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THE ECOLOGY OF SYCAMORE IN BRITISH WOODLAND

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TITLE The Ecology of Sycamore in British Woodland

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This thesis, "The Ecology of Sycamore in British Woodland" firstly examines the method by which sycamore (Acer pseudoplatanus) has been introduced to the British environment and seeks to ascertain the common locations of these introductions . An approximately $300km^2$ section of West Suffolk is selected to be an example of a typical, intensively farmed, lowland, rural landscape. Classification and definition of the vegetational types present is undertaken. The area is then surveyed according to techniques designed, primarily, by the author. The survey produces an accurate description of vegetational composition, from which the demography of sycamore can be examined, and a data base of ecologically significant factors for individual vegetation units. Subsequent research is concerned with analyzing the data from the survey in conjunction with additional studies of specific sites.

An investigation of the occurrence of sycamore in relation to other native tree species and common vegetational types is effected to reveal the 1980's status of sycamore in terms of vegetational classification. The physical structure of woodlands is then examined to produce an estimation of sycamore's past and future competitive status in comparison with the native tree community, particularly interpreting the anthropogenic influence of woodland management. Specific sites are chosen for more detailed observation and some of the conservational implications of sycamore invasion are discussed.

The way (including rate and method) in which sycamore disperses through the West Suffolk area is considered. Whether sycamore invasion of individual woodland conforms to predictable demographic patterns is questioned by mapping invasive sycamore populations . Areas of Epping Forest are included to provide an example of a management variant.

The thesis continues to give an account of the possible resistance of some woodland to invasion which could be related to the physical form and species composition of individual woodlands and to the intrinsic niche exploitation capability afforded to sycamore by virtue of its dispersal adaptation. The 'strategy' and 'life mode' of sycamore is reflected upon with regard to its tolerances to various ecological components of woodland ecosystems and to the British climatic regime both past and present.

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LIST OF ABBREVIATIONS USED IN THE TEXT

Tree Species

Abbreviation	Common Name	Latin Name
Ald	Alder	Alnus glutinosa
	Apple	Malus sp.
Ash	Ash	Fraxinus excelsior
Bir	Downy Birch	Betula pubescens
Bir	Silver Birch	Betula pendula
	Blackthorn, Sloe	Prunus spinosa
	Butcher's Broom	Ruscus aculeatus
Be	Beech	Fagus sylvatica
	Cherry, Gean	Prunus avium
	Dogwood	Cornus sp.
D.Fir	Douglas Fir	Pseudotsuga menziesii
Eld	Elder	Sambucus nigra
Elm	Wych Elm	Ulmus glabra
	Invasive Elm	Ulmus procera sp.
F.Ac	False Acacia, Locust	Robinia pseudoacacia
F.Map	Field Maple	Acer campestre
	Wild greengage	Prunus domestica ssp.italica
	Guelder Rose	Vibernum opulus
Haw	Common Hawthorn	Crataegus monogyna
	Midland Hawthorn	Crataegus laevigata
Haz	Hazel	Corylus avellana
Hol	Holly	Ilex aquifolium
HChes	Horse Chestnut	Aesculus hippocastanum
Hor	Hornbeam	Carpinus betulus
Jun	Juniper	Juniperus communis
Lim	Lime	Tilia cordata
NMap	Norway Maple	Acer platanoides
Oak	Oak	Quercus robur
	Oak	Quercus petraea
Pop	Poplar	Populus sp.
	Plane	Platanus acerifolia

ABBREVIATIONS (Contd.)

Pin	Scots Pine	Pinus sylvestris
SFir	Silver Fir	Abies alba
	Spindle	Euonymus europaeus
SChes	Sweet Chestnut	Castanea sativa
Syc	Sycamore	Acer pseudoplatanus
	Turkey Oak	Quercus cerris
	Walnut	Juglans regia
	Wayfaring Tree	Viburnum latana
	Wild Service	Sorbus torminalis
Wil	Willow	Salix sp.
Yew	Yew	Taxus baccata

Animals

Green bush grasshopper	Meconema thalassinum

Woodland abbreviations (graphical notations)

(see also p 36)

D	Deciduous plantations	
C	Coniferous plantations	
S	Secondary woodland	
A	Ancient woodland	
Inv	Invasion	
O	Open	ground flora- GF, gf
O/C	Open / Closed	ground flora- GF, gf
C	Closed	ground flora- GF, gf
W	Woodland with sycamore	
N	Woodland with no sycamore	
P	Plateau	
Ht	Hilltop	
Vl, Va	Valley	
2-6°	Slope	
>6°	Slope	
B	Brashings	

N.B. There is no figure 67.

PREFACE

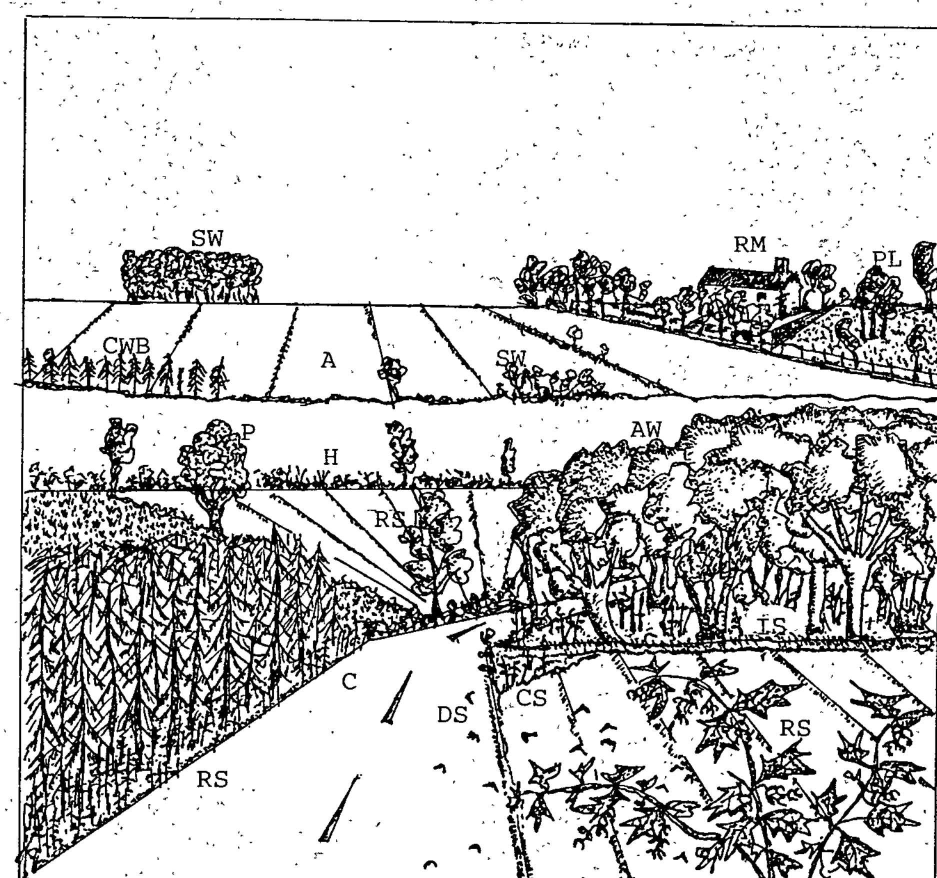
Considering the large number of plants and animals that have arrived in Britain through human intervention, it is perhaps surprising that so few of these immigrants can find a niche within the vast number of habitats that are potentially available to them. Of course, there have been notable exceptions; for instance, pheasants, rabbits and grey squirrels in the animal world. As for trees, sweet chestnut and sycamore are perhaps the only introduced species that have managed to maintain themselves, on a large scale, in any satisfactory way. Sycamore alone can do this throughout the length and breadth of the country. What then is so special about this tree? And, importantly, is it exploiting niches that are empty or is it outcompeting a native species to gain its place?

In fact, the native tree world which is facing this alien invasion is already one involved in great change. The relationship that has existed for at least a thousand years between trees and humans and, in particular, the balance between construction and destruction of natural environment, in many cases no longer remains. Is it that sycamore can now find new niches to which native trees themselves cannot adapt, at the same pace as the rapid rate of induced change that is now befalling their habitats?

Humans, however, have not been entirely insensitive to the battle for tree supremacy in their wooded wastelands. The immigrant sycamore has been viewed as an unwanted one but is it already a permanent fixture in the British countryside? Will it overwhelm the native British tree population and will this, in turn, affect all those plants and animals that have become reliant on the stability of their native woodland environments?

Scientists have begun to take the sycamore seriously; foresters have grown it in pots in greenhouses, testing out different soils; naturalists have made their subjective comments stumbling on it on their rambles; and conservationists have un-methodically damned its existence. The aim of the forthcoming thesis is to give field ecologists an interpretation of the present ecological status of sycamore in a typical settled rural British environment and to relate the occurrence of sycamore to its ability to compete with the native tree flora species. It is intended to use this interpretation both to predict sycamore's future status and to answer some priority questions, such as : why is sycamore successful? what is its mode of niche exploitation? and what ecological impact will sycamore have on the complete rural ecosystem?

Frontispiece : Composite illustration of a typical West Suffolk woodland/arable landscape



A	Arable fields	H	Hedge
AW	Ancient woodland	IS	Invasive sycamore
C	Coniferous plantation	P	Pollard
CS	Colonising sycamore	PL	Parkland
CWB	Coniferous windbreak	RM	Rural mansion
DS	Dispersing sycamore	RS	Roadside sycamores

SW Secondary woodland

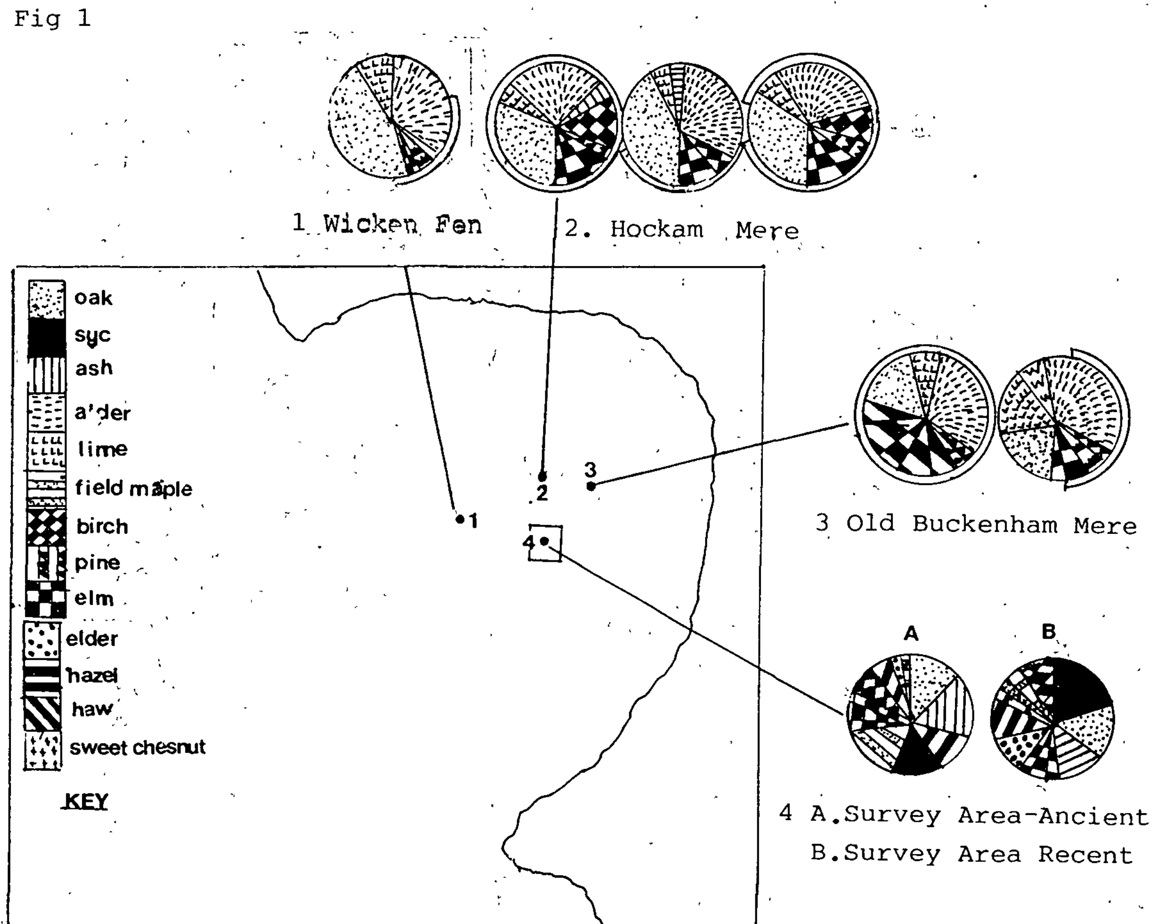
Chapter 1

A. THE HISTORY OF SYCAMORE INTRODUCTION TO BRITAIN

Acer pseudoplatanus (sycamore) is considered to be an exotic introduction to Britain. Its entry into Britain is thought to have been achieved through the actions of man. There are no records of sycamore prior to glaciation. However, the Merlewood Research and Development paper No 48[29] suggests that it might have existed at this time. Its absence in pollen-sediment records could be due to the fact that sycamore is not readily preserved and that sycamore produces less pollen than many native wind pollinated trees. Sycamore is an insect pollinated species. Godwin[19] records two incidents of sycamore pollen in his post glacial history of British woodland but suggests that these are due to sediment contamination or misidentification. According to Rackham[64] the pollen record within the West Suffolk area, and near to it, shows no record of sycamore (see fig 1).

Diagram illustrating the composition of Atlantic wildwood at four East Anglian sites (data from Rackham) and the composition of West Suffolk woodland

Fig 1



Prehistoric sycamore artifacts have, however, been recorded by Cooper [10]. The artifacts in the form of fragments from ladles and skimmers have been unearthed at lacustrine villages at Glastonbury in Somerset. The source of timber for these artifacts is thought unlikely to be native. Similarities between these artifacts and skimmers and ladles found in the Thuringian Forest dated at about 2000 - 3000 BC suggests that the British utensils are representative of trade between the two areas.

Mitchell [46] states that sycamore was probably introduced by the Romans. This would be the earliest historic date of introduction that has been found. Applebaum [1] considered that there are remains of a sycamore wind belt on a Roman farm in Derbyshire. Several authors have questioned the validity of this Roman date. Their scepticism lies in the argument that it would seem illogical for the Romans to have brought a timber producing tree to a country with an already abundant timber supply. However, the logic could lie in the fact that sycamore, in its natural range, is a mountain species. It is therefore arguably resistant to exposure. Edlin[13] states that sycamore woodland is the most northerly in the British Isles. Sycamore could have been an obvious import choice for Romans settling in upland areas of Britain and finding it difficult to regenerate native trees for shelter belts. Excavations of a Roman farm in the survey area (see text fig 3.5) showed no evidence of sycamore.

The distribution of sycamore in Europe is widespread, particularly in the mountain regions of central and southern Europe. Historical introductions would have been likely to originate from this area. Presuming that there was no post-glacial natural migration of sycamore from Europe or prehistorical introduction, then the need is to find the agents of historical introductions. Mitchell [46] sets the date of the earliest sycamore introductions about 1200 years earlier than most authors, who generally consider a date somewhere in the thirteenth century to be more realistic. Early records seem to be confused by a similarity between the name sycamore (Acer pseudoplatanus) and the fig mulberry (Ficus sycomonis). The latter tree has certain biblical connections. This confusion may, according to Edlin [13] have led monks of the thirteenth century to bring back seed of the sycamore from the continent to be grown in British monasteries. There are various records of authors using the name 'sycamore' in their work around the thirteenth, fourteenth and fifteenth century. These include Chaucer [8].

An Extract from Chaucer's The Flowre and the Leafe

So small, so thicke, so short, so fresh of hew *That most like vnto greene welwot it was.* *The hegge also that yede in compas* *And closed in all the green herbere* *With Sicamour was set and eglatere.*

Greenoak [20] (p 144) mentions examples of thirteenth century leaf carvings of sycamore at Southwell Minster, Notts. and also at Christchurch Cathedral , Oxfordshire. Firmer evidence of a significant fourteenth century sycamore population has been put forward by Cooper [10]. He states that King Edward III's parliament of 1340 legislated to safeguard the sycamore tree from over exploitation. Cooper [10] further supports a date around the thirteenth century by quoting figures taken from Hutchison [93] concerning an ancient Scottish sycamore tree known as the 'Great Tree of Kippenross'. He suggests that growth statistics taken from this tree would place its planting at least as early as the thirteenth century and possibly even as early as the twelfth century. There are many existing old trees in Scotland and some in England. Certainly some of these trees could date from the fifteenth century. Several authors, such as Cooper [10] feel that there may have been a close connection between these early fourteenth, fifteenth and sixteenth century introductions and historical links between Scotland and France. A famous example is that sycamore was planted at many residences of Mary, Queen of Scots. Jones [35] refers to three Scottish sycamores that were probably planted in the late fifteenth century at Castle Methuen, Perth, Calder House and a specimen at New Battle Abbey near Edinburgh. From these rather unsatisfactory records, it is difficult to draw too many conclusions about the scale of introductions prior to the sixteenth century.

More mention is made in literature throughout the sixteenth and seventeenth centuries. Hulme[33] quotes the writings of Gerard[16] (see below) in the sixteenth century and Parkinson[54] (see below) and Evelyn[15] (below) from the seventeenth century. The Oxford English Dictionary gives 1615 as the first use of the name sycamore for the tree Acer pseudoplatanus. Greenoak [20] relates that St. Edmunds Church, Sarum bought sycamore trees in 1693.

An Extract from Gerard's Herball, 1597

> *" The great Maple is a stranger in England, only it groweth in the walks and places of pleasure of noble men, when it specially is planted for the shadow sake, and vnder the name of Sycomore. "*

An Extract from Parkinson's Theatrum Botanicum, 1640

> *" It is nowhere found wilde or naturall in our land, that I can tell, but only planted in orchards or walkes for the shadow sake. "*

An Extract from Evelyn's A Sylva or a Discourse on Forest Trees, 1612

> *" It is much more in reputation for its shade than it deserves; for the honey-dew leaves, which fall early, like those of the ash, turn to mucilage and noxious insects, and putrify with the first moisture of the season, so as they contaminate and marr our walks, and are therefore, by my consent, to be banished from all curious gardens and avenues. "*

The following extracts from Harvey[27] show that nurseries were stocking sycamore in the late seventeenth century and selling at least in small numbers, probably as ornamental trees. By the mid-eighteenth century and early nineteenth century it seems that sycamore was being sold in large numbers, possibly for planting larger areas of woodland.

Extract from <u>a bill for plants</u> sold by George Rickets to Levens in Westmorland in 1689

	£	s	d
22 Peaches & Nectarines	*1*	*13*	*0*
62 Pears dwarfs	*1*	*11*	*0*
16 Aple-trees		*8*	*0*
4 Mullbury trees		*8*	*0*
400 Gooseburys & Currants	*2*	*0*	*0*
13 Lime trees		*13*	*0*
30 Black cherrys		*10*	*0*
16 Sycamores		*8*	*0*
(sycamores over 6 old pence each)			

Forester's report Kiveton Park, South Yorkshire -

<u>Plants in ye nursery</u>	1708
Limes under ye Cikamoores	*13*
Cikamores fitt to plant out this season	*40*
There are no trees in ye Pond Garden quarters vnless some few Cicamoores	

1730 William Mason's stock inventory included 1300 sycamore

1755 Henry Clark unpaid stock list at Chipping Campden

	£	s	d
15 Beach at 1/		*15*	*0*
10 Syckamores at 1/		*10*	*0*
25 Scotch firs at /6		*12*	*6*

1760 Catalogue from Hanbury Trust Nursery records sycamore

1813 Hanks and Dunhill Nursery in South Yorkshire planted at £6 an acre including 2000 sycamore for the Doncaster Corporation

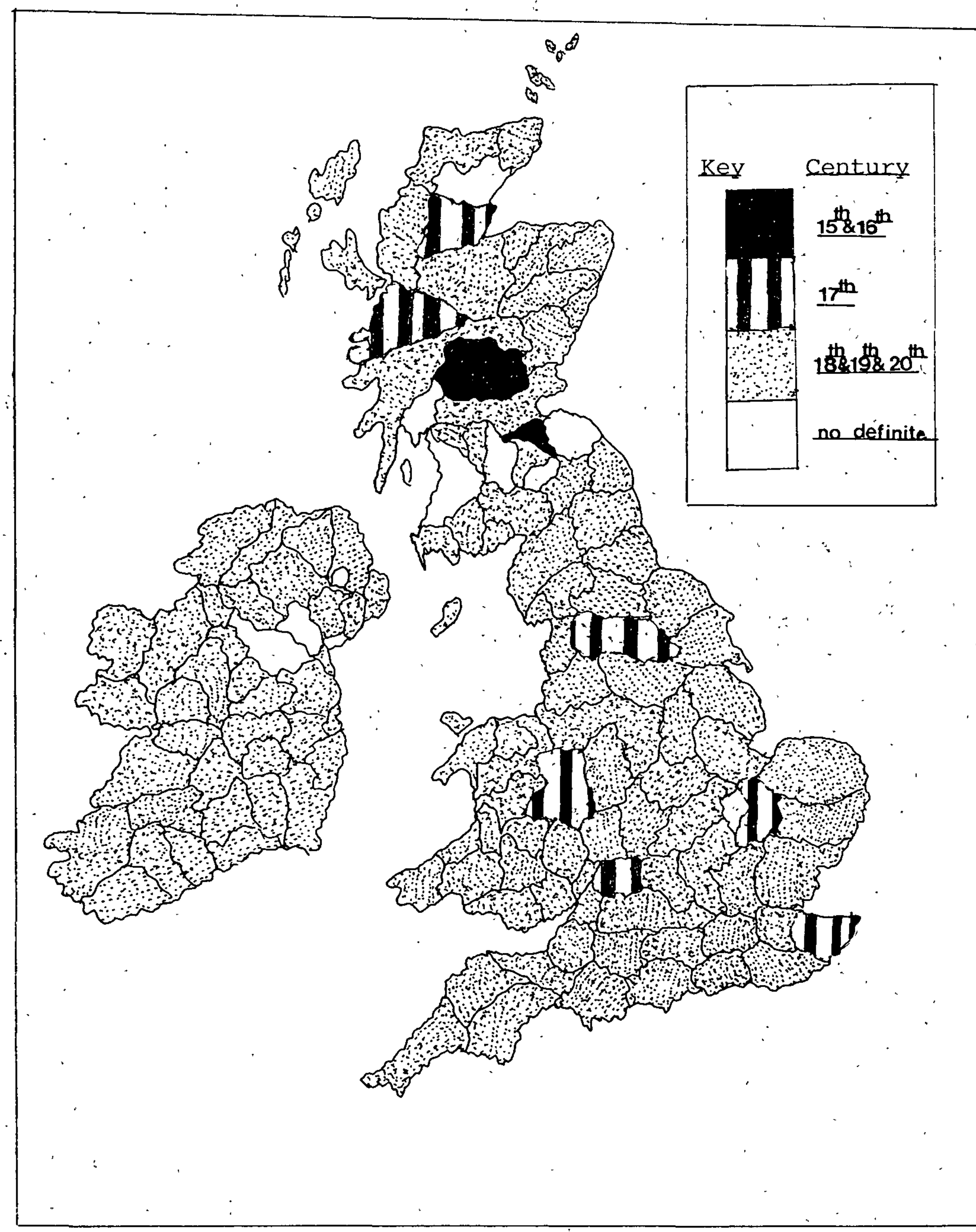
It is important to substantiate the time of sycamore introduction for several reasons, not least of which is in the assessment of its rate of population expansion, but also in correlating this expansion to changes in the native tree flora and changes in woodland management.

The report for 1708 at Kiveton Park (page 5) suggests that sycamore may have been regenerating as there is a very vague mention that sycamore 'may be found by the pond quarters'. Sycamore may have begun invading native habitats at this early date. This indicates that little acclimatization to the British climate was necessary for regeneration to occur.

Certainly sixteenth and seventeenth century introductions are likely to have been carried out by those elements of society that could afford to buy plants from the early tree nurseries, primarily landowners and churches. Introductions would therefore have been isolated. The examples of old sycamore trees recorded in the survey area (see text fig 5 -trees of greater than 2m girths at 1.3m) are isolated and confined mainly to parkland sites of landowners' country mansions. The 1813 record of a larger scale introduction (see text page 5) by Doncaster Corporation suggests a change in introduction pattern by the nineteenth century. This could be related to a change in socio-economic structure; society enabling industrialists to spend money on tree planting projects. Jones'[35] records of sycamore (see fig 2) illustrates that he could find few records of sycamore before the eighteenth century.

Jones[35] places a major expansion in the degree of sycamore planting in the mid-nineteenth century. At this time planting may have been for shelter belts, hedges and amenity parks. He records that out of twenty four Dorset woods in which sycamore was present, twenty of the woods were not shown on the first Ordnance Survey maps. Three of the remaining four were in parks where planting was at a slightly earlier date. Therefore in this example, expansion of sycamore populations on a wider scale seems to be associated with the development of man-cultured woodland.

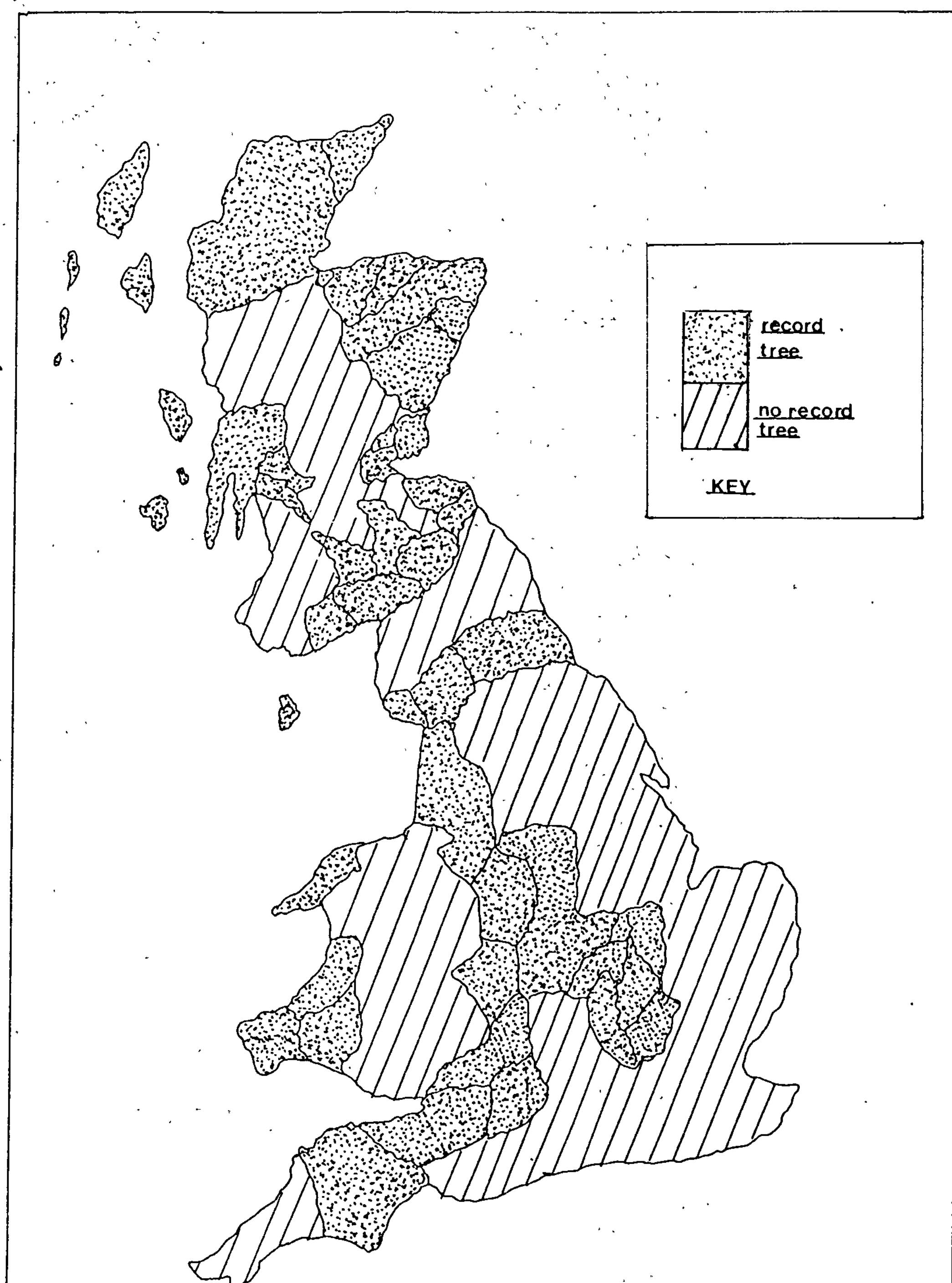
Fig 2 Redrawn from Jones'[35] map of sycamore introduction dates, based on counties



Mitchell's[46] Forestry Commission list of record size sycamore trees (fig 3) - usually above 70 feet in height and over 12 feet in girth - shows large numbers of counties with no record trees, indicating a limitation to the number of early introductions.

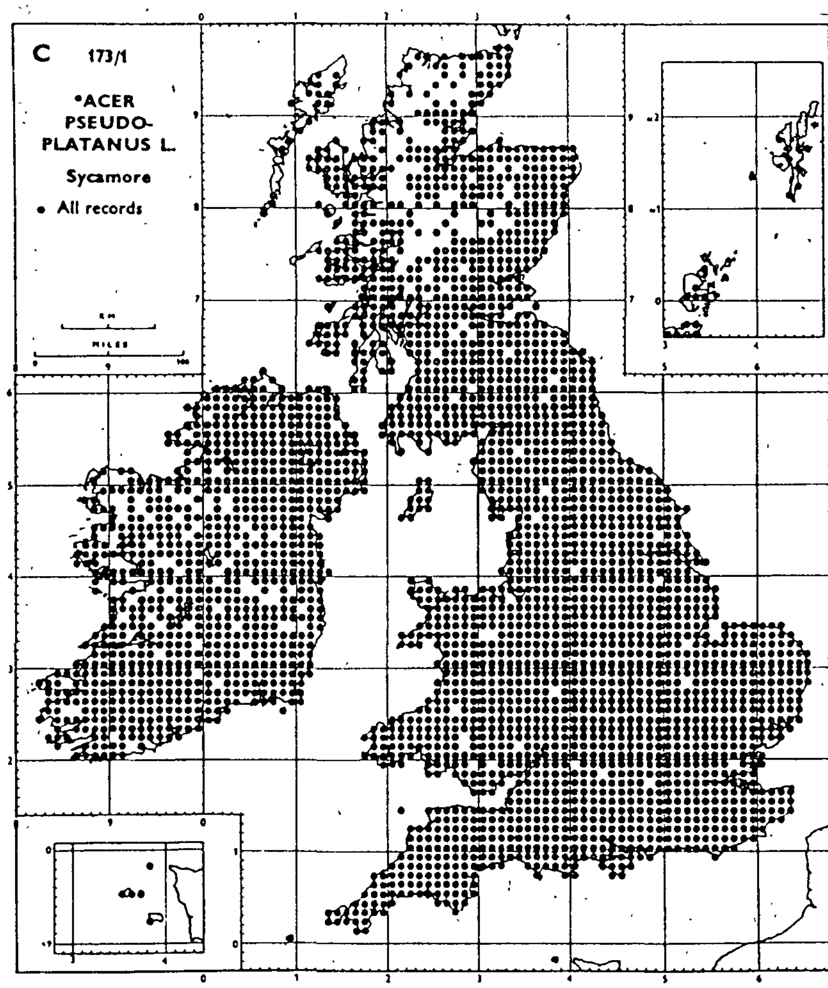
Mitchell's records are however somewhat inaccurate. The West Suffolk survey area included about ten trees which would be included, according to Mitchell's description, as record trees.

Fig 3 Occurrences of record size sycamore trees in individual counties. Data from Mitchell Forestry Commission



Perring and Walter's[57] 1962 record of sycamore (Fig 4) shows that the tree is now widespread throughout Britain and is now, arguably, fully naturalized. It has undoubtedly invaded native woodland through Britain as it has done in the West Suffolk survey area.

Fig 4 The distribution of sycamore (Acer pseudoplatanus) in the British Isles (Perring & Walters, 1962)

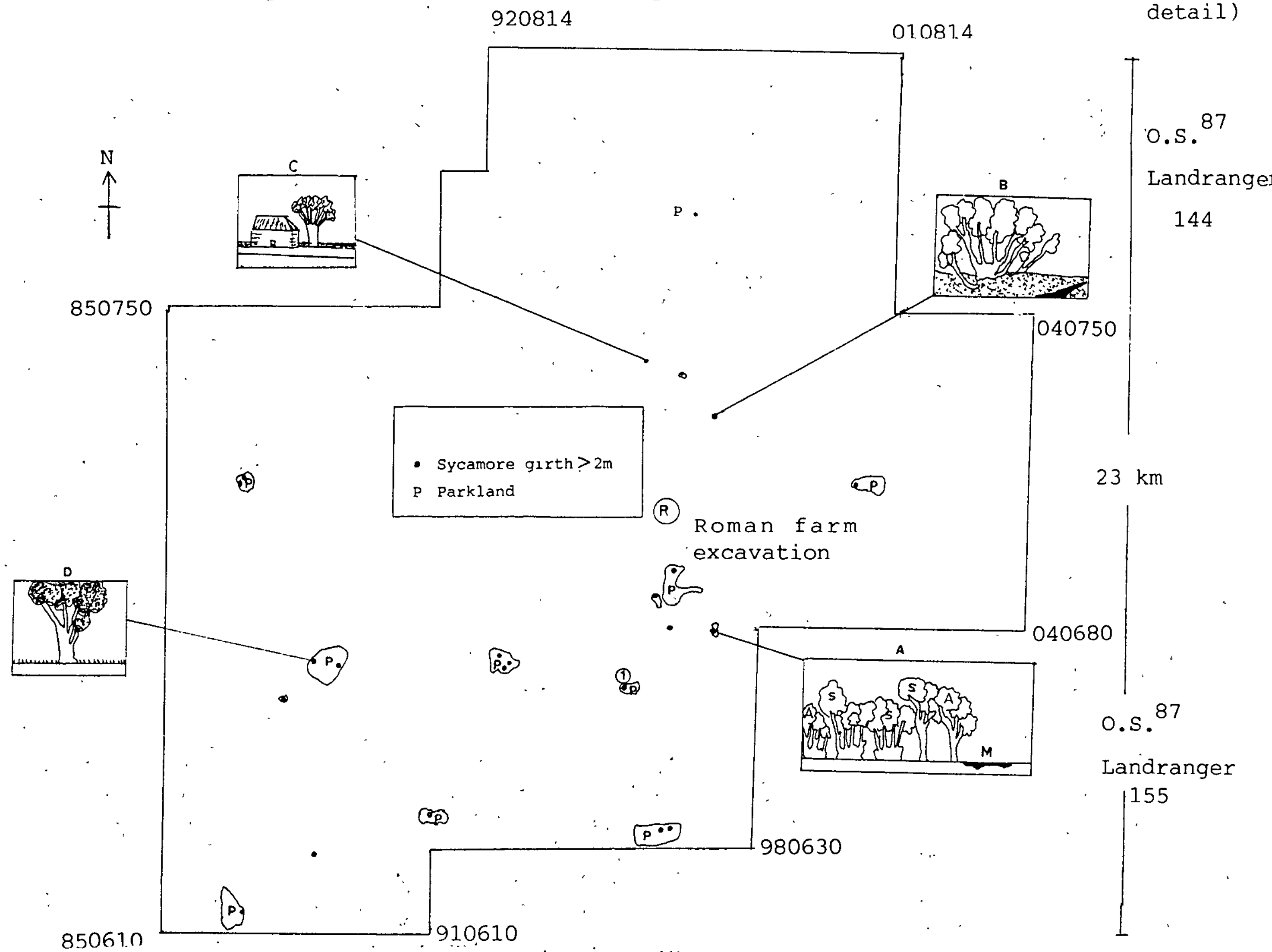


B. THE HISTORY OF SYCAMORE INTRODUCTION TO WEST SUFFOLK

Sycamore was first recorded in the 'flora of Suffolk' in 1775[72]. Several trips to the Suffolk Records Office failed to gain any more exact date or conclusive proof of introductions. Over forty local landowners were approached by letter and asked if they had records of sycamore planting or introduction. Only three replies were received and did not prove conclusive. Verbal contact with local landowners suggested little knowledge of sycamore planting in their lifetimes. Access to parkland sites was difficult to obtain but some records of large sycamores (girths at 1.3m high exceeding 2m) were recorded at parkland sites (fig 5). The parkland sites were amenities for large country residences. The typical form of a parkland tree is illustrated as (D) on fig 5 (see text). The parkland sycamores are thought to be the main original sources of invasion to West Suffolk. Boring of a particularly large sycamore, 270cm girth at Little Haugh Farm (see Plate 1) suggested an age of between 180 to 220 years, corresponding to a late eighteenth, early nineteenth century date of introduction. Comparing this tree to the trees found in other parks it would seem that introductions during the nineteenth century were most common. Plate 1 illustrates a typical parkland sycamore, greater than 2m girth.

Plate 1 Parkland sycamore - Little Haugh Farm

Fig 5 Map of the general survey area illustrating possible early sites of introduction of sycamore (see fig 35, page 62 for greater detail)



Large sycamores near settlements were occasionally observed. Sycamore (C) of fig 5 was a pollarded tree found close to an old cottage. This could have been as old, or older than the parkland trees. Sycamore (B) fig 5 was an extremely large coppiced sycamore tree (see Plate 3). A 1.5m rule has been placed in the photograph. The age of this tree would be difficult to measure but may be older than the late eighteenth to early nineteenth century date of the parkland trees. It was situated near a relatively recent settlement. Its origin is uncertain. It lies at the top of a deep gulley cut in chalk, which,in itself,is an unusual surface feature of the West Suffolk landscape.

Plate 2 Photograph of a large coppiced sycamore at Stanton Grundle wood no 17

Sycamore Wood (A) fig 5 consisted of the only example of mature sycamore coppice stools found in the West Suffolk area (see Plate 3).

The woodland (Stowlangtoft Wood One No 54, see fig 34) has a pond marked (M) in it, labelled <u>moat</u> on the O.S. Map.[51] This suggests an historic site of settlement. The woodland basically conforms to an ancient woodland type format (see text p16). The stools of all coppice in the woodland appeared to be particularly old. The sycamore stools were large with a considerable bryophytic cover. The character of the stools (S) was unlike any other sycamore found in the survey area. The distribution of sycamore in the woodland is also unusual in that it has an invasive front (see text p217) moving towards a road and a parkland site. It is considered that a direct introduction must have been made to the ancient woodland at some point in the woodland's history.

Plate 3 Photograph of Stowlangtoft Coppice Stool

Peterken[59] has observed secondary woodland of the period 1700-1800 in Lincolnshire, managed in the coppiced ancient woodland style but including alien species such as sycamore, presumed to have been planted. However, the similarities between the size and character of sycamore stools and ash stools,(A) fig 5, at the Stowlangtoft site suggests a more ancient origin of the sycamore. Without a firm date of introduction or way of aging the stools, it can only be assumed that the sycamore stools are an example of early invasion from an isolated introduction possibly as early as medieval times. The woodland was not completely invaded, so that the sycamore at this woodland was either unwanted by woodmen,so removed where possible,or the sycamore has had a very slow rate of invasion.

More recent introductions of sycamore do not appear to have occurred on a wide scale. Few examples of sycamore deciduous plantations were recorded in the general survey (see text p 47) Some very recent planting of isolated sycamores has been observed, mainly at roadside locations. These are shown in fig 184. Some planting in gardens and settlements may have also taken place. The analysis of sycamore dispersion and invasion is therefore to be primarily concerned with the dispersion of sycamore from parkland sites of introduction and the natural regeneration of propagules from parkland trees.

Summary

1. Sycamore was not represented in prehistoric pollen analysis.
2. Sycamore may have been introduced in upland regions during the Roman period 0-100 AD but the introduction did not expand quickly.
3. 13th and 14th century introductions may have occurred possibly at monasteries or religious sites but populations were again slow to expand.
4. 15th and 16th century introductions are definitely recorded, particularly in Scotland.
5. 17th and 18th century nursery records show stocking and sale of sycamore.
6. 19th century introductions were common particularly at the amenity parks of landowners and industrialists.
7. Sycamore introduction to the West Suffolk area probably most commonly occurred at parkland sites from the late 18th to 19th centuries.
8. There is little evidence of 20th century introduction of sycamore except in the 1940s and 1980s at roadsides. Conifers have been the common plantation tree.

Chapter 2

CLASSIFICATION OF WOODLAND AND WOODLAND TREES INVESTIGATED IN THE GENERAL SURVEY AND THE METHOD OF THE GENERAL SURVEY

The woodlands in the West Suffolk survey area have a variety of origins and have been influenced throughout their history by different forms of woodland management. This thesis is concerned with examining the status of sycamore throughout this range of woodland types. The woodlands were classified according to evidence gained from their present conditions. The woodland categories so formed were : ancient woodland, ancient derelict woodland, ancient wood pasture, secondary woodland, deciduous plantations, coniferous plantations, parkland, hedges and settlement gardens. The survey did not include orchards. The characteristics used to define these woodland types are illustrated in Table 1. They are derived from the work of Rackham[64] and Peterken[59] but include items from the writer's own familiarity with the woodlands. The characteristics described formed a diagnostic checklist for use in the general survey (see text, page 47).

Table 1 Diagnostic features of woodland classification used in thesis

	Ancient Woodland	Derelict Anc.W'dland	Ancient Wood Pasture	Secondary Woodland	Decidous Plantation	Coniferous Plantation
Species Competition	deciduous species	deciduous species	deciduous species	deciduous species	deciduous species	coniferous species
Perimeter form	regular, straight	regular, straight	regular, sometimes straight	irregular, sometimes straight	regular, straight	regular, straight
Boundaries	high bank, deep ditch isolated pollards	low bank ditch isolated pollard canopies	low bank ditch isolated pollard canopies	no bank sometimes bushy sometimes hedges	sometimes ditch sometimes hedges cut	sometimes ditch sometimes hedges cut
Pathways, Rides	regular rides cut	regular rides overgrown	regular rides overgrown irregular pathways	irregular pathways	irregular pathways	regular rides cut
Compartments	obvious species compartments	obvious species compartments	species compartments	no species compartments	occasional species compartments	occasional species compartments
Tree distribution	some trees in rows	some trees in rows	no trees in rows	irregular no trees in rows	regular all trees in rows	regular all trees in rows very strict rows dense
Tree form	coppice with standards	coppice pole or canopy with standards	pollards standards	standards	standards	standards, poles

Table 1 (continued) Diagnostic features of woodland classification used in thesis

	Ancient Woodland	Derelict Anc.W'dland	Ancient Wood Pasture	Secondary Woodland	Deciduous Plantation	Coniferous Plantation
Coppice stools	cut coppice large stools	coppice uncut very large stools	pollards not cut	some small stools uncut	small coppice stools uncut	no coppice stools
Age stratification	simple-even age	complex-not even age	simple-even age	complex-not even age	simple-even age	simple-even age
Tree felling	occasional felling	no felling	no felling	signs of felling	felling	felling
Tree grubbing	no grubbing	no grubbing	no grubbing	signs of grubbing	signs of grubbing	signs of grubbing
Soil	flat - no disturbance	flat - no disturbance	flat - no disturbance some firing	disturbance pits, excavations,furrows	furrows	furrows, some firing
Dead trees	no dead trees dead elm poles	dying coppice stools	few dead trees	dead canopies and poles	no dead trees	uprooted trees
Ivy - *hedera helix*	no ivy	little ivy	little ivy	considerable ground and tree ivy	no ivy	no ivy
Ground flora *	ancient indicator species	ancient indicator species nothing/ rubus	ancient indicator species/ nothing/rubus grass sward	some ancient species/urtica calluna/rubus hedera/ pteridium	urtica/rubus hedera	very little

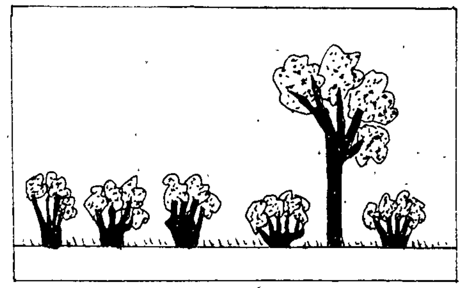
* refer to ground flora associations fig 204, Page 267

Table 1 (continued) Diagnostic features of woodland classification used in thesis

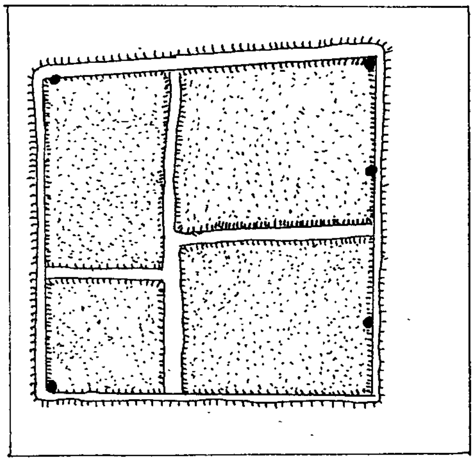
	Ancient Woodland	Derelict Anc.W'dland	Ancient Wood Pasture	Secondary Woodland	Deciduous Plantation	Coniferous Plantation
Tree species	usually 1-4 sp. per stand	usually 1-5 sp. per stand	usually 1-5 sp. per stand	usually 1-10 sp. per stand	usually 1-3 sp. per stand occasionally 1 - 15	Usually 1 - 2 species
Anthropogenic disturbance	none	some	some	some	none	none
Scrub	none	some	some	common	none	none
Exotics	none	some	some	common	common	common

Fig 6

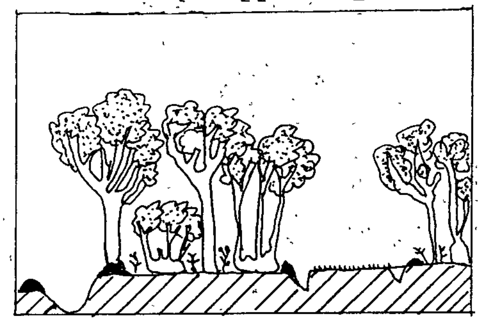
Diagnostic woodland plans and woodland profiles according to criteria outlined in table, Table 1



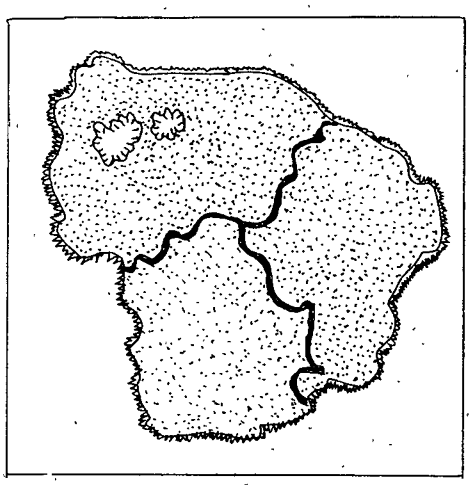
Recently coppiced profile



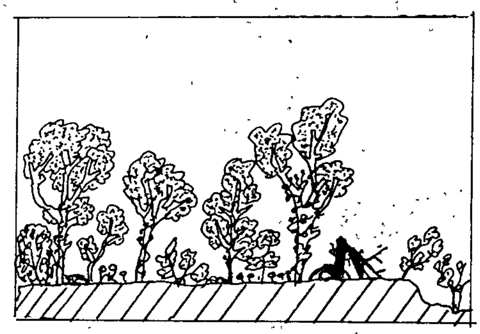
Ancient woodland plan



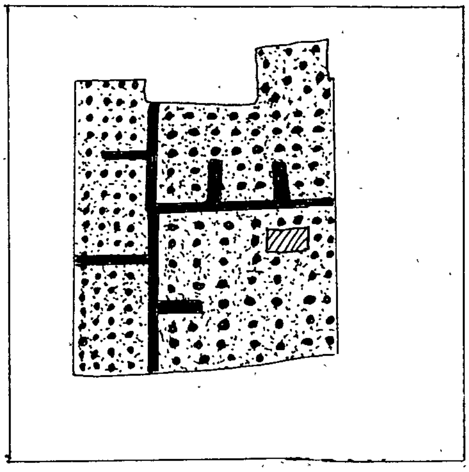
Derelict profile



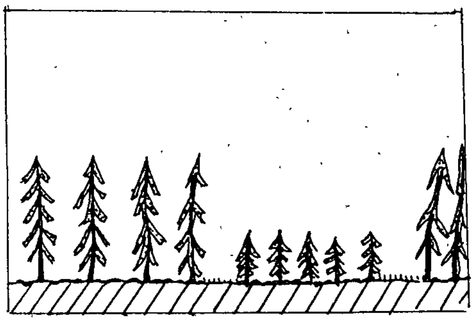
Secondary woodland plan



Secondary woodland profile

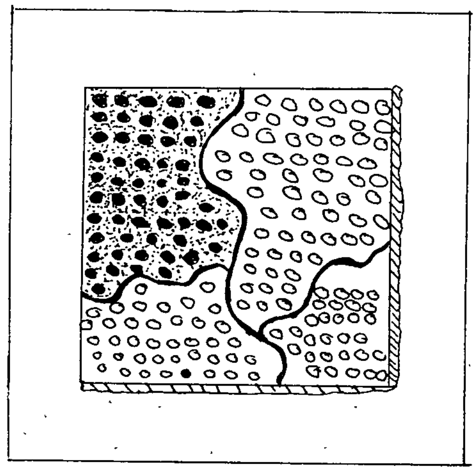


Coniferous plantation plan

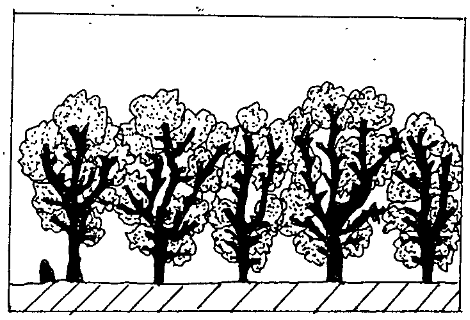


Coniferous plantation profile

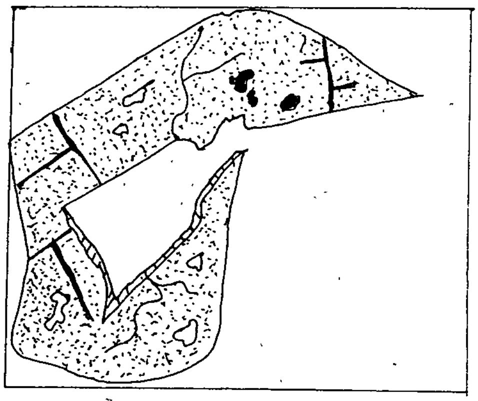
Fig 6 (contd) Diagnostic woodland plans and woodland profiles according to criteria outlined in Table 1



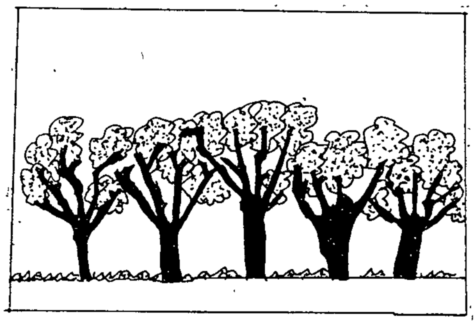
Deciduous plantation plan



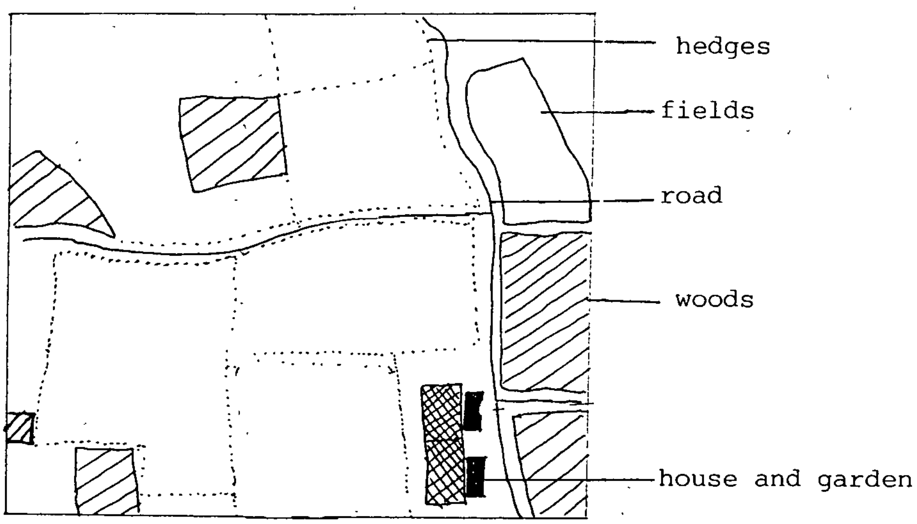
Deciduous plantation profile



Wood pasture plan

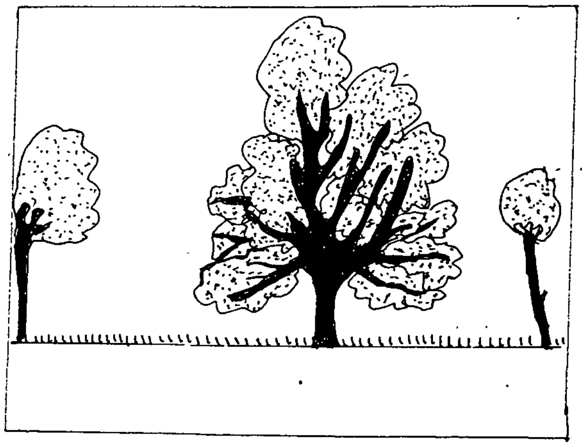


Wood pasture profile

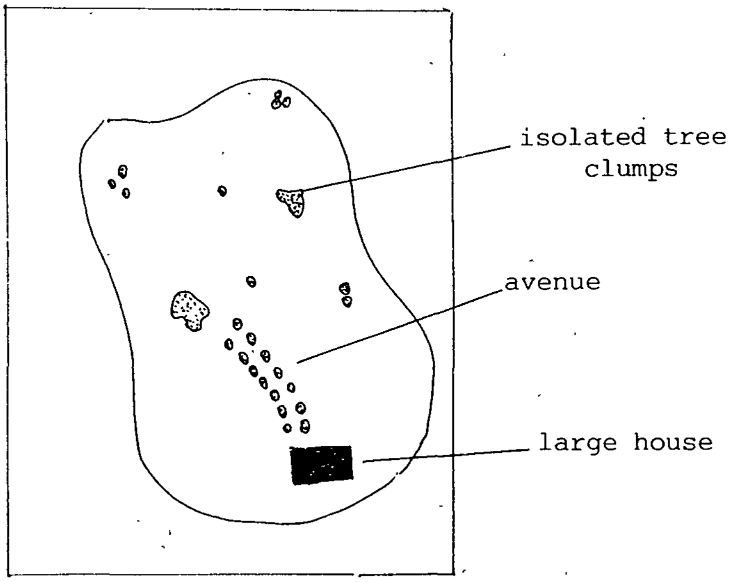


Plan of hedges

Fig 6 (contd) Diagnostic woodland plans and woodland profiles according to criteria outlined in Table 1



Parkland profile

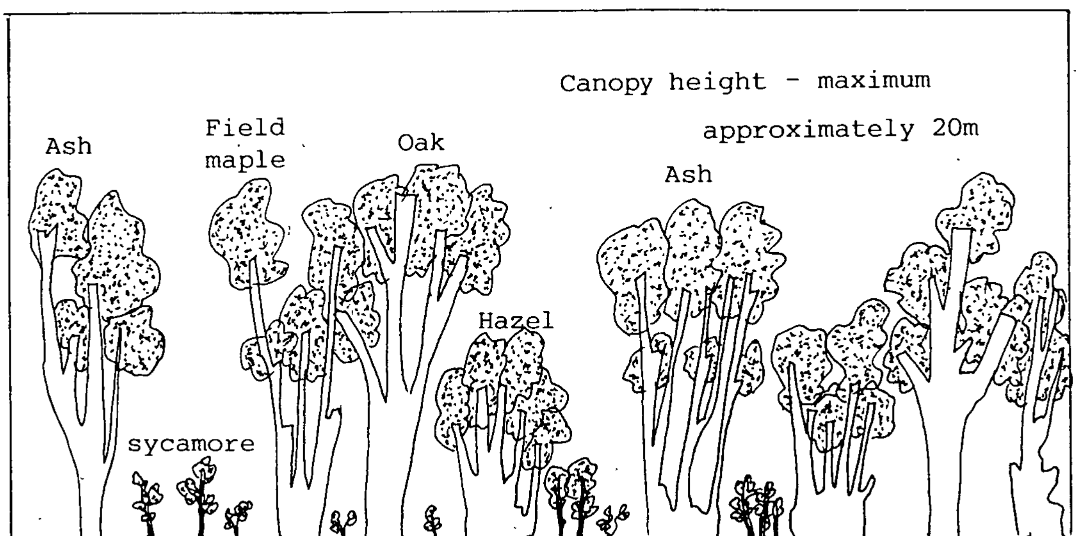


Parkland plan

Ancient woodland

Ancient woodland consists of woodland that has been managed for wood products from historic times. Ancient woodland is presumed to be at least five hundred years old. The origins of tree species community in ancient woodland may be partly natural but will have undergone considerable modification by man's management, with the proliferation of desired species and the exclusion of less desired species. The species structure tends to consist of coppice trees of a certain species and timber trees of a certain species. Coppice trees have been cut at regular intervals to produce a small girth wood crop. Timber trees are left uncut to produce large girthed timber. Each wood crop has had particular uses in traditional crafts. Grazing is excluded from these woods by earthworks and ditches. The wood may also be divided into compartments by clear pathways or rides. Each compartment may have a different species structure composition. In fact, only one example of ancient woodland was found in the survey area. This was a site where maintenance of the woodland in its managed form had continued to the present day.

Fig 7 Diagram illustrating the woodland profile of Pakenham Wood



Ancient derelict woodland

Ancient derelict woodland results from the cessation of management of an ancient woodland. This neglect of practice is largely a twentieth century phenomenon and has greatly accelerated since the 1939 - 45 war (Rackham [64]). In such a derelict condition, the earthworks and ditches became eroded allowing for large mammals to re-enter the wood to graze. Coppice trees grow for longer than their original cropping rotation period, producing a structural form of woodland that is historically unique. The invasion of these woodlands has coincided with the only significant change in the character of these woodlands since the onset of ancient management in the medieval period or earlier. Figs 7 - 12 illustrate the woodland profiles of some ancient derelict woodland in the early stages of sycamore invasion. Peterken [59], both at Swithland Wood (Leics) and at Wytham Wood (Oxon) records that sycamore invasion has coincided with the cessation of ancient woodland management techniques.

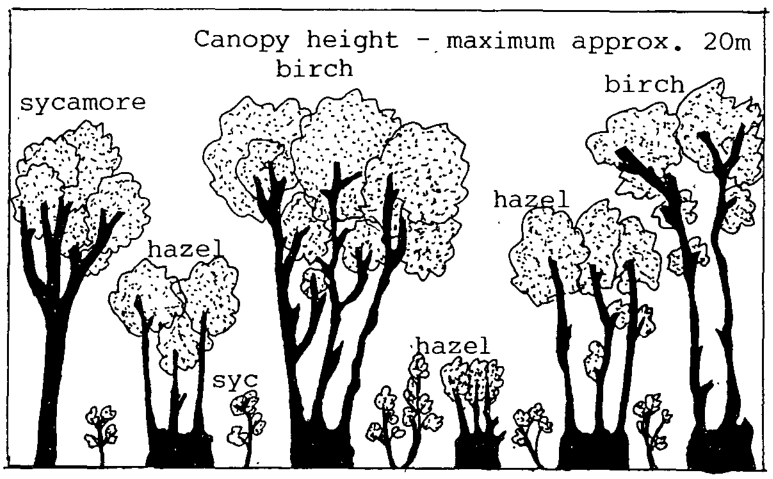
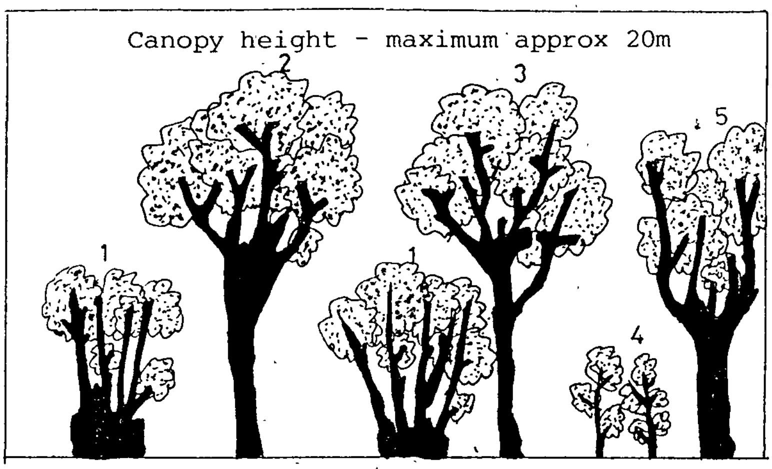
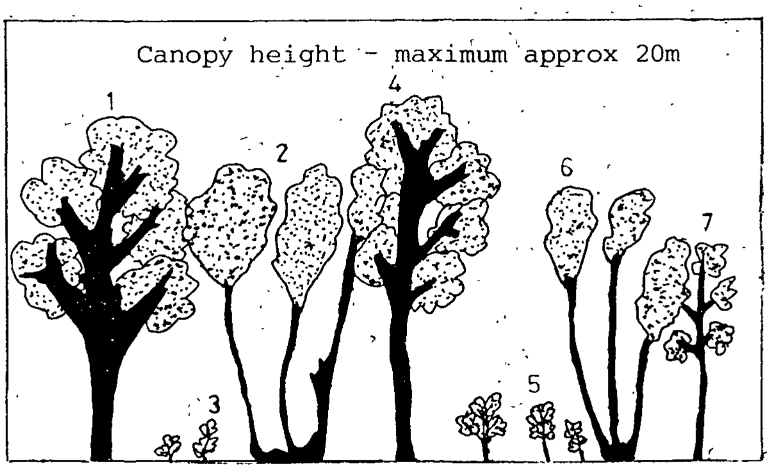


Fig 8 Diagram illustrating the woodland profile of Calke Wood



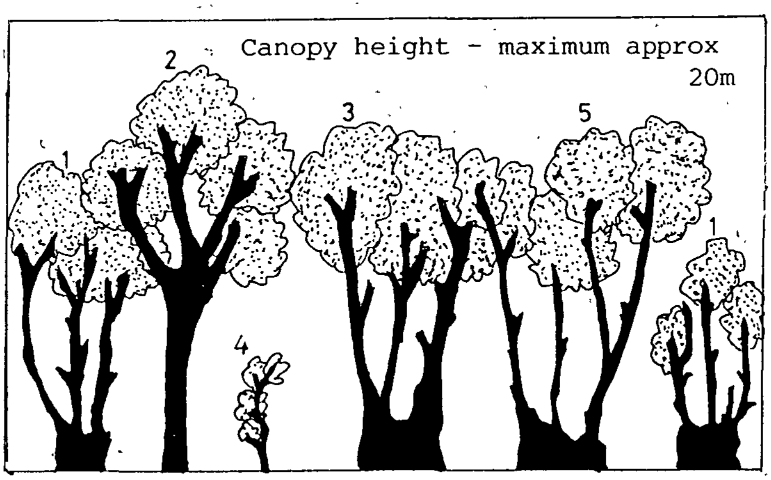
1 Hazel
2 Ash
3 Oak
4 Sycamore sapling
5 Sycamore mature

Fig 9 Diagram illustrating the woodland profile of Rougham Copse



1 Oak
2 Ash coppice
3 Holly
4 Ash
5 Sycamore
6 Elm
7 Elm

Fig 10 Diagram illustrating the woodland profile of Great Barton Wood



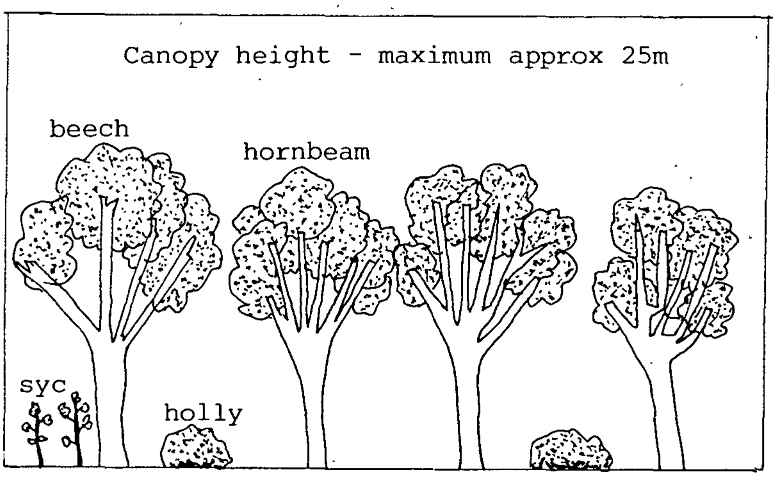
1 Hazel
2 Ash/Oak
3 Field maple
4 Sycamore sapling
5 Birch

Fig 11 Diagram illustrating the woodland profile of Norton Wood

Ancient derelict wood pasture

Ancient derelict wood pasture was not present in the West Suffolk area, but was the predominant management regime of Epping Forest. It was for this reason that Epping Forest was actually investigated. It represented another major management technique employed by traditional woodmen. In ancient woodland coppice was cut at a height of between ground level and 1m, producing short coppice stools with regrowth. However in wood pasture, stock and wild animals were allowed to graze the woodland so that, in order to preserve the growing shoots of trees, cutting was carried out at a height of between 3 - 5m producing pollard trees. The technique of pollarding has been largely abandoned in a way similar to that of ancient woodland. The remaining pollard trees have now grown far larger than would have originally been intended. Again sycamore invasion of these woods coincides with a major change in the structural character of the woodland (fig 12).

Fig 12 Diagram illustrating the woodland profile of Epping Forest woodland pasture



Secondary woodland

Secondary woodland in its purest form would be woodland that originates from the natural colonization of treeless ground by a tree community where that ground had at one time possessed a tree cover. The wood then would be totally unmanaged and develop as a natural succession. The woodlands may be as old as ancient woodland but in most cases, this would be unlikely. Woodland, in historic times, would have usually either been managed or cleared for agriculture. Secondary woodland is likely to have had a more recent date of origination than ancient woodland. Some woodlands found could have conformed to this pure model of secondary woodland, such as the disused pit sites (see fig 133). In most cases, secondary woodland tended to be smaller than ancient woodland but their importance as 'islands of refuge' for wildlife,in an otherwise barren arable landscape, makes such sites worthy of investigation. Other secondary woodlands do not conform to the pure model. They may have been managed to a certain extent possibly by coppicing. In these cases, the stools of the coppice trees would have a far smaller girth than their ancient counterparts. In some circumstances, the odd ancient stool might be present with evidence of timber tree felling, suggesting the colonization of a partly clear felled ancient woodland. Planting may have also occurred within the secondary woodland. However the classification of secondary woodland is based on what the predominant character of the woodland appears to be. To confirm fully the secondary status of such woodland would necessitate a very detailed examination of historical records. Figs 13 - 16 illustrate the woodland profiles of some sycamore invaded secondary woodland.

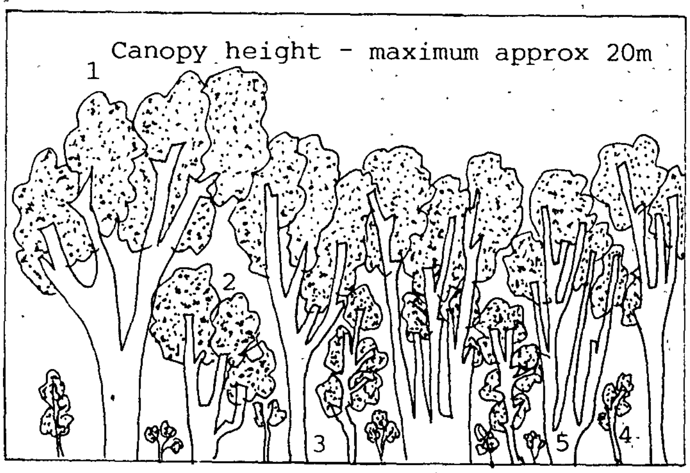


Fig 13

Diagram illustrating the woodland profile of Moreton Hall Copse

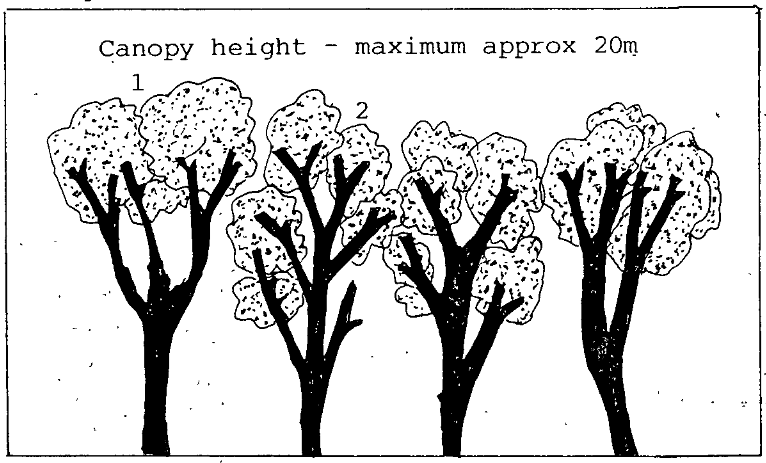
1 Oak

2 Hawthorn

3 Sycamore sapling

4 Elder

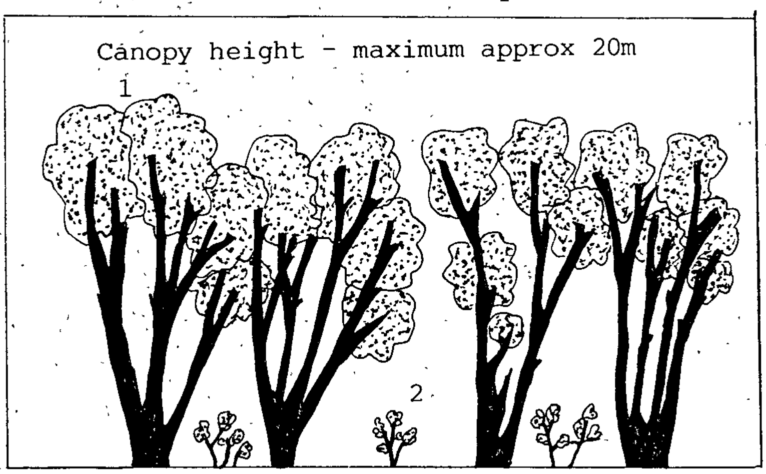
Fig 14 Diagram illustrating the woodland profile of Pakenham Pit - Secondary woodland



1 Sycamore

2 Ash

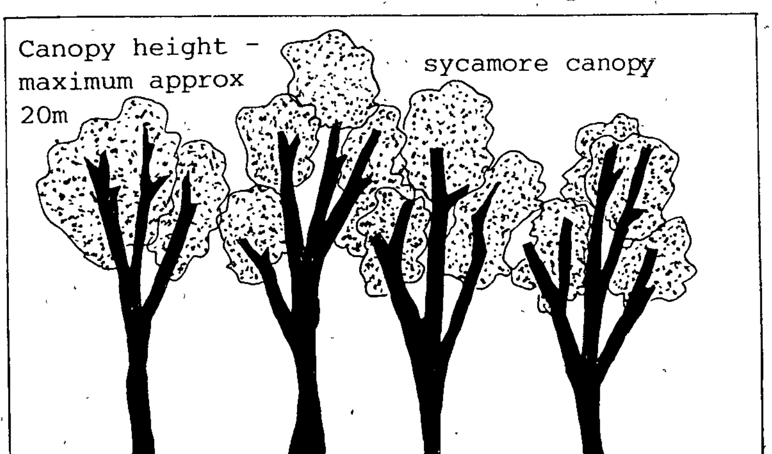
Fig 15 Diagram illustrating the woodland profile of Thurston School Copse - Secondary woodland



1 Sycamore

2 Elder

Fig 16 Diagram illustrating the woodland profile of Ixworth Pit - Secondary woodland



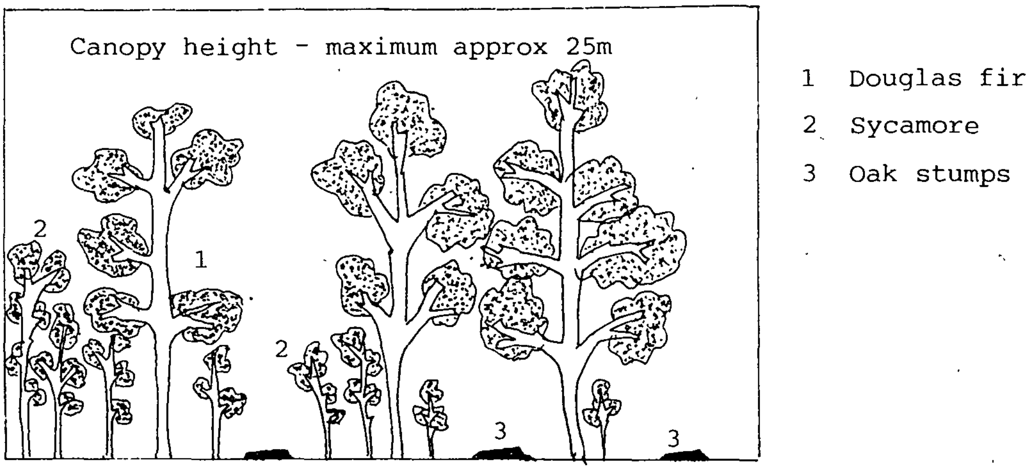
Deciduous plantation

These woodlands have been planted by man. They tend to be of a very distinctive species structure, often monospecific or containing a variety of exotic species depending on their purpose. The woodlands were relatively easy to diagnose and were rare. They lack coppice trees and are either of recent origin (less than the life span of a tree species)or have been clear felled at periods throughout a more lengthy history. There was no evidence to presume that sycamore has been planted to any significant extent in deciduous plantations.

Coniferous plantations

Coniferous plantations have been planted by man and are of relatively recent origin. They would appear to be related to either the planting for the purposes of providing cover for game birds or for a timber crop. They have a distinctive species structure and profile. Their development in the West Suffolk area, largely in the twentieth century has also coincided with the invasion of woodlands by sycamore. In some cases the existence of deciduous tree stumps suggests conifer planting following the clear felling of native woodland. Fig .17 illustrates the woodland profile of a sycamore invasion of a coniferous plantation.

Fig 17 Diagram illustrating the woodland profile of Ampton Field Plantation



Parkland

Parkland can only just be considered as a woodland type. Parkland usually consists of large open grassy areas surrounding rural mansion houses. The areas have historically had a recreational value. Trees have been planted in small areas or as individuals or as avenues within the grassy areas. The parklands are important as they have often been planted using both exotic and native species, according to taste! Parklands may therefore represent the origins of sycamore introduction to the survey area.

Hedges

Hedges are a 'peripheral' woodland type. They may surround woodlands, fields, settlements or run along roadsides or railways. Hedges may have a very ancient origin possibly before the time of ancient woodlands but at least of comparable age. They are likely to have been managed throughout their history by traditional hedge laying techniques. Some hedges have a more recent origin and have a less diverse species composition. These hedges will have been planted. Some of the older hedges could have developed from natural colonization and succession. Hedges are in some cases still managed but rarely by traditional hand laying methods. Mechanical trimming of roadside and field hedges is common. In rare circumstances, hedges have been left unmanaged. Sycamore invasion of hedges was considered to be of interest because of the wildlife value of such hedges.

Settlement gardens

Settlement gardens including churchyards, cemeteries and recreation areas may contain limited numbers of trees. These, again, were thought to be important as possible sites of sycamore introduction or colonization.

The tree classification used in the survey

Preliminary observations of West Suffolk woodland had suggested a considerable variety of species compositions and management regimes. Attempts at boring sycamores to give age estimates had also proved to be difficult. The extremely white wood of sycamore produced pale bores with indistinct annual rings particularly in younger trees. Boring to gain age structure estimates for all species within woodlands of a considerable variety of composition would have also been overly time consuming and possibly misleading as it was considered that a survey of a large proportion of woodlands would give a clearer impression of the status of sycamore within the West Suffolk woodland community, rather than a more detailed survey of a few woodlands. Furthermore, the occurrence of coppicing makes even more difficult the use of boring to produce age estimates and it is clearly evident that coppicing will prolong the natural longevity of trees. This would have invalidated attempts to use age estimates for mathematical population modelling or the description of woodland profiles.

Consideration of these points led to the need to produce a system of tree recognition relevant to the peculiarities of the West Suffolk survey area and the needs of assessing the status of sycamore throughout a large proportion of woods in that area. Whether the system that has been produced is unique is unclear. It has, however, not been based on an existing system but has been constructed from preliminary observation and familiarity with the condition of West Suffolk woodland and Epping Forest. The system does recognise traditional elements of woodland classifications, such as coppice trees, canopy trees, pollards and seedlings.

The system of tree classification used for the survey of West Suffolk woodland

Five criteria were considered to be important to the system of classification used to define an individual tree.

Criterion 1 <u>The species of the tree</u>

This was determined using field guides (see page 284). In most cases no distinction was made between *Quercus petrae* and *Quercus robur* or *Crataegus oxyacantha* and *Crataegus monogyna* or the various species of willow and elm. Species recognised using common names were oak, ash, field maple, elm, rhododendron, hazel, hawthorn, hornbeam, elder, sweet chestnut, holly, false acacia, blackthorn, birch, Scots pine, beech, box, yew, horse chestnut, sycamore, Norway maple and willow. (Dogwood, spindle, guelder rose, wayfaring tree, gean and wild apple were not included for data analysis.)

Criterion 2 <u>The morphological form of a tree</u>

This was determined using a personally devised pictorial key, figs 19-29. Rough sketches were made in the field of individual trees throughout the typical range of woodland types in the West Suffolk area. Photographs were also taken for comparison. Compilation and matching of the initial sketches produced the major forms. These were unmanaged trees, coppiced trees, pollarded trees, suckering trees, bushes and oskar forms.

Unmanaged woodland trees have a relatively straight central trunk with radiating branches which tend to join the main trunk nearer to the top half of the tree especially when growing amongst coppice trees, although this is not always the case. Branches may occur uniformly from low down on the trunk, in some instances. The unmanaged trees have had no cutting of their branches at any stage of their growth.

Coppiced trees have been cut near to their main trunk at some time, in accordance with ancient woodland management techniques. The cutting would have been repeated at regular intervals and the cropped branches used for a variety of purposes such as thatching, hurdle making, tool making and house building. The effect of this is to produce a very short fat trunk termed a stool, from which relatively thin branches radiate from a uniform height, usually no more than 1.5m from the ground. Some trees have been cut at ground level to produce a very low stool. In most woods in the West Suffolk area, coppicing has been discontinued so that the usual cycle of cutting between five and twenty five years, depending on species and management objectives has been interrupted (see text page 23). The result has been that coppice trees often have large trunks (probably fewer in number than originally intended) radiating from stools. The trunks were often as high as the highest unmanaged trees with trunks of equivalent girth.

Pollard forms have a similar management history to coppice forms excepting that the cutting of radiating branches was done at a higher level from 4-6m to avoid the grazing of new growth. These pollard forms were the dominant feature of Epping Forest. Discontinuation of pollarding now means that main trunks are taller than they were intended to be and radiating branches much larger.

Bush forms are nearly self descriptive. Only holly, hawthorn and blackthorn were found in bush forms. Bush had no main trunk but many trunks radiating from a central node near to ground level. The bush forms rarely exceeded 5m in height.

Suckering trees were trees that took the form of two or more unmanaged trees joined together by an underground stolon or stolon just above the soil surface. Elm was the most common suckering tree forming large clones, where a single tree has formed many main trunks numbering from 1 - over 100. Suckering trees at times had a similar form to coppiced trees cut at ground level. At these times identification had to be made in terms of the overall pattern of management in a woodland and the species concerned. Sycamore and false acacia were seen to sucker on occasions.

Oskar forms (name taken from Silvertown[70]) could be recognised as unmanaged trees with a more procumbent or dwarfed form than unmanaged trees of an equivalent height above ground level. They were often more radially branched and from a lower level on the main trunk than unmanaged forms, although this was not always the case. Oskars can have a more bent appearance than unmanaged trees which tend to have an erect central stem where the apical meristem is perpendicular to the ground. The apical meristem of oskars can be parallel to the ground. Oskars may have several central trunks or branches radiating from a central node at ground level as in bush forms but in these cases, species type was taken into account. Holly, hawthorn and blackthorn were not recorded as oskars, the oskar form being exclusive to trees not usually found as bushes in woodland situations. It has been presumed that oskars are formed from the result of inhibition most probably from shading but possibly from grazing or other environmental factor. They certainly have growth retardation in terms of height and in some cases girth. They may be found in the same wood as unmanaged trees of a similar age. Whether the oskar form represents a form that may later develop into an unmanaged tree is not known. It may be that oskars are a form that contribute to the success of specific tree species and that they represent a definite strategy that a tree can employ to delay its growth until conditions are more favourable. Sycamore and ash were the most common oskar forms (see text pages 126 and 140).

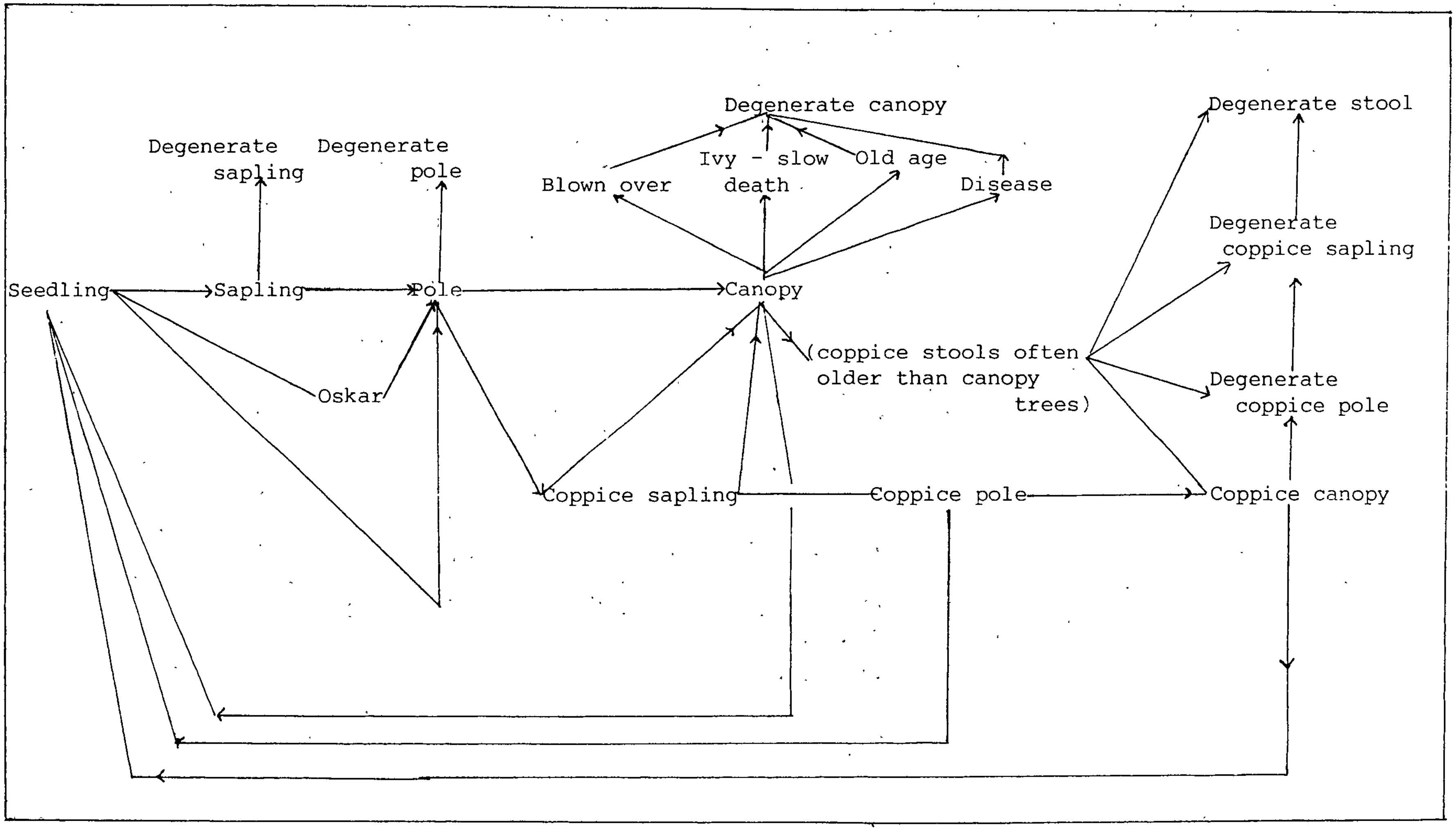
Criterion 3 Dominance in woodland profile (structure or strata)

This recognises that each form of tree occupies a stratum within their specific woodland profile (see text, fig 27). The foliage canopy of each form was considered to be the significant feature of each form. The relative position of each form within each of the four strata was recognised as (in ascending order): seedling, sapling, pole and canopy. In some cases the foliage canopy occupied more than one stratum as designated by their form. In these cases the highest strata occupied were recorded. The important point of the the profile classification was that the only empirical value used was the 2m height which conveniently corresponds to a rough head height. Each stratum is present relative to the other strata present. The Cn or canopy stratum consisted of all trees forming the highest point of the canopy of that woodland. However canopy trees could not be recorded as being lower in height than 2m. In most circumstances the canopy would be about 20m but varies considerably. The Po or pole stratum was recorded if there were trees with a foliage canopy beneath an upper canopy layer and above 2m. Saplings(or Sa)were recorded if there was a foliage canopy stratum below poles. If there were no poles saplings were recorded if the trees were below 2m in height. Saplings also had to be greater than 4 years old. Below the age of 4 years they were regarded as seedlings. Annual ring scars or destructive sampling were usually used to determine seedling age. Using the simple rules outlined differentiation could be made between four foliage strata and the structural profiles of woodlands could be compared without regard to detailes height measurements. Although this is an artificial differentiation, it effectively describes the actual structural condition of most West Suffolk woodland. Such structural differentiation is thought to depend largely on the consistency of management techniques.

Criterion 4 Age distribution

It has been suggested (see text p 30) that age distributions and structures based on the recording of empirical measurements, such as annual ring counting or girth-age relationships would be inappropriate to the needs of the survey. However, the classification used recognises the stages of growth of the tree rather than the more traditional measurements mentioned above. Such stages of growth have been used by foresters (Ovington 52). The categories of growth according to the morphological criteria were seedlings, oskars, saplings, poles and canopy. These are further divided by the strata criteria so that there might also be coppice saplings, coppice poles and coppice canopy. The position of oskars on the strata profile corresponds to that of saplings but recognises the morphological characteristics of oskars. To complete the definition of age structure, degenerating trees were also recorded. These had a variety of forms. It was also recognised that trees in some instances change their form as well as their size as they grow. This is particularly evident with sycamore trees. It has also been recognised that coppice stools represent a completely different stage of growth from non-managed trees, but that their regrowth could be equated to similar stages of growth in non-managed trees. Coppice trees also appear to have a different pattern of degeneration or progress to senescence from non-managed trees. Non-managed trees themselves may degenerate at different points in their growth cycle and in different ways or they may be cut down. The complete growth cycle of trees in West Suffolk woodland has been illustrated (see fig 18).

Fig 18 Growth Cycle of Trees in West Suffolk



Criterion 5 Practical Field Guide

The fifth criterion of the woodland classification was that a practical workable key with a suitable notation had to be devised to incorporate the various overlapping characteristics of the previous criteria. In order to sample successfully many woodlands, the classification had to be clearly represented so that quick recognition of the field categories could be achieved and recorded in the field.

Using the original morphological field sketches, diagrammatic representations of each morphological category were drafted (see text figs 19-28).The main morphological forms were abbreviated as follows -

Se	Seedling
Sa	Sapling
Os	Oskar
Po	Pole
CnSt	Canopy Standard
Co	Coppice
Pl	Pollard

This notation for managed forms also corresponds to the strata profile, Criterion 3. Coppice trees or pollard trees were then given a further two letter abbreviation according to their position on the strata profile (see fig 19 in text) -

SaCo	Coppice sapling
PoCo	Coppice pole
CnCo	Coppice canopy

Finally, a third abbreviation (De) to denote a degenerating tree was added where appropriate -

DeSa	Degenerate sapling
DePo	Degenerate pole
DeCn	Degenerate canopy
DeCo	Degenerate coppice
DeStu	Degenerate stump

The notations Bu for bush or Su for suckering tree were added but the trees were considered to be either poles, saplings or canopy standard trees.

