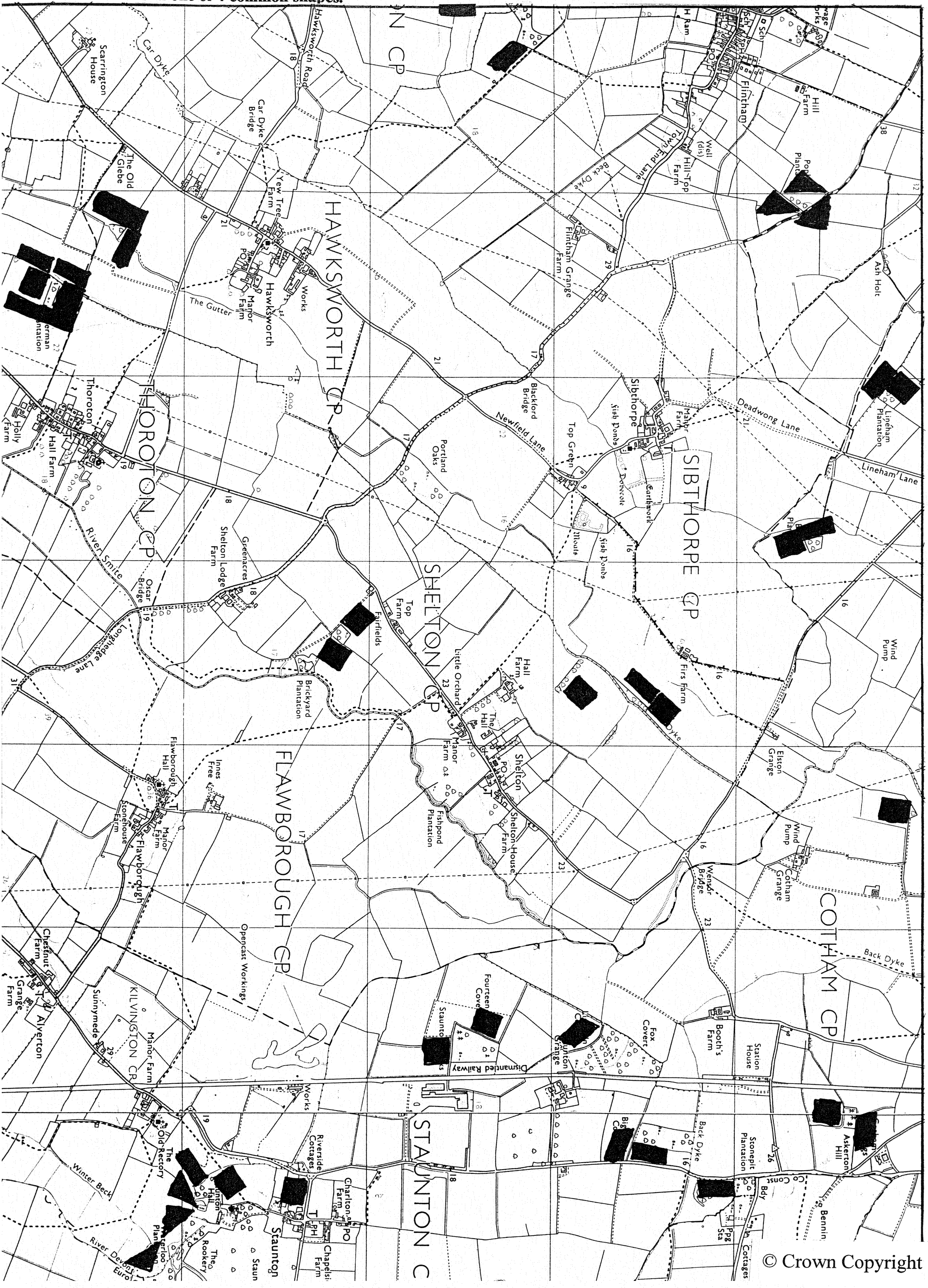
Random planting of 2ha blocks throughout the study area at a rate of approximately 1ha per km



Trent Valley & Rises - Scenario 2
Random planting of 2ha blocks in 'envelopes' based on the pattern of existing woodland. Envelopes are based on the pattern of existing existing.

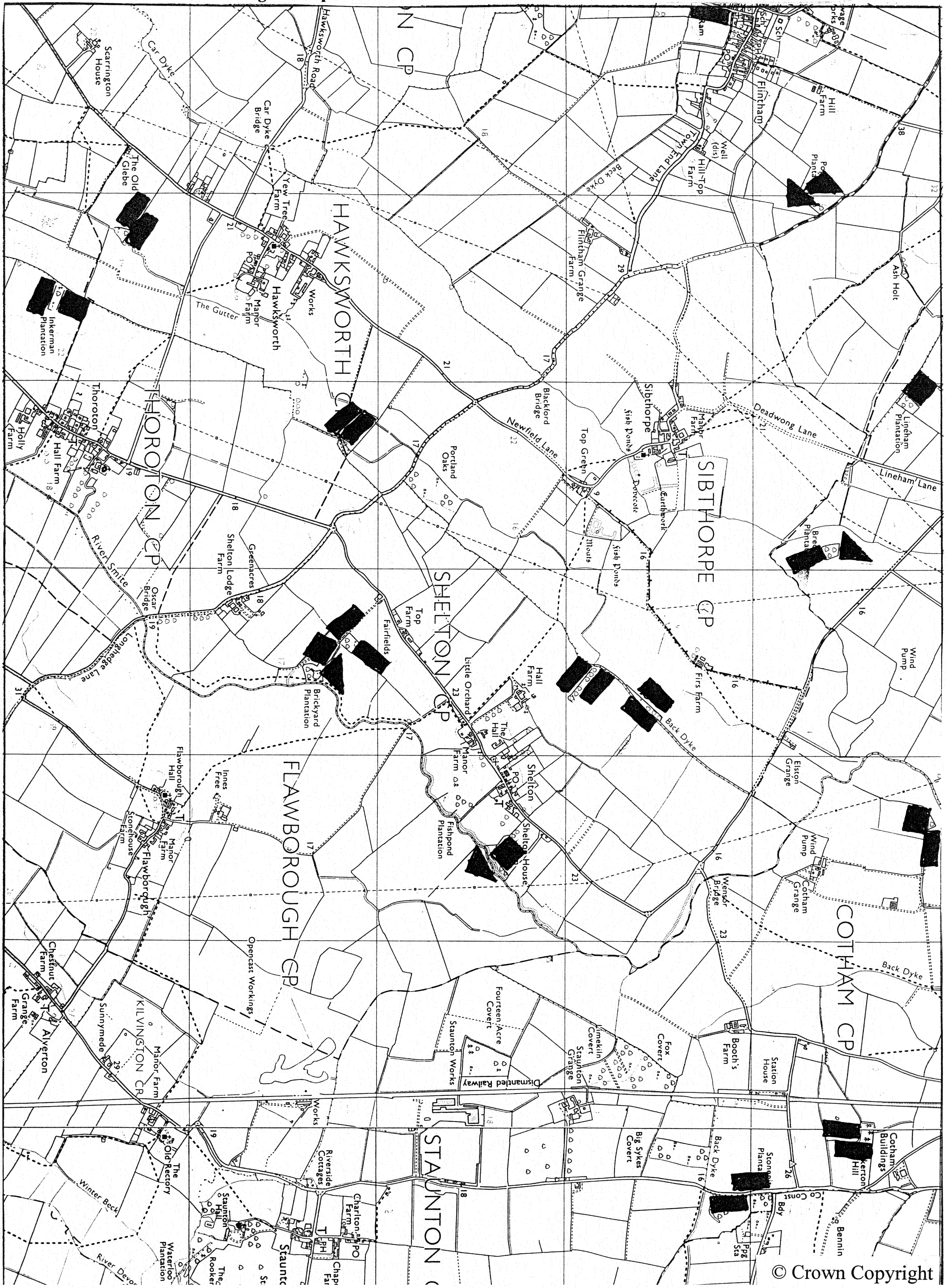


Trent Valley & Rises - Scenario 3
Random buffering of existing woods, a 2ha block has been added in the nearest field corner or other feature in one of 4 common shapes.