Fig 19 Diagram illustrating the technique and notation used to record the profile of woodlands in the survey area

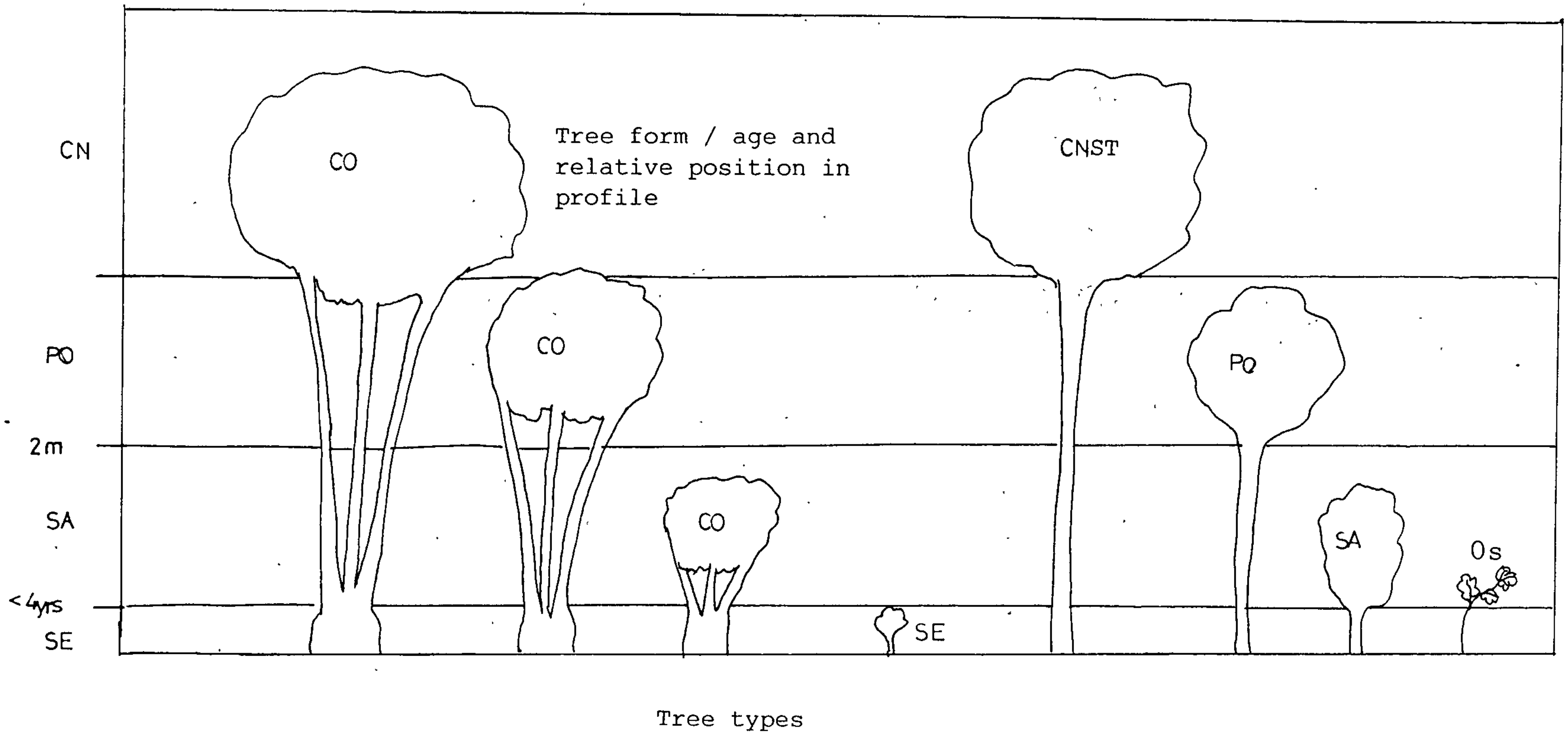


Fig 20 Diagram illustrating several different forms of seedlings of less than 4 years old

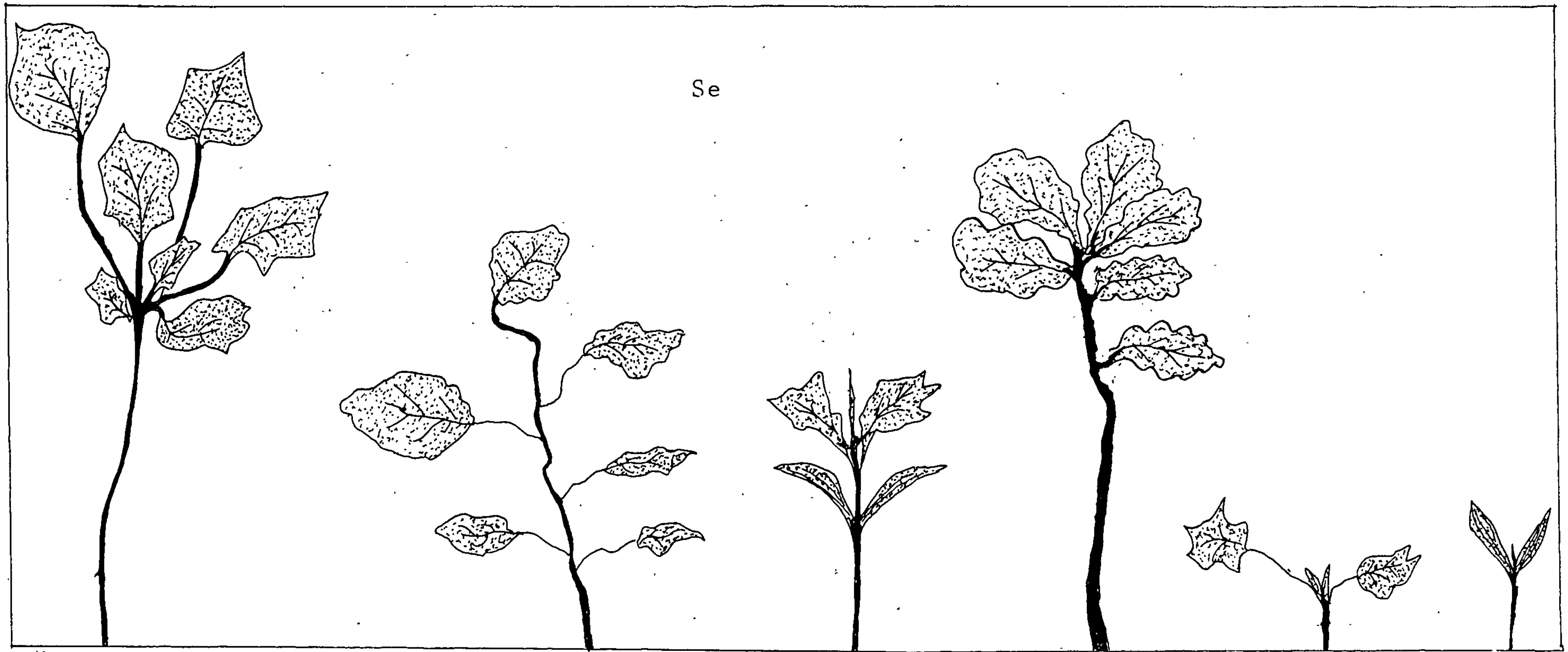


Fig 21 Diagram illustrating the comparison of the morphological forms of sycamore saplings and sycamore oskars - all trees below 2m in height

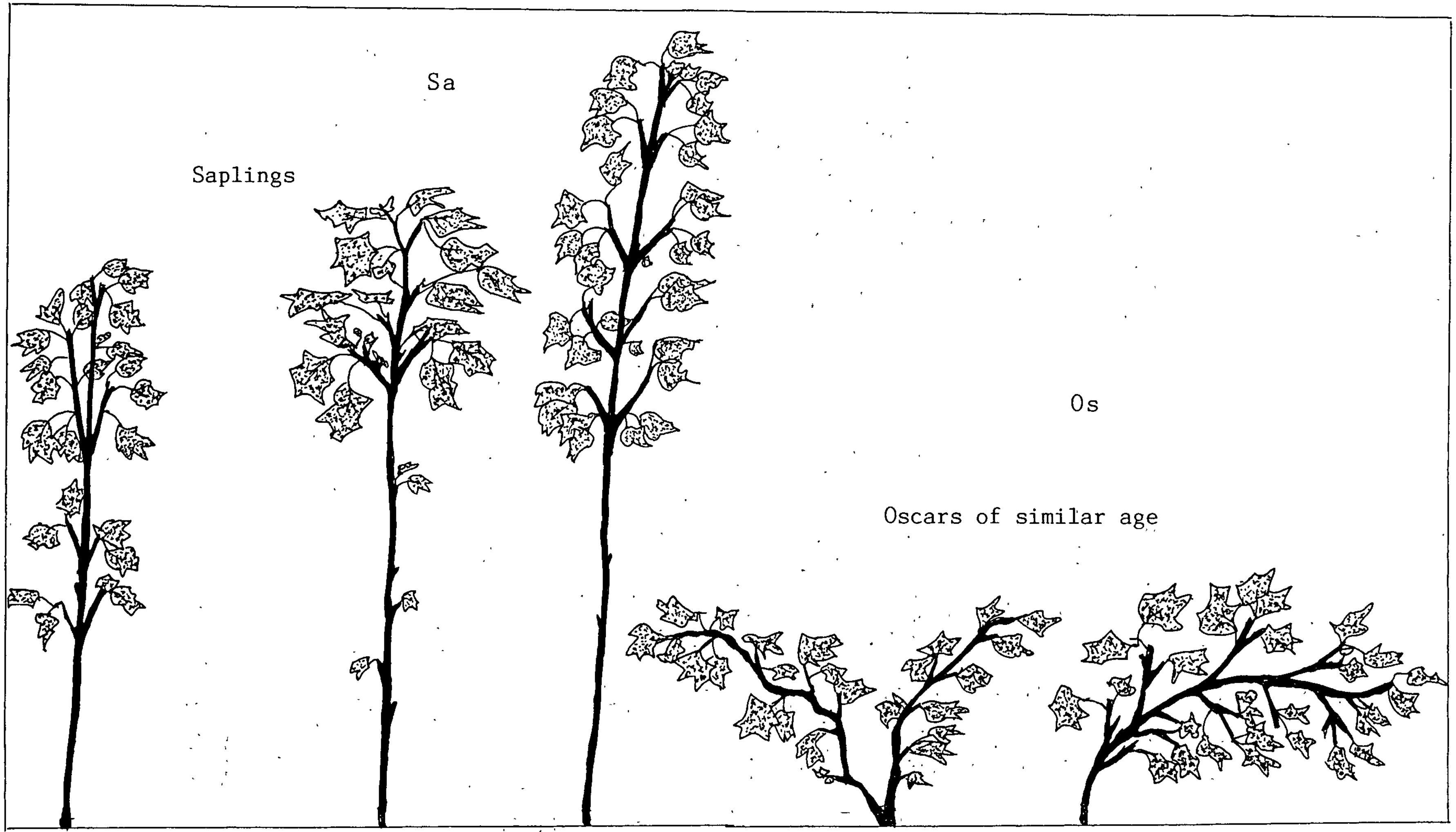


Fig 22 Diagram illustrating the growth of bush forms of tree in the survey area

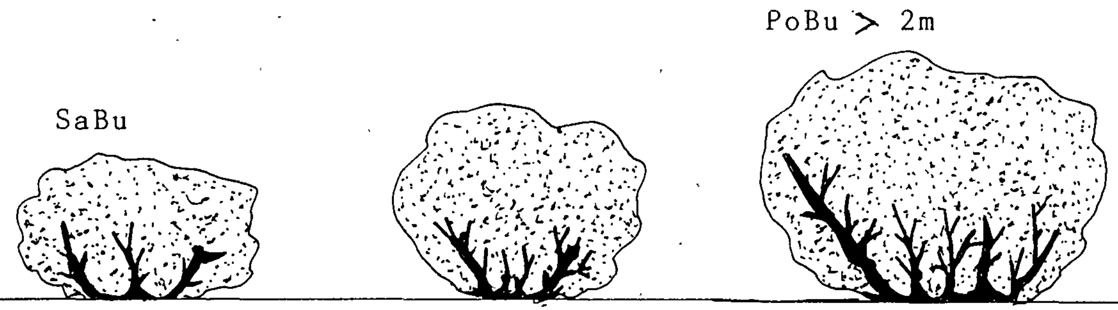


Fig 23 Diagram illustrating the morphological forms of oskars found in the survey area

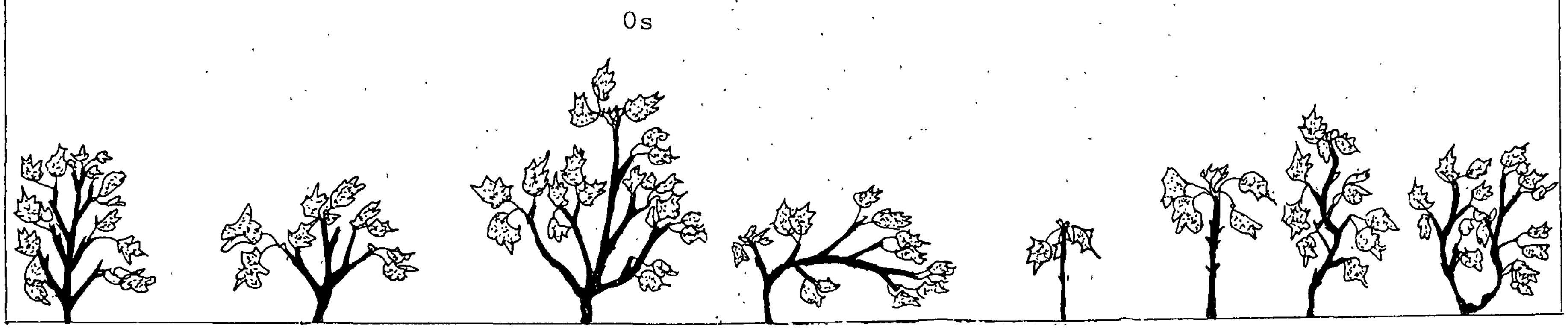


Fig 24 Diagram illustrating several different morphological forms of poles in the survey area - all trees above 2m in height

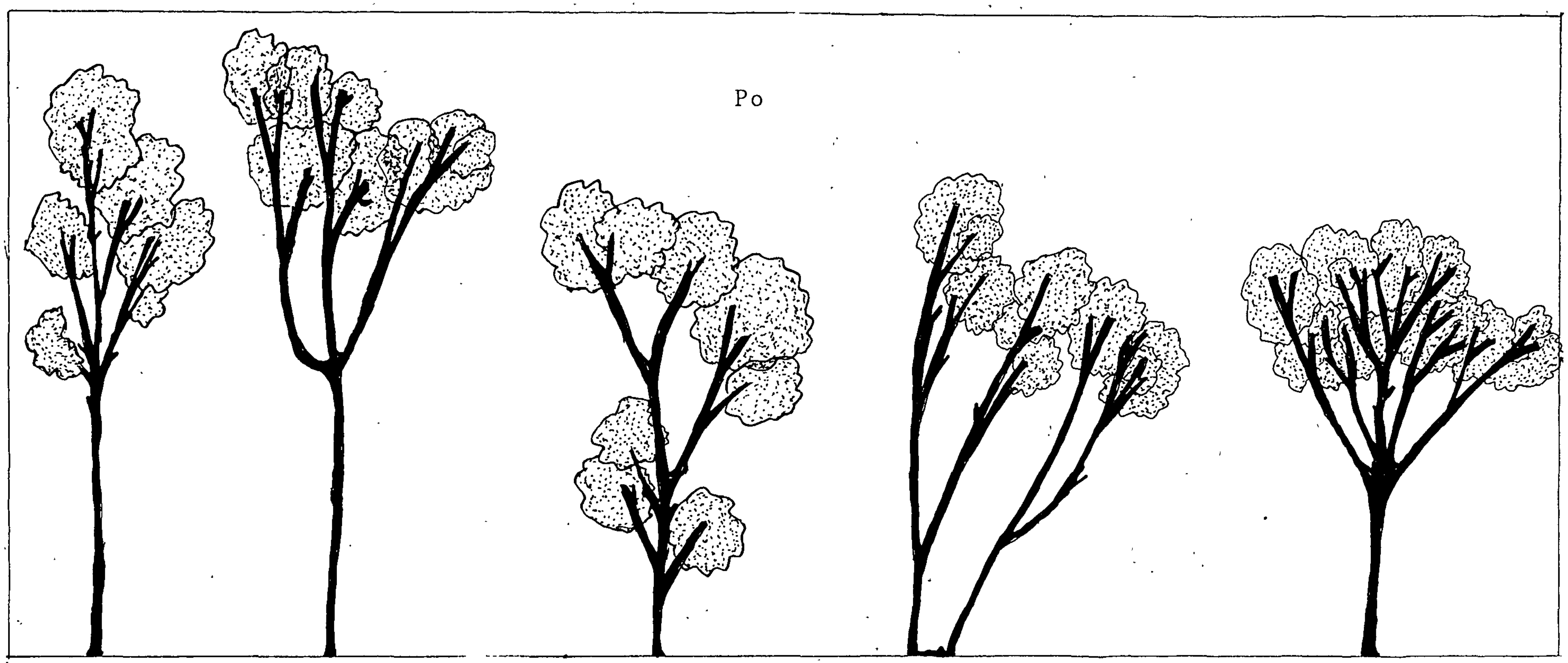


Fig 25 Diagram illustrating three typical morphological forms of canopy standard trees in the survey area

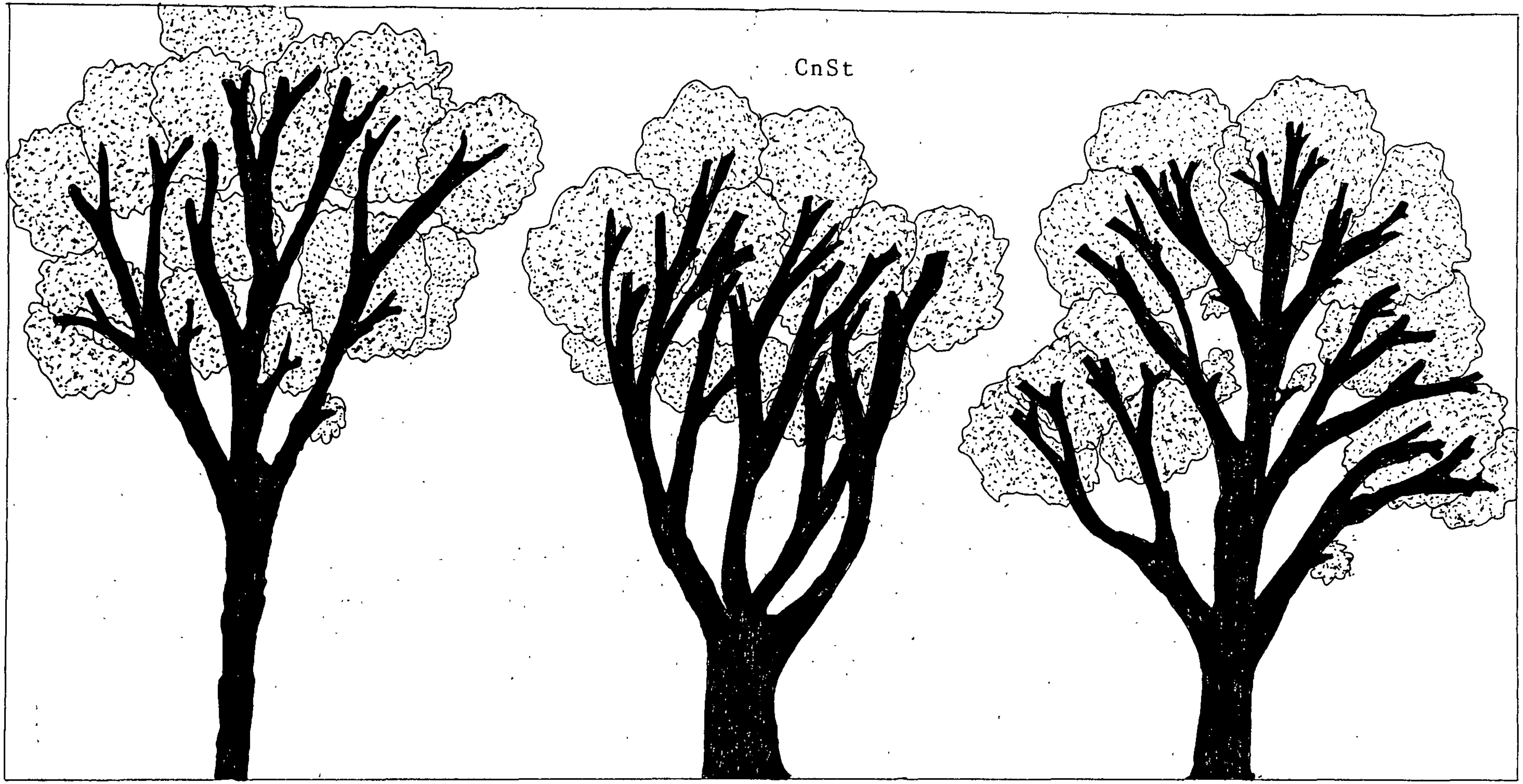


Fig 26 Diagram illustrating three common forms of ancient woodland coppice

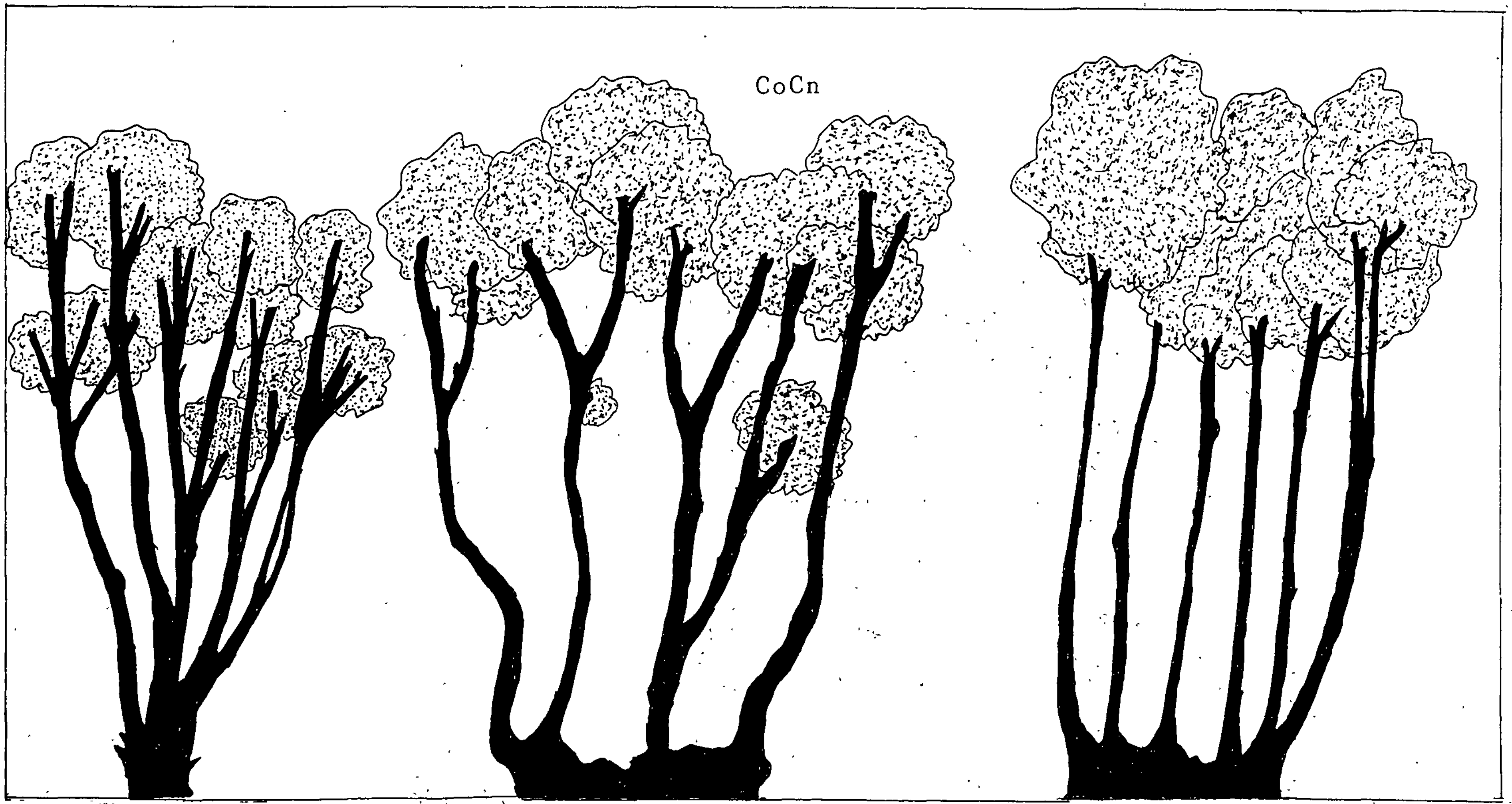


Fig 27 Diagram comparing the coppice canopy, coppice poles and coppice sapling forms of trees in the survey area

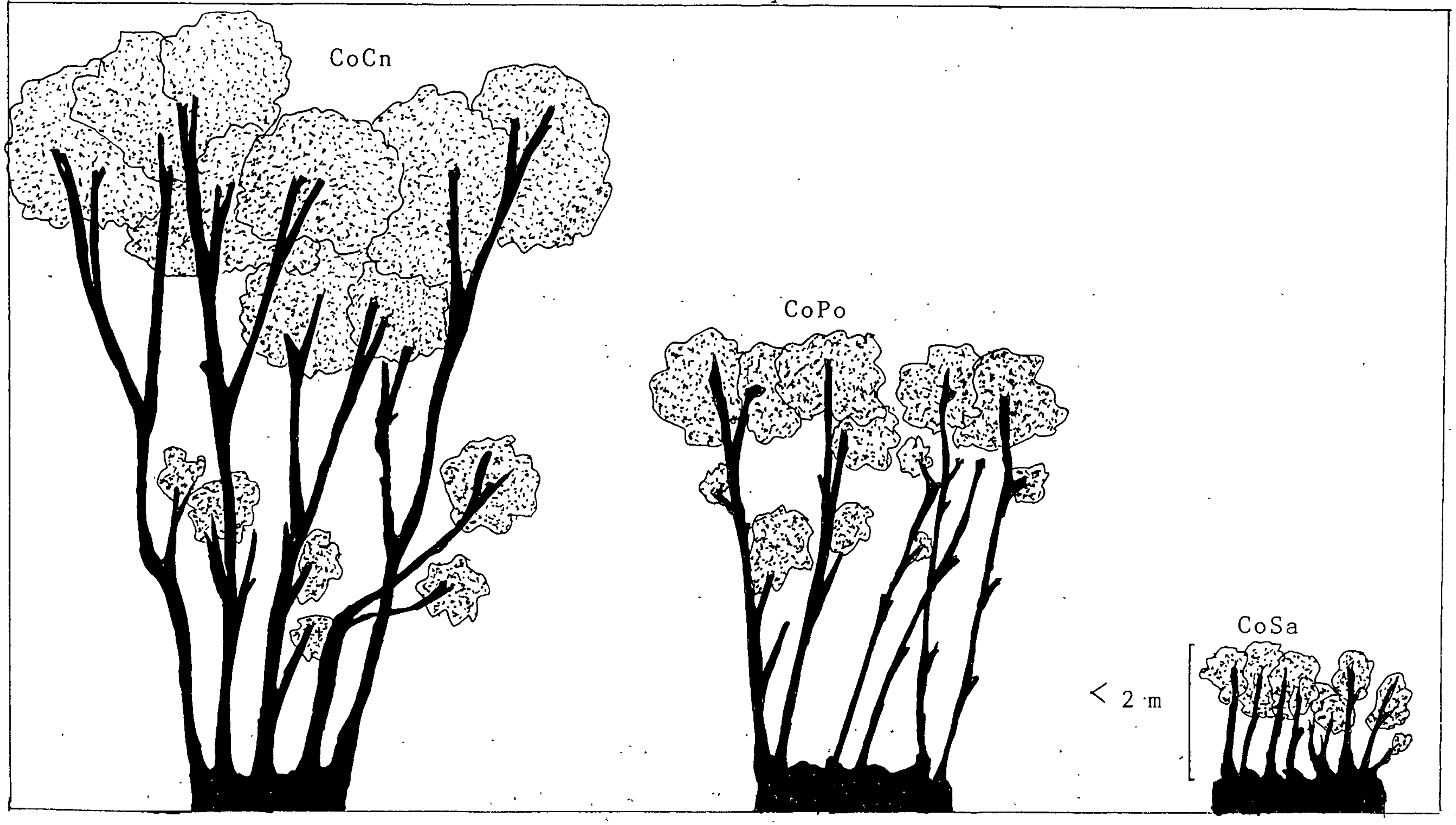


Fig 28

Diagram illustrating the formation of a degenerate coppice stool from an uncut coppice tree such as those found in some ancient woodlands in the survey area

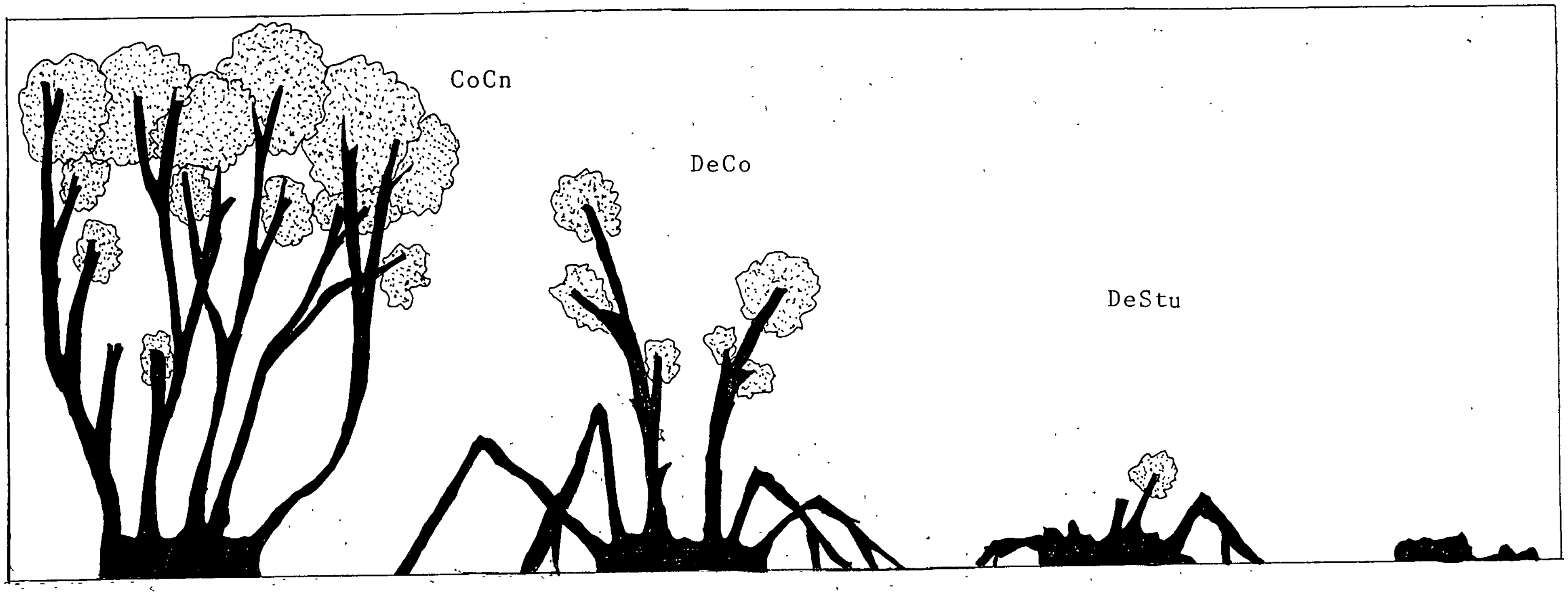


Fig 29 Diagram illustrating the degeneration of a typical secondary woodland canopy standard

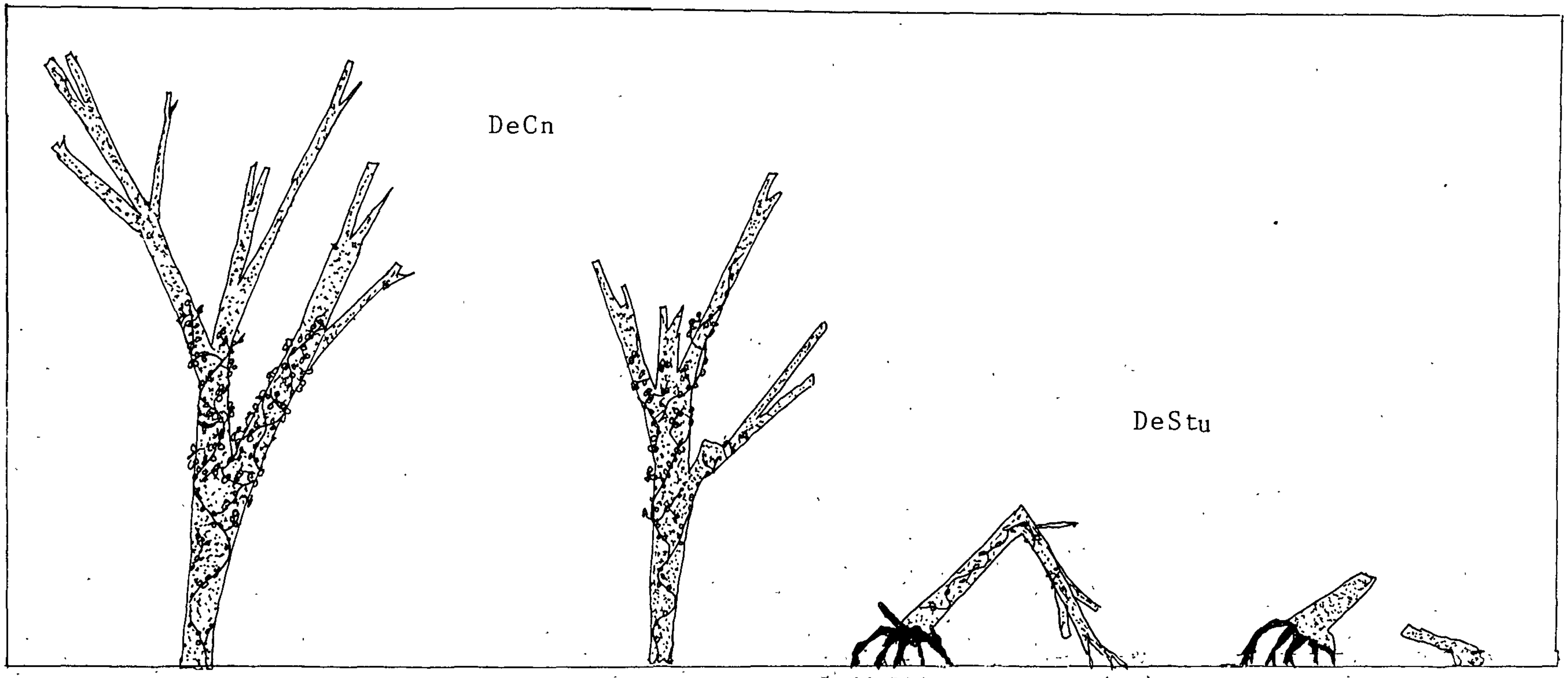


Table 2 The most common forms used as the basis of the general survey, Record Card 2 (see page 50)

DeStu	Degenerate stump
DeCo	Degenerate coppice
DeCn	Degenerate canopy
DePo	Degenerate pole
DeSa	Degenerate sapling
CnSt **or Cn**	Canopy **Standard**
CnCo	Coppice canopy
Po	Pole stage tree
PoCo	Pole coppice
Sa	Sapling
SaCo	Sapling coppice
Os	Oskar
Se	Seedling

<u>Method of General Survey of Woods in West Suffolk Area</u>

Once a workable classification of woodland tree, growth stages and morphological forms had been established and a criteria related classification of woodland management regimes had also been produced, it was possible to produce a plan for surveying all the woods within the survey area (see text, fig 35), or at least those for which access permission could be obtained. It was considered that sampling of woodlands would not have produced the detailed picture of sycamore dispersal ability required. Finding occurrences of sycamore invasion was considered to be the priority of the survey as it was planned to do a more detailed analysis of sycamore invasion demography at suitable sites. With this point in mind, two survey record cards (see text figs 30 , 31) were devised to abbreviate the information needed from the initial survey of each woodland. The classification of woodland types (see text table 1), the classification of ground flora types (see text page 267) and the Ordnance Survey 1:50,000 Map[51] for the area were used to help complete each survey card. Additional information and recordings were taken at each site where appropriate.

It was not always easy to gain permission to survey woods in the area. The main problem facing the surveyor were that many were woods used for rearing game birds for the sport of shooting (see text p. 186). Shooting takes place from September to December. The most inappropriate time for surveying was during this period but it was also suggested by landowners that the summer months, from May to September, were a time when game birds also fared better by having no disturbance. More disturbance, it was argued, would make it more difficult to 'flush the birds from their cover during the shooting season'. However permission was often gained when the nature of the survey was explained. The general survey had therefore to guarantee speed, (a two hour period in a wood was often the maximum time obtained for access) and simplicity in that habitat destruction or the transportation of equipment to a site would have most definitely been frowned upon by certain landowners.

A description of Record Sheet One

A record sheet of this type has been used by Rackham [64] but has been modified to meet the requirements of the survey. District, grid reference and Map Nos. were obtained from the O.S. map 1:50,000.The main districts were West Suffolk or Epping Forest. The names of the woods were either those used on the O.S. map[51] or were aliases of personal choosing (see map in text fig 35). The surveyor was the candidate with help from various assistants. The date and time in the wood were recorded at the time of the survey. The map was drawn from the Ordnance Survey map by eye and abbreviated or enlarged upon where appropriate to the survey. Generally,areas of sycamore invasion were plotted on the map either by pacing or by tape against reference points in the wood, for instance a woodland edge or a ride or a pond

Characteristics of the wood based on the classification of woodland types and the ground flora classification were also plotted on the map. Abrupt changes in the woodland species types or management practices were also recorded where obvious. Ancient woodland (see text fig 6) was often compartmentalised, being divided into specific species communities by rides. These features were drawn on the map.

Fig 30

Record Card One of general survey

Data for complete woodland

SPECIMEN RECORD SHEET ONE

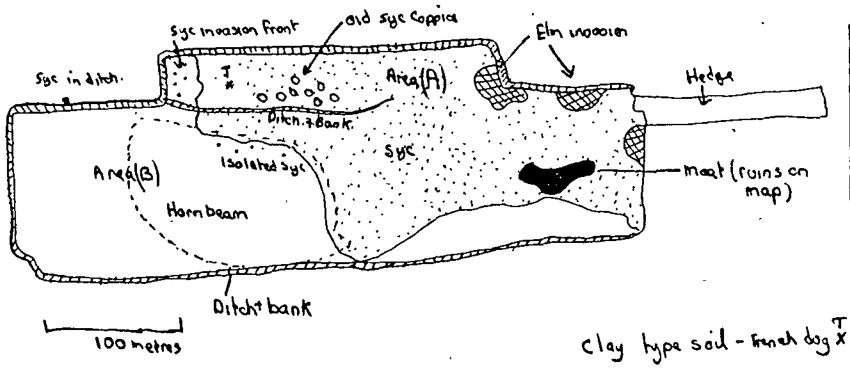
DISTRICT	GRID REF	MAP No	NAME OF WOOD	SURVEYOR	DATE	TIME IN WOOD
West suffolk	972678	155 O.S.	Stowlangtoft wood One	Neil	12·9·84	2hrs.

MAP

Wood type. Ancient

2. stand types. (A) has ino Hornbeam

completely enclosed by Arable land.



Clay type soil - French dog X

SITUATION	HILL TOP	PLATEAU	SLOPE 2.6°	SLOPE 76°	VALLEY BOTTOM	OTHER NOTES ON SITE
				✓		Close to group of Ancient woodlands.

RECENT		SPECIES	ANCIENT		SPECIES
Clear Felling			Coppice	✓	Syc, Ash, Hor, Elm F.map
Selective Felling			Standards		Ash, horn, R map Haz, Ald
Grubbing			Pollard		
Planting Native Deciduous			Earthworks	✓	evidence of Ancient compartments
Planting Exotic Deciduous			Ditch	✓	
Planting Sycamore			Ride	✓	
Pollarding					
Coppicing	✓	Syc, Haz			
Game	✓	managed for game			
Planting Conifers					
Sycamore Invasion	✓				
Other Natural Regen.		Syc, Ash.			
Other Features					

Ground Flora	Open	Closed	O/C	Type
		✓	✓	8B 1B 1A 2A

Other Notes.

unusual presence of old coppice sycamore possibly linked to ruins and moat. Sycamore. some sycamore fairly recently coppiced, many Bryophytes on stool. presence of Hornbeam also relatively unusual.!

Fig 31

Record Card Two, record of stand tree community structure

NAME OF WOOD	Stowlangtoft wood One	MAP REF. 972678	STAND A

ESTIMATE BY % OF RELATIVE SPECIES PROPORTION OF EACH CLASS PRESENT THROUGHOUT SAMPLE STAND

TREE SPECIES	DEGENERATE STUMPS	DEGENERATE COPPICE	DEGENERATE CANOPY	DEGENERATE POLE	DEGENERATE SAPLING	CANOPY STANDARD	CANOPY COPPICE	POLE	POLE COPPICE	SAPLING	SAPLING COPPICE	OSKAR	SEEDLINGS	SPECIES SPECIFIC NOTES
OAK													25	
ASH		90				50	35			100			75	Some clumping of seedlings - v old stools - with many bryophyte
HAZEL														
FIELD MAPLE							25							
SYCAMORE		10				50	35	80				100		
HORNBEAM														
ELM				100				20						some elm regenerating from Po
HAWTHORN														
ELDER														
BIRCH														
ALDER							5							Isolated occurrence
PINE														
HOLLY														
WILLOW														
SWEET CHESTNUT														
NORWAY MAPLE														
BEECH														

ESTIMATE % AREA SYCAMORE	Rough 20% of woodland with sycamore cover.	Distinct invasion fronts. present	NOTES ON INVASION	Elm invasions also frequent.
OTHER NOTES i.e. Ground flora	Invasion appears to be progressing from the moat end of the wood. Broad belt + pinpoint invasions – worth mapping! Considerable number of very ancient degenerating Ash coppice stools. Distribution of tree species not as consistent as might be expected A lot of Ash standards in clumps. Seedlings of Ash sometimes had clumped distribution but at other times evenly spread			
EfC type 8B1B Dense relatively unbroken mats of cover. of a Closed Type.				

The recording of clear felling, selective felling, grubbing, planting native deciduous, planting exotic deciduous, planting sycamore, pollarding, coppicing, game management, planting conifers, sycamore invasion and other natural regeneration were recorded as present or absent according to the species concerned with each treatment. Game management was recorded as present or absent. The presence of coppice with standards, pollards, earthworks, ditches and rides were recorded as present or absent and these features were divided from those previously mentioned. They were labelled as characteristics of ancient woodland as opposed to recent management characteristics. The two categories, ancient,on the right of the record sheet and recent,on the left,were not considered to be mutually exclusive, given the great variety of management traditions and changes in management regimes within individual woodlands.

The presence of ground flora according to the ground flora vegetation key (see text, fig 204) was recorded and other notes often, although not always, consisted of further notes on the identified ground flora present at each site. A detailed floral list at each site would not have been required. The intention was to look at woodlands on the basis of their tree species communities rather than tree ground flora associations as in the Institute of Terrestrial Ecology's woodland classification, Bunce's[5] or Peterken's[59] woodland ground flora associations. It was also considered that the demography of woodland ground flora and its morphological structure might bear a clear relation to woodland regeneration and sycamore invasion. The woodland flora classification itself took some considerable number of preliminary site visits to produce, although it was added to throughout the general survey. Indeed, the complete record card system (see text figs 30 and 31) and woodland and tree classifications (see text,Table 1 and figs 6 - 29) were designed to have some inherent flexibility to allow for new features to be included. The inclusion of a record of the topographical situation of each woodland was considered initially to be important to test Rackham's[64] suggestion that sycamore is a predominantly valley wood species.

The research was initially intended to include a record of edaphic conditions at each of the sites in the general survey, in order to correlate, particularly, the demography of sycamore to soil conditions. Whilst the thesis still does not ignore that soil conditions may be an important limiting factor to sycamore distribution, it was, after consideration of the following points, excluded from the general survey :

1. Soil conditions in a single wood are extremely variable (Rackham [64]) and therefore need a considerable number of samples to be taken at each site.
2. Several different soil parameters would be needed to provide an accurate description of soil types. Helliwell [29] considers phosphorus to be important; Jones [35] and Helliwell [30] suggest ph ; Piggott [61] suggests soil moisture; Rackham [64] proposes nitrogen, potassium, iron salts;and litter depth,(Linehart and Whelan [37]) might also be important.
3. Soil conditions in relation to sycamore germination are being studied by Piggott [61] et al. at the University of Lancaster.
4. Soil conditions might not be as important to the working conservationist as an understanding of the relationship of woodland management to tree species success.
5. These factors would prohibit the sample size of the investigation and reduce the size of the survey area.
6. It was obvious from preliminary observations that sycamore had a very cosmopolitan distribution.
7. Some evidence of soil distribution within the West Suffolk area was available from the O.S. general soil survey [87] and from the presence of different ground cover forms known to be indicators of soil conditions, *Urtica dioica*, nettle, a phosphorus indicator species,for example. Where possible trenches were dug and soil samples taken to confirm the O.S. [87] soil geography, particularly the difference between sandy and clay-loam soils.
8. Management conditions and the historic situation of a wood also suggested differences in soil conditions. For instance there might be differences between ancient woodland

and coniferous woodland according to the chemical breakdown of their leaf litters. Abandoned arable land now covered by woodland may have a higher soil nutrient status than ancient woodland due to N.P.K. fertilizers. Therefore some account of soil conditions could be made by inferences gained from other data.

The research also intended to review climatic conditions within woodlands in the general survey. Again, some of the points that excluded a detailed soil analysis from the general survey are also applicable to climatic conditions and,again,it must be remembered that an unlimited amount of time in each wood was not available. However, there were some specific climatic conditions that were of interest, namely, light conditions and their relation to woodland regeneration and wind conditions within woodlands. Ground flora demography may give some relevant information concerning light conditions within woodlands as can the recording of woodland strata, but of course, this would not be conclusive evidence of direct relationships between light and regenerative conditions. It would have been desirable but time consuming to correlate light conditions using empirical values, rather than relative ones, to such factors as the management form (see text Table 1) of a wood or the species present in different woods. Considering this, records of light conditions were made at specific woods, where a clear sycamore invasive front was found. These were relative to the light conditions on the day of recording. Wind recordings were also made in conjunction with the light recordings. Wind was considered to be important because sycamore is considered to be a wind dispersed tree species. A detailed account of the methodology of these recordings is included in the text (page 253). Climatic conditions are also referred to on a wider historic and geographic basis at other times in the text (see pages 305-318). Some data has been presented for the West Suffolk area as a whole gained from Honington R.A.F. Meteorological Station.

The significance of the data recorded on data sheet one

The results obtained from Record Sheet One were therefore specifically aimed at :

1. Locating sycamore and its approximate distribution in woodlands.
2. Plotting woodland types according to management regimes.
3. Giving a detailed description of the historic (recent and past) management of a woodland.
4. Recording the dominant ground flora types in woodlands in the West Suffolk area.

The data for individual woods could later be used to produce an account of the dispersal ability of sycamore throughout the West Suffolk area and the demographic expansion of its population. This would be supported by records made of sycamore introductions to the survey area and also by investigations of hedges, settlement areas and parkland sites. Some comparison between the population expansion of sycamore and other exotic species could also be made from the data from Record Sheet One. A more detailed account of the data analysis used to extract (from Record Sheet One) information relevant to the conservationist is given later in the text.

The use of Record Sheet One

No sampling of woods was undertaken when using Record Sheet One. All woods, or at least all woods where access was available, in practice about 80% of all woods in the survey, were surveyed, again, so that as much sycamore as possible could be found, but also for a number of other reasons :

1. So that the chances of finding woods with invasion 'fronts' could be located.
2. Sampling would have excluded many woods of particular interest and where valuable details, such as recent management history, were available.
3. The variable size of West Suffolk woodland, its variable management regimes within woodlands and the highly variable distribution of woodland cover throughout the survey area would have made it difficult to produce a meaningful or

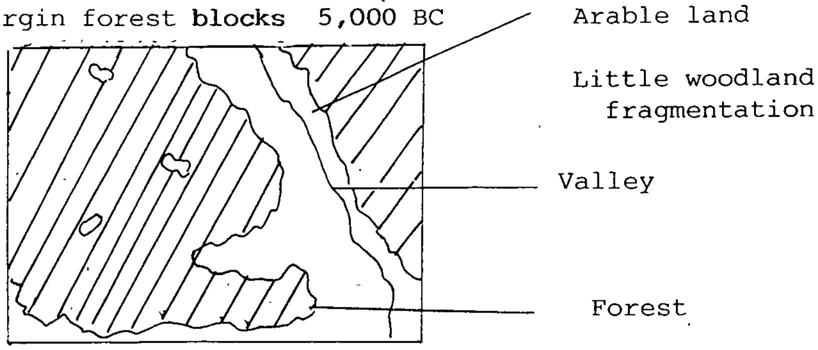
useful sample size or sample locating procedure.

4. The data gained from the investigation of all woodland could in itself be sampled randomly at a later date if required.
5. The overall commitment to assessing the competitive status suggested to the author that the woodland of West Suffolk should be treated as a community in itself. Woodland fragmentation and anthropogenic management of the land has reduced woodland cover considerably. However, the seed dispersal of trees between woodlands is still possible. Therefore the author suggests that competitive status of native species within the woodlands in the Suffolk area should be related to sycamore as if the individual woodlands of the area were closely related biologically if not geographically. A considerable amount of woodland fragmentation has been comparatively recent (Rackham [64]) - up to 30% of woodland has been lost since 1945. It must be remembered that it is anthropogenic influence that reduces the ability of tree species to assume demographic distributions based solely on their competitive abilities under natural environmental conditions. The species demography within existing ancient woodland may give some record of the distribution of species prior to large scale woodland management or fragmentation. Therefore it was considered useful to include as much ancient woodland as possible within the survey. Ideally it would have been even more useful to find areas of primary woodland that have been totally unmanaged, see fig 32.

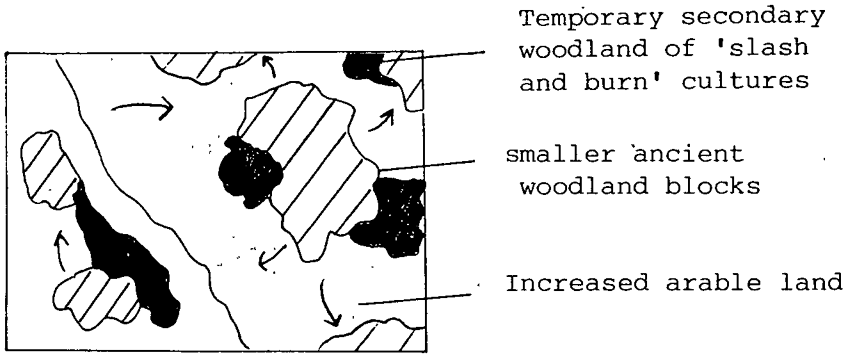
For some of the reasons outlined above, it was also decided that individual woods would not be sampled but as much as possible of a wood be taken into consideration when completing the record sheet. However, it was thought that some degree of standardisation would be a useful reference point for the surveyor and would be likely to yield more accurate results.

Fig 32 4 Maps illustrating a possible model of the historic fragmentation of large woodland blocks to form smaller woodland units (⤳ = seed dispersals)

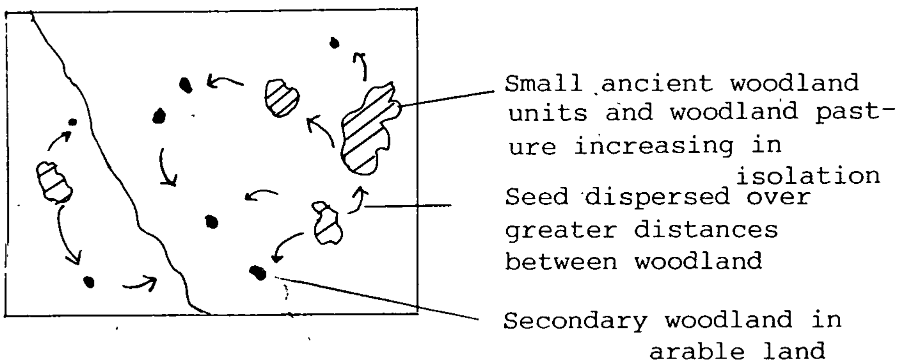
1. Large virgin forest blocks 5,000 BC



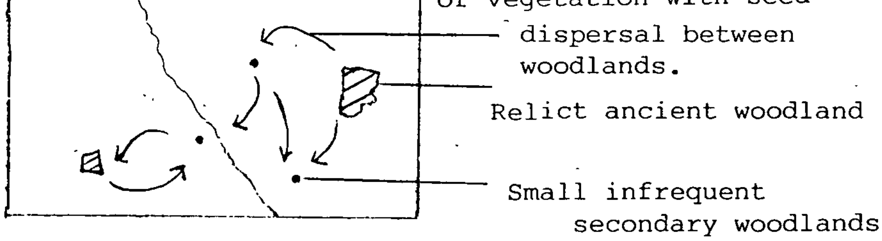
2. Large prehistoric woodland blocks 3,000 BC - 500 AD



3. Woodland blocks felled for arable land - dispersal of woodland trees between woods 500 AD - 1900 AD



4. 19th and 20th century increased woodland destruction Although now more isolated, woodlands should still be considered as a community of vegetation with seed dispersal between woodlands.



Observations made from a standard route

A standard walk was made to fill in details for Record Sheet One. It consisted of walking the complete perimeter of a wood (Route A - see fig 33) then walking along a line following the longest straight route from perimeter to perimeter (Route B - see fig 33). This would usually bisect the centre of the woods. It was difficult in large woods to follow this line exactly, however a compass was used to help. It was considered that most tree species and tree forms could be recognised from a distance of about 20m, except seedlings which could be seen up to 5m, within a wood, so that for many of the smaller woodlands the pattern of the walk enabled them to be completely surveyed. At the very least, it could be seen whether sycamore had invaded either the edge of the woodland or the centre of the woodland. From preliminary investigation it was apparent that sycamore invasions seemed to begin at some point on the edge of a woodland. However, without the walk following the line through the wood, some important discoveries of sycamore invasion would not have been found, for example Stowlangtoft Wood (1) see text, fig 35. If a sycamore invasion was found there, the surveyor also attempted to follow a walk line tracing the outer edge of the canopy of the invasion (Route C, see fig 33). Some searching of the area beyond the obvious invasion point was made to discover isolated invasive sycamores (Routes D - see fig 33). In certain circumstances the lines of walks had to be modified to take into account lack of access or the peculiar shape of a wood. On other occasions considerably more walking and searching was undertaken to fill in extra details for Record Sheet One.

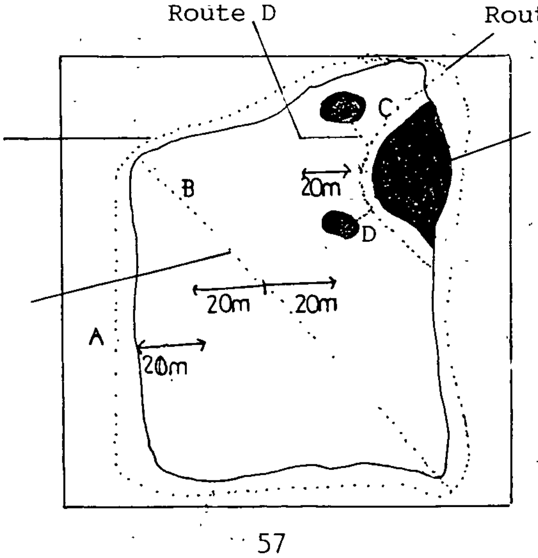
Fig 33

Route D

Route C

Route A

Route B



Key

route walked

sycamore invasion

Map illustrating the routes walked to complete Record Card 1 suggesting a visual range of 20m within woodland canopy. The area illustrated represents a complete woodland.

It was originally intended to spend a standard time in an individual wood. This became impractical due to the considerable variations in size of woods and their accessibility. Generally the walks took from between twenty minutes and three hours to complete, walking at a slow speed.

Each element of Record Sheet One was filled in as it was observed, the sheet forming a checklist. There is a more detailed account of the ground flora tabulation in the text (see text page 266).

Description of Record Sheet Two

Record Sheet Two is initially a simple grid on the vertical axis where all the common tree species found in the survey area, from preliminary investigation (and added to during the general survey) are listed. On the horizontal axis the subdivisions of tree types are found. These are illustrated in the text, (fig 31) and their origination explained (see text, page 36). The aim of the record sheet was to gain a representative estimate of the species diversity of trees in each category so that a generalised profile of the wood could be drawn from the data. A profile illustration could have been used but they are time consuming to complete and it is difficult to record the exact details of each species and each class of tree. In some cases, illustrations were made of specific woodland profiles or parts of them.

The system of recording was designed so as to produce the description of a woodland that would be of most value to a working conservationist. The thesis addresses itself to the task of assessing the conservational implications of sycamore invasion. Therefore, statistically sound age structure distributions based on empirical age values were thought to be inappropriate. The method used in Record Sheet Two was designed to give a workable estimate of species diversity and species abundance. A recording of any percentage in any box on the grid would mark that the tree in the form suggested occurred in any single wood. As it was intended to record sycamore as being present in a wood, from a walk designed specifically to find sycamore (round the perimeter), it was also thought appropriate to record as many occurrences of other species as possible. In this way a more accurate assessment of the status of sycamore could be made.

The routes of the standard walks devised for Record Sheet One were considered to be useful transect lines for acquiring the data for presence or absence of sycamore in a wood which contained only one dominant stand type. (Stand type - a stand of trees was considered to be an unbroken community of trees of a similar species.) Large single woods were sometimes subdivided by paths or rides, (see fig 6). Where woodland subdivisions were made, a similar route pattern as used for Record Card One was employed for each compartment (see figs 33 and 34). It would have been sufficient for most of the data analysis of the thesis merely to walk the routes at an even slow pace recording as presence or as absence on the grid all the species types observed within the 20m vision depth suggested (see text p.57), producing a time effecient method of standardising the results for different size stands. A set period of observation time would have improved standardization, as in Rackham,[64] but was difficult to achieve. A further walk along a line at right angles to the woodland perimeter, at the site of a sycamore invasion, was also undertaken to make sure that all trees were recorded from a wood that came in direct demographic contact with a sycamore invasion (see fig 34 Route E).

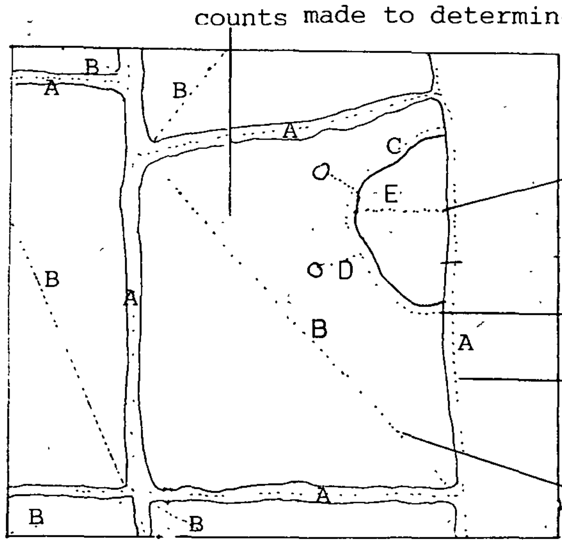


Fig 34

Diagrammatic map illustrating the routes walked to complete Record Cards 2 for a woodland with stand subdivisions, i.e. Langham Hills Wood.

Since recordings were being made of presence and absence of species types and forms, using Record Card 2 (fig 31), it seemed that to produce an abundance estimate of each presence or absence recording could also be made.

However, to do this in the time allowed and on the scale needed caused considerable problems for it was the main aim to sample a large number of woods using the simple presence or absence criteria. Obviously sampling of tree numbers or tree cover would be necessary. The problems with using a quadrat sampling method include :

1. the size of quadrat considering the vastly different scale of densities for different species forms, for instance, there could be 250 times more seedlings than coppice in a $1 m^2$ quadrat.

2. the size of quadrat to use considering the different difficulties in finding species forms, particularly locating seedlings in dense ground cover.

3. the number of quadrats to use considering the variability of woodland types and their species demographies and the sampling system, a random or systematic technique, that should be used. A coniferous plantation could be accurately described by one randomly placed $5m^2$ quadrat, whereas a secondary woodland might need 10 x $5m^2$ quadrats due to the greater variability of its species composition.

4. the size and number of quadrats to be used considering the variability in size of all woodlands.

5. the standardisation of method for each wood.

In the light of these problems it was considered that a simple technique for assessing species form abundances for use in the general survey be adopted that could be included with the presence, absence recordings of Record Card Two.

The aim of the abundance estimates was to produce an approximate estimate of the differences in proportion by number of individual tree forms. The use of the common different forms, thirteen of which were initially listed as a check list on Record Sheet Two, made it possible to reduce the number of chances of two species occurring under any one form. In practice, up to five species were recorded in a particular category but often only one or two. Therefore, recording presence or absence was relatively easy and was undertaken from observing trees whilst walking the lines A – E. The proportions of trees in each category were estimated by observations along routes A-E fig 34 suggesting proportions of species by percentage. The estimate was made of the woodland seen throughout the length of the walks. The proportions of each species were obtained by estimating the proportions of each species within the visual distance of the routes and recording these proportions as percentages. Where one tree form was the only form represented by one species, it was recorded as 100%. If two species were recorded with the same form, the proportion was estimated by the surveyor stopping and counting the trees at a point where the two species forms occurred together in their typical distribution. Generally the visual distance meant that relatively few trees, from 1-50 trees, were counted to produce an estimate of the two proportions, for example, 50% oak canopy to 50% ash canopy. The same procedure was used for estimating more than two species of the same form. Problems were greater when similar forms but different species occurred separately as distinct populations with no demographic overlap. In these cases, which were,on the whole, rare,the relative densities and the area occupied by the tree species had to be taken into account.

The limits to accuracy of this subjective method of assessing abundance were recognised. Therefore the results were only to be used where they were helpful to the specific analysis of a particular wood. They also often helped to give a more complete description of a generalised woodland stand profile. The matrices obtained from these estimates were often useful indicators of specific woodland management regimes and gave some impression of species dominance at individual sites. However, the aim of the general survey was not to use these estimates for assessing the status of sycamore within the complete West Suffolk woodland community. For this reason the presence or absence of different tree forms were the commonly used criteria. Some more accurate studies of the species structure of particularly interesting woods was made at a later stage from the analysis of the data contained in the general survey Record Sheets One and Two.

The information gained from analysing the data recorded in this general survey is produced later (in the text) where an outline is given in more detail of the specific aims of each recording of data.

They are discussed under individual sections where reference is being made to a particular aspect of sycamore ecology thought to be relevant to the conservationist.

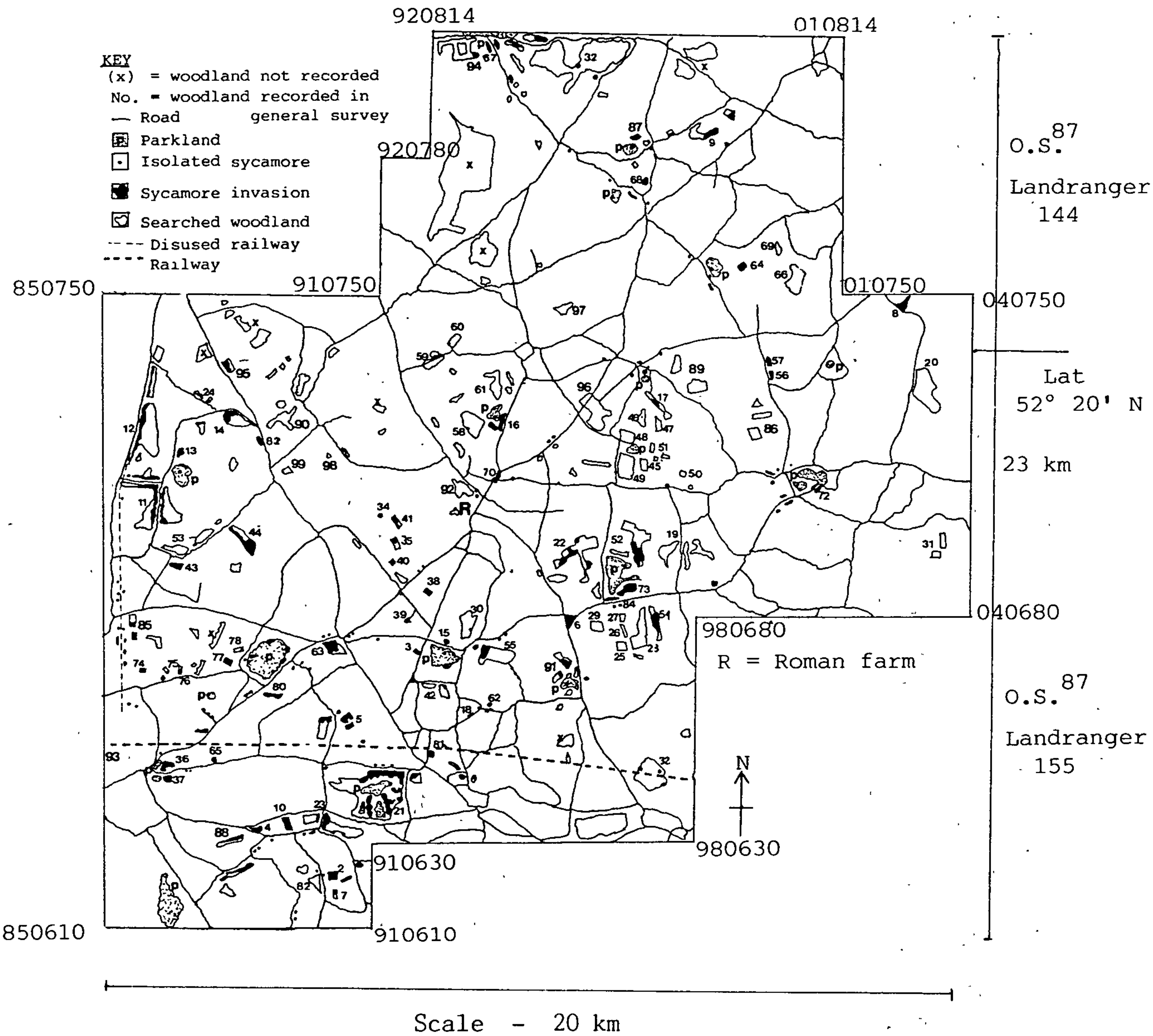


Fig 35 Map illustrating the woods and parkland recorded in the general survey area - a numbered wood, in some cases, denotes more than one wood or more than one stand in a particular wood

Table 3 Site List % area of stands within woodland

Wood No	Name of Wood	No. of stands	Anc	Sec	Con	Dec	Map Ref.
1	Fornham Wood		10	90			844677 A
2	Rougham Plantation		5		60	35	901623 A
3	Thurston Sewage Copse		100				919669 A
4	Rougham A45 Copse		100				886634 A
5	East Barton Copse			90		10	905658 A
6	Stowlangtoft Spinney			90		10	953678 A
7	Rougham Green Copse		100				902618 A
8	Calke Wood	3	50		25	25	023748 B
9	Market Weston Fen			100			980786 B
10	Gorse Wood Rougham			50	50		892635 A
11	Ampton Field Wood	3			80	20	864708 A
12	Folly Grove			50	50		860720 A
13	Ampton Common Copse			90		10	867716 A
14	Sansoms Plantation	3			100		872720 A
15	Pakenham Pit			95		5	925674 A
16	Bardwell Plantation					100	938722 A
17	Grundle Wood	2	40	60			972728 A
18	Thurston Green Farm Pit			100			932658 A
19	Langham Wood		100				975695 A
20	Westhall Wood		100				026750 B
21	Mill Heath				80	20	916652 A
22	Fish's Heath	3	90			10	953694 A
23	Rougham Nursery	2	20		80		902634 A
24	Brand Spinney			100			873728 A
25	Stowlangtoft Copse (1)		100				968672 A
26	Stowlangtoft Copse (2)		100				964878 A
27	Stowlangtoft Copse (3)		100				964673 A
28	Stowlangtoft Woods (2)		100				968675 A
29	Stocking's Wood			100			958678 A
30	Pakenham Fen		30			70	928677 A
31	Shrubbery Farm Copses		100				032694 A
32	Knettishall Heath	17	40	20	40		955804 B
33	Norton Wood	3	100				970645 A
34	Game Close Copse			100			913707 A
35	Great Queach		100				914695 A
36	Moreton Hall Wood (1)		100				869648 A
37	Moreton Hall Wood (2)			100			869644 A
38	Ixworth Copse			50	50		922685 A
39	Ixworth Pit			100			917079 A
40	Queach Farm Copse			100			913692 A
41	Game Close Covert		100				914706 A
42	Netherhall Woods		70		20	10	924664 A
43	Timworth Covert		10	10	80		868692 A
44	Timworth Hall Covert	3	40		60		883697 A
45	Ash Grove		100				971713 A
46	Sleight House Wood		100				967723 A
47	Shepherd's Grove		100				972722 A
48	Dove House Wood		100				964718 A
49	Wyken Wood		85	10	5		965716 A
50	Mulley's Grove		95		5		978712 A

Table 3 (Contd) Site List % area of stands within woodland

Wood No	Name of Wood	No. of Stands	Anc.	Sec	Con	Dec	Map Ref.
51	Ash Copses		10	90			972715 A
52	Langham Hills	10	90		5	5	965695 A
53	Timworth Green Covert				100		867694 A
54	Stowlangtoft Woods (1)		100				972678 A
55	Pakenham Wood	3	60		40		936672 A
56	Sumner Road Copse (1)		90			10	994732 A
57	Sumner Road Copse (2)		100				994735 A
58	Bangrove Wood	3	100				932723 A
59	Ixworth Thorpe Copse A			100			936924 A
59	Ixworth Thorpe Copse B			100			921735 A
60	Thorpe Carr		70	25		5	926739 A
61	Great Carr		60			40	928740 A
62	Thurston Bayer Copse		100				935631 A
63	Great Barton Wood	3	10	80		10	901677 A
64	Wytchingham Plantation			70		30	987757 A
65	Moreton Hall Copse		100				877649 A
66	Brockley Wood		50		50		000754 B
67	Rushford Hall Woods	3		10	30	60	928812 B
68	Barningham Copse					100	968775 B
69	Ivy Nook Copse		100				966760 B
70	Ixworth School Pit			100			937709 A
71	West Stow Forest Sect.				100		805710 A
72	Walsham Copse		100				000705 A
73	Stowlangtoft Park Wood					100	965695 A
74	Hollow Road Copse (1)		100				860668 A
75	Hollow Road Copse (2)		100				865665 A
76	Colton Copse		100				872669 A
77	Great Barton Copse (1)		100				879670 A
78	Great Barton Copse (2)		95			5	882674 A
79	Bradfield Woods		100				930575 A
80	Gt Barton Bury Rd Copse			100			888673 A
81	Thurston School Copse			100			918649 A
82	Eastlow Hill Wood		90		10		898622 A
83	Virginia's Copse			100			884720 A
84	Stowlangtoft St. Copse			50		50	965683 A

Additional sites not included in the woodland general survey data sample

85	Brick Kiln Plantation	3			100		858678 A
86	Walsham Aerodrome Wds.	3	80		20		994720 A
87	Coney Weston Hall	3		50	50		909783 B
88	Broom Plantation					100	880630 A
89	Upthorpe Copses		100				976730 B
90	Slades Covert	2				100	890721 B
91	Little Haugh Fm Copse	3	100				954668 A
92	Ixworth Priory Plnt.					100	928708 B
93	Tayfen Road			100			850650 A
94	Spaldings Hill			50	25	25	937807 B
95	Brand Copse				80	20	878734 B

Table 3 (Contd) Site List % area of stands within woodland

Wood No	Name of Wood	No. of Stands	Anc	Sec	Con	Dec	Map Ref.
96	Kiln Wood		100				958225 B
97	Stanton Chair		100				950747 B
98	Troston Hall Copse			100			900715 B
99	Joh's Plantation					100	892712 B

A = Ordnance Survey Map 155 Land Ranger Series 1:50,000

B = Ordnance Survey Map 144 Land Ranger Series 1:50,000

The woodlands recorded in the Site List are illustrated in Table 3, in which the column headed 'No. of Stands' denotes the number of stands recorded for the purpose of the general survey. More than one stand was recorded at a particular woodland site because, either more than one distinct wood (woodland separated by a small area of non-woodland) or more than one distinct tree community or management regime was present. In some cases, small sub-areas of woodland not in management character with the majority of the particular wood were not included in the general survey analysis.

The following section includes the headed tables of data obtained from the general survey.

Table 4 Table illustrating the estimated % area invaded by sycamore, the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for ancient woodland with sycamore)

Woodland List	Estimated % area sycamore					Species regeneration	Ground flora	
	<1	1-25	26-50	51-75	76-100	Seedling	Cover	Type
Colton Copse					x	Syc	O	5B
Great Barton Copse (1)					x	0	O	8B 5B 1A
Great Barton Copse (2)	x					0	O	5B 4A
Rougham Green Copse	x					0	C	8B
Knettishall Heath E	x					0	C	4B 7B
Knettishall Heath P,Q					x	Syc	O	0
Pakenham Wood B,A			x			Syc,Ash	O	1A 1B
Nether Hall Wood				x		0	C	8B 5B
Moreton Hall Wood (1)					x	0	C	1A 2A 5B
Norton Wood	x					0	C	8B 1A
Fish's Heath A,C		x				Syc,Ash	O	6B
Pakenham Fen A	x					0	C	3A 1A
Sumner Road Copse (1)					x	Syc	O	6B
Bangrove Wood	x					Ash	O	1A 1B
Wyken Wood	x					0	C	1A 5B
Langham Hills (4)	x					0	O	1A
Langham Hills (6)					x	Syc	-	-
Langham Hills (8)					x	0	-	-
Langham Hills (10)				x		Ash	-	-
Langham Hills (7)			x			0	O	0
Sumner Road Copse (2)					x	Syc	C	8B
Calke Wood B	x					Syc	O	2B 1A
Calke Wood A		x				0	O	2B 1A
Calke Wood C		x				0	-	-
Game Close Covert	x					0	O	2A
Stowlangtoft Woods A					x	Syc,Ash	C	8B 1B
Stowlangtoft Woods C	x					0	O/C	8B 1B 1A 2A
Pakenham Wood B	x					0	O/C	6B
Fish's Heath B	x					0	O	6B
Hollow Road Copse	x					0	C	4A 5B

Table 5 Table illustrating the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for ancient woodland without sycamore)

Woodland List	Species regeneration Seedling	Ground flora Cover	Ground flora Type
Grundle B	0	O	0
Eastlow Hill Wood	Ash,Hol	C	1A 1B
Westhall Wood	0	O	2A 1A 3A
Knettishall Heath A	0	C	4B 7B
Knettishall Heath B	0	C	3B 4B
Knettishall Heath C	0	C	7B 4B
Knettishall Heath F	0	C	7B 3B 4B
Knettishall Heath H	0	C	7B 3B 4B
Felsham Hall Wood	0	C	1A 2B
Shrubbery Farm Copse	0	O	6B 1B
Thorpe Carr	0	O	4A 6B
Pakenham Wood C	Ash	C	1B 1A
Great Queach	0	O	0
Norton Wood B	Ash	O	8B 1A
Stowlangtoft Copse (1)	0	O/C	8B 1A
Stowlangtoft Wood (2)	Ash	O	1A 1B
Stowlangtoft Copse (2)	0	C	1A 1B
Stowlangtoft Copse (3)	0	C	1A 1B
Langham Wood	0	O/C	1B 1A 4A 2B
Brockley Wood A	0	C	1A 1B
Ash Grove	0	C	1A 1B
Sleight House Wood	0	C	1A 1B
Shepherds Grove	Ash	O/C	1B
Dove House Wood	0	C	1A 1B
Kiln Wood	0	O/C	1A 1B
Ash Copses	0	C	1B 1A
Langham Hills 2,3,4,5,9	0	C	1B 1A
Langham Hills 1	0	C	1B 1A
Mulleys Grove	0	C	1B 8B

Table 6 Table illustrating the estimated % area invaded by sycamore, the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for secondary woodland with sycamore)

Woodland list	Estimated % area sycamore					Species regeneration	Ground flora	
	<1	1-25	26-50	51-75	76-100	Seedling	Cover	Type
Grundle A		x				Syc	O	4A
Bury Road Copse					x	0	O	5B
Walsham Copse A				x		0	C	6B 8A
Walsham Copse B					x	0	O	0
Pakenham Pit					x	Oak, Syc	O	0
Ixworth School Pit					x	0	C	5B 8B 6B
Green Farm Pit					x	0	C	8B 6B
Thurston School Copse					x	0	C	5B 8B
Ampton Common Covert					x	Oak, Ash Syc, Hol	C	8B 1A 6B
Gorse Wood					x	0	O	1A 8B
Brand Spinney					x	0	O	3B 2A 5B
East Barton Copse					x	0	O	1B 5B
Stowlangtoft Spinney					x	Oak, Syc	O	0
Fornham Wood A					x	0	O	1A
Fornham Wood B					x	0	C	1A
Thurston Sewage Copse					x	Syc, Oak F.Map	O	6B 8B
Moreton Hall Copse					x	0	O/C	6A
Bayer Copse					x	0	O	6B 1A 5B 2A
Great Barton Wood				x		0	-	-
Virginia's Copse				x		0	C	1B 5B 3A
Timworth Hall A				x		Syc, Oak	O/C	4B
Queach Farm Copse					x	Syc	C	1A 5B 8B
Ixworth Pit					x	0	O/C	1B 8A
Game Close Copse					x	0	O	5B 8A
Tayfen Road Copse					x	0	O	1B
Moreton Hall Wood (2)					x	0	O	0
Stowlangtoft Pk. Wood			x			0	C	5B 1A
Market Weston Fen			x			0	O/C	4A
Langham Hills (2)					x	Ash, Syc	O/C	1A

Table 6 (contd.) Table illustrating the estimated % area invaded by sycamore, the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for secondary woodland with sycamore)

Woodland list	Estimated % area sycamore <1	1-25	26-50	51-75	76-100	Species regeneration Seedling	Ground flora Cover	Type
Knettishall Heath I					x	Syc	O	3B 4B
Knettishall Heath N					x	Syc	O	0
Knettishall Heath S					x	Ash, Syc	O	3B 4B
Fish's Heath B	x					0	O	6B 7B
Knettishall Heath X					x	0	C	7B
Spaldings Hill (1)					x	0	C	3B
Folley Covert				x		0	O	1B
Hollow Road (1)					x	Oak, Syc	O	5B
Great Barton Wd. A					x	0	O/C	1B 8B 2B
Great Barton Wd. B					x	Syc	O/C	2B 8B 1A
Great Barton Wd. C					x	0	C	8B 1B

Table 7 Table illustrating the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for secondary woodland without sycamore)

Woodland List	Species regeneration Seedling	Ground flora Cover	Type
Norton Copse (2)	0	C	2A 6B
Norton Copse (1)	0	C	2A 6B
Stockings Wood	Ash	C	8B 1B
Ixworth Thorpe Copse (1)	0	C	5B 4B 8B
Knettishall Heath D,E, G,Q	0	C	4A 3B 7B
Knettishall Heath L	0	C	4B 3B 7B
Calke Wood C	0	C	2B

Table 8 Table illustrating the estimated % area invaded by sycamore, the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for coniferous plantations with sycamore)

Woodland list	Estimated % area sycamore <1	1-25	26-50	51-75	76-100	Species regeneration Seedling	Ground flora Cover	Type
West Stow For. Section	x					0	O	0
Sansoms Plantation (1)			x			0	O	0
Sansoms Plantation (2)		x				0	O	0
Rougham Rookery		x				Syc, Eld	O	3B 8B
Mill Heath Rougham Pk.		x				0	O/C	8B 4A
Rougham Plantation					x	Ash, Syc	O	8B
Timworth Covert			x			0	O/C	5B
Ixworth Court B			x			0	O	5B
Ampton Field A				x		0	O	5B
Ampton Field C		x				0	O	3B
Pakenham Wood D		x				Ash	O	1A 4A
Calke Wood D		x				0	C	1A 2B
Timworth Hall Covert			x			0	C	5B

Table 9 Table illustrating the occurrence of seedling regeneration, ground ocver and ground flora type, for each stand recorded in the general survey (for coniferous plantations without sycamore)

Woodland list	Species regeneration Seedling	Ground flora Cover	Type
Folly Grove, B	0	O	1A 8B
Brand Copse	0	O	0
Ixworth Hall Covert	0	O	5B
Knettishall Heath J	0	O	1A 8B
Brockley Wood B	0	O	0
Timworth Green Covert	0	O	0

Table 10 Table illustrating the estimated % area invaded by sycamore, the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for deciduous plantations with sycamore)

Woodland list	Estimated % area sycamore <1	1-25	26-50	51-75	76-100	Species regeneration Seedling	Ground flora Cover	Type
Bardwell Plantation					x	0	C	5B
Wytchingham Plantation				x		Ash, Syc Haw	O/C	8B
Barningham Copse					x	Ash, NMap Haw	O/C	8B 5B 1A
Stowlangtoft Street					x	0	C	5B 1B
Knettishall Heath Q		x				0	C	0
Knettishall Heath O				x		Syc, NMap	O/C	0
Ampton Field B			x			0	C	0

Table 11 Table illustrating the occurrence of seedling regeneration, ground cover and ground flora type, for each stand recorded in the general survey (for deciduous plantations without sycamore)

Woodland list	Species regeneration Seedling	Ground flora Cover	Type
Pakenham Fen B	0	C	3A 4A
Ivy Nook Copse	Ash	O	1A
Ixworth Plantation	0	C	4A 5A
Great Carr A	0	C	4A 5A
Bury Copse	0	C	4B
Knettishall Heath T	0	C	4B

Table 12 Table illustrating the various topographical features of individual ancient woodlands with sycamore
Data from O.S.Map

Name of Wood	Site	Area mm^2	Perimeter mm.	Nearest route mm.	Nearest Park mm.	Nearest settlement mm.	Nearest sycamore mm.
Hollow Road Copse (2)	Ht	4	48	0	30	20	11
Colton Copse	Ht	4	48	4	80	15	7
Great Barton Copse (1)	Ht	3	7	4	75	3	7
Great Barton Copse (2)	Ht	3	8	2	75	2	2
Rougham Green Copse	Ht	2	6	6	65	10	4
Knettishall Heath E	Ht Pit	9	12	8	75	35	7
Knettishall Heath P,Q	Va	12	16	0	35	15	1
Pakenham Wood B,A	Ht	65	36	0	5	1	7
Nether Hall Wood	$> 6^o$	30	22	0	0	15	2
Moreton Hall Wood (1)	Ht	5.5	15	0	50	1	1
Norton Wood	Ht	108	48	0	20	15	45
Fish's Heath A, C	Pl	57	62	4	5	25	23
Pakenham Fen A	Va	8	12	2	6	2	5
Summer Road (1)	$2-6^o$	2.5	12	0	45	5	3
Bangrove Wood	Pl	120	44	5	75	6	6
Wyken Wood	Pl	70	34	0	34	35	35
Langham Hills (4)	$> 6^o$	98	55	11	3	14	13
Langham Hills (6)	$> 6^o$	98	55	10	0	13	11
Langham Hills (8)	$> 6^o$	98.25	55	11	2	13	20
Langham Hills (10)	$> 6^o$	92.25	55	10	2	14	11
Langham Hills 1	$> 6^o$	98.25	55.5	10	0	14	12
Summer Road (2)	$2-6^o$	2	6	0	46	35	3
Calke Wood B	$> 6^o$	12.8	21	1	85	20	60
Calke Wood A	$> 6^o$	12.5	21	1	85	20	60
Calke Wood C	$> 6^o$	12.5	21	1	85	20	60
Game Close Covert	Pl	10	14	22/1	55	30	6
Stowlangtoft Woods A	$> 6^o$	38	32	5	11	4	7
Stowlangtoft Woods C	$> 6^o$	38	32	4	9	4	6
Pakenham Wood B	$> 6^o$	8	12	2	7	4	97
Fish's Heath B	Pl	57	62	6	5	25	23
Totals mm		1080	1014	1059	1083	435	5199
Averages mm		36	33.8	35.3	36.1	14.5	17.33

Table 13 Table illustrating the various topographical features of individual ancient woodlands without sycamore

Data from O.S.Map

Name of Wood	Site	Area mm^2	Perimeter mm.	Distance to Route mm	Distance to Park mm.	Distance to Settlement mm.	Distance to nearest sycamore mm.
Grundle B	$> 6^o$	1	4	17	60	15	3
Eastlow Hill	$2-6^o$	25	23	0	30	6	2
Westhall Wood	Pl	10	54	0	55	20	28
Knettishall A	$2-6^o$	4	8	0	65	15	11
Knettishall B	$2-6^o$	4	8	2	66	16	10
Knettishall C	$> 6^o$	4	8	4	67	17	9
Knettishall F	Ht	8	12	8	73	20	8
Knettishall H	$2-6^o$	3	8	0	74	1	12
Felsham Hall Wood	Pl	25	94	2	95	6	-
Shrubbery Farm Copse	Pl	22	28	13		30	65
Thorpe Carr	Vl	24	20	0	90	25	35
Pakenham Wood C	Ht	8	12	2	7	4	7
Great Queach	Ht	12.5	15	13	45	35	3
Norton Wood B	Ht	108	48	4	23	17	45
Stowlangtoft Copse (1)	HS	5	7	23	25	21	16
Stowlangtoft Wood (2)	$>6^o$	100	19	5	10	5	9
Stowlangtoft Copse (2)	Ht	15	18	5	7	4	5
Stowlangtoft Copse (3)	Ht	20	18	17	18	16	17
Langham Wood	Ht	40	31	0	8	3	7
Brockley Wood A	$2-6^o$	64	35	4	80	22	24
Ash Grove	$>6^o$	20	18	5	40	35	22
Sleight House Wood	Pl	18	20	7	60	7	4
Shepherds Grove	Pl	24	20	14	65	15	4
Dove House Wood	Pl	25	25	0	50	20	15
Kiln Wood	Pl	121	59	0	15	35	16
Mulleys Grove	$2-6^o$	16	16	5	40	37	22
Ash Copses	$> 6^o$	6	24	14	45	28	20
Langham Hills 2,3, ,5, 9.	$>6^o$	98	55	11	18	16	25
Langham Hills 1	Ht	98	55	5	12	28	15
Totals mm		910.5	762	170	1243	516	459
Averages mm		31.3	26.2	5.86	42.8	17.7	15.8

Table 14 Table illustrating the various topographical features of individual secondary woodlands with sycamore

Data from O.S.Map

Name of Wood	Site	Area mm^2	Perimeter mm.	Nearest route mm.	Nearest Park mm.	Nearest settlement mm.	Nearest sycamore mm.
Hollow Road (1)	Ht	3	7	5	70	10	11
Grundle A	$>6^o$	13	15	4	65	4	43
Bury Road Copse	$2\text{-}6^o$	4	10	4	60	5	20
Walsham Copse A	$>6^o$	1	4	0	5	3	6
Walsham Copse B	Vl	2	6	0	6	32	5
Pakenham Pit	$>6^o$	1	4	0	1	0	13
Ixworth School Pit	Ht	1	4	0	23	1	22
Green Farm Pit	$>6^o$	1	5	0	17	12	14
Thurston School Copse	Vl	6	10	0	20	1	27
Ampton Common Covert	$2\text{-}6^o$	1	4	0	5	3	13
Gorse Wood	Ht	17.5	19	0	27	10	11
Brand Spinney	$2\text{-}6^o$	8	16	0	27	26	6
East Barton Copse	$2\text{-}6^o$	22	29	2	34	10	22
Stowlangtoft Spinney	$>6^o$	12.5	13	0	7	15	16
Fornham Wood A	Vl	14	15.5	0	25	2	1
Fornham Wood B	Vl						
Thurston Sewage Copse	Vl	4	8	0	5	15	12
Moreton Hall Copse	$>6^o$	4	8	0	55	8	7
Bayer Copse	Ht	1	4	2	19	6	5
Great Barton Wood	$2\text{-}6^o$	40.5	26	0		1	15
Great Barton Wood A	$2\text{-}6^o$	40.5	26	0	43	2	15
Great Barton Wood B	$2\text{-}6^o$	40.5	26	0	41	1	16
Great Barton Wood C	$2\text{-}6^o$	40.5	26	0	37	1	18
Virginia's Copse	$2\text{-}6^o$	1	4	0	28	6	23
Timworth Hall A		58	33	0	24	26	25
Queach Farm Copse	$2\text{-}6^o$	6	10	4	42	31	17
Ixworth Pit	Pl	3	8	3	15	8	14
Game Close Copse	Ht	2	6	13	55	25	40
Tayfen Road Copse	$2\text{-}6^o$	2	6	0	35	0	23
Moreton Hall Wood (2)	Ht	3	8	4	40	0	3
Stowlangtoft Park Wood	Vl	4	10	0	0	0	1
Market Weston Fen	Vl	43	71	8	130	4	25
Langham Hills 7	Ht	98.25	53.5	13	0	15	11
Knettishall Heath I	$>6^o$	1	4	0	75	16	29
Knettishall Heath N	Vl	21	26	0	43	37	10
Knettishall Heath S	$2\text{-}6^o$	12	14	5	45	19	4
Fish's Heath B	Pl	1	1	6	5	25	23
Knettishall Heath X	Vl	20	24	2	50	40	40
Spaldings Hill (1)	$2\text{-}6^o$	18	36	0	30	5	2
Folley Covert	$2\text{-}6^o$	64	62	0	11	7	5
Totals mm		6347	663	75	1220	422	611
Averages mm		15.8	16.5	1.8	28.0	10.5	15.2

Table 15 Table illustrating the topographical features of individual secondary woodlands without sycamore

Data from O.S.Map

Name of Wood	Site	Area mm^2	Perimeter mm.	Distance to Route mm.	Distance to Park mm.	Distance to Settlement mm.	Distance to nearest sycamore mm.
Norton Copse (2)	Vl	14	15	2	38	8	12
Norton Copse (1)	Vl	12	14	0	35	4	8
Stockings Wood	$2-6^{o}$	20	18	5	8	5	7
Ixworth Thorpe Copse (1)	Vl	24	30	0	30	5	35
Ixworth Thorpe Copse (2)	Vl	4	8	0	36	35	38
Knettishall Heath, D, E, G, Q.	$2-6^{o}$	50	37	0	55	18	5
Knettishall Heath L	$2-6^{o}$	160	40	0	38	25	2
Calke Wood C	$>6^{o}$	2	6	0	84	25	2
Totals mm		286	168	7	324	125	109
Averages mm		35.75	21	0.87	40.5	15.6	13.6

Table 16 Table illustrating the topographical f?atures of individual coniferous woodlands with sycamore

Data from O.S.Map

Name of Wood	Site	Area mm^2	Perimeter mm.	Nearest route mm.	Nearest Park mm.	Nearest setlement mm.	Nearest sycamore mm.
West Stow Forest Section	$>6^{o}$	25	10	4	17	5	40
Sansoms Plantation (1)	$2-6^{o}$	25	19	2	19	15	0
Sansoms Plantation (2)	$2-6^{o}$	88	32	0	19	15	8
Rougham Rookery	$2-6^{o}$	38	32	0	12	1	14
Mill Heath Rougham Park	$2-6^{o}$	380	10	0	0	6	4
Rougham Plantation	$2-6^{o}$	8	12	8	24	10	4
Timworth Covert	$2-6^{o}$	12	14	0	35	10	15
Ixworth Covert B	Ht	9	12	5	20	20	12
Ampton Field A	Ht	70	83	0	3	3	15
Ampton Field C	$>6^{o}$	85	44	0	3	10	15
Pakenham Wood D	Ht	24	20	3	11	5	0
Calke Wood D	$>6^{o}$	12	14	2	80	29	0
Timworth Hall Covert	$>6^{o}$	16	20	0	25	10	0
Totals mm		792	321	24	267	139	127
Averages mm		60.9	24.6	1.84	20.5	10.6	9.7
As above, continued, without sycamore							
Folly Grove B	$2-6^{o}$	86	50	5	8	4	0
Brand Copse	$2-6^{o}$	2	6	0	25	30	2
Ixorth Hall Covert	Ht	15	19	0	25	20	2
Knettishall Heath J	$2-6^{o}$	186	64	4	14	27	6
Brockley Wood B	$2-6^{o}$	64	35	4	80	22	24
Timworth Green Covert	Vl	40	28	0	25	4	10
Totals mm		483	202	13	177	107	44
Averages mm		80.5	33.6	2.16	29.5	17.8	7.3

Table 17 Table illustrating the topographical features of individual deciduous woodlands with sycamore

Data from O.S.Map

Name of Wood	Site	Area mm 2	Perimeter mm.	Nearest route mm.	Nearest Park mm.	Nearest settlement mm.	Nearest sycamore mm.
Bardwell Plantation	Vl	11	18	0	0	20	20
Wytchingham Plantation	Vl	6	11	4	90	10	50
Barningham Copse	2-6°	6	10	1	95	4	25
Stowlangtoft Street	Vl	6	14	1	1	1	1
Knettishall Heath Q	Vl	10	12	0	25	2	2
Knettishall Heath O	Vl	18	18	0	30	15	1
Ampton Field B	Vl	24	24	0	18	7	3
Totals mm		81	107	6	159	50	102
Averages mm		11.5	15.2	0.85	37	7.1	14.5
As above, continued, without sycamore							
Pakenham Fen B	Vl	25	28	3	8	3	6
Ivy Nook Copse	2-6°	16	16	5	23	90	3
Ixworth Plantation	Vl	73	82	0	5	2	15
Great Carr A	Vl	45	35	5	6	6	5
Bury Copse	> 6°	5	12	0	65	12	10
Knettishall Heath T	Vl	20	18	0	55	16	18
Totals mm		184	171	18	162	129	56
Averages mm		30.6	28.5	2.16	27	21.5	9.3

Table 18 - The occurrence of tree species in individual ancient woodland

Tree Species	Oak	Ash	Haz	FMap	Syc	Elm	Hor	Eld	Haw	Bir	Ald	Pin	Hol	Wil	SwCh	HChes	NMap	Rho	Bla	Yew	Con	Bee	Pop	Lim
Knetishall Health PC	x				x										x									
Knettishall Heath PB	x				x	x	x								x									
Knettishall Heath PO	x				x										x									
Knettishall Heath K	x									x														
Knettishall Heath H	x														x									
Knettishall Heath F	x														x									
Knettishall Heath C	x									x														
Knettish ll Heath B	x									x														
Knettishall Heath A	x									x														
Shrubbery Farm Coppe	x	x		x					x															
Calke Wood A-B Sample 1			x		x					x														
Summer Road Wood	x	x			x				x															
Great Carr area B.	x	x	x					x		x														
Thorpe Carr	x	x	x					x	x					x									x	
Bangrove Wood	x	x	x	x		x																		
Sumner Road Copse	x	x	x	x																				
Pakenham Wood C	x	x	x	x																				
Pakenham Wood B		x	x	x				x		x														
Pakenham Wood A	x	x	x	x	x			x																
Stowlangtoft Wood one B		x	x	x			x				x													
Stowlangtoft Wood one A		x	x	x	x	x					x													
Langham Hills Ten	x	x	x		x																			
Langham Hills nine		x	x																					
Langham Hills eight	x	x	x	x	x																			
Langham Hills six	x				x	x																		
Langham Hills five		x	x	x		x																		
Langham Hills four	x	x	x			x																		
Langham Hills three		x	x	x																				
Langham Hills two	x	x	x							x														
Langham Hills one.	x	x	x				x																	
Ash Copses '3'	x			x		x																		
Mulleys Grove	x	x		x					x															
Wyken Wood	x	x	x	x																				
Dove House Wood	x	x	x	x																				
Shepherds Grove		x					x	x					x											
Sleight House Wood	x	x	x	x																				
Ash Grove		x	x	x																				
Timworth Hall Covet B	x	x	x		x							x										x		
Pakenham Nether Hall	x	x	x		x										x									
Game Close Copse	x	x	x	x								x												
Moreton Hall Wood one	x	x			x		x	x	x															
Great Queach	x	x	x						x															
Norton Wood B'				x																				
Norton Wood A	x	x	x	x					x	x	x													
Fish's Heath	x	x	x	x	x	x			x															
Stowlangtoft Copse one	x	x	x	x				x	x		x													
Stowlangtoft Copse two		x	x	x		x			x										x					
Stowlangtoft Copse three	x	x	x	x					x															
Pakenham Fen A		x									x													
Langham Wood	x	x	x			x				x														
Brockley Wood A	x	x	x	x			x																	
Grundle Copse	x										x													
Felsham Hall Wood	x	x					x				x													
Hollow Road Copse two	x		x	x	x	x		x							x									
Eastlow Hill Wood	x	x	x	x																				
Colton Copse	x				x	x																		
Great Barton Copse one	x	x			x	x		x																
Great Barton Copse two	x	x			x	x		x					x			x								
Westhall Wood	x	x	x			x	x			x														

Wayfaring tree, guelder rose, spindle, dogwood, gean are only recorded in the competitive strategies chapter, page 290
These figures are taken directly from Record Card 2 of the general survey

Table 19 - The occurrence of tree species in individual secondary woodlands

Tree Species	Oak	Ash	Hazel	Field Maple	Sycamore	Elm	Hornbeam	Elder	Hawthorn	Birch	Alder	Pine	Holly	Willow	Sweet Chestnut	Horse Chestnut	Norway Maple	Rhododendron	Blackthorn	Yew	Other Conifer	Beech	Poplar	Lime	False Acacia
Fish's Heath B		X		X	X																				
Moreton Hall Wood two					X			X																	
Tayfen Road Copse					X																				
Norton Copse two	X	X				X			X																
Norton Copse one	X	X				X			X																
Grundle A	X	X			X	X		X														X			
Bury Road Copse					X			X																	
Walsham Copse B		X			X	X																			
Walsham Copse A					X			X																	
Pakenham Pit	X	X			X											X									
Ixworth School Pit		X			X																				
Thurston Green Farm					X			X																	
Thurston School Copse	X				X			X																	
Hollow Road Copse one	X				X	X		X																	
Knettishall Heath S					X			X																	
Knettishall Heath N					X					X							X								
Knettishall Heath L										X															
Knettishall Heath I					X			X																	
Knettishall Heath G	X																								
Knettishall Heath E										X															
Ampton Common Copse	X	X			X								X												
Brand Spinney	X				X	X																			
Gorse Wood	X				X			X																	
East Barton Copse	X	X			X			X																	
Stowlangtoft Spinney	X				X			X										X							
Fornham Wood	X				X																				
Thurston Sewage Copse	X	X		X		X		X	X												X				
Calke Wood C		X																							
Moreton Hall Copse	X				X			X	X																
Great Barton Wood D	X														X										X
Great Barton Wood A	X	X			X	X																			
Great Barton Wood B	X	X			X	X									X										
Great Barton Wood C Thurston Bayer Copse	X	X			XX	X		X	X																
Ixworth Thorpe Copse2	X	X						X		X															
Ixworth Thorpe Copse1		X				X		X						X											
Langham Hills seven	X	X			X							X			X										
Virginia's Copse		X			X	X																			
Queach Farm Copse	X	X				X			X	X			X												
Ixworth Pit	X				X			X																	
Ixworth Covert A	X				X	X		X		X															
Game Close Copse		X		X	X		X	X	X																
Stockings Wood	X	X	X			X							X		X										
Folly Grove A	X	X			X			X							X	X									
Market Weston Fen B											X														
Market Weston Fen A	X				X																				

Table 20 - The occurrence of tree species in individual coniferous plantations

Tree Species	Brockley Wood B	Folly Grove B	Ampton Field A	Ampton Field C	Ixworth Covert B	Nether Hall B	Timworth Hall B	Timworth Covert	Pakenham Wood D	Calke Wood D	Rougham Plantation	Rougham Rookery A	Mill Heath	Knettishall Heath J	Knettishall Heath M	Sansoms Plantations	West Stow Forest Section
Oak								X									
Ash											X						
Hazel																	
Field Maple																	
Sycamore			X				X		X	X	X		X		X		
Elm								X									
Hornbeam																	
Elder					X		X					X	X				
Hawthorn								X									
Birch		X			X												
Alder																	
Pine	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Holly																	
Willow																	
Sweet Chestnut																	
Horse Chestnut																	
Norway Maple															X		
Rhododendron																	
Blackthorn																	
Yew																	
Other Conifer	X	X	X	X	X				X				X	X			X
Beech																	
Poplar																	
Lime																	
False Acacia																	

Table 21 - The occurrence of tree species in individual deciduous plantations

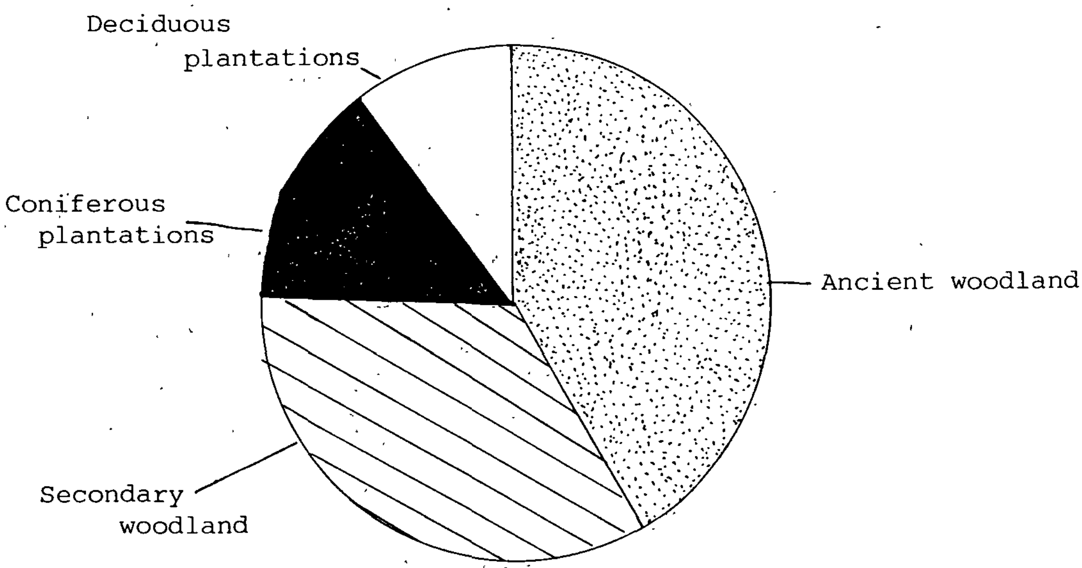
Tree Species	Ivy Nook Copse	Barningham Copse	Ampton Field Area B	Pakenham Fen B	Wytchingham Plantations	Calke Wood E	Knettishall Heath O	Knettishall Heath Q	Knettishall Heath T	Ixworth Plantations	Bury Copse	Great Carr A	Bardwell Plantation	Stowlangtoft Street
Oak	X	X			X									
Ash	X	X			X									
Hazel	X				X									
Field Maple														
Sycamore		X			X	X	X	X					X	X
Elm														X
Hornbeam	X													
Elder														
Hawthorn	X	X			X									
Birch														
Alder				X					X					
Pine					X									
Holly		X												
Willow				X										
Sweet Chestnut	X													
Horse Chestnut													X	X
Norway Maple		X					X	X						
Rhododendron														
Blackthorn														
Yew	X													
Other Conifer														
Beech			X				X	X			X			X
Poplar										X		X		
Lime														X
False Acacia														

Chapter 3

WOODLAND COMMUNITY CLASSIFICATION IN THE WEST SUFFOLK AREA WITH REFERENCE TO THE STATUS OF SYCAMORE

A central aim of the thesis has been to produce a woodland classification for the West Suffolk area that includes all woodland forms and incorporates the presence of sycamore in these. Primarily, a clear distinction has been made between four main woodland forms: derelict ancient woodland, secondary woodland, coniferous plantations and deciduous plantations. Fig 36 illustrates the proportions of each of these woodland forms for those woodlands recorded in the general survey (see table 3).