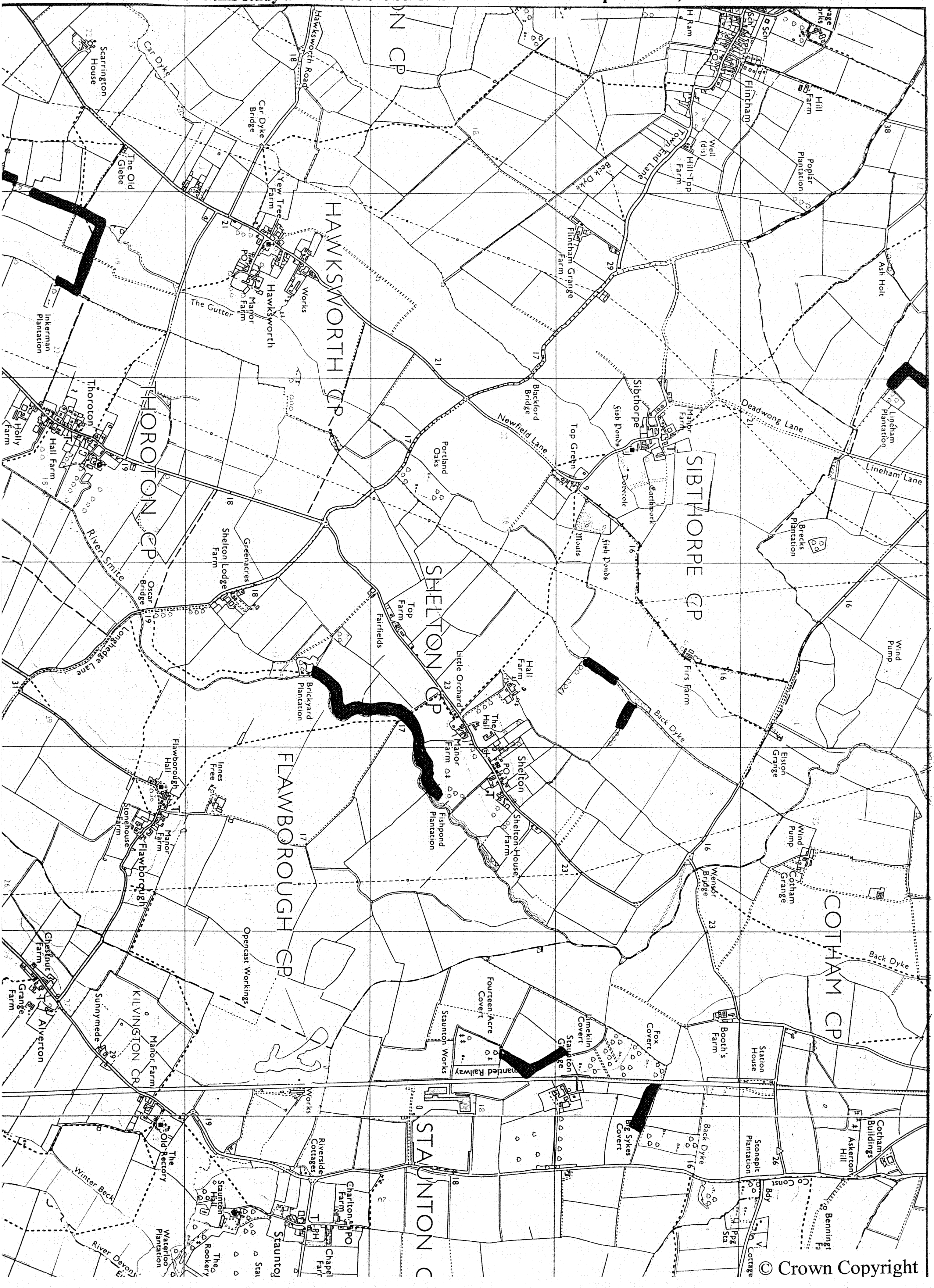
Trent Valley & Rises - Scenario 4

Preferential buffering of the smallest woodlands (in this case the smallest 50), using the same criteria and range of shapes as above