Fig 36 The proportion of each woodland form as a percentage of the total number of woodlands recorded



Ancient woodland is the most frequently occurring woodland form followed by secondary woodland with coniferous woodland and deciduous of less common occurrence. Using the data from the general survey for occurrences of species in the West Suffolk woodlands the relative proportions of individual tree species in each woodland form could be calculated. Table 22 abbreviates the results of the general survey. (Tables 18-21)

Table 22 A table illustrating the number of occurrences of species within a woodland category and the percentage of that occurrence within the total number of occurrences for each woodland category and the sum of all occurrences from the four woodland categories

Wood type	Oak	Ash	Haz	FMap	Syc	Elm	Hor	Eld	Haw	Bir	Ald	Sw. Ches	Pin	Hol	Others	Total	Bch	Pop	FAc	NMap
Ancient	47	44	36	26	27	15	8	10	11	12	7	7	1	2	3	256				
%	18	17.4	14.2	10.1	10.5	5.8	3.1	3.9	4.2	4.6	2.7	2.7	0.3	0.6	1.9					
Secondary	28	22	1	2	33	15	1	21	7	6	1	5	1	2	5	150				
%	18.6	14.6	0.6	1.2	22	10	0.6	41	4.6	4	0.6	3.3	0.6	1.2	3.3					
Coniferous	1	1	0	0	7	1	0	4	1	2	1	0	18	0	5	41				
%	2.4	2.4	0	0	17	2.4	0	9.7	2.4	4.8	2.4	0	43.9	0	12					
Deciduous	3	3	2	0	5	1	1	0	3	0	2	3	1	1		36	5	2	1	3
%	8.1	8.1	5.4	0	13.5	2.7	2.7	0	8.1	0	5.4	8.1	2.7	2.7			13.5	5.4	2.7	8.1
Total	79	70	39	28	72	32	10	38	22	20	11	15	21	5	24	483				
%	16.3	14.4	8.0	5.7	14.8	6.6	2.0	7.2	4.5	4.1	2.2	3.0	4.3	1.0	5.3					

Relative abundance has been calculated using the formula (eg. for oak in ancient woodland)

$$\% \text{ abundance} = \frac{\text{Number of occurrences of oak in ancient woodland}}{\text{Total number of occurrences of all species in ancient woodland}} \times 100$$

The sum of each tree's abundance for each woodland category was used to estimate relative abundance in all woodlands.

The results shown in table 22 have been expressed as pie diagrams.

Fig 37 The relative abundance of species in all West Suffolk woodland based on frequency of occurrence

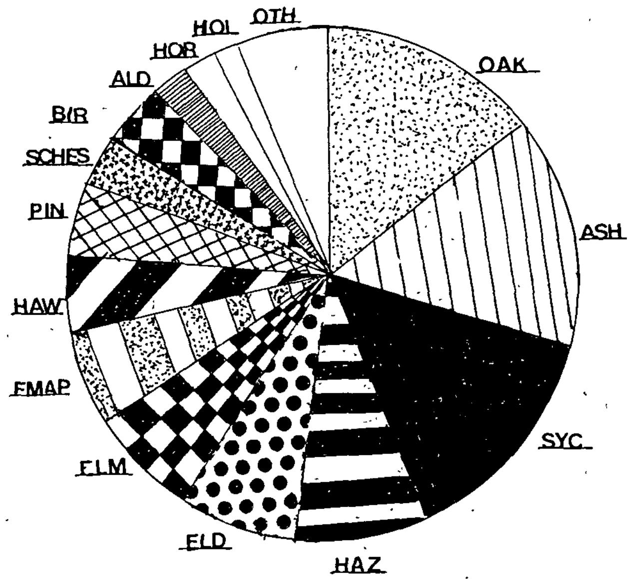


Fig 37 illustrates that the most frequently occurring species are oak, ash, sycamore, hazel, elder, elm, field maple, hawthorn, pine, sweet chestnut and birch. The relatively frequent occurrence of sycamore suggests that it would be inaccurate to ignore sycamore in a woodland classification on the basis that it is an exotic species.

Fig 38 The relative abundance of tree species in West Suffolk ancient woodland based on frequency of occurrence

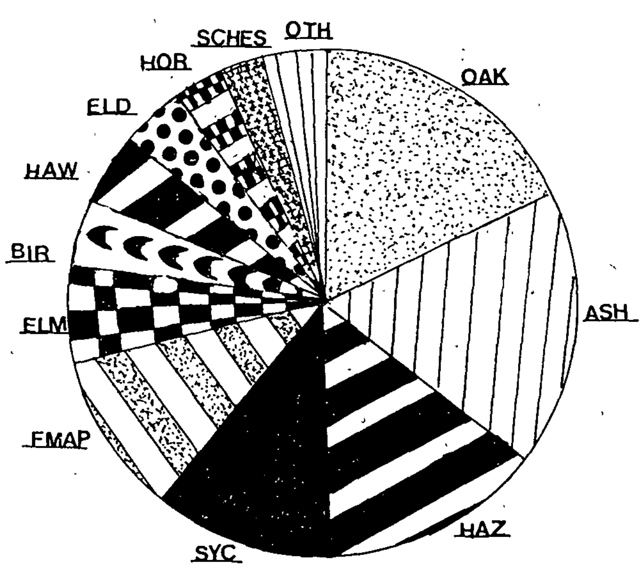


Fig 38 illustrates that in ancient derelict woodland in the West Suffolk area, oak, ash, hazel, sycamore, field maple, elm, birch, hawthorn, elder, hornbeam and sweet chestnut are the predominant species. Of these species, oak, ash, field maple and hazel would appear to be the most frequently occurring native species.

Fig 39 The relative abundance of tree species in West Suffolk secondary woodland based on frequency of occurrence

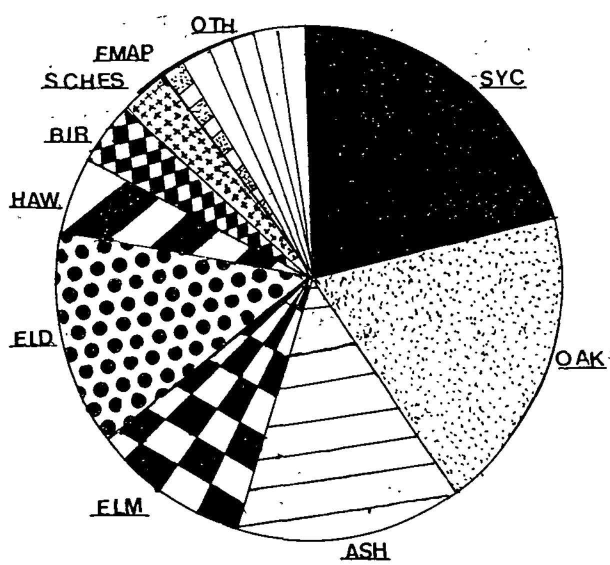
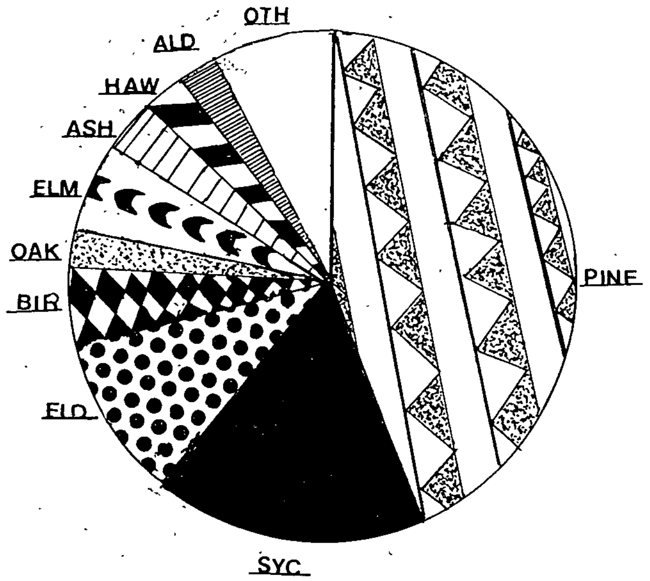


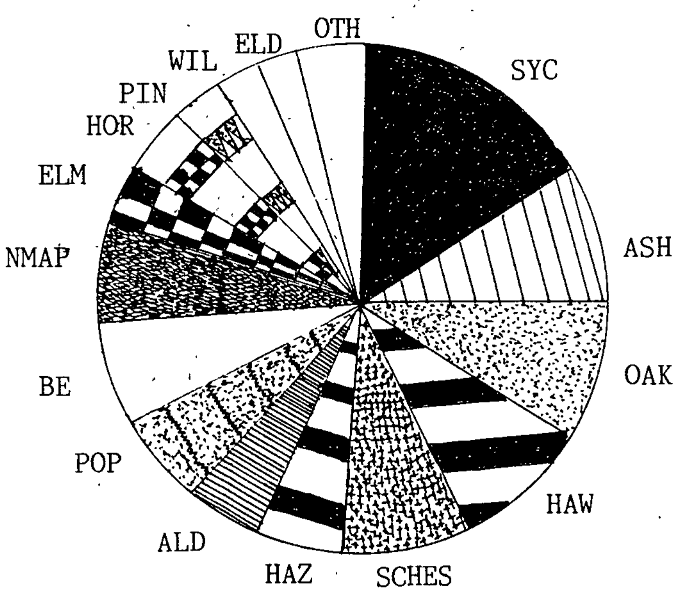
Fig 39 indicates some clear differences between the species community structure of secondary woodlands and ancient derelict woodland. Hazel and field maple are far less frequently occurring whilst elder, sycamore and elm have a greater relative abundance in secondary woodland than ancient derelict woodland.

Fig 40 The relative abundance of tree species in West Suffolk coniferous plantations based on frequency of occurrence



Coniferous plantations are dominated by pine species as their name would suggest. The pine species was usually *Pinus sylvestris*. However, both sycamore and elm were present.

Fig 41 The relative abundance of tree species in West Suffolk deciduous plantations based on frequency of occurrence



Some deciduous plantations had a considerable variety of deciduous tree species, whereas others could be monospecific. This was thought to be dependent on whether they were planted for timber, amenity or other purpose. Species such as beech, Norway maple, poplar, willow, sweet chestnut and alder were more frequently occurring in deciduous plantations than in other woodland categories.

The differences in the frequency of occurrence of individual species can be more clearly demonstrated by regarding the distribution by occurrence of each species in each of the four woodland categories. Fig 42 illustrates the percentage occurrences of individual species calculated as the percentage of all occurrences of that species - hence for oak in ancient woodland:

$$\text{\% abundance of oak in ancient woodland} = \frac{\text{number of occurrences of oak in ancient woodland}}{\text{total number of occurrences of oak in all woodland types}}$$

The source data comes from the general survey (tables 18 - 21) and totals are obtained from table 23, page 87.

Table 23 Table illustrating the distribution of each species in the four woodland types - A (ancient derelict), S (secondary), C (coniferous), D (deciduous) based on % occurrence

Wood type	Oak	Ash	Haz	FMap	Syc	Elm	Hor	Eld	Haw	Bir	Ald	SChes	Pin	Hol
% A	59.4	62.8	92.3	92.8	37.5	46.8	80	26.3	50	60	63.6	46.6	4.0	40
% S	35.4	31.4	2.5	7.1	45.8	46.8	10	55.2	31	30	9	33 .3	4.0	40
% C	0.1	1.4	0	0	9.7	3.1	0	10.5	4.5	10	9	0	85.7	0
% D	3.7	4.2	5.1	0	6.9	3.1	10	0	13.6	0	18	20	4.0	20

Fig 42 Histograms illustrating the % occurrence of individual tree species in each woodland category

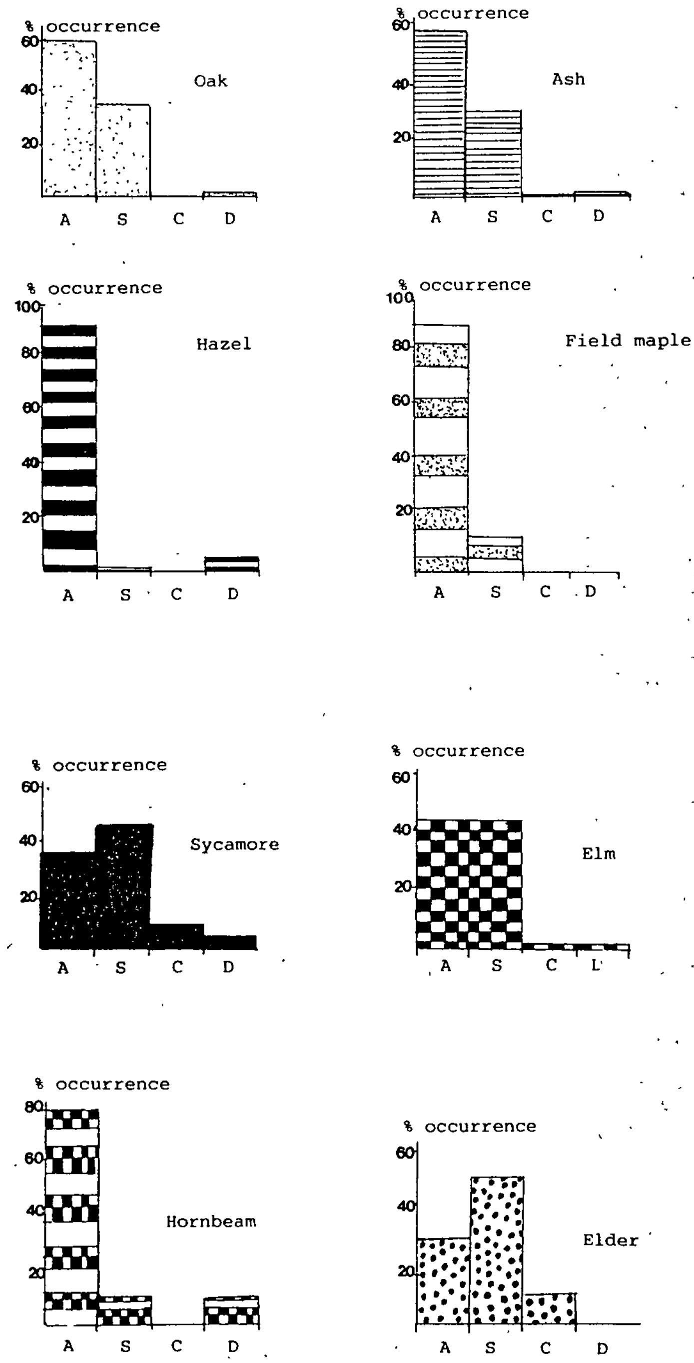


Fig 42 (contd)

Histograms illustrating the % occurrence of individual tree species in each woodland category

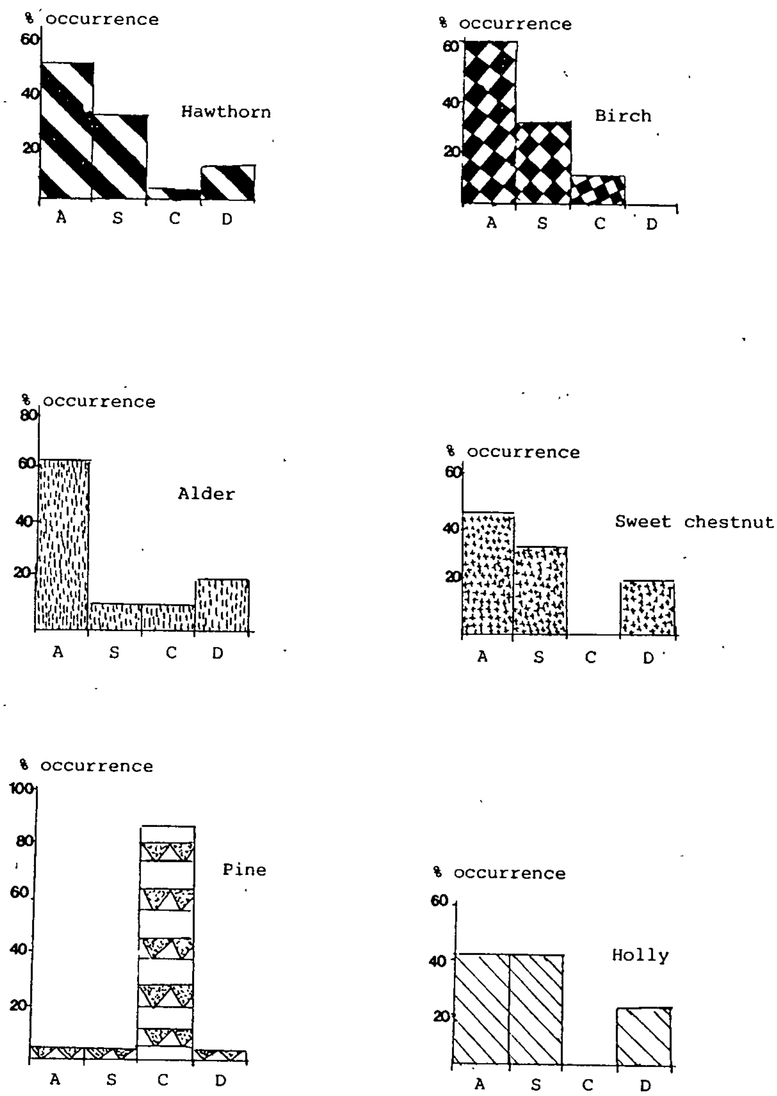


Fig 42 illustrates that oak, ash, field maple, hornbeam, hawthorn, birch, alder and sweet chestnut are more commonly in ancient woodland than in other woodland categories. These may therefore form the basis of an ancient woodland tree species association. Elder and sycamore are more likely to occur in secondary woodland than ancient woodland. These species may form the basis of a secondary woodland species association. Pine, again, is clearly almost totally confined to plantations. Holly and elm occur in similar frequencies in both secondary woodland and ancient woodland.

Classification of the woodlands of West Suffolk was extended to investigate associations between species. Again, the four instrumental woodland types were used and the frequency of two species occurring together in each woodland type was calculated from the results of the general survey (see tables 18-21 , pp 78 - 81). The data illustrating paired associations is illustrated in tables 24 - 28. The results have been plotted using a personally devised procedure (see figs 43, 44, 45). The vertical axis denotes the frequency of occurrence of a pair of species. The horizontal axis illustrates the ranked relative frequency of occurrence of each pair of tree species. Each pair is then plotted in terms of its ranked position and numerical occurrence in that particular sample of woodlands.

Table 24

Table illustrating the number of times two species occurred together in ancient woodland in the West Suffolk survey area

Tree Species	OAK	ASH	HAZEL	FIELD MAPLE	SYCAMORE	ELM	HORNBEAM	ELDER	HAWTHORN	BIRCH	ALDER	PINE	HOLLY	WILLOW	SWEET CHESTNUT	HORSE CHESTNUT	NORWAY MAPLE	RHODODENDRON	BLACKTHORN	YEW	OTHER CONIFER	BEECH	POPLAR	LIME	FALSE ACACIA
OAK																									
ASH	35																								
HAZEL	28	37																							
FIELD MAPLE	20	26	24																						
SYCAMORE	15	11	7	4																					
ELM	12	10	8	6	8																				
HORNBEAM	6	7	7	3	2	2																			
ELDER	8	9	5	3	5	3	2																		
HAWTHORN	9	10	7	7	2	2	0	2																	
BIRCH	9	6	6	2	1	2	1	1	0																
ALDER	3	6	4	4	3	2	1	0	2	0															
PINE	2	2	2	1	1	0	0	0	0	0	0														
HOLLY	2	3	1	0	1	1	1	2	0	0	0	0													
WILLOW	1	1	1	0	0	0	0	1	1	0	0	0	0												
SWEET CHESTNUT	6	1	1	0	4	1	1	0	0	0	0	0	0	0											
HORSE CHESTNUT	1	1	0	0	1	1	0	1	0	0	0	0	1	0	0										
NORWAY MAPLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
RHODODENDRON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BLACKTHORN	2	2	1	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0							
YEW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
OTHER CONIFER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
BEECH	2	2	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0				
POPLAR	1	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0			
LIME	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
FALSE ACACIA	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Tree Species	OAK	ASH	HAZEL	FIELD MAPLE	SYCAMORE	ELM	HORNBEAM	ELDER	HAWTHORN	BIRCH	ALDER	PINE	HOLLY	WILLOW	SWEET CHESTNUT	HORSE CHESTNUT	NORWAY MAPLE	RHODODENDRON	BLACKTHORN	YEW	OTHER CONIFER	BEECH	POPLAR	LIME	FALSE ACACIA
OAK																									
ASH	3																								
HAZEL	2	2																							
FIELD MAPLE	0	0	0																						
SYCAMORE	2	2	1	0																					
ELM	0	0	0	0	0																				
HORNBEAM	1	1	1	0	0	0																			
ELDER	0	0	0	0	0	0	0																		
HAWTHORN	2	1	1	0	0	0	1	0																	
BIRCH	0	0	0	0	0	0	0	0	0																
ALDER	0	0	0	0	0	0	0	0	0	0	1														
PINE	1	1	1	1	0	0	0	0	1	0	0														
HOLLY	1	1	0	0	1	0	0	0	0	0	0	0													
WILLOW	0	0	0	0	0	0	0	0	0	0	2	0	0												
SWEET CHESTNUT	1	1	1	0	0	0	1	0	1	0	0	0	0	0											
HORSE CHESTNUT	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0										
NORWAY MAPLE	1	1	1	0	3	0	1	0	1	0	0	0	1	0	0	0									
RHODODENDRON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BLACKTHORN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
YEW	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0						
OTHER CONIFER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
BEECH	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	2			
POPLAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2		
LIME	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0		
FALSE ACACIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 25

Table illustrating the number of times two species occurred together in deciduous plantations in the West Suffolk survey area

Table 26

Table illustrating the number of times two species occurred together in coniferous plantations in the West Suffolk survey area

Tree Species	OAK	ASH	HAZEL	FIELD MAPLE	SYCAMORE	ELM	HORNBEAM	ELDER	HAWTHORN	BIRCH	ALDER	PINE	HOLLY	WILLOW	SWEET CHESTNUT	HORSE CHESTNUT	NORWAY MAPLE	RHODODENDRON	BLACKTHORN	YEW	OTHER CONIFER	BEECH	POPLAR	LIME	FALSE ACACIA
OAK																									
ASH	0																								
HAZEL	0	0																							
FIELD MAPLE	0	0	0																						
SYCAMORE	0	1	0	0																					
ELM	1	0	0	0	0																				
HORNBEAM	0	0	0	0	0	0																			
ELDER	0	0	0	0	2	0	0																		
HAWTHORN	1	0	0	0	0	1	0	0																	
BIRCH	0	0	0	0	0	0	0	1	0																
ALDER	0	0	0	0	0	0	0	0	0	0															
PINE	1	1	0	0	6	1	0	3	1	2	0														
HOLLY	0	0	0	0	0	0	0	0	0	0	0	0													
WILLOW	0	0	0	0	0	0	0	0	0	0	0	0	0												
SWEET CHESTNUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
HORSE CHESTNUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
NORWAY MAPLE	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0									
RHODODENDRON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BLACKTHORN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
YEW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
OTHER CONIFER	0	0	0	0	4	0	0	2	0	2	0	8	0	0	0	0	0	0	0	0					
BEECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
POPLAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
LIME	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
FALSE ACACIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 27

Table illustrating the number of times two species occurred together in a secondary woodland of the West Suffolk survey area

Tree Species	OAK	ASH	HAZEL	FIELD MAPLE	SYCAMORE	ELM	HORNBEAM	ELDER	HAWTHORN	BIRCH	ALDER	PINE	HOLLY	WILLOW	SWEET CHESTNUT	HORSE CHESTNUT	NORWAY MAPLE	RHODODENDRON	BLACKTHORN	YEW	OTHER CONIFER	BEECH	POPLAR	LIME	FALSE ACACIA
OAK																									
ASH	15																								
HAZEL	1	1																							
FIELD MAPLE	3	3	0																						
SYCAMORE	19	14	0	2																					
ELM	13	11	1	1	8																				
HORNBEAM	0	1	0	1	1	0																			
ELDER	13	8	0	2	18	6	1																		
HAWTHORN	6	6	0	2	3	4	0	4																	
BIRCH	3	2	0	0	2	2	0	2	1	2															
ALDER	0	0	0	0	0	0	0	0	0	0	1														
PINE	1	1	0	0	1	0	0	0	0	0	0														
HOLLY	3	3	1	1	1	2	0	1	1	0	0	0													
WILLOW	0	1	0	0	0	1	0	1	0	0	0	0	0												
SWEET CHESTNUT	5	3	1	1	3	2	0	0	0	0	0	0	1	0											
HORSE CHESTNUT	2	2	1	0	2	0	0	1	0	0	0	0	0	0	1										
NORWAY MAPLE	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0									
RHODODENDRON	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0								
BLACKTHORN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
YEW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
OTHER CONIFER	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0					
BEECH	1	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0				
POPLAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
LIME	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
FALSE ACACIA	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 28

Table illustrating the number of times two species occurred together in all Woodland in the West Suffolk survey area

Tree Species	OAK	ASH	HAZEL	FIELD MAPLE	SYCAMORE	ELM	HORNBEAM	ELDER	HAWTHORN	BIRCH	ALDER	PINE	HOLLY	WILLOW	SWEET CHESTNUT	HORSE CHESTNUT	NORWAY MAPLE	RHODODENDRON	BLACKTHORN	YEW	OTHER CONIFER	BEECH	POPLAR	LIME	FALSE ACACIA
OAK																									
ASH	53																								
HAZEL	31	40																							
FIELD MAPLE	23	29	24																						
SYCAMORE	40	33	13	11	3																				
ELM	26	21	9	7	18																				
HORNBEAM	7	9	8	4	7	2	1																		
ELDER	21	17	5	5	29	9	3																		
HAWTHORN	18	16	8	9	5	7	1	6																	
BIRCH	12	8	6	2	3	4	3	3	2	2															
ALDER	3	6	4	4	4	2	1	0	2	1	2														
PINE	5	5	3	2	10	1	0	3	2	2	0	4													
HOLLY	6	7	2	1	4	2	1	3	1	0	0	0													
WILLOW	1	2	1	0	0	0	0	2	0	0	1	0	0												
SWEET CHESTNUT	12	5	3	1	7	3	2	1	0	0	0	0	1	0											
HORSE CHESTNUT	3	3	1	0	6	1	0	2	0	0	0	0	1	0	1										
NORWAY MAPLE	1	1	1	0	5	1	1	0	1	1	0	1	1	0	0	0									
RHODODENDRON	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0								
BLACKTHORN	2	2	1	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0							
YEW	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0						
OTHER CONIFER	1	1	0	0	4	1	0	3	1	2	0	8	0	0	0	0	0	0	0	0					
BEECH	3	3	2	0	5	1	0	1	1	0	0	0	0	0	0	2	3	0	0	0	0	2			
POPLAR	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
LIME	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0		
FALSE ACACIA	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

The paired association of ancient woodland (fig 43) indicates that hazel/ash and oak/ash pairs most frequently occur together. These pairs are separated from hazel/oak, field maple/ash and field maple/hazel pairs which are somewhat less frequent but do appear to show a strong pair association. Following rank order, field maple and oak are the next most frequently occurring pair and complete the permutations of the four main ancient woodland species, ash, hazel, oak and field maple. Field maple is less frequently occurring in ancient woodland than sycamore (see fig 43) but appears to be more strongly associated with the other prominent ancient woodland species than sycamore, which is to be found with oak as the seventh most frequent pairing. Oak, field maple, ash and hazel are recognised ancient woodland species (Rackham[64]). Sycamore is not. The paired associations may result from the tendency of woodmen to select species according to ancient woodland management. Ancient woodland compartments have often been modified to conform to a particular species structure on the basis of wood product required. Often this means the growing of certain species of coppice with certain species of timber in the West Suffolk area. Oak was predominantly grown as standard timber trees, hazel as coppice with ash and field maple grown as both coppice and standard timber trees.

Following the sycamore/oak pair separation, separation by paired frequence is less marked. Invasive elm, elder, hawthorn and sycamore are found in association with the common ancient woodland species. These species are likely to represent invasions of ancient woodland communities. Birch/oak is also present. Birch is a recognised ancient woodland species but is less common in the West Suffolk area than other ancient species.

Fig 43 also illustrates less frequently associated pairs of ancient woodland species. Hornbeam, alder and sweet chestnut make an appearance paired with either ash, hazel or oak but not with field maple. Hornbeam and sweet chestnut are usually thought to be more common in woodlands in the south of the British Isles. Although Rackham has noted hornbeam in East Anglia , sweet chestnut was found as a coppice stool with a 9 metre girth at one site which would seem to authenticate its presence as having an ancient origin. Alder, according to Rackham, is most frequently found in valleys or on plateaux.

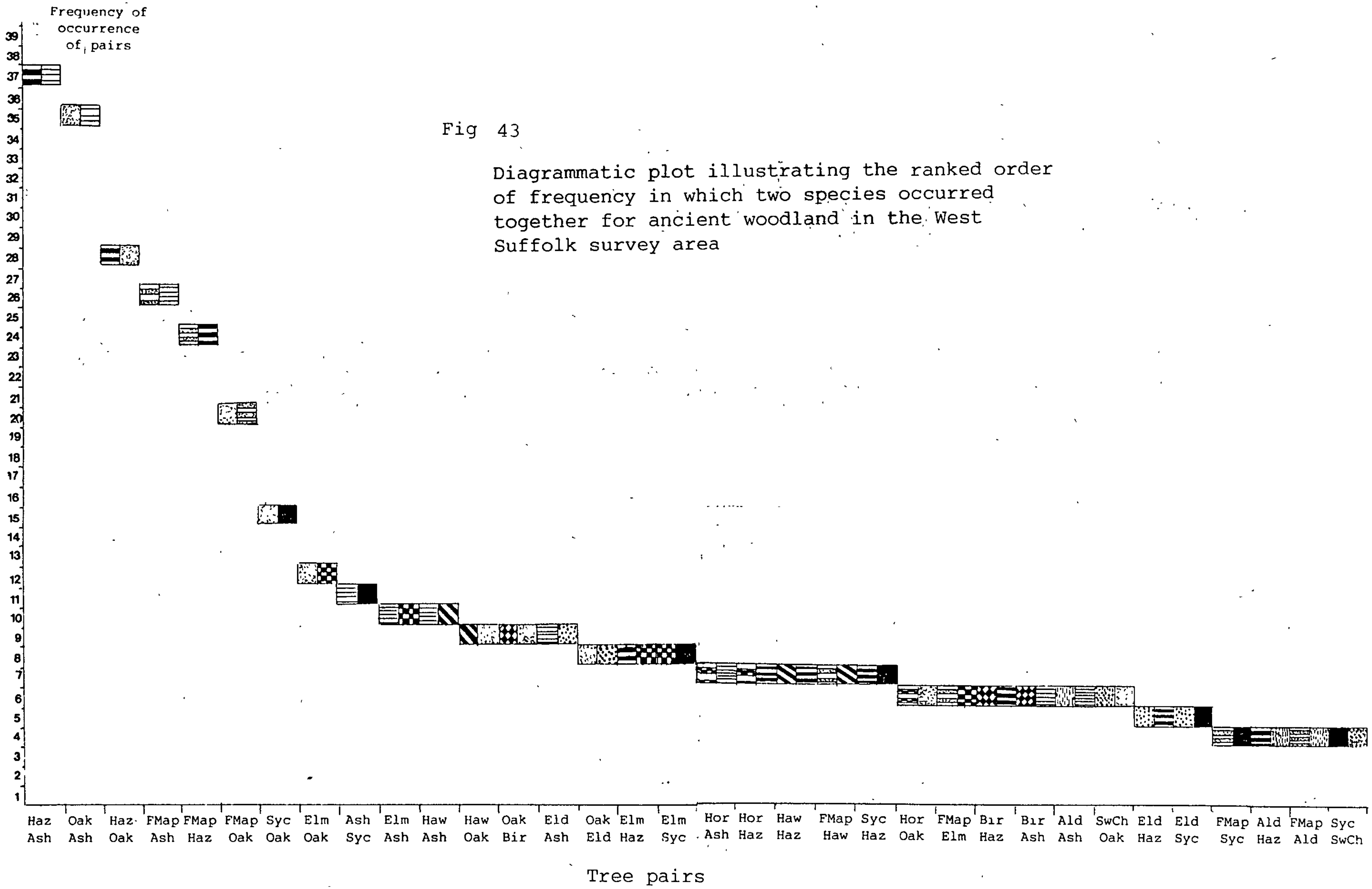


Fig 43

Diagrammatic plot illustrating the ranked order of frequency in which two species occurred together for ancient woodland in the West Suffolk survey area

Fig 44

Diagrammatic plot illustrating the ranked order of frequency in which two species occurred together for secondary woodland in the West Suffolk survey area

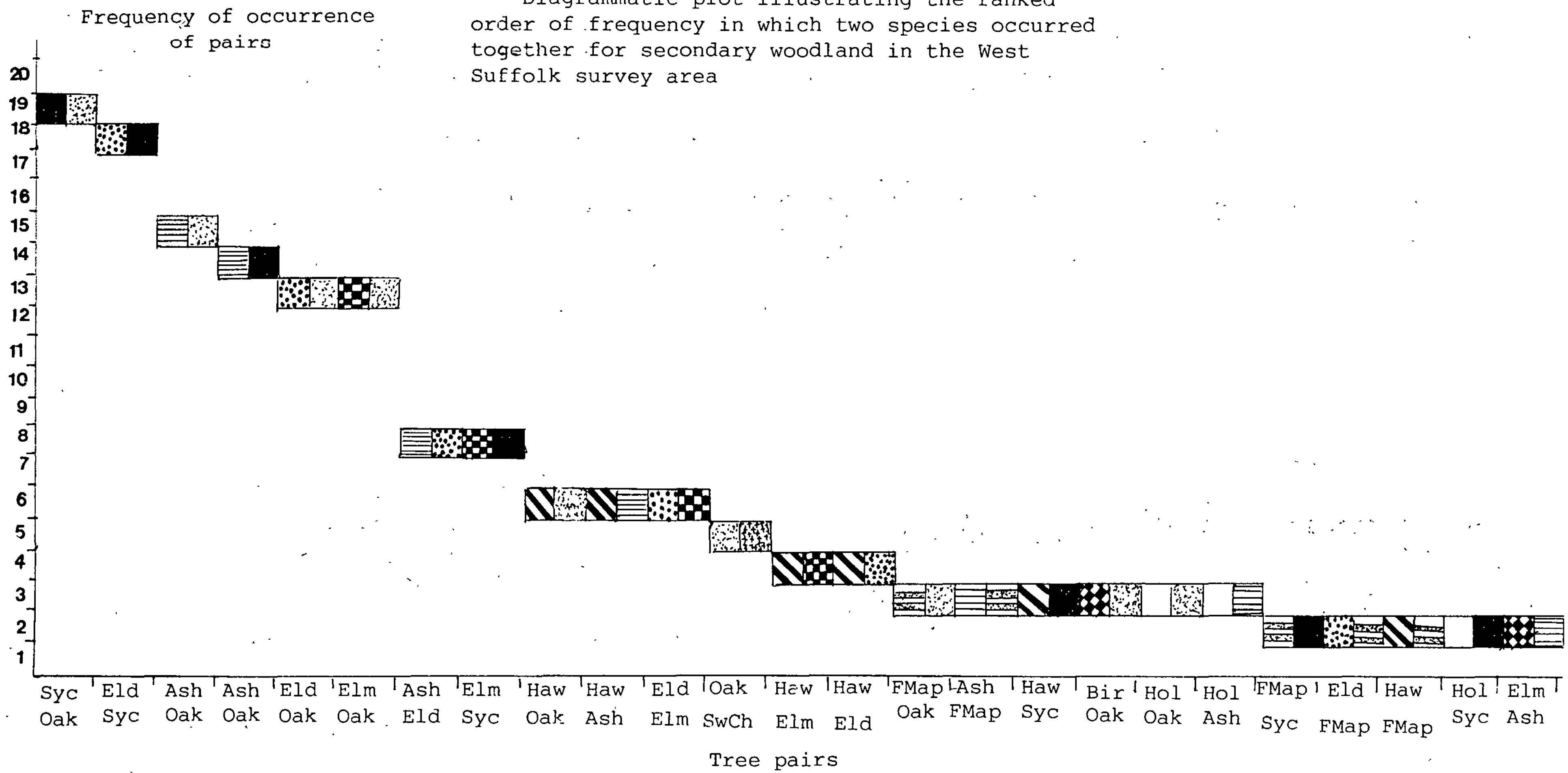


Fig 44 illustrates a ranked paired frequency plot for secondary woodland. Sycamore, oak and elder are the most frequently occurring tree species in various permutations. Ash/oak, ash/sycamore, elm/oak pairs are also relatively frequently occurring pairings. Hawthorn/oak and hawthorn/ash mark the point on the plot where there is no clear separation of species association by the frequency of paired occurrence.

Fig 45

Diagrammatic plot illustrating the ranked order of frequency in which two species occurred together for coniferous woodland in the West Suffolk survey area

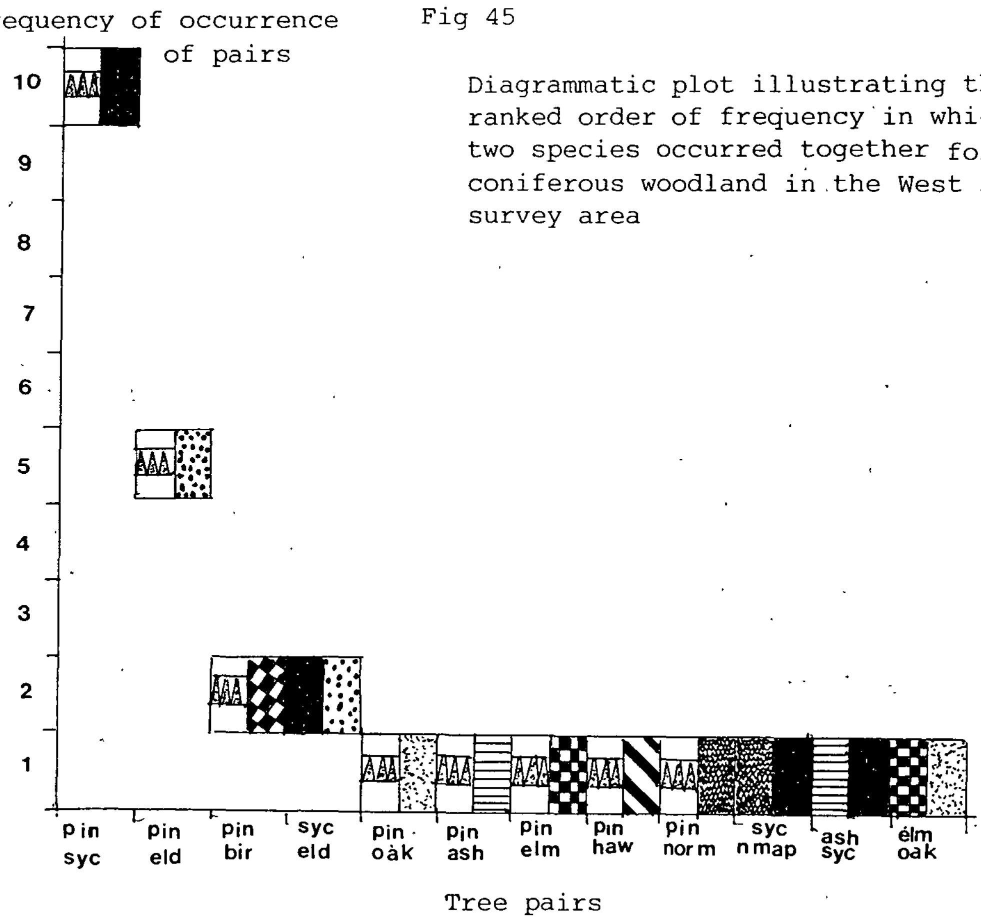


Fig. 45 illustrates paired frequency occurrences for coniferous woodland. It is clear that sycamore and elder are the most likely species to be found in association with conifers.

The sample for deciduous woodland was considered too small to apply this form of analysis.

Table 29 The combinations of species occurrences found in individual ancient woodlands in the West Suffolk area

Oak Ash Hazel Field Maple
Oak Ash Hazel Field Maple Hornbeam
Sycamore Oak Sweet Chestnut Elm Elder
Sycamore Oak Elm
Sycamore Oak Ash Elder Elm
Sycamore Oak Ash Elm Elder
Oak Ash Hazel Hornbeam Birch Elm
Sycamore Oak Ash Hazel Holly
Oak Birch
Oak Birch
Oak Birch
Oak Ash Field Maple Hawthorn
Oak Ash Hazel Hawthorn Elder
Ash Hazel Hornbeam Field Maple Alder
Sycamore Ash Hazel Field Maple
Sycamore Oak Ash Hazel Field Maple Elder
Ash Hazel Field Maple Birch Elder
Oak Ash Hazel Field Maple Birch Alder
Sycamore Oak Ash Hazel Sweet Chestnut
Sycamore Oak Ash Hornbeam Elder
Sycamore Oak Ash Hazel Field Maple Birch Hawthorn Elm Alder
Oak Ash Hazel Hornbeam
Oak Ash Hornbeam Field Maple Hazel Birch
Hornbeam
Oak Ash Hazel Field Maple Hawthorn Elder
Field Maple Hawthorn Elm Ash Hazel
Oak Ash Hazel Hornbeam Field Maple Alder
Oak Ash Hazel Field Maple Hawthorn
Ash Alder
Oak Ash Hazel Birch
Oak Ash Hazel Field Maple Hornbeam
Oak Ash Hazel Field Maple Elm
Sycamore Oak Ash Hazel Field Maple Chestnut Hawthorn
Ash Hazel Field Maple

Table 29 (continued)

The combination of species occurrences found in individual ancient woodlands in the West Suffolk area

Oak	Ash	Field Maple	Hazel	
Ash	Hornbeam	Elm		
Oak	Ash	Hazel	Field Maple	
Oak	Ash	Hazel	Field Maple	Hawthorn
Oak	Field Maple			
Sycamore	Oak	Ash	Sweet Chestnut	
Sycamore	Oak	Ash		
Ash	Hazel			
Oak	Ash	Hazel	Elm	
Sycamore	Oak	Ash	Hazel	
Oak	Ash	Hornbeam	Hazel	
Oak	Ash	Hazel	Birch	
Ash	Hazel	Field Maple		
Ash	Hazel	Field Maple	Elm	
Sycamore	Ash	Elm		
Sycamore	Oak	Ash	Hawthorn	
Sycamore	Hazel	Birch		
Hornbeam				

Only stands that were 100% pure to their woodland type were used in this investigation.

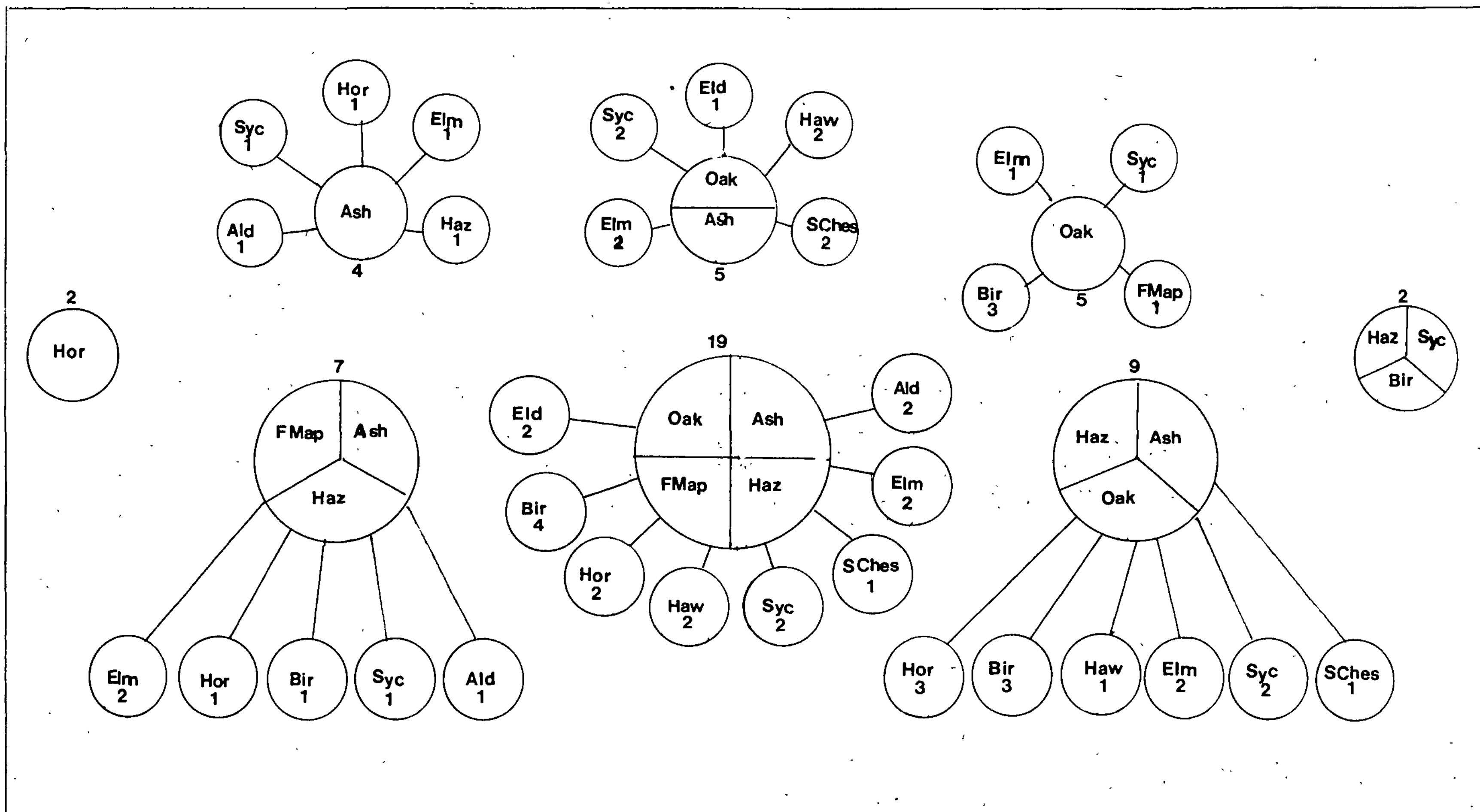


Fig 46 Main tree species association of ancient woodland in the West Suffolk area. Numbers inside circles are the number of times the species occurred with the association to which they are connected by a line. Based on species occurrences in West Suffolk woodland from the general survey

The analysis of pair associations provides a simple estimation of community structures in ancient woodland, coniferous plantations and secondary woodlands. Further classification of secondary woodlands and ancient woodlands was undertaken by selecting the specific combinations of species that occurred with the greatest frequency in each woodland sample. (Data from the general survey see figure for ancient woodland, table 18).

The most common combination was oak/ash/field maple/hazel (fig 46). In other woodlands either hazel or field maple was missing from the original oak/ash/field maple/hazel association. Four types of less frequent association were produced, ash, oak/ash, oak, hazel/sycamore/birch and pure hornbeam. In each of these associations only two species of the original oak/ash/field maple/hazel could be found in an individual woodland. Tree species that were found less frequently associated with each of the eight associations are illustrated in fig 46 and are considered to represent sub-communities of the main eight associations. It is apparent that sycamore is only absent from pure hornbeam woodland. This may be a result of the rarity of such woodland. Sycamore has invaded all the eight associations. This suggests that sycamore is unlikely to be excluded from invading ancient woodland because of interspecific competition between it and native species. It would also seem to appear that sycamore sycamore has no preference for invading specific tree associations. Peterken [59] and Rackham [64] have produced the most comprehensive existing classifications of ancient woodland types. Much of their work was undertaken in the East Anglian area, although not from the West Suffolk survey area. Rackham considers that there is a strong association between sycamore and ash/maple/hazel woods. The three most common associations recorded in the West Suffolk area are all probably of a similar type to Rackham's ash/maple/hazel woodlands. The oak components of the West Suffolk associations were usually uncoppiced standard trees. These are not included in Rackham's classification. In terms of predicting future tree species associations that include sycamore in the light of the abandonment of ancient management, the inclusion of uncoppiced trees would seem to be essential. Rackham [64] also confines his work to pure ancient woodland. Peterken [59] discounts the presence of sycamore in his classification of ancient woodland although he does suggest that sycamore may be commonly associated with valley ash/wych elm woodlands. Rackham[64] also considers that sycamore may be associated with valley woodland. Out of thirty one ancient woodlands with sycamore in the survey area, only two woodlands were of a valley floor type, casting some doubt on the general application of Rackham[64] and Peterken[59] to all areas of Britain.

Another difference between the classifications of Rackham[64] and Peterken[59] and that carried out in the West Suffolk area is the density of sampling which was much greater in the West Suffolk classification representing an intermediate scale of classification between individual woodlands and woodlands on a national scale. The Institute of Terrestrial Ecology's woodland classification (Bunce[5]) is based on ground flora associations and is, therefore, considered in the section of the thesis relating to ground flora (see page 226).

The same technique was used to produce a classification of species association for secondary woodland, see table 30 and fig 47. Five principle associations were evident: sycamore/oak/ash, sycamore/elder, sycamore, oak and ash/sycamore/elm. Elm was also strongly associated with the sycamore/oak/ash association. Hazel and field maple are very rare in secondary woodland and it would seem that sycamore replaces these species in secondary woodland. Ash, oak and elm remain well represented and form association with sycamore. Alder, sweet chestnut, birch and hornbeam are not represented in the secondary woodland associations. They are confined almost entirely to ancient woodland. Hawthorn appears in both the sycamore/elder and the sycamore/oak/ash association. In other sections of the thesis (see pp.122,128) it has been shown that ash, oak and sycamore are the most frequent and often the only species regenerating in ancient woodland. It is possible that future associations of ancient woodland and secondary woodland are developing towards a similarity of species composition, i.e. an oak/ash/sycamore association.

Table 30 The combinations of species occurrences found in individual secondary woodlands in the West Suffolk area

Ash	Oak	Elm				
Sycamore	Ash	Oak				
Sycamore	Elder					
Sycamore	Oak	Ash	Elm	Holly		
Sycamore	Oak	Elder				
Oak	Ash	Elm	Holly			
Sycamore	Ash	Field Maple	Hawthorn	Elm	Elder	
Sycamore	Ash	Elm				
Sycamore						
Sycamore	Oak	Elm	Elder			
Sycamore	Ash	Elm				
Sycamore	Elder					
Sycamore	Elder					
Sycamore	Ash	Elm				
Sycamore	Oak	Ash				
Sycamore	Ash					
Sycamore	Elder					
Sycamore	Elder					
Sycamore	Oak	Ash	Holly			
Sycamore	Elder					
Sycamore	Elm					
Sycamore	Ash	Hazel	Elder			
Sycamore	Oak					
Sycamore	Oak	Elder	Rhododendron			
Sycamore						
Sycamore	Oak	Ash	Field Maple	Hawthorn	Elm	Elder
Sycamore	Oak	Ash	Elm			
Sycamore	Oak	Hawthorn	Elder			
Sycamore	Oak	Ash	Hawthorn	Elm	Elder	
Sycamore						
Sycamore	Oak	Ash	Elm			
Oak						
Oak	Ash	Hawthorn				
Ash	Elm	Elder				
Oak	Ash	Birch	Elder			

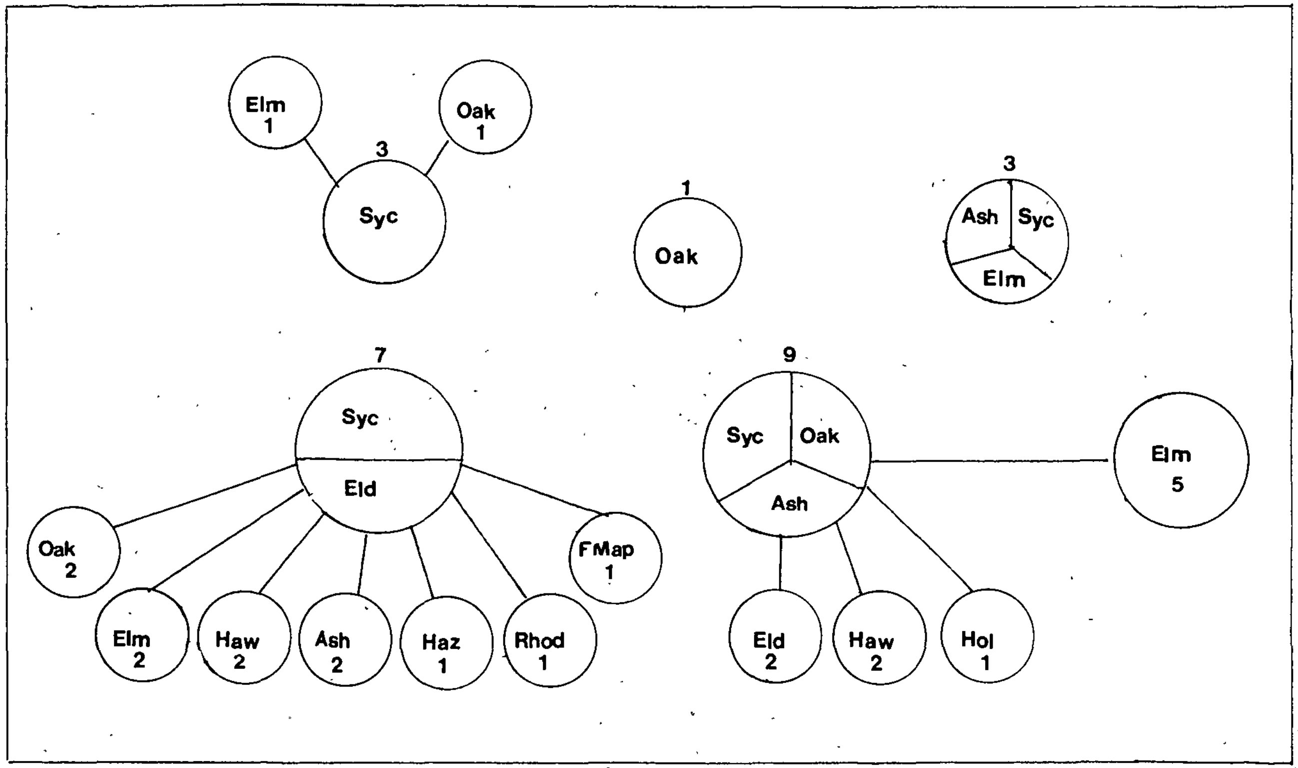


Fig 47 Main tree species association of secondary woodland in the West Suffolk area. Numbers inside the circles are the number of times the species occurred with the association to which they are connected by a line. Based on species occurrences in West Suffolk woodland from the general survey

The distribution of soils in the West Suffolk area

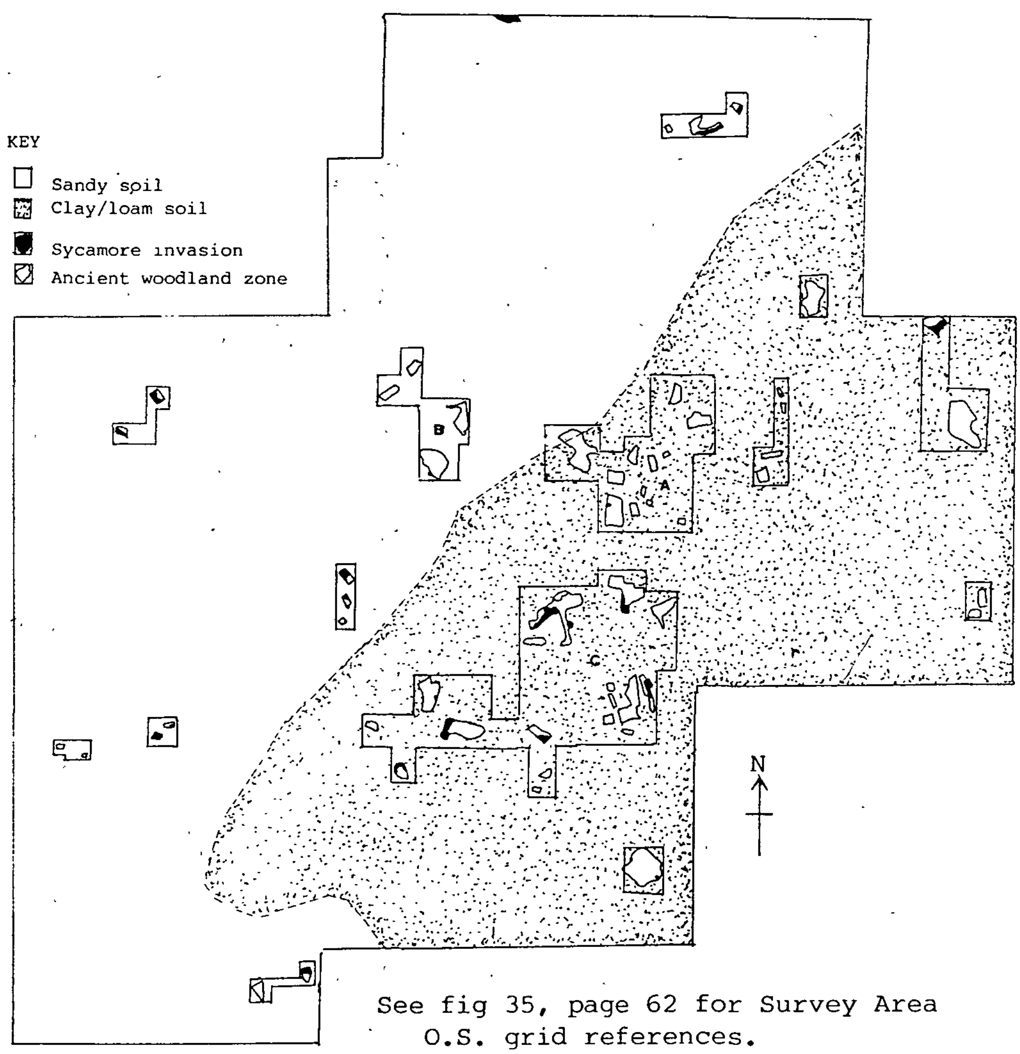
For most of the analysis of the status of sycamore in the West Suffolk community, the origins of woodlands and form of management to which woodlands have been subjected, have been considered to be of primary importance. It could be argued that edaphic or climatic conditions might be more significant in determining species distribution. The thesis does not seek to resolve this argument. This would require very detailed environmental analysis and possibly an alternative survey methodology. Evidence gained from such a study would also have to be carefully related to the effects of woodland origins, management practices and species dispersal amongst other environmental factors that affect species distribution in late twentieth century woodland habitats.

The concentration of effort on these factors can be justified by their relevance to conservation in rural areas and importantly, the impact of sycamore in the rural ecosystem with regard to practical conservation. However, the demographic distribution of soil types in the West Suffolk area is such that at least two types of soils with somewhat different characteristics exist. The two most readily identifiable soil types beneath the humus layer of woodlands (which of course, may be as important in determining species regeneration) are, according to the Soil Survey.[87] clay-loam or stragnoley soils and brown sands. The clay-loam soils overlay boulder clay and/or chalk. The brown sands overlay calcareous sands. The brown sands are a product of either wind blown loess or glacial out-wash and are comparable to Breckland soils. The survey area includes the margins of the East Anglian Brecklands. The brown sands are considered to be well drained and have a cumulative annual soil moisture deficit of greater than 100mm. The clay-loam soils are considered to have generally impeded drainage, but are considered to have a cumulative annual soil moisture deficit of more than 180mm, suggesting that they dry out considerably in the summer. As yet, the Soil Survey has made no detailed survey of soil types in the West Suffolk area. The scale therefore of their present interpretations make it difficult to define accurately the division between the two soil types. It is likely that there is a transition of soil types across this division. Trenches were dug at many woodland sites in the general survey (see text page 47). These assisted the identification of soil distribution, however greater variations were noted than suggested by the general Soil Survey[87]. These could be attributable to anthropogenic disturbance of soils or by the relationship between soils and their vegetation cover. However, a basic geographical distribution of the two soil types was produced from field soil examination and the general Soil Survey[87] and local familiarity. Division was made between soils of predominantly clay-loam character and those of a predominantly sandy character.

Fig 48 is a map of the West Suffolk survey area and indicates the distribution of clay-loam soils. Ancient woodlands and the distributions of sycamore in the general survey area have been included. Concentrations of groups of ancient woodlands have been outlined. It appears that most ancient woodland is located on the clay-loam soils although there were three relatively large ancient woodlands present on Breckland type soil which could not be included in the survey due to not being able to gain access permission. These have not been illustrated. It is also evident that the concentrations of ancient woodland marked (A) and (B) are relatively free of sycamore invasion. If conservationists in the West Suffolk area consider it desirable to maintain areas of ancient woodland without sycamore, it would seem sensible that these are the areas to which their efforts should be targeted. It could be that soil is limiting sycamore in these areas, but this would not seem to be related to whether soils are sandy or clay-loam.

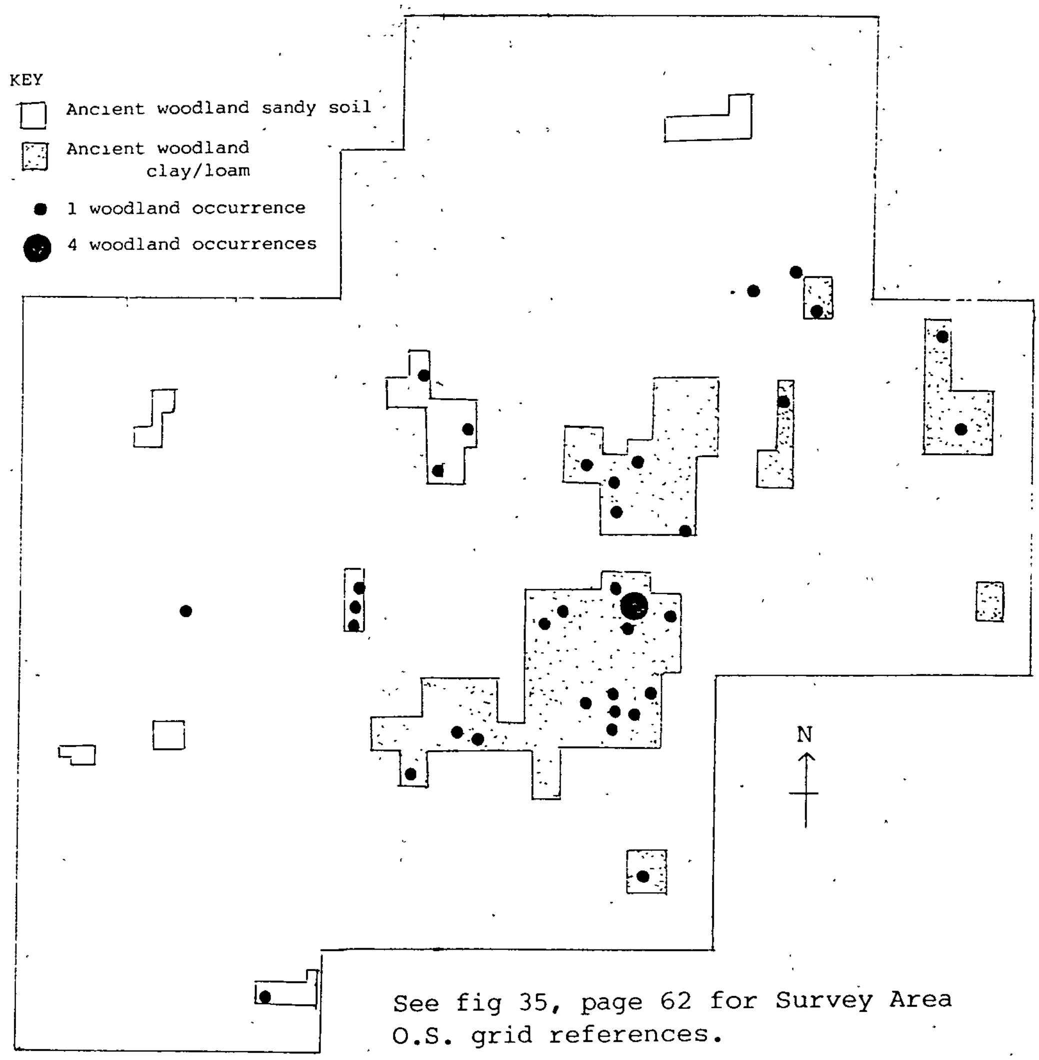
In figs 49, 50, 51 and 52 which follow, the distributions of all trees were plotted on a map of the survey area using graded circles to represent the occurrences of a species in a woodland. For closely situated woodlands, occurrences in each woodland were amalgamated and recorded with a circle size relative to the number of occurrences. Figs 49 and 50 illustrate the occurrences of field maple and hazel with the outlined areas (from fig 48) of ancient woodland superimposed. Both hazel and field maple distributions are mainly concentrated in the ancient woodland clay-loam soil areas. Again it is not clear whether it is the relationship of hazel and field maple to ancient woodland or soils that affects their distribution. Fig 51 and fig 52 are similarly mapped distributions of ash and oak. Whilst commonly found in ancient clay-loam woodlands, both species are also found on sandy sites and outside areas of ancient woodland.

Fig 48 Map of the West Suffolk survey area illustrating the distribution of ancient woodland, sycamore invasions, ancient woodland zones, sandy soils and clay-loam soils



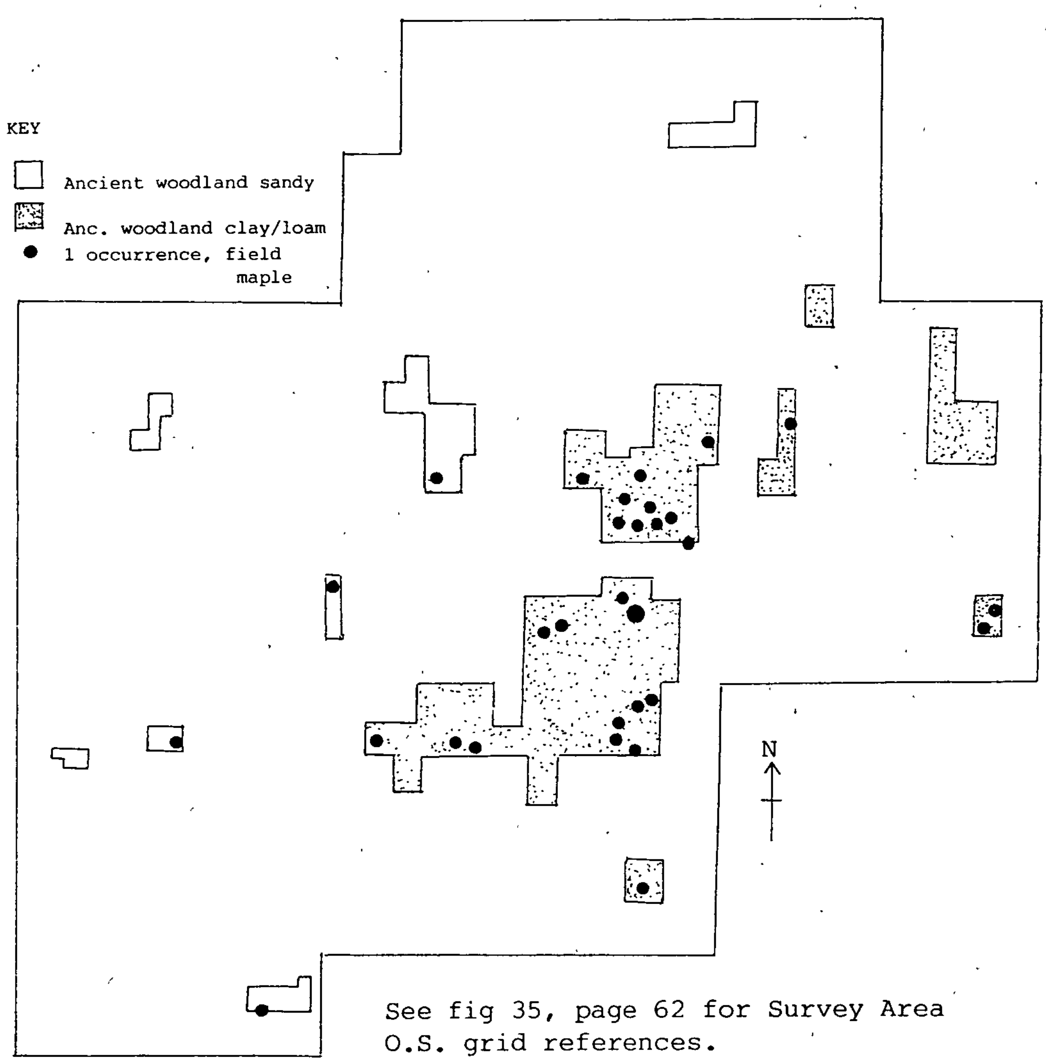
See fig 35, page 62 for Survey Area O.S. grid references.

Fig 49 Map of the West Suffolk survey area illustrating the woodland occurrences of hazel, the distribution of ancient woodland clay-loam zones and the distribution of ancient woodland sandy zones



See fig 35, page 62 for Survey Area O.S. grid references.

Fig 50 Map of general survey area illustrating the distribution of field maple occurrences in ancient woodland sandy soil and ancient woodland clay-loam zones



See fig 35, page 62 for Survey Area O.S. grid references.

Fig 51 Map of the general survey area of West Suffolk illustrating the woodland occurrences of ash, the distribution of clay-loam zones and ancient woodland sandy zones

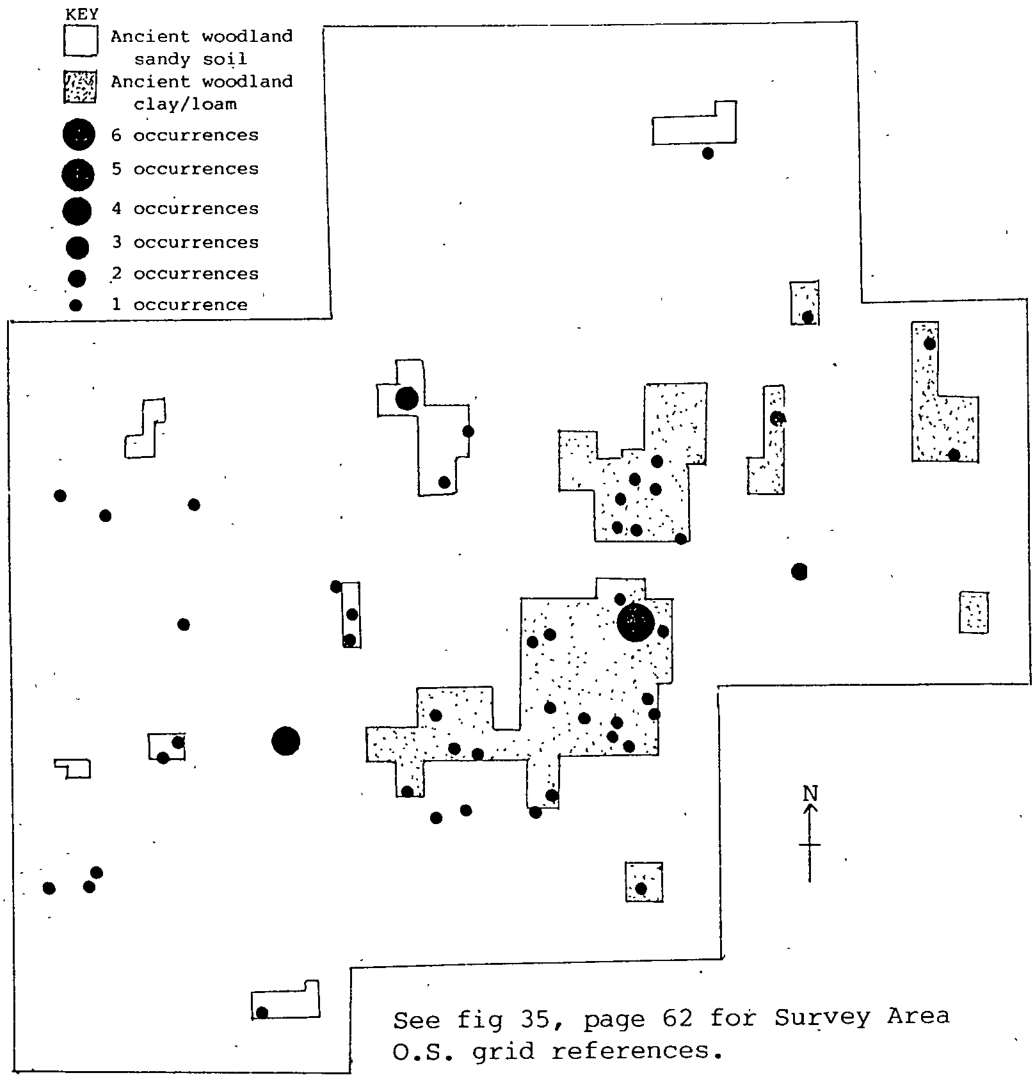
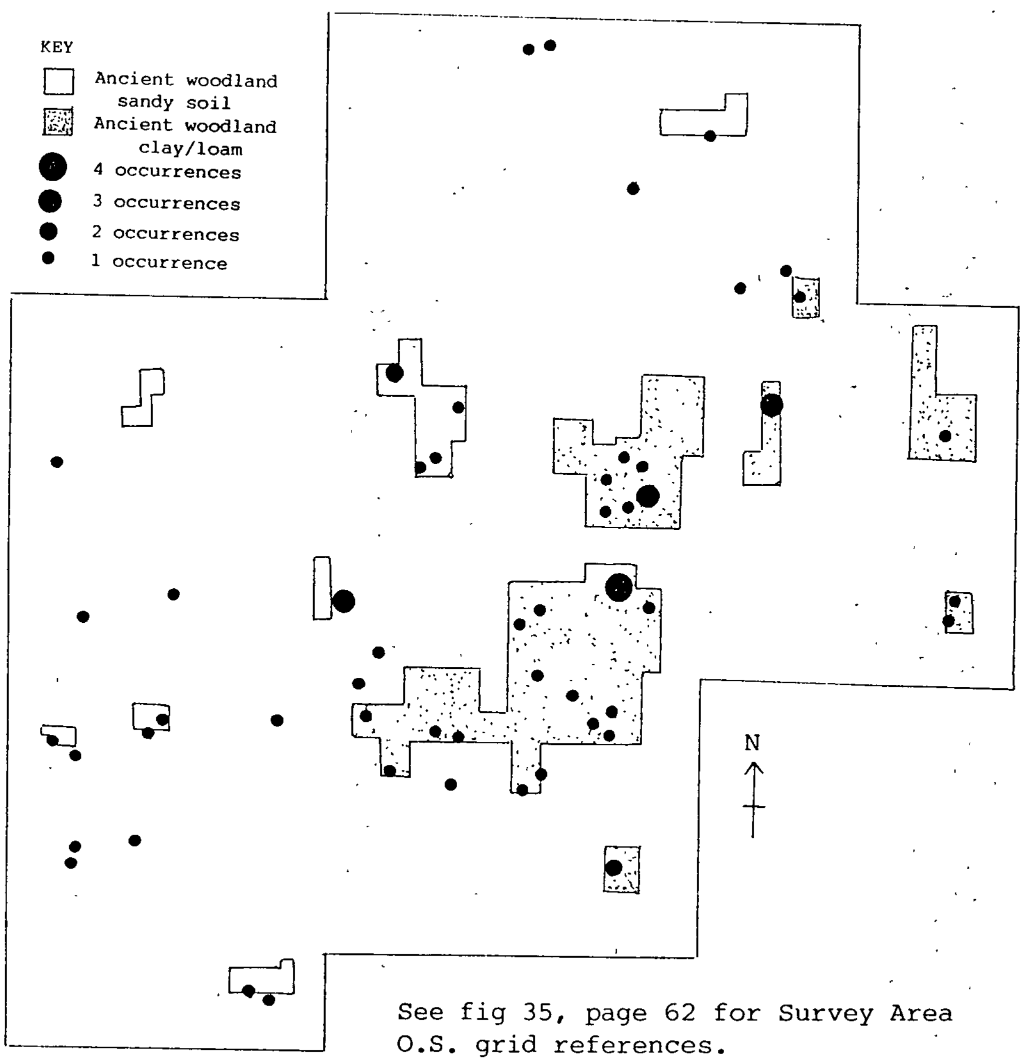


Fig 52 Map of the West Suffolk survey area illustrating the distribution of oak woodland occurrences, the distribution of ancient woodland clay-loam zones and ancient woodland sandy zones



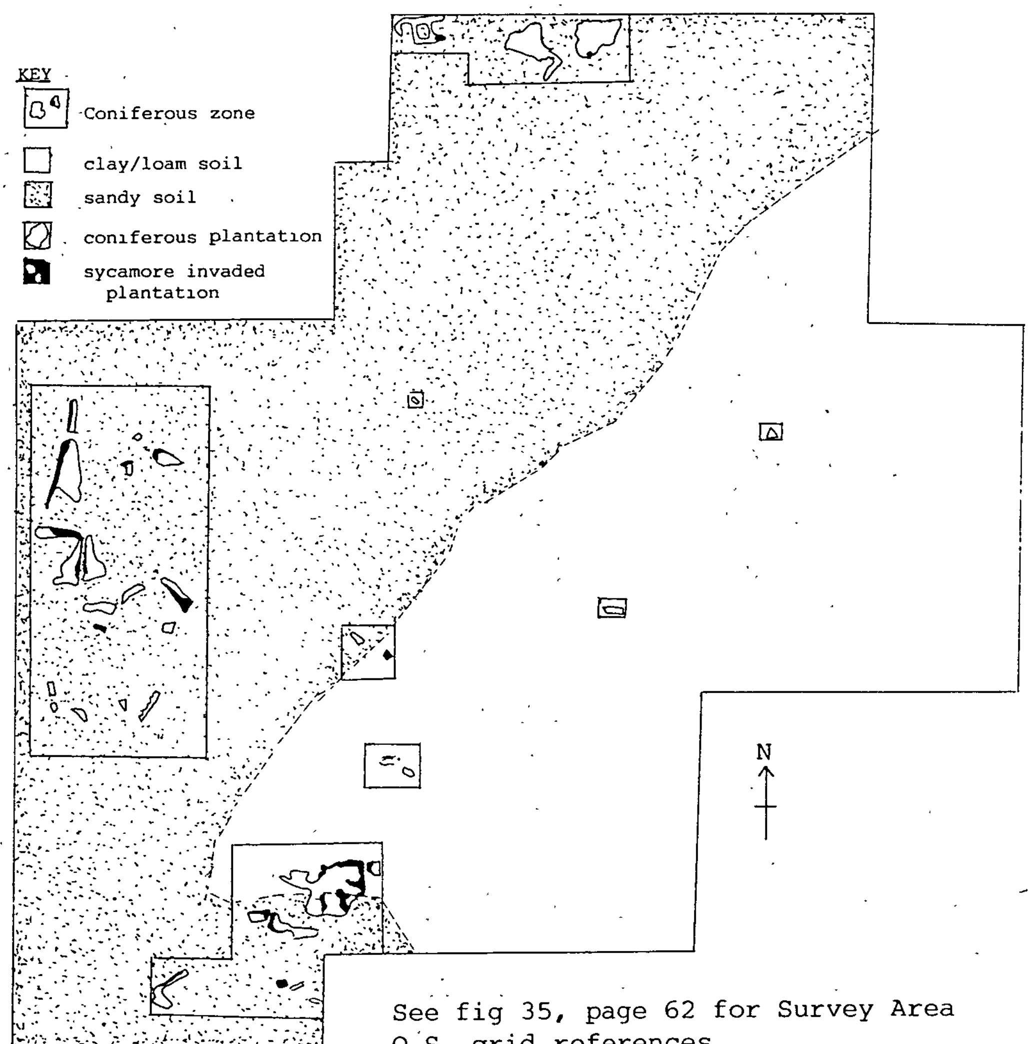
See fig 35, page 62 for Survey Area O.S. grid references.

Fig 53 following, illustrates the distribution of sandy soils and indicates the presence of coniferous plantation areas. Most coniferous plantations are found on the sandy loam area.

Fig 54 illustrates the distribution of secondary woodlands. Areas of secondary woodland have been plotted as for coniferous plantations and ancient woodland. Fig 56 illustrates the distribution of sycamore in relation to these secondary woodland zones. It can be seen that neither the distribution of sycamore or secondary woodland is limited to a particular soil type. The soils of secondary woodland are likely to have been modified by anthropogenic influence.

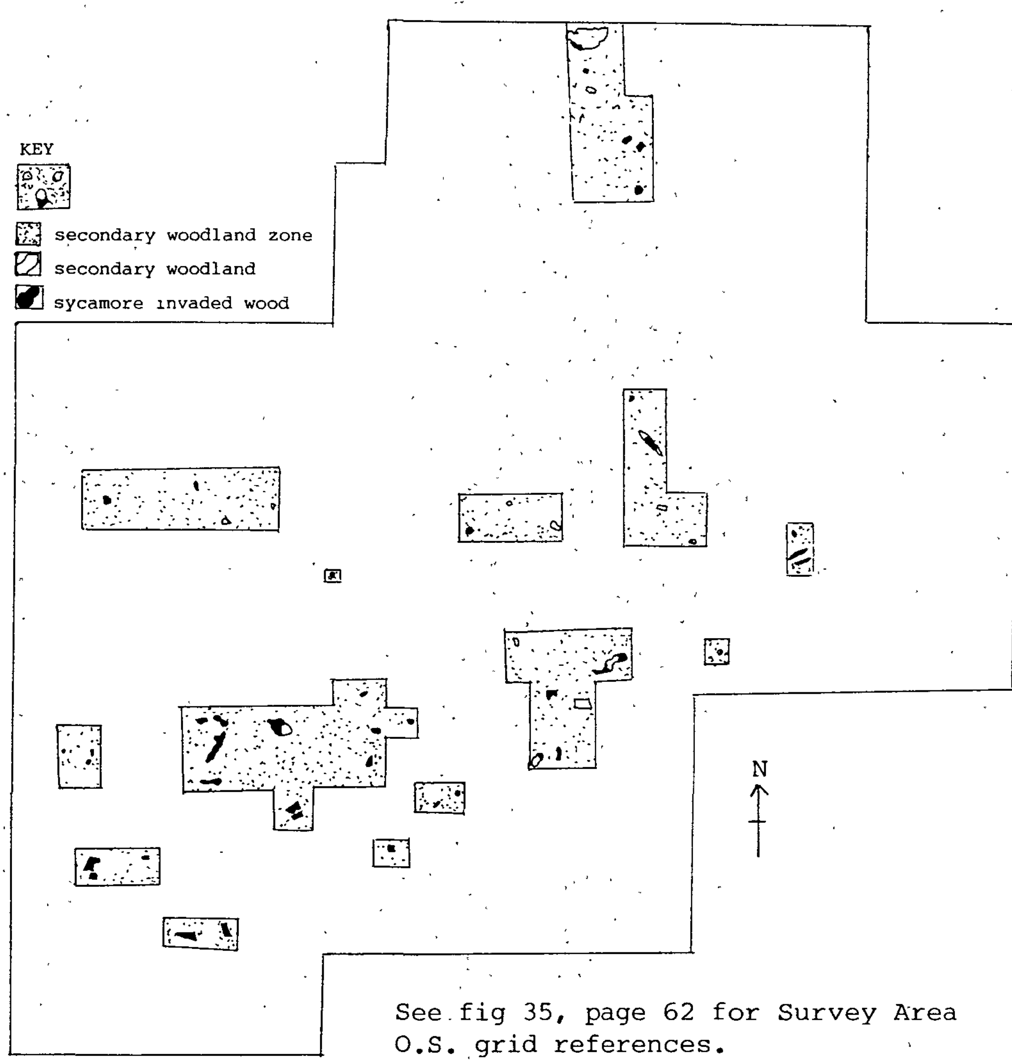
Fig 55 illustrates the distribution of elder (commonly found in association with sycamore in ancient woodland). If anything, both the distribution diagrams of sycamore and elder, figs 55 and 56, indicate a greater frequency of occurrence in the areas marked (A). This area is nearest to the closest town-size settlement to the survey area, Bury St. Edmunds. The relative abundance of sycamore occurrence could be a result of a greater historic anthropogenic disturbance of woodland in area (A). A greater incidence of sycamore introductions, routeways and secondary woodland may also have some involvement in this relationship. It is possible that more detailed soil analysis would reveal a more favourable soil type to sycamore and elder in areas (A).

Fig 53 Map of the West Suffolk survey area illustrating coniferous woodlands on clay-loam soil, coniferous woodland on sandy soil, coniferous woodland zones and sycamore invasions



See fig 35, page 62 for Survey Area O.S. grid references.

Fig 54 Map of the West Suffolk survey area illustrating secondary woodland, all sycamore in secondary woodland and secondary woodland zones



See fig 35, page 62 for Survey Area O.S. grid references.

Fig 55 Map of the general survey area illustrating the distribution of woodland elder occurrences and secondary woodland zones

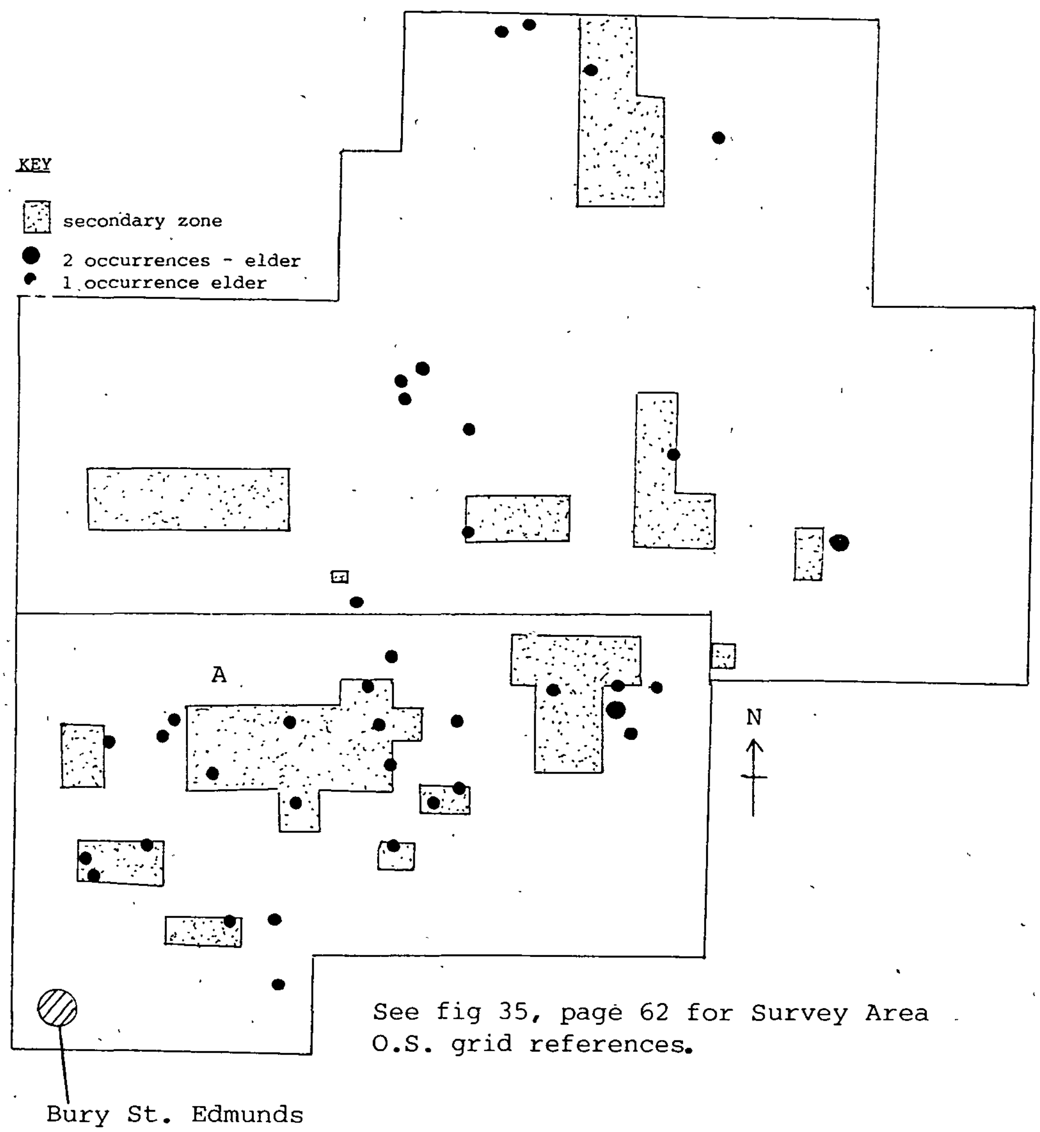
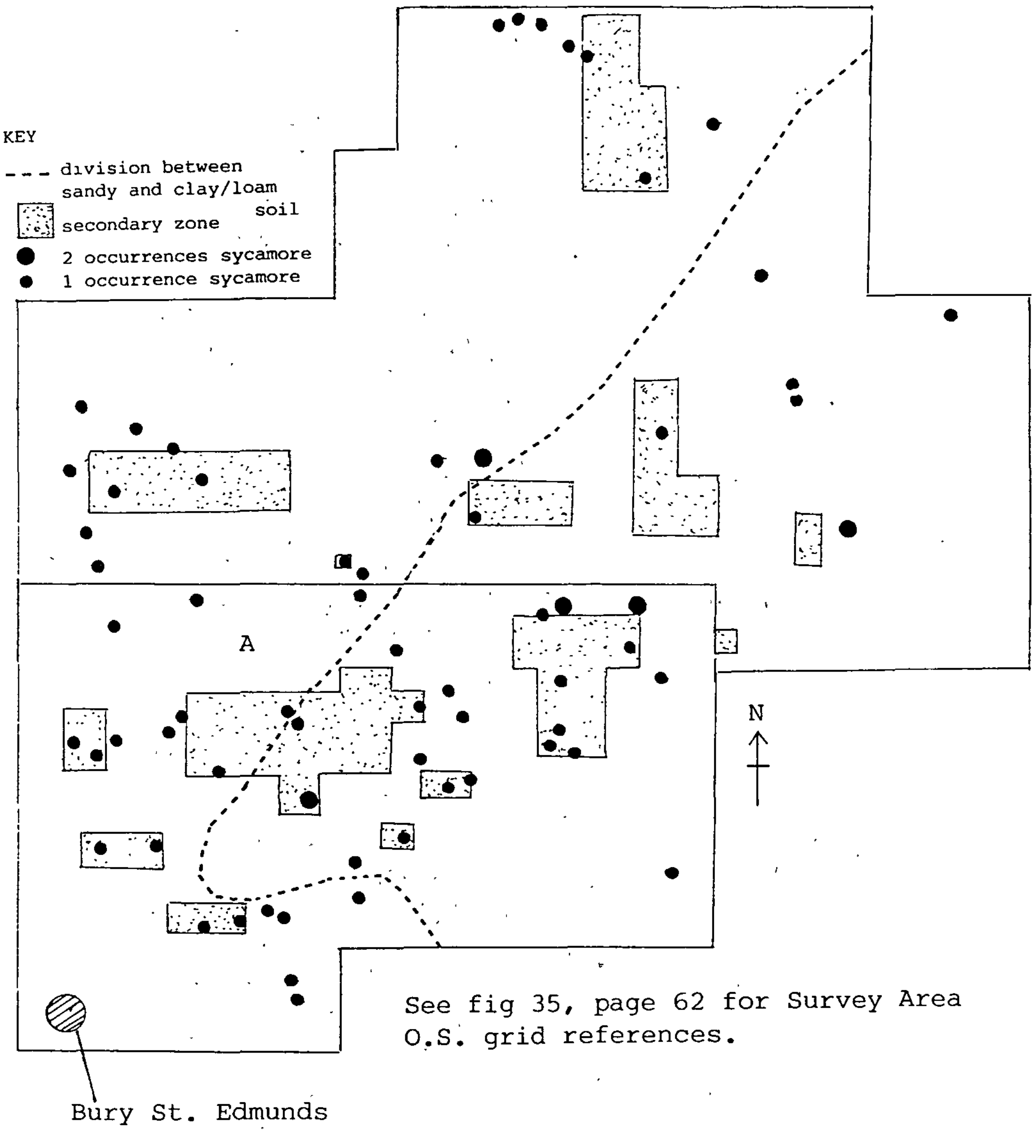


Fig 56 Map of the West Suffolk survey area illustrating the distribution of sycamore woodland occurrences, secondary woodland zones and the division between sandy soil and clay-loam soils



See fig 35, page 62 for Survey Area O.S. grid references.

The climate of West Suffolk according to the Ordnance Survey bioclimatic classification [87] is 'D4' with mean annual daytime temperatures of between 5° – 6° C and mean annual rainfall of 560mm.* This rainfall is relatively low for the British Isles. Piggot [61] suggests that sycamore distribution may be related to rainfall and that sycamore regeneration requires relatively moist conditions. The occurrence of sycamore in roadside ditches and ancient woodland ditches suggests that soil moisture may indeed aid sycamore regeneration or deter the regeneration of other species. However the fact that sycamore regenerates freely on both soil types in the West Suffolk area, each with substantial soil moisture deficits, suggests that rainfall and moisture availability is not a limiting factor in sycamore regeneration. In most woodlands in the West Suffolk area, woodland soils could actually have greater water retention properties than those quoted in the Ordnance Survey surveys [87].

The classification of woodlands has so far been based on present associations. The occurrence of all seedlings and degenerate+ trees found in the general survey were recorded according to species and the wood in which they were found. The % estimates from Record Sheet Two of the general survey (see text page 50) were used to produce pie charts of seedlings and degenerate trees for each woodland in which they occurred. The % estimates are recorded in tables 31 and 32 . They have been plotted as pie charts on woodland maps of the West Suffolk survey area (see figs 57 and 58).

The distribution of seedlings shows no clear demographic zonation of regeneration - both ash and sycamore are regenerating throughout the survey area. They may occur together or with less commonly regenerating species or as a single regenerating species in a woodland. Throughout the survey area, again with no clear demographic zonation, elm and oak are the most frequently occurring degenerate trees.

\+ degenerate = senescent, fallen or decaying from disease

* 1974 - 1986 Information obtained from Honington R.A.F. Meteorological Station

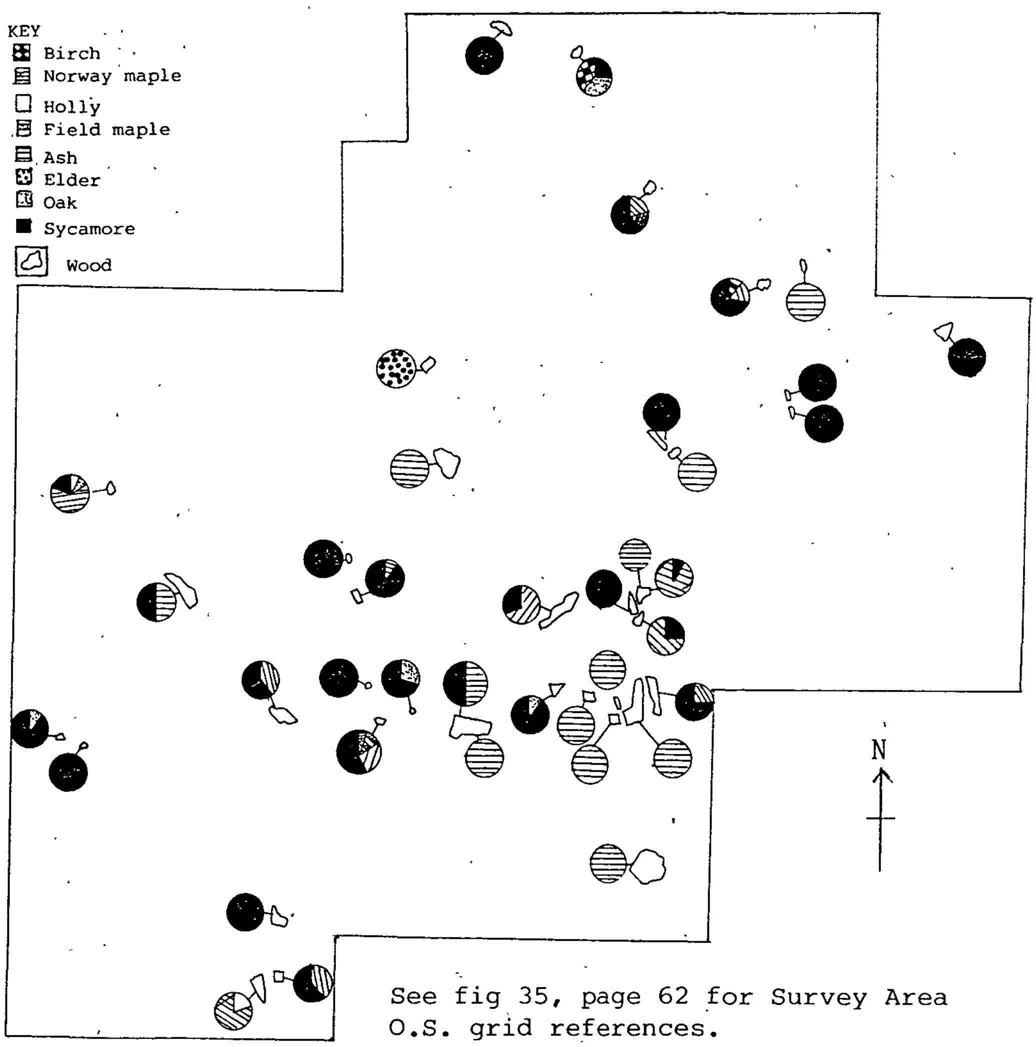
Table 31 Figures for seedlings from Record Sheet Two data (fig 31) % estimates of seedling abundance

Names of woods	Ash	Hol	Syc	Oak	FMap	Bir	NMap	Eld	Haw
Barningham Copse	20	0	60	0	0	0	20	0	0
Eastlow Hill	80	20	0	0	0	0	0	0	0
Ivy Nook Copse	100	0	0	0	0	0	0	0	0
Pakenham Wood C	100	0	0	0	0	0	0	0	0
Wytchingham Plantation	20	0	70	0	0	0	0	0	10
Stowlangtoft Wood Two	100	0	0	0	0	0	0	0	0
Stockings Wood	100	0	0	0	0	0	0	0	0
Stowlangtoft Copse 3	100	0	0	0	0	0	0	0	0
Shepherd's Grove	100	0	0	0	0	0	0	0	0
Colton Copse	0	0	100	0	0	0	0	0	0
Knettishall Heath P, Q	0	0	100	0	0	0	0	0	0
Pakenham Wood B, A	50	0	50	0	0	0	0	0	0
Fish's Heath A, C	70	0	30	0	0	0	0	0	0
Sumner Road One	0	0	100	0	0	0	0	0	0
Bangrove Wood	100	0	0	0	0	0	0	0	0
Langham Hills Six	0	0	100	0	0	0	0	0	0
Langham Hills Ten	100	0	0	0	0	0	0	0	0
Sumner Road Two	0	0	100	0	0	0	0	0	0
Calke Wood B	0	0	100	0	0	0	0	0	0
Calke Wood A	0	0	100	0	0	0	0	0	0
Stowlangtoft Woods A	25	0	75	0	0	0	0	0	0
Fish's Heath B	70	0	30	0	0	0	0	0	0
Hollow Road One	0	0	90	10	0	0	0	0	0
Grundle A	0	0	100	0	0	0	0	0	0
Pakenham Pit	0	0	70	30	0	0	0	0	0
Ampton Common Covert	75	10	10	5	0	0	0	0	0
Stowlangtoft Spinney	0	0	100	0	0	0	0	0	0
Thurston Sewage	30	0	60	5	5	0	0	0	0
Great Barton A	40	0	60	0	0	0	0	0	0
Timworth Hall	50	0	50	0	0	0	0	0	0
Langham Hills Seven	70	0	30	0	0	0	0	0	0
Rougham Plantation	40	0	60	0	0	0	0	0	0
Knettishall Heath O	20	0	60	0	0	0	20	0	0
Rougham Rookery	0	0	100	0	0	0	0	0	0

Table 32 Figures for degenerate trees from Record Sheet Two (fig 31) % estimates of seedling abundance

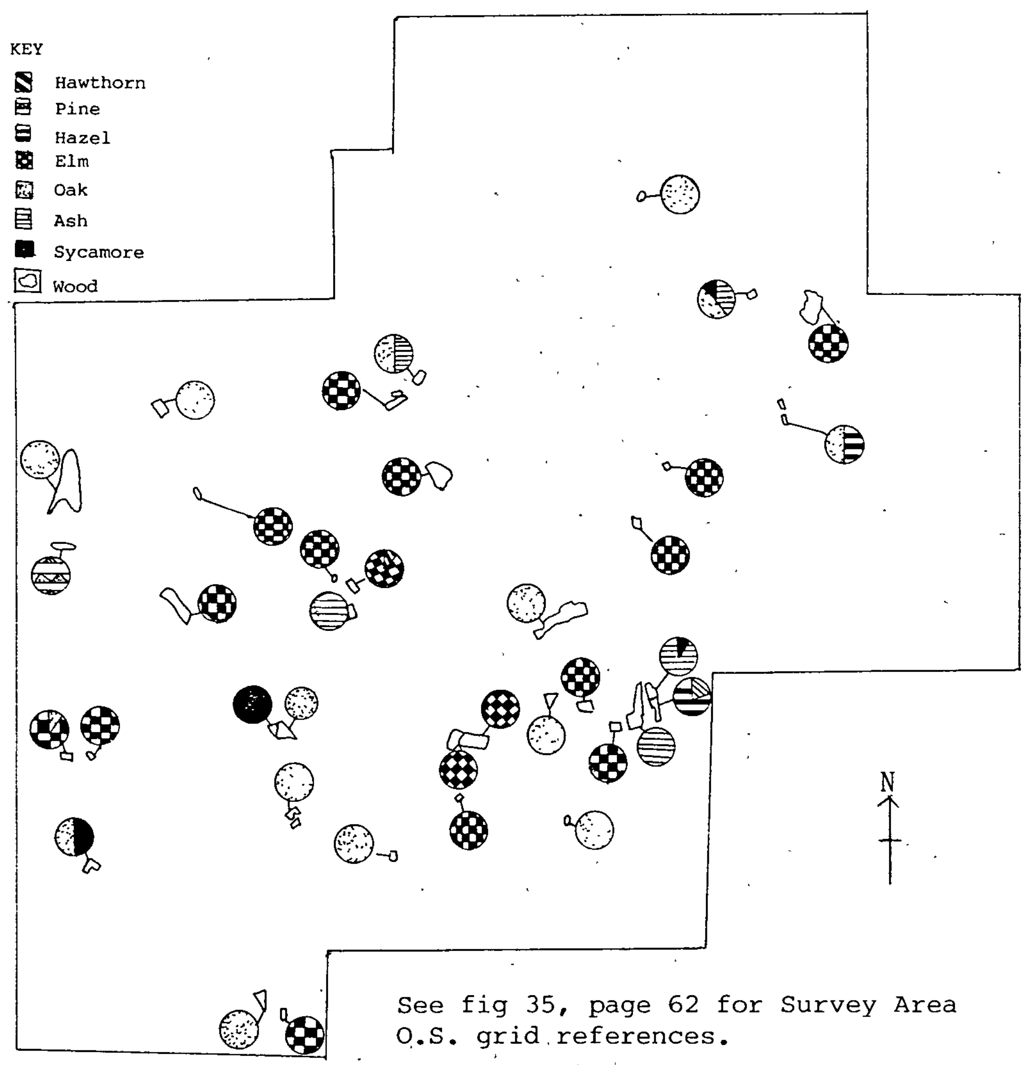
	Oak	Elm	Ash	Haz	Syc	Bir	Haw	Pine
Eastlow Hill	100	0	0	0	0	0	0	0
Colton Copse	0	100_{Cn}	0	0	0	0	0	0
Hollow Road Two	0	100_{Cn}	0	0	0	0	0	0
Thorpe Carr	50_{Cn}	0	50_{Cn}	0	0	0	0	0
Stowlangtoft Wood A	0	0	20	80	0	0	0	0
Stowlangtoft Wood B	0	0	90	0	10	0	0	0
Pakenham Wood B	0	0	0	0	0	100	0	0
Pakenham Wood C	0	0	0	0	0	100	0	0
Great Queach	0	0	100	0	0	0	0	0
Fish's Heath	100	0	0	0	0	0	0	0
Stowlangtoft Wood Two	0	0	100	0	0	0	0	0
Stowlangtoft Copse One	0	100	0	0	0	0	0	0
Brockley Wood	0	100	0	0	0	0	0	0
Sumner Road One	50	0	0	50	0	0	0	0
Bangrove Wood	0	100	0	0	0	0	0	0
Shepherd's Grove	0	100	0	0	0	0	0	0
Mulley's Grove	0	100	0	0	0	0	0	0
Ash Copses	0	100	0	0	0	0	0	0
Hollow Road One	10	90	0	0	0	0	0	0
Thurston School Copse	100_{St}	0	0	0	0	0	0	0
Brand Spinney	100_{St}	0	0	0	0	0	0	0
East Barton Copse	100_{St}	0	0	0	0	0	0	0
Stowlangtoft Spinney	100_{St}	0	0	0	0	0	0	0
Moreton Hall	50_{CoCn}	0	0	0	50_{CoCn}	0	0	0
Thurston Bayer	0	100	0	0	0	0	0	0
Great Barton A	0	0	0	0	100	0	0	0
Great Barton B	100	0	0	0	0	0	0	0
Ixworth Thorpe Copse	0	100	0	0	0	0	0	0
Virginia's Copse	0	100	0	0	0	0	0	0
Queach Farm	0	0	0	0	0	90	10	0
Stocking's Wood	0	100	0	0	0	0	0	0
Game Close Copse	0	100	0	0	0	0	0	0
Barningham Copse	100	0	0	0	0	0	0	0
Wytchingham	40	0	40	0	10			
Timworth Covert	0	100	0	0	0	0	0	0
Ampton Field	0	0	0	0	0	0	0	100
Folly Grove	100_{St}	0	0	0	0	0	0	0

Fig 57 . Map of West Suffolk survey area illustrating the distribution of regenerating trees. Pie diagrams for each wood depict proportions of regenerating trees at each wood . Based on general survey Record Card Two data.



See fig 35, page 62 for Survey Area O.S. grid references.

Fig 58 Map of West Suffolk area illustrating the distribution of degenerate trees. Pie diagrams for each wood depict proportions of degenerating trees at each wood. Based on general survey Record Card Two data.



See fig 35, page 62 for Survey Area O.S. grid references.

Summary

1. Oak, ash, hazel, field maple, birch and hornbeam, hawthorn and elm are the most common ancient woodland species. Sycamore frequently occurs as an invasive species.

2. Sycamore, oak, ash, elm, elder and hawthorn are the most commonly occurring secondary woodland species. Field maple and hazel are almost absent from secondary woodland.

3. Permutations of hazel, ash, oak and field maple are the most frequently associated pairs of trees in ancient woodland.

4. Permutations of sycamore, elder, ash, oak and elm are the most frequently associated pairs of species in secondary woodland.

5. The ancient woodlands of West Suffolk can be divided into seven main associations . The three most frequently occurring associations are oak/ash/field maple/hazel; field maple/ash/hazel and hazel/ash/oak.

6. Secondary woodlands in West Suffolk can be divided into five main associations. The two most common of these are sycamore/elder and sycamore/oak/ash.

7. Ancient woodland without sycamore invasion is most commonly found on clay-loam soil relatively far away from the largest anthropogenic settlement in the area.

8. Secondary woodland is more common nearer to the largest anthropogenic settlement.

9. Coniferous plantations are more frequent on sandy soils.

10. There appears to be no clear relationship between species regeneration and degeneration to either of the two West Suffolk soil types. Sycamore and ash are regenerating throughout the survey area. Elm and oak are degenerating (or have been felled) throughout the survey area.

Chapter 4

THE COMPETITIVE STATUS OF SYCAMORE WITHIN THE WEST SUFFOLK WOODLAND TREE SPECIES COMMUNITY

Each woodland in the West Suffolk area was considered to represent a sub-unit of the complete woodland community of West Suffolk. The following section of the thesis seeks to examine the status of sycamore in the woodland community. The species-structure classification (see p 30) has been used extensively and the results of the general survey (see p 47) have been the source data for the analyses presented. Table 33 (see p. 126) illustrates the number of occurrences of species according to structural class as a total for all ancient woodlands included in the general survey. Only ancient woodlands and secondary woodlands are investigated in this analysis. Table 36 (p. 140) illustrates the number of occurrences of species according to structural class as a total of all occurrences in secondary woodland. The total occurrences for secondary woodland and ancient woodland are further subdivided into woodlands with sycamore present and woodlands with sycamore absent. These subdivisions are used for a later analysis.

The analysis of tree species occurrence in ancient woodland

The thirteen structural classes illustrated in Table 33, Total all ancient woodland occurrences, were reduced to four sub-categories for analysis. These categories were 1) saplings, oskars and seedlings; 2) canopy standards and poles; 3) all coppice categories and 4) all degenerate trees. These sub-categories are illustrated in table 34. The % occurrence of each species according to the four sub-categories of structure has been calculated by the formula :

$$\% \text{ occurrence} = \frac{\text{occurrence of species sub-category}}{\text{total of all occurrences in sub-category}} \times 100$$

The results give a useful description of the occurrence of species structural classes in relation to the complete ancient woodland tree community in the survey area.

Table 33 TOTAL ALL ANCIENT WOODLAND OCCURRENCES

A Without sycamore (NS)

Tree Species	DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se	Total
Oak	1	0	3	0	0	22	5	5	0	3	0	0	0	39
Ash	0	3	1	0	0	18	15	1	9	0	4	0	7	57
Hazel	0	1	0	0	0	0	1	1	20	0	10	0	0	33
Field Maple	0	0	0	0	0	7	9	0	9	0	3	0	0	28
Sycamore	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elm	0	0	1	4	0	1	0	4	0	0	0	0	0	10
Hornbeam	0	0	0	0	0	0	5	1	2	0	0	0	0	8
Elder	0	0	0	0	0	0	0	1	0	3	0	0	0	4
Hawthorn	0	0	0	0	0	0	0	4	0	5	0	0	0	9
Birch	0	1	2	0	0	3	3	2	1	4	0	0	0	16
Alder	0	0	0	0	0	2	1	0	1	0	0	0	0	4
Pine	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Holly	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willow	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Sweet chestnut	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Horse chestnut	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway Maple	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhododendron	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blackthorn	0	0	0	0	0	1	0	1	0	1	0	0	0	3
Yew	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other conifer	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beech	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poplar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0
False Acacia	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Total sites 23

B With sycamore (WS)

Tree Species	DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se	Total
Oak	2	0	3	0	0	20	1	1	0	0	0	0	0	27
Ash	0	2	0	0	0	10	8	2	2	6	0	0	6	36
Hazel	0	0	0	0	0	0	1	0	11	0	6	0	0	18
Field Maple	0	1	0	0	0	6	8	3	2	0	0	0	0	20
Sycamore	0	0	1	0	0	6	4	7	4	14	1	5	7	49
Elm	0	3	3	3	0	1	1	4	1	2	0	0	0	18
Hornbeam	0	0	0	0	0	0	3	0	0	0	0	0	0	3
Elder	0	0	0	0	0	0	0	0	0	4	0	0	0	4
Hawthorn	0	0	0	0	0	0	0	2	0	2	0	0	0	4
Birch	0	0	0	0	0	1	1	0	0	0	0	0	0	2
Alder	0	0	0	0	0	1	3	0	0	0	0	0	0	4
Pine	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Holly	0	0	0	0	0	0	0	0	0	2	0	0	1	3
Willow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet chestnut	0	2	0	0	0	2	0	0	2	0	1	0	0	7
Horse chestnut	0	0	0	0	0	0	2	0	1	0	1	0	0	4
Norway Maple	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhododendron	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blackthorn	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yew	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other conifer	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beech	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Poplar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0
False Acacia	0	0	1	0	0	1	0	0	0	1	0	0	0	3

Total sites 41

C All woodland

Tree Species	DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se	Total
Oak	2	0	6	0	0	42	6	6	0	3	0	0	0	65
Ash	0	5	1	0	0	28	23	3	11	6	4	0	13	94
Hazel	0	1	0	0	0	0	2	1	31	0	16	0	0	51
Field Maple	0	1	0	0	0	13	17	3	11	0	3	0	0	48
Sycamore	0	0	1	0	0	6	4	7	4	14	1	5	7	59
Elm	0	3	4	7	0	2	1	8	1	2	0	0	0	28
Hornbeam	0	0	0	0	0	0	8	1	2	0	0	0	0	11
Elder	0	0	0	0	0	0	0	1	0	7	0	0	0	8
Hawthorn	0	0	0	0	0	0	0	6	0	7	0	0	0	13
Birch	0	1	2	0	0	4	4	2	1	4	0	0	0	18
Alder	0	0	0	0	0	3	4	0	1	0	0	0	0	8
Pine	0	0	0	0	0	1	0	1	0	0	0	0	0	2
Holly	0	0	0	0	0	0	0	0	0	2	0	0	1	3
Willow	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Sweet chestnut	0	2	0	0	0	2	2	0	2	0	1	0	0	9
Horse chestnut	0	0	0	0	0	0	2	0	1	0	1	0	0	4
Norway Maple	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhododendron	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blackthorn	0	0	0	0	0	1	0	1	0	1	0	0	0	3
Yew	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other conifer	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beech	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Poplar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0
False Acacia	0	0	1	0	0	1	0	0	0	1	0	0	0	3

Total sites 54

Table 34 Ancient woodland - % species occurrences reduced to four structural sub categories (abbreviated from General Survey data, C All woodland, table 33)

Tree Species	DeStu	DeCo	DeCn	DePo	DeSa	Total	%	CnSt	Po	Total	%	CoCn	CoPo	CoSa	Total	%	Sa	Os	Se	Total	%
Oak	2	0	6	0	0	8	22.2	42	6	48	34.2	6	0	0	6	3.7	3	0	0	3	4.2
Ash	0	5	1	0	0	6	16.6	28	3	31	22.1	23	11	4	38	23.7	6	0	13	19	26.7
Hazel	0	1	0	0	0	1	2.7	0	1	1	0.7	2	31	16	49	30.6	0	0	0	0	0
Field Maple	0	1	0	0	0	1	2.7	13	3	16	12.2	17	11	3	31	19.3	0	0	0	0	0
Sycamore	0	0	1	0	0	1	2.7	6	7	13	9.2	4	4	1	9	5.6	14	5	7	26	36.6
Elm	0	3	4	7	0	14	38.8	2	8	10	7.1	1	1	0	2	1.2	2	0	0	2	2.8
Hornbeam	0	0	0	0	0	0	0	0	1	1	0.7	8	2	0	10	6.2	0	0	0	0	0
Elder	0	0	0	0	0	0	0	0	1	1	0.7	0	0	0	0	0	7	0	0	7	9.8
Hawthorn	0	0	0	0	0	0	0	0	6	6	4.2	0	0	0	0	0	7	0	0	7	9.8
Birch	0	1	2	0	0	3	8.3	4	2	6	4.2	4	1	0	5	3.1	4	0	0	4	5.6
Alder	0	0	0	0	0	0	0	3	0	3	2.1	4	1	0	5	3.1	0	0	0	0	0
Pine	0	0	0	0	0	0	0	1	1	2	1.4	0	0	0	0	0	0	0	0	0	0
Holly	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	3	4.2
Sweet chestnut	0	2	0	0	0	2	5.5	2	0	2	1.4	2	2	1	5	3.1	0	0	0	0	0
						36				71					160					140	

Fig 59 A histogram illustrating the percentage occurrence of saplings, oskars and seedlings in ancient woodland according to species

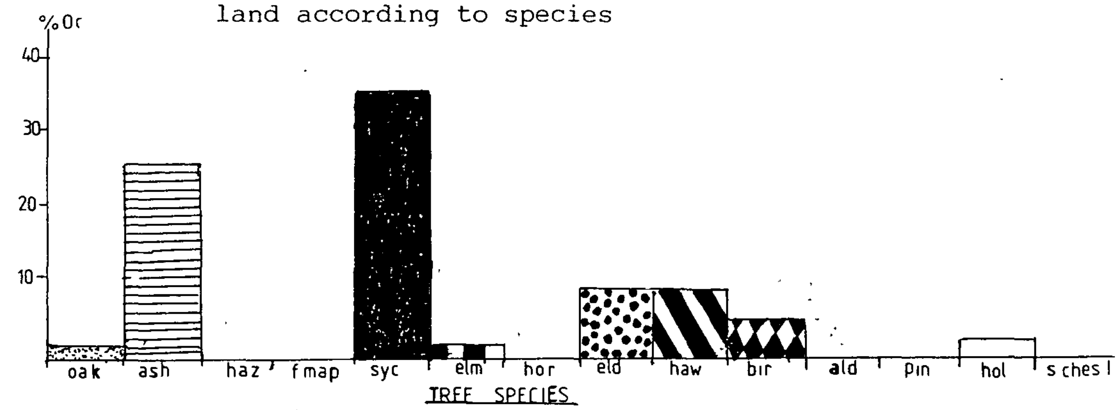


Fig 59 illustrates the species occurrence of sub-category (1) representing relatively juvenile lower canopy trees, either seedling; saplings or oskars. Sycamore has the greatest occurrence, suggesting active regeneration or invasion in ancient woodland. Ash is the most commonly regenerating native species in ancient derelict woodland. Oak does regenerate to a limited extent but hazel, hornbeam and field maple are not regenerating in ancient derelict woodland at all. Elm regeneration present indicates that Dutch Elm disease may not, as was feared, cause elm extinction. The berry trees, elder, hawthorn and holly - trees never usually reaching upper canopy dominance, are represented in sub-category (1) of ancient woodland. Birch can also be found regenerating at some ancient woodland sites. Sub-category (1) should eventually produce the future mature trees inthe composition of the West Suffolk woodland community and may be compared to the existing mature tree species-structure composition illustrated in fig 60 and fig 61.

Fig 60 A histogram illustrating the percentage occurrence of poles and canopy standard trees in ancient woodland according to species

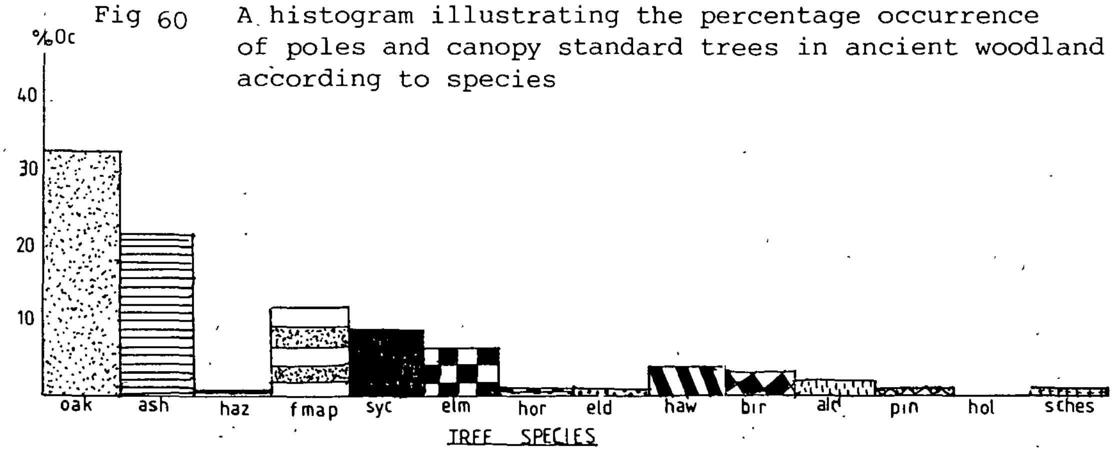
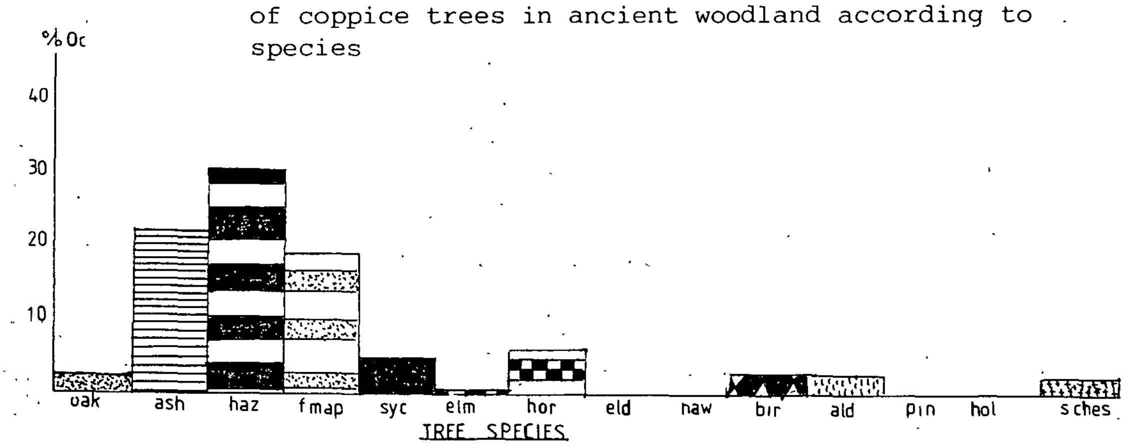


Fig 61 A histogram illustrating the percentage occurrence of coppice trees in ancient woodland according to species



The comparison reveals that oak, field maple, birch, alder, elm and sweet chestnut are more frequent as standard trees than juvenile forms and are, thus, in decline as members of the West Suffolk woodland community. Hazel, field maple and hornbeam are present frequently as coppice trees. They are also species that are apparently in decline according to the comparison between fig 59 and fig 60 . Ash is represented in similar frequencies in each of figs 59, 60 and 61. It is not in decline. Sycamore is present as the fourth most frequently occurring canopy standard in ancient woodland suggesting that sycamore has already gained a significant status in the West Suffolk ancient woodland community, but will achieve an even more significant status in future woodland generations.

Fig 62 The difference between the existing ancient community and possible future community

Present community		Coppice	Standards
	Frequent	Ash, Haz, FMap	Oak, Ash, FMap, Elm
	Less frequent	SChes, Oak, Horn	Alder, Birch
			sycamore invasion
Future community			
		No coppice unless return to ancient management	Oak, Syc, Ash, Eld, Haw

Most importantly sycamore status will increase. Ash will continue to be as frequent with elder and hawthorn sub-canopy strata. This considerable reduction in species diversity places ash as the major future competitor of sycamore at a community level.

Fig 63 A histogram illustrating the percentage occurrence of degenerate trees in ancient woodland in the West Suffolk area

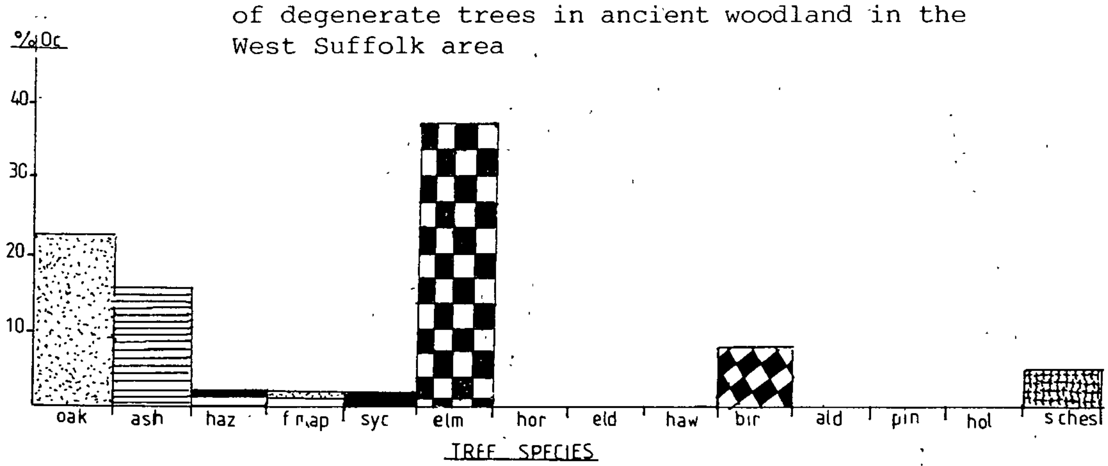


Fig 63 confirms that oak, ash, hazel, field maple, elm, birch and sweet chestnut are the most frequently degenerating trees suggesting that the generation of these tree species, that now exists in ancient woodland, has begun to die. Ash, oak, elm and birch have been seen to be regenerating at least to some extent, however, sweet chestnut, hazel and field maple are not regenerating in ancient woodland; although, field maple and hazel are common hedge species (see fig 187) in the West Suffolk area and may be regenerating in this habitat. Sycamore is rapidly replacing some native woodland species perhaps, most interestingly, field maple, a member of the same tree family as sycamore.

Using the data of table 33 , it was possible to examine the status of sycamore in relation to individual species in greater detail. The percentage occurrence of each of the thirteen structural classes for each species was calculated from the following formula:

$$\text{\% occurrence of each structural class for a species} = \frac{\text{The number of occurrences of the structural class}}{\text{Total number of all occurrences of the species}} \times 100$$

Table 35 Table illustrating the percentage occurrence of each species according to the structural types indicated

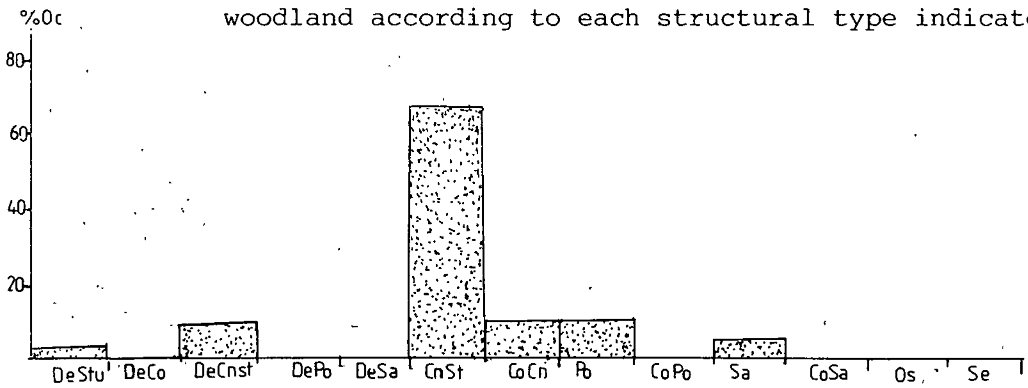
Each individual structure frequency is calculated from the total of all occurrences of a species

Species		Structural Classes												
		DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se
Oak	NS	2.5	0	7.6	0	0	56.4	12.8	12.8	0	7.6	0	0	0
	WS	7.4	0	11.0	0	0	74.0	3.7	3.7	0	0	0	0	0
	Total	2.8	0	9.2	0	0	64.6	9.2	9.2	0	4.6	0	0	0
Ash	NS	0	5.2	1.7	0	0	31.3	26.3	1.7	18.7	0	7.0	0	12.2
	WS	0	5.5	0	0	0	27.7	22.2	5.5	5.5	16.6	0	0	16.6
	Total	0	5.3	1.0	0	0	29.7	24.4	3.1	11.7	6.3	4.2	0	13.8
Haz	NS	0	3.0	0	0	0	0	3.0	3.0	60.6	0	30.3	0	0
	WS	0	0	0	0	0	0	5.5	0	61.1	0	33.3	0	0
	Total	0	1.9	0	0	0	0	3.9	1.9	60.7	0	31.3	0	0
FMap	NS	0	0	0	0	0	25.0	32.0	0	32.0	0	10.7	0	0
	WS	0	5.0	0	0	0	30.0	40.0	15.0	10.0	0	0	0	0
	Total	0	2.0	0	0	0	27.0	35.4	6.2	22.9	0	6.2	0	0
Elm	NS	0	0	10.0	40.0	0	10.0	0	40.0	0	0	0	0	0
	WS	0	16.6	16.6	16.6	0	5.5	5.5	13.8	5.5	11.1	0	0	0
	Total	0	10.7	14.2	25.0	0	7.1	3.5	28.5	3.5	7.1	0	0	0
Bir	NS	0	6.2	12.4	0	0	18.7	18.7	12.4	6.2	25.0	0	0	0
	WS	0	0	0	0	0	50.0	50.0	0	0	0	0	0	0
	Total	0	5.5	11.0	0	0	22.2	22.2	11.0	5.5	22.2	0	0	0

The competitive status of sycamore in ancient woodland

The results for oak, ash, hazel, field maple, elm and birch in ancient woodland are illustrated in figs 64-82 . The division of woodlands into woodland with sycamore (WS), woodland without sycamore (NS) and the total for all woodlands was again used.

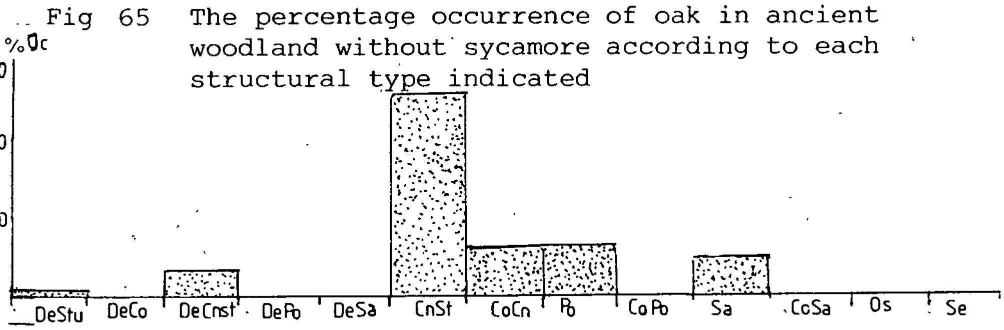
Fig 64 The percentage occurrence of oak in all ancient woodland according to each structural type indicated



Structural Classes

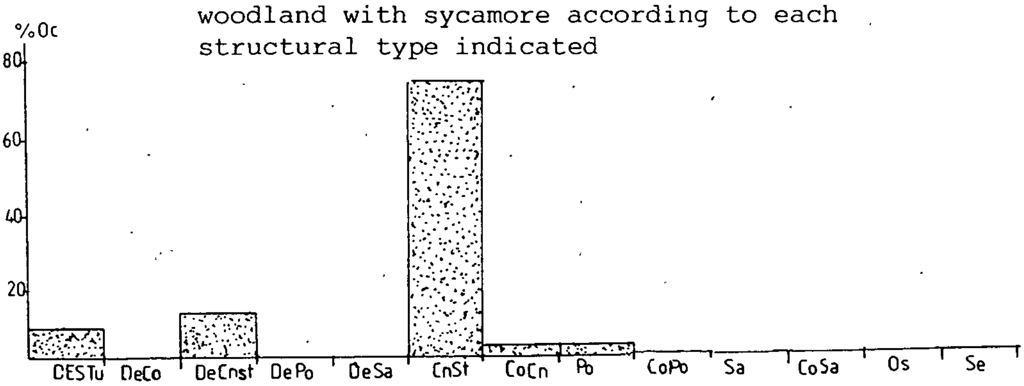
Oak is represented by a high frequency of canopy standards with some degenerating trees, coppice and sub-mature oak.

Fig 65 The percentage occurrence of oak in ancient woodland without sycamore according to each structural type indicated



Structural Classes

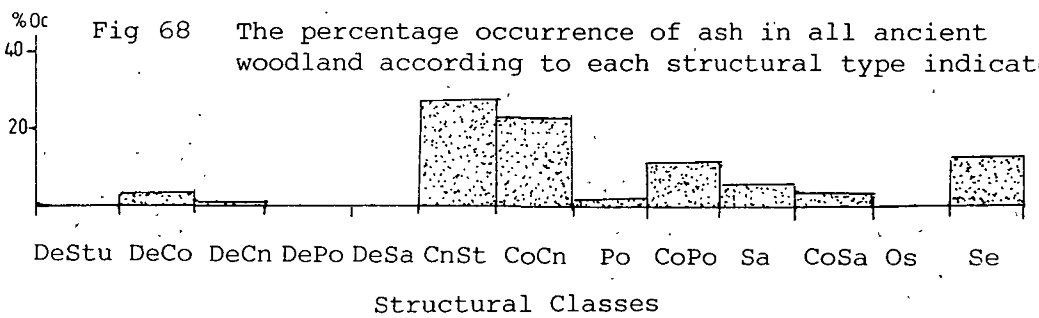
Fig 66 The percentage occurrence of oak in ancient woodland with sycamore according to each structural type indicated



Structural Classes

Comparison of fig 65 and fig 66 indicates that, in ancient woodland with sycamore, there tends to be a greater occurrence of degenerating oak, less coppice oak and fewer sub-mature oak than for ancient woodland without sycamore. This result suggests that :
1 sycamore may be exploiting a lack of oak regeneration; 2 sycamore invasion may be inhibiting oak regeneration; 3 that oak degeneration favours sycamore invasion; 4 that the presence of oak coppice is inhibiting sycamore invasion, or 5 that oak regeneration inhibits sycamore invasion.

Fig 68 The percentage occurrence of ash in all ancient woodland according to each structural type indicated



Ash (fig 68) illustrates a greater proportional occurrence of coppice in all ancient woodland than oak. Ash coppice is degenerating to a small extent, but ash regeneration, from seedling to poles, is present. Ash is commonly represented by both coppice and standard tree types.

Fig 69 The percentage occurrence of ash in ancient woodland without sycamore according to each structural type indicated

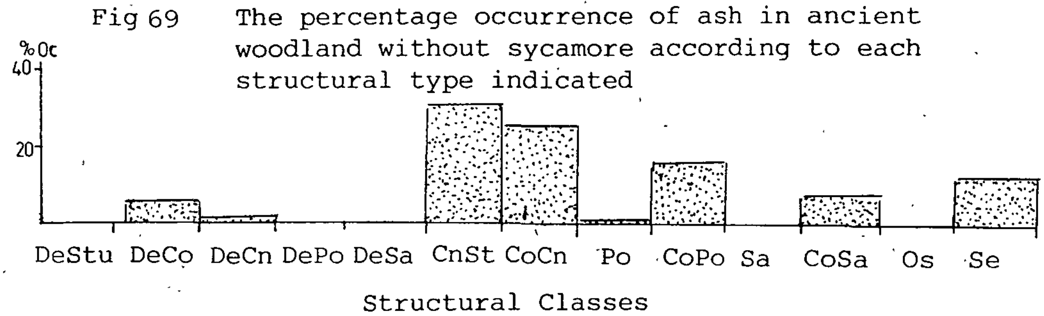
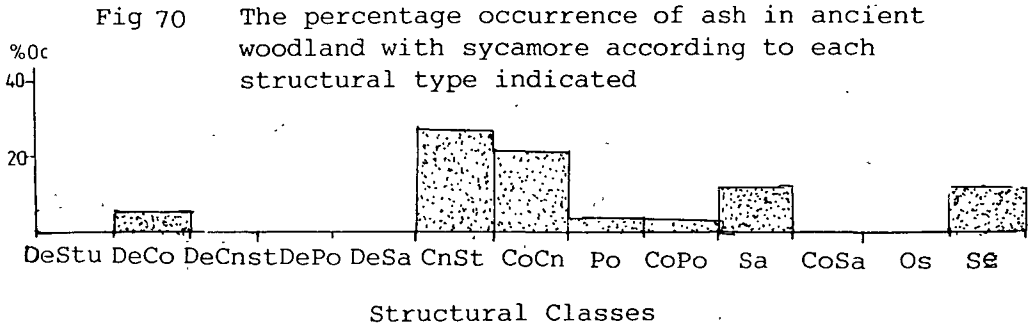


Fig 70 The percentage occurrence of ash in ancient woodland with sycamore according to each structural type indicated



Comparison of the structural class distributions for ash in ancient woodland without sycamore (fig 69) and ancient woodland with sycamore (fig 70) indicates little difference in the distribution of structural classes. This suggests that there is a competitive equilibrium between ash and sycamore in ancient woodland. Okali[49] and Brotherton[4] discuss ash-sycamore competitive balances in Derbyshire. The presence of coppice saplings in the ancient woodland without sycamore histogram (fig 69) could represent a tendency to more recent management of such ancient woodland. This supports the hypothesis that ancient woodland dereliction has encouraged sycamore invasion. Peterken[59] has noted that both ash and sycamore have invaded his sub type 1Aa (Calcareous Ash-Wych Elm woods) following coppicing, if dereliction occurs soon after coppicing. This has been a significant trend following the last coppice of many woodlands in his Lincolnshire sample area. Peterken[59] has also observed that in Swanton Novers wood in Norfolk, the decline of coppicing between 1920-1950 and the subsequent lack of removal of 'weed' species led to a sycamore and birch 'pioneer' type invasion that has begun to compete with the coppice. Peterken[59] has further noted that invasion may affect disturbed and improved stands. He quotes an example of the sycamore invasion at Bedford Pulieus, "An invasion following stand improvement spread from the southern part of the wood after a period of felling and replanting of oak coppice."

Peterken's[59] observations support the hypothesis that ancient woodland dereliction can lead to sycamore invasion but that coppicing or other disturbance may in itself favour sycamore invasion.

Fig 71 The percentage occurrence of hazel in all ancient woodland according to each structural type indicated

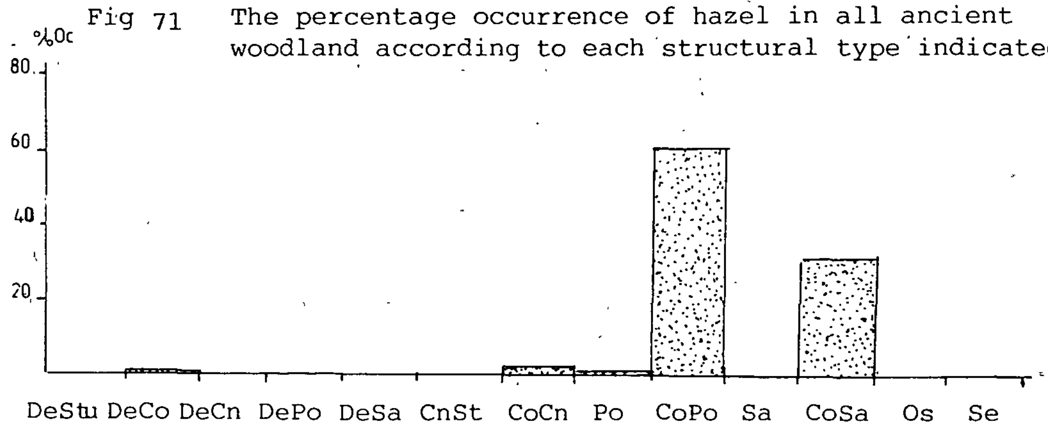


Fig 71 illustrates the structural distribution of hazel in all ancient woodland. Hazel appears most frequently as coppice and is not a recently regenerating species. There is a greater proportion of coppice saplings than for ash. Hazel was often managed on a shorter rotation than for ash. Hazel for thatching requires 4-6 years whereas ash was often left uncut for 12-14 years. This may account for the difference in coppice distribution.

Fig 72 The percentage occurrence of hazel in ancient woodland without sycamore according to each structural type indicated

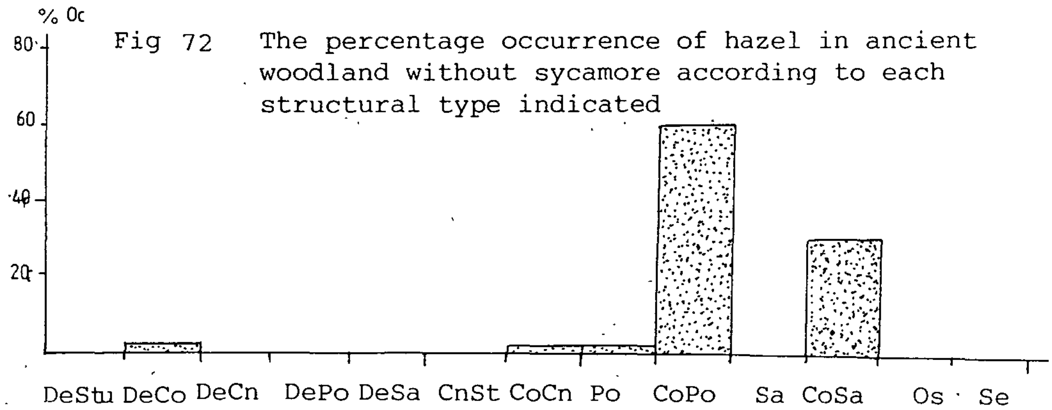
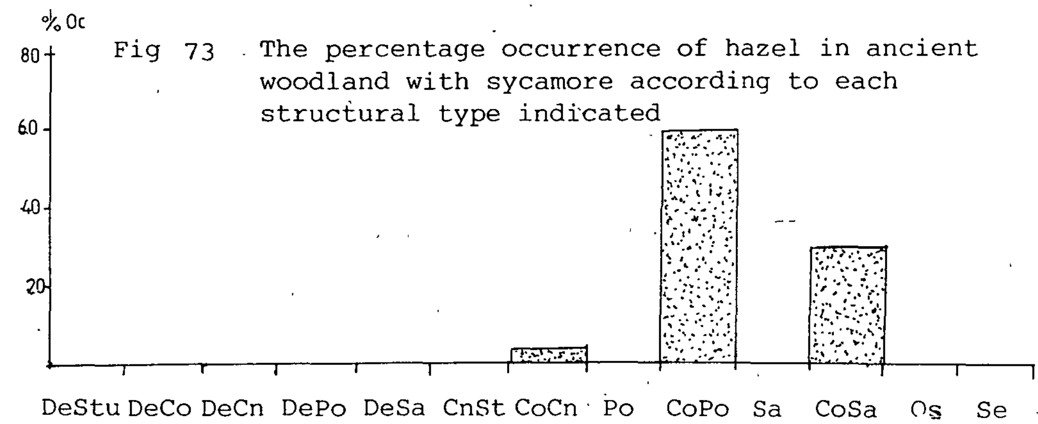
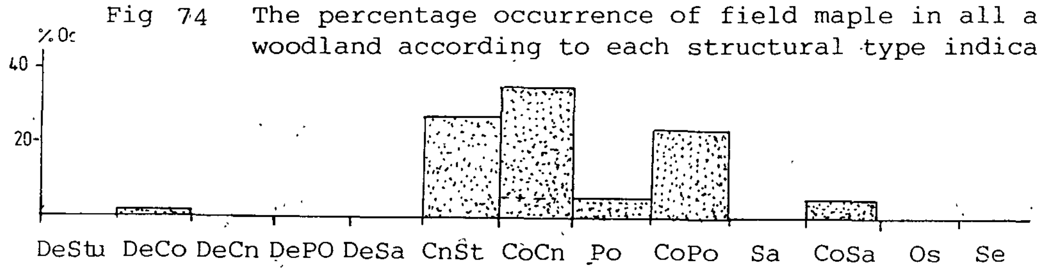


Fig 73 The percentage occurrence of hazel in ancient woodland with sycamore according to each structural type indicated



The comparison of fig 72 and fig 73 reveals only small differences between the hazel distribution in ancient woodland without sycamore and ancient woodland with sycamore. The incidence of hazel poles in woodland without sycamore might indicate that hazel regeneration is impeded by sycamore. However a larger woodland sample size would be needed to test this argument.

Fig 74 The percentage occurrence of field maple in all ancient woodland according to each structural type indicated



Field maple, fig 74 occurs frequently as coppice and standard trees. Some pole trees suggest at least a stage of field maple regeneration but no recent regeneration is evident.

Fig 75 The percentage occurrence of field maple in ancient woodland without sycamore according to each structural type indicated

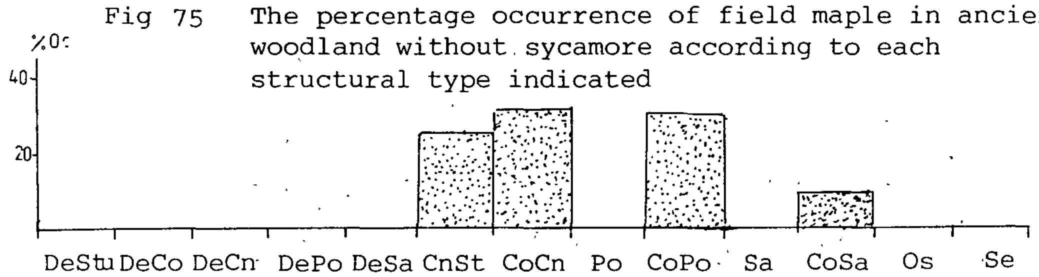
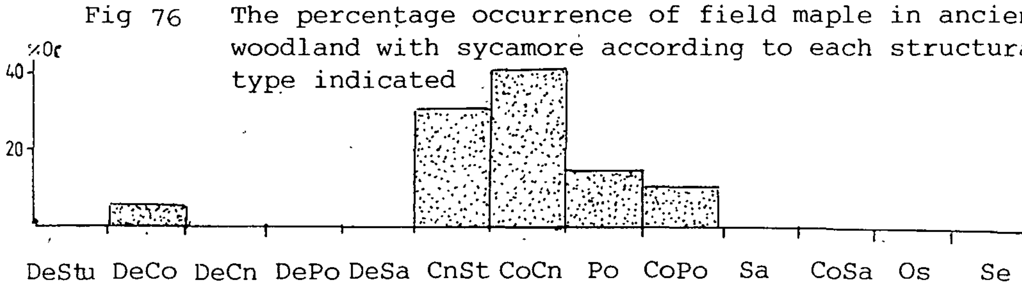


Fig 76 The percentage occurrence of field maple in ancient woodland with sycamore according to each structural type indicated



The distribution of field maple in non-sycamore invaded ancient woods and in sycamore invaded ancient woods can be compared using fig 75 and fig 76. The two distributions are somewhat different. More coppice poles and coppice saplings in ancient woodland without sycamore again suggests that the earlier the date of active woodland management finishing the greater the likelihood of sycamore invasion. Coppice poles and coppice saplings of field maple may also be inhibiting sycamore invasion through competition. Degenerate field maple coppice in sycamore invaded woodland may have favoured invasion.

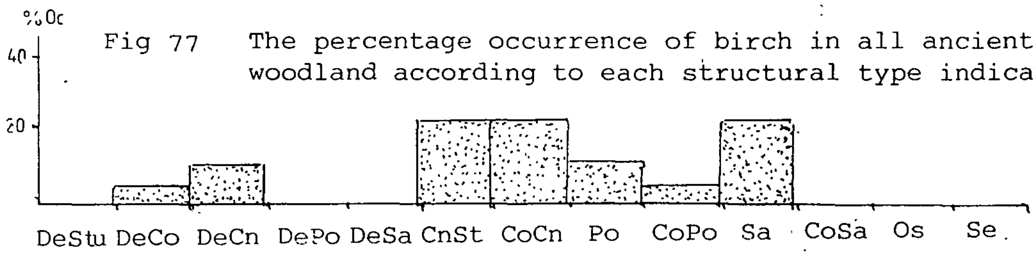


Fig 77 The percentage occurrence of birch in all ancient woodland according to each structural type indicated

The structural distribution of birch in ancient woodland illustrates both coppice and standard trees. Degenerates are relatively frequent, possibly because birch has a shorter life span as a standard tree than other native species. Birch regeneration is also relatively frequent.

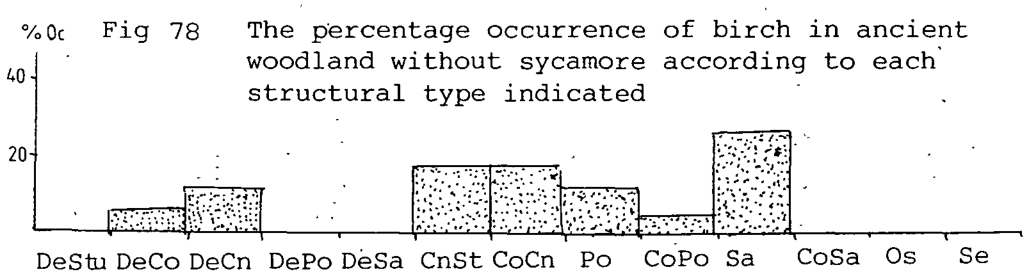


Fig 78 The percentage occurrence of birch in ancient woodland without sycamore according to each structural type indicated

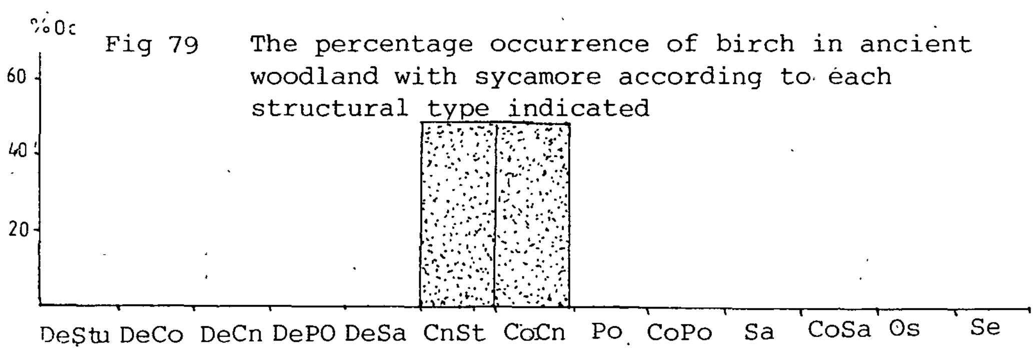
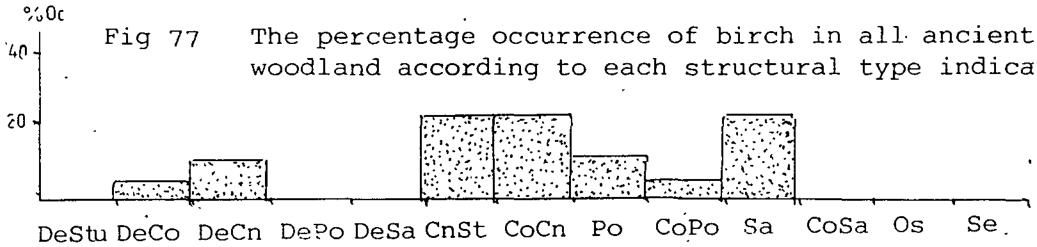


Fig 79 The percentage occurrence of birch in ancient woodland with sycamore according to each structural type indicated

Fig 78 and fig 79 illustrate a very clear difference in the structural distributions of birch between ancient woodland without sycamore and sycamore invaded ancient woodland. Ancient woodland without sycamore again has coppice poles suggesting more recent dereliction than for sycamore invaded woodland. Birch regeneration would only appear to occur in woodland without sycamore. However the occurrence of degenerating birch only to be found in the absence of sycamore is puzzling.

Fig 77 The percentage occurrence of birch in all ancient woodland according to each structural type indicated



The structural distribution of birch in ancient woodland illustrates both coppice and standard trees. Degenerates are relatively frequent, possibly because birch has a shorter life span as a standard tree than other native species. Birch regeneration is also relatively frequent.

Fig 78 The percentage occurrence of birch in ancient woodland without sycamore according to each structural type indicated

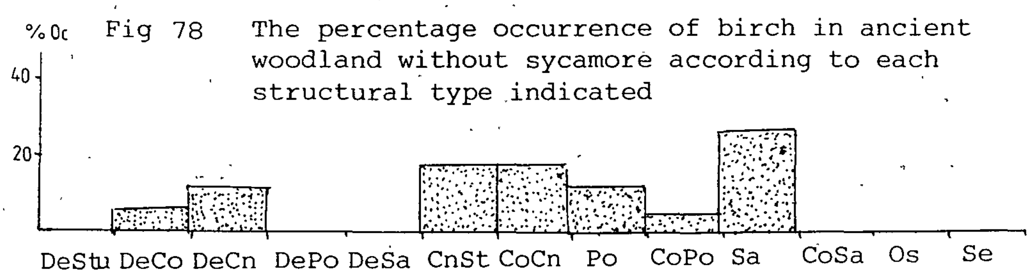


Fig 79 The percentage occurrence of birch in ancient woodland with sycamore according to each structural type indicated

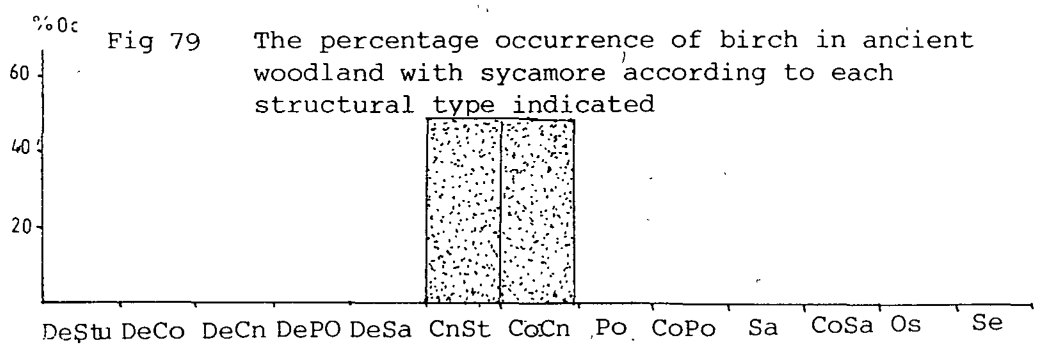
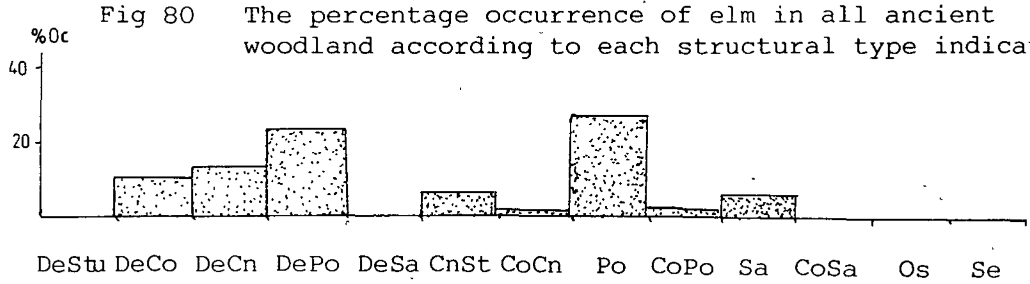


Fig 78 and fig 79 illustrate a very clear difference in the structural distributions of birch between ancient woodland without sycamore and sycamore invaded ancient woodland. Ancient woodland without sycamore again has coppice poles suggesting more recent dereliction than for sycamore invaded woodland. Birch regeneration would only appear to occur in woodland without sycamore. However the occurrence of degenerating birch only to be found in the absence of sycamore is puzzling.

Fig 80   The percentage occurrence of elm in all ancient woodland according to each structural type indicated



The structural distribution of elm in ancient woodland illustrates that many elms are in degenerate forms as a result of Dutch Elm disease. However, some living canopy and coppice trees have remained and regeneration is occurring (often from degenerating stumps).

Fig 81   The percentage occurrence of elm in ancient woodland without sycamore according to each structural type indicated

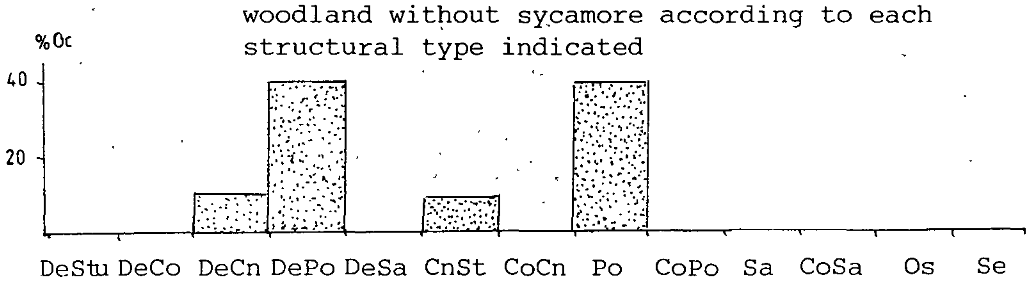


Fig 82   The percentage occurrence of elm in ancient woodland with sycamore according to each structural type indicated

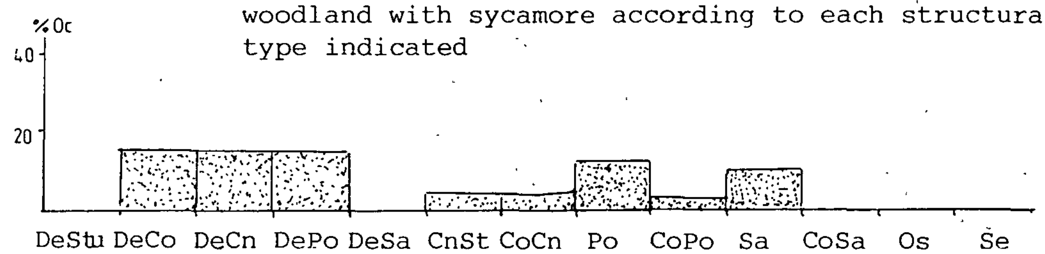


Fig 81 illustrates that there is no coppice elm in ancient woodland without sycamore whereas coppice elm does occur in ancient woodland with sycamore. Elm poles are also more common in non-sycamore woodland. Elms may be found as coppice in some ancient woodland. Elms occur in several varieties and, whilst no record was made of the different varieties in the general survey, it is wych elm (Rackham[64]) that is usually coppiced. Invasive elm (Rackham [64]) does not coppice well. The difference in structural distributions could relate to the occurrence of the two species. Invasive elms tend to invade woodlands from hedges in a clonal form. Coppiced wych elm does not tend to sucker as frequently as invasive elm and can be thought of as an invasive species. Elm poles are characteristic of woodland invading elm. Their presence suggests relatively recent invasions of ancient woodland without sycamore. The demography of elm invasions and sycamore invasions was never observed to coincide in ancient woodland. It is possible that elm invasions may therefore be more competitive than sycamore in certain ancient woodland situations.

Table 36

TOTAL ALL SECONDARY WOODLAND OCCURRENCES

A Without sycamore (NS)

Tree Species	DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se	Total
Oak	0	0	0	0	0	5	1	3	0	1	0	0	0	10
Ash	0	0	0	0	0	5	2	0	0	0	0	0	1	8
Hazel	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Field Maple	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sycamore	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elm	0	0	3	0	0	3	1	2	0	2	0	0	0	11
Hornbeam	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elder	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Hawthorn	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Birch	0	0	0	0	0	2	1	1	0	3	0	0	0	7
Alder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pine	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Holly	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet chestnut	0	0	0	0	0	1	2	0	0	0	0	0	0	3
Horse chestnut	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway maple	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhododendron	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blackthorn	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yew	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other conifer	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beech	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poplar	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0
False Acacia	0	0	0	0	0	0	0	0	0	0	0	0	0	0

B With sycamore (WS)

Tree Species	DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se	Total
Oak	4	1	1	0	0	13	2	3	0	1	0	0	4	29
Ash	0	0	0	0	0	16	2	2	0	2	0	2	6	30
Hazel	0	0	0	0	0	0	0	0	1	0	1	0	0	2
Field Maple	0	0	0	0	0	1	0	0	0	0	0	0	2	3
Sycamore	0	1	1	3	4	21	17	15	4	14	0	8	10	98
Elm	0	1	6	2	5	1	1	0	0	0	0	0	0	16
Hornbeam	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elder	0	0	0	0	0	0	0	7	0	10	0	0	0	17
Hawthorn	0	0	1	0	0	0	0	3	0	1	0	0	0	5
Birch	0	0	0	0	0	1	1	0	0	0	0	0	0	2
Alder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pine	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Holly	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Willow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet chestnut	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Horse chestnut	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Norway maple	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Rhododendron	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Blackthorn	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yew	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other conifer	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beech	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Poplar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0
False Acacia	0	0	0	0	0	0	0	0	0	0	0	0	0	0

C All woodland

Tree Species	DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se	Total
Oak	4	1	1	0	0	18	3	6	0	2	0	0	4	39
Ash	0	0	0	0	0	21	4	2	0	2	0	2	7	38
Hazel	0	0	0	0	0	0	0	0	2	0	1	0	0	3
Field Maple	0	0	0	0	0	1	0	0	0	0	0	0	2	3
Sycamore	0	1	1	3	4	21	17	15	4	14	0	8	10	98
Elm	0	1	0	2	5	4	2	2	0	2	0	0	0	27
Hornbeam	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elder	0	0	0	0	0	0	0	8	0	11	0	0	0	19
Hawthorn	0	0	1	0	0	0	0	3	0	2	0	0	0	6
Birch	0	0	0	0	0	3	2	1	0	3	0	0	0	9
Alder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pine	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Holly	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Willow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet chestnut	0	0	0	0	0	3	2	0	0	0	0	0	0	5
Horse chestnut	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Norway maple	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Rhododendron	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Blackthorn	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yew	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other conifer	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beech	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Poplar	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Lime	0	0	0	0	0	0	0	0	0	0	0	0	0	0
False Acacia	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Total sites 33   Total sites 11   Total sites 44

Table 37 Secondary woodland - % species occurrences reduced to four structural sub categories (abbreviated from General Survey data, C All woodland table 36)

Tree Species	DeStu	DeCo	DeCn	DePO	DeSa	Total	%	CnSt	Po	Total	%	CoCn	CoPo	CoSa	Total	%	Sa	Os	Se	Total	%
Oak	4	1	1	0	0	6	26.1	18	6	24	22.4	3	0	0	3	9.1	2	0	4	6	8.5
Ash	0	0	0	0	0	0	0	21	2	23	21.4	4	0	0	4	12.1	2	2	7	11	15.7
Hazel	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	9.1	0	0	0	0	0
Field Maple	0	0	0	0	0	0	0	1	0	1	0.9	0	0	0	0	0	0	0	2	2	2.8
Sycamore	0	1	1	3	4	9	39.1	21	15	36	33.6	17	4	0	21	63.6	14	8	10	32	45.7
Elm	0	1	0	2	5	8	34.7	4	2	6	5.6	2	0	0	2	6.0	2	0	0	2	2.8
Hornbeam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elder	0	0	0	0	0	0	0	0	8	8	7.4	0	0	0	0	0	11	0	0	11	15.7
Hawthorn	0	0	1	0	0	1	4.3	0	3	3	2.8	0	0	0	0	0	2	0	0	2	2.8
Birch	0	0	0	0	0	0	0	3	1	4	3.7	2	0	0	2	6	3	0	0	3	4.2
Alder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pine	0	0	0	0	0	0	0	1	0	1	0.9	0	0	0	0	0	0	0	0	0	0
Holly	0	0	0	0	0	0	0	0	1	0	0.9	0	0	0	0	0	1	0	0	0	1.4
Sweet chestnut	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
						23				107					33					70	

The competitive status of sycamore in secondary woodland

The percentage occurrence of species in West Suffolk woodland was calculated using the same method (see p 125) as that used for ancient woodland. Firstly, species occurrence was calculated for the four sub-categories of woodland structure. The source data was from the general survey and is illustrated in table 36. Table 37 displays the percentage occurrences of species in the four structural sub-categories.

Fig 83 A histogram illustrating the percentage occurrence of seedlings, saplings and oskars in secondary woodland for species indicated

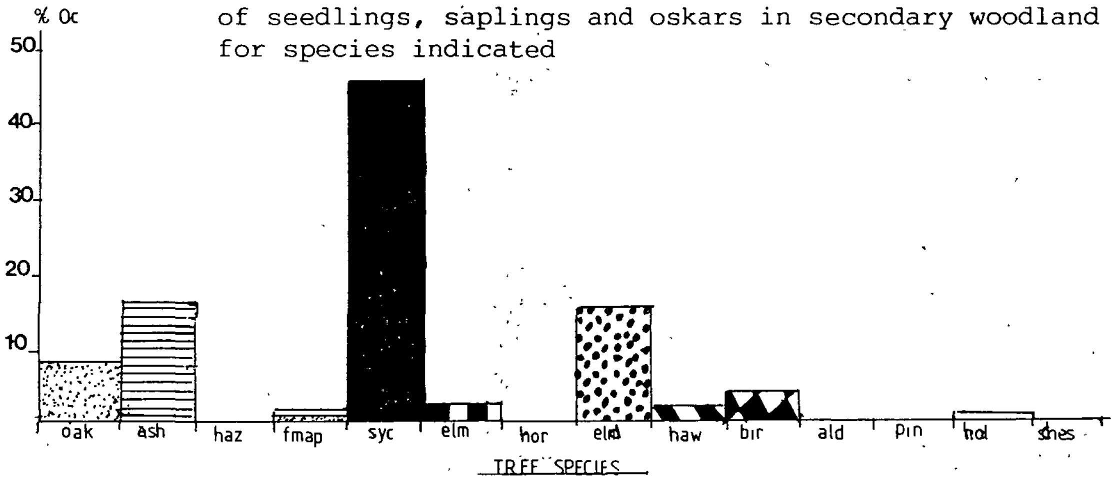


Fig 83 indicates a greater proportion of sycamore, elder and oak oskars, saplings and seedlings than for ancient woodland. There is a lesser proportion of ash than there is in ancient woodland. Hazel and hornbeam are not represented at all, with field maple infrequent.

Fig 84 A histogram illustrating the percentage occurrence of poles and canopy standards in secondary woodland according to species indicated

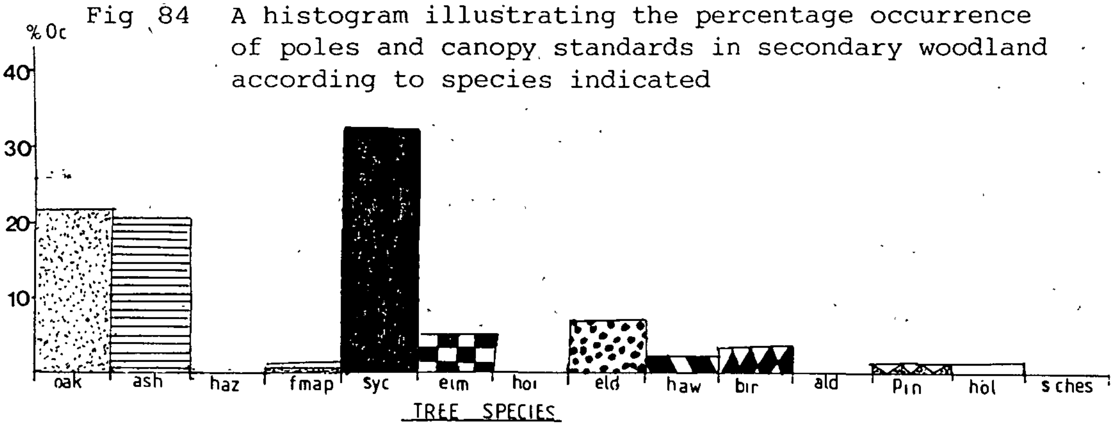


Fig 84 illustrates that sycamore is the most commonly occurring canopy standard or pole although slightly dominant than has been seen for the juvenile structural classes. Oak and ash have a greater proportional frequency as canopy trees in secondary woodland than for juvenile trees. Field maple and sycamore are less well represented as a canopy standard tree or pole than they are in ancient woodland (see fig 60). Alder, hornbeam and hazel are absent as canopy standards in secondary woodland. Elder, elm, hawthorn and birch are present as less frequent canopy standards in secondary woodland.

Fig 85 A histogram illustrating the percentage occurrence of coppice trees in secondary woodland according to species indicated

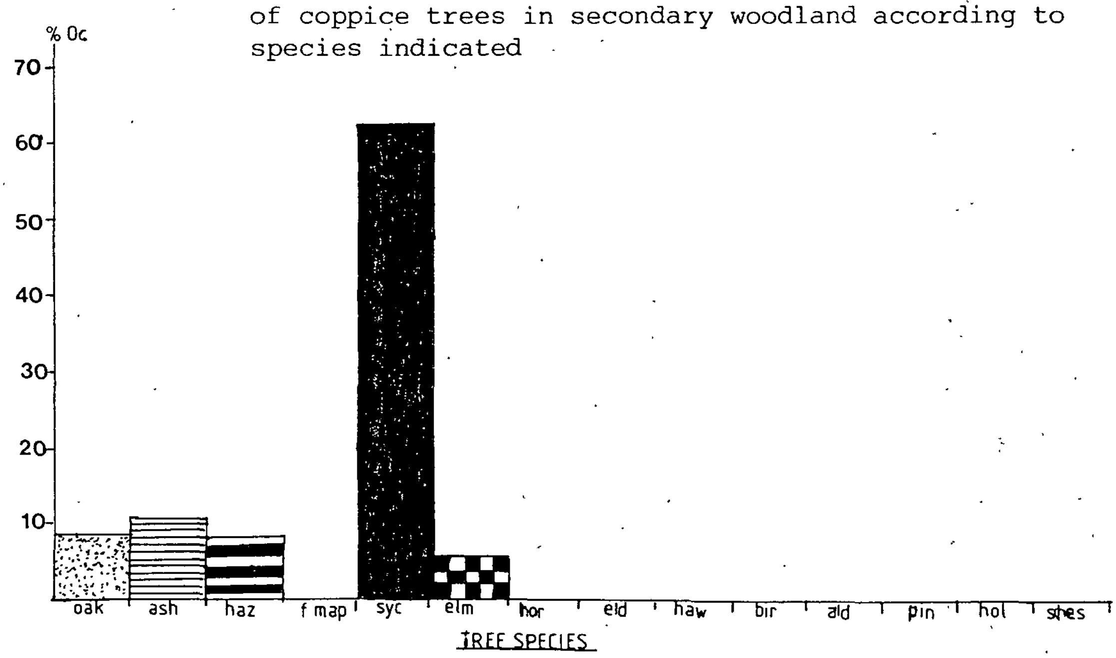


Fig 85 illustrates that sycamore is the most frequently occurring coppice species in secondary woodland. Only half the number of species are to be found as coppice trees in secondary woodland than were found in ancient woodland. This is a clear distinction between secondary woodland and ancient woodland and suggests that the methods used to classify the woodland into secondary and ancient have succeeded in accurately dividing the two woodland types. The presence of coppice in secondary woodland may well have been a relatively recent phenomenon. Coppice certainly does not automatically make woodland 'ancient' with a long history of management.