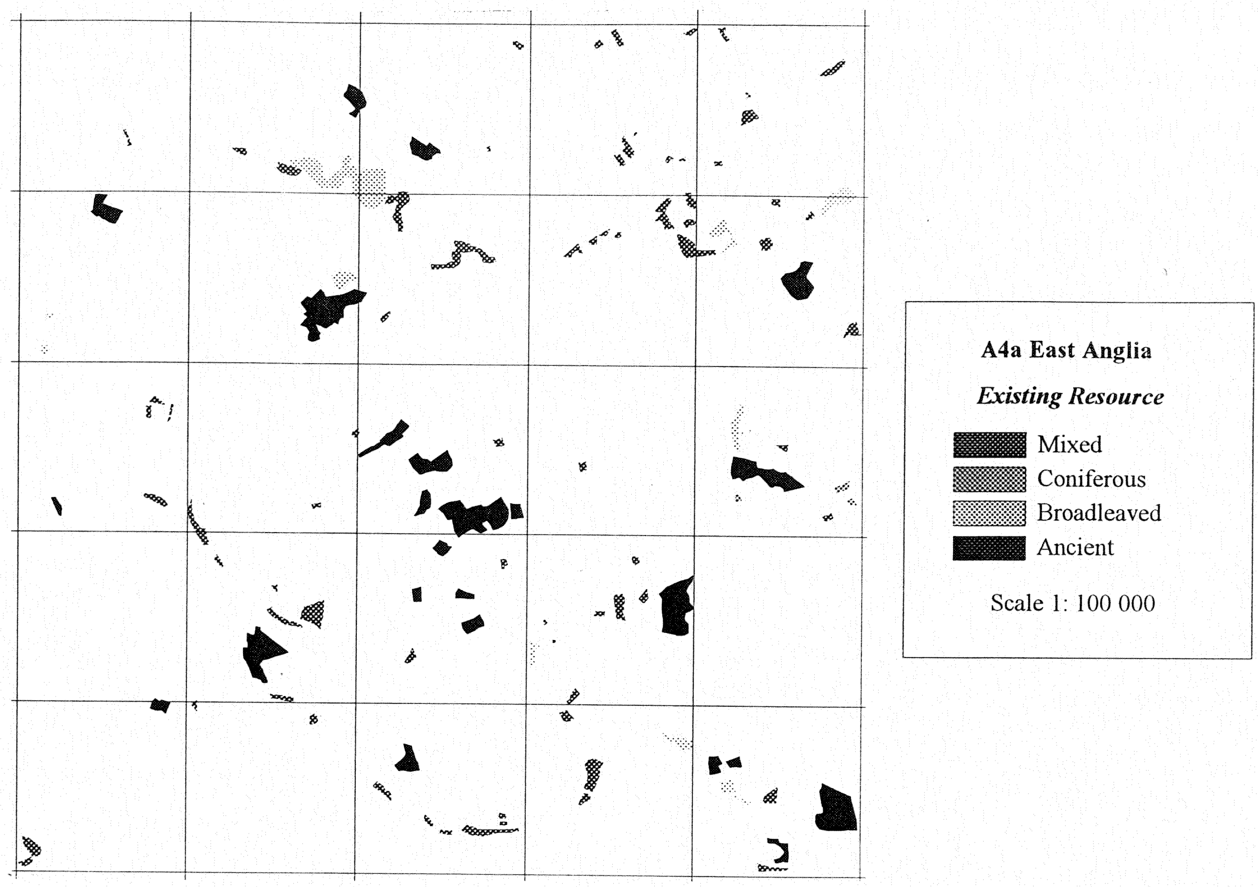
Trent Valley & Rises - Scenario 5

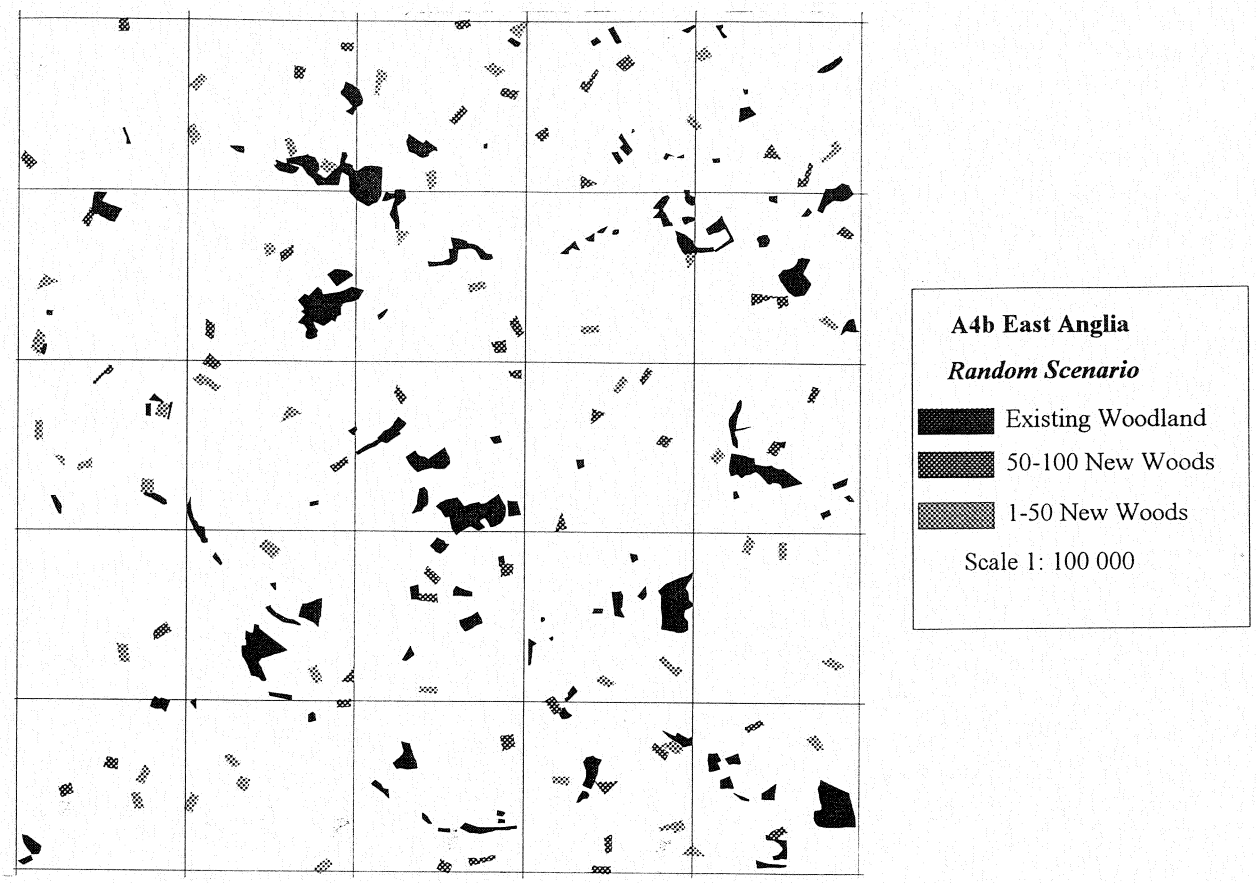
Linking of woodlands, using a 57m strip to use up around 100ha (few opportunities existed for further links in this study area due to the constraints such as roads and powerlines)