Fig 86 A histogram illustrating the percentage occurrence of degenerate trees in secondary woodland according to species indicated

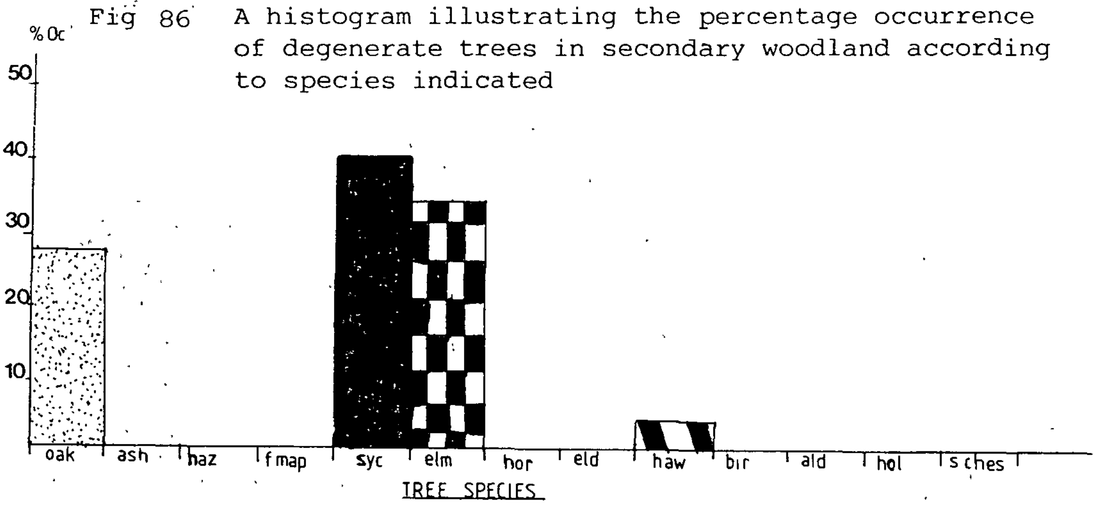


Fig 86 illustrates half the number of species degenerating in secondary woodland than for ancient woodland. Elm has a high frequency of degeneration again caused by Dutch Elm disease. Sycamore degeneration is often the death of sub-mature structures. Oak is frequently to be found in degenerate forms. However ash is not found as a degenerating tree in secondary woodland. It could be argued that the oak populations of secondary woodland may be older than ash populations. This leads to the conclusion that oak could well have been an early colonizer of secondary woodland. The occurrence of degenerate hawthorns also suggests that it may have been an early colonizer of secondary woodland.

Table 38 The difference between the existing secondary woodland community and possible future community

	Coppice	Standards
Early colonizing community		Oak, Haw, Elm
Present community	Oak, Ash, Haz, Syc, Elm	Oak, Ash, FMap, Syc, Elm, Eld, Haw, Bir
Future community	None unless return to coppice management	Frequent Oak, Ash, Syc, Eld, Haw Less frequent FMap, Bir, Hol

Table 38 illustrates a possible model of species structure development in the secondary woodland community of West Suffolk. It is apparent that sycamore has a high competitive status in secondary woodland. Ash, oak, hawthorn and elder are likely to be its main competitors. It would also seem that the future species structure of ancient woodland will be similar to the species structure of secondary woodland, if anthropogenic influence on either woodland types remains static.

The structural distribution of individual species in secondary woodland was analyzed according to the method described for ancient woodland (see p 130). The structural distributions of sycamore invaded woods, woodland without sycamore and all secondary woodland were compared. Table 39 denotes the results for the analysis taken from the general survey records (see table 36). The most frequent secondary woodland species, oak, ash, elm, elder and birch were included in the survey.

Table 39 Table illustrating the percentage occurrence of each species according to the structural types indicated

Each individual structure frequency is calculated from the total of all occurrences of a species

Species		Structural Types												
		DeStu	DeCo	DeCn	DePo	DeSa	CnSt	CoCn	Po	CoPo	Sa	CoSa	Os	Se
Oak	NS	0	0	0	0	0	50	10	30	0	0	0	0	10
	WS	13.7	3.4	3.4	0	0	44.8	6.8	10.3	0	3.4	0	0	13.7
	Total	10.2	2.5	2.5	0	0	46.1	7.6	15.3	0	6.8	0	0	13.7
Ash	NS	0	0	0	0	0	62.5	25.0	0	0	0	0	0	12.5
	WS	0	0	0	0	0	53.3	6.6	6.6	0	6.6	0	6.6	20.0
	Total	0	0	0	0	0	55.2	10.2	5.2	0	5.2	0	5.2	18.4
Elm	NS	0	0	27.2	0	0	27.2	9.0	18.1	0	18.1	0	0	0
	WS	0	6.2	37.5	12.5	31.2	6.2	6.2	0	0	0	0	0	0
	Total	0	3.7	33.3	7.4	18.5	14.8	7.4	7.4	0	7.4	0	0	0
Eld	NS	0	0	0	0	0	0	0	50.0	0	50.0	0	0	0
	WS	0	0	0	0	0	0	0	41.1	0	58.8	0	0	0
	Total	0	0	0	0	0	0	0	42.1	0	57.8	0	0	0
Bir	NS	0	0	0	0	0	28.5	14.2	14.2	0	42.8	0	0	0
	WS	0	0	0	0	0	50.0	50.0	0	0	0	0	0	0
	Total	0	0	0	0	0	33.3	22.2	11.1	0	33.3	0	0	0

Fig 87 The percentage occurrence of oak in all secondary woodland according to each structural type indicated

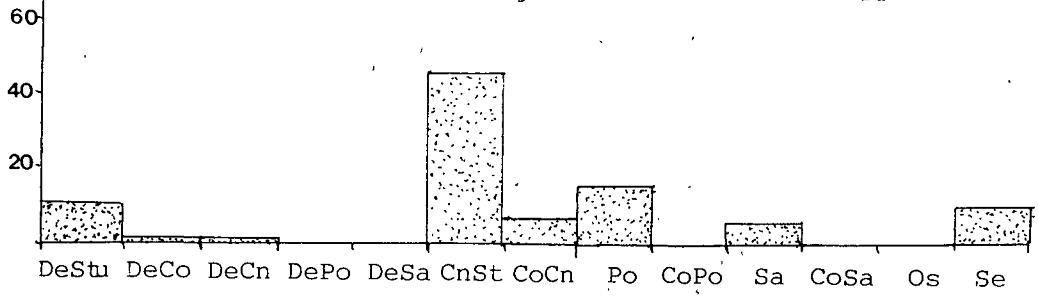


Fig 87 illustrates the structural distribution of the oak in the West Suffolk woodland community. Canopy standards are the most common class but the existence of degenerate trees, poles, saplings and seedlings suggests several actively regenerating generations of oak.

Fig 88 The percentage occurrence of oak in secondary woodland without sycamore according to each structural type indicated

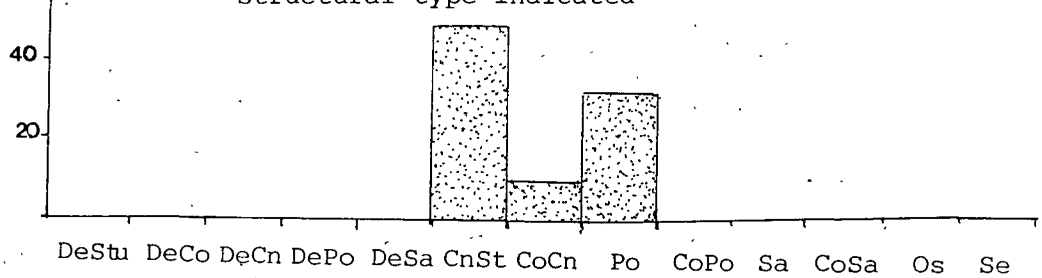
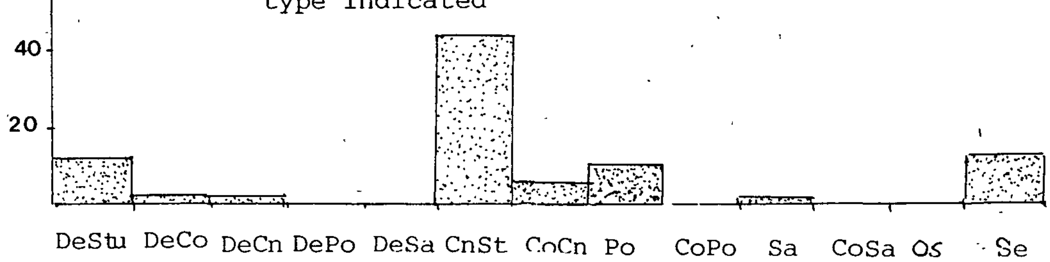


Fig 89 The percentage occurrence of oak in secondary woodland with sycamore according to each structural type indicated



The distribution of oak in sycamore invaded secondary woodland is similar to that for all woodland (see figs 87 , 89). However, the distribution of oak in secondary woodland without sycamore (fig 88) is condensed into three categories: canopy standards, coppice canopy and poles, with no degenerating trees, saplings nor seedlings. A possible explanation for this could be that the presence of degenerating oak may have favoured the invasion of secondary woodland by sycamore but has also encouraged oak regeneration. However it is possible that the oak woodlands without sycamore and of an even age structure are affected by some other factor creating a different structural distribution. For instance, the secondary woodland without sycamore could be planted oak and hence a deciduous plantation with some secondary woodland characteristics. The sycamore invaded woodland could be naturally regenerated woodland with an uneven age structure. Edaphic factors and climatic factors could be limiting sycamore invasion of some oak woodlands but the presence of regenerating oak would still be expected in such woodlands. The demographic distribution of both oak and sycamore (see figs 52 and 56) illustrates that both species have a cosmopolitan distribution throughout the survey area which,again,does not support the climate or soil argument. Colonization of arable land to form mixed oak and sycamore woodland has been observed at Rothamsted [66]. In this case, oak was first seen to colonize followed by later sycamore invasion. The secondary woodland without sycamore could represent sites that were able to be colonized by oak but are beyond the dispersal range of sycamore. Other factors such as grazing pressure or ground flora associates could be eliminating the regeneration of both oak and sycamore at certain sites.

Fig 90 The percentage occurrence of ash in all secondary woodland according to each structural type indicated

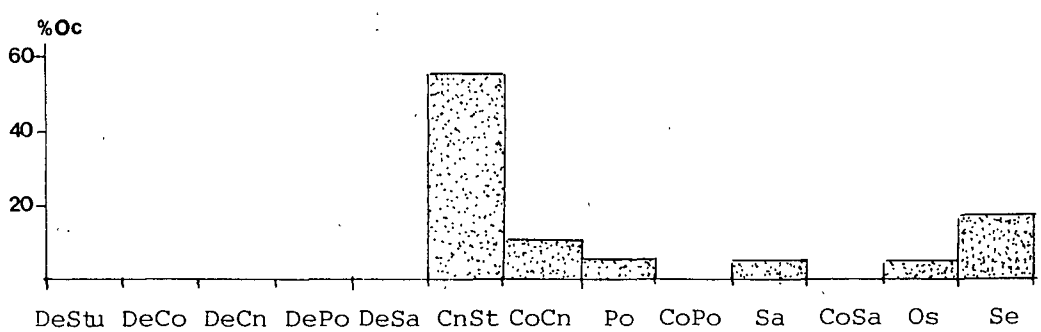


Fig 91 The percentage occurrence of ash in secondary woodland without sycamore according to each structural type indicated

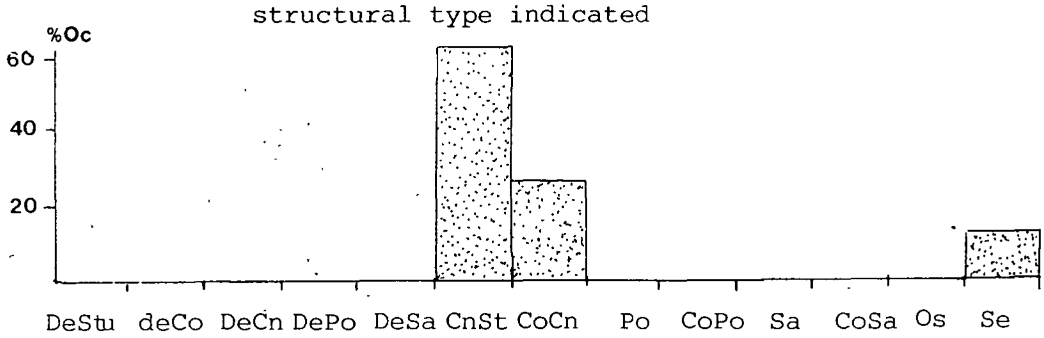
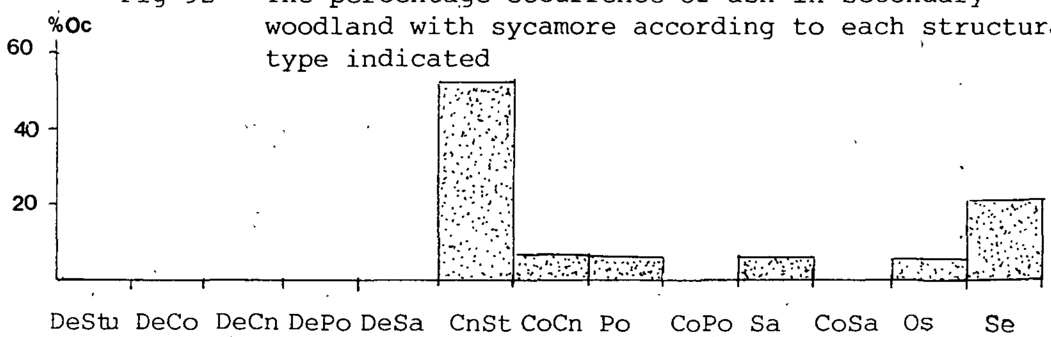
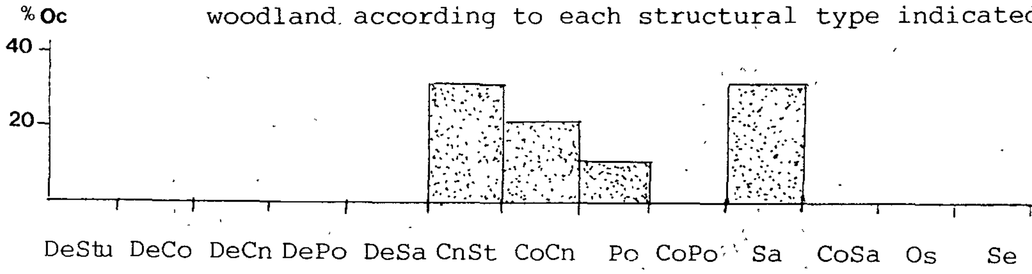


Fig 92 The percentage occurrence of ash in secondary woodland with sycamore according to each structural type indicated



The structural distributions of ash in all secondary woodland (fig 90) and in secondary woodland with sycamore (fig 92) are similar: no degenerate ash, a large proportion of canopy standards with some coppice canopy and juvenile trees. They differ from secondary woodland without sycamore (fig 91) which has no poles, saplings or oskars. There are some seedlings but of a lesser frequency. This might be explained by the view that ash and sycamore have similar requirements for regeneration in mature woodland. The canopy standard ash trees could be the result of colonization which has subsequently limited ash or sycamore regeneration. The presence of regenerative classes of ash in sycamore woodland indicates that the two species are likely to form mixed species associations at some point in future time.

Fig 93 The percentage occurrence of birch in all secondary woodland according to each structural type indicated



Birch has been considered to be a species that is classically able to colonize new ground and to form secondary woodland (Peterken[59]).

Fig 94 The percentage occurrence of birch in secondary woodland with sycamore according to each structural type indicated

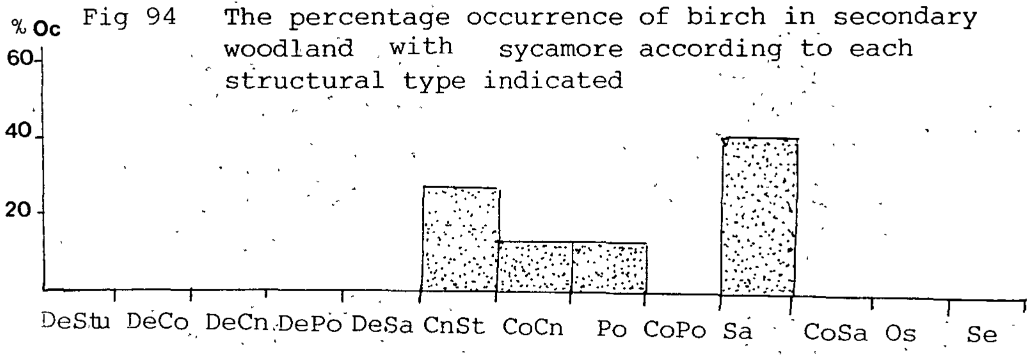
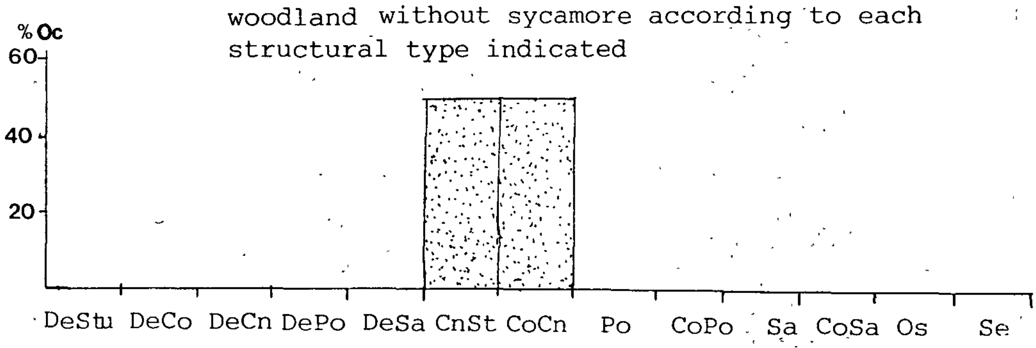


Fig 95 The percentage occurrence of birch in secondary woodland without sycamore according to each structural type indicated



The distributions of birch structural classes in the secondary woodland community of West Suffolk is similar for woodland without sycamore (fig 93) and for the total of all secondary woodland. Coppice canopy, canopy standards, poles and saplings are present in each woodland type with similar frequencies. The presence of these structures suggests that these woodlands are not plantations but are bona fide secondary woodland with uneven age structures. Birch has successfully regenerated in the presence of sycamore suggesting similar environmental requirements for regeneration or an ability to exploit similar habitats. There are no regenerative classes (saplings, poles, oskars or seedlings) of birch present in the secondary woodland without sycamore category (fig 95). This could be due to birch colonising to form secondary woodland but subsequently not regenerating. The woodlands formed may be beyond the dispersal range of sycamore.

Fig 96 The percentage occurrence of elm in all secondary woodland according to each structural type indicated

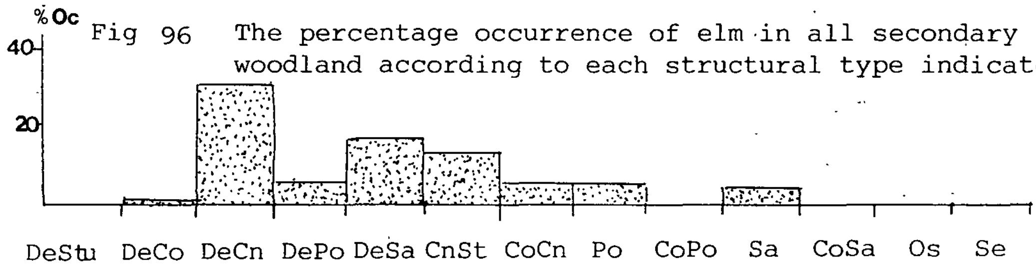


Fig 97 The percentage occurrence of elm in secondary woodland without sycamore according to each structural type indicated

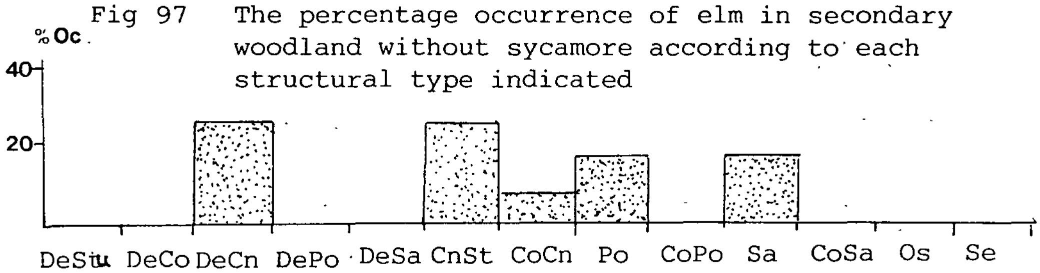
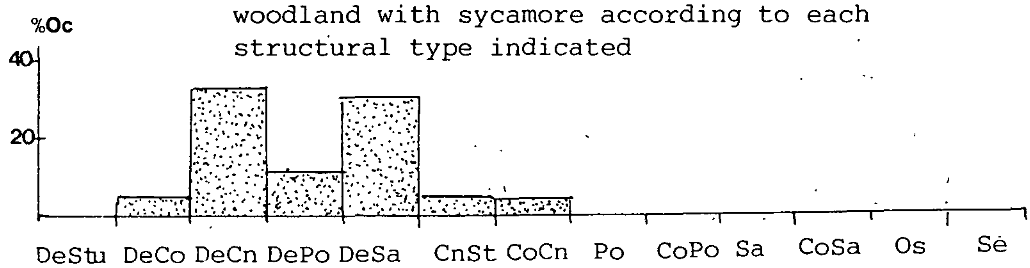


Fig 98 The percentage occurrence of elm in secondary woodland with sycamore according to each structural type indicated



Comparison of the structural distribution of elm at secondary woodland sites with sycamore (fig 98), without sycamore (fig 97) and as total of all secondary woodland (fig 96) suggests that elm is most frequent in all categories as degenerate trees. This is because of the widespread effect of Dutch Elm disease. Degenerates are less frequent in woodland without sycamore and regenerative classes are more frequent. This infers that elm is more successful in woodland without sycamore. It is a fact that sycamore does not invade woodland with actively growing elm as frequently as it might invade woodland with dead elm.

Competitive Status - Summary

1. Oak, ash and birch are the only typical native ancient woodland species to be regenerating and of these only ash is prolifically regenerating.

2. Sycamore is regenerating prolifically in ancient woodland.

3. Ancient woodland without sycamore would appear to show some differences in the structural composition of particular species compared with ancient woodland with sycamore.

4. Sycamore may be exploiting ancient woodland as a result of the decline in woodland management and the effect this has on ancient woodland structure. Dereliction may not have favoured the regeneration of native species.

5. There are distinct differences between the structural and species compositions of ancient woodland and secondary woodland.

6. Secondary woodland without sycamore would appear to show some differences in the structural composition of particular species compared with secondary woodland with sycamore. There may be some evidence to suggest that oak degeneration encourages sycamore invasion and that ash and sycamore occupy similar ecological niches within woodland.

Chapter 5

AN ANALYSIS OF WOODLAND STRUCTURE AT SPECIFIC SITES

The woodlands of West Suffolk show great variability of species composition (see text p78). There is also considerable variability in the age structures of these woodlands. Some of the problems with sampling the composition and age structures of such woodlands have been suggested (see text p30). However the tree classification (see text p36) allows some simplification of age structure analysis. This classification has been used to survey individual woodland sites in the following section. The analysis is used to provide further evidence of the status of sycamore in West Suffolk woodlands and its implications for conservation and to record woodland structure and composition in a way that might be useful for assessing past and future changes in the woodlands.

The aim of this particular investigation of individual sycamore invaded sites was to record the frequencies of the species-structure units according to the tree classification (see text p36). There are some inherent problems with this aim and choice of technique, however it was considered to be a more appropriate line of approach than some woodland modeling techniques, such as Markovian matrices, outlined in the literature, for instance Harper[25] or Horn[32]. Apart from the obvious problem of the woodland variability characteristic of the Suffolk woodlands, difficulties in selecting sample sizes were encountered because of the widely differing frequencies of species and their structural units. It was also thought necessary to consider that the regenerative cycle of a woodland may be reflected by the presence of several different age structures within a single wood according to the demographic distribution of the species. For large woods the problem might be relatively negligible if a large number of samples was taken. For small woods where, for example, regeneration may only take place at favourable sites within the wood, or at a certain favourable time in the history of the wood's development and then, perhaps, as a consequence of the presence of a single invasive species, to use a random sampling technique might be to lose a vital component of the regenerative cycle of that particular woodland. For this reason, the sampling used in this investigation was based on choosing quadrats (relevées) thought to represent most clearly the typical structure of a woodland. Some criteria were used to assist this choice.

Criteria used for selecting woodland sample

1. That the sample should represent a typical example of woodland structure and composition.
2. That as many species units as possible be included in each sample.
3. That the sample include as many of the most common species in that woodland as possible.
4. That the samples include sycamore if present in the woodland and any other species thought to be successful invaders of that woodland or thought likely to play a significant role in the species composition of the woodland for whatever reason.
5. The sample was to exclude any major geographical variations from the normal character of the woodland. i.e. rides, pathways, pheasant runs, clearings.

Quadrats of $10m^2$ were used, this size thought large enough to include a sufficient number of older trees but small enough to make practical the counting of younger age classes, and the numbers of each class of species were recorded for each quadrat. Individuals found on the perimeter of the quadrat were included within the quadrat, but eliminated from a subsequent quadrat if adjoining the first recorded quadrat. Woods were selected from each of the main woodland types outlined in the classification (see text p16).

To interpret the data obtained, the records made of all degenerate trees for a species were added together. All recordings of coppice trees for a particular species were also added together. The abbreviated results are shown as a species structure matrix of personal design, five species on the horizontal axis, structural categories on the vertical axis.

In order to analyse the results of age structure data for woodlands, according to Krebs[88] two criteria have to be fulfilled. Firstly, that sub-reproductively mature classes are in a steady state, or represent a stationary age distribution under that particular canopy. Secondly, that it is an intrinsic factor of most mathematical projection techniques that a stationary age composition or regular cyclical change of species must occur after a certain number of generations.

From preliminary observations and consideration of the intrinsic variability of the sample woods, it would seem that both of these criteria for sycamore invaded woods are unlikely to be completely fulfilled. A specific assumption for making model analysis is that replacement probabilities of one tree by another do not change with time, ie. they do not depend on successional change or local edaphic conditions. Such projections are therefore likely to be at their most effective in large, totally unmanaged woods with relatively little chance of invasion by new species. The woods in the survey area again hardly correspond to these criteria.

Two assumptions have been made from the analysis of quadrat data in terms of the discussion relating to the past and the future status of age structure: that known normal longevities of tree species are adhered to, with which, of course, coppicing may at times interfere and secondly, that a more stable woodland in terms of species composition is one that conforms to the model of there being more individuals within younger age classes than those within classes immediately older than them. In other words that population distributions should conform to the normal pyramid of numbers that might be expected in stable natural populations of many species. The analysis of the results obtained from the frequency survey consisted of plotting the distribution of the frequencies of each species-structure class according to a method designed by the writer.

<u>The frequency distribution plotting method</u>

The plotting method consists of kite diagrams plotted for each species, with the frequency (actual count number) plotted on the horizontal axis and the structural class plotted on the vertical axis. The vertical axis therefore broadly corresponds to the position of each tree category in the woodland profile. It also corresponds to the relative ages of the categories; seedlings at the bottom, degenerating trees at the top as is usual with age distribution plots. Coppice woodland presents some difficulty as its regrowth may be younger than standard trees but its stools older. Coppice is plotted on the vertical scale above standard type upper canopy trees with all groups of coppice in the same category. The results of each species kite diagram are plotted as totals for each species structure class.

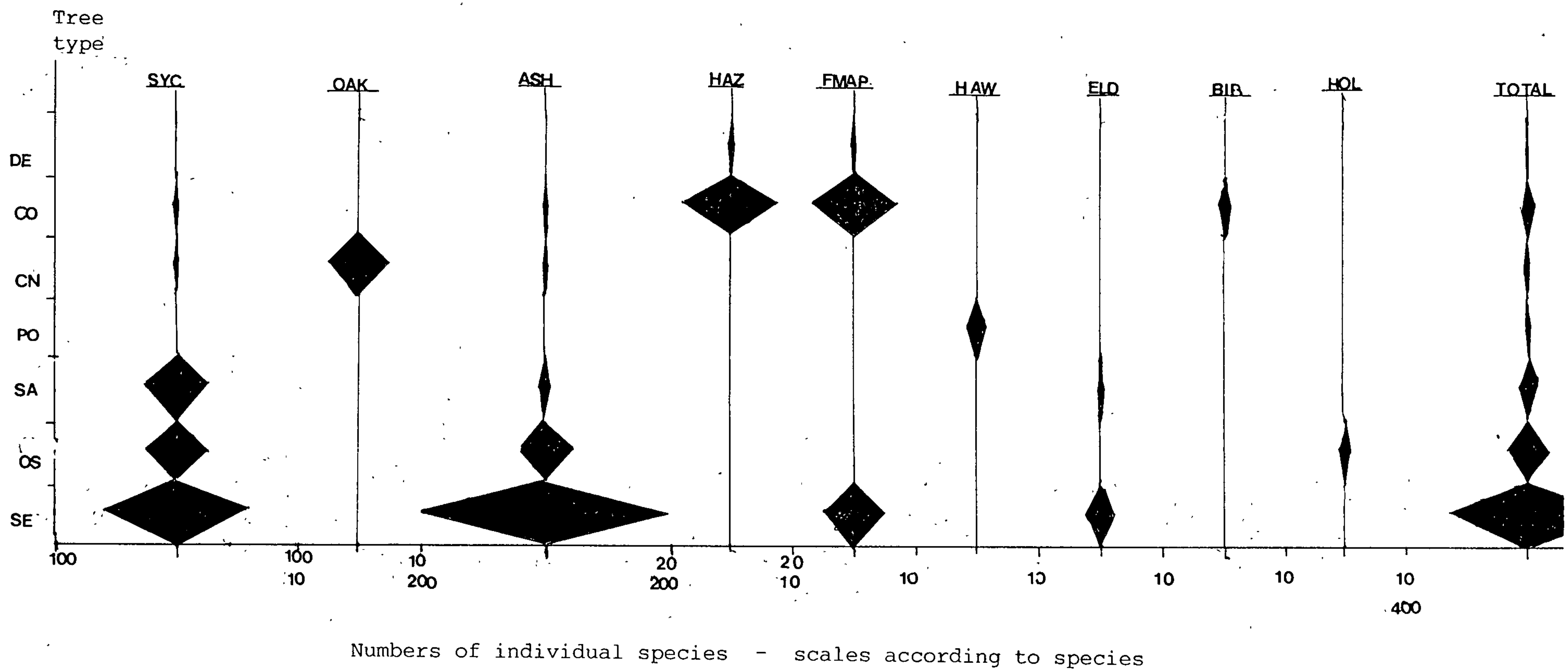
This therefore represents the total structural distribution of the woodland regardless of species. The method clearly illustrates the structural status of a woodland.

The analysis of population distribution in ancient woodlands

Table 40 Quadrat analysis of Pakenham Wood using $10x10m^2$ quadrats

Struct. Class	Tree Species										
	Syc	Oak	Ash	Haz	FMap	Haw	Eld	Bir	Hol	Guel	Tot
De	0	0	0	2	1	0	0	0	0	0	3
Cop	2	0	4	31	14	0	0	2	0	0	53
CnSt	1	8	4	0	0	0	0	0	0	0	13
Po	0	0	0	0	0	6	0	0	0	0	6
Sa	55	0	10	0	0	0	1	0	0	3	69
Os	55	0	86	0	0	0	0	0	2	0	143
Se	126	0	395	0	10	0	5	0	0	0	536

The $100m^2$ sample of Pakenham Wood (no 55) (see table 40, fig 99) was a sycamore invaded ancient wood. The kite diagrams illustrate a basic ash, hazel, field maple and birch coppice strata with oak and ash standard trees. This could be considered to be the original ancient woodland structure. The coppice trees were often as high in the woodland profile as the standard trees suggesting that the last coppice occurred several years earlier. A bore made of the ash coppice poles suggested a date prior to 1950. Since this date some degeneration of coppice stools has taken place for field maple and hazel. Of the original ancient species, field maple and ash are regenerating. Invasion of the wood by sycamore has occurred; both mature sycamore and juvenile classes of sycamore are represented. Coppice sycamore is also represented suggesting an invasion before the date of the last coppicing. Clearly, for this woodland, it could be envisaged that hazel and field maple will continue to degenerate. Field maple seems likely to be able to replace itself. Birch and oak however, do not appear to be regenerating. It would therefore seem that the most prolifically regenerating trees are sycamore and ash. It would therefore seem likely that a mixture of these two tree species will eventually replace the ancient woodland structure. Interestingly, Fig 99 The population distributions of tree species in Pakenham Wood ancient woodland illustrated as kite diagrams according to the numerical abundance in 10x10m² quadrats for each species present within each category of the tree type classification



hawthorn, elder, holly and guelders are present as lower woodland strata. Of these only guelder rose is really characteristic of ancient woodland. The other bird dispersed species may also be recent invaders of Pakenham Wood. These species are likely to be found in association with any future sycamore - ash species community. The conservationists' fear that sycamore invasion will ultimately progress to an ecologically sterile monospecific sycamore structure may not be fully justified. However, the replacement of some ancient and conservationally desirable species ie. oak, hazel and birch is likely to occur from the analysis of the existing woodland structure.

The combined structure profile suggests a well balanced population distribution, seedlings, juveniles, mature and degenerating trees. The structures of individual ancient species, particularly of oak, hazel and birch, even if combined do not suggest a normal population structure, without the inclusion of the invading sycamore. The lack of sub-mature trees of these species suggests that these species could be outcompeted by any successfully regenerating or invasive species. It could be postulated that the population structure of ancient derelict woodland is one that favours invasion by sycamore.

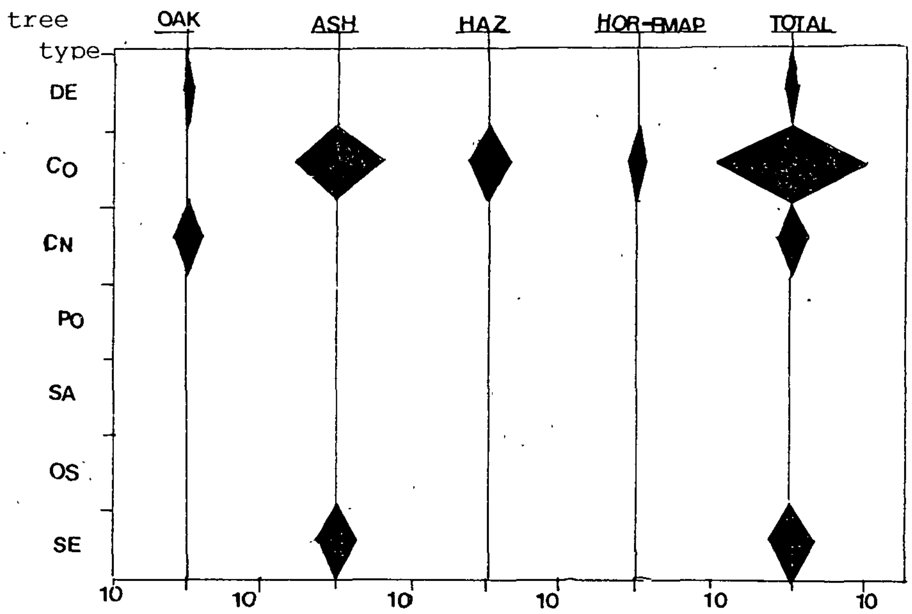
Table 41 Quadrat analysis of Eastlow Hills W.No 82 using $10x10m^2$ quadrats

Tree Species

St. Class	Oak	Ash	Haz	Hor	FMap	Tot
De	1	0	0	0	0	1
Cop	0	11	6	2	2	21
CnSt	4	0	0	0	0	4
Po	0	0	0	0	0	0
Sa	0	0	0	0	0	0
Os	0	0	0	0	0	0
Se	0	6	0	0	0	6

The $100m^2$ sample of Eastlow Hills ancient woodland (W.No 82) illustrates an ancient woodland with ash, hazel, hornbeam and field maple coppice with oak standards. The wood has not been invaded by

Fig 100
The population distributions of tree species in Eastlow Hills ancient woodland illustrated as kite diagrams according to the numerical abundance in 10x10m^2 quadrats for each species present within each category of the tree type classification



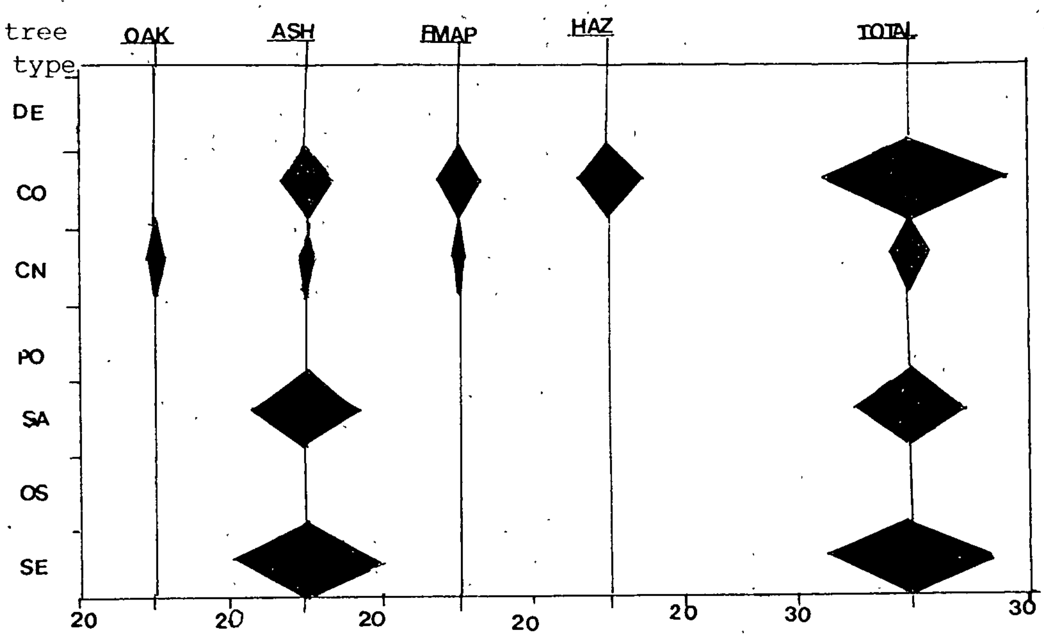
Nos. of individual species - scales according to species

sycamore. However there were sycamores within close range of the woodland (see text fig 135,p195) and it seems likely that the wood will be threatened by sycamore invasion in the future. Only ash appears to be successfully regenerating (see fig100). The kite diagram distributions of oak, hazel, hornbeam and field maple (figures combined with hornbeam) populations suggests aging unstable populations represented by no sub-mature trees. It is only by combining all species population distributions as illustrated under the 'total' plot (see text fig100) that a more evenly distributed population structure for the woodland can be seen. It would seem that in its present state a sycamore invasion would only have to compete with ash. Although it must be considered that at this woodland site and throughout other ancient woodlands in the survey area there was a relative absence of degenerating trees - in the Eastlow Hills case only oak. This factor could already be limiting the regeneration of the existing native species. Greater proportions of outgrown coppice and standards of the existing generation of trees will reach the end of their natural life span at some time in the future. This may create more opportunities for the regeneration of native species.

Table 42
Quadrat analysis data of Bangrove Wood ancient woodland using 10x10m^2 quadrats

Struct. Class.	Oak	Ash	FMap	Haz	Tot
	Tree Species				
De	0	0	0	0	0
Cop	0	14	13	18	45
CnSt	4	3	2	0	9
Po	0	0	0	0	0
Sa	0	29	0	0	29
Os	0	0	0	0	0
Se	0	40	0	0	40

Fig 101
The population distributions of tree species in Bangrove Wood ancient woodland illustrated as kite diagrams according to the numerical abundance in 10x10m^2 quadrats for each species present within each category of the tree type classification



The population distribution (see fig 101) kite diagrams of Bangrove

Wood (W.No 58 see text p62) again show the familiar ash, field maple coppice with oak standards. Unlike Eastlow Hills Wood, ash and field maple were also represented by standard trees. There were no degenerating trees in the sample and only ash was regenerating. There was no sycamore invasion but there were juvenile sycamores in a ditch surrounding the wood. It would seem likely that any sycamore invasion of Bangrove Wood would have to compete at juvenile stages with ash alone.

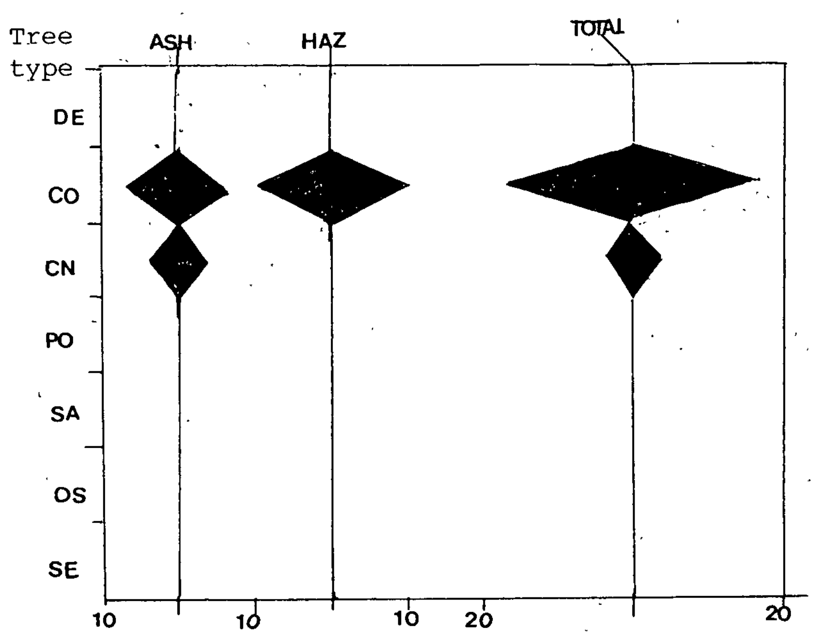
Table 43

Quadrat analysis of a compartment of Langham Hills Wood ancient woodland using 10x10m^2 quadrats

Structural Class	Tree Species Ash	Haz	Tot
De	0	0	0
Cop	14	20	34
CnSt	8	0	8
Po	0	0	0
Sa	0	0	0
Os	0	0	0
Se	0	0	0

Fig 102

The population distributions of tree species in Langham Hills Wood compartment (9) ancient woodland illustrated as kite diagrams according to the numerical abundance in 10x10m^2 quadrats for each species present within each category of the tree type classification



Nos. of individual species - scales according to species

In some ancient woodlands, in this case a compartment of an ancient woodland, the number of species present could be as few as two. The illustration of population structure (see fig 102) depicts ash and hazel coppice with ash standards. Ash was often found regenerating in ancient woodland (see text fig 59)but in this case there was no evidence of ash regeneration. The close proximity of the compartment to mature sycamore, about 70m, suggests that sycamore invasion is probable at some time in the future. It would appear that, unless there is some change in the existing population structure of the woodland, sycamore invasion would not have to compete with any sub-mature population categories of existing species.

Ancient woodland specific site analysis - Summary.

1. The regenerative status of ancient woodlands is such that only ash is commonly represented as sub-mature species and therefore it would seem that,in ancient woodlands, ash might be the main competitor to sycamore invasion.
2. Ancient woodland can be categorised by a mature stand and coppice structure, with generally more species of coppice than standard.
3. The existing structure of ancient woodland may be unfavourable to the regeneration of native trees.

The analysis of population distribution in specific secondary woodlands

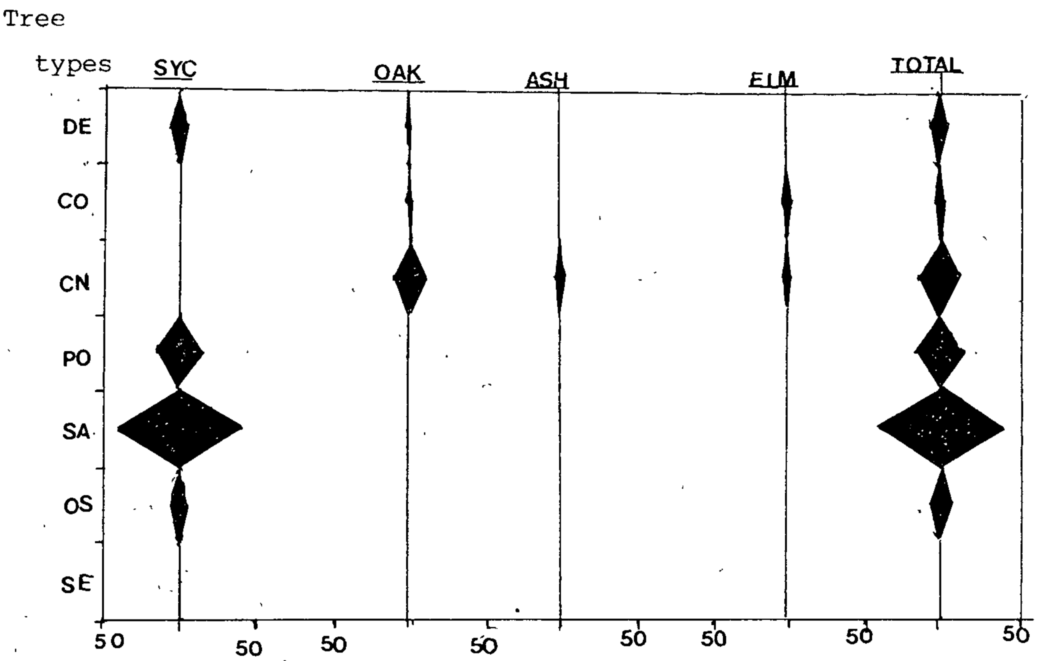
Table 44

Quadrat analysis of Great Barton Wood (W.No 63) using $10x10m^2$ quadrats

	Tree Species				
Str.Class	Syc	Oak	Ash	Elm	Tot
DeStu	0	0	0	0	0
DeCo	0	0	0	0	0
DeCn	0	1	0	0	1
DePo	2	0	0	0	2
DeSa	4	0	0	0	4
CnSt	0	20	4	2	26
CnCo	0	1	0	0	1
Po	29	0	0	0	29
PoCo	0	0	0	2	2
Sa	80	0	0	0	80
SaCo	0	0	0	0	0
Os	12	0	0	0	12
Se	0	0	0	0	0

Fig 103

The population distributions of tree species in Great Barton Wood illustrated as kite diagrams according to the numerical abundance in 10x10m[2] quadrats for each species present within each category of the tree type classification



Numbers of individual species - scales according to species

The population distribution diagram (see fig 103)illustrates a woodland containing mature oak, ash and elm trees. Sycamore is represented as sub-mature trees. The degenerate sycamore are degenerating poles. The presence of degenerating pole stage trees suggests that a process of 'self-thinning' (Silvertown[70] p118) may be taking place. In several woodlands the density of sub-mature sycamores was so great that it was difficult to see how the wood could support such a density of trees as they become mature. Silvertown[70] suggests that all populations of trees exhibit such density dependant mortality and that such mortality will often occur at a specific stage in a population's growth. This 'self-thinning line' would be a function of density and mean plant weight for a population of trees.

The presence of 'oskars' (see text p32) may also be a significant feature of the structure of Great Barton Wood. Silvertown relates oskars to the particular life mode and competitive strategy of certain tree species. He suggests that :

"Apart from a few exceptions, the seeds of trees do not have the

> capacity to lie dormant for long periods so that seeds cannot wait to exploit a future break in the canopy. However a similar ecological strategy can be employed by the formation of oskars. These are trees of advanced ages that persist as structurally and morphologically juvenile individuals."

Species such as Tsuga canadensis, Norway Spruce, Quercus alba, holly and beech are known to exploit this strategy (Grime[23]). In the U.S.A. oskars of Acer pensylvanicum occur in the forest floor for up to 20 years, suffering little mortality, while they await an opening in the tree canopy. If an opening appears, they grow rapidly to fill it, flower and reproduce (Silvertown[70] p21). From the survey analysis of West Suffolk, oak, ash and sycamore should be included as oskar-forming trees.

The importance of the role of oskars in woodland succession, particularly in the West Suffolk area, cannot be overestimated as they were found to be widely abundant. The sycamore tree may be well adapted to the formation of oskars. From the investigation of leaf opening times, it would seem that the lower strata of the woodland may flush significantly earlier than the main canopy. In the case of sycamore, seedlings, oskars, saplings and poles flushed four weeks earlier than the main canopy where that canopy did not contain sycamore. This may allow enough photosynthetic effort to maintain the oskar. However flushing of the main canopy would then limit photosynthetic effort and thus restrict the growth of the individual with the result of oskar formation. Further research beyond the scope of this thesis would be necessary to confirm this theory.

Returning to the population distribution kite diagram for Great Barton Wood (see fig 103), it would again seem that the existing native species are not actually regenerating. The absence of juvenile ash, oak or elm suggests that sycamore will not be affected by competition from other species. Sycamore invasion might therefore be encouraged.

Great Barton Wood was 'common ground'. Unlimited access was therefore available. For this reason a more detailed age structure analysis of the woodland was undertaken. A $50m^2$ section of the wood was mapped to scale (see fig 104) and subdivided into $10m^2$ quadrats. The quadrats were marked in the field using canes with coordinate numbers attached to them (see text fig 105). Individual $10m^2$ quadrats were chosen using random numbers generated from picking two digits from a bag containing digits from one to five marked on pieces of paper. Girths of all trees in each quadrat were measured. For trees below 2m in height (head height), girths were measured halfway up the main stem of the tree. For trees above 2m in height, girths were measured at the 2m point. Tree girth is often used to measure age structures of trees. However the limitations of this technique have been suggested in the text (see text p 30) and therefore no age-girth measurements were taken. Girth was considered to be an approximation of the relative maturity of trees.

Fig 104 Quadrat grid for Great Barton Wood

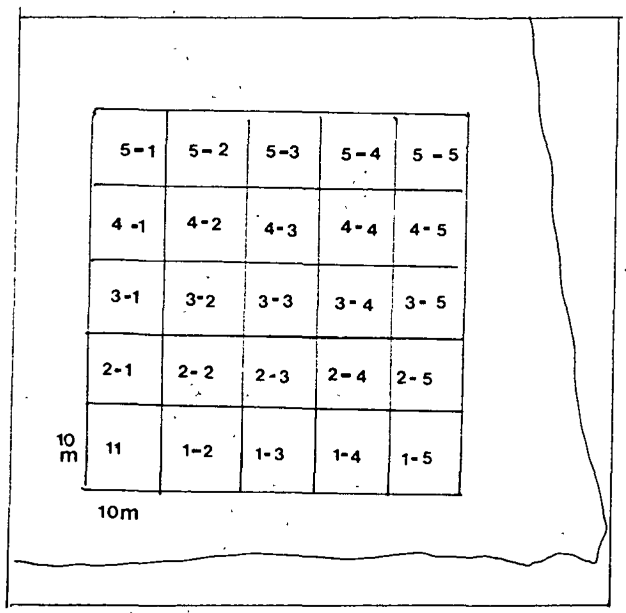


Fig 105 Diagram of method used to mark quadrat grid for Great Barton Wood and other woods

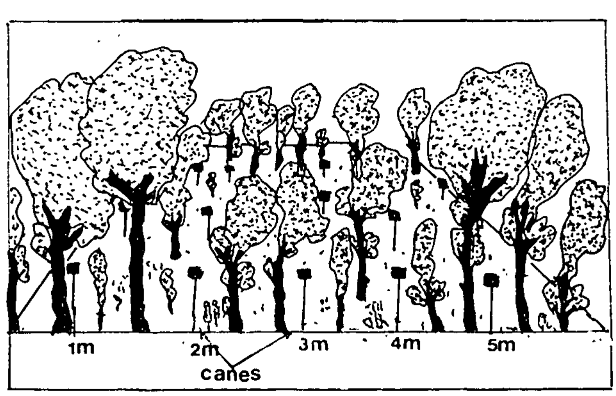


Fig 106 A histogram illustrating the distribution by girth measurements of oak, ash and sycamore in Great Barton Wood

Tree girths in 2cm classes

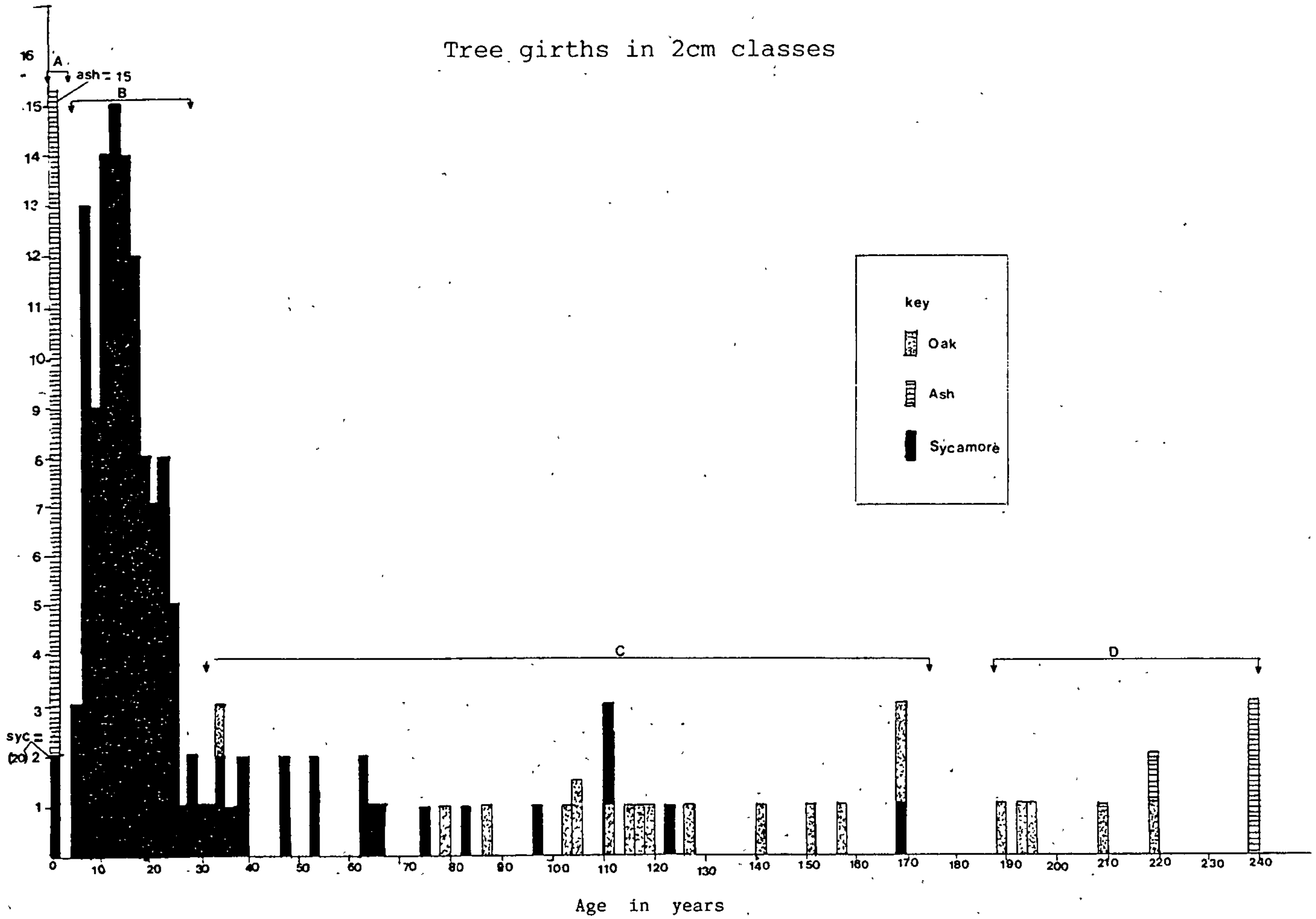


Table 45

Girth distributions - Great Barton Wood

using 10x10m^2 quadrats

Girth measurements were recorded in 2cm classes and only oak, ash and sycamore trees were included.

Sycamore

0-1.9	4-5.9	6-7.9	8-9.9	10-11.9	12-13.9	14-15.9	16-17.9
20	3	12	9	14	15	14	13

18-19.9	20-21.9	22-23.9	24-25.9	26-27.9	28-29.9	30-31.9
8	7	8	5	1	2	1

32-33.9	34-35.9	36-37.9	38-39.9	40-41.9	48-49.9	52-53.9
1	1	2	1	2	2	1

64-65.9	66-67.9	68-69.9	76-77.9	84-85.9	112-113.9
2	1	1	1	1	2

124-125.9	170-171.9
1	1

Ash

0-1.9	220-221.9	240-241.9
15	1	2

Oak

80-81.9	88-89.9	104-105.9	106-107.9	112-113.9	116-117.9
1	1	1	2	1	1

118-119.9	120-121.9	128-129.9	142-143.9	152-153.9	158-159.9
1	1	1	1	1	1

170-171.9	190-191.9	194-195.9	196-197.9	210-211.9	220-221.9
2	1	1	1	1	1

A histogram of the results has been drawn (see fig106). The greater sample size of this investigation has led to the inclusion of juvenile ash. Other than the very young ash, only relatively old ash were found. Oak had a more evenly distributed population throughout the larger sized girth classes. A large girth sycamore was found, presumably the 'mother' tree for the juvenile sycamore. The populations marked A,B, C, D on the histogram (see text fig 106) would seem to suggest four distinct regenerative phases of the woodland: Phase D exploited by ash and oak; Phase C exploited by sycamore and oak; Phase B exploited by pure sycamore; Phase A exploited by ash and sycamore. These populations either reflect changes in the conditions necessary for the regeneration of different species in the past history of the woodland or alternatively they may reflect interspecific competition between species. A simple prediction of future canopy structures for the woodland can be based on these population phases and might be :

A ⟷ B ⟶ C ⟶ D
oak/ash/elm — oak/sycamore — sycamore — ash/sycamore

(no elm regeneration was found)

These results are important to the conservationist as, although at first the woodland might be thought to be heading towards pure sycamore woodland, these results indicate that this might not be the case.

The methodology used to record girth measurements was extremely time consuming suggesting that the method used to classify trees according to morphological and structural type was a useful practical abbreviation.

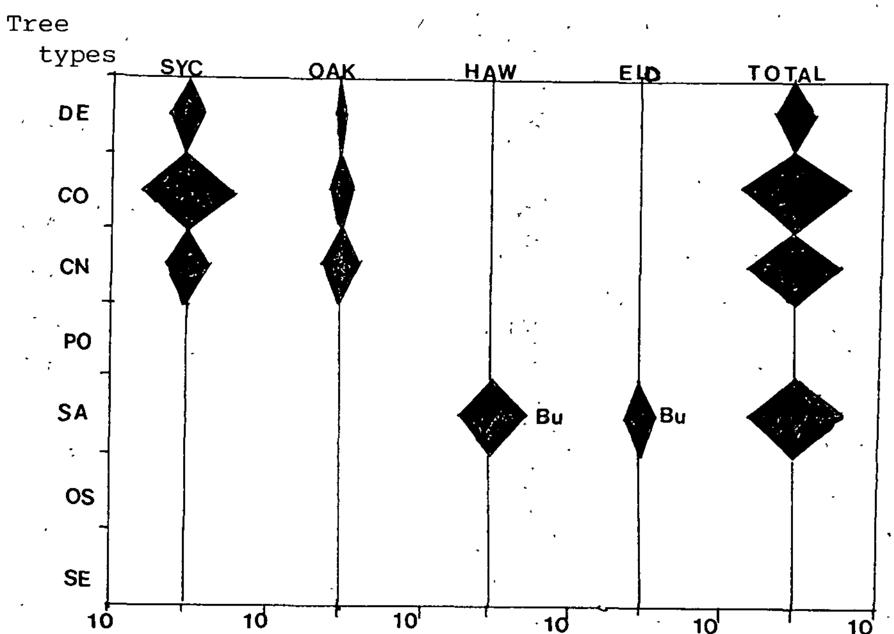
Table 46 Quadrat analysis of Moreton Hall Copse Secondary Woodland using 3x10m^2 quadrats

	Tree Species				
Str.Class	Syc	Oak	Haw	Eld	Tot
DeStu	0	0	0	0	0
DeCo	3	1	0	0	4
DeCn	2	0	0	0	2
DePo	0	0	0	0	0
DeSa	0	0	0	0	0
CnSt	7	5	0	0	12
CnCo	0	3	0	0	3
Po	0	0	0	0	0
PoCo	12	0	0	0	12
Sa	0	0	9	4	13

SaCo, Os, Se } 0 for all Species

Fig 107

The population distributions of tree species in Moreton Hall Copse illustrated as kite diagrams according to the numerical abundance in 3x10m^2 quadrats for each species present within each category of the tree type classification



Numbers of individual species - scales according to species

The distributions of oak and sycamore appear to overlap with both species being present as canopy forms. The coppice sycamore present were however coppice poles forming a sub-canopy strata. Neither oak nor sycamore were apparently actively regenerating at this time. The classification of the wood as a secondary woodland suggests that it may once have been bare soil which was colonized by oak and sycamore. The presence of coppice oak and coppice sycamore suggests that at some stage there has been coppicing. Hawthorn and elder produce a sub-canopy strata. These species are however not juvenile but occur as bush forms (see text fig 22). They again must represent colonizers of secondary woodland.

An investigation of the wood was also made according to the basic method outlined (see text p164). However some modifications were undertaken. Only three quadrats were taken and the radii of the trees were calculated. A technique devised by Mulholland[48] was used to calculate the radii of multi-stemmed trees. For each of the trees sampled, the cross-section of the trunk was assumed to be circular; the girth of each tree was converted into the radius of this notational circle by dividing it by 2 pi.

If we assume that the volume of wood produced by a multi-stemmed coppice tree of a given height and canopy area is equivalent to that of a single stem tree of the same species then we can compare single and multi-stemmed trees by the following calculation. If we calculate the cross-sectional area for each stem of the coppice tree, we can calculate the radius of a single stem tree which would give us the same area.

$$\text{Equivalent radius} = \sqrt{\left[\frac{\text{Girth 1}}{2\text{pi}}\right]^2 + \left[\frac{\text{Girth 2}}{2\text{pi}}\right]^2 + \left[\frac{\text{Girth 3}}{2\text{pi}}\right]^2}$$

Results of radii quadrat analysis - Moreton Hall Copse

Table 47 Radii measurements were recorded in 2cm classes

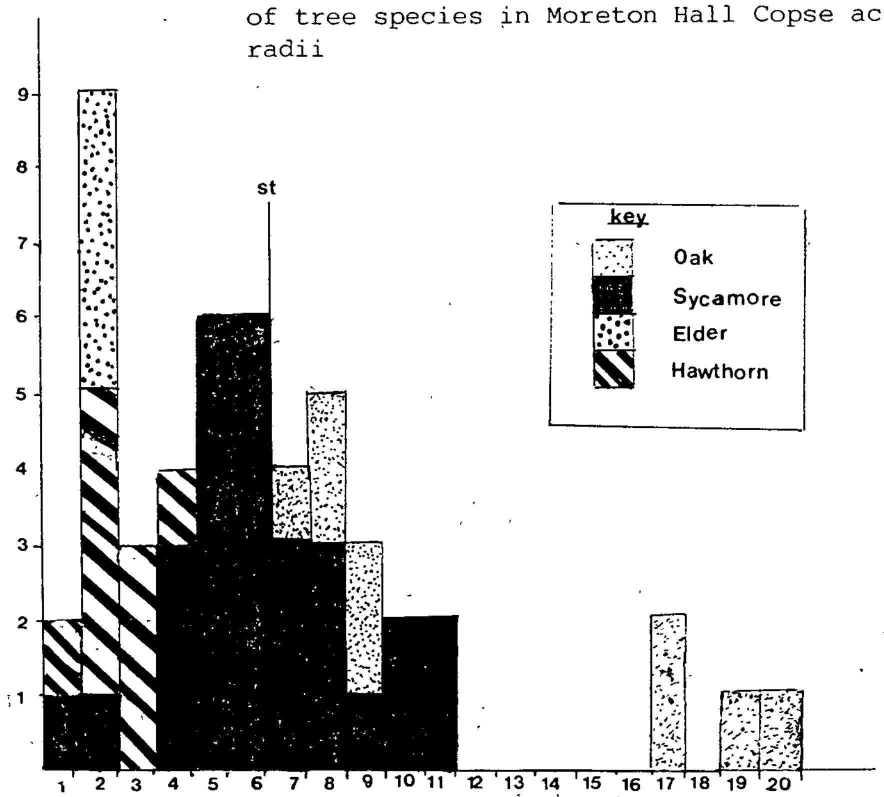
Sycamore								
	0-1.9	2-3.9	6-7.9	8-9.9	10-11.9	12-13.9	14-15.9	16-17.9
	1	1	3	6	6	3	3	1
	18-19.9	20-21.9						
	2	2						
Oak								
	12-13.9	14-15.9	16-17.9	32-33.9	36-37.9	38-39.9		
	1	2	2	2	1	1		
Hawthorn								
	0-1.9	2-3.9	4-5.9	6-7.9				
	1	4	3	1				
Elder								
	2-3.9							
	5							

This investigation reveals a more juvenile class of sycamore, most probably the coppice poles. There is also a clear division between mature oak and the most mature sycamore suggesting that oak may have arrived at the woodland before sycamore. Lack of smaller radii class oak indicates that oak is unlikely, under the present conditions, to regenerate in the woodland. The line marked 'st' on the histogram (see fig 108) could be a point of 'self-thinning' for the sycamore population. It would seem likely that the wood will become a sycamore dominated upper canopy with a sub-canopy of elder and hawthorn.

Numerical abundance

Fig 108

Histogram illustrating the population distribution of tree species in Moreton Hall Copse according to radii



radii classes of 2cm

Table 48

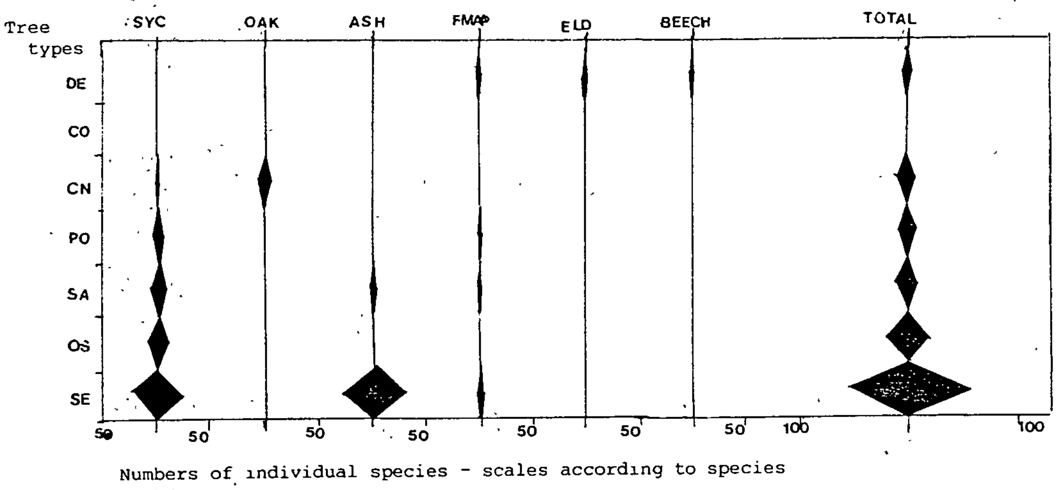
Quadrat analysis of Thurston Sewage Farm Secondary Woodland using 3x10m^2 quadrats

	Tree Species						
Str.Class	Syc	Oak	Ash	FMap	Elm	Bch	Tot
DeStu	0	0	0	0	0	0	0
DeCo	0	0	0	0	0	0	0
DeCn	0	1	0	1	1	1	4
DePo	0	0	0	0	0	0	0
DeSa	0	0	0	0	0	0	0
CnSt	1	13	0	0	0	0	0
CnCo	0	0	0	0	0	0	0
Po	13	0	0	1	0	0	14
PoCo	0	0	0	0	0	0	0
Sa	15	0	3	1	0	0	19
SaCo	0	0	0	0	0	0	0
Os	20	0	0	0	0	0	20
Se	51	0	60	2	0	0	113

In this secondary woodland field maple and beech are the degenerating species. Neither species occurs in the general survey (see text p 85) as commonly secondary woodland species or commonly regenerating species. The presence of beech actually casts some doubt on the classification of the woodland as secondary woodland.

Fig 109

The population distributions of tree species in Thurston Sewage Farm Copse illustrated as kite diagrams according to the numerical abundance in $3x10m^2$ quadrats for each species present within each category of the tree type classification



The single beech found was probably, in fact, planted. However, other characteristics of the woodland, such as the presence of sycamore and the lack of coppice trees, indicates a more positive secondary woodland character. Oak is the dominant canopy species. Oak may have been a colonizer of this woodland. Ash, sycamore and, atypically, field maple are present as sub-mature classes of tree. Sycamore is represented in the canopy suggesting that invasion of the woodland has not been very recent. The presence of sycamore and ash, presumably as invasive species after oak, has contributed to a more even age structure for the total population distribution of all species. Again, it can be seen that the lack of oak or significant beech and field maple regeneration has meant sycamore and ash have little competition at a sub-canopy level.

A further investigation was undertaken according to the methodology outlined (see text p164). Modifications to this procedure were : only $3x10m^2$ quadrats were used, results were grouped in $5cm^3$ girth classes and the results were displayed graphically rather than using a histogram.

Table 49

Results of Girth Analysis at Thurston Sewage Farm Copse using $3 \times 10m^2$ quadrats

Girth measurements were recorded in 5cm classes								
Sycamore								
	0-5	5.1-10	10.1-15	15.1-20	20.1-25	25.1-30	30.1-35	70.1-75
	81	8	7	5	3	2	3	1
Oak								
	30.1-35	40.1-45	55.1-60	70.1-75	75.1-80	80.1-85	85.1-90	
	1	1	11	2	2	2	1	
	95.1-100							
	1							
Ash								
	0-5	10.1-15	135.1-140					
	66	2	1					

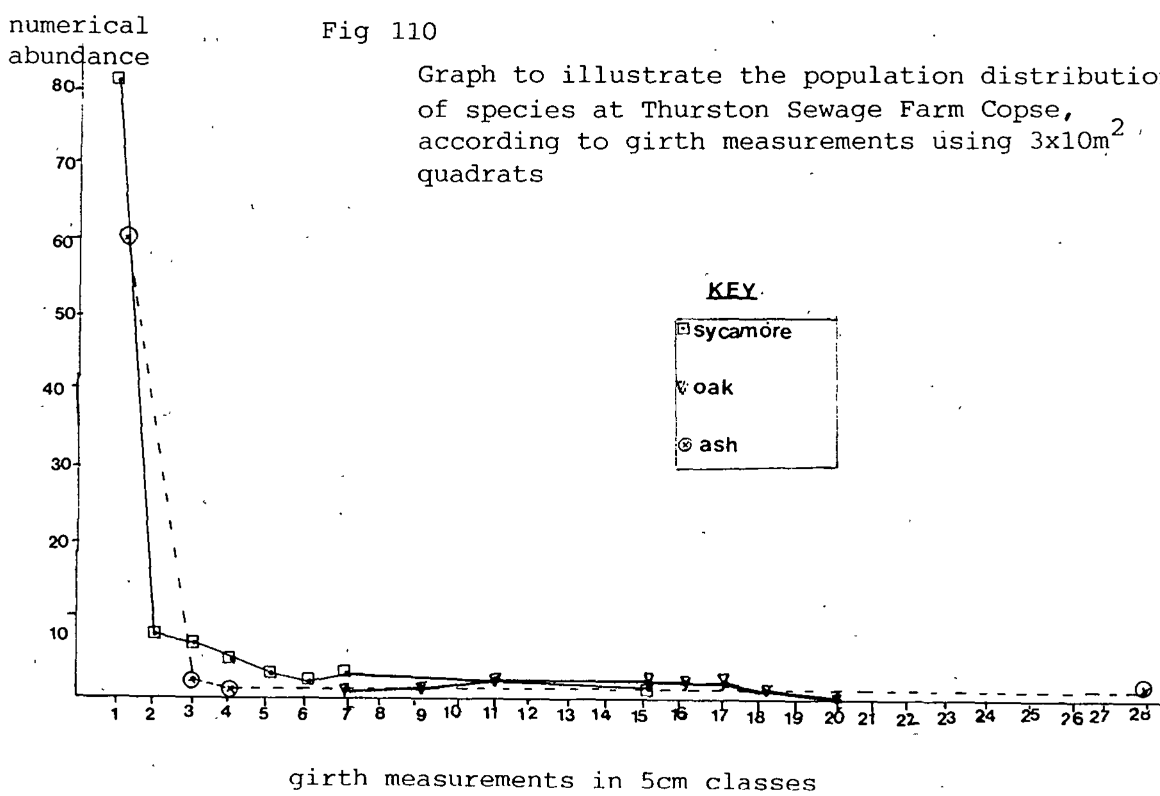


Fig 110

Graph to illustrate the population distribution of species at Thurston Sewage Farm Copse, according to girth measurements using $3 \times 10m^2$ quadrats

The graph (see fig 110) indicates a large number of both ash and sycamore in the 0-5cm girth class. This highlights a problem with some standard age class recording techniques particularly when they are applied to juvenile trees. From the kite diagram (see fig 109) using the tree classification it is apparent that a proportion of the 0-5cm was made up of oskars, trees up to fifteen years old (found from some destructive sampling), whereas a common sapling age was 5-6 years. Without the use of the classification key or destructive sampling on a larger scale, this characteristic of the woodland population structure would have been lost. However, the fate of such oskars in the woodland and their role is not known. The wide range of girth measurements for oak suggests that for a considerable period of time in the woodland's history, oak was successfully regenerating and out-competing ash which was found in small numbers, in this survey, as a mature tree. The precise conditions that now favour ash and sycamore are unknown.

Table 50

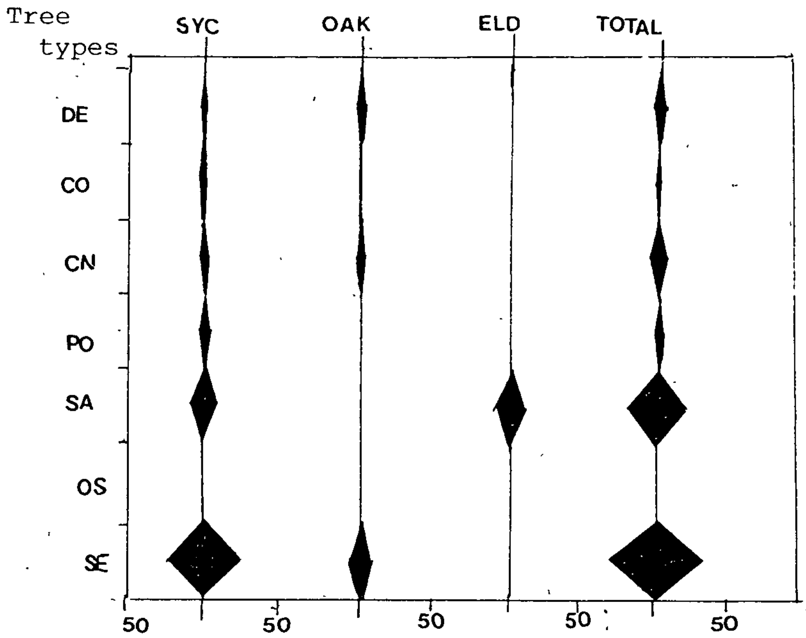
Quadrat analysis of Stowlangtoft Spinney, Secondary Woodland using 3x10m quadrats

	Tree Species			
Str.Class	Syc	Oak	Eld	Tot
DeStu	0	4	0	4
DeCo	0	0	0	0
DeCn	0	1	0	1
DePo	0	0	0	0
DeSa	2	0	0	2
CnSt	6	4	0	10
CnCo	3	0	0	3
Po	4	0	0	4
PoCo	0	0	0	0
Sa	17	0	20	37
SaCo	0	0	0	0
Os	0	0	0	0
Se	50	12	0	62

The presence of degenerate oak stumps of a significantly greater age than the present oaks at this site suggests that it was once an almost pure oak woodland, the wood being felled at some stage. Sycamore and oak are present as mature canopy trees. The oaks were regularly distributed in 'rough' rows and it is possible they may have been planted. However, the presence of canopy sycamore of an irregular distribution indicates that invasion may have begun at a similar time to the planting. The canopy of oaks may have been the result of oak colonization. Both oak and sycamore appear to be successfully

Fig 111

The population distributions of tree species in Stowlangtoft Spinney illustrated as kite diagrams according to the numerical abundance in 3x10m^2 quadrats for each species present within each category of the tree type classification



Numbers of individual species - scale according to species

regenerating. Although sycamore was the more abundant, the absence of oak oskars, saplings or poles has made it possible for sycamore poles and saplings to be devoid of significant competition at the pole and sapling stage. Elder is present at a sub-canopy level. A future composition of the woodland might eventually become oak, sycamore and elder. That is, if future competition between sycamore and oak at seedling, oskar, sapling and pole level does not exclude either species.

Secondary woodland specific site analysis - Summary

1. The regenerative status of secondary woodlands is such that ash, oak and sycamore are regenerating according to the circumstances of particular woodlands.
2. Oak may be an early colonizer of secondary woodland but may eventually be outcompeted by ash and sycamore.
3. A characteristic structure of secondary woodlands might be a canopy of ash, oak or sycamore, exclusively or in combination with juvenile trees of either species present at sub-canopy levels.

4. Hawthorn and elder might be characteristic sub-canopy species.

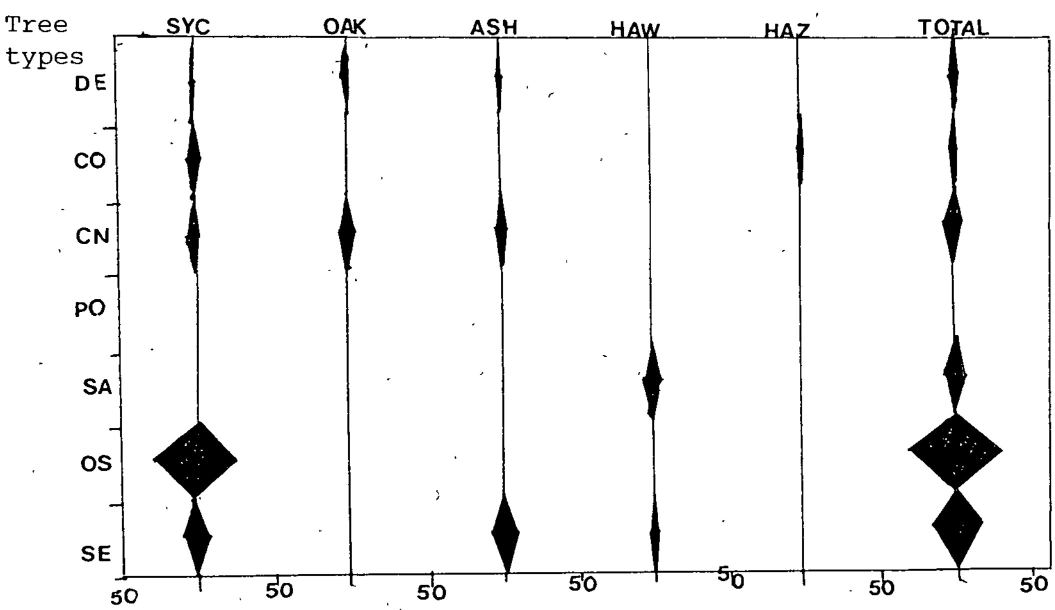
The analysis of population distribution in specific plantations

Table 51 Quadrat analysis of Wytchingham Plantation

using $3 \times 10 m^2$ quadrats

Struct. Class	Syc	Oak	Ash	Haw	Haz	Tot
DeStu	0	0	0	0	0	0
DeCo	0	0	0	0	0	0
DeCn	1	2	1	0	0	4
DePo	0	0	0	0	0	0
DeSa	0	0	0	0	0	0
CnSt	2	5	4	0	0	11
CnCo	3	0	0	0	0	3
Po	0	0	0	0	0	0
PoCo	0	0	0	0	0	0
Sa	0	0	0	10	0	10
SaCo	0	0	0	0	1	1
Os	57	0	0	0	0	57
Se	12	0	16	2	0	30

Fig 112
The population distributions of tree species in Wytchingham Plantation illustrated as kite diagrams according to the numerical abundance in $3 \times 10 m^2$ quadrats for each species present within each category of the tree type classification



Numbers of individual species - scales according to species

Wytchingham Plantation is characteristic of several of the deciduous plantations of the West Suffolk Area. Fig 112 illustrates that hazel coppice was present. It has to be assumed that these hazel coppice stools are relicts of management before the site was planted with oak and ash. Oak and ash are represented by upper canopy standard trees. Both ash and oak upper canopy trees are also showing signs of degeneration. Ash shows recent signs of successfully regenerating. However, the absence of ash or oak saplings or poles, suggests that if sycamore develops to saplings or poles, it will face little competition from either ash or oak at a sub-canopy level. Sycamore is present as seedlings and oskars. The presence of oskars could indicate that conditions within the wood are not favourable for sycamore sapling and pole development. But the presence of canopy sycamore indicates that sycamore has, at some time in the past, passed through sapling and pole stages. Hawthorn occurs as a sub-canopy species and has presumably invaded since ash and oak were planted. It is not known from this data whether sycamore has been planted in the wood or whether it has truly invaded the woodland from an outside source.

A further investigation of the wood was undertaken according to the technique outlined in the text (see p 164). There were modifications to the technique. Firstly, radii were calculated using Mulholland's[48] formula for multi-stemmed trees. Radii were therefore used for the basic recording parameter instead of girth. Each tree measured was also aged using either destructive felling with annual ring counting or by counting ring scars.

Table 52 Results of age-radius analysis of Wytchingham Plantation using $3x10m^2$ quadrats

Sycamore

Calculated Radius cm	22.6	1.63	1.48	1.36	1.80	1.46	1.58	1.24		
Estimated Age Yrs	36	13	14	15	17	16	16	14		
Calc Rad	1.39	1.61	1.48	1.64	1.71	1.60	1.47	1.61	1.74	1.36
Est Age	15	17	16	17	19	16	15	18	19	14
Calc Rad	1.29	18.4	22.0	1.59	1.52	0.66	0.79	1.35	0.81	1.43
Est Age	13	32	29	18	23	13	13	16	13	16
Calc Rad	1.14	1.84	1.87	1.64	1.83	1.71	1.95	1.21	1.44	1.32
Est Age	12	16	16	15	19	18	19	13	17	15
Calc Rad	1.81	1.22	1.05	1.90	1.91	1.83	1.64	1.79	1.35	1.91
Est Age	14	13	12	19	20	14	13	17	16	15
Calc Rad	1.26	1.87	1.62	1.78	1.71	1.75	1.41	1.46	0.95	22.73
Est Age	19	18	17	19	18	19	17	15	14	34
Calc Rad	20.85	20.71								
Est Age	28	31								

Table 52 (contd.)

Sycamore contd.

There were also 12 trees at less than 0.5cm

Oak

Calculated Radius cm	20.82	16.84	19.4	33.5	21.3	15.41	14.33
Estimated Age Yrs	54	56	48	80	46	85	82

Ash

Calc Rad	17.03	11.94	13.61	10.98	13.6
Est Age	49	38	40	55	49

There were also 12 trees at less than 0.5cm

Hawthorn

Calc Rad	4.81	1.59	2.38	4.80	3.98	1.90	2.07	3.98	3.50	3.34
Est Age	26	18	11	24	20	16	15	18	15	13

There were also 2 trees at less than 0.5cm

Hazel

Calc Rad	173
Est Age	158

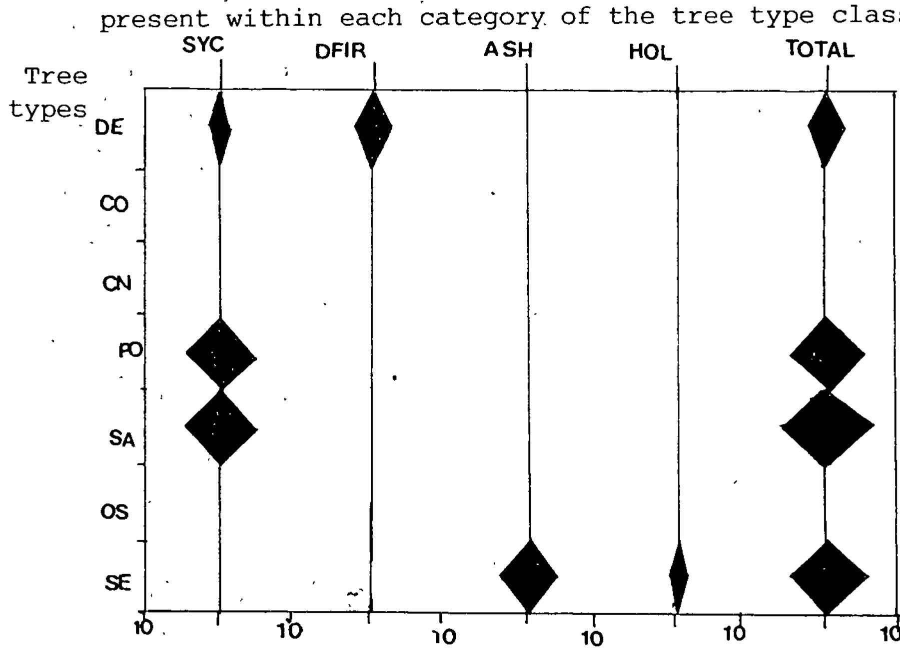
The results of table 52 have been plotted on fig 114 with estimated radius on the horizontal axis and estimated age on the vertical axis. Lines have been drawn through the 'scattergram' distributions of plotted points of each species. These lines give some indication of the age to growth relationship for each species. Some of the problems with producing such curves and displaying more than one species together are apparent. The scales on each axis are discontinuous in order to accommodate vastly differing ages and radii measurement. Seedlings produce a problem as they are difficult to measure accurately and are illustrated by numerical abundance at a point on the graph determined by their size and age. The graph does reveal that planting probably took place about 70-90 years ago and that a sycamore population depicted by 'Syc inv' on the graph may have become established in the 10-20 years after planting. It can also be seen that the rate of radial increment (growth) of the sycamore would seem to be slightly faster than either ash or oak. Sub-canopy sycamore can be up to 20 years old. It is interesting that the degenerating ash and oak (see fig 177) are within the age range 50-100 years. This is far earlier than would normally be expected as a natural life span for the trees. Sycamore poles were also found degenerating at this site in the 'self-thinning' manner described in the text (see text p162).

The future of Wytchingham plantation will be determined by whatever anthropogenic influence there is at the site in the future. It is probably likely that at some point the ash and oak will be felled, perhaps leaving the site to a developing sycamore and ash population with hawthorn sub-canopy strata.

Table 53 Quadrat analysis of Ampton Field Plantation using $1 \times 10m^2$ quadrats

St.Class	Tree species: Syc	DFir	Ash	Hol	Tot
DeStu	0	1	0	0	1
DeCo	0	0	0	0	0
DeCn	0	4	0	0	4
DePo	0	0	0	0	0
DeSa	3	0	0	0	3
CnSt	0	0	0	0	0
CnCo	0	0	0	0	0
Po	9	0	0	0	9
PoCo	0	0	0	0	0
Sa	11	0	0	0	11
SaCo	0	0	0	0	0
Os	0	0	0	0	0
Se	0	0	8	2	10

Fig 113
The population distributions of tree species in Ampton Field Plantation illustrated as kite diagrams according to the numerical abundance in $1 \times 10m^2$ quadrats for each species present within each category of the tree type classification



Numbers of individual species - scales according to species

Fig 114 . Graph illustrating relationship between radius and age of tree species at Wytchingham Plantation

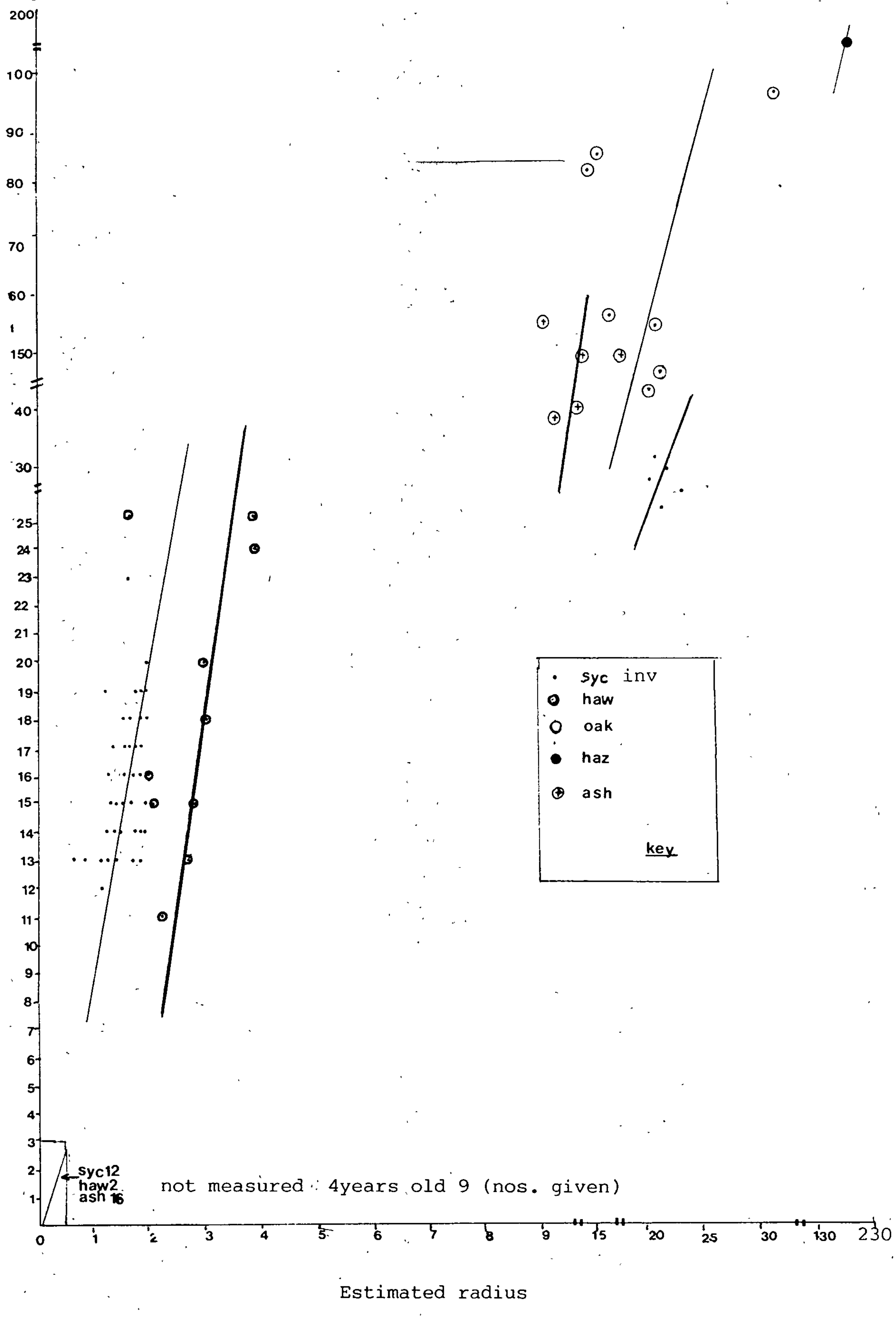


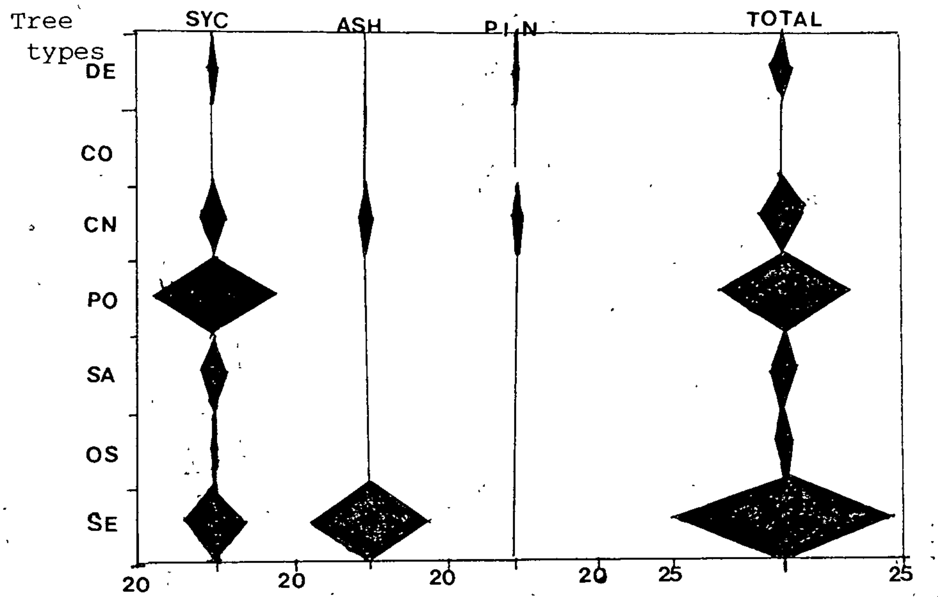
Fig 113 depicts a degenerating upper canopy of a mature conifer plantation (Douglas fir) with invasive sycamore lower canopy strata. Ash and holly are also present as seedlings. It can be presumed that the conifers will either be felled at some point in the future or will die of natural causes leaving sycamore to develop to a mature canopy. There was some evidence of stumps of an unknown species at the site. The invasion by sycamore is likely to have been encouraged by the lack of sub-mature examples of the conifer or any other species. There are many other examples in the text of monospecific conifer plantations invaded by sycamore. For example Sansom's Plantation (Wood 14 fig 50). The growth of sycamore beneath such tree stands may be of interest to the conservationist. The sycamore increases the structural and species diversity of otherwise somewhat 'sterile' woodland. For the conservationally minded farmer, there might also be the possibility of an economic rotation of timber felling involving sycamore and conifers growing together. Sycamore lower canopy strata could in some circumstances be thought of as useful ground cover for game birds.

Table 54 Quadrat analysis of Rougham Plantation using $3x10m^2$ quadrats

Str.Class	Tree species Syc	Ash	Pine	Total
DeStu	0	0	0	0
DeCo	0	0	0	0
DeCn	0	0	2	2
DePo	2	0	0	2
DeSa	1	0	0	1
CnSt	6	4	3	13
CnCo	0	0	0	0
Po	34	0	0	34
PoCo	0	0	0	0
Sa	7	0	0	7
SaCo	0	0	0	0
Os	2	0	0	2
Se	17	31	0	48

The diagram (fig 115) illustrates a pine-ash plantation, represented as canopy standards with an apparently advanced sycamore invasion. The sycamore invasion was like many found in the survey area including Wytchingham Plantation already mentioned in the text. The absence of clear invasion fronts could suggest that sycamore may not be invasive but planted at some time in the wood's past history. However, the owner of the woodland confirmed from Estate records

Fig 115
The population distributions of tree species in Rougham Plantation illustrated as kite diagrams according to the numerical abundance in 1x10m^2 quadrats for each species present within each category of the tree type classification



Numbers of individual species - scales according to species

that no sycamore had been planted and that the sycamore was a result of a natural invasion. This seemed to confirm the accuracy of the methods used to diagnose sycamore invasions at other woodland sites. It was considered that rapid invasion may have occurred due to the absence of sub-canopy forms of either pine or ash. Ash is now to be seen as seedlings in the wood and may compete with sycamore in the future. The pines are beginning to degenerate.

Further investigation was undertaken at the wood according to the random quadrat methodology suggested in the text (see p 164). The method was modified by using radii instead of girth and the Mulholland[48] formula for multi-stemmed trees was used to calculate radii.

Table 55 Results of random quadrat analysis of Rougham Plantation

Radii measurements were recorded in 2cm classes

Sycamore

0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	14-15.9	18-19.9	20-21.9
31	5	2	11	1	3	2	2

Ash

16-17.9	18-19.9	20-21.9
1	1	2

Pine

12-13.9	14-15.9	16-17.9	18-19.9
1	2	1	1

Fig 116
A histogram illustrating the distribution of sycamore by radius class at Rougham Plantation using $3x10m^2$ quadrats

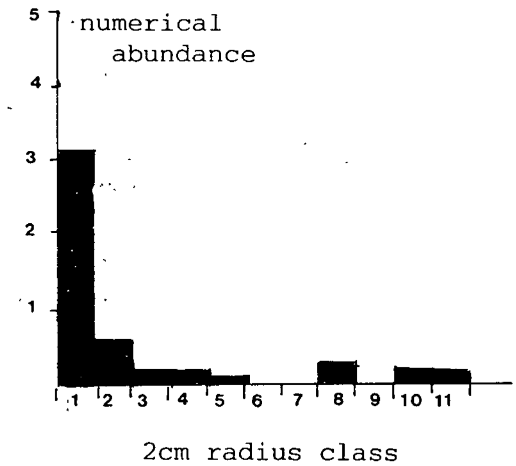


Fig 117
A histogram illustrating the distribution of ash by radius class at Rougham Plantation

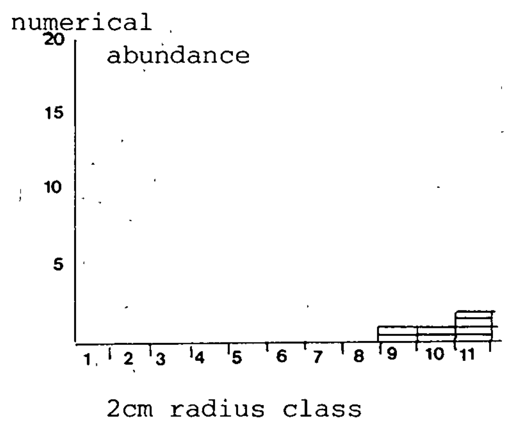
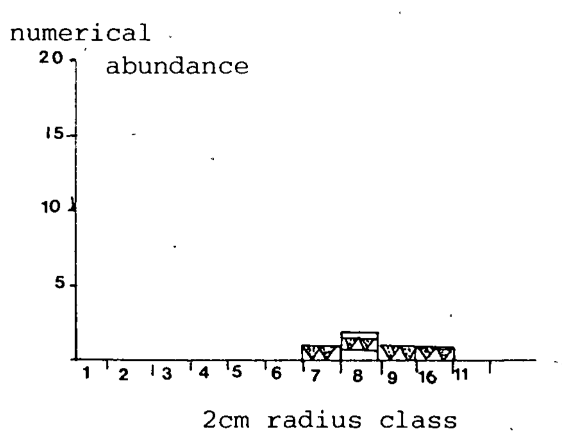


Fig 118
A histogram illustrating the distribution of pine by radius class at Rougham Plantation

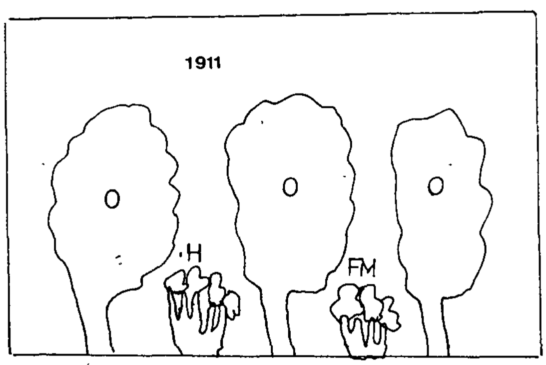


This more empirical analysis confirms a mature sycamore invasion with an apparently stable even age distribution (that is if radii can be equated to age). It would seem that either sycamore invaded very soon after planting of ash or pine or that its growth rate has been relatively quicker.

Some history is known of Rougham Plantation from the owner's report. The Estate to which the plantation belongs is the only one in the survey area to employ a forester on a permanent basis.

Before 1912 the woodland was of an ancient type with oak standards and hazel and field maple coppice. One field maple stool remains and there are signs of some large decaying stumps in the wood.

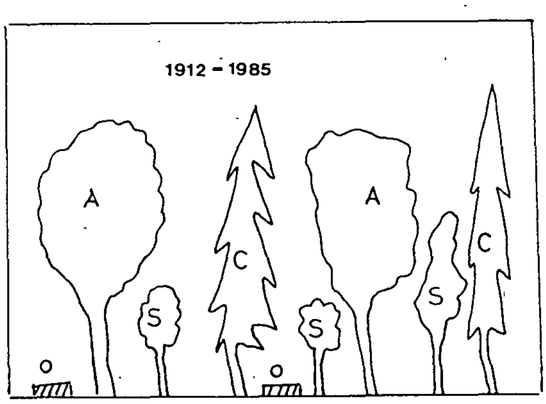
Fig 119 Profile diagram of Rougham Plantation before 1912



O = Oak
H = Hazel
FM = Field Maple

In 1912 the woodland was clear felled and ash with pine was planted with the intention of producing a timber crop and supplying cover for game (pheasants, rabbits, partridge and hares). The woodland was invaded soon after. The oldest sycamore found in the wood by the writer was 56 years old.

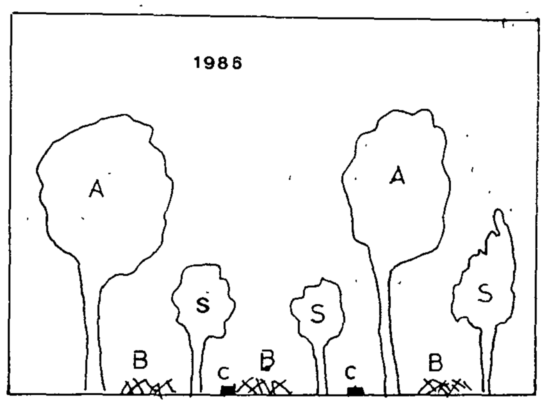
Fig 120 Profile diagram of Rougham Plantation from 1912-1985



A = Ash
C = Conifer
S = Sycamore
O = Oak

The owner had hoped that ash would regenerate to produce a less shading canopy. The owner considered that sycamore shading was reducing the ground cover of the woodland lessening its suitability for game species. The owner also suggested that grazing by deer and hare affected ash far more than sycamore. Ring barking of ash suggested this to be true. Grey squirrels are controlled at the wood to reduce their contribution to ring barking. The owner's 1986 solution to the problem was to crop the pine in the woodland in order to 'open up the canopy' and therefore encourage the growth of ground flora. Brashings from the pine have been left to encourage game species in the short term.

Fig 121 Profile diagram of Rougham Plantation in 1986



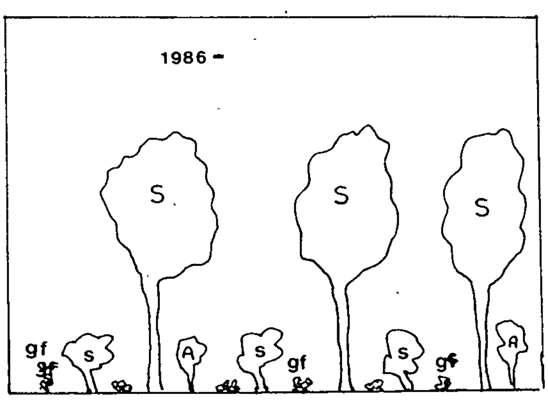
A = Ash
S = Sycamore
B = Brashings
C = Conifer

Plate 4 Photographs of pine logs removed from Rougham Plantation. Sycamore poles can be seen amongst the ash canopy

Plate 5
Photograph of Rougham Plantation following removal of pine. Tree species present are ash and sycamore (Light sufficient for snapshot camera!)

The owner suggests that a future management plan will involve the cropping of ash.

Fig 122 <u>Diagram of a possible future profile of Rougham Plantation</u>



S = Sycamore
A = Ash
gf = ground flora

The rapid growth of sycamore may allow a third timber crop to be produced within twenty years. The economic advantages that may be obtained from managing sycamore invasions are therefore clear. Sycamore is apparently naturally regenerating beneath conifer canopies (considered to be highly shading). It can also produce even age population distributions allowing continuous recruitment to the canopy and grows straight beneath canopies (see tree type classification in text p 39). Conservationists will undoubtedly have to consider the economic advantages of sycamore as well as the conservational impact of the tree. Management will also have to regard game species as an economic resource and the sycamore's suitability for game woods. A day's shooting can cost in excess of £1,000 on some West Suffolk estates.

<u>Summary</u>

1. There is evidence to suggest that West Suffolk woodlands have existing unstable species age structures which sycamore could be exploiting.

2. Alternatively, sycamore invasion could be creating instability of existing species populations in some woodlands.

3. Ancient derelict woodland without sycamore apparently has a particularly unstable age structure.

4. Sycamore may represent a useful economic resource in some woodland.

Chapter 6

THE DISPERSAL MODE OF SYCAMORE IN THE WEST SUFFOLK AREA

Sycamore seeds are adapted to dispersal by wind. The seeds are variable in size. The seed proper (fig123) can be from 5mm to 20mm in length and from 5mm to 15mm in width. Each seed has a winged appendage approximately three times the length of the seed. Usually the seeds are found as joined pairs but up to four seeds were found joined together (see fig124). Several seeds (double samaras) are attached to a stalk. The complete structure is a raceme (see fig 123). Racemes can still be seen on a tree in the spring following the year in which the seed was set. Seeds may fall as double samaras, as complete racemes or individually. Individual seeds gyrate as they fall, probably increasing their dispersal distance. The seeds of sycamore appear to contain chlorophyll for most of the year.

Fig 123 Illustration of a typical sycamore raceme

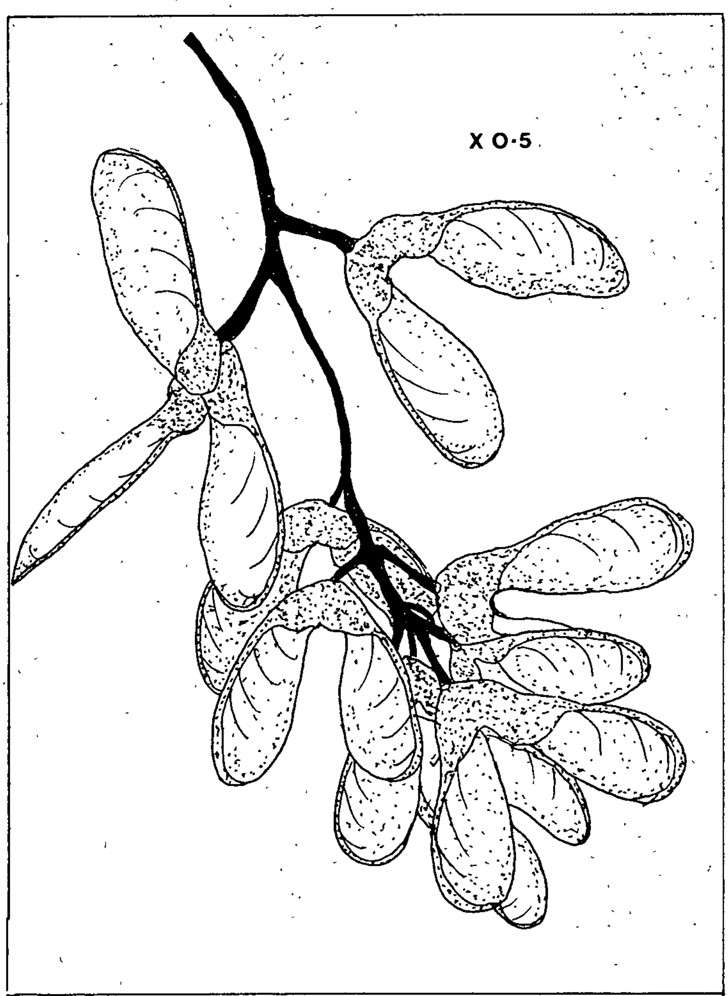
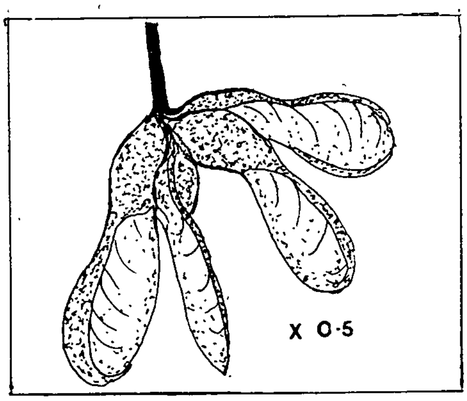


Fig 124 A quadruple sycamore samara



The numbers of seeds on trees of varying ages were recorded. Each tree was divided into units (see fig 192). The total number of branches was counted. The number of twigs on a single branch was counted. The racemes on a twig of the branch selected were counted. The number of samaras on a raceme on the twig was counted. The process was repeated three times for each tree and the average number of each unit recorded. The number of seeds on the tree was estimated using the formula :-

No. of seeds = (Av samaras per raceme x Av racemes per twig x Av twigs per branch x Branches per tree) x2

Trees were estimated in the month following leaf abscission.

Fig 125 Diagram illustrating seed counting technique

A Branches
B Twigs
C Racemes
D Samaras

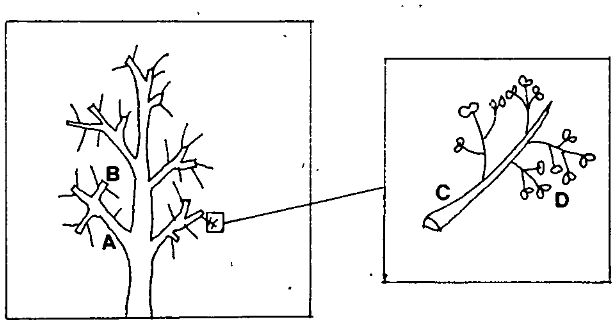
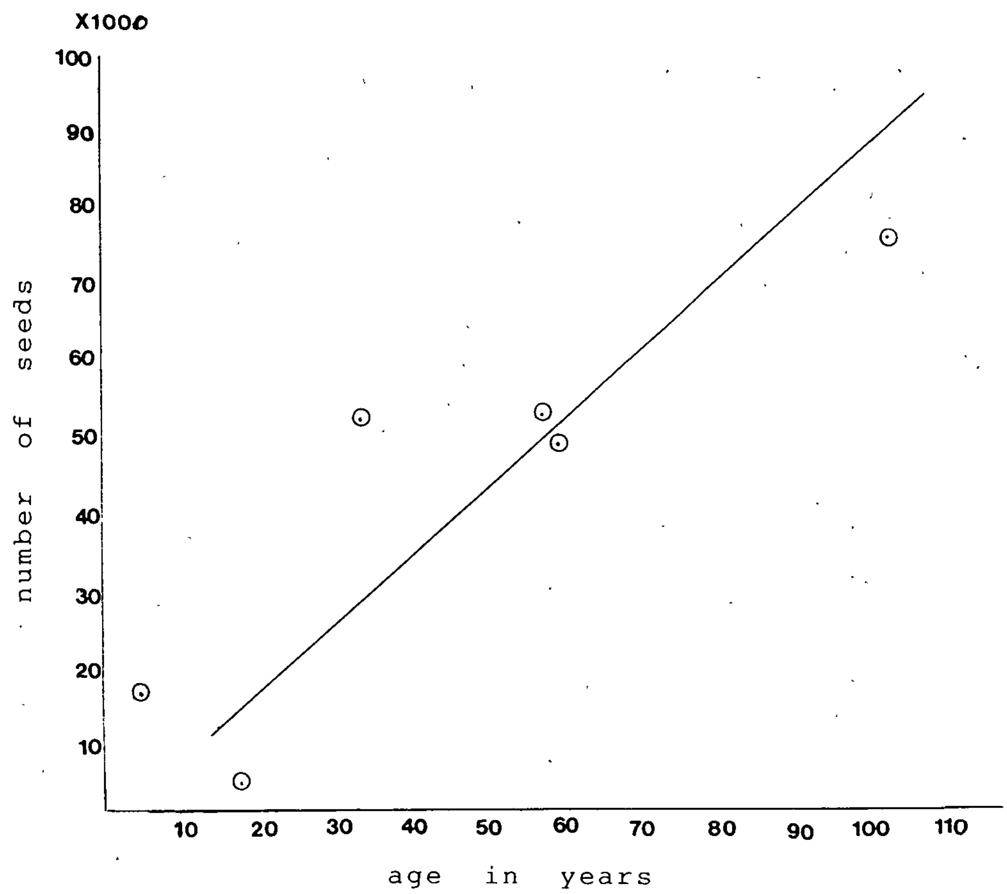


Table 56 Table of results illustrating the numbers of seeds on trees of different ages

Tree age	Av. samaras	Av. racemes	Av. twigs	Av. branches x2	Total seed nos.
104	16	5.2	27	34	76,377
60	24.8	6.75	16	18	48,211
58	19	6.3	19.1	23	52,584
34	22	4	54	11	52,272
18	17	6	4	12	4,896
5	6	10	9	5	16,200

Fig 126 Graph illustrating the relationship between tree age and the seed yield of trees



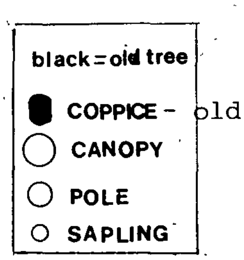
The graph (fig 126) illustrates that the older the tree is, the more likely it is to produce large numbers of seeds. In excess of 70,000 aerially mobile seeds can be produced per mature tree. Trees as young as five years old can also produce seed. The five year old tree was in a garden where conditions may have been particularly favourable to it. The 18 year old tree was at a woodland edge (see wood no 9 fig 35).

The aim of the following section of the thesis is:

1) to identify the dispersal range of these seeds in the field;
2) to relate dispersal range to the rate at which sycamore moves between woodlands in the West Suffolk area;
3) to examine factors that may affect this relationship.

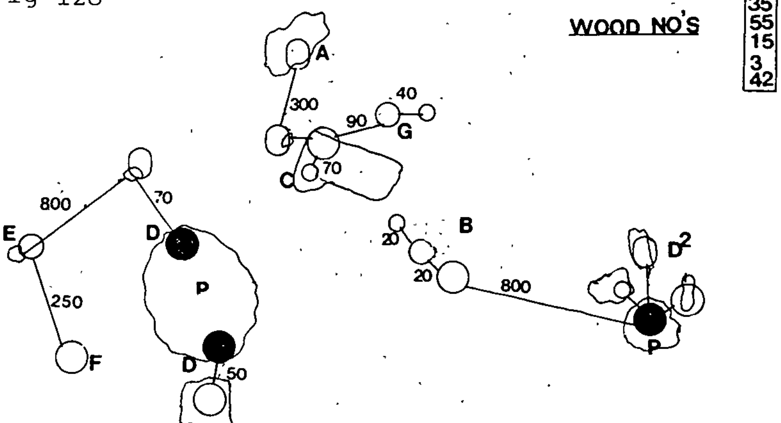
A number of groups of woodlands were selected from the general survey (see text p 47). The woodland groups have been mapped in a diagrammatic fashion. Distances of dispersal ranges given in metres are not drawn to scale but are estimates of distances based on the O.S. map[51] or from actual tape measurings or pacing. The maps approximately represent the actual geographical positions of the woods concerned (see text fig 35 p 62). The maps are intended to illustrate a likely pattern of dispersion from the site of a sycamore introduction. The assumption is made that sycamore invasion of woodlands is most likely to occur from the dispersal of seeds from the nearest mature sycamore trees present. The oldest form of sycamore, according to the tree type classification (see text p 36), at each site of complete invasion was recorded. Where an invasion front within a wood was present, the tree type at the invasion front was was also recorded on each map.

Fig 127 Key to tree types used for dispersal maps throughout the following section.



Coppice includes all coppice trees. Canopy means canopy standards according to the tree classification (see text p 36). Pole and saplings are also in accordance with the tree type classification. Particularly old trees and possible introduced trees are blackened. Woodlands and parkland are outlined in freehand. Parklands are labelled P. Dispersal distances are ruled lines joining sycamores. Distances are measured to the nearest point of sycamore in a woodland and to the furthest point of an invasion front within a woodland. The woodlands concerned were from the general survey with the further inclusion of any isolated sycamores found during the survey.

Fig 128

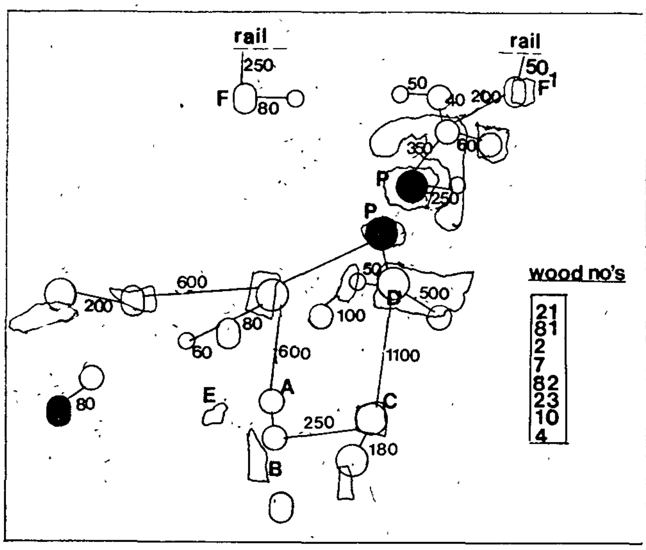


Distance in m

The map (fig 128) indicates two parkland sites with mature sycamore marked (D). Mature coppice and canopy woodlands were 70m and 50m from these parkland trees and may represent a first stage of dispersion. Wood (E) only has sycamore poles suggesting a younger woodland than the first stage woodlands. This woodland is 800m from the first stage of invasions. Woodland (F) may represent another stage of dispersion 250m from woodland (E). Woodland (C) was only invaded to a depth of 70m. Woodland (A) had a single specimen of coppiced sycamore. It could be that coppicing has affected sycamore's continued invasion, perhaps by retarding seed formation. There was no clear source of introduction for woodland (C) and woodland (A). The source tree may be enclosed within settlement. Younger trees (G) are 90m from the more mature sycamores at (C). Woodland (D^2) is similar to woodland (D) in that they are between 90m and 150m from parkland trees. These may represent a first stage of dispersion. However sycamore trees (B) are 800m from the same parkland trees. The trees at (B) were canopy pole and sapling forms with 20m between each form suggesting a second stage of dispersal of 40m at most.

Dispersal ranges for this set of woodlands appear to be within the range 20m to 800m. The two largest figures 300m and 800m were both roadside locations.

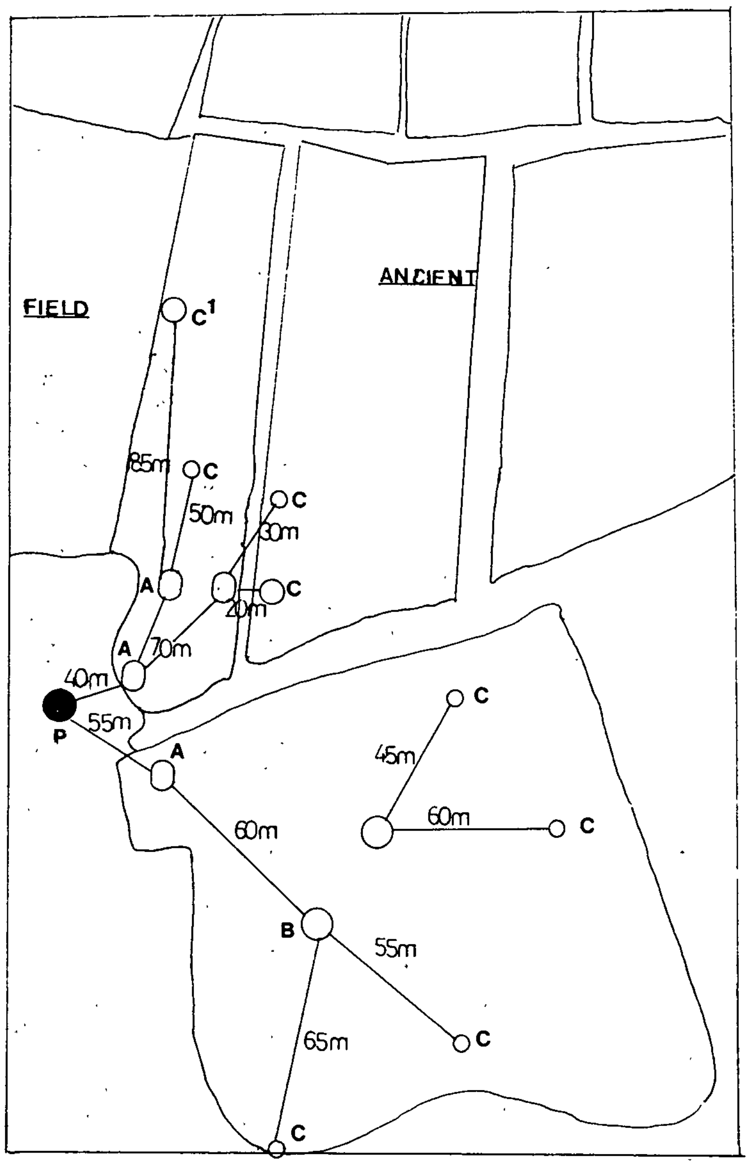
Fig 129



Distance in m

Fig 129 illustrates dispersal from a split parkland site (split by a new road). It is likely that dispersion has occurred in several stages with dispersal ranges of between 50m and 1100m. Wood (C) was 1100m from a mature sycamore invasion. The land between (C) and (D) was arable with some settlement. An unmarked source tree within a settlement could be the reason for the unusual dispersal distance. An extensive search of hedges between (C) and (D) revealed no sycamore. Sycamore (A) (250m range) was at a roadside. Woodland (B) was 40m away from a sycamore pole and could therefore be likely to represent a further stage of dispersal in the future. Woodland (E) unlike wood (B) was approximately 200m from a roadside. It had no sycamore invasion. Sycamores (F) are relatively close to railways which may represent alternative sources of introduction. (F^1) may therefore represent an initial stage of dispersal.

Fig 130 Wood no 52



The dispersal map illustrated in fig 130 indicates dispersal from a parkland source tree (P). The invasion suggests two or three generations of sycamore: (A) generation one, (B) generation two and (C) generation three. Dispersal ranges are from between 40m and 85m. The sycamore with the largest dispersal range to (C^1) was located at the woodland edge. The woodland was directly adjacent to a parkland site of introduction.

Fig 131

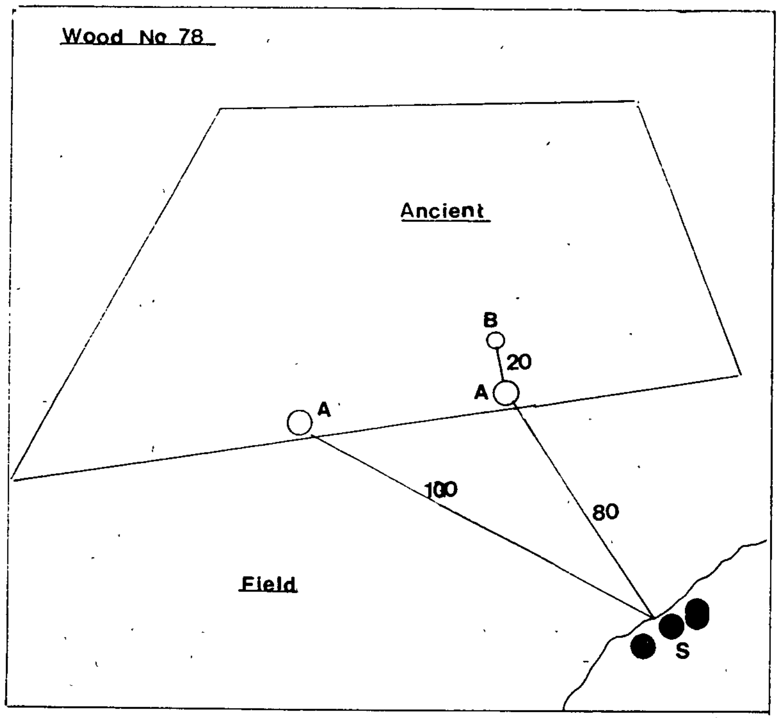


Fig 131 illustrates a possible two stage dispersal from source sycamores at a settlement site (S) to sycamores (A) then saplings (B) within an ancient woodland. The initial (S) to (A) dispersal range was from between 80m to 100m across arable land.

Fig 132

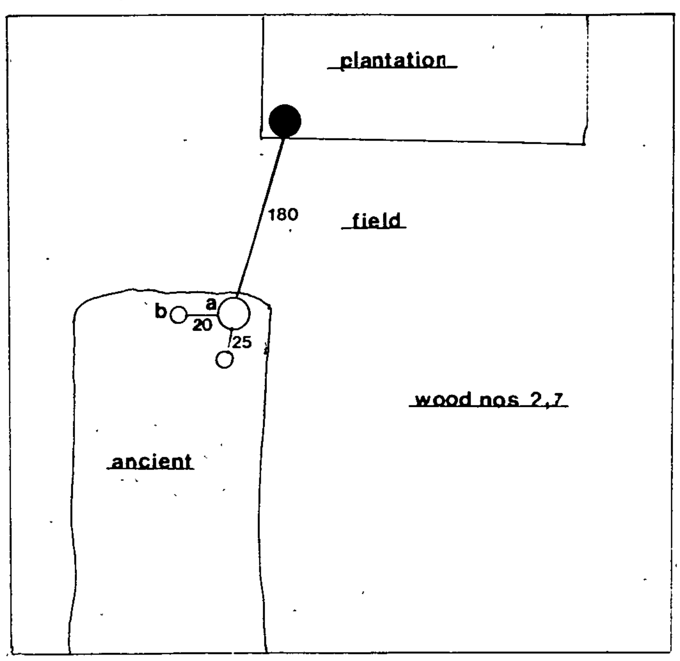


Fig 132 illustrates a 180m dispersion from plantation to ancient woodland across arable land and a second stage of dispersal from (a) to (b) within the ancient woodland. The range for the second stage dispersal was 25m.

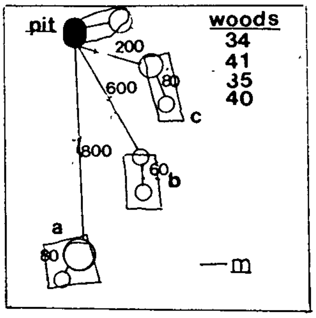


Fig 133

Fig 134 Typical sycamore invasion of a pit

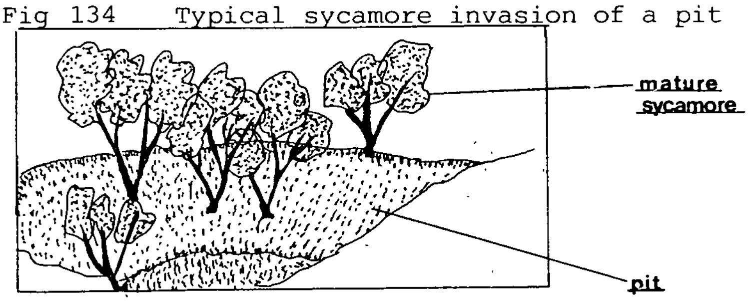


Fig 133 illustrates dispersal from an old coppice source tree at a pit site. Sycamore was found in association with pits at several woodland sites including woods 34, 74, 49. The origin of the pit is unknown but may have been originally used for clay or gravel extraction. Recently, such pits (see fig 134) have been used for rubbish dumping. Dispersions of ranges 200m and 600m across arable land to two coniferous plantations (b) and (c) are evident. A second stage of dispersal within these woods has taken place. Woodland (a) is 800m from the source tree and mature sycamore were present suggesting an earlier date of invasion than woods (c) or (b).

Fig 135

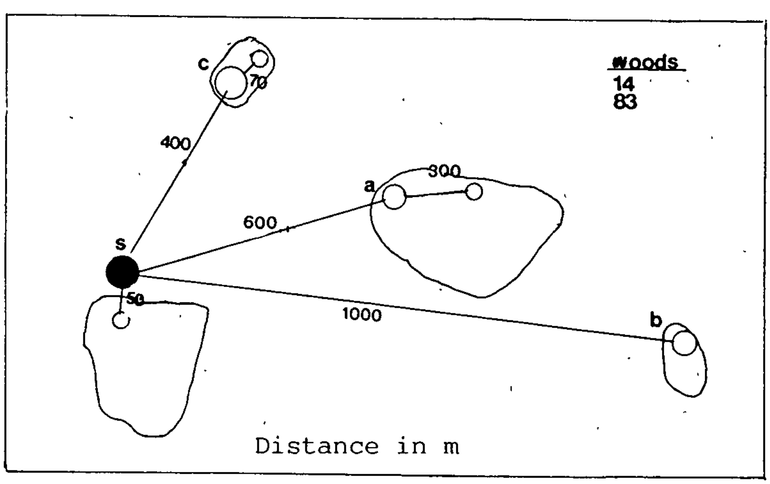
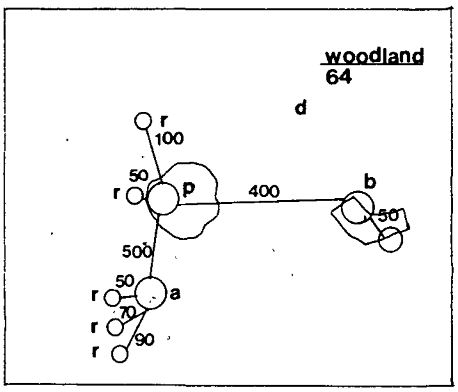


Fig 135 illustrates dispersion from a non-parkland source of introduction. Source trees (s) are isolated planted sycamores. The source trees have dispersed 600m to coniferous plantations (a). Woodland (a) has a roadside location as has woodland (c), an ancient woodland. Sycamores at woodland (a) are poles suggesting a relatively recent invasion compared to (c). Invasion is continuing in both woodlands indicating a second generation of dispersal. Woodland (b) is a secondary woodland 1000m from source trees (s). Arable land and pasture separates the two woods. The dispersal range is unusually great. It is possible that woodland (b) has developed from seeding poles at (a) or that the roadside location of woodland (b) has favoured its invasion via a less direct but faster route from source trees (s).

Fig 136

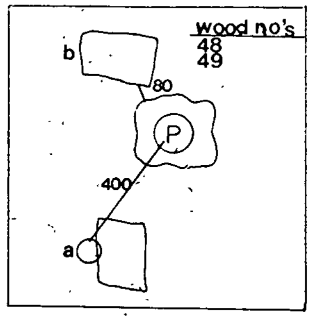


Distance in m

Fig 136 illustrates invasion from a parkland site. The immature sycamores (r) are all roadside sycamores. The mature sycamore (a) represents a first stage of invasion from source tree (p). It also has a roadside location. The road to which it is adjacent runs beside source tree (p). This may provide an explanation for the 500m dispersal range. Woodland (b) is 400m from the source tree. Other sycamore may have been present in the park and associated settlement which would reduce the first stage dispersal distance.

It was not possible to search all settlement and parkland sites for sycamore. However in the following set of dispersal diagrams the existence of source introductions at unsurveyed sites is assumed.

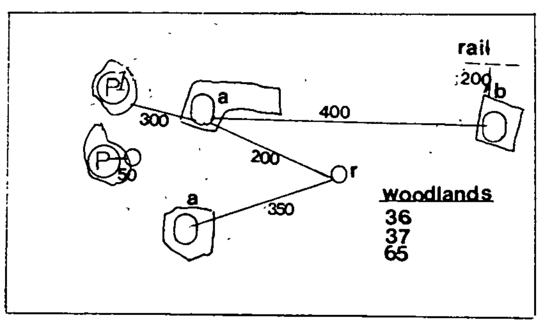
Fig 137



Distance in m

Fig 137 illustrates a parkland site 400m from an isolated sycamore invasion of an ancient woodland. The sycamore (a) had a roadside location. Wood (b) 80m from the parkland is as yet uninvaded.

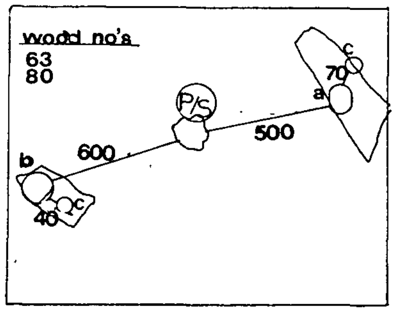
Fig 138



Distance in m

Fig 138 illustrates invasions from two parkland sites (P) A mature parkland sycamore has since been confirmed at (P^1). The mature coppice invasions (a) represent a first stage of invasion. The sycamores (r) are roadside hedge sycamores. They may represent a second stage of dispersal from (P). Wood (b) was 400m from (a). It also had a roadside distribution and may represent a second stage of invasion from (P) via (a). However the close rail site at (b) may represent another seed source.

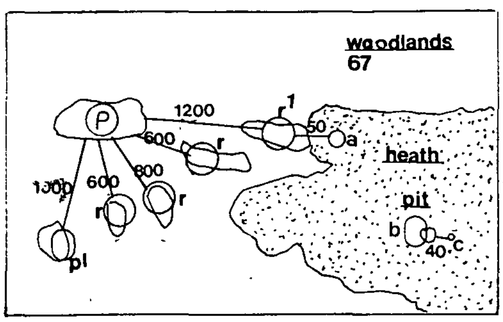
Fig 139



Distance in m

Fig 139 illustrates dispersal in two directions from parkland-settlement site. Invasion at woodland (a) was, unusually, not at the roadside edge. Invasion at (b) was at a roadside site. The seed dispersal range of 600m between (P/S) and (b) is unusually great. (b) and (a) represent a first stage of dispersal with (c) at each site representing a second stage of woodland invasion via trees at (a) and (b).

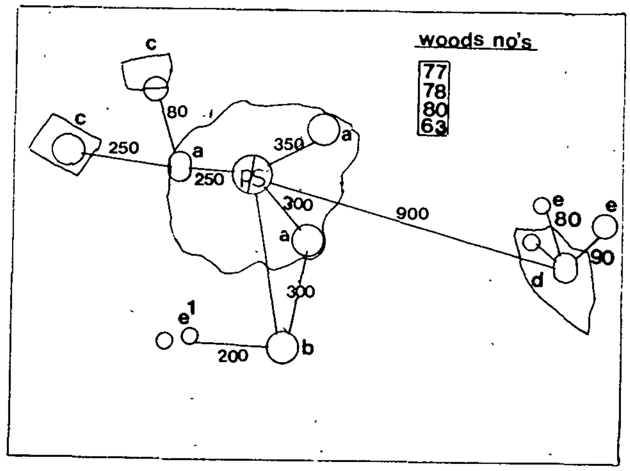
Fig 140



Distance in m

Fig 140 illustrates dispersal from a parkland site (P) to roadside woodlands (r). Sycamores at (a) are invading *Calluna vulgaris* heathland and are a second stage of dispersal (P^1) and (r^1). (P^1) represents an unusual pollarded sycamore woodland. It was not adjoining a roadside and its dispersal distance from (P) was 1000m. The woodland (P^1) may therefore have origins not relating to dispersal from (P). Sycamore at the pit (b) was invading *Calluna vulgaris* heathland at (c). Sycamore (b) was a completely isolated mature occurrence suggesting anthropogenic introduction at the site. Seeds might be transported to the site via seed contaminated rubbish dumping.

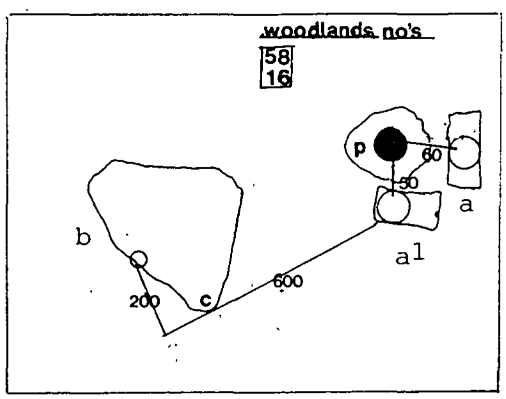
Fig 141



Distance in m

Fig 141 illustrates dispersal from a parkland site (P/S). However the parkland site had been converted to settlements in the 1960s. Sycamores (a) are mature trees in gardens. Sycamores at (b) are a pure stand of sycamore secondary woodland representing an initial stage of invasion from (a). (e^1) may be a further dispersal stage. Woodlands (c) are a first stage of dispersal from (a). Woodland (d) is 900m from (P/S); it may therefore not be related to dispersal from (P/S). Some sycamores at (d) were mature. Sycamores at (e) were likely to have been dispersed from (d) at a range of 80 - 90m. Both (e)s had a roadside location.

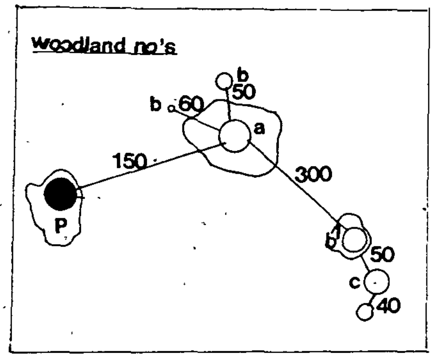
Fig 142



Distance in m

Fig 142 illustrates dispersal from a known mature sycamore tree at a parkland site. Initial dispersal to two deciduous plantations (a),(a^1) has occurred, ranges 60m and 50m. A second stage of dispersal has occurred at the edge of an ancient wood (b). Two saplings were present in a ditch at the edge of the wood. The saplings were at least 800m from the nearest mature sycamores. The dispersal route between (a) and (b) appears to be blocked by an uninvaded bluff of the ancient woodland (c). It seems unlikely that wind action on seeds could have produced this effect. An explanation might be that seeds become attached to a farm vehicle and were subsequently deposited at site (b). Site (c) may not be a suitable site for sycamore regeneration.

Fig 143

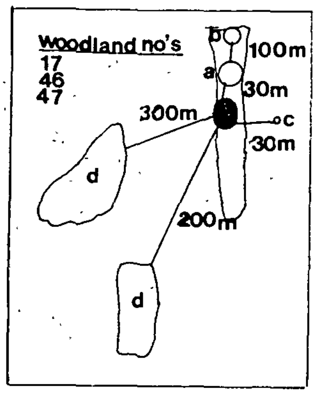


Distance in m

Fig 143 illustrates a dispersal from a known parkland site to woodland (a). (a) is dispersing in a second dispersal stage to (b) and possible third stage to (c). The 300m dispersal distance from (a) to (b^1) may have been encouraged by a road linking the two woods. Seedlings at (b^2) are temporary as the ground was arable land left fallow in 1985.

The following two dispersal maps illustrate that woodlands can be between 200m and 300m from a mature and actively dispersing sycamore and yet remain uninvaded.

Fig 144



The origin of the source coppice tree for dispersal map (fig 144) is unclear. It was not a parkland site. The origins of the tree are discussed in the text (see p 13). The tree has dispersed apparently in several generations to (a) and (b). Sycamores (c) are seedlings invading the headland of arable land and may only be temporary. Woodlands (d) are separated from the sycamore introduction by 200 - 300m of arable land. This may represent a distance beyond the normal wind dispersal distance of sycamore.

Fig 145

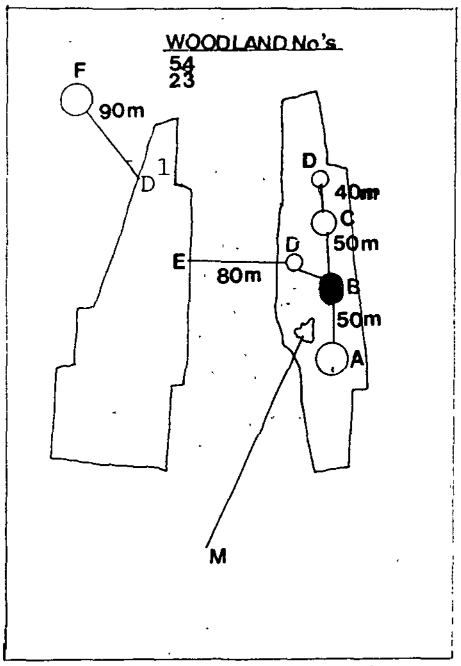


Fig 145 again illustrates sycamore dispersal from a non-parkland site. (M) on the map signifies moat. An earlier dated O.S. map revealed the moat was the site of an old hall. Coppice sycamore at (B) were extremely mature. Invasion is continuing at (C) and (D). (F) denotes the site of another mature sycamore. The range between (D^1) and (F) was from 80-90m. The woods were separated by arable land. The arable land was preventing the invasion of (E) from woodland sycamore (B) or (D).

Jones[35] quotes that Hegi[28] has recorded that sycamore seed can travel up to 4km. Mackay[41] has records of sycamore travelling from 90m - 650m and climbing 215m. A more common distance for sycamore dispersal between woods in the West Suffolk area per generation of tree would be between 100m and 400m. In some circumstances, particularly where woods have roadside locations, up to 800m can be recorded with figures of 1000m or over being somewhat dubious. As for climbing height 215m may be accurate. The gyrating nature of the sycamore seed may be adapted more to ascending and descending mountains than it is to travelling any great distance. This would be coherent with sycamore's native mountainous range. Sycamore could actually have a relatively short dispersal range compared with other native trees. Sycamore is more likely to invade near woodland or colonize near bare earth than it is to invade distant woods or colonize distant primary sites. In most cases, sycamore will be an invader of existing woodland due to its relatively short dispersal range. Sycamore may, in fact, be adapted specifically for this purpose (see text, p 284).

Although Jones[35] quoting Ridley suggests sycamore may be found in bird droppings, it seems unlikely from the dispersal maps (except for, perhaps, fig 140) that birds play any part in sycamore dispersal. Ground feeding game birds, e.g. pheasants[89] may eat sycamore seeds but the seed has no real adaptation for passing through the animal's gut unharmed. The seed is hardly really adapted for whole swallowing either.

It is apparent that the distribution of routeways (road and rail), parklands and settlements has some relationship to sycamore dispersal. The following section analyzes these relationships in more detail.

Fig 146 A diagrammatic map of the demography of sycamore in woodlands indicated, illustrating a tendency to roadside distribution and suggested dispersal routes

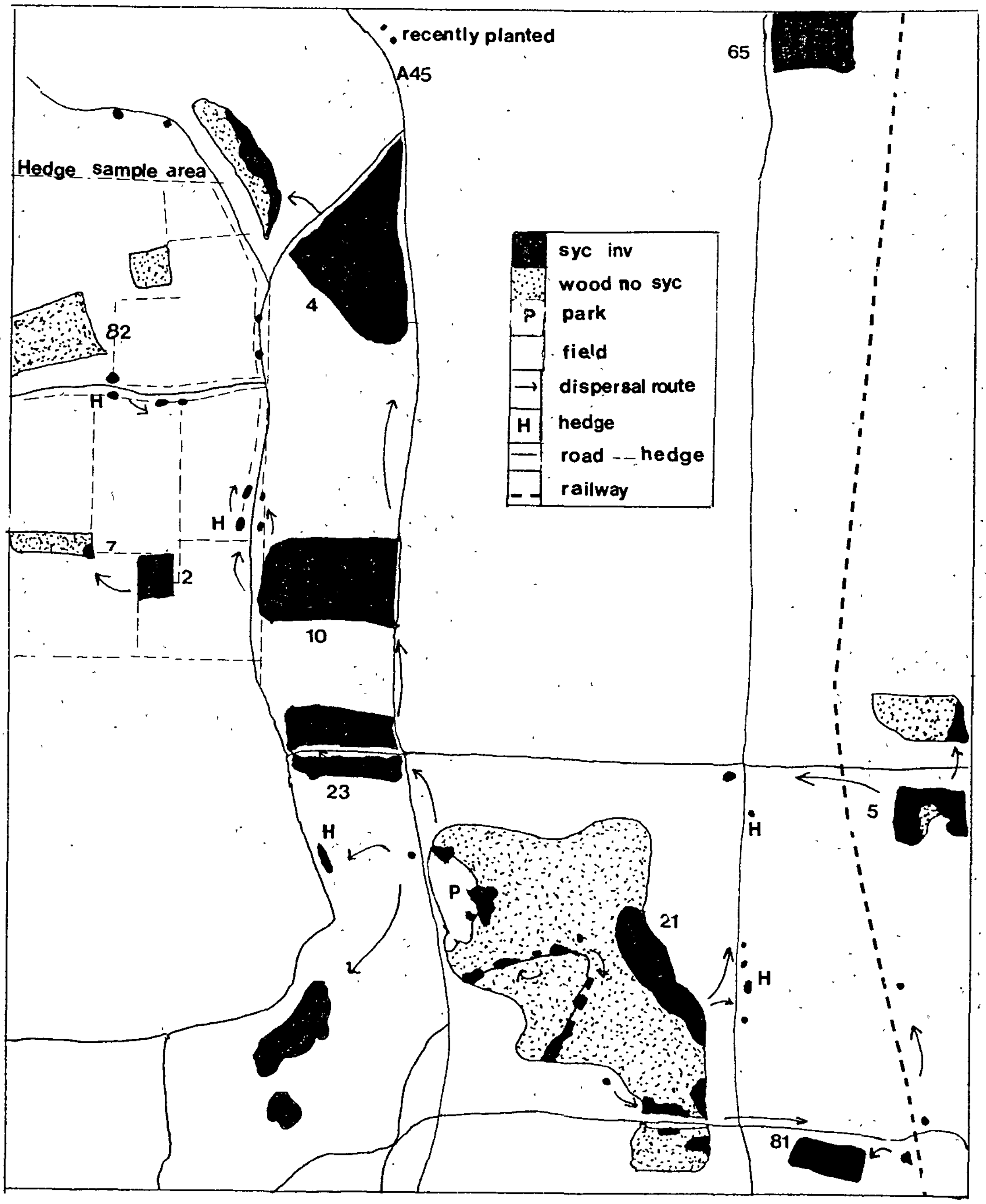


Fig 146 clearly illustrates that sycamores are often distributed at roadside or railside locations, either as woods or in hedges. The arrows on the diagram depict possible routes taken by dispersing sycamore seeds. There were few sycamores found isolated by arable land. All hedges within the lightly dashed hedge sample were checked for sycamore. Only roadside hedges showed sycamore present.

Fig 147 A diagrammatic map of the demography of sycamore in the woodlands indicated, illustrating a tendency to roadside distribution and suggested dispersal routes

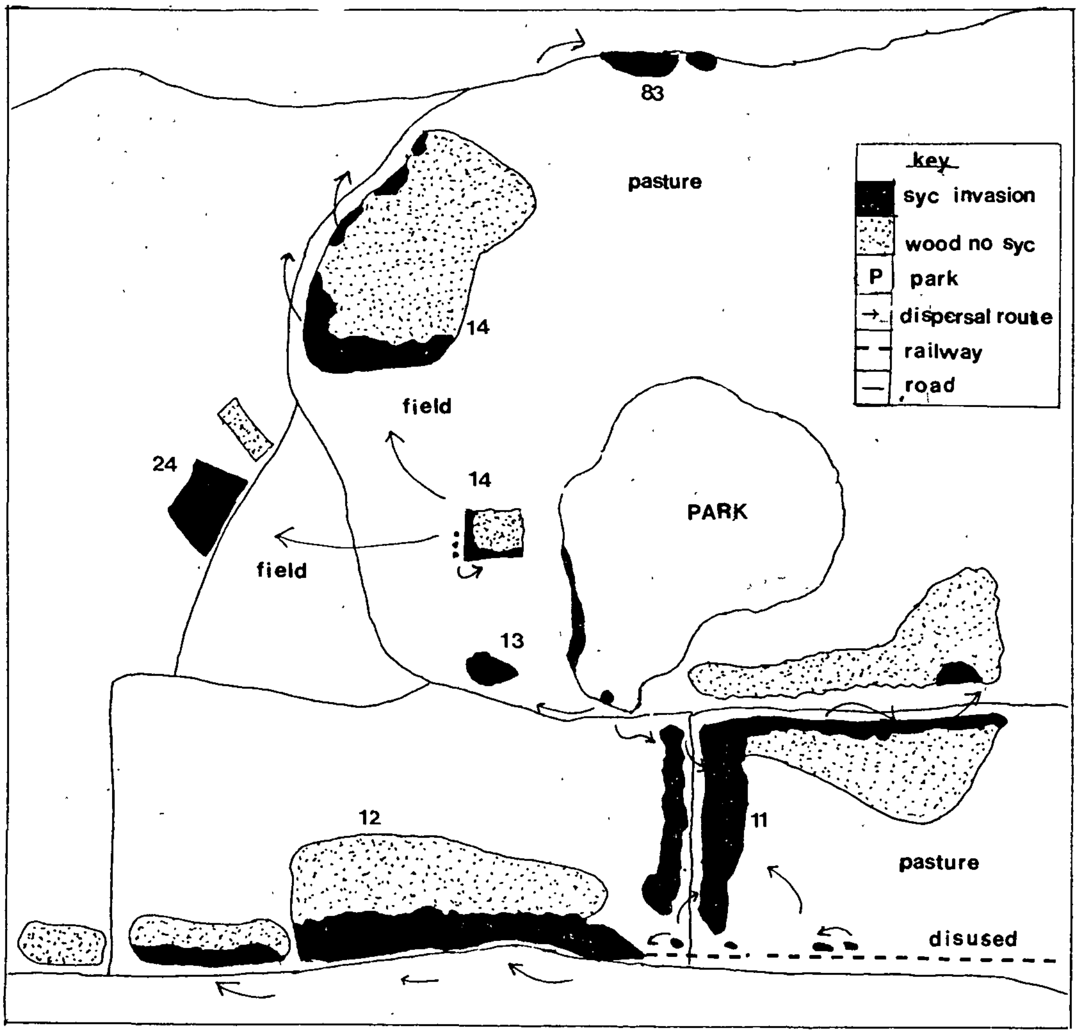


Fig 147 again illustrates the favourability of roadside sites to sycamore invasion. Woodland (12) marks the site of a disused railway. Sycamore was present on the embankment of this railway at several sites along its length. Railway embankments are a common site for sycamore in urban areas.

Fig 148 A diagrammatic map of the demography of sycamore in the woodlands indicated, illustrating a tendency to roadside distribution and suggested dispersal routes

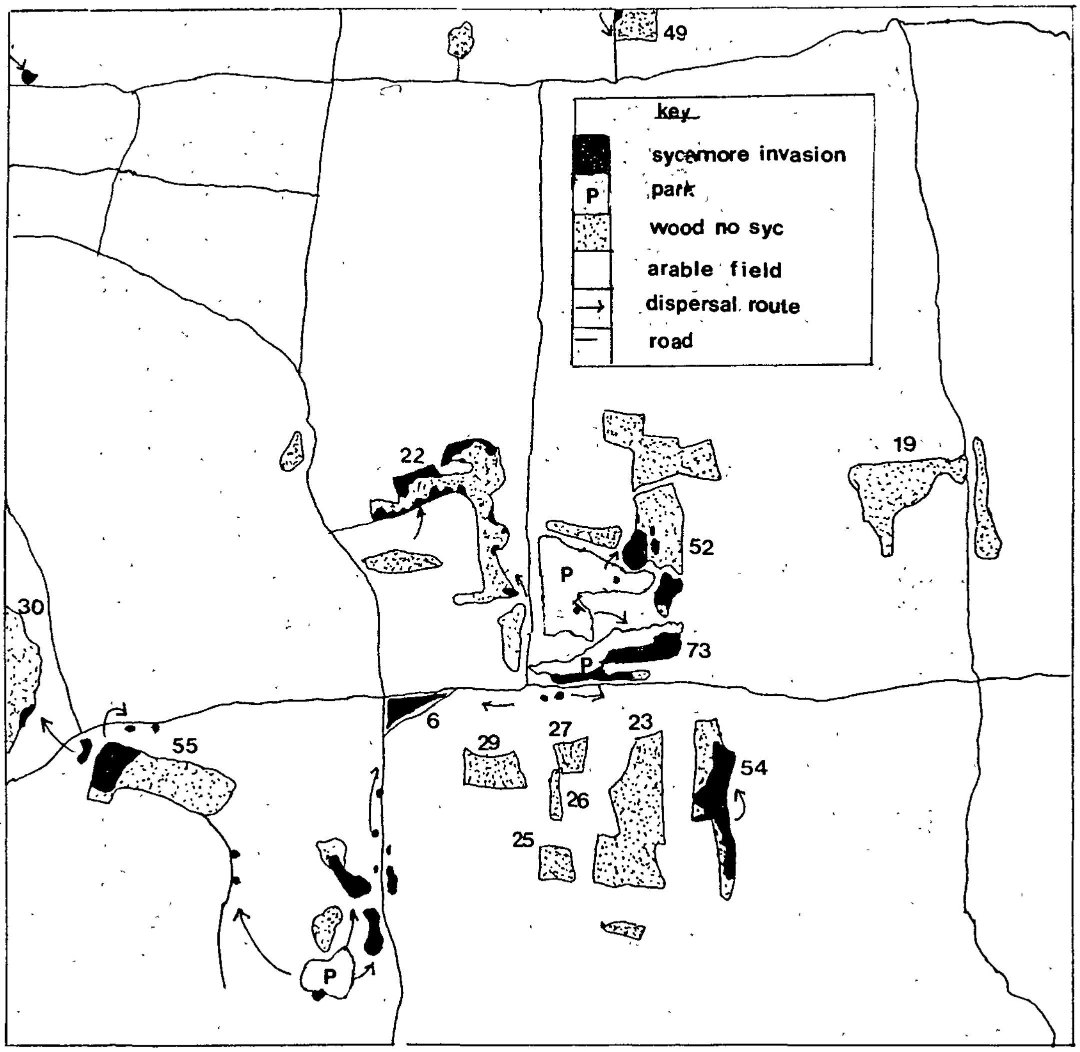


Fig 148 further illustrates a positive relationship between parklands, roads and sycamore distribution.

Fig 149 Map of Norton Wood illustrating distribution of sycamore and suggested dispersal routes

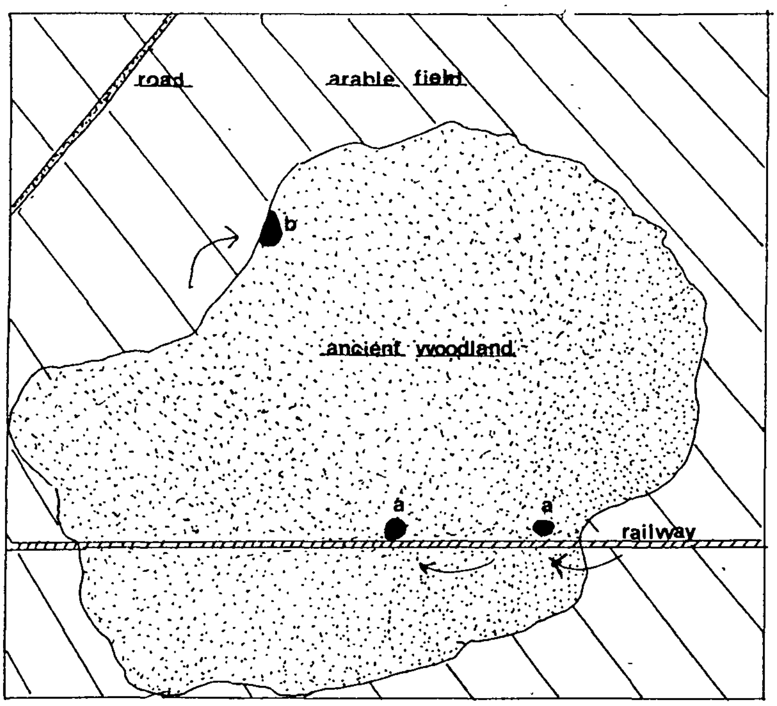


Fig 149 illustrates invasion of an ancient woodland bisected by a railway. Sycamore invasions (a) were close to the railway. Sycamore (b) was an isolated mature sycamore 200m from a road and further from saplings (a). Its origin is uncertain. This tree and those at Bangrove Wood (see text, fig 142) represent the few examples of extraneous sycamore invasions.

<u>The statistical analysis of the relationship between sycamore demography and settlements, parks, routeways and source sycamores</u>

The results of the general survey (see text p60-65) were used to produce mean average distances of ancient woodland (A), secondary woodland (S), coniferous plantations (C) and deciduous plantations (D) to nearest routeways, parklands, settlements and source sycamores (nearest mature sycamore tree). Each category was further subdivided into woodland with sycamore (W) and woodland with no sycamore (N). The results of the general survey were taken from millimetre measures on the O.S. map [51] and converted to metres. The mean average for all woodland categories with sycamore and with no sycamore was calculated and is illustrated as Total with sycamore (Tot W) and Total without sycamore (Tot N). The totals have been divided by four to make graphical comparison with the individual woodland categories. Reference points for measuring from parks and settlements were taken as the central point of the nearest settlement or park. All known settlements and parks were circled using a 1mm, 2mm or 3mm graded circle stencil depending on settlement or park size and the centre of the circle taken as the reference point. The reference points were fixed for all the recording but are likely to be over estimates of the actual distance of park or settlement perimeter to woodland perimeter. The sum of the four parameters, nearest routeways, nearest parkland, nearest settlement and nearest mature sycamore, was calculated to give an index of woodland isolation from likely sycamore seed sources. The sum and mean average for the four treatments are recorded as Total isolation (TI). The sums of all woodlands, with and without sycamore, are divided by four for graphical comparison with individual woodland categories.

Table 57 Table illustrating the average distance of woodlands in the general survey of West Suffolk woodland to routeway, parklands, settlements and mature sycamores

	Distance to woodland categories (m)								Tot	Tot	÷4	÷4
	AW	AN	SW	SN	CW	CN	DW	DN	WS	NS	WS	NS
1 Nearest route	176.5	293	93.5	43.5	92	108	42.5	108	404.8	552.5	101.2	138
2 Nearest park	1805	2143	1400	2025	1025	1475	1850	1350	6080	6993	1520	1748
3 Nearest Settlement	725	885	527.5	780	530	890	357	1075	2139.5	3630	534.8	907.5
4 Nearest Sycamore	866.5	791	760	680	488	366.5	725	466.5	2839.5	2304	709.8	576
Total Isolation	3753	4112	2781	3528.5	2135	2839.5	2974	2999	-	-	-	-
T I Index	893	1028	695	882	533.5	709.8	743	749	2866	3368	716	842

Fig 150 A histogram illustrating the mean distance of woodlands from routeways

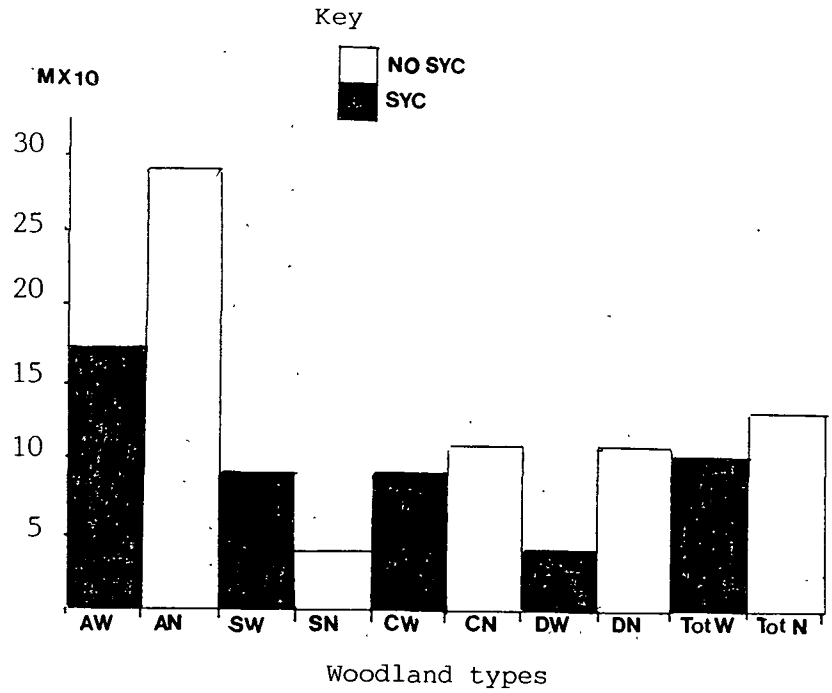


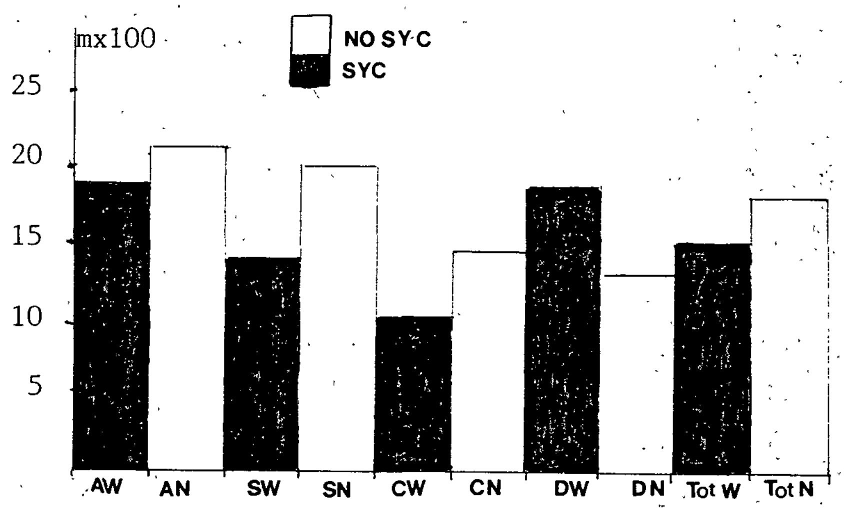
Fig 150 illustrates that the mean distance from ancient woodlands, coniferous plantations and deciduous plantations to routeways is greater for woodlands without sycamore than for sycamore invaded woodlands. This suggests that routeways may play a positive role in sycamore seed dispersal. The distribution of secondary woodland however refutes this hypothesis. This could be due to sycamore colonizing unwooded sites and so forming secondary woodland,whereas sycamore will have had, in most cases, to invade existing ancient, coniferous and deciduous woodlands.

Roads possess several characteristics that make them ideal vectors for wind dispersed seeds. They are relatively free from obstructions and road traffic ensures that air movements at ground level are continuous. Gulleys and ditches along roads often mean water movement. Railways and railway embankments may have a similar vector status for sycamore seeds. A comparison may perhaps be drawn to the expansion of other species populations such as that of Oxford Ragwort via the rail network. The presence of sycamore at Norton Wood (see fig 149) is perhaps an example of this. Increased road construction and road use in the twentieth century may therefore have greatly favoured sycamore expansion by increasing air movement and by bringing more woods within closer proximity to regularly used roads. A policy of planting sycamore along trunk routes such as the A.45 (see text, fig 184) may well further enhance sycamore dispersal and mobility in the future. In 1957, Mitchell[45] observed infrequent sycamore along a three and a half mile stretch of the old A.45 from Stowmarket to Needham Market, just beyond the West Suffolk survey area.

The precise mechanism relating roads and railway to sycamore dispersal lies beyond the scope of the thesis. However, dispersal might be encouraged by : 1) increased air movement, 2) the attachment of seeds to mud on the underside of vehicles, 3) by the action of snow ploughs in winter throwing seeds up from roadsides, 4) the formation of an unobstructed (from ground level to tree level) aerial pathway for wind blown seeds, 5) water movement may also aid sycamore dispersion.

Plate 6 Photograph of a roadside sycamore in the West Suffolk area

Fig 151 A histogram illustrating the average distance of woodlands from the nearest parkland



It is suggested that parklands were source sites of sycamore introduction in the survey area. Therefore, it can be hypothesised that the further away from a parkland a wood is, the longer it should take for a woodland to become invaded. Fig 151 indicates that secondary woodland with sycamore, ancient woodland with sycamore and coniferous woodland with sycamore are closer to parklands than are woodlands of the same type that have not been invaded by sycamore and so supports the site of introduction hypothesis.

Sycamore dispersal within settlements, for example, churchyards, car parks and gardens were difficult to locate on a large scale but are common in the West Suffolk area. Their contribution to the overall demography of sycamore is difficult to assess.

Plate 7 Photograph of a naturally regenerated garden sycamore in the West Suffolk area.

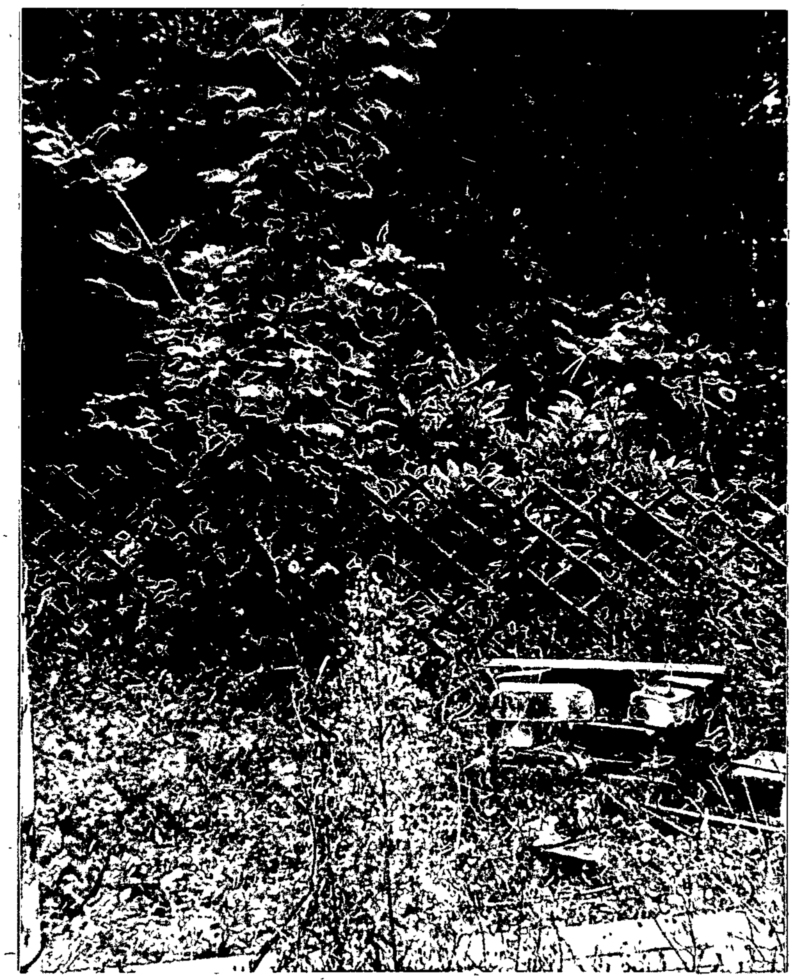
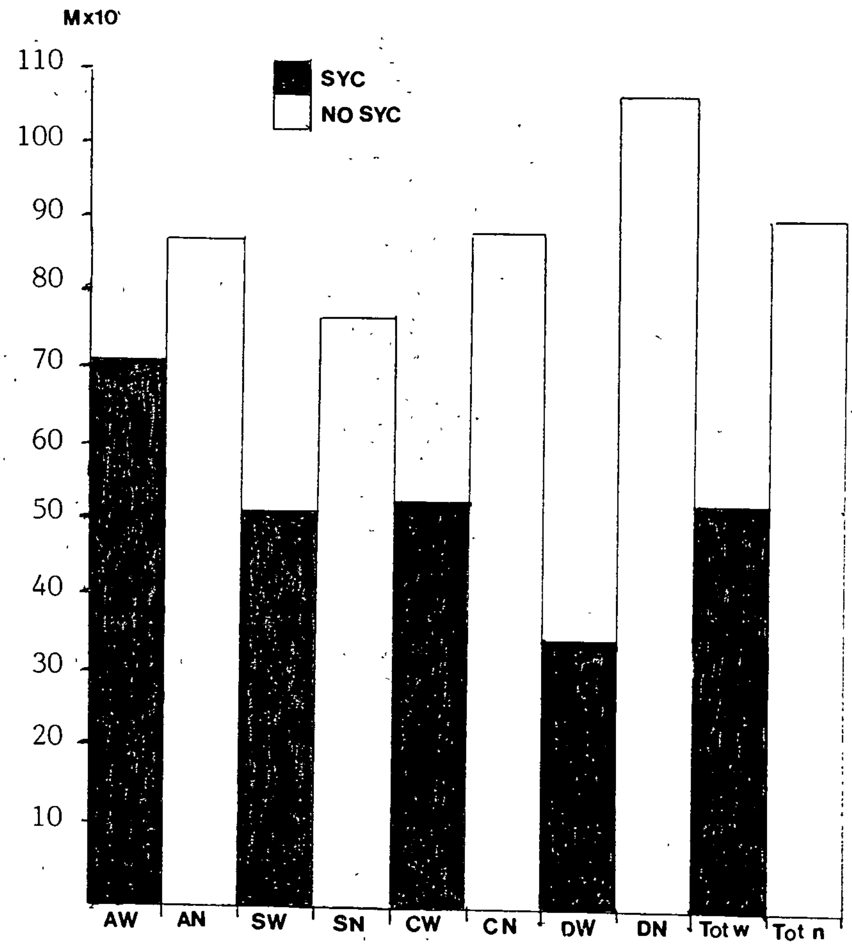


Fig 152   A histogram illustrating the mean distance of woodlands from settlements



However, fig 152 clearly illustrates, that for all woodland categories the further woodlands are away from settlements, the more likely they are to remain free from sycamore invasion. Settlements are therefore likely to act as source sites for sycamore dispersal. It has been shown that dispersion of sycamore seeds usually takes place over relatively short distances between 100 - 400m in a single generation. Therefore it could be hypothesised that sycamore invasion of a woodland will be more likely if there is a sycamore seed source within this dispersal range.

Fig 153 A histogram illustrating the mean distance of woodlands from nearest sycamore

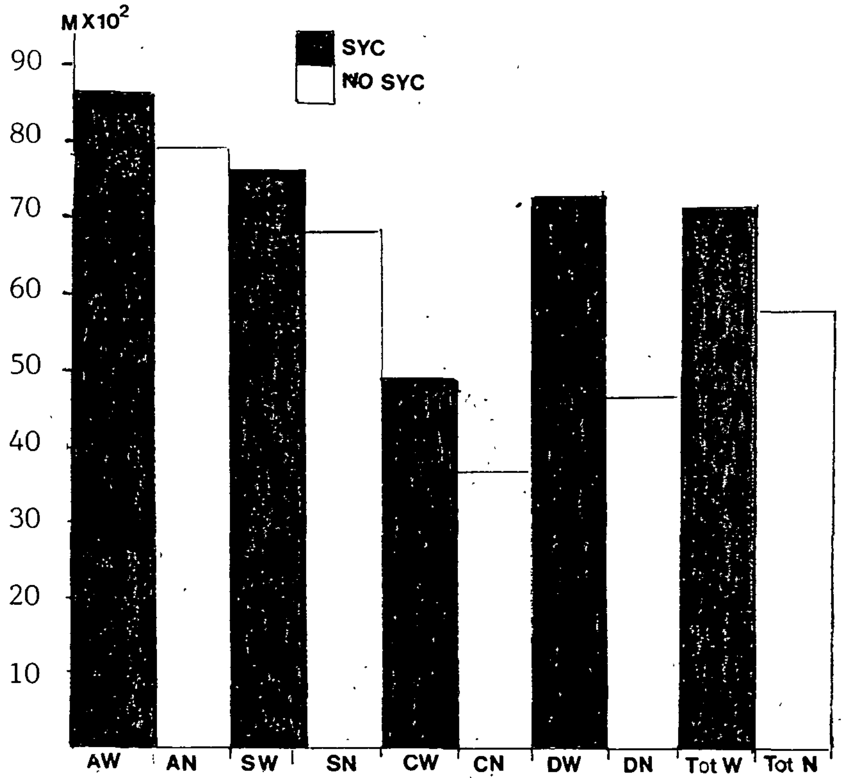


Fig 153 contradicts this hypothesis for ancient and secondary woodland and coniferous plantations where it seems that dispersal distance from an existing sycamore has no distinctive relationship to the likelihood of invasion. If anything, non-invaded woodlands are likely to be nearer to source sycamores than invaded woodland. Two possible explanations for this are : one, that other factors affecting dispersal,such as the proximity or routeways, have a modifying effect or, two, that some woodlands may have some inherent resistance to invasion. This factor is discussed in the text (see page 247).

The estimation of woodland isolation or isolation index (see text page 207) reveals for all woodland categories that the greater the isolation from routeways, settlements, parklands and existing sycamore the more likely a woodland will be devoid of sycamore invasion.

Fig 154 A histogram illustrating the mean distance of woodland from settlement, routeways, parks and existing sycamore (combined as isolation index) (see text page 207).

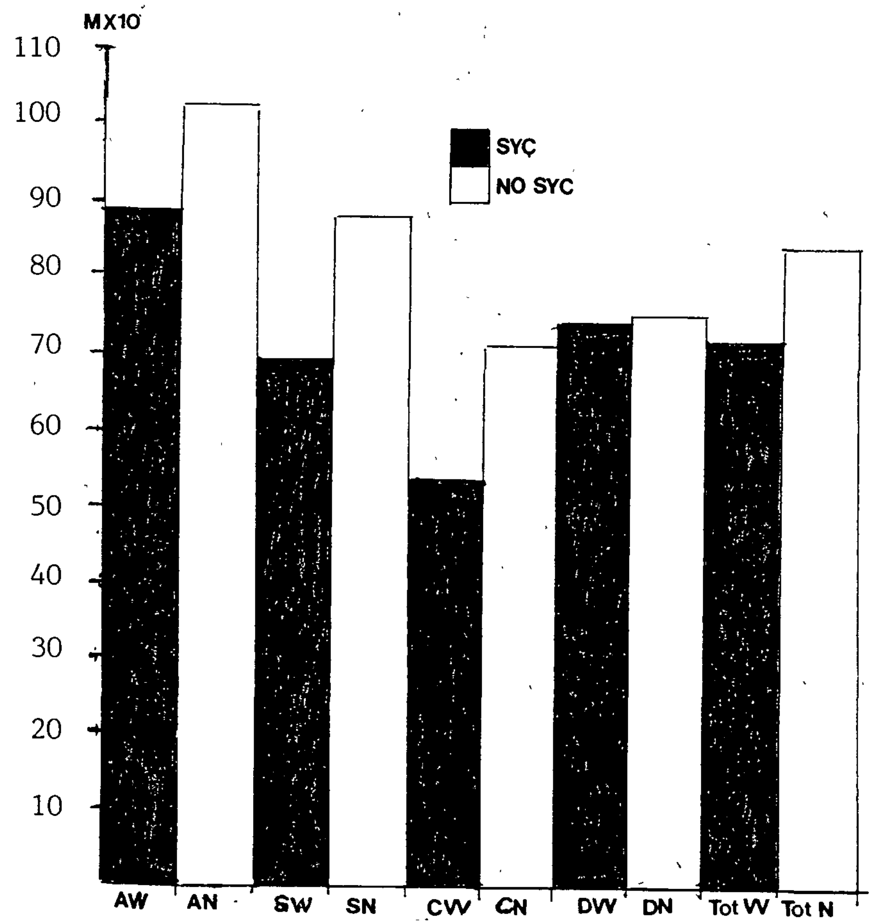
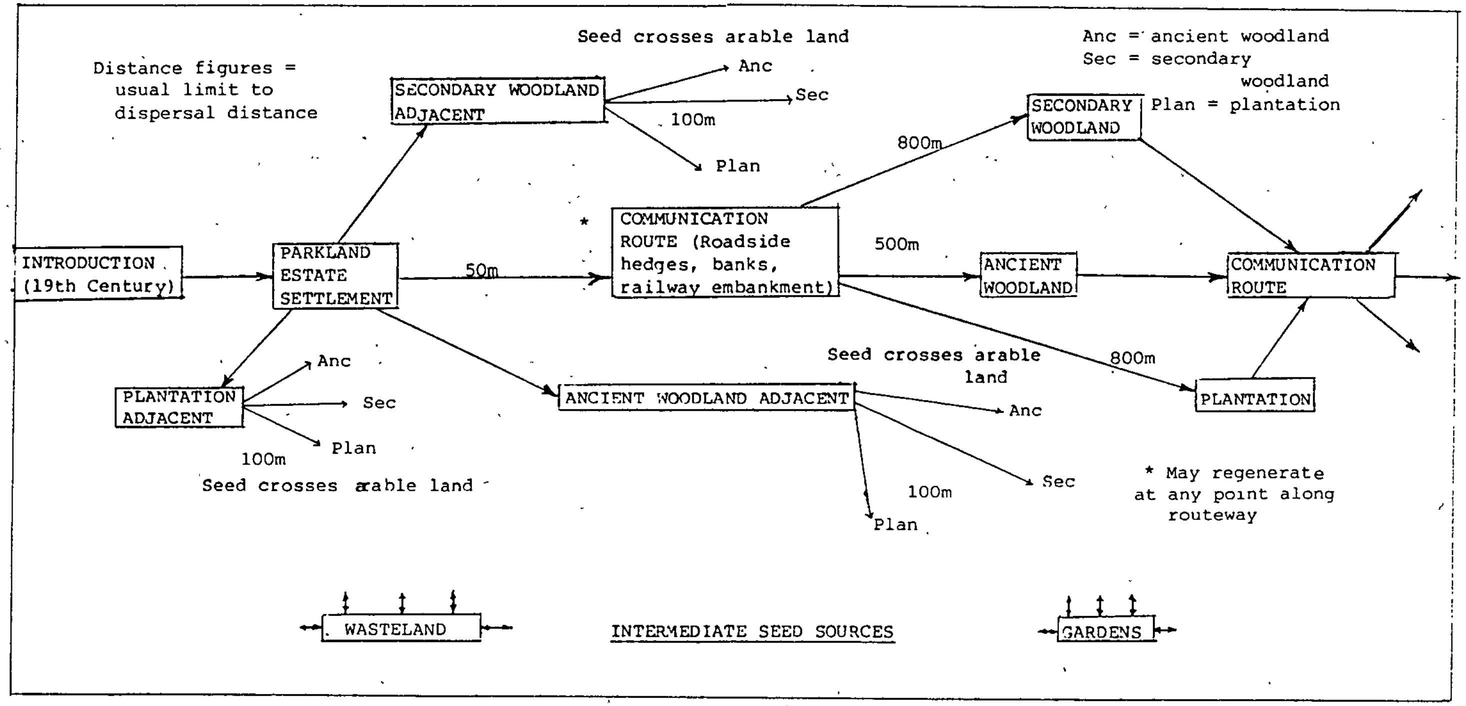


Fig 155 (see p 215) illustrates a model of a sycamore dispersal from a parkland site. It is clear that even following anthropogenic introduction, anthropogenic influence continues to have a significant effect on the dispersal of sycamore throughout the survey area. It is unlikely that the tree would be able to disperse as rapidly as it is doing in a non-anthropogenically disturbed environment. Sycamore is not naturally adapted to long range dispersal. Short range dispersal suggests that sycamore is naturally an invasive species. Conservationists will obviously have to consider

Fig 155 Model pattern of sycamore dispersal from a parkland introduction. Approximate limits to dispersal ranges as indicated



the mode of sycamore dispersal outlined in the preceding section before deciding on whether to allow sycamore naturalization to take place. Dispersal can be accurately modeled allowing for the prediction of the locations of source trees which would aid eradication or control. However, the close relationship of sycamore to the various anthropogenic factors discussed will undoubtedly continue to encourage sycamore population expansion in the foreseeable future. The relatively slow rate of dispersal of sycamore suggests that dispersal to all woodlands, particularly isolated woods, will take some time to come.

Summary

1. Sycamore dispersal often originates from parkland sites of introduction.

2. The probability that a wood will be invaded by sycamore depends on a woodland's proximity to roads, settlements, railways, parklands and existing mature sycamore.

3. Sycamore disperses more rapidly along or across routeways (particularly roads) than it does across arable land.

4. Dispersal rate of sycamore in a rural environment may have a range of up to 800m per generation if a wood is near a communication route but is often considerably less, between 50m and 300m. Dispersal range may be even more limited if a wood is completely isolated by arable land.

Chapter 7

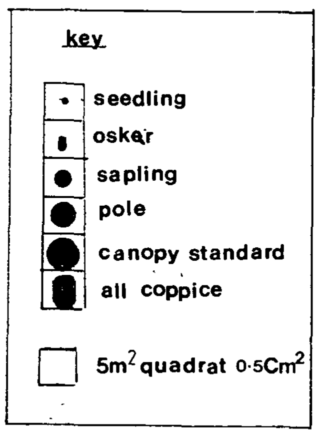
THE INVASIVE MODE OF SYCAMORE

The significance of investigating invasive mode is that invasive patterns may reflect competitive relations between species. The invasive area is an active interface of interspecific competition. The invasive pattern should conform to the ecological and dispersal adaptation displayed by individual species and to the environmental tolerance of individual species. A clear example might be a comparison between wild cherry or wild service and the wind dispersed sycamore. Here there is a clear difference in dispersion strategy; both cherry and wild service may be transported via birds. They may therefore be more likely to penetrate considerable distances into woodland, (a greater dispersion range). However, this dispersion is likely to be represented by fewer numbers than is usually apparent with sycamore invasions.

In some woodlands, sycamore invasions had not completely dispersed throughout the site. Preliminary observations suggested that the demographic limits of sycamore within such woodlands could be plotted. From such a plot the dispersal range of sycamore in woodland, the rate of invasion (by time and by generation) and the competitive mode of sycamore invasions could be analysed.