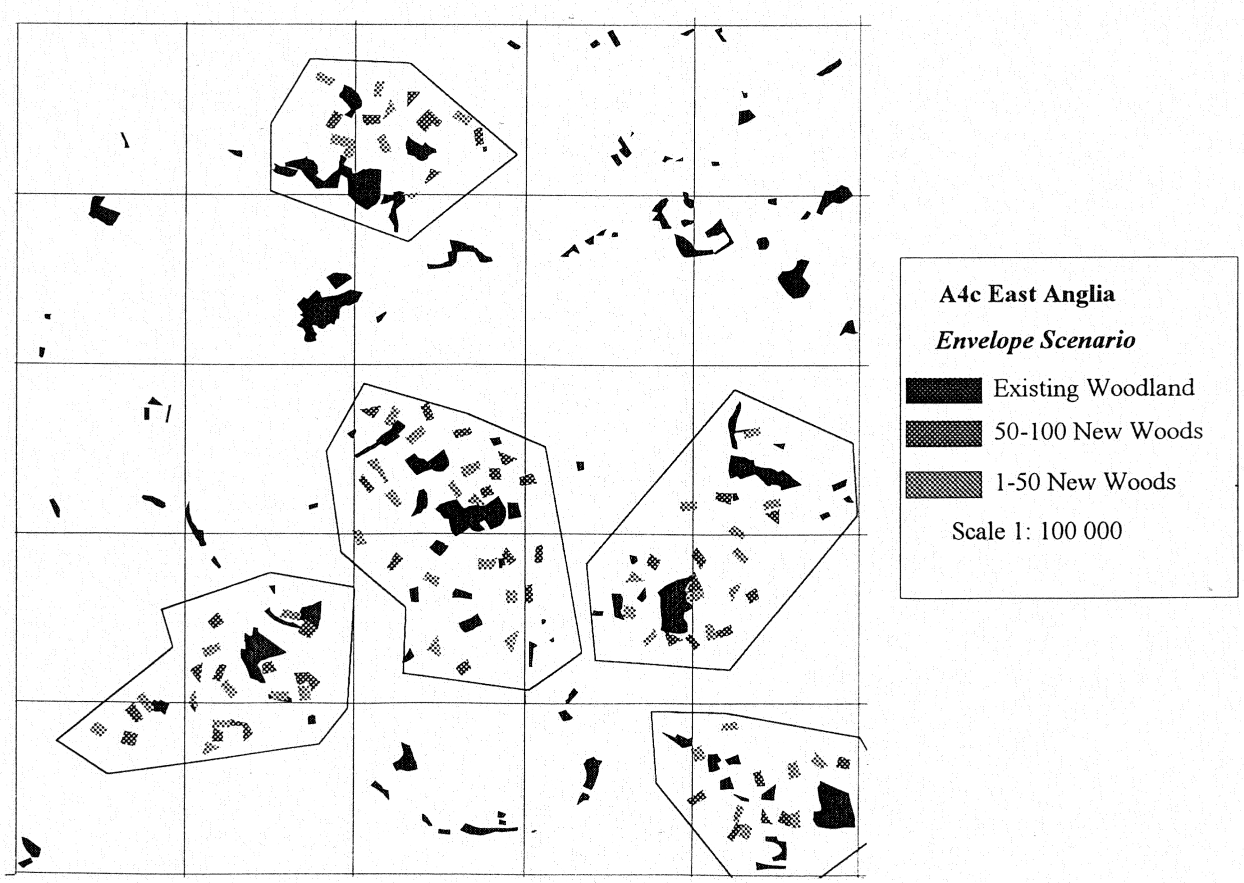


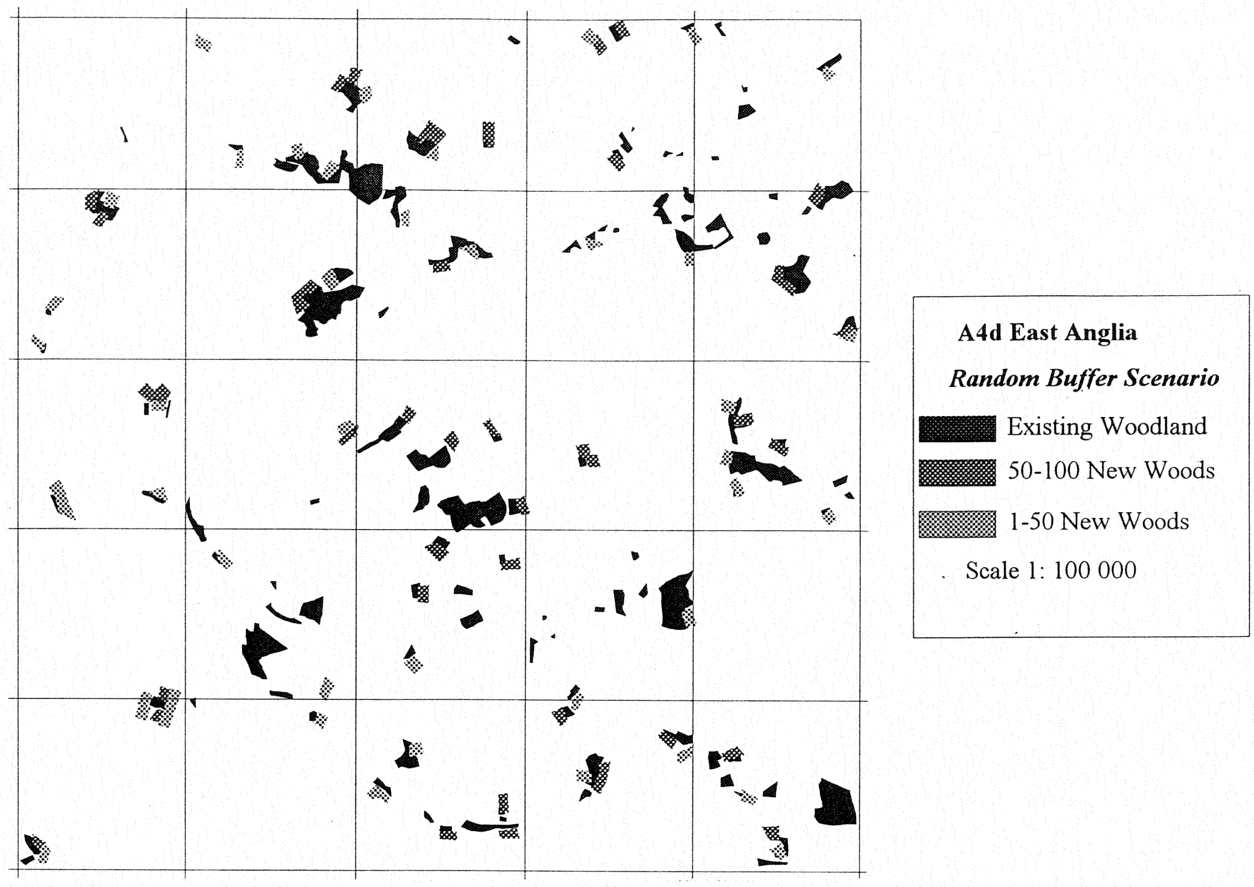
Appendix 4

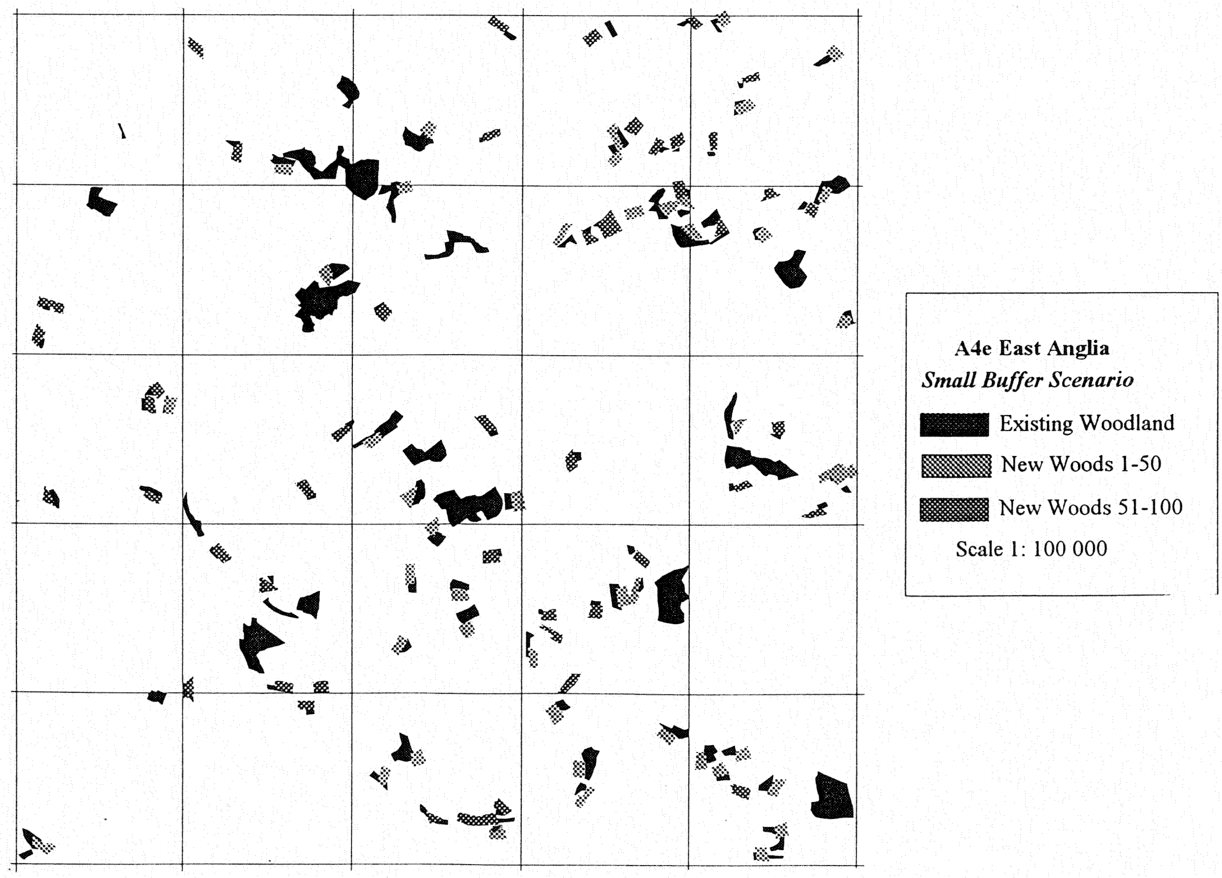
East Anglian Plain planting scenarios

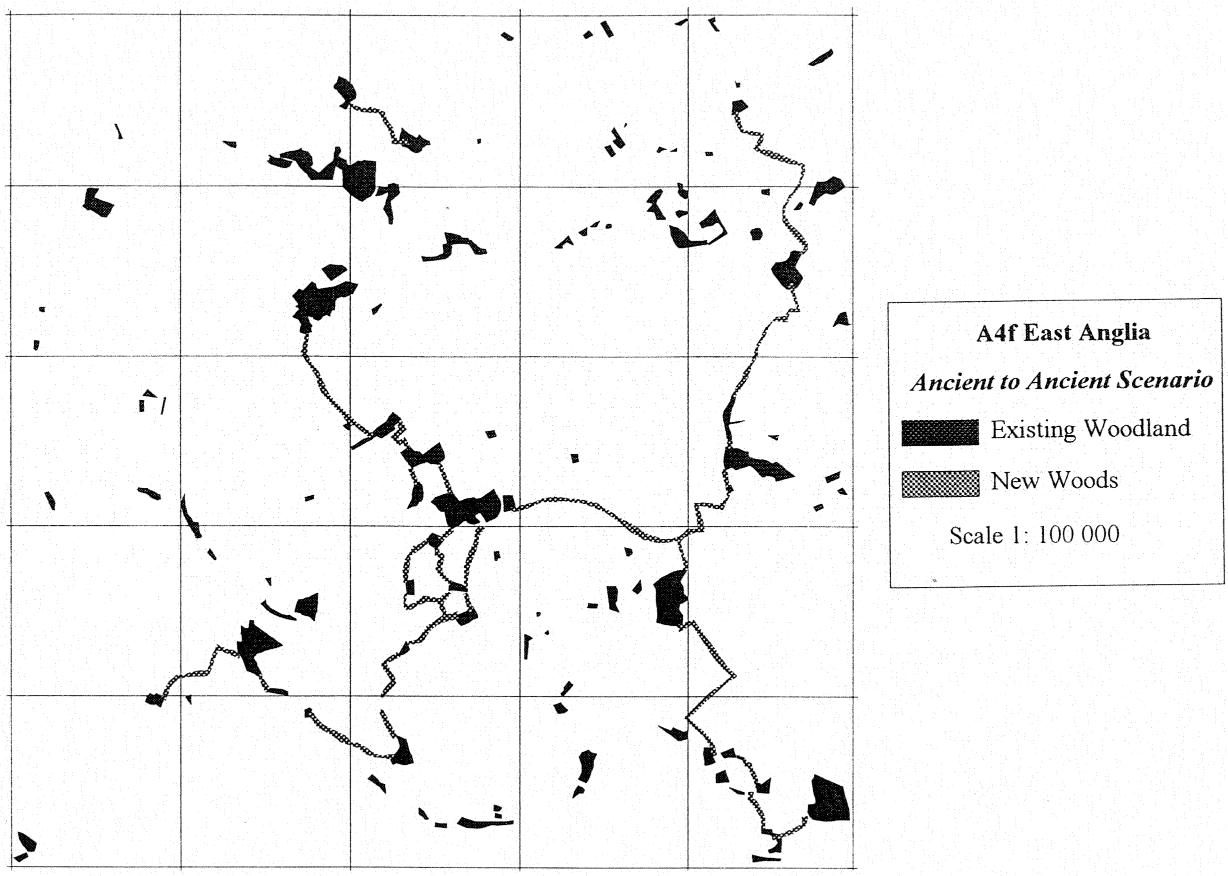

A4a East Anglia
Existing Resource
Mixed
Coniferous
Broadleaved
Ancient
Scale 1: 100 000


A4b East Anglia
Random Scenario
Existing Woodland
50-100 New Woods
1-50 New Woods
Scale 1: 100 000

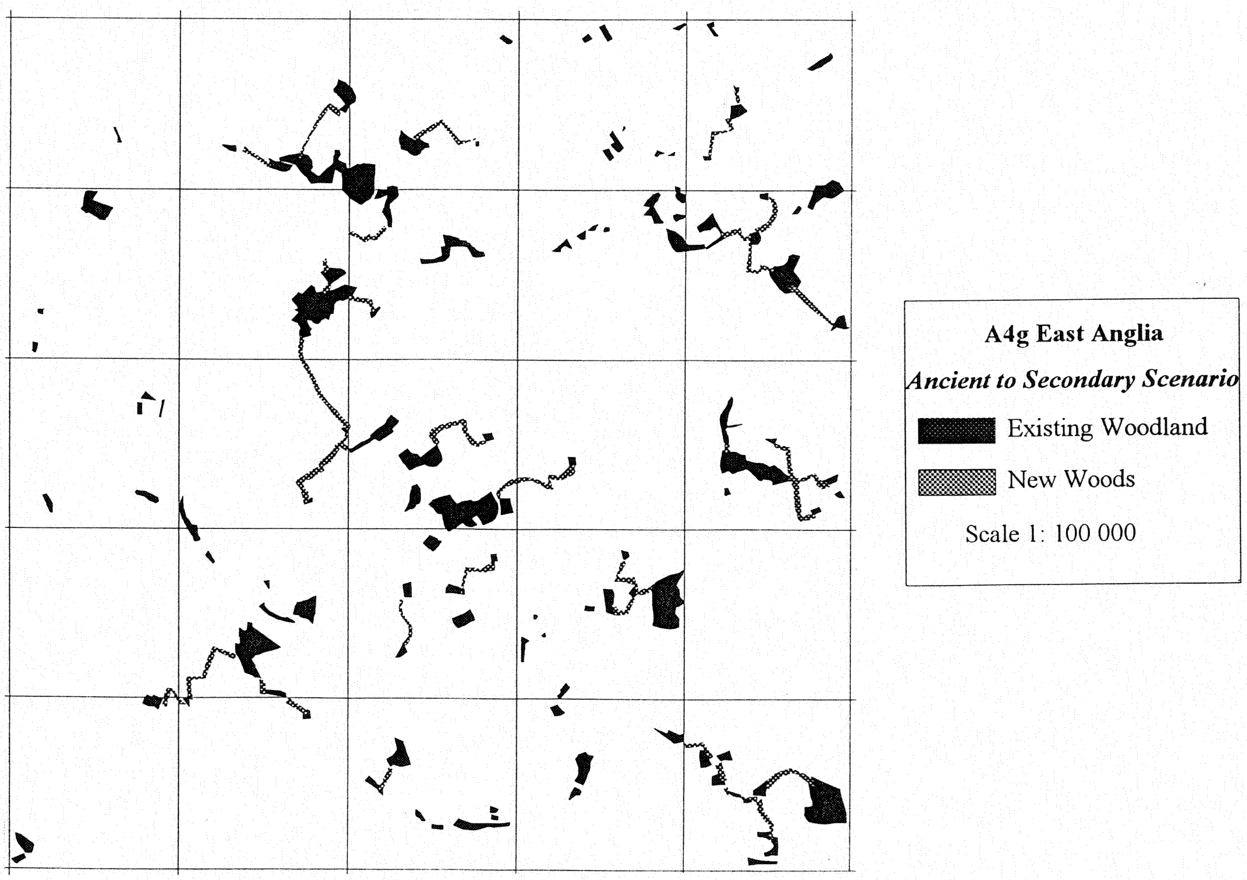

A4c East Anglia
Envelope Scenario
Existing Woodland
50-100 New Woods
1-50 New Woods
Scale 1: 100 000


A4d East Anglia
Random Buffer Scenario
Existing Woodland
50-100 New Woods
1-50 New Woods
Scale 1: 100 000


A4e East Anglia
Small Buffer Scenario
Existing Woodland
New Woods 1-50
New Woods 51-100
Scale 1: 100 000