Woods were selected on the basis that they were incompletely invaded. The area of the woods in which sycamore was present and the interface between presence and absence was plotted using a $5m^2$ grid. The structural classification (see text, p 36) was used to record different sycamore forms. The grid was marked by the cane and quadrat method illustrated in fig 100 (see also p 164). Alignment of the canes enabled straight lines to be produced. The grid was measured with a tape. The oldest structural classes of tree were bored to gain an age estimate. Boring again proved difficult; the white wood of sycamore made annual rings obscure. Older trees were a little more clear than younger trees. Several vegetable dyes and pencil lead were used on tree cores with little effect. Sandpapering cores proved to be more helpful in some cases. The presence or absence of structural units of sycamore in each $5m^2$ quadrat was recorded using the notation in the text (see p 218). The woodland edge and other topographical features of the wood were plotted from observation at the site, orientation to the grids and using the O.S. map[51]. The method proved to be relatively time consuming and in numerous cases only sections of the sycamore invasion were plotted. The methodology made some landowners concerned about disturbance to woodlands. Thus the sites that could be studied by this method were restricted to accessible sites. The 'letter' notation originally used to record the occurrence of a structural type was later converted to a symbol notation for illustration. The occurrence of more than one structural type in a particular quadrat gave difficulty in the illustration of the sycamore demographies.

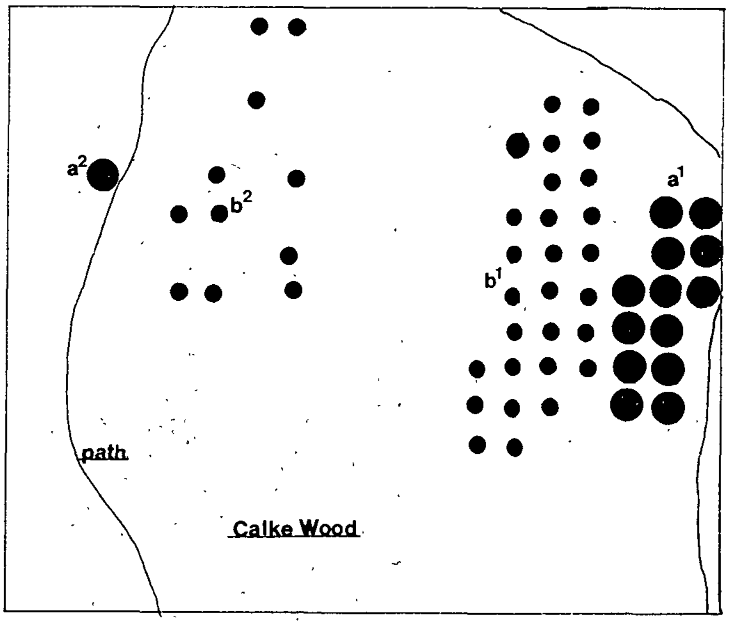
Fig 156 A diagram illustrating the key to structural types used in the plotting of invasion demographies. All types of coppice are included with the same notation. The quadrat scale is indicated.



The invasive mode of sycamore in ancient woodlands

Fig 157 illustrates the sycamore invasion of Calke Wood, ancient woodland. The canopy standard sycamore at (a^1) are likely to be the source trees for the invasion. Their even age structure suggests they may have been planted. (a^2) is a mature sycamore. It could have regenerated from dispersal from (a^1) or it may have other origins. It is at the site of canopy break (a path). Dispersal from (a^1) is represented by saplings (b^1). These form a continuous belt of saplings extending to an invasive front 35m into the wood. Saplings at (b^2) appear to originate from the dispersal of (a^2). The saplings form a discontinuous invasive belt with the invasive front 35 – 45m from the source trees. The invasion (a^1) to (b^1) represents two generations of sycamore. There is a clear difference in the

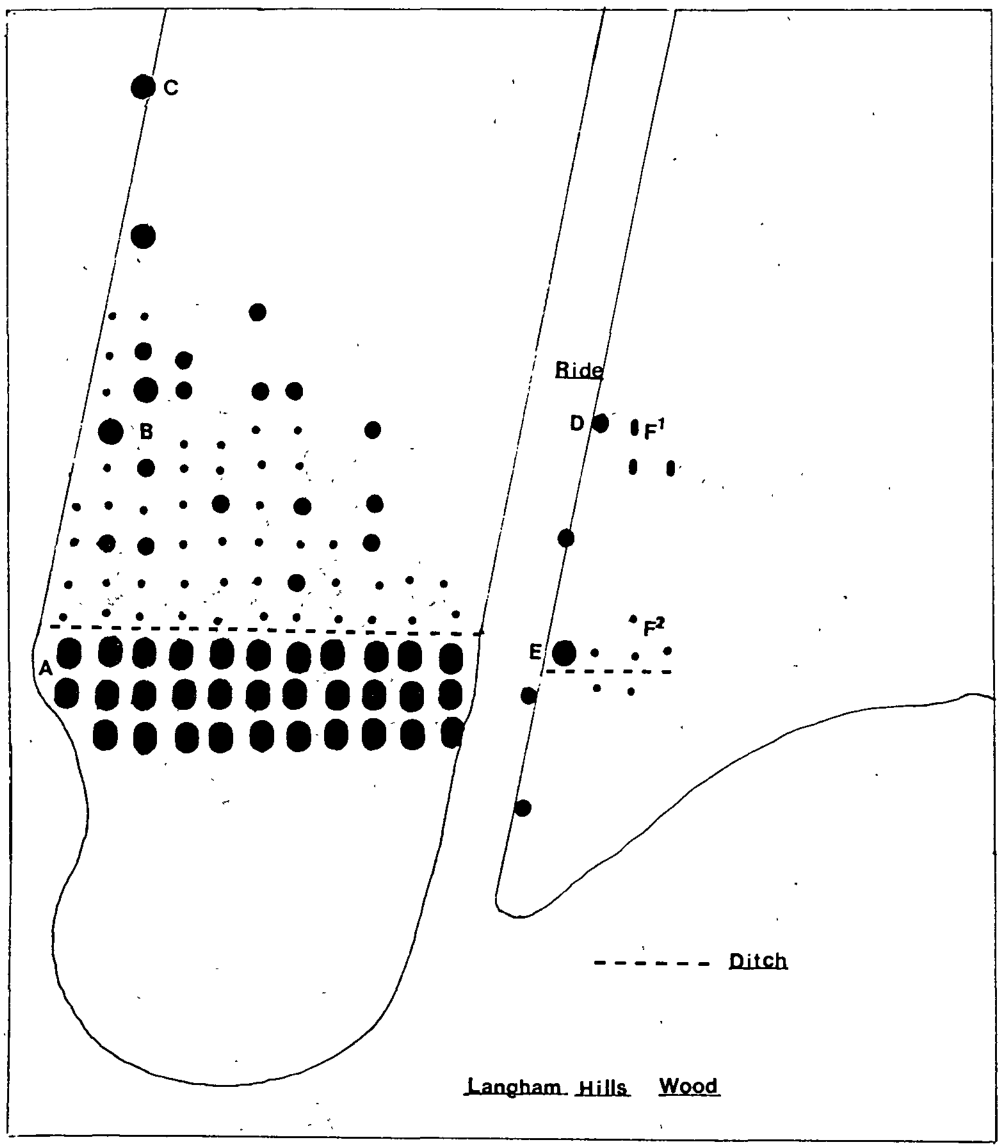
Fig 157 A sycamore invasion plot of a section of Calke Wood based on presence or absence of structural types in 5m² quadrats



invasive demographic patterns of (b^2) and (a^2). There may be several reasons for this: one, the difference in number of source trees; two, a difference between the dispersal capability of sycamore in woodlands and sycamore at the edge of woodlands; or three, differences in the environmental character of the woodland areas being invaded by (b^1) and (b^2).

The invasion of Langham Hills Wood (see fig 158) originates from coppice woodland at (A). This may be coppiced secondary woodland. Saplings and seedlings at (B) have invaded from 80 - 90m into the ancient wood. The saplings have a 'clumped' distribution with saplings found in isolated 5m² quadrats. Seedlings have a more regular distribution. Seedlings were sometimes found in sapling quadrats but are not illustrated. Coppice (A) and saplings (B) are separated by a ditch. This could mark an original boundary of the ancient woodland. Sycamore (C) is a pole 140m from the coppice (A). Its location at the edge of the woodland could have assisted its dispersal. Sycamores (D) and (E) are located at the edge of a ride. The open nature of the ride may have assisted their dispersal from coppice (A). (F^1) represents oskars probably dispersed from (D). (F^2) are seedlings in a

Fig 158 A sycamore invasion plot of a section of Langham Hills Wood based on presence or absence of structural types in 5m² quadrats



ditch probably dispersed from (E). Therefore three generations of tree are present at Langham Hills Wood: generation one - coppice (A); generation two - saplings, poles and seedlings (B),(C),(D),(F); and generation three - oskars and seedlings (F^1) and (F^2). The clumped distributions of saplings (B) can be compared to the saplings (b^2) at Calke Wood (see fig 157, p 219).

Some of the oskars at (F^1) Langham Hills Wood (fig 159) were apparently grazed. An original stem had been stripped of bark, and regrowth had then taken place. Grazing may therefore slow the rate of growth of sycamore but would seem unlikely to completely halt growth or produce death in all circumstances.

Fig 159 Diagram of sycamore oskar illustrating regrowth as a response to grazing

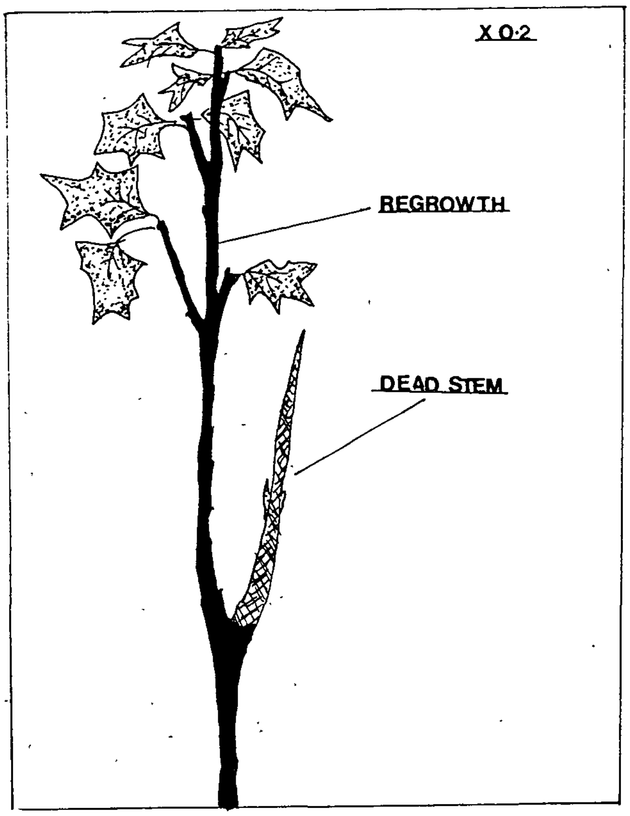


Fig 160 A sycamore invasion plot of Great Barton Copse (2) based on presence or absence of structural types in $4m^2$ quadrats

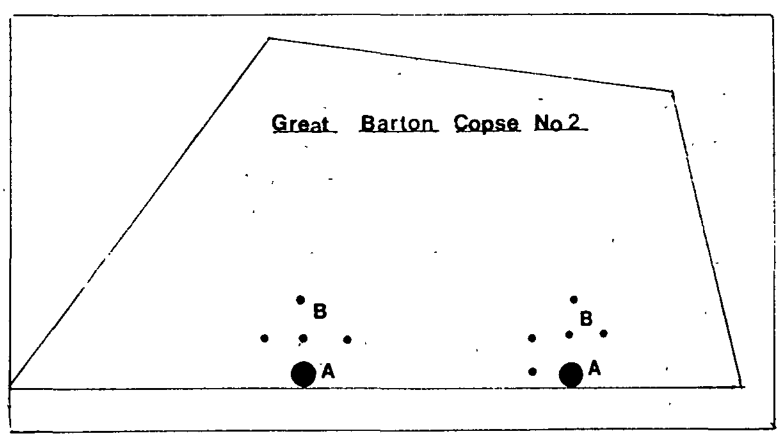
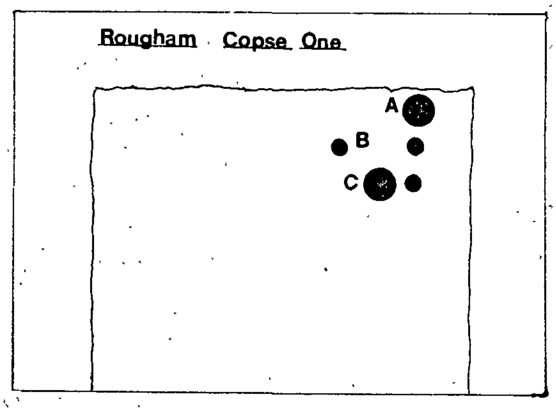


Fig 160 illustrates the sycamore invasion pattern for Great Barton Copse (2) (wood no 78). The invasion is represented by two poles (A) and seedlings (B). Seedlings (B) are less than

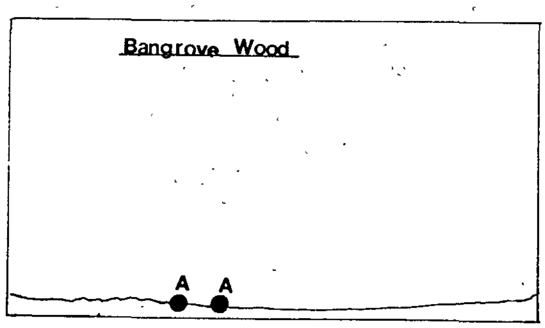
6m from poles (A). Poles (A) were represented by two isolated pole trees at the woodland edge. This is distinctly different from Calke Wood or Langham Hills Wood.

Fig 161 A sycamore invasion plot for a section of Rougham Copse One based on occurrence of structural classes in a $5m^2$ grid



The invasion pattern for Rougham Copse One (fig 161) is similar to Great Barton Copse (2)(fig 160) in that both invasions occur from isolated individual sycamore. (A) at Rougham Copse One is likely to be the seed source for the invasive sycamore (B) and (C), however (C) may be of the same generation as (A). The absence of seedlings or other juvenile structures further than 20m from (A) or (C) implies that dispersal range within the wood is limited or there is some other factor limiting the process of dispersal in this ancient wood.

Fig 162 Sycamore invasion plots of sections of Bangrove Wood, Wyken Wood, Norton Wood, Hollow Road Copse Two and Pakenham Fen based on the occurrence of structural class in $5m^2$ quadrat grids



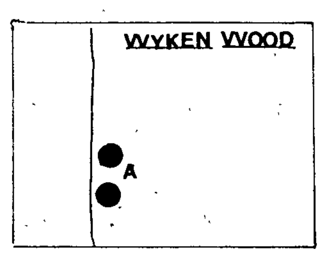
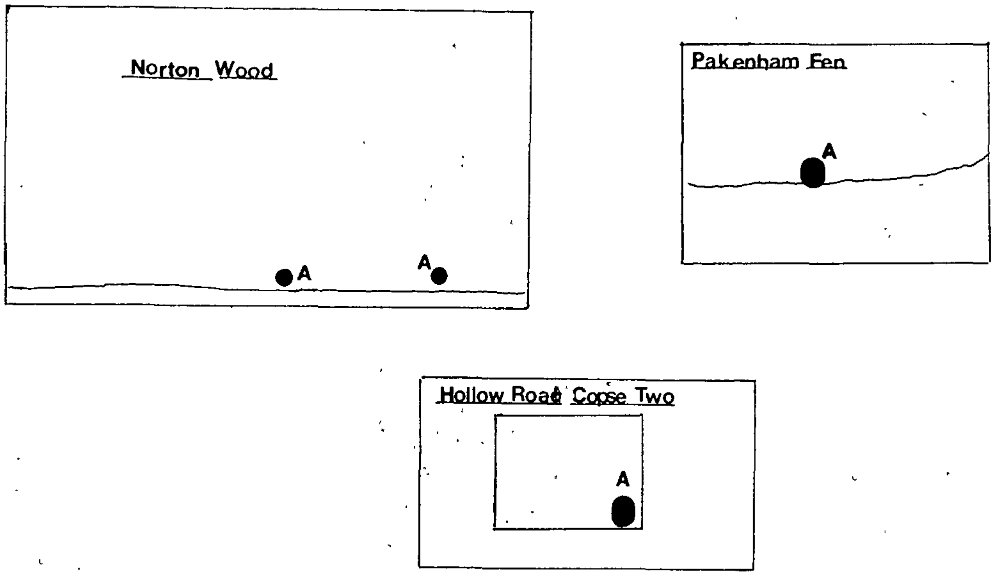
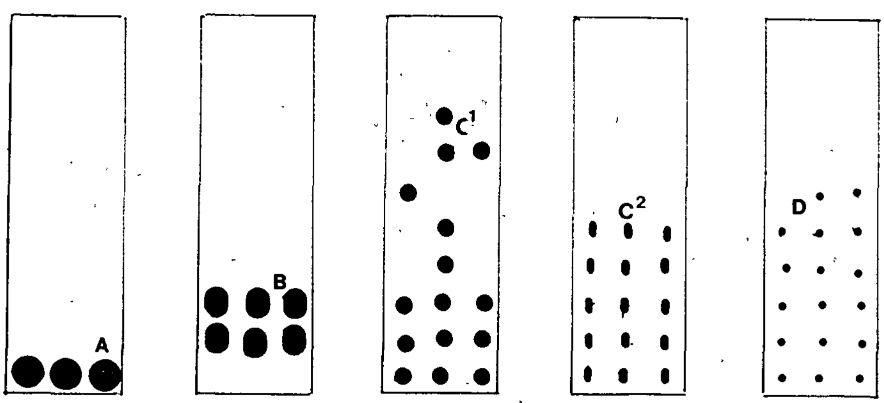


Fig 162 (contd)



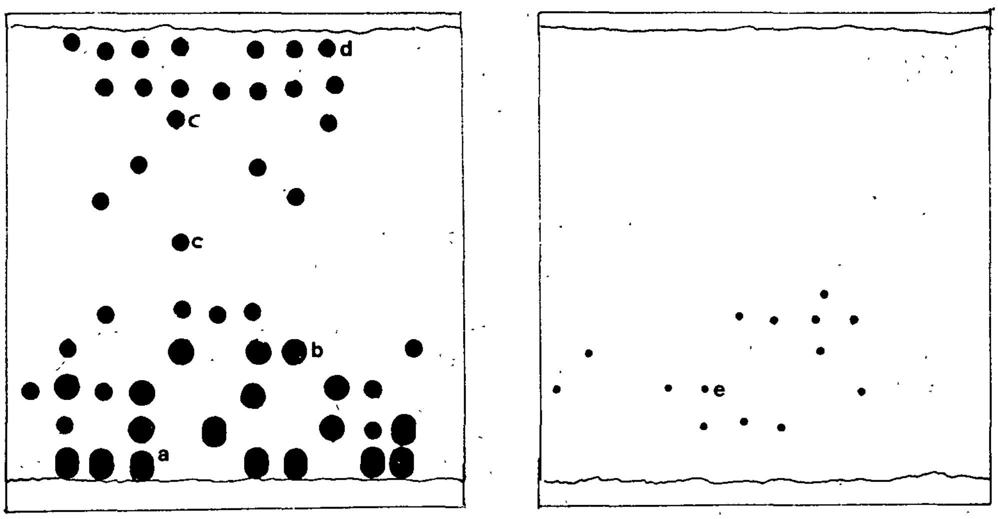
The invasions of Bangrove Wood (fig 162), Wyken Wood (fig 162) and Norton Wood (fig 162) are restricted to isolated sycamore (A) at the edge of the woodlands. Dispersal has not continued into the woodland, suggesting that there is a factor limiting dispersal in these woodlands. Pakenham Fen (fig 162) has a similar occurrence of an isolated sycamore (A) at the woodland edge. The sycamore has been coppiced. It is possible that the coppicing has reduced the dispersal potential of the tree. Hollow Road Copse Two (fig 162) has exactly the same dispersal pattern as Pakenham Fen. Its limited dispersal may also be a result of coppicing.

Fig 163 Sycamore invasion plot of section of Pakenham Wood based on the occurrence of structural class in a $10m^2$ quadrat grid



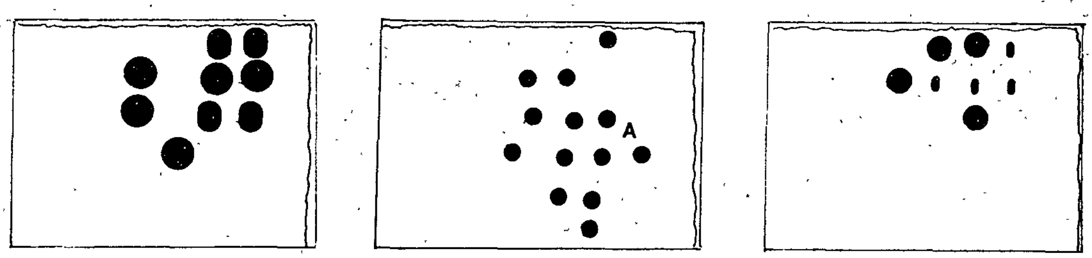
The distributions of structural types for a single section of wood have been mapped according to a single structural class. It is possible that the presence of canopy standards (A) and coppice (B) represent two generations of tree with a limited dispersal distance of 20m for a first stage of invasion from (A) to (B). The presence of (C^1), (C^2) and (D) indicate another generation of invasion. Invasion from (B) to (C^2) and (D) is again less than 40m. However, the isolated clumps of saplings extend to 70m beyond (B).

Fig 164 A sycamore invasion plot of a section of Fish's Heath based on the occurrence of structural classes in a $5m^2$ quadrat grid

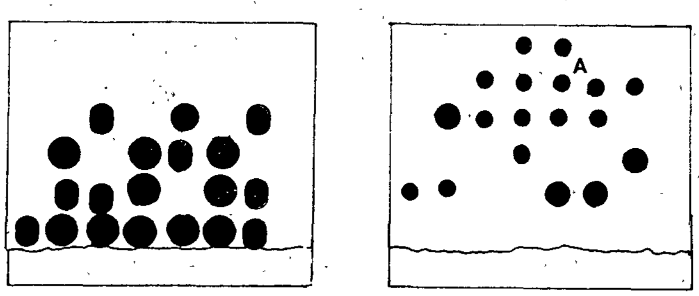


The sycamore invasion pattern at Fish's Heath suggests three generations of tree: one, coppice (a); two, poles (b); and three, saplings (c) and (d). The presence of a more uniform distribution of saplings at (d) towards the woodland edge than at (c) near the centre of the woodland suggests a difference of environmental conditions. For example, light levels at (d) are greater as it is located near the woodland edge which may encourage sycamore regeneration. The saplings at (c) were of the isolated clump type as in Pakenham Wood. This common clumping of saplings in small areas could be a response to environmental conditions influenced by differences in canopy structure at points corresponding to the sapling clumps (Brotherton [4]). There was no evidence that degeneration of a canopy tree demographically corresponded to the sapling clump sites. Other possible explanations might be: one, a correlation with another environmental factor; two, a function of the dispersal mode of the sycamore. Sometimes complete sycamore racemes with a number of seeds appear to detach from a tree and fall in complete form to the ground. It is possible that this could result in the regeneration of a dense cluster or clump of trees. The directional pattern of wind movement through canopies could also be involved; vortexing of wind through obstacles could concentrate seed in one area. Observations suggest that seeds often fall from a tree in response to particularly strong gusts of wind. A more detailed examination of dispersal mechanics would be necessary to test this hypothesis. The coppice sycamore intimates that sycamore was present before the last coppicing. If this is the case then the people who coppiced either did not consider the tree to be unwanted or they considered that coppicing might prevent its progress. Invasion has since proceeded at the rate of 20 - 80m per generation of trees.

Fig 165 Sycamore invasion plots of sections of Nether Hall Wood, Timworth Hall Covert, Colton Copse One and Little Haugh Farm Copse based on the occurrence of structural classes in a 5m² quadrat grid

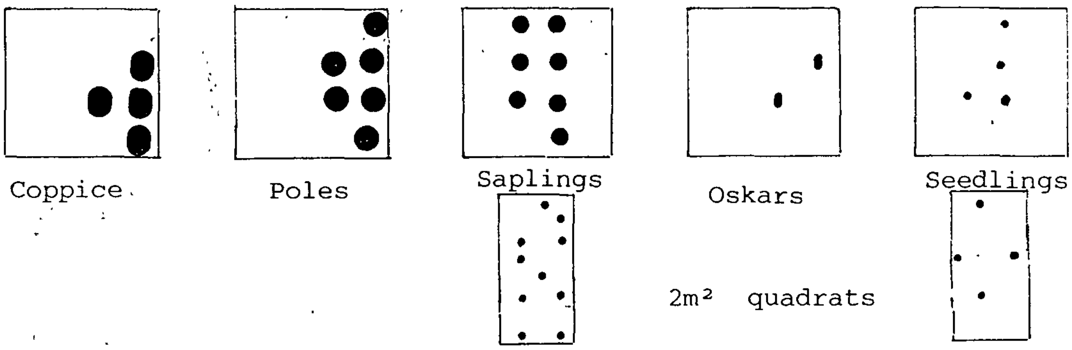


Nether Hall Wood

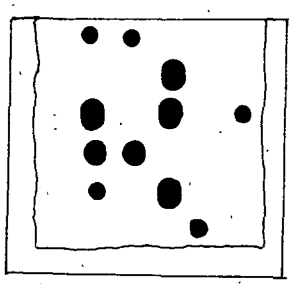


Timworth Hall Covert

Fig 165 (contd)



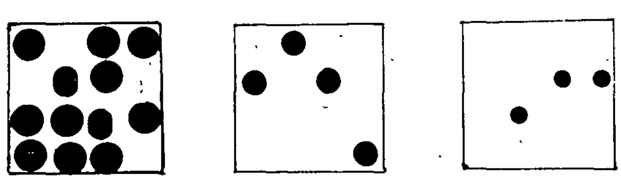
Colton Copse One



Little Haugh Farm Copse

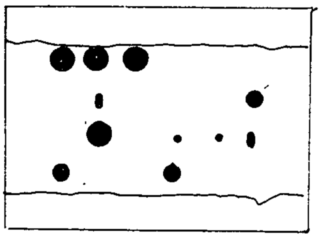
Nether Hall Wood, Timworth Hall Covert, Colton Copse One and Little Haugh Farm Copse each illustrate at least two or possibly three generations of invasion. In each case the total dispersal is no more than 60m. The dispersal patterns of saplings for Nether Hall and Timworth Covert are of more uniform distribution than the isolated clumps of saplings at (c) in Fish's Heath (fig 164). The dispersal range of the saplings (A) at Nether Hall (fig 165) and Timworth Covert (fig 165) are less than for the clumped saplings of Fish's Heath (fig 164). The smaller quadrat belt transects for Colton Copse One reveal a more clumped distribution of saplings and seedlings. In this case it was noticeable that these sapling and seedling clumps corresponded to the location of the removal of a coppice stool.

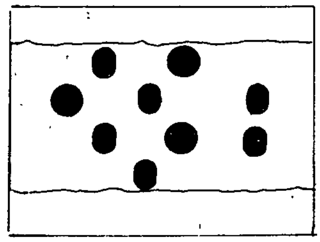
Fig 166 Sycamore invasion plots of Great Barton Copse One, Summer Road Copse One and Summer Road Copse Two based on the occurrence of structural units in a $5m^2$ quadrat grid

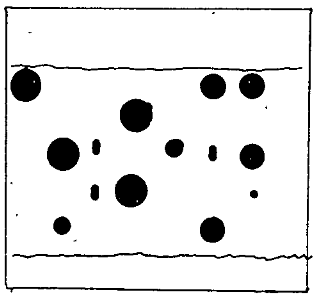


Great Barton Copse One

Fig 166 (contd) Summer Road Copse One







Summer Road Copse Two

Great Barton Copse One (fig 166), Summer Road Copses One (fig 166) and Two (fig 166) are ancient woodland completely invaded by sycamore. They are however relatively small woodlands compared to woodland like Langham Hills (fig 158). At Great Barton Copse One and Summer Road One coppice is evident indicating sycamore presence before management ceased. The presence of oskars at Summer Road One and Summer Road Two could reflect a certain amount of environmental pressure on sycamore regeneration.

The invasive mode of sycamore in secondary woodland

In the case of ancient woodland, sycamore is always invading a well developed woodland community. Invasion of secondary woodland may involve the invasion of land that has not already been colonized by trees. In this case, sycamore is not acting strictly as an invader but as a colonizer. Examples of the early stages of large scale invasion of such habitats were rare in the West Suffolk area at the present time, but are thought to have been more frequent in the past.

Fig 167 A sycamore invasion plot for Coney Weston Hall Copse One based on the presence or absence of structural types in a $5m^2$ grid. The number of ash seeds, sycamore seeds and sycamore seedlings in $1m^2$ quadrats along belt transect line (B) is also illustrated

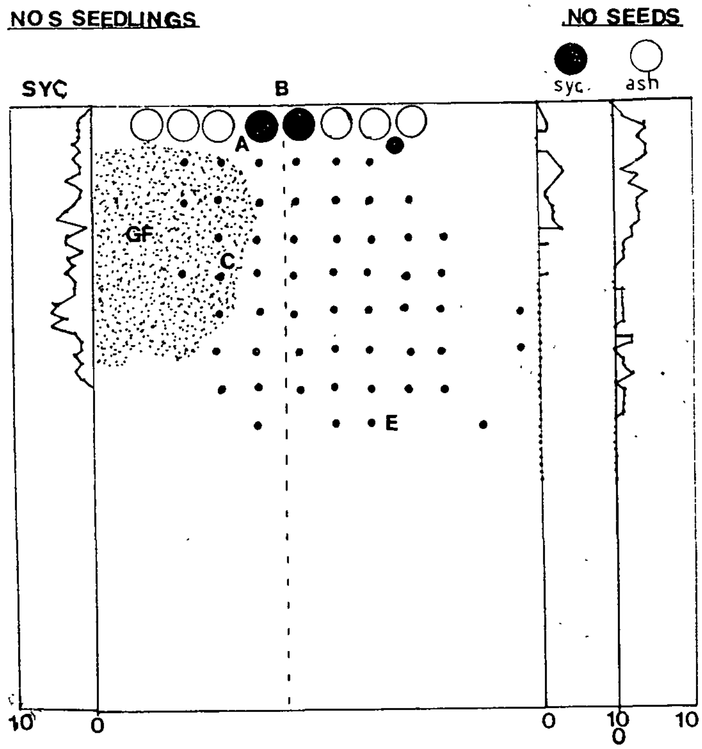


Table 58 Results of $1m^2$x 45m belt quadrat see (B) (fig 167)
The numerical abundance of each $1m^2$ quadrat is recorded

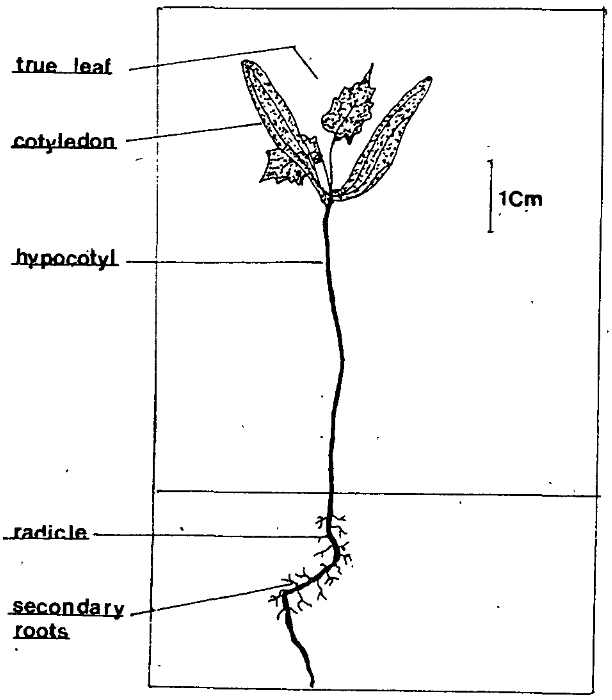
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Ash seeds)	0	1	4	4	3	4	4	2	1	3	3	2	4	3	4	3	2
Syc seeds)	0	0	1	1	0	0	1	0	3	0	0	1	2	2	2	2	3
Syc seedlings	1	1	1	2	1	2	1	1	4	1	1	4	2	3	5	1	3

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Ash seeds)	2	1	1	1	2	3	2	1	1	1	1	1	0	2	2	0	1
Syc seeds)	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syc seedlings	3	1	3	2	3	2	2	2	4	5	3	5	2	1	1	2	1

	35	36	37	38	39	40	41	42	43	44	45
Ash seeds)	1	2	0	1	1	1	0	0	0	0	0
Syc seeds)	0	0	0	0	0	0	0	0	0	0	0
Syc seedlings	2	1	0	0	0	0	0	0	0	0	0

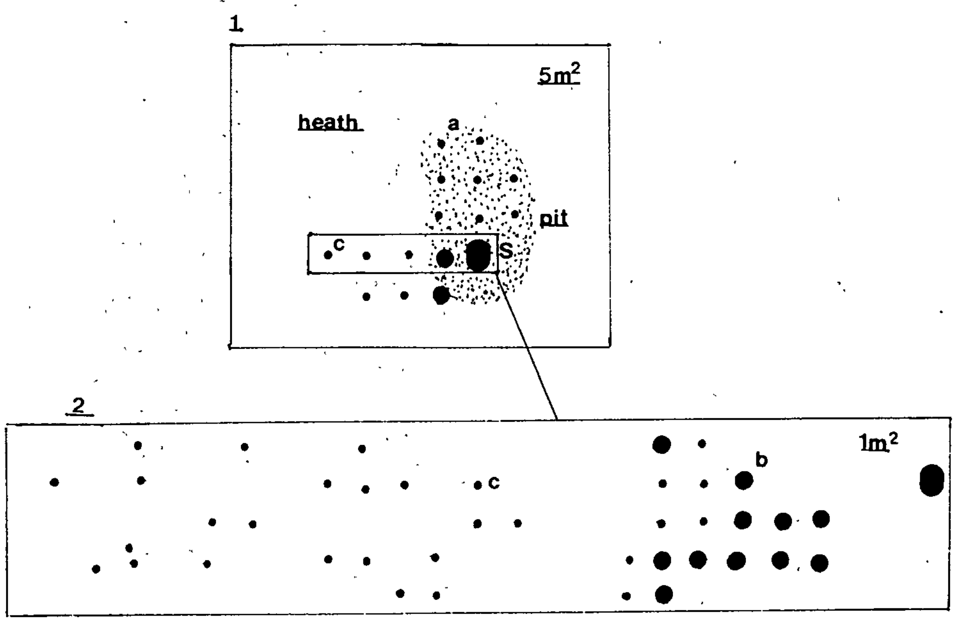
Fig 167 illustrates an invasion of fallow arable land. The arable land was cleared in July 1984 and the recording was made in April 1985. The sycamore seedling illustrated below (fig 168) is therefore in its first season of growth.

Fig 168



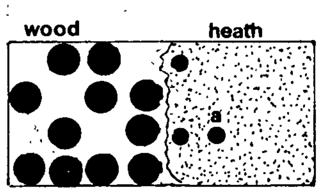
The dispersal range from mature sycamore (A) to seedling (C) was no more than 40m. Sycamore and ash seeds were also present. The dispersal distance of sycamore seeds illustrated at the side of fig 167 was 36m maximum. For ash seeds a dispersal range of 40m was recorded. The distribution of seeds corresponded to the distribution of seedlings indicating that the invasive front was formed by a change in environmental conditions. The lack of ash seedlings confirms that ash usually takes two winters to break seed dormancy. This might be a particularly important factor controlling the competitive equilibrium between the two species. Sycamore's potential to germinate in the first season following seed setting will enable it to grow with any ground flora that colonizes a bare earth site. The seed bank within the soil (Harper[24]) and the ability of ruderal species to colonize rapidly a site, in the first year following abandonment, may mean that ash seedlings will have to compete against a ground cover of these species. Sycamore can exploit a safe site (Harper Williams [24] and Ovington[52]) before ground flora forms a full cover. (GF), see fig 167, denotes an area of ground flora colonizing the site. Sycamore seedlings are growing amongst the ground flora. It has been observed that sycamore is inversely correlated to some closed ground flora (fig 206 p 270) Colonization by sycamore could have occurred in these sites in the first year following removal of vegetation.

Fig 169 A sycamore invasion plot for Knettishall Heath based on occurrence of structural types in a $5m^2$ quadrat 1 and a $1m^2$ quadrat 2



The invasion plot for Knettishall Heath (fig 169) illustrates the dispersal from a coppice tree (S) which was situated in a disused pit. The regenerative site for seedlings (a) is disturbed gravel at an access point to the pit, seedlings (c) are amongst Breckland *Calluna vulgaris* heathland, (b) and (c) represent regeneration of sycamore with a maximum dispersal range of 20m.

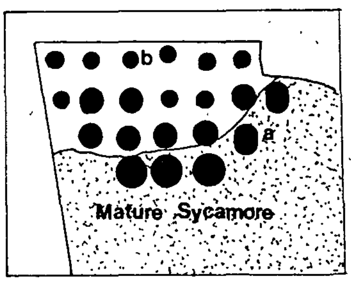
Fig 170 A sycamore invasion plot for Knettishall Heath based on occurrence of structural types in a $5m^2$ grid



Another invasion of heathland fig 170 confirms a dispersal range of only 20m for a first generation of invasion (a) of the same *Calluna vulgaris* heathland.

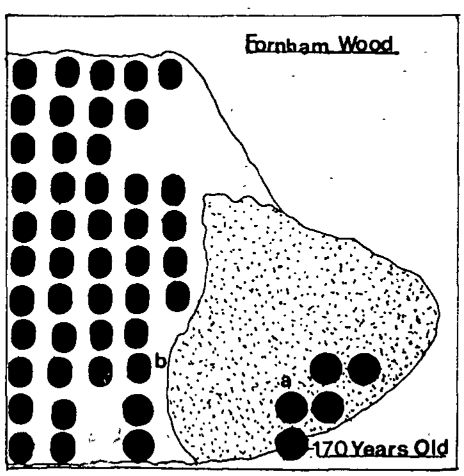
Examples of distinctive sycamore invasion fronts in secondary woodlands were rare. Secondary woods were either completely invaded or were completely uninvaded. Secondary woodlands in the survey area are generally small and might therefore be completely invaded in one or two generations. A generation of a sycamore may be between 15 - 30 years, from germination to seeding(see fig 126, p 189). Great Barton Wood (fig 171) is a relatively large secondary woodland with an invasion front.

Fig 171 A sycamore invasion plot for Great Barton Wood based on the occurrence of structural classes in 5m² quadrats



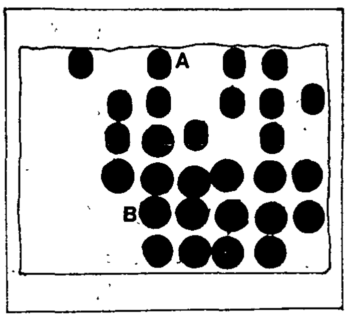
The presence of coppice, canopy standard, pole and saplings of sycamore suggests several generations of tree with less than 30m dispersal range. The invasion is unusual as it is occurring towards an open woodland edge. This may have had an effect on limiting the dispersal potential of sycamore.

Fig 172 A sycamore invasion plot for Fornham Wood (just beyond the survey area) based on occurrence of structural classes in 10m² quadrat grids

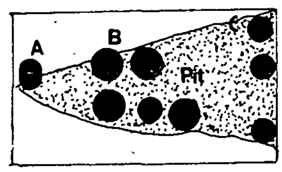


Fornham Wood (fig 172) illustrates dispersal of sycamore from trees (a) (bore age 170 years) to coppice (b). Sycamore has invaded the complete woodland. The even structure distribution suggests that the woodland represents one generation of trees, possibly having colonized the woodland within a relatively short period of time.

Fig 173 Sycamore invasion plots for Brand Spinney and Game Close Copse based on occurrence of structural classes in a $5m^2$ quadrat grid



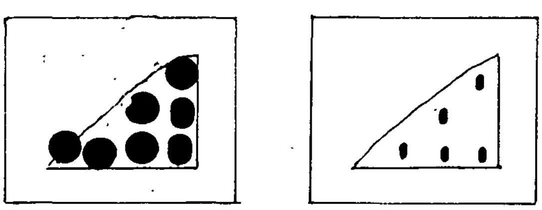
Brand Spinney



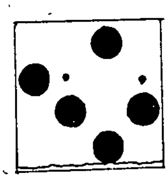
Game Close Copse

The sycamore invasion of Brand Spinney has two obvious generations, coppice (A) and canopy standards (B). The coppice is likely to have invaded before woodland management declined in the area. The invasion of Game Close from source tree (A) appears to have occurred in two stages (A) to (B) to (C). This again would suggest invasion rates through woods of 30m or less per generation.

Fig 174 Sycamore invasion plots for sections of Thurston Green Farm Copse, Thurston School Copse, Pakenham Pit, Ampton Common Copse and Thurston Bayer Copse based on the occurrence of structural units in $5m^2$ quadrats

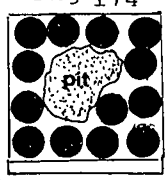


Thurston Bayer Copse

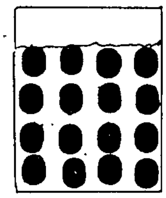


Ampton Common Copse

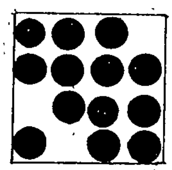
Fig 174 (contd)

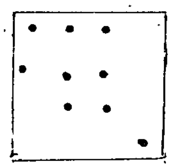


Thurston Green Farm Copse



Thurston School Copse





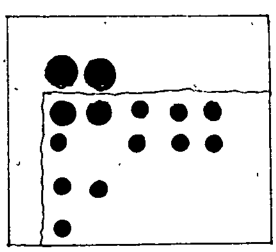
Pakenham Pit

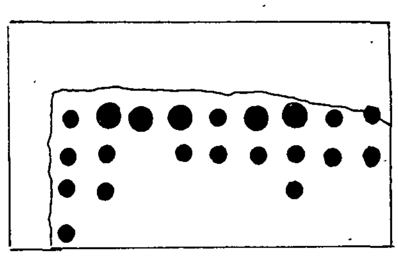
Canopy standards Seedlings

Fig 174 illustrates secondary woodlands with complete invasion with a variety of structures.

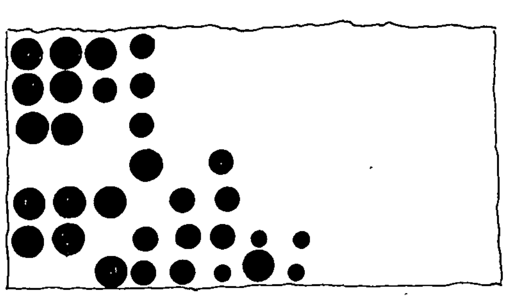
The invasion mode of sycamore in coniferous plantations

Fig 175 Sycamore invasion plots for coniferous plantations based on the occurrence of sycamore structural classes in a $5m^2$ quadrat grid



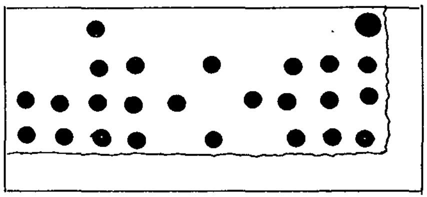


Sansoms Plantations

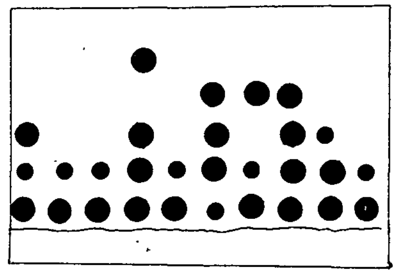


Timworth Green Covert

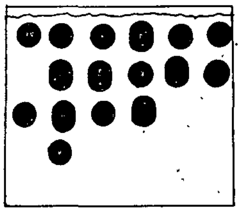
Fig 175 (contd)



Rougham Rookery



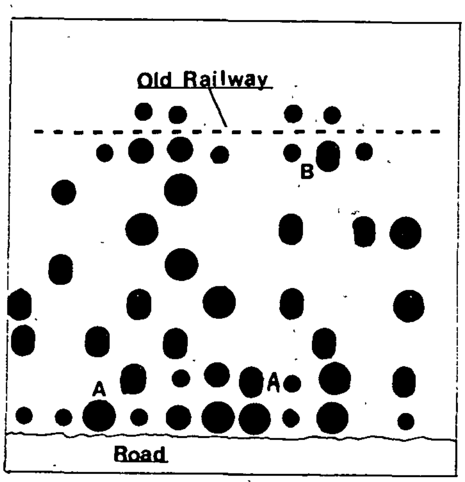
Ampton Field



Ixworth Covert

The invasive patterns for the coniferous plantations show no sapling clumping as seen at some ancient woodlands. Invasions generally occur in regular distributed belts of saplings. The conifer plantations appear to be confined to two or three generations of trees. Invasion rates are therefore approximately 30m for each generation. The regular distribution could be a result of the safe sites, Harper[24], afforded by regularly planted rows of conifers.

Fig 176 A sycamore invasion plot for Folly Grove based on the occurrence of sycamore structural classes in a 5m² quadrat grid



It had been originally considered that the invasion at Folly Grove had begun from coppice (A) and canopy standards (A) at the roadside edge of the wood. However the presence of coppice (B) 60m from (A) implied an unusual pattern. Later it was noticed that a railway had once passed through the site. Plate 8 and plate 9 illustrate a sycamore coppice of similar type to (B). This tree was found with others along a section of the same disused railway (see fig 35) as the ones indicated on fig 176. It can therefore be concluded that the dispersal pattern of Folly Grove (fig 176) was likely to have begun from coppice sycamore on the original railway embankment. This further supports the hypothesis that sycamore dispersal may be encouraged by railways.

Plate 8 Sycamore on a disused railway embankment

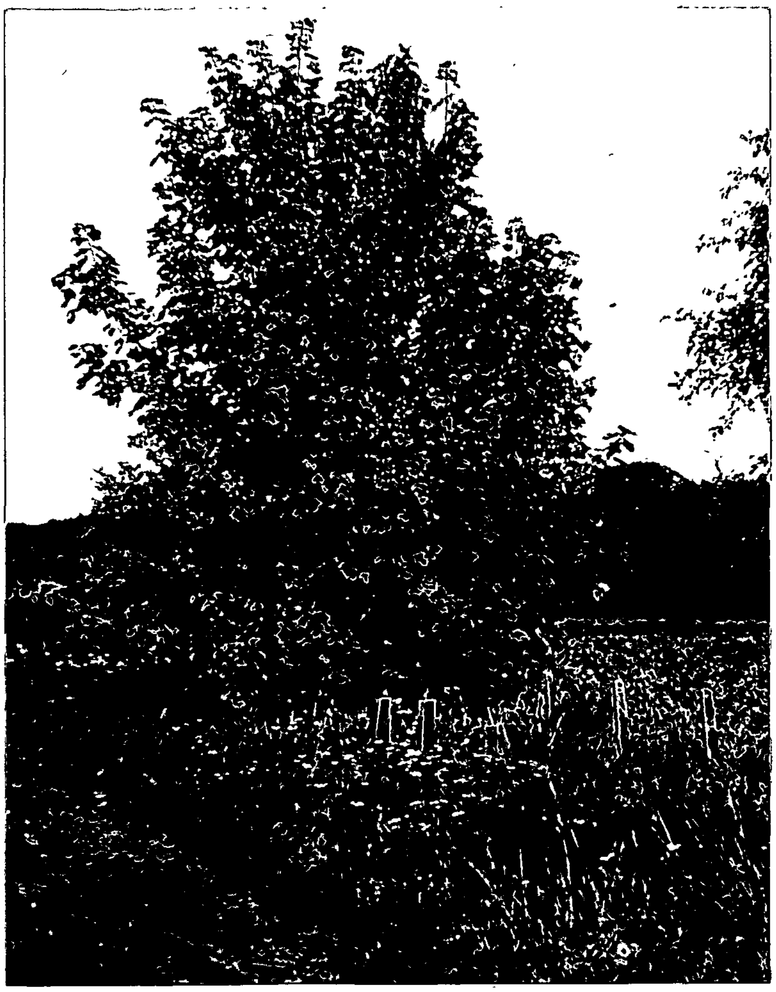
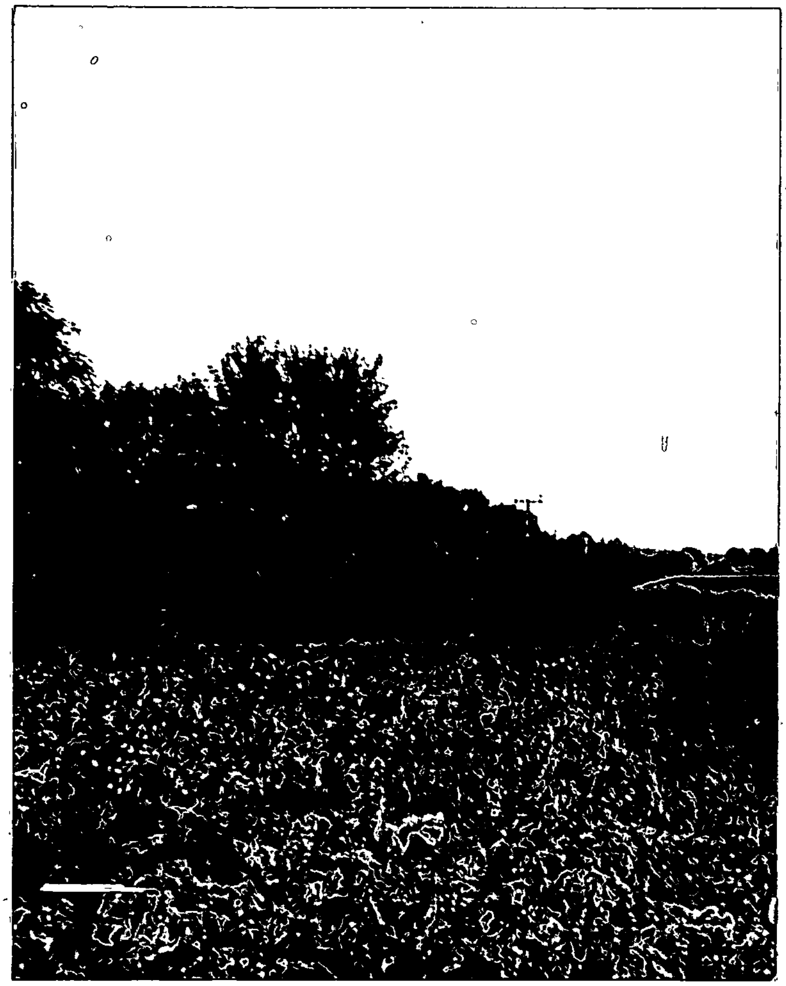


Plate 9 A coppiced sycamore on a disused railway embankment in the West Suffolk survey area



The invasive mode of sycamore in deciduous plantations

Invasions patterns of deciduous plantations were plotted using $10m^2$ quadrats.

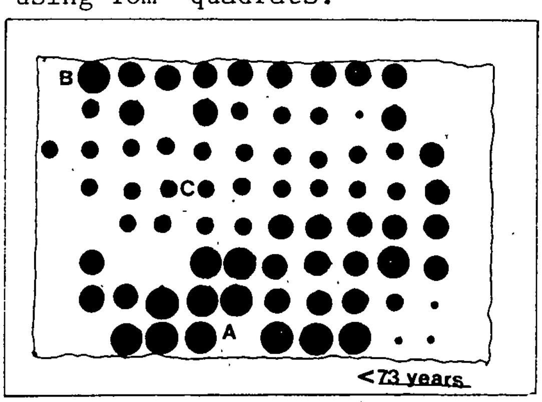


Fig 177
Rougham Copse

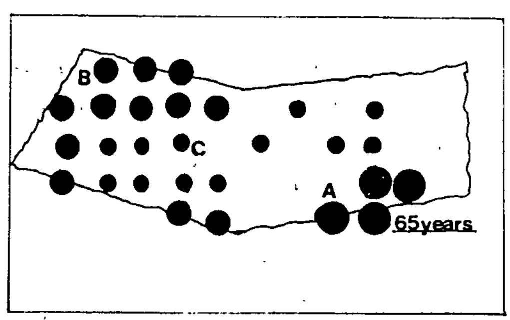


Fig 178
Wytchingham Plantation

In Wytchingham Plantation (fig178) the oldest sycamore recorded was 65 years old ± 10 years. Sycamores at (B) and (C) appear to represent two subsequent generations of tree. However the distribution of structural classes are unusual; the older poles (B) are further from (A) than the sapling (C). Each type may have originated from (A).

Rougham Copse One (fig177) was invaded less than 73 years ago (see text p183). (A), (B) and (C) could again represent two or three generations of sycamore with a dispersal range of 25 - 25m from each generation.

The invasion mode of sycamore in wood pasture

The wood pasture of Epping Forest represented a different management regime to those found in the West Suffolk area (see text p25).

The invasion of three sites in Epping Forest wood pasture based on the occurrence of structural classes in a $5m^2$ quadrat grid

Fig 179 Epping Forest One

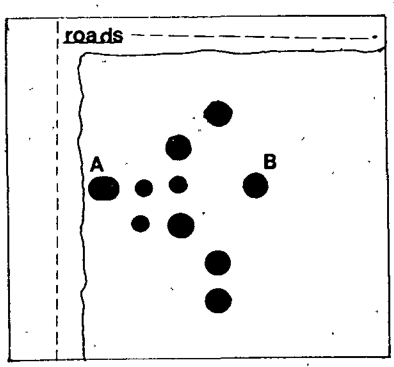


Fig 180 Epping Forest Two

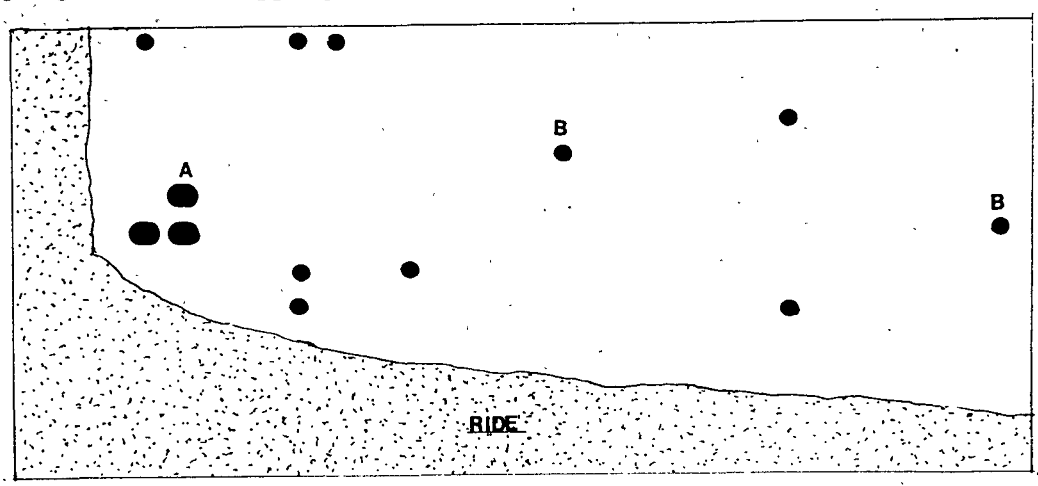
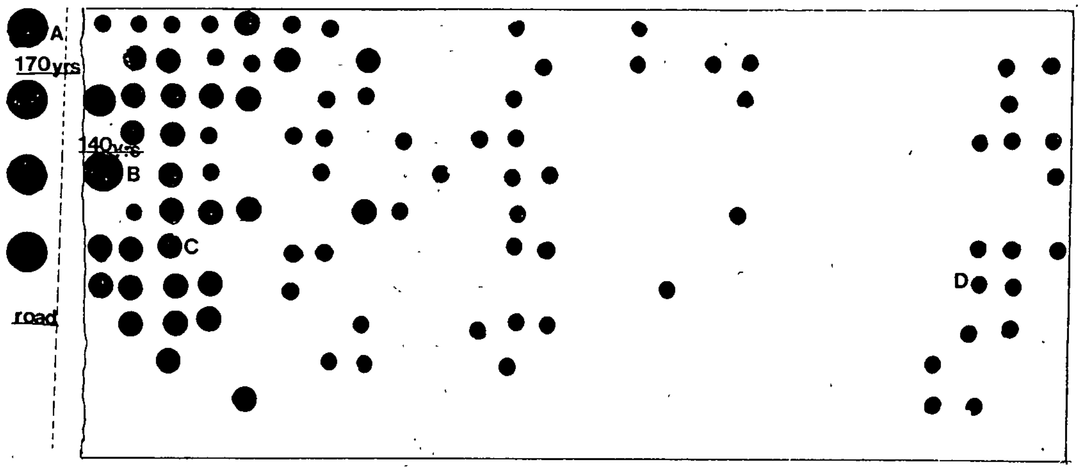


Fig 181 Epping Forest Three



The invasive patterns for Epping Forest One (fig179) and Epping Forest Two (fig180) illustrate two generations of sycamore (A) and (B). The dispersal range(150m) to (B) in Two (fig180) is far greater than that for One (fig179) (30m). A possible explanation for this could be that (A) in Epping Forest One began to set seed in small quantities as a pole tree but was subsequently coppiced stopping seed setting and therefore limiting invasion. The height of trees might also be important in affecting dispersal range. It would be expected that the greater the height of a tree the further might be its dispersal range. Low cut coppice trees would,according to this hypothesis, have a shorter potential dispersal distance than canopy standard trees. The source sycamore (A) in Epping Forest Two may have been coppiced whilst immature stopping seed setting and limiting dispersal. Dereliction of woodland management has allowed (A) in Two to grow taller than (A) in One. Dispersal has been recent in Epping Forest Two. The pattern is one of isolated sycamore saplings ranging over a considerable distance. Epping Forest Three (fig181) illustrates an invasion that may have taken place over three or four generations, (A), (B), (C) and (D). Boring suggested ages of (A) - 170 years and (B) - 140 years. A total dispersal range of 140m has been achieved in four sycamore generations. If (A) are source trees, then it would appear that sycamore dispersal in this case has taken place at about 1m of woodland a year.

Invasion Models

It was assumed that the invasion patterns for different woods resulted from the date at which the invasions occurred. The patterns for individual woods have been described in terms of the number of generations present. From one to three generations were usually found. There was an obvious difference between two types of invasion pattern. One was characterized by broad belts of regularly distributed invasive trees and the other, invasions that appeared to progress by the dispersal of isolated clumps or pockets of trees. Type one has been termed 'broad belt invasion' and type two has been termed 'pin point invasion'. Tansley [81] (pp 397-404) has observed a similar difference in invasion patterns for beech invading oak/ash woodland. He suggests the terms 'en masse invasion' for broad belt and 'calliper invasion' for pin point. The patterns are likely to be a function of the ability of sycamore to exploit sites beneath existing canopies. Fig 182 and fig 183 illustrate models of the two invasion types based on the patterns for individual woods. The models indicate four tree generations in the horizontal plane with the likely sycamore structure and patterns to be found in each generation. The vertical plane illustrates changes produced by growth or coppicing between generations. The invasion patterns make little difference in the rate at which a woodland is invaded but may have consequence for the structure of a completely invaded woodland. Tansley [81] suggests that 'en masse' or broad belt invasions produce even age stand structures and, 'calliper' or pin point invasions eventually produce mixed age structure woodlands of the invading species. It would also seem logical that pin point invasions are more likely to encourage a mixed species structure than broad belt invasions.

The mode of invasion seems to depend on the way in which the invasion originates. Broad belt invasions often correspond to roadside locations, coniferous plantations and the invasion of arable land. Pin point invasions often occur at ancient woodland sites and wood pasture. Both invasion models characterize sycamore as a relatively slow colonizer. If a generation is considered to be as short as thirty years (from seedling to seeding tree) an invasion front rate will only tend to advance by 1m a year or 30m per generation.

Fig 182 Invasive model of Broad Belt invasions based on the structural invasive patterns of different woods. Each wood is presumed to have undergone initial invasion at a different time. The range of dispersal distance for each generation is indicated based on the invasion plots of individual woods

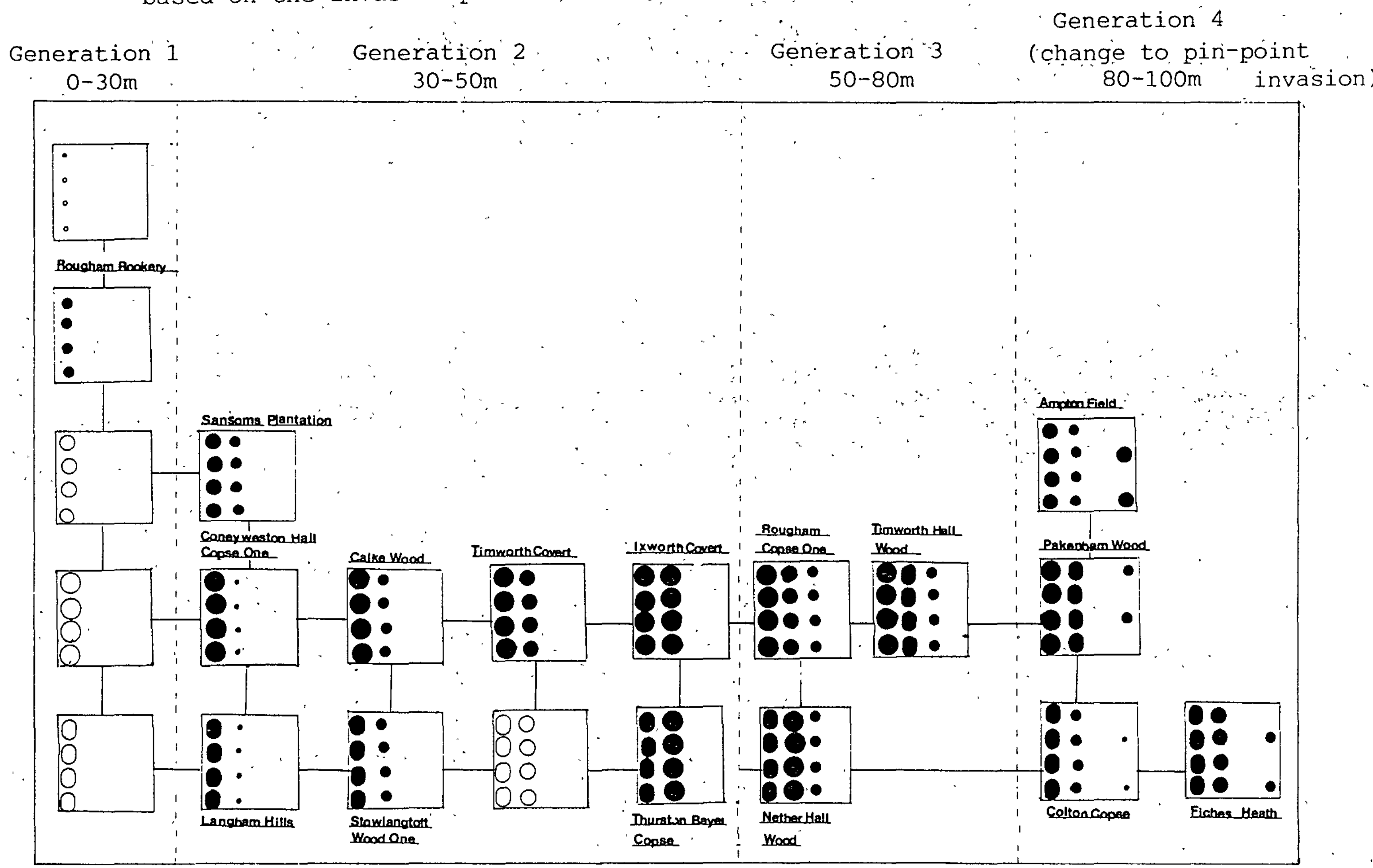


Fig 183 Invasive model of Broad Belt invasions based on the structural invasive patterns of different woods. Each wood is presumed to have undergone initial invasion at a different time. The range of dispersal distance for each generation is indicated based on the invasion plots of individual woods

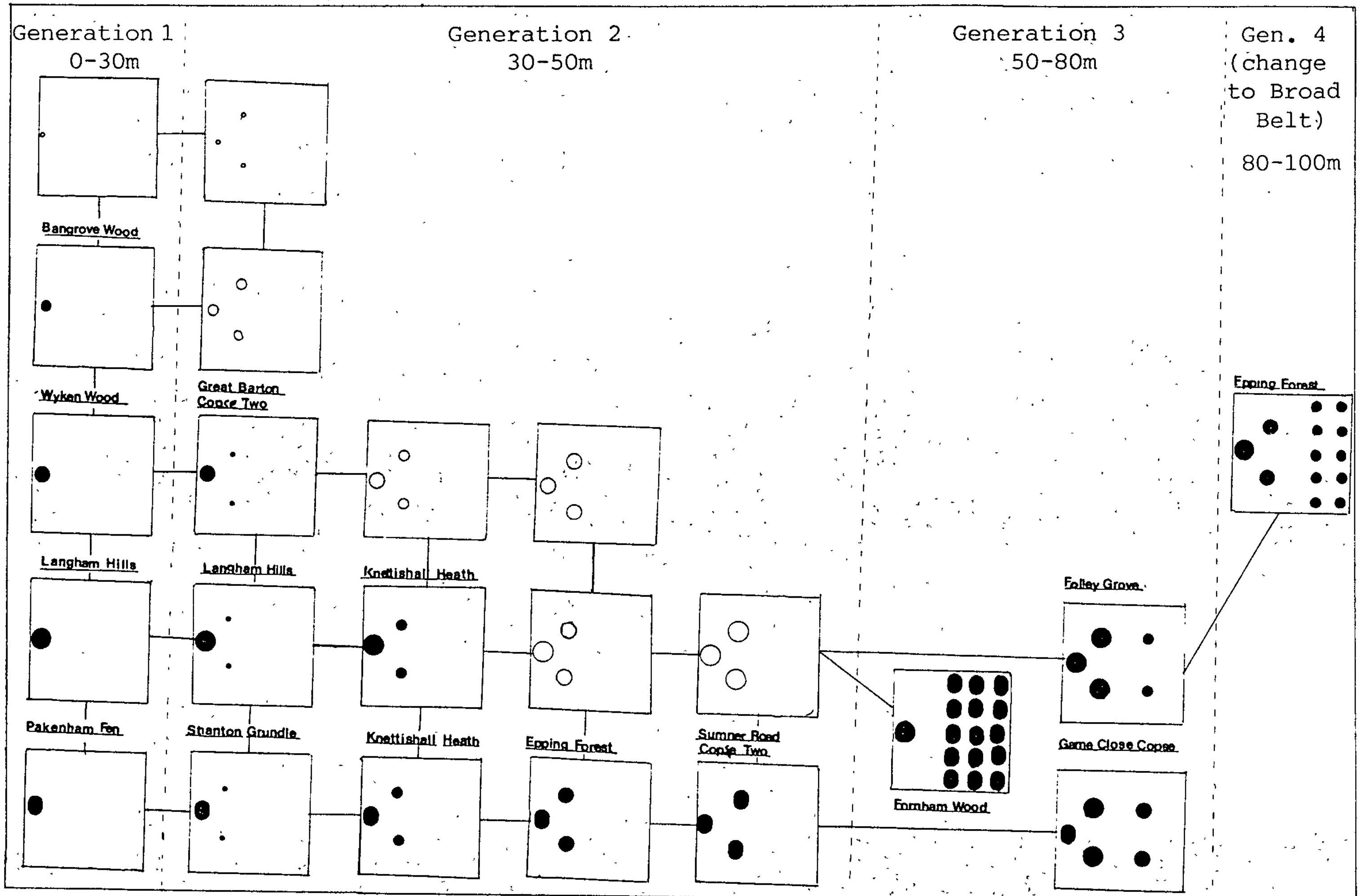
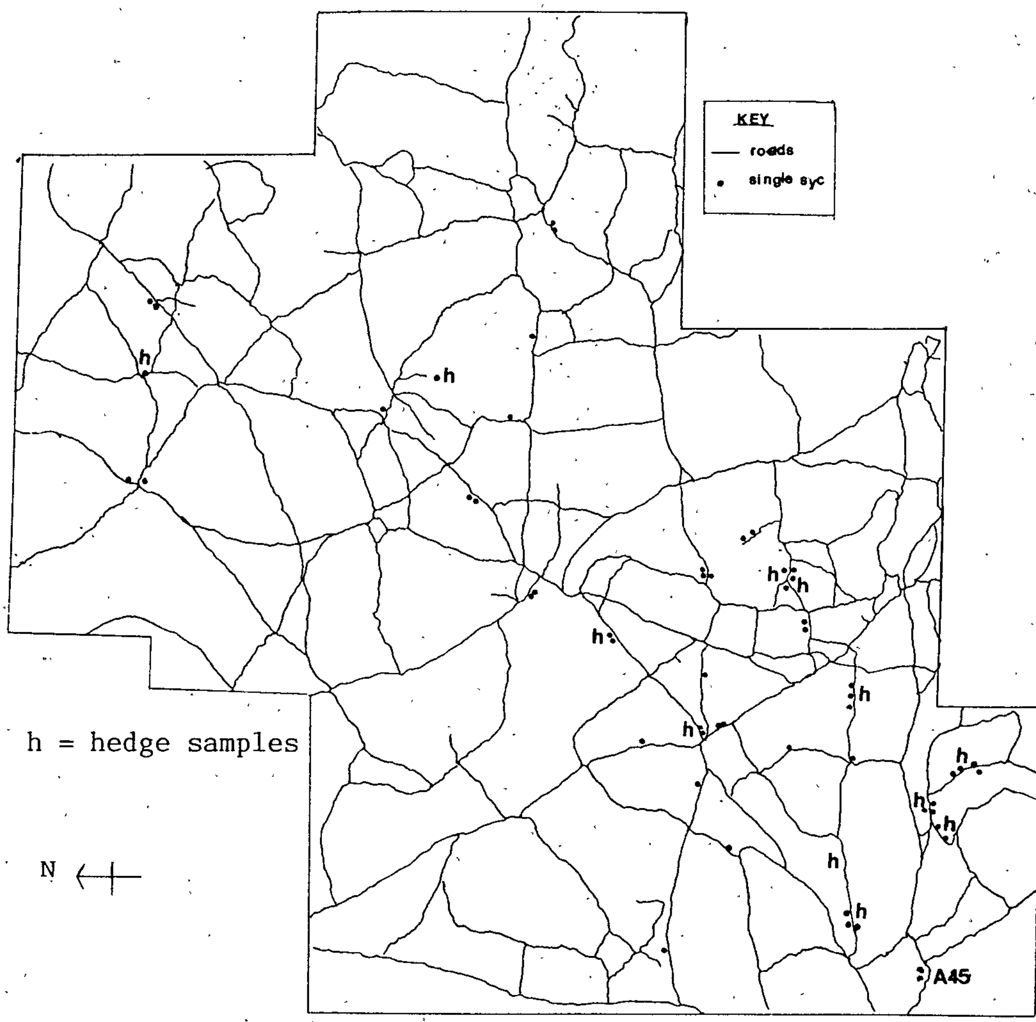


Fig 184 Map of the West Suffolk General Survey area illustrating the location of roadside sycamore



See fig 35, page 62, for Survey Area O.S. grid references.

Compared to some wind or animal transported seeds, this figure does not represent the same potential for long range colonization or fast invasion. Relating this to the regenerative status of woodlands before significant anthropogenic influence. it is likely that sycamore could have been competitively excluded from woodland because of this slow invasion rate and a consequent lack of potential to exploit 'new' habitats. Certainly the complete invasion of particularly ancient woodland by sycamore will take at least another three generations of sycamore.

The invasive mode of sycamore in hedges

Hedges represent another category of woodland in the survey area (see text p 29). Sycamores were only found in hedges located along roadsides. Examples of roadside hedge sycamore are illustrated in fig 184. Hedges are of important conservational value. Two forms of hedge are present in the West Suffolk area. These are illustrated in figs 185 and 186.

Fig 185

Regularly trimmed hedge

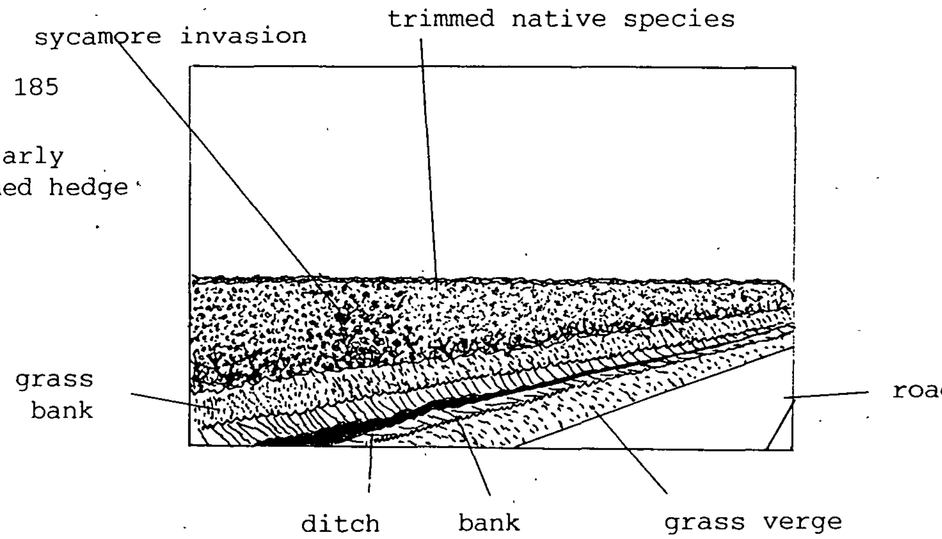


Fig 186

Uncut hedge

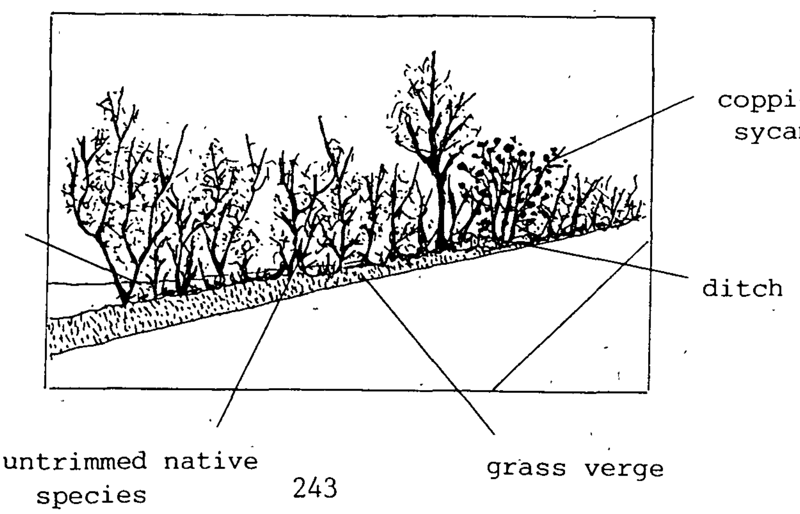
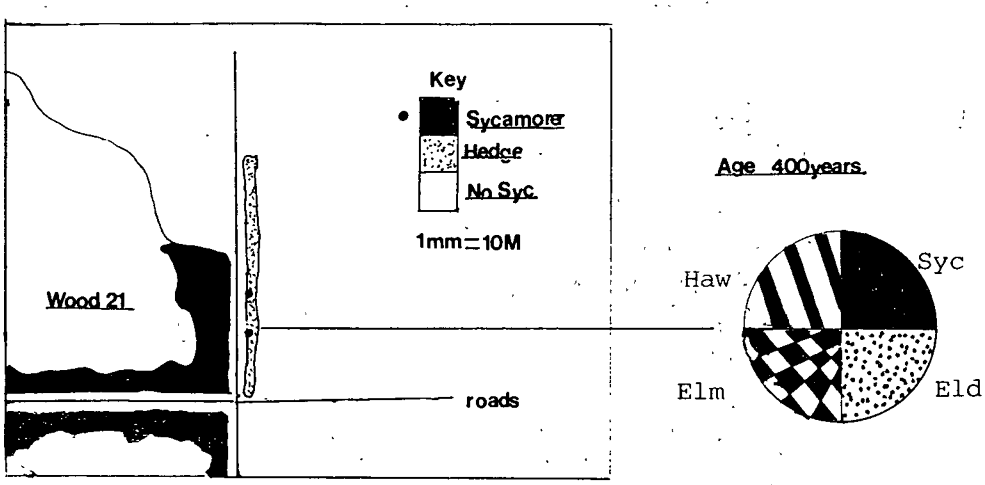


Plate 10 Regularly cut hedge with sycamore invasion

Plate 11 Uncut hedge with sycamore invasion

Some hedges (fig 185, plate 10) are cut in the early autumn which may restrict the seed dispersal of sycamore in hedges. Other hedges (fig 186, plate 11) are left uncut. Sycamore would appear to be able to invade both habitats. Hedges are often associated with ditches which may act as invasion sites for sycamore. Corder[11] suggests that sycamore has been planted as a hedge species because of its shallow rooting character. However, most occurrences of sycamore in the West Suffolk area were naturally regenerated. Sycamore were found in ancient hedges (according to Hooper's[31] hypothesis for ageing hedges). Common species in these hedges were hazel, ash, oak, field maple, dogwood, spindle, elder and elm (see fig 188). Sycamore was also found in more recent hawthorn dominated hedges (see fig 187). Pollard[62] suggests sycamore is a relatively insignificant hedge species throughout the British Isles. Its roadside occurrence in the West Suffolk area would seem to be expanding. Such roadside sycamore may if left uncut become the future source trees of sycamore invasions.

Fig 187 Pie diagram illustrating the number of species (and hence age) in 30m sample of sycamore invaded hedges.



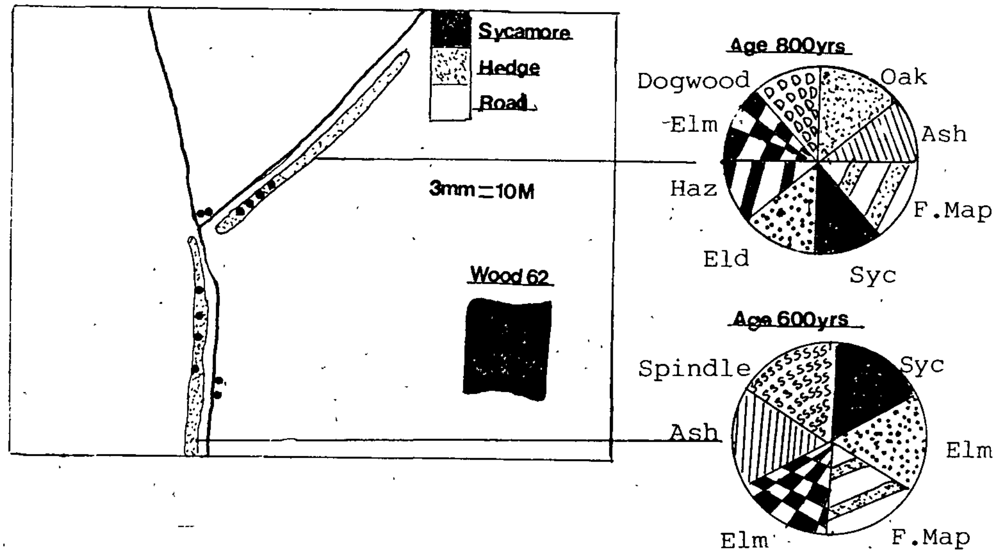


Fig 188 Pie diagram illustrating the number of species (and hence age) in 30m sample of sycamore invaded hedges.

Invasive Mode - Summary

1. Sycamore invasions conform to two common patterns of distribution - pin point and broad belt.

2. The invasive demographies of sycamore may be related in some circumstances to the structure and type of the existing woodland but may equally be due to the dispersal adaptation of sycamore.

3. Sycamore invasive rate rarely exceeds 100m in a generation and is often a lot less.

4. Pin point invasion may represent a greater dispersal distance for a given generation of trees than broad belt invasion. Pin point and broad belt invasions are not mutually exclusive in a single wood over successive generations.

5. Sycamore can invade ancient hedge communities.

Chapter 8

THE RESISTANCE OF WOODS TO SYCAMORE INVASION

The analysis of sycamore invasions (see text p217) and the overall distribution of sycamore in the survey woods reveals that sycamore can form distinctive invasion fronts as it invades woods (see text fig158). Isolated sycamores at the edge of woodlands were also located. The demography of some of these invasions indicates a sycamore distribution to the edge of woodlands (see text p232). It has been suggested that these distributions may be a function of the dispersal adaptation (see text p187) of sycamore and the rate at which sycamore is capable of geographically expanding its population (see text p215). 'Edge' habitats are considered to be ideal habitats for wild life, often being more dense and with greater species and structural diversity than larger habitat units. Hedges are perhaps the most striking example of such 'edge' habitats.

Fragmentation of woodland since medieval times and continuing dramatically in the 20th century (Rackham [64]) has undoubtedly created many smaller woodlands from large woodland blocks. Large woodlands are likely to have a smaller perimeter to area ratio than small woodlands. The shape of a woodland will also affect this ratio; woodlands squeezed between strips alongside roads and between fields may have large perimeter to area ratios. Large ratios mean more edge habitat. The results obtained from the general survey made it possible to examine the relationship between sycamore and the area to perimeter ratio of woodland in the West Suffolk area.

METHOD

The woodlands of the general survey were divided into the sub-categories: ancient woodland; secondary woodland; coniferous plantations and deciduous plantations. Further subdivision of each category into woodland with sycamore and woodland without sycamore was also undertaken. The areas and perimeters of each woodland were estimated using measurements taken from the O.S.Map [51]. Difficult shaped woods were subdivided into smaller more regular units (see text fig189) for area estimation. Areas of angular shaped woodland (see text fig 190 were estimated by enlarging the regular angles to rectangles and subdividing by the appropriate figure, usually two. In these cases, breaking woodlands down to smaller units again helped. Totally irregular woodland shapes (see text fig 191) were more difficult and some estimation was necessary with the shape matched to regular shapes. The measurements were made to the nearest 0.5 of a millimetre. The results are illustrated in tables 12–17 of the general survey results. The millimetre recordings were later translated to metres.

Fig 189 A diagram illustrating the measuring technique for perimeters and areas of regular woods

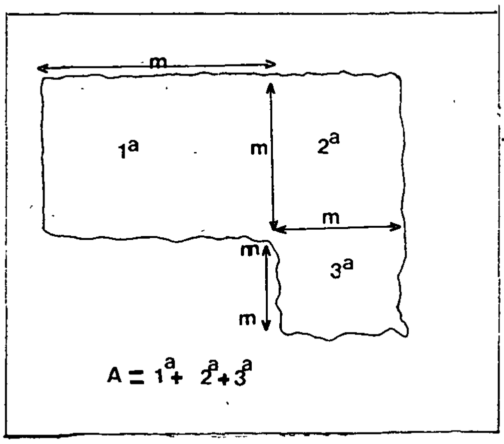


Fig 190 A diagram illustrating the measuring technique for perimeters and areas for angular woods

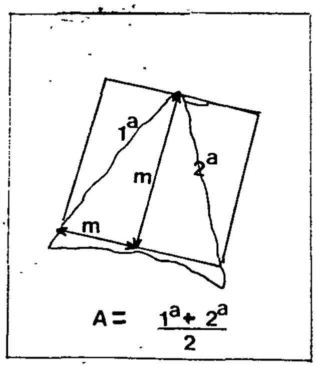


Fig 191 A diagram illustrating the measuring technique for perimeters and areas for irregular woods

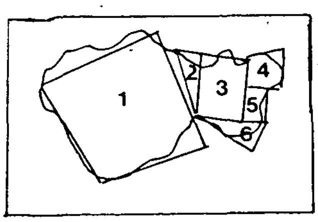


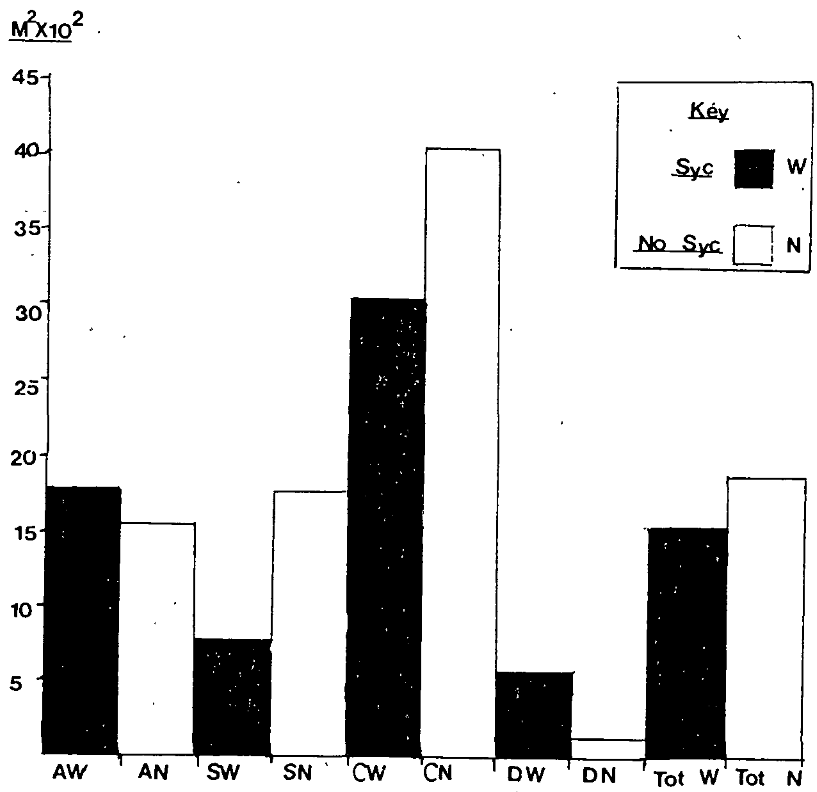
Table 59 Results of the general survey abbreviated to the mean total areas and perimeters for each woodland category.

	AW	AN	SW	SN	CW	CN	DW	DN
Area m²	1800	1565	793	1787	3046	4025	578	153
Perimeter m	1694	1810	825	1050	1230	1680	760	4425

	Total with sycamore	Total without sycamore	Total with sycamore ÷4	Total without sycamore ÷4
Area m²	6217	7530	1554	1882.5
Perimeter m	4509	8965	1127.25	2241.25

Histogram illustrating the mean areas for woodland with sycamore and woodland without sycamore for each of the woodland types. The total mean areas (divided by four) for sycamore and non-sycamore woodland are also shown.

Fig 192

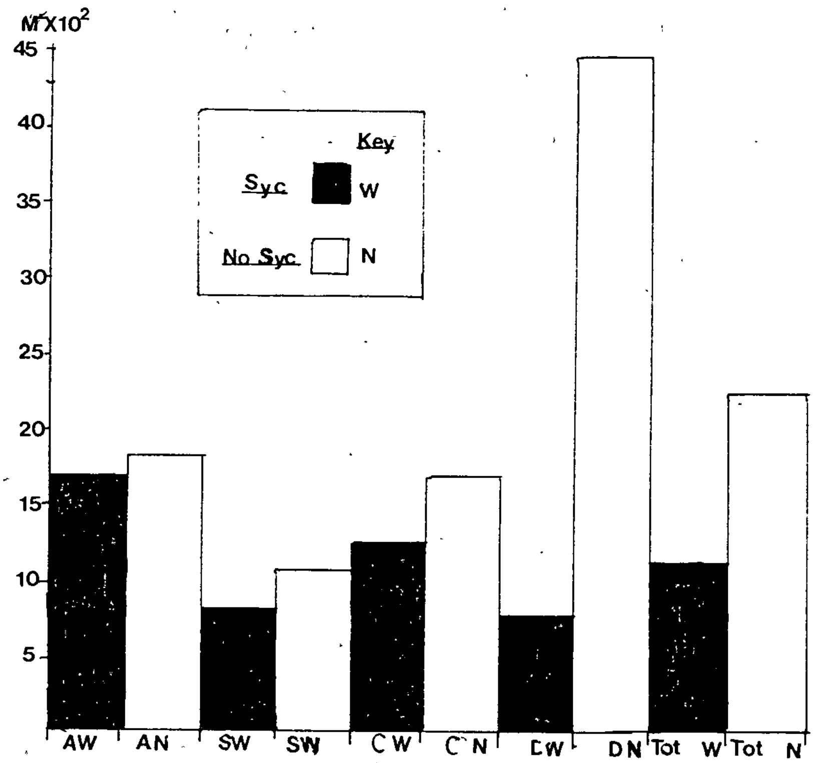


Woodland Types

Fig 192 indicates that for ancient woodland, area makes little difference to the likelihood of invasion. Secondary woodland and coniferous woodlands of mean average larger area appear to be less likely to be invaded by sycamore than woodland of a mean average smaller size. Sycamore distribution in deciduous plantations would seem to favour woodland of mean area of smaller size. The mean average for all woodland suggests that sycamore invasion might slightly favour smaller area woodlands; the trend being more strongly shown in coniferous and secondary woodland.

Histogram illustrating the mean perimeter lengths for woodland with sycamore and woodland without sycamore for each of the woodland types. The total mean perimeter (divided by four) for sycamore and non-sycamore woodland are also shown.