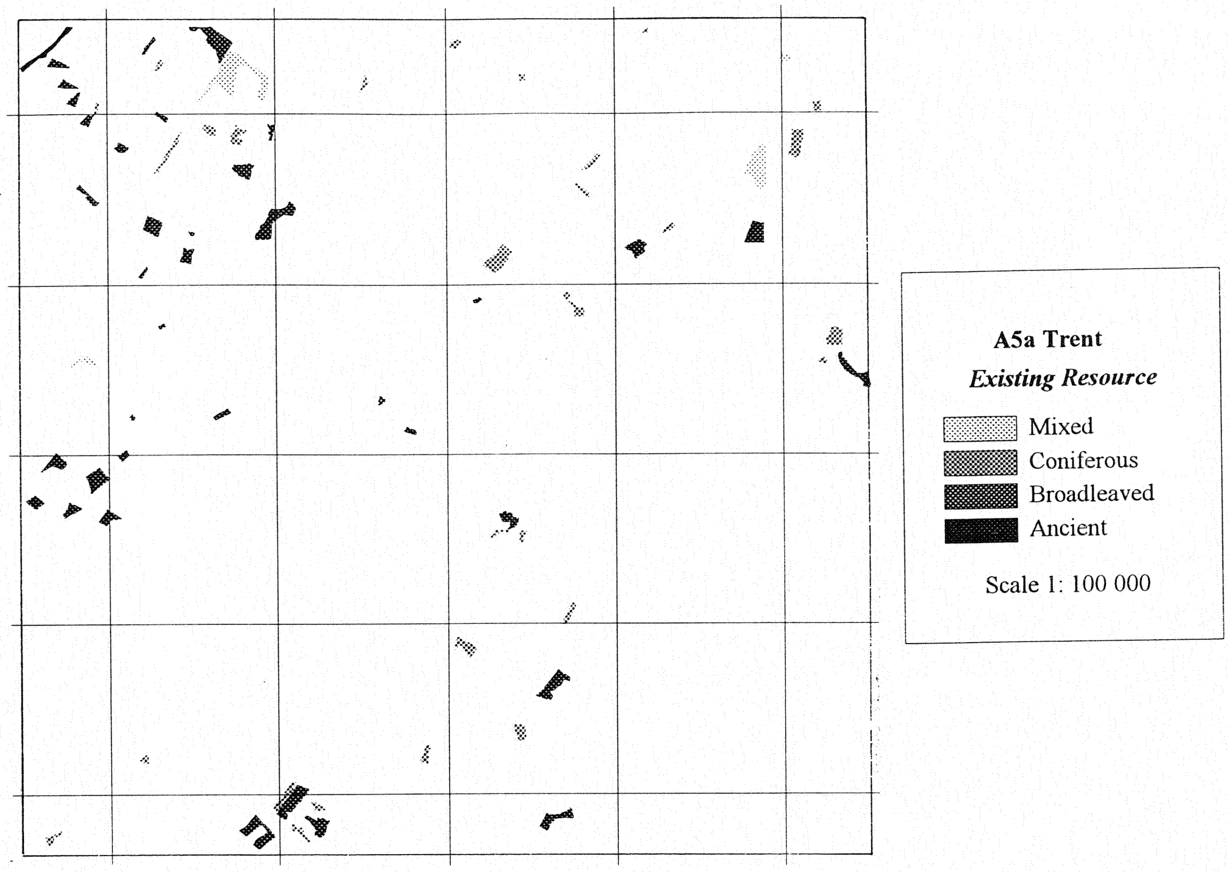
A4f East Anglia
Ancient to Ancient Scenario
Existing Woodland
New Woods
Scale 1: 100 000

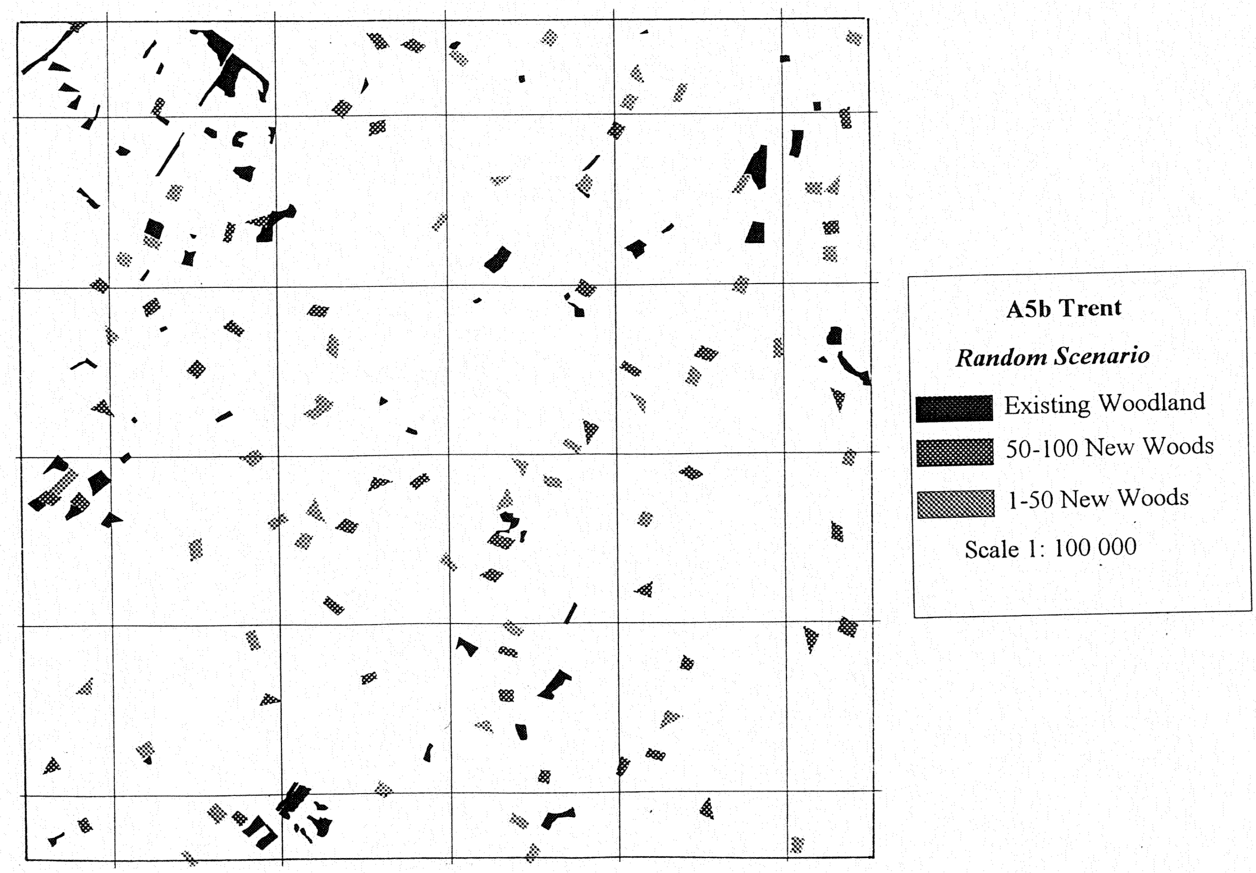


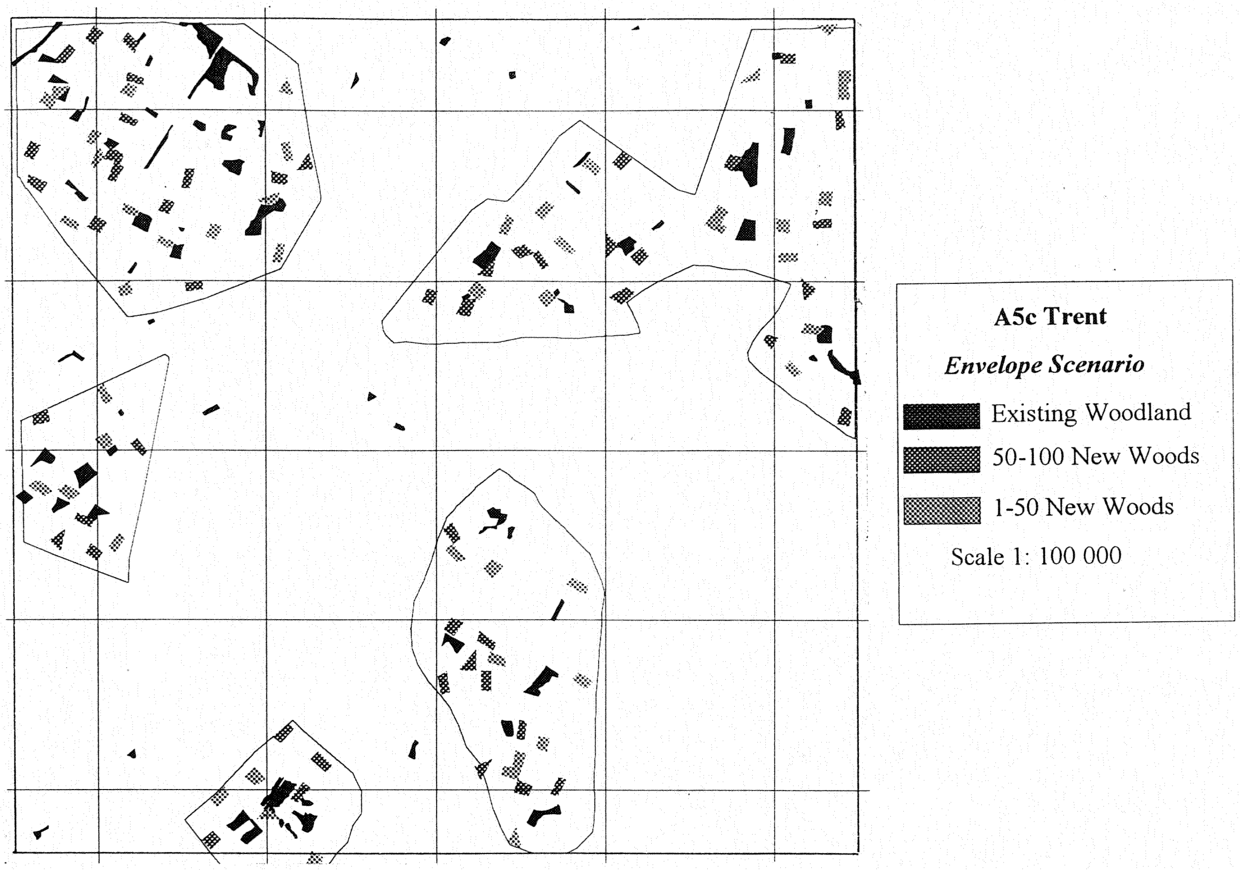
A4g East Anglia
Ancient to Secondary Scenario
Existing Woodland
New Woods
Scale 1: 100 000

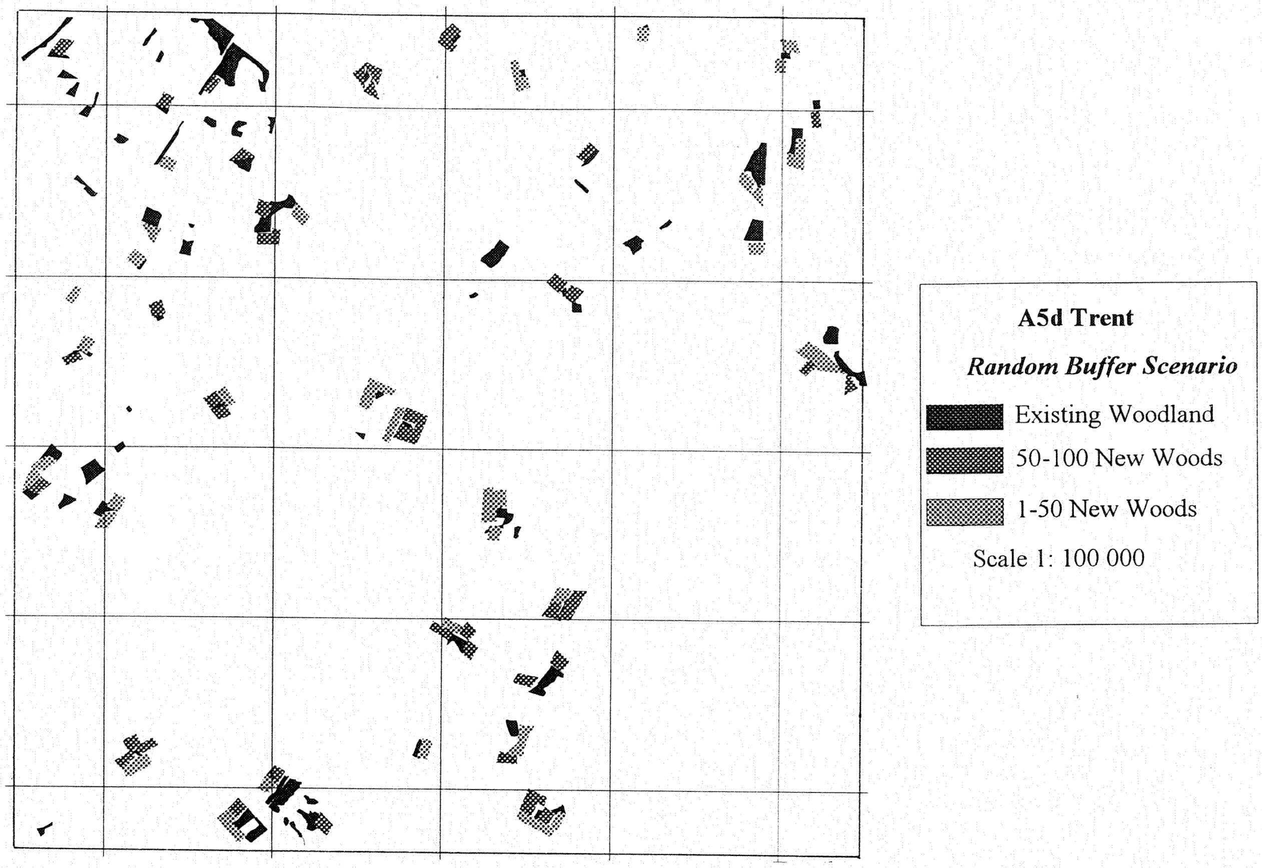
Appendix 5

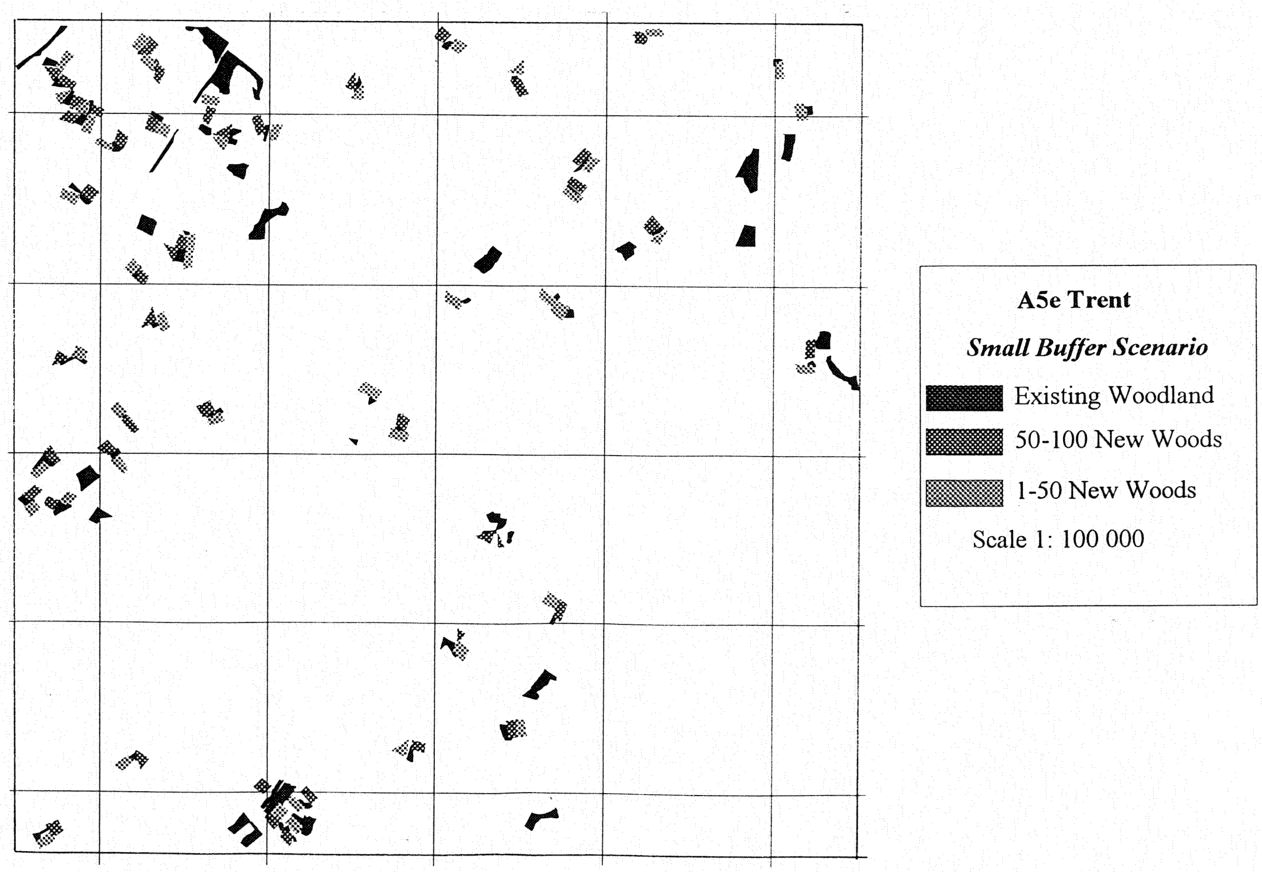
Trent Valley and Rises planting scenarios

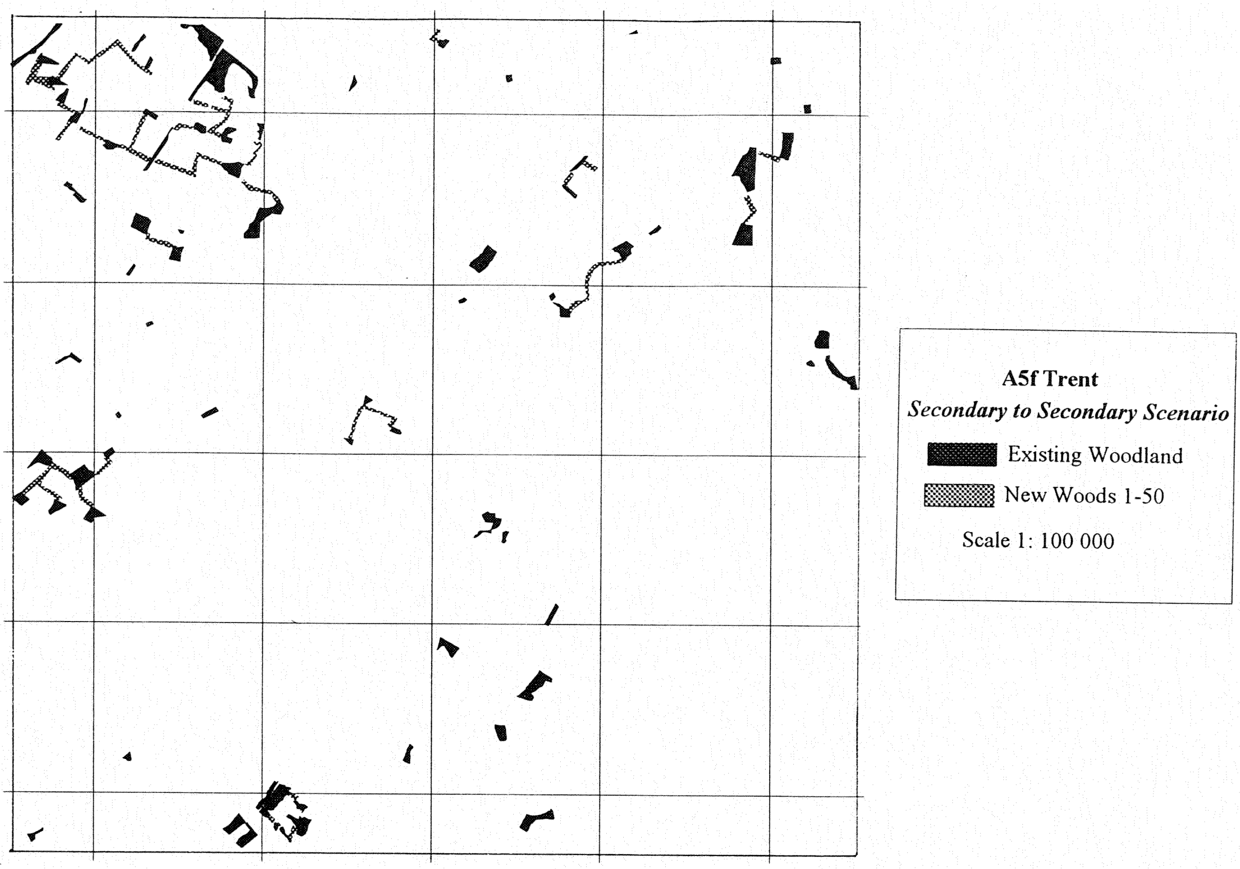

A5a Trent
Existing Resource
Mixed
Coniferous
Broadleaved
Ancient
Scale 1: 100 000


A5b Trent
Random Scenario
Existing Woodland
50-100 New Woods
1-50 New Woods
Scale 1: 100 000


A5c Trent
Envelope Scenario
Existing Woodland
50-100 New Woods
1-50 New Woods
Scale 1: 100 000


A5d Trent
Random Buffer Scenario
Existing Woodland
50-100 New Woods
1-50 New Woods
Scale 1: 100 000


A5e Trent
Small Buffer Scenario
Existing Woodland
50-100 New Woods
1-50 New Woods
Scale 1: 100 000


A5f Trent
Secondary to Secondary Scenario
Existing Woodland
New Woods 1-50
Scale 1: 100 000

Appendix 6

Species lists drawn from the Natural Area Profiles

Species	East Anglian	Rockingham	Trent Valley	Vale of Taunt
mother Shipton moth				
deadwood beetle fauna			•	
purple hairstreak butterfly			•	
white letter-hairstreak butterfly			•	
Gonomyia masoni		•		
Platypalpus aeneus		•		
Platypalpus stigma		•		
Osphyia biopunctata		•		
Cheilosia chrysocoma		•		
black hairstreak		•		
concolourous moth		•		
Agrilus sinuatus		•		
Machimus rusticus		•		
Micrambe lindbergorum		•		
Smicroryx reichi		•		
Stenelmis canaliculata		•		
purple emperor		•		
wood white		•		
chalk-hill blue		•		
hairy dragonfly		•		
variable damselfly				
ruddy darter		•		
barberry carpet moth	•			
Vertigo moliriana	•			
Vertigo angustior	•	•		
stag beetle	•			
Nuctenea umbratica	•			
Duke of Burgundy	•			•
brown hairstreak				•
double line moth				•
chalk carpet				•
barn owl		•	•	•
bullfinch	•			•
buzzard			•	•
corn bunting	•		•	
grasshopper warbler			•	
grey partridge	•	•	•	•
hawfinch		•		
hen harrier		•		
kingfisher				•
linnet	•		•	•
nightingale		•		•
peregrine Falcon				•
quail			•	
red kite		•		
redstart		•	•	
reed bunting	•			•
short eared owl		•		
skylark	•	•	•	•
snipe		•		
spotted flycatcher	•	•		•
teal			•	
tree sparrow			•	

Species		East Anglian	Rockingham	Trent Valley	Vale of Taunt
turtle dove		•	•	•	
willow tit				•	
woodcock			•		
woodpecker spp				•	
yellow hammer				•	
adders tongue fern				•	
black poplar					•
bluebell				•	
Brachythecium salebrosum					
broad-leaved spurge			•		
crested cow-wheat			•		
herb paris				•	
man orchid			•		
oxlip		•			
pignut					
Plot's elm			•		
rare spring sedge			•		
Seligeria donniana					
slender bedstraw			•		
small leaved lime		•			
spring snowflake					•
tormentil				•	
unspotted lungwort		•			
wild pear		•			
willow spp				•	
wood barley			•		
yellow archangel				•	
great crested newt		•	•	•	•
adder			•		•
grass snake					•
slow worm			•		•
palmate newt					•
smooth newt					•
common frog					•
common toad					•
barbsatelle bat					•
brown hare			•	•	•
common shrew					•
dormouse		•	•		•
lesser horseshoe bat					•
long-eared bat					•
noctule bat					•
otter		•	•	•	•
pipistelle bat		•	•		•
pygmy shrew					•
water vole		•	•	•	•
whiskered bat			•		