Fig 193



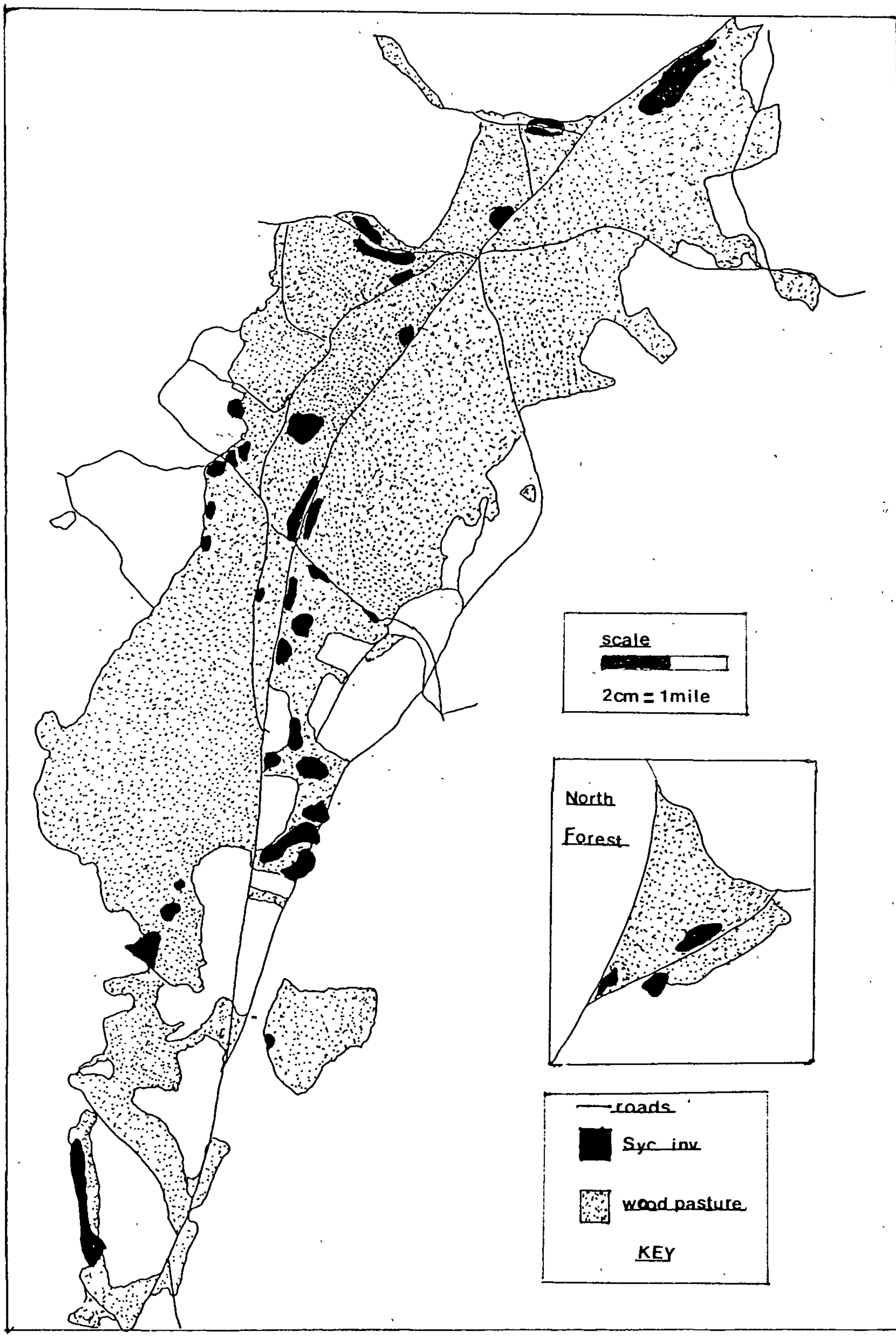
Woodland Types

Fig 193 indicates that the mean average perimeter lengths for sycamore invaded woodland is somewhat less that the mean perimeter length for woodland without sycamore for ancient woodland, secondary woodland and coniferous woodland. This does not confirm the hypothesis that a greater amount of woodland edge favours sycamore invasion. The result for deciduous plantations does confirm the hypothesis but the sample size for deciduous woodland was small and its effect on the total mean averages, which apparently confirms the hypothesis, should not be considered to be conclusive for all woodland in the survey area. It would seem that for ancient woodland, secondary woodland and coniferous woodland, small woodland area and short perimeters could favour sycamore, suggesting a general model of invasions having a greater likelihood of affecting small regularly shaped (see fig 189) woodlands. Such woodlands could be those formed by the fragmentation of larger blocks of woodland to form arable land or by woodland planting and secondary woodland.

The distribution of sycamore towards woodland edges (see text p247) is, according to this analysis, not clearly related to the actual amount of woodland edge to be invaded. Although there is some evidence to suggest that the smaller the perimeter to area ratio of a woodland, the less likely it is to be invaded.

Epping Forest was included in the survey because it presented a woodland with a completely different management history to that of the four management categories described for the West Suffolk area. Epping also represents a much larger single unit of woodland than was found in the West Suffolk area. The distribution of sycamore invasions in Epping Forest is illustrated in fig 194. The invasions again seem to be confined mainly to woodland edges where the woodland abutts roadsides, settlements or agricultural land. The relationship between sycamore and roads appears most convincing, such that if roads did not interrupt the woodland canopy there is indication that sycamore invasion of the main forest block might be limited. It has been suggested (see text p 208) that roads may aid sycamore dispersion. However, the hypothesis that "the particular environmental conditions of 'edge habitats' favours sycamore invasion", may have some validity.

Fig 194 Map of Epping Forest redrawn from Lloyd[38] illustrating the distribution of sycamore amongst the forest block



Pakenham Wood (Wood no 55) was a typical derelict ancient woodland of the West Suffolk area. It has been invaded by sycamore to a distance of 80m from the woodland edge. However it has a distinct invasion front (see fig195) with clusters of sycamore saplings that extend beyond the invasion front. The first 30m of the woodland (see fig195,p254) shows the presence of mature coppice or standard trees. The dispersal distance between the last mature trees to the most deeply invading saplings was approximately 50m.

Several investigations were undertaken at the site to explore the relationship between environmental conditions at the woodland edge and those found further into the wood. The distribution of sycamore and other species at the site was also recorded.

A 110m^2 belt transect from the woodland edge, running parallel to the assumed line of sycamore invasion was chosen. The transect was divided into 10m^2 quadrats. The species composition and structure of each quadrat were recorded according to the tree type classification (see text p 36). Numerical abundance of all trees was recorded. These are illustrated as pie charts in fig 195. The approximate positions (using a tape) of clusters of sycamore and ash saplings were recorded with the positions of canopy standard and coppice trees. These are illustrated on fig 195. Three recordings of wind speed and light were made at one minute intervals at the centre of each quadrat. A standard anemometer was used, measuring wind speed in km/h, the apparatus held for five seconds at a height of 1m above the ground. A Griffin environmental comparator with probe was used for light intensity. The mean average of the three measurements was recorded. Before the investigation, ten recordings, at one minute intervals, of light intensity and wind speed were made at an unsheltered point beyond the woodland edge. The investigation was undertaken on a uniformly clear day with a gusting wind speed varying between 10 and 25 km per hour. All wind speed and light intensity results are expressed (table 61) as a percentage of the mean average for the open recordings.

Fig195(see text) illustrates that light intensity drops by approximately 20% within the first 10 metres of the woodland and remains fairly constant throughout the woodland suggesting that light conditions at the woodland edge are little different from its interior. Light conditions may therefore not be limiting the invasion of sycamore to the edge of the woodland at this woodland site. Pakenham Wood however, may be atypical of other woodland sites.

Fig 195 Diagram of Pakenham Wood illustrating species structure distribution and environmental parameters

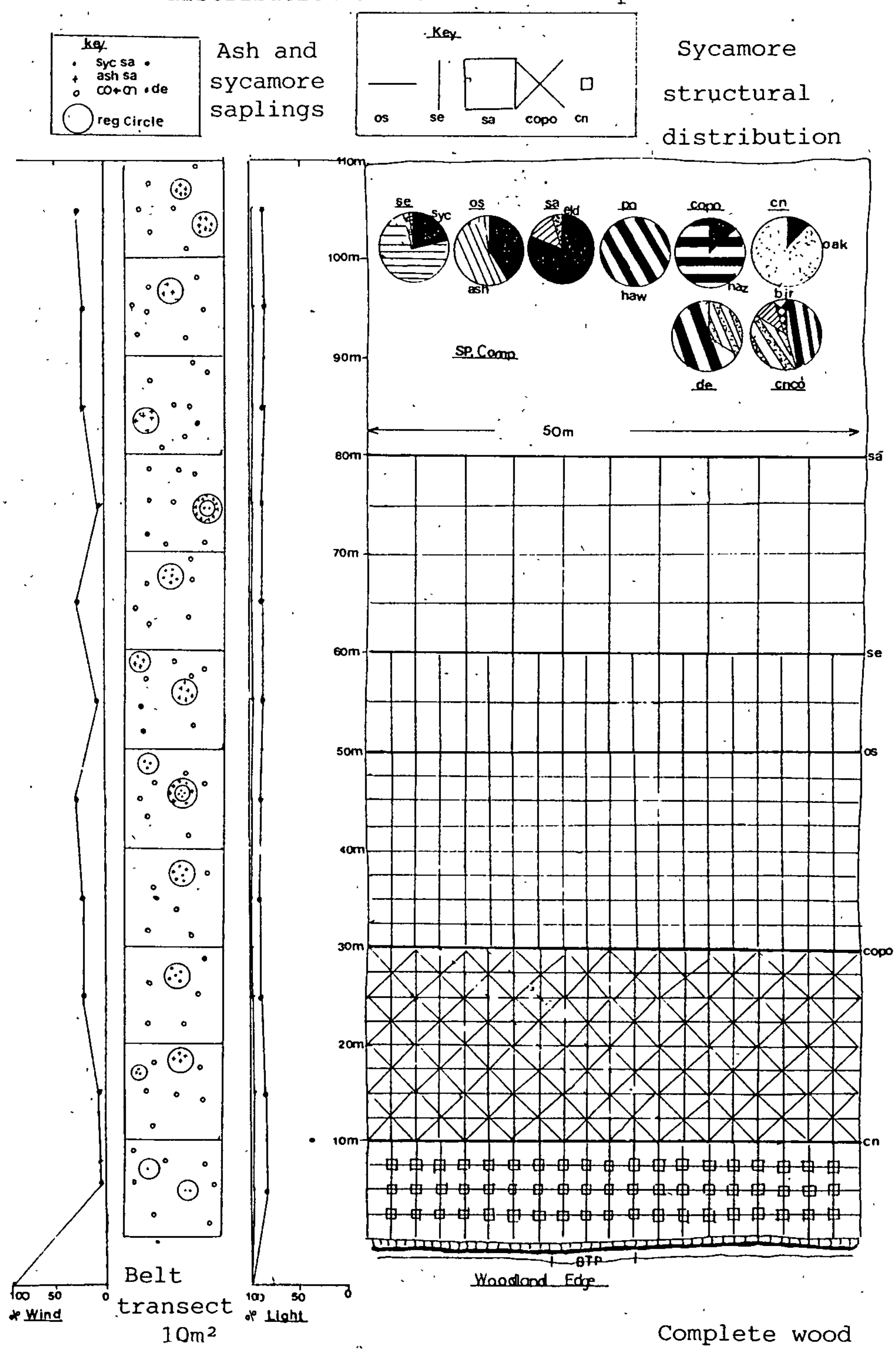


Table 60 Results of the species and structure recordings for Pakenham Wood

Density Analysis of Pakenham Woods - 15.8.85

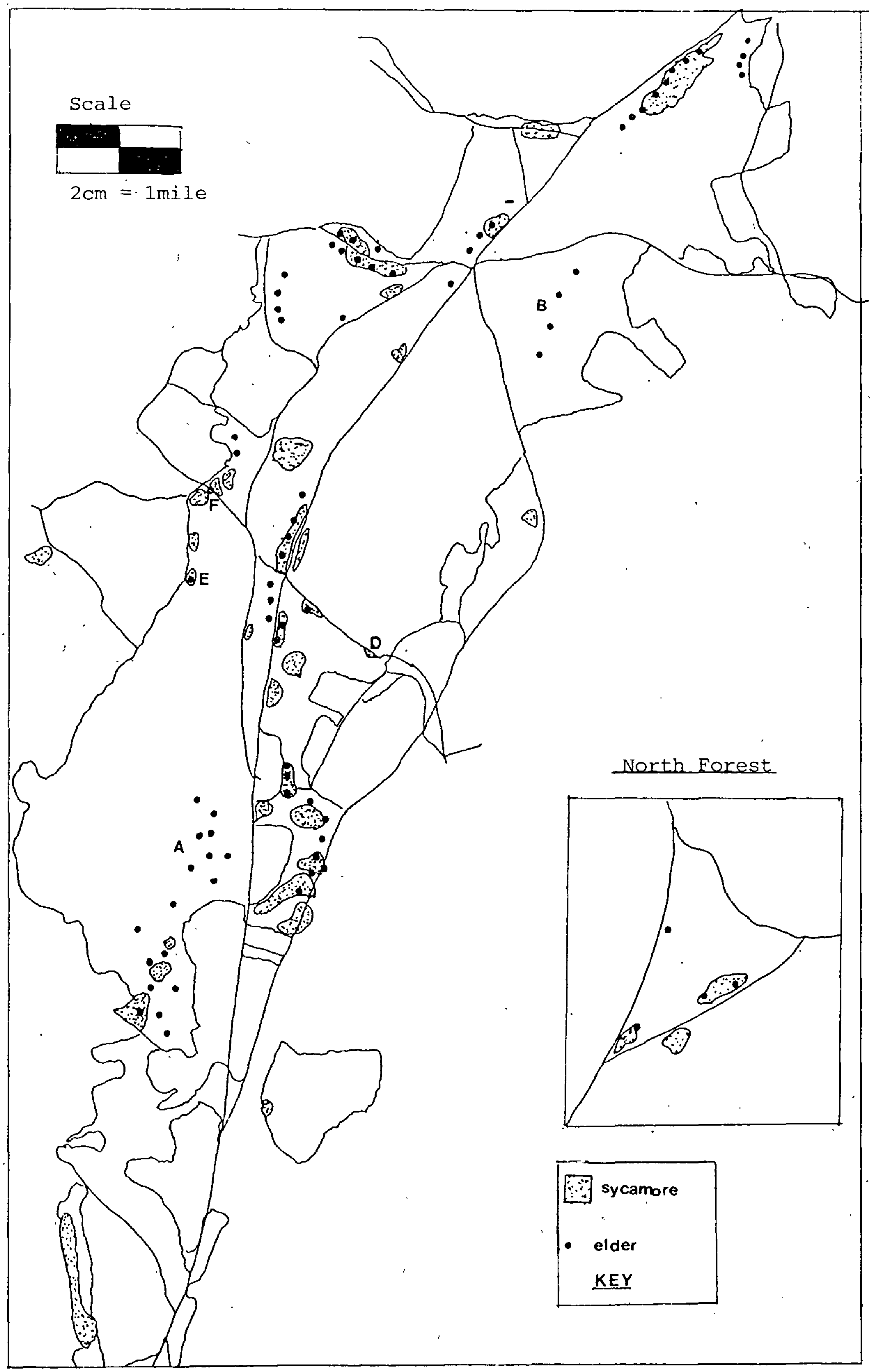
Species type	Quadrat nos. - Numerical abundance 1	2	3	4	5	6	7	8	9	10	Tot abundance	* % abundance
Syc cn	1	0	0	0	0	0	0	0	0	0	1	12.5
Syc copo	0	1	1	0	0	0	0	0	0	0	2	13.3
Syc sa	12	11	13	6	4	2	4	2	1	0	55	83
Syc os	15	21	18	7	3	0	0	0	0	0	64	41.2
Syc se	23	12	8	65	11	6	0	0	0	0	125	21.4
Ash cnco	1	0	1	0	0	1	0	0	1	0	4	10.2
Ash sa	0	0	6	0	0	0	0	0	3	1	10	15.1
Ash os	11	6	5	0	8	9	8	30	7	5	39	57.4
Ash se	6	13	25	150	38	21	52	240	78	22	445	76.4
FMap co	2	2	1	2	1	1	2	1	1	1	15	38.4
FMap se	9	0	0	0	0	0	0	0	0	0	9	1.5
Haz cnco	3	3	2	0	2	1	3	0	2	2	18	46.1
Haz copo	1	1	1	4	1	3	0	0	1	1	13	86.6
Oak cn	0	2	1	1	1	0	1	0	1	1	7	87.5
Haw po	3	2	1	0	0	0	0	0	0	0	6	100
Eld sa	0	1	0	0	0	0	0	0	0	0	1	1.5
Eld se	4	0	0	1	0	0	0	0	0	0	5	0.8
Hol os	1	0	0	0	0	0	0	0	1	0	2	1.2
G.Ros	0	1	0	0	1	0	0	0	1	0		
Bir cnco	0	0	0	1	0	0	1	0	0	0	2	5.1

$$* \% \text{ abundance} = \frac{\text{Total abundance of a species structure}}{\text{Total abundance all similar structures}}$$

Table 61 Results of wind speed and relative light intensity expressed as % of mean open values taken to be 100% daylight - recorded at Pakenham Wood

Quadrat Nos.	1	2	3	4	5	6	7	8	9	10	11
Rel. light	85.7	84.7	84.7	83.9	83.9	83.9	83.9	84.7	82.8	84.7	83.9
Rel. wind Km/hr	15.3	6.5	20	20	26.6	13.3	26.6	6.6	20	20	26.6

Fig 196 Map of Epping Forest redrawn from Lloyd illustrating the distribution of sycamore and elder



The distributions of sycamore throughout the individual woodlands of the survey area never indicated invasion from within a wood. Wherever sycamore was present it was always found near to the edge of at least part of the woodland. It was considered that this might be in accordance with the nature of sycamore dispersal adaptation to wind dispersal (see text p187). Fig 196 (see p 256) illustrates that invasion of Epping Forest by sycamore and elder (Lloyd [38]). Elder was considered to be adapted to dispersal by bird transportation. The elder invasions A and B do not appear to have originated from a woodland edge. Mature sycamores were found at the edge of Epping Forest (D, E and F - Fig196) associated with invasions restricted to a narrow region at the forest edge. It was considered that there might be resistance to invasion of woodland including Epping Forest and many of the Suffolk woodlands. The resistance could be related to the dispersal adaption of sycamore. For this reason an investigation was undertaken to test the effect of woodland structure and composition on ambient wind speeds. It was assumed that wind speed has a positive relationship with the dispersal distance of the sycamore seed.

Method

A section of Langham Hills Wood (Wood no 52) was selected as it offered three basically different types of woodland structure and composition. Langham Hills Wood was a typical derelict ancient woodland with both mature and recent areas of sycamore invasion. Three transect lines were selected: transect (1) through ancient woodland; transect (2) through recently invaded ancient woodland and transect (3) through mature sycamore woodland. These are illustrated on fig 197 p 258. Wind speed recordings were made using a standard anemometer at 5m intervals along each transect line. At each 5m station the anemometer was held at 1m height for thirty seconds and the maximum wind speed recorded. In some cases recordings were made at 1m intervals. The wind direction was approximately W/SW.

Fig 197 Map illustrating the transect lines used for wind speed analysis at Langham Hills Wood

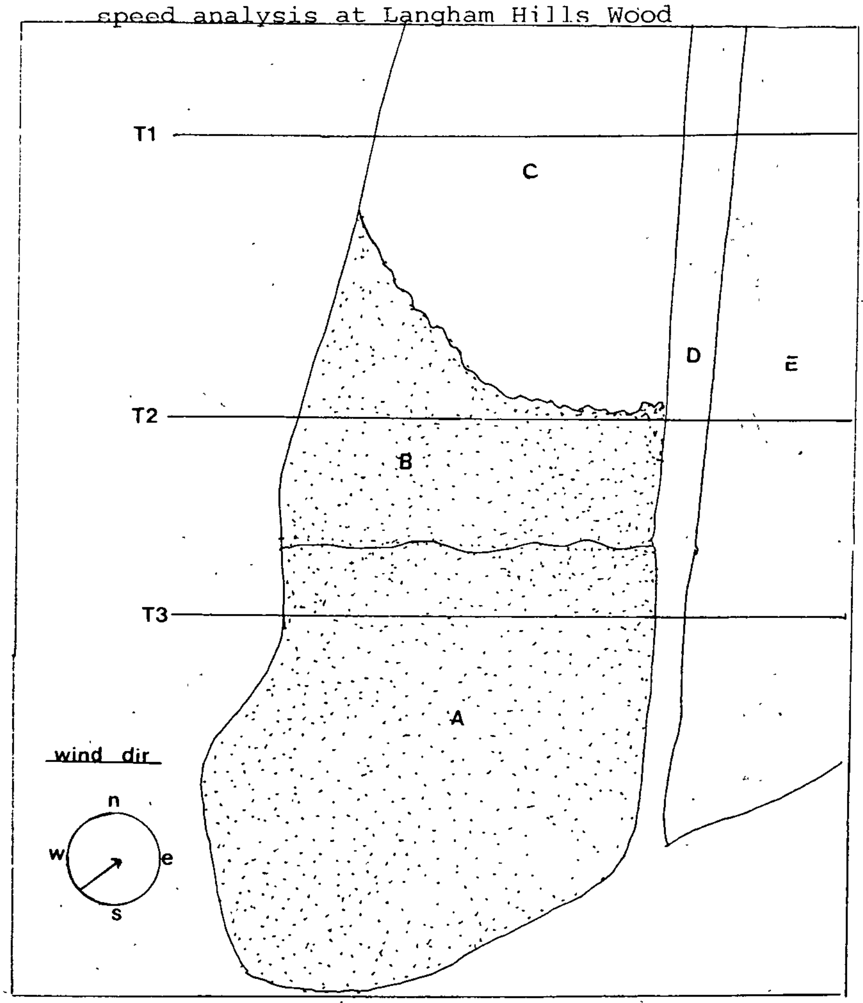


Table 62.
Results of wind speed transects at Langham Hills Wood

Transect 1	5m stations							Arable land								
Station No	1	2	3	4	5	6	7	8	9	10	11	12	13			
Km/hr	15	15	15	10	15	18	21	15	20	26	28	16	15			
	5m stations							Ancient Woodland								
Station No	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Km/hr	8	3	3	0	1	0	0	0	0	0	0	0	0	1	0	0
Transect 2	5m stations							Arable land								
Station No	1	2	3	4	5	6	7	8	9	10	11	12	13			
Km/hr	17	22	15	19	14	10	20	22	21	17	19	20	15			
	5m stations							Sycamore invasion								
Station no	14	15	16	17	18	19	20	21	22	23	24	25	26			
	5	3	4	0	0	0	0	0	0	1	0	0	1			

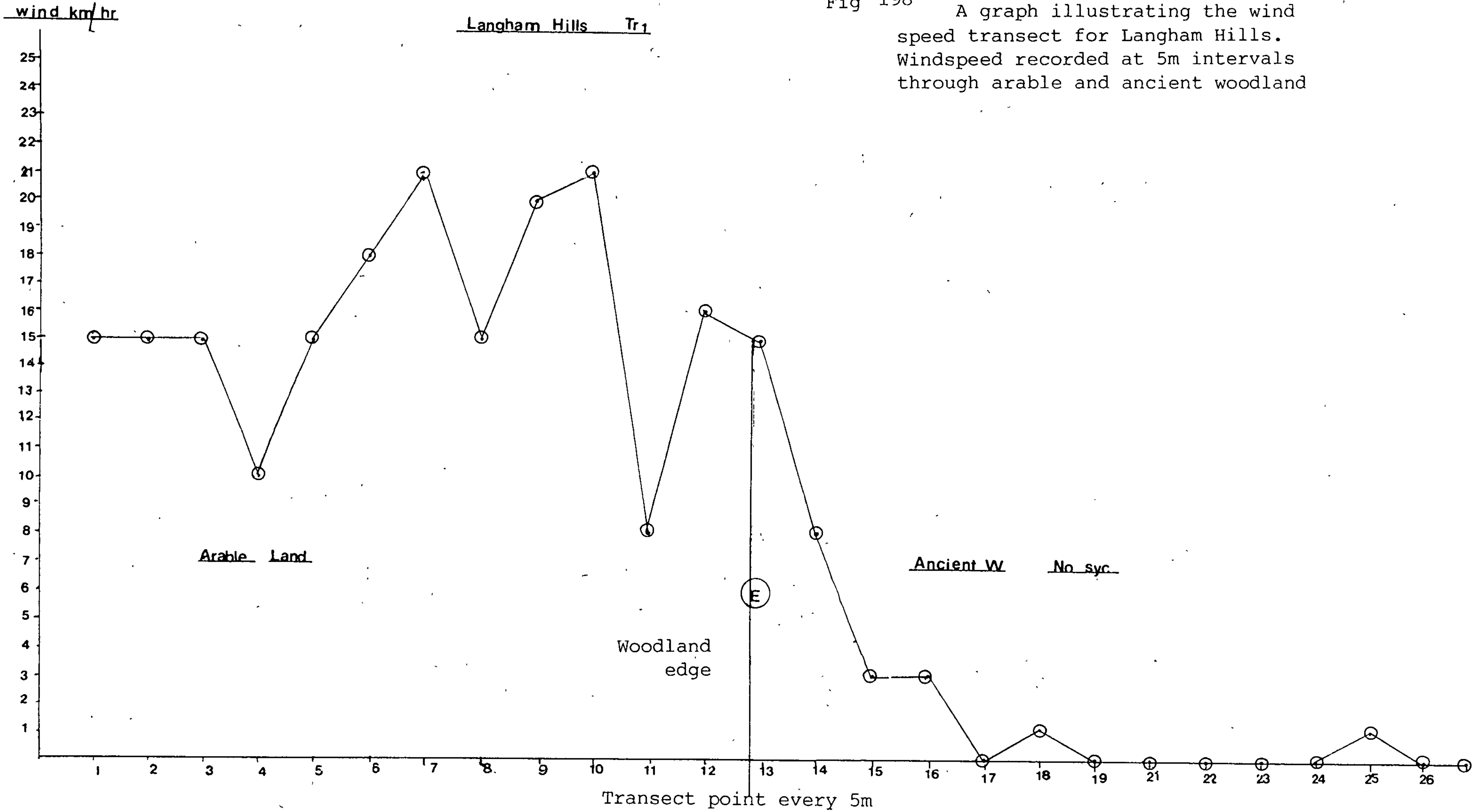


Fig 198 A graph illustrating the wind speed transect for Langham Hills. Windspeed recorded at 5m intervals through arable and ancient woodland

Table 62 (contd)

Transect 2 (contd)	1m stations							Ride						
Station No	27	28	29	30	31	32	33	34	35	36	37	38	39	
Km/hr	1	0	5	0	2	6	0	2	1	0	4	1	0	
	5m stations							Ancient Woodland						
Station No	40	41	42	43	44	45	46	47	48	49	50	51	52	53
Km/hr	3	1	0	0	0	1	0	1	0	0	0	1	0	0
Transect 3	5m stations							Arable land						
Station No	1	2	3	4	5	6	7	8	9	10	11	12	13	
Km/hr	26	24	15	22	13	15	13	15	20	21	25	16	17	
	5m stations							Mature sycamore woodland						
Station No	14	15	16	17	18	19	20	21	22	23	24	25	26	
Km/hr	6	4	3	3	1	0	2	0	3	3	2	0	2	

Fig 198 illustrates that there is a dramatic difference in wind speed between open arable land and the interior of ancient woodland. However wind values from the woodland edge (marked E) for a distance of 25m towards the interior were significantly higher than the usual interior woodland edge values which showed an almost complete reduction in wind speed. This $25m^2$ edge habitat represented a larger distance than was recorded for light values at the woodland edge of Pakenham Wood (see fig 195 p254). Although the wind speed at Pakenham Wood declined more rapidly than at Langham Hills Wood (see fig 198 p259). The Pakenham wind transect and the Langham Hills transect (1) clearly demonstrate that derelict ancient woodland reduces wind velocity. This effect could clearly inhibit sycamore dispersal range. Derelict ancient woodland may in this way display some natural resistance to invasion by wind dispersal seeds such as sycamore.

Fig 199 illustrates a common early invasion of sycamore with juvenile sycamore confined to ditches and banks beyond the woodland edge of an ancient woodland.

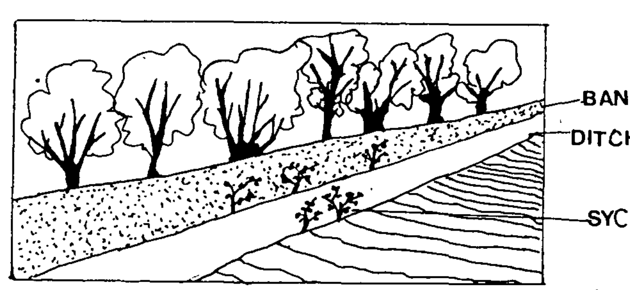


Fig 199 Sycamore on woodland bank, Bangrove Wood

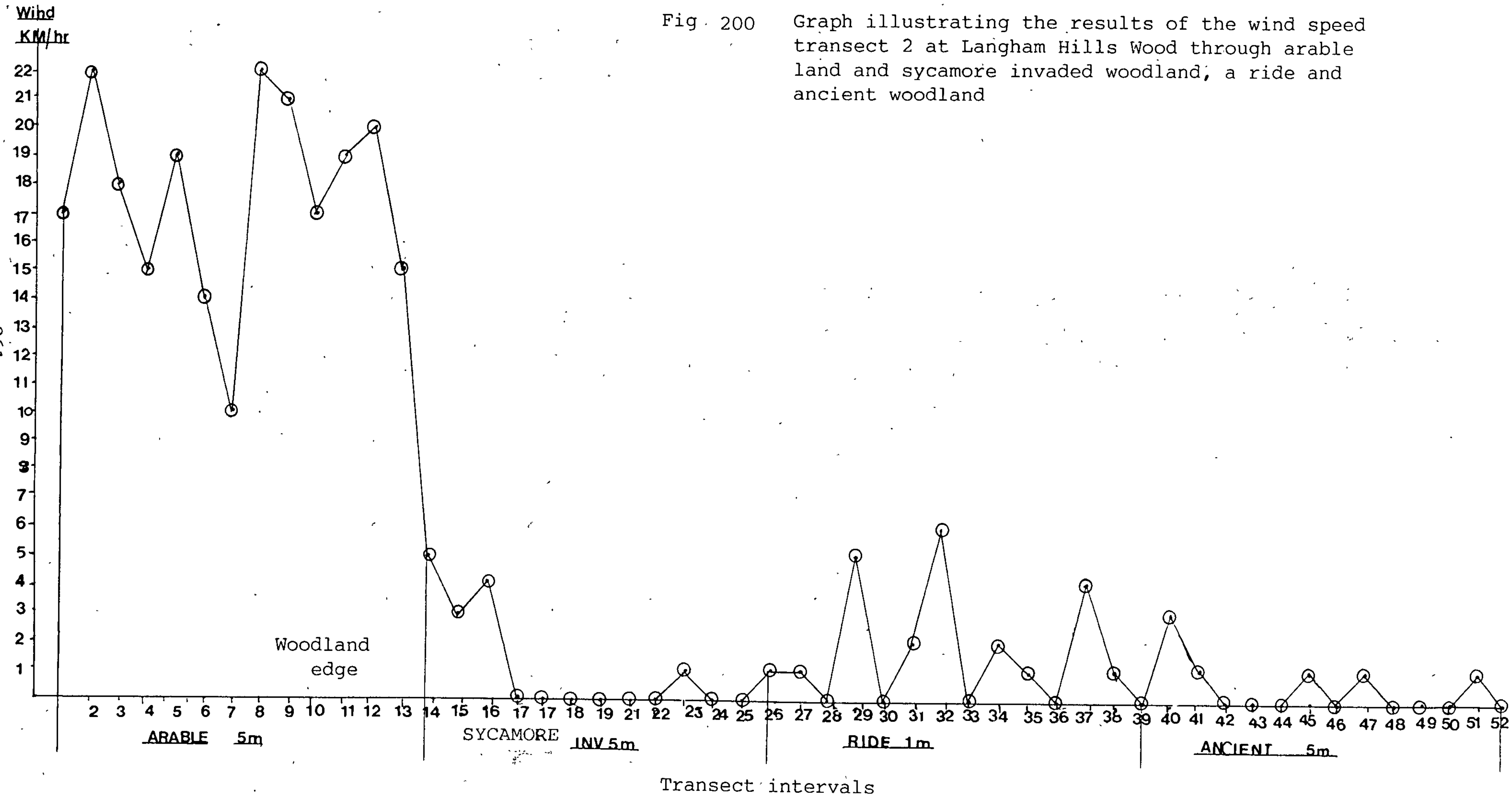


Fig 200 Graph illustrating the results of the wind speed transect 2 at Langham Hills Wood through arable land and sycamore invaded woodland, a ride and ancient woodland

Transect (2) (table62 text p 260) illustrates maximum wind speeds from arable land to a recently sycamore invaded ancient woodland to a ride and t hrough to ancient woodland with no sycamore. The graph of this transect (fig200) illustrates a drop in wind speed in sycamore invaded woodland compared to the wind speeds for arable land. The wind speeds in the ride area are lower than for arable land but with higher values than for either sycamore invaded wood or the ancient woodland sector of transect. So that whilst sycamore may actually inhibit the transportation of its own seed and ancient woodland significantly reduces wind strength, the rides of ancient woodland may represent favourable pathways for the dispersion of sycamore seeds. This may be an important point for conservationists. Unmanaged rides might be particularly encouraging to sycamore invasions. Fig 201 illustrates that sycamore saplings are present at the ancient woodland edge of a ride that divides pure ancient woodland from sycamore invaded woodland at Langham Hills.

Fig201 Sycamore in ride,
Langham Hills Wood

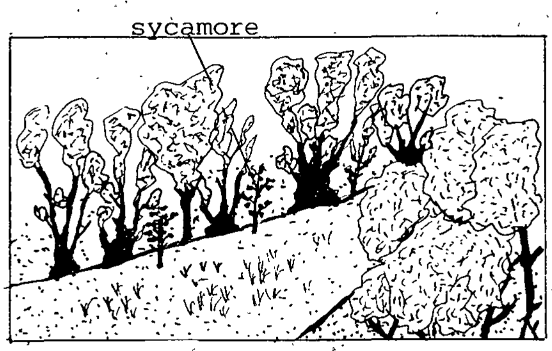


Fig 202, the third transect at Langham Hills Wood crosses from arable land to mature sycamore/ash woodland, thought not to be of an ancient woodland type. Again a reduction of wind speed is evident. However, the rate at which wind speed drops in the sycamore woodland is slower than that for the invaded ancient woodland or the pure woodland (see text, figs 200 and198) indicating that woodland structure and composition can have an effect on the wind speed/woodland relationship. The modification of open wind speeds is also less in the interior of the sycamore woodland than for the other woodland types studied at Langham Hills. The obvious difference in structure between ancient and secondary woodland was the abundance of coppice type tree types in ancient woodland. Coppice tree strata may well greatly contribute to reductions of wind speed and hence add to the resistance of ancient woodland to invasion by wind dispersed seeds, such as sycamore.

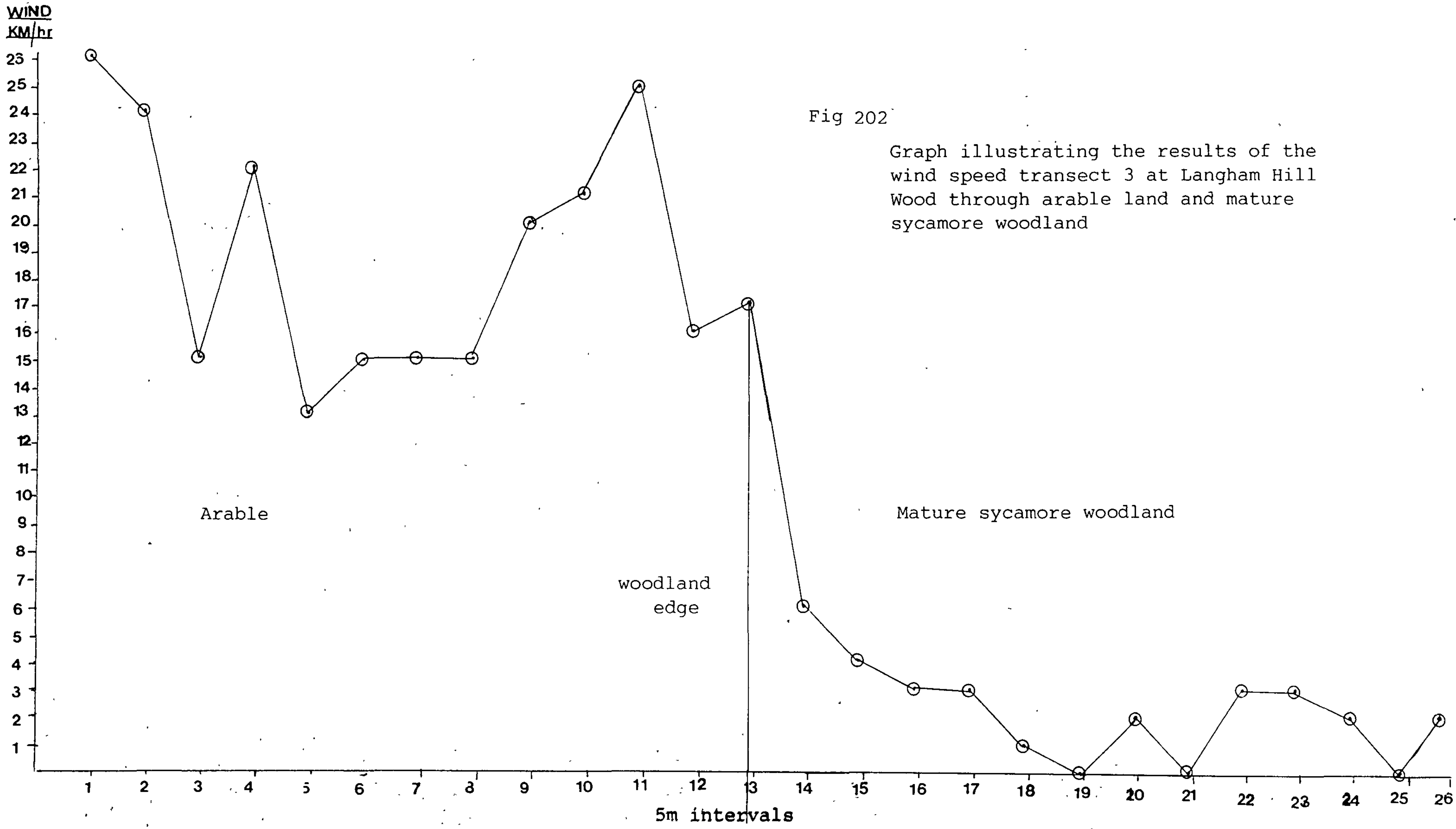


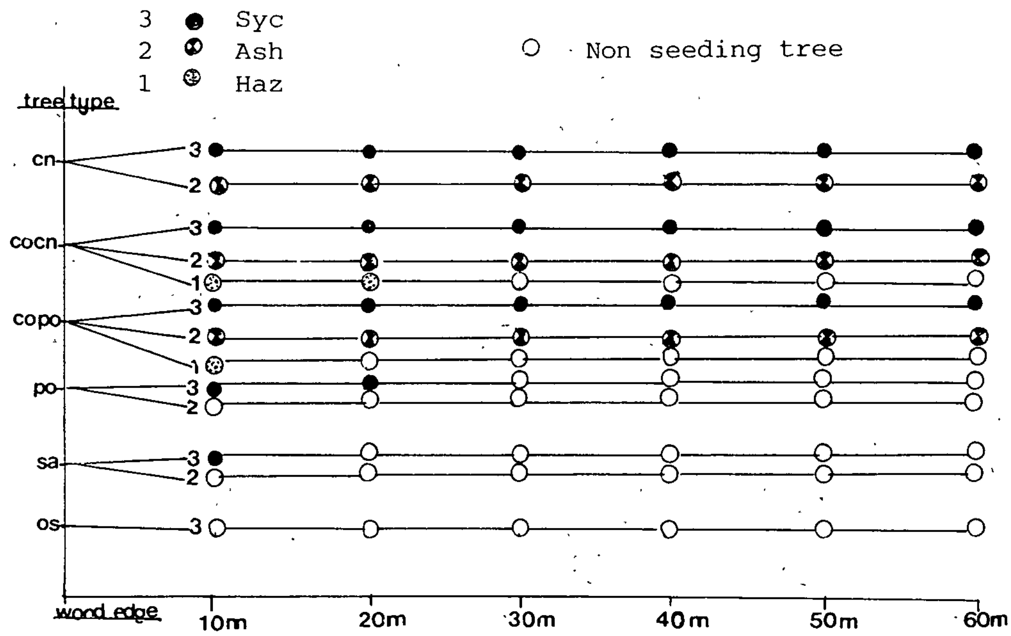
Fig 202

Graph illustrating the results of the wind speed transect 3 at Langham Hill Wood through arable land and mature sycamore woodland

Factors such as the internal regeneration of native species and the presence of competitive ground flora may also contribute to resisting sycamore invasion. The factors are considered in other sections of the text (see pages 284,266). The present structure of ancient derelict woodlands indicates that decaying trees are relatively rare. At Langham Hills and Pakenham Wood that were few degenerate trees. The regeneration circles plotted in the Pakenham Wood transect (see fig 195, p 254) were not usually exploiting gaps in the canopy created by the death of an existing native tree as may have been expected, although in some circumstances this may be occurring. Degenerate trees were too few for this to be the case. The relatively even age structure of coppice and standards at many ancient woodlands suggests that at some time in these woods future degenerative trees may be found in far greater proportions. Coppice trees will die relatively quickly if left uncoppiced. However, the bio-historic stage in which ancient woods are now often found in the West Suffolk area may be resistant to sycamore invasion due to a lack of existing tree degeneration.

Preliminary observation of woodland in the West Suffolk area had suggested that seeding trees might be confined to woodland edge of a wood. The trees found within the belt transect of Pakenham Wood (see fig 195 , text p254) recorded according to whether they were seeding or not. The results for ash, hazel and sycamore are illustrated in fig 203. The diagram indicates that demographic position is not likely to affect sycamore seeding, although more juvenile forms of sycamore will seed at the woodland edge. Ash did not seed at Pakenham in juvenile forms. Hazel, however, appears far more likely to seed at the woodland edge. Therefore it is unlikely that sycamore invasion is limited to edge habitats by its ability to seed in these habitats. The results found for hazel are comparable to observations made by Rackham[64].

Fig 203 Pakenham Wood illustrating the occurrence of seeding trees in relation to their distance from woodland edge



Summary

1. It is likely that the creation of small woodlands rather than the large woodland blocks of historical times has encouraged sycamore invasion.

2. Wind speed is reduced towards the interior of woodlands depending on species structure. This may be a factor that acts as a resistance to sycamore invasion.

3. Sycamore often has a distribution towards the edge of woodlands in the West Suffolk area but this is unlikely to be a function of the improved light conditions of an 'edge habitat'.

4. Regeneration circles are not always created by the degeneration of trees.

Chapter 9

WOODLAND GROUND FLORA AND ITS RELATIONSHIP TO SYCAMORE INVASION

Preliminary observations of woodland in the West Suffolk area suggested that ground flora could be classified in terms of the dominant species present at a site. It was considered that producing a detailed floral list with possible estimates of species abundance (either empirical or relative) might be beyond the scope and the needs of the survey. However the role of ground flora may be an important factor in determining which conditions are satisfactory for tree regeneration. Ground flora distribution at woodland sites may also suggest environmental conditions being created by the tree species of a particular site; for instance the amount of shading or edaphic conditions at a particular site. Ground flora has further significance to the aims of the thesis in that the impact of sycamore invasion on ground flora could be relevant to its conservational desirability.

An original system of classifying ground flora was designed and is illustrated in fig 204. The design includes two main elements, firstly, a scale of cover; ground flora was estimated at three levels open, open/closed and closed and, secondly, a species community classification.

Description of three cover values

Preliminary investigations suggested that ground flora cover within individual woodlands was often uniform, particularly where the tree species cover was of a uniform demography. The open category ground flora was defined as woodland with no ground flora cover. The open/closed category was defined as woodland with an incomplete cover of ground flora. The closed ground flora category was defined as woodland with a complete cover of ground flora (see fig 204). The classification was very simple but related quite accurately to the observable demographies of ground flora in West Suffolk woodland. Further subdivision of these three categories would have made it necessary for a measuring or counting technique to be used to estimate abundance , rather than simply recording the occurrence of each category. Again as with the methodology of the general survey, each woodland or stand of trees was considered to be a sample population

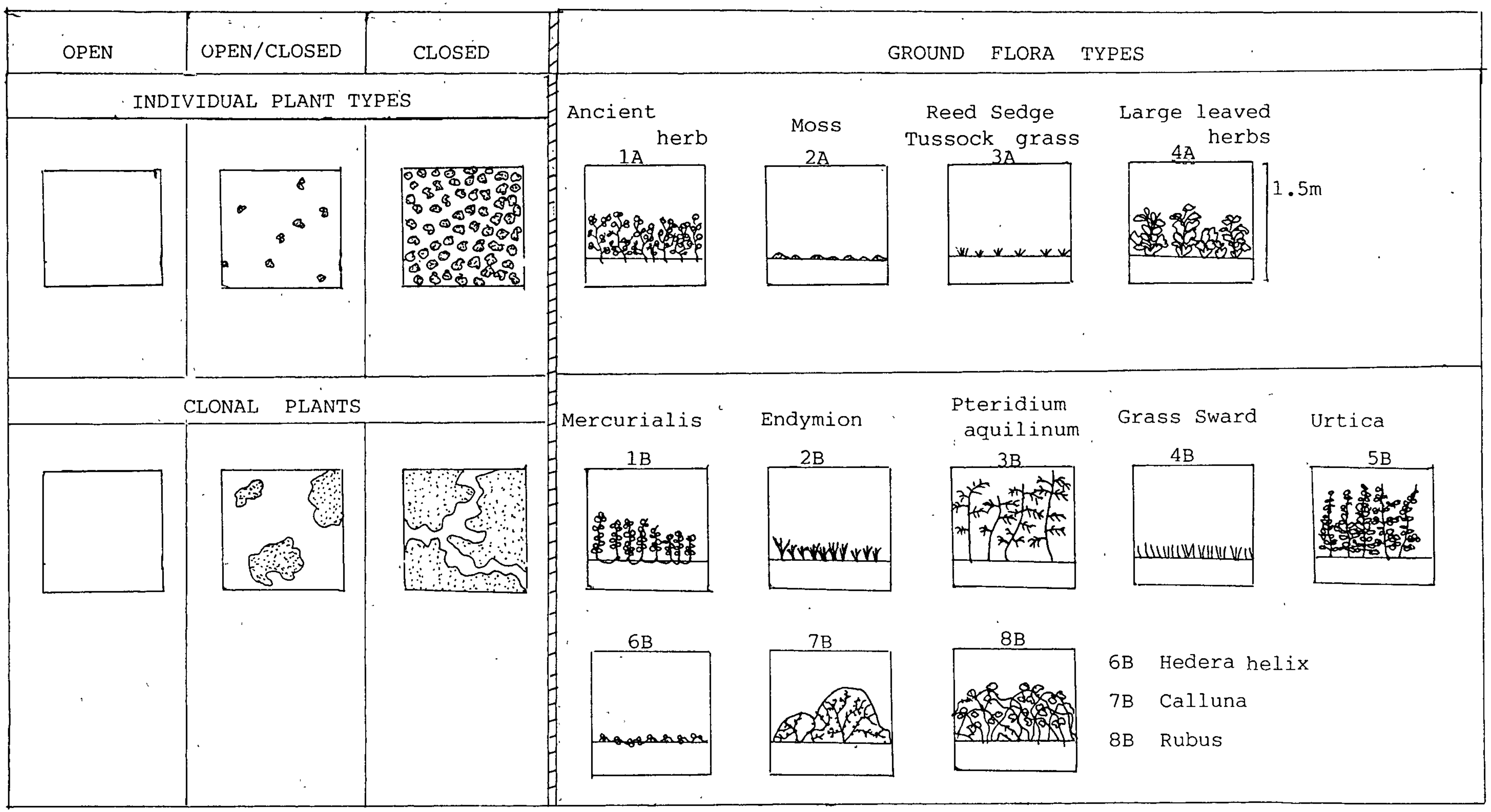


Fig 204 Ground flora classification

of the complete West Suffolk woodland community and the data obtained from the ground flora of part of the survey was to be analyzed in this context.

The second criterion of the ground flora classification was species type. Preliminary observations suggested that the relatively small individual woodlands of the West Suffolk area were often dominated by a single ground flora species or an association of a few species. Twelve such species associations are illustrated (see fig 267). These represent the most frequent dominant ground flora species. Types 1A and 2A are associations of species and may be variable in composition. Type 1A consists of ancient woodland herbaceous indicator species such as herb robert, *Geranium robertianum* or wood avens, *Geum urbanum* which generally had small leaves (Rackham [64]). Type 4A consists of larger leaved herbaceous species such as primrose or cowslip, *Primula sp.* The major reason for excluding a detailed species analysis of each category was that it was the morphological form of ground flora cover that was of interest. A clear division was made between clonal ground flora species and those that consisted of individual plants so that categories 1B - 8B consisted of dense mats of ground flora with little of the woodland soil evident. Types 1A - 4A consisted of individual plants that tended to allow areas of visible woodland soil. It was considered that clear woodland soil might represent safer sites (Harper [24]) for tree regeneration than areas covered with vegetation.

The interest in morphological form is based on questioning whether any of the morphological types excluded sycamore regeneration. Preliminary observations suggested that sycamore could not be found regenerating amongst a dense sward whereas examples of oak and hazel regeneration amongst a grass sward had been observed (see plate 12, page 269). In the text, a more detailed examination of the seed morphology and adaption of sycamore, in relation to other species, is suggested (see page 284). Analysis is made of the exploitation of particular ecological niches within woodland. This was seen to be a further method of predicting the future composition of the West Suffolk woodland community and therefore highly relevant to the aims of the thesis.

Plate 12 Photograph of hazel regenerating amongst a closed grass sward

The species categories were not exclusive and more than one type could be recorded at a woodland site. Record was made on the basis of the occurrence of the species type from observation made during the general survey walk.

Analysis of the data collected for woodland ground flora in the West Suffolk area

1) Aim to relate the occurrence of sycamore to the presence of open (O), open/closed (OC) and closed (C) ground covers (see fig 204)

2) Method The occurrence of each category was recorded for all woods in the general survey (see text, record card 1 fig 30). The data was collated, see table 63. The total number of each type was calculated and plotted on a histogram, fig 205 . The totals were then subdivided into two categories, woodland with sycamore and

woodland without sycamore. These results were plotted on two histograms, figs 206 and 207.

Table 63 The occurrences of ground cover types according to numerical abundance in woodland categories (graphically illustrated below)

Ground flora types	Ancient with sycamore	Ancient without sycamore	Secondary with sycamore	Sec.without sycamore	Deciduous with sycamore	Decid.without sycamore	Coniferous with sycamore	Conif.without sycamore	Total with sycamore	Total without sycamore	Total all woodland
Open	13	6	26	0	0	0	10	3	49	9	58
Open/Closed	2	3	5	0	3	1	2	2	12	6	18
Closed	11	19	11	8	4	5	2	1	28	32	60

Fig 205
All woodlands

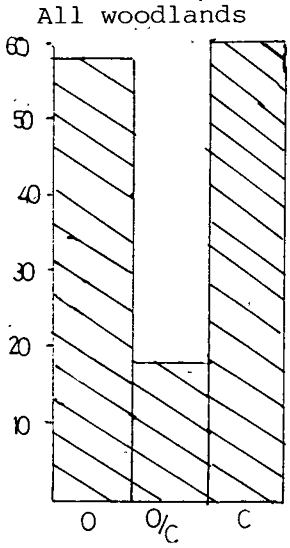


Fig 206
Woodlands without sycamore

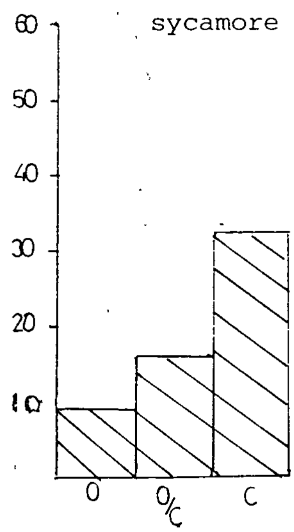
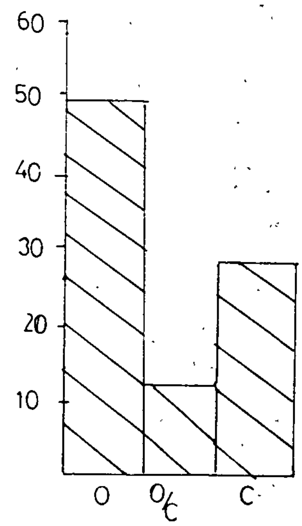


Fig 207
Woodlands with sycamore



The histogram for the total of each ground flora category in all woodland suggests that a clear division can be made between open and closed types with rather less of the intermediate category, open/closed. Comparison of the histograms (fig 206 and fig 207) illustrating totals of each category where sycamore was present and where it was absent, suggests that the initial premise of the investigation, that sycamore prefers an open ground flora, might have some validity. The distribution of occurrences in woodland with sycamore suggests either a preference for open ground floras at its regenerative stage or that sycamore has some other relationship to open ground floras. For instance, it is a widely held conservationist view that sycamore reduces ground cover by shading. These results would add support to this theory. However, definite proof could only be established by analyzing a large sample of mature pure sycamore woodlands. Such a sample was not present in the West Suffolk area. It is my suggestion that sycamore will undoubtedly increase shading during its invasive stage in a woodland by adding one or more further foliage strata to the woodland profile. Other factors that may relate sycamore to this open ground flora type might be the condition of the leaf litter produced by sycamore. Sydes and Grime [79] have worked on the effect of different leaf litters on ground cover. They thought sycamore litter to be of a fairly persistent nature. They applied this fact to two effects of the litter depending upon whether there was a large or moderate input of litter. It was felt that with a moderate input (a) the persistant litter would reduce the abundance of dominant grasses and therefore allow a diverse 'specialised' herb layer. If the input of litter was greater (b), a different effect was thought to take place. In this case the litter was only thought to allow the growth of a low diversity of very specialised plants.

The sample of all woodlands in the general survey was further subdivided into the four categories, ancient woodland, secondary woodland, coniferous plantations and deciduous plantations and the total occurrences of the three cover values of each type were calculated (see Table 63). Each woodland category was further subdivided into woodland with sycamore and woodland without sycamore. Histograms of these figures were plotted for each subdivision , see figs 208 - 215 .

Fig 208 Ancient woodland with sycamore

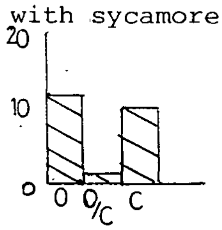
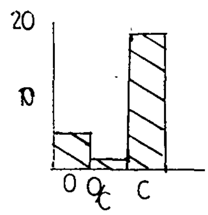


Fig 209 Ancient woodland without sycamore



Occurrence of cover types in ancient woodland according to numerical abundance

Comparison of the two histograms for ancient woodland, figs 208,209 suggests that closed ground flora has a positive relationship with sycamore absence, open ground flora being more closely associated with sycamore presence. Again, it is not known whether open ground flora actually encourages sycamore invasion or whether it is a product of that invasion.

Fig 210 Secondary woodland with sycamore

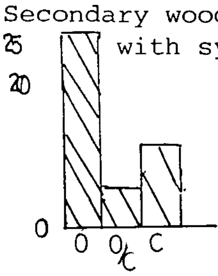
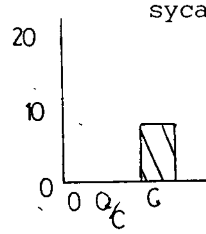


Fig 211 Secondary woodland without sycamore



Occurrences of cover types by numerical abundance

Comparison of the histograms for secondary woodland, figs 210, 211 again reinforces the positive relationship between sycamore and open ground flora. The plantation samples have been treated similarly.

Fig 212 with sycamore

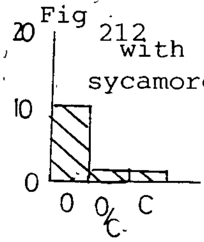


Fig 213 without sycamore

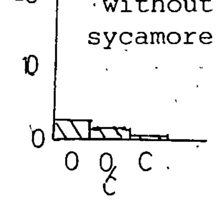


Fig 214 with sycamore

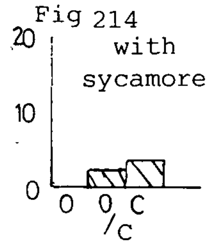
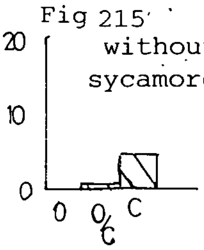


Fig 215 without sycamore



Coniferous plantations Deciduous plantations

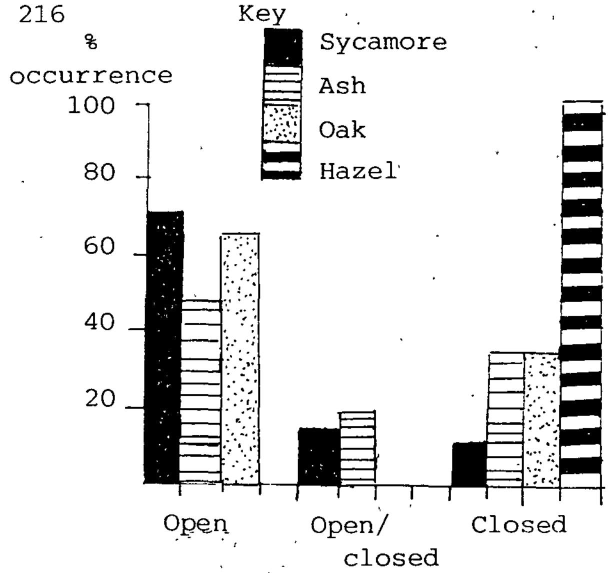
The histograms for coniferous plantations (figs 212, 213) and deciduous plantations (figs 214, 215) also show a similar distribution of ground flora occurrence in relation to sycamore suggesting that plantation management of the woodland makes little difference to the relationship. Sycamore presence corresponds to an increased probability of open or open/closed ground covers.

Before this hypothesis was accepted, the suggestion that sycamore may be related to open ground flora, by virtue of its success at regenerating under such conditions, had to be investigated. Existing examples of open ground flora beneath mature sycamore invasions may be related to there having been an open ground flora at the site when the sycamore invasion initially took place. The absence of ground flora at the present time might be accounted for by a lack of recolonization or inhibition of ground flora due to other factors such as the edaphic limitations or the shading effect of the non sycamore tree foliage canopy. To investigate the occurrence of the relationship between regeneration and ground flora, the presence of seedlings of ash, sycamore, oak and hazel were calculated according to the type of ground flora in which they occurred (table 64). The results were plotted on a histogram, fig 216.

Table 64 Table illustrating the occurrences of four tree species in each of the ground cover types

Tree species	Numerical occurrence				Expressed as percentages of occurrences		
	O	O/C	C	Total	O	O/C	C
Sycamore	18	4	3	25	72	16	12
Ash	10	4	7	21	47.6	19	33
Oak	4	0	2	6	66	0	33
Hazel	0	0	1	1	0	0	100

Fig 216



Histogram illustrating % occurrence of four tree species in each of the ground cover types

The histogram illustrates that sycamore regeneration is more common at sites where ground flora is of an open type, whereas ash and, to some extent, oak and hazel appear to be less inhibited by a closed ground flora.

The relationship between the dominant species of ground flora and the presence of sycamore

Aim To investigate the relationship between the occurrence of sycamore and the occurrence of different ground cover species.

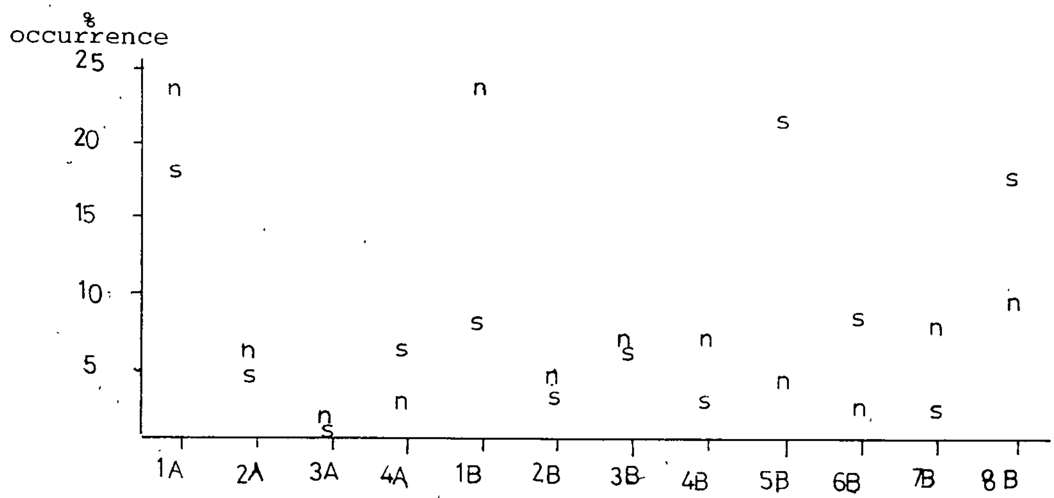
Method The total woodland sample from the general woodland survey was subdivided into woods with sycamore present and woods with sycamore absent. The total occurrences of the dominant ground flora species associations, defined in the ground flora vegetation classification, were calculated in relation to the sycamore present, sycamore absent subdivisions. The occurrences were plotted as a percentage of all occurrences of ground flora types within that subdivision, table 65, fig 217.

Table 65 Table illustrating the occurrences of ground flora types in all woodland with sycamore and all woodland without sycamore

	Totals with sycamore	% of all recordings	Totals without sycamore	% of all recordings
1A	18	17.4	17	23.6
2A	5	4.8	4	5.5
3A	1	0.9	1	1.3
4A	6	5.8	2	2.7
1B	8	7.7	17	23.6
2B	3	2.9	3	4.1
3B	6	5.8	5	6.9
4B	3	2.9	7	9.7
5B	22	21.3	3	4.1
6B	9	8.7	2	2.7
7B	3	2.9	5	6.9
8B	19	18.4	6	8.3
	103		72	

The results of the plot are illustrated in figure 217.

Fig 217 Graph illustrating the percentage occurrence of ground flora types in all woodland with sycamore(s) and all woodland without sycamore (n)



The species associations that appear to be most strikingly related to sycamore occurrence are 5B - *Urtica dioica*, 6B - *Hedera helix* and 8B - *Rubus sp.* There may be several reasons for these positive relationships with sycamore. Firstly, the environmental conditions at the woodland with sycamore sites where 5B, 6B and 8B associations occur may be favourable to both the ground flora species and to sycamore. *Urtica dioica* was considered to be an indicator of relatively high phosphorus. Helliwell [29] has suggested that phosphorus might be a limiting factor to sycamore germination and growth under laboratory conditions. The relationship between *Urtica dioica* and sycamore in West Suffolk woodland supports this claim. However, detailed soil analysis would be necessary to prove the phosphorus/sycamore relationship and was eventually considered to be beyond the scope of the thesis. A possible reason for high phosphorus levels at woodland sites in the West Suffolk area might be that some woodland has been created by the abandonment of agricultural land. Such agricultural land may well have had fertilizer treatments. Ancient woodlands, on the other hand, may have a relatively low nutrient status (Rackham [64], Packham and Harding [53]) due to the decay cycle of such woodlands being interrupted by coppicing management.

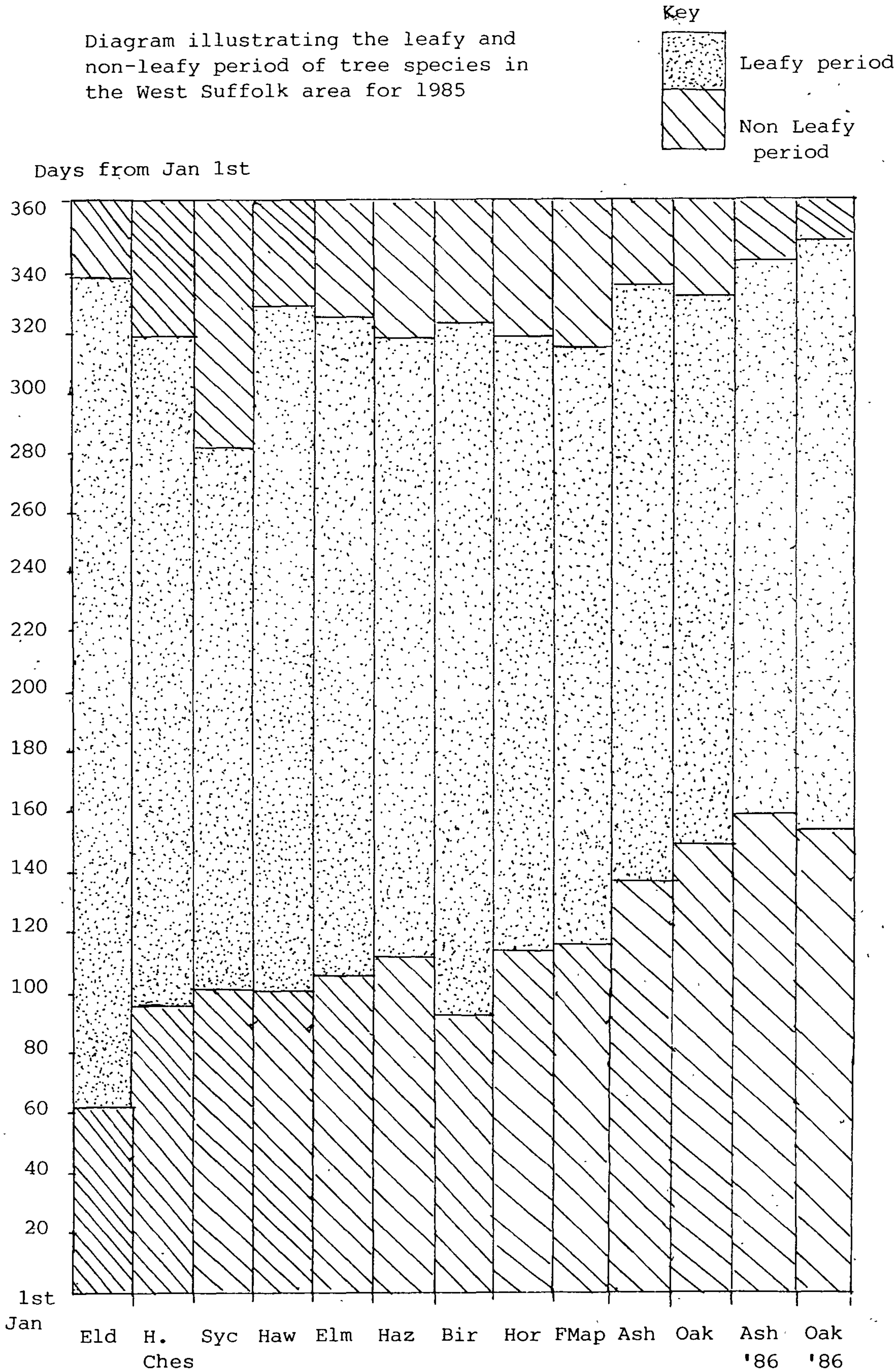
The relationship between sycamore and ivy can perhaps be explained by the suggestion that ivy is characteristic of secondary woodland (Rackham [64]). Sycamore has a relatively high occurrence in secondary woodland (see fig 39, p 85) and the distributions of the two species may overlap. Ground ivy is an evergreen species which may give it an advantage in shaded conditions created by sycamore invasion. The presence of ivy in secondary woodland might also suggest limited anthropogenic intervention in these woodlands. Ivy would have probably been cleared from ancient woodland. The relationship between *Rubus* and sycamore might also be explained in terms of an overlap in the distribution of the two species in secondary woodland. *Rubus* is a fast colonizer via bird dispersal and vegetative propagation. *Rubus species* are almost evergreen in character and may again be tolerant of shaded conditions.

From the conservationist viewpoint, an association between *Urtica dioica*, *Rubus sp.*, *Hedera helix* and sycamore might not be considered to be too desirable. The I.T.E. woodland classification [5] suggests a further association between sycamore and *Oxalis acetosella*. However, it can be assumed that native ground flora may take some time to adapt to a new tree species dominating the woodland community. Firstly, it must be considered that woods with a significant proportion of sycamore may, in most cases, have been relatively recently invaded. In some of these woods, ancient management techniques will have been abandoned and in other woods sycamore may have been coppiced once and left to grow out. I would suggest that neither of these woodlands represents canopy conditions that would be present in a mature woodland with sycamore as a dominant species that had no anthropogenic interference. Observations of examples of mature sycamore found in parkland and settlement sites (see text, page 11) suggested that these trees have smaller leaves and far more open canopies than individual sycamore in juvenile stages of invasion. I have also suggested (see text p152..) that coppicing followed by dereliction may produce an abnormal number of canopy foliage strata, added to by invasive sycamore.

A further complication of the adaptation of ground flora to sycamore is that the period when sycamore is in leaf is somewhat different from other common tree species in the West Suffolk area.

Fig 218

Diagram illustrating the leafy and non-leafy period of tree species in the West Suffolk area for 1985



A record of this was made during the 1985 season. Observations were made at different locations including Great Barton Wood, Pakenham Wood, The Grundle, Coney Weston Hall Copse and Shepherds Grove Woods to produce the data illustrated.

Table 66   Days of flushing and of abscission in West Suffolk woodland tree species for 1985 - days counted from January 1st

Day of	Oak	Ash	FMap	Haz	Syc	Elm	Hor	Eld	Haw	Bir	HChes	BThorn
Flushing	150	138	117	113	103	107	115	62	101	94	97	95
Abscission	333	335	315	318	281	325	319	338	329	323	318	

The dates shown are on average for 5 - 10 mature canopy trees in different situations. Flushing was taken as the winter bud split and a leaf was visible. Abscission was more difficult as it occurred over a longer period, but was estimated as the date when 10% or less of the leaves remained. This was estimated by eye. These results have been illustrated in fig 218.

Although the results are only approximations, it is clear that sycamore flushes earlier than most other common species in the West Suffolk area. It also loses its leaves earlier. This may be a response to the British climate and could be a result of sycamore's adaptation to its mountain distribution in its native range. It has also been suggested that sycamore may gain a competitive advantage from this over common native trees, especially through interspecific competition for light amongst saplings.

In terms of its effect on ground flora, it would seem that ground flora species best adapted to exploit the non-leafy period of sycamore canopies would be those that could leaf very early in the year or species that could capitalize on the early abscission of sycamore. Such species could have their dominant growth and reproductive period from September onwards. An example could be *Lamiastrum galeobdolon*, Packham and Harding[53] (found at Rougham A45 Copse - see text p 62) or *Oxalis acetosella* (Packham and Harding [53])

The analysis of tree associations (see text p. 105) suggests a strong relationship between sycamore and elder (*Sambucus nigra)*. This relationship supports the hypothesis that native species, particularly ground flora species, might only be successful if they can respond to the new season of canopy foliage created by sycamore. Elder, in fact, (see fig 218) comes into leaf before sycamore and continues in leaf well after the abscission of sycamore. Elder is a sub-canopy tree and sometimes ground flora species with a creeping form.

The most significant difference in leafing times of tree species is between sycamore and the foliage season of ash and oak (see fig 218). These species come into leaf well after sycamore and lose their leaves much later. The species are the two most common other tree species in the West Suffolk area (see text page 84, fig 37).

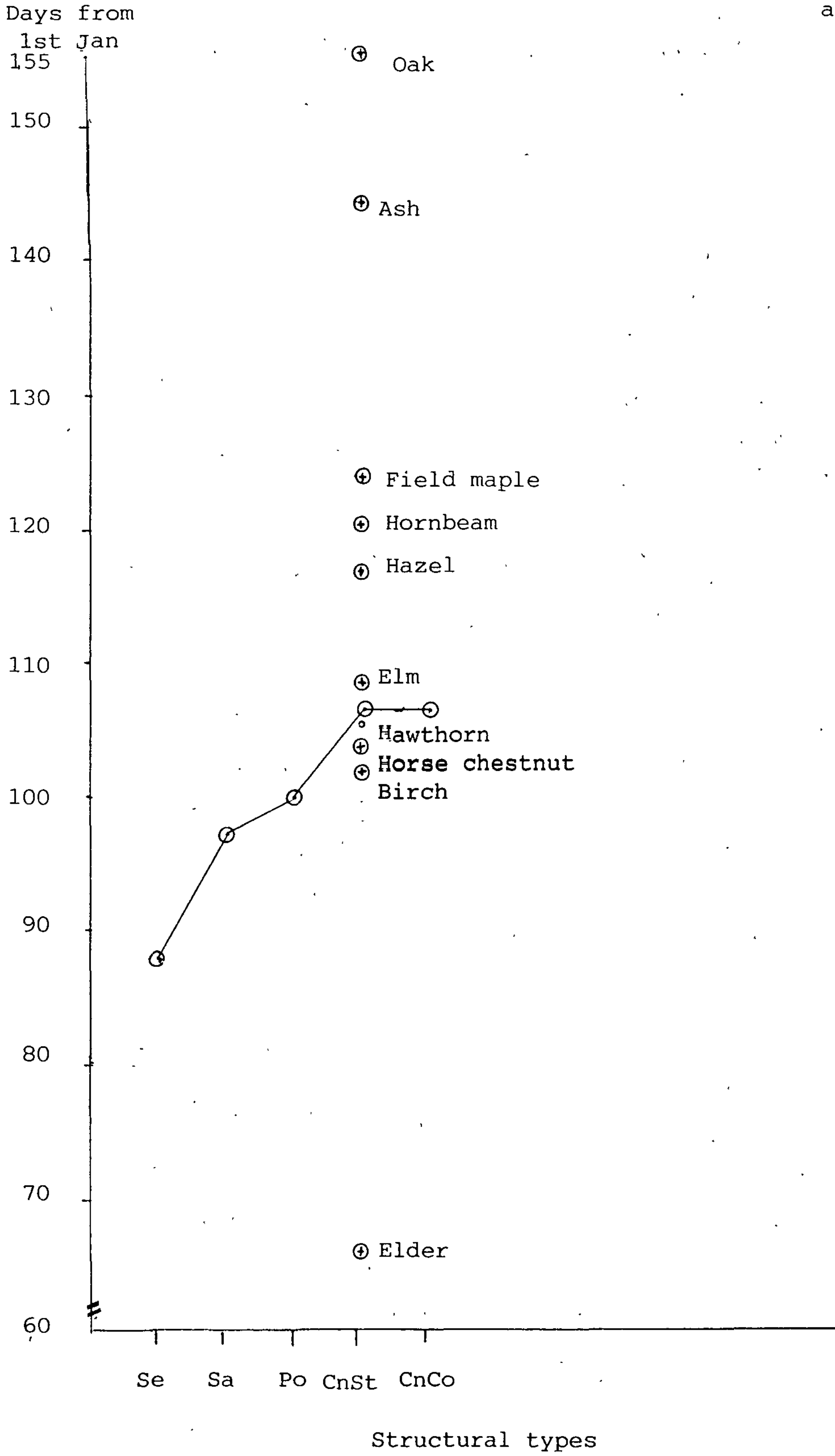
There is another factor which may also contribute to sycamore's effect on ground flora. It was noticed that sub-canopy trees flushed earlier than main canopy trees. The graph, fig 219 , illustrates this point. The data for this plot comes from data and observations made of flushing times for trees of different structural types at Great Barton Wood (see table 67).

Table 67 Flushing and abscission times for sycamore trees of different structural types at Great Barton Wood - ash / oak canopy

	Flushing	Abscission
CnCo	13th April	103)
CnSt	13th April	103)
Po	8th April	98) days from January 1st
Sa	4th April	94)
Se	29th March	86)

These results were plotted against the canopy flushing times of other tree species. It is clear from the plot that the early flushing of sycamore is further exaggerated by the fact that its juvenile forms flush even earlier than its canopy representatives. The conservationists's observation that sycamore inhibits ground flora by virtue of shading is therefore understandable. However, such

Fig 219 Diagram illustrating the onset of leaf flushing for trees in the West Suffolk area. The flushing times for different structural types of sycamore are shown



observations may be a result of the early flushing of juvenile invasive strata of sycamore. It should not be considered that such a woodland foliage profile will be continuous throughout the future history of a sycamore invaded woodland.

A number of positive relationships between ground flora species and sycamore have been suggested. The graph (fig 217) illustrates that some ground flora species may more commonly occur in woodland where sycamore is not present. Type 1A (see fig 217) ancient woodland herbs and type 2B, *Endymion non-scriptus*, are more commonly found in ancient woodland as might be expected. Ancient herb plants have evolved and owe their presence to a close relationship with the coppice cycle of ancient woods (Rackham [64]), sycamore's distribution being more common in secondary woodland. Type 2A, moss, has a similar occurrence in sycamore and non-sycamore woodland, suggesting to the conservationist that bryophytic species may not be totally threatened by sycamore expansion. In some of the ancient woodland sites, particularly in certain compartments, moss cover was the only ground flora found. Moss cover was found commonly with ivy in secondary woodland. The distribution of 1B, *Mercurialis*, again may be the result of the characteristic distribution of *Mercurialis* in ancient woodland. It is known that *Mercurialis* requires well drained soils (Rackham [64]). It could be that sycamore does not favour such soils. Piggot[61] suggests (see text p. 52) that sycamore distribution is related to rainfall and hence presumably soil moisture. Some observations of sycamore exploiting microhabitats within woodland in the survey area may support this conclusion (see text p 280). Type 7B, *Calluna*, would appear to occur more often without sycamore. Again, this may be related to soil conditions. *Calluna* was only recorded at the Knettishall Heath site (see fig 35). This was on Breckland sandy soils (see text fig 53) with rapid drainage and a low nutrient status. Where sycamore was regenerating at this site, it was commonly found in association with *Calluna* clumps (see diagram, fig 220).

Fig 220

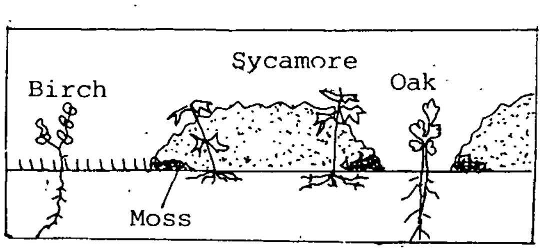


Diagram of sycamore oak, birch, seedlings growing amongst Calluna clumps

The micro climate and edaphic conditions inside the *Calluna* clump may have supported Piggot's[61] view that moisture is important to sycamore but it also may mean the *Calluna* clumps are responsible for a higher nutrient status such as phosphorus. The commonly regenerating species of this area were pine, oak and birch.

Type 4B grass sward does appear to be more common in non-sycamore woodland. This supports the original premise of the thesis that sycamore is not encouraged to regenerate amongst a grass sward. This is important and is a subject discussed at other points in the text (see page 284). Could it be that there is a reduced abundance of ground flora in ancient woodland that has been left to become derelict, and that disturbed land devoid of plant cover such as disused agricultural land or pits has encouraged sycamore invasion?

The division of species into clonal or individual forms and the pictorial representation of each species in terms of their morphological forms was made with the intention of examining whether particular morphological forms actually inhibited sycamore regeneration. The results were inconclusive. Clonal forms as well as individual forms were found in association with sycamore as were bushy forms like *Rubus* or grassy forms. Relationships could be explained by the distribution of species in relation to environmental factors other than any special relationship with sycamore. However, clearly, there does seem to be a relationship between the abundance of ground cover, its species type and the presence of sycamore even if this relationship is not yet fully understood.

Ground flora - Summary

1. A classification of dominant ground flora types in the West Suffolk area was constructed.

2. Sycamore tends to be more closely related to open type ground cover throughout a range of management conditions. This may be because sycamore represses ground flora or that sycamore favours invading woodland with open ground flora.

3. Woodland with sycamore has a more common association with *Urtica dioica*, *Rubus sp.*, large leaved herbaceous plants and *Hedera helix* than woodland with no sycamore.

4. Woodland with sycamore is equally commonly associated with moss, reed sedge, tussock grass, *Endymion non scriptus*, *Pteridium aquilinum* as woodland with no sycamore.

5. Woodland with no sycamore is more commonly associated with ancient woodland herbs, *Mercurialis*, grass sward and *Calluna vulgaris*.

6. The conclusions drawn in 3, 4 and 5 above may indicate that sycamore invasion is favoured by the environmental factors that have already favoured certain species of ground flora or that sycamore invasion has in itself changed the woodland environment to favour these species. The reverse of this argument could apply in the case of those species with which sycamore is not associated. Sycamore may not be favoured by the environmental conditions at these sites.

7. The invasion of wood by sycamore is likely to create a change in the seasonal pattern of light conditions in a woodland and may encourage ground flora species that either have a very early spring growth period, are evergreen or have an autumn growth period.

8. Sycamore invasion at *Calluna* heathland may be achieved by the exploitation of a moist micro-habitat with *Calluna* clumps.

Chapter 10

THE COMPETITIVE STRATEGY OF SYCAMORE

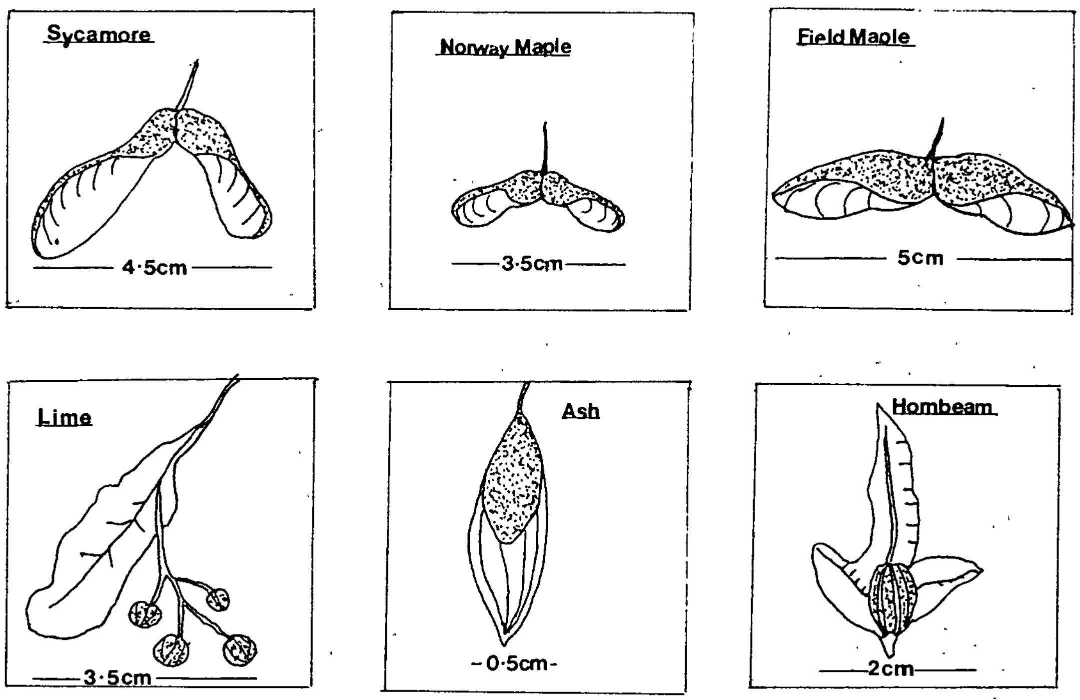
Sycamore has been almost the only introduced tree species to approach a naturalised status in British woodland. This has also been true for the West Suffolk area. Sycamore has either been able to exploit niches not already fully utilized by native trees or it has displaced native trees from existing niches. The following text seeks to explore those aspects of sycamore's competitive strategy that have contributed to its ability to invade native woodland communities.

The seed strategy of sycamore

It is through the dispersal of seeds that tree species are able to colonize new habitats. The adaptation of seeds is therefore very important in determining the types of habitat that a tree can colonize. The physical qualities of seed types have been used as predictors of plant species' ability to colonize unstable or stable environments, (Macarthur and Wilson[39]) ; e.g. large immobile seeds with abundant food stores for stable environments and small mobile seeds for colonizing unstable environments. In order to apply this hypothesis to the West Suffolk biome, stable and unstable environments have to be defined. It has been suggested (see p 186) that ancient woodlands are now in an unstable state in terms of their species structure. Abandoned arable land and 'pits' would be considered to be unstable environments. Rackham[64] considers the classic view of climax status of vegetation in British woodland to be inappropriate. Anthropogenic interference within the West Suffolk rural environment has undoubtedly created instability. In fact, native woodland tree seed types show more adaptive differentiation than purely small and large.

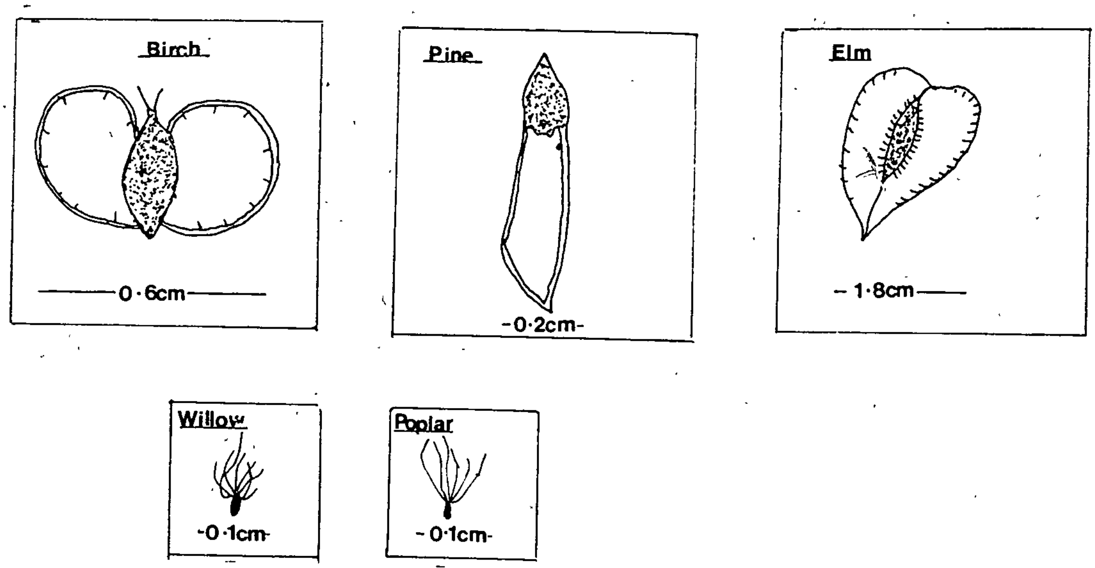
The tree species of the West Suffolk woodland flora were classified according to their phenotypic adaptation to dispersal. Dispersal adaptation was considered to be a parameter of the potential of tree species to colonize new habitats. Nine dispersal guilds were identified (see figs 221 - 229) as a result of drawings of seeds taken from the survey area and from the notes of Hulme[33] , Step[76] , Crabtree[12] , Stokoe[77] , Poruba et al[63] and Phillips[60] .

Fig 221 Guild One - short distance dispersal



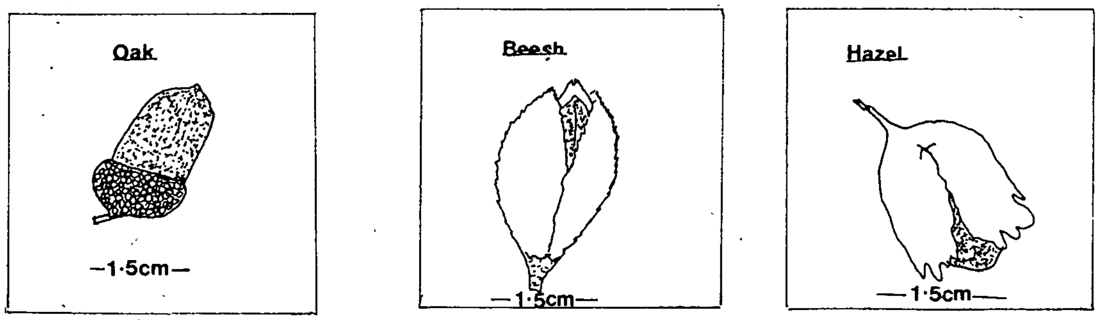
Guild One consists of seeds adapted to wind dispersal. These seeds are relatively larger than Guild Two wind dispersed seeds.

Fig 222 Guild Two - long distance dispersal



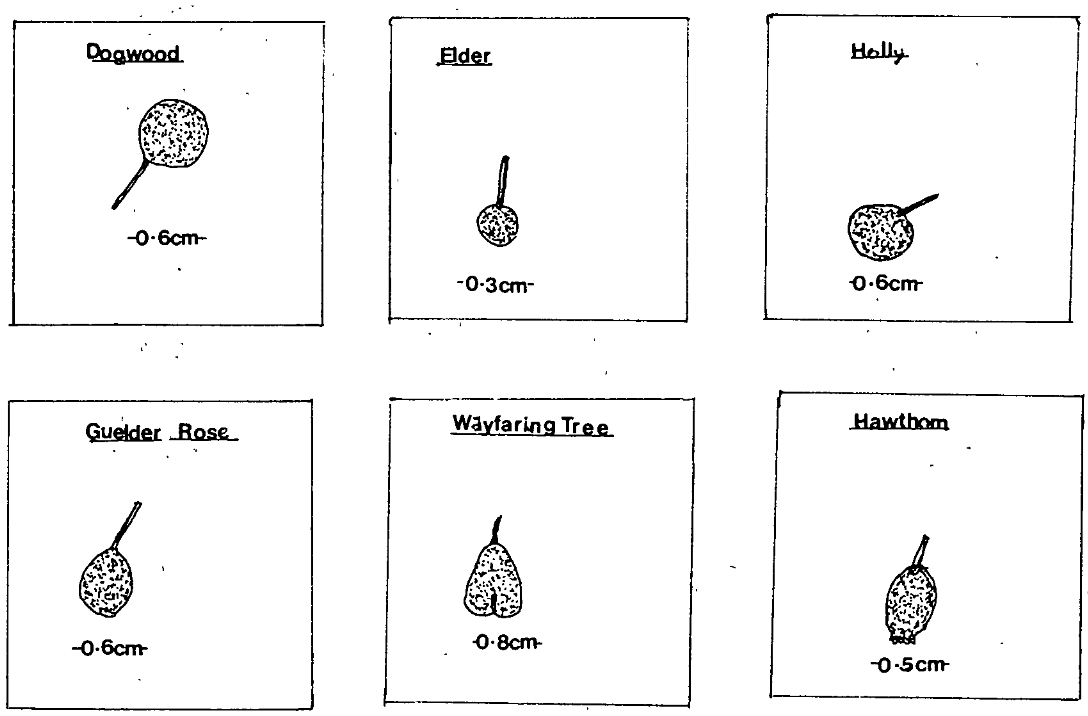
Guild Two are wind dispersed seeds of a smaller size than Guild One.

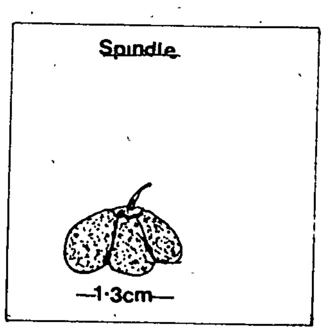
Fig 223 Guild Three - medium distance dispersal



Guild Three are large seeds with no obvious adaptation to wind dispersal. Each seed may be dispersed by animals such as jays or squirrels but are not likely to pass in a viable state through the gut.

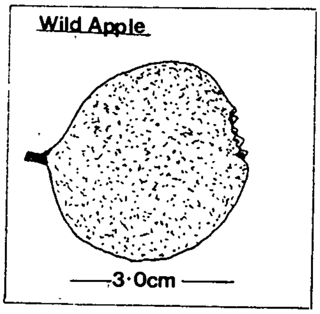
Fig 224 Guild Four - very long distance dispersal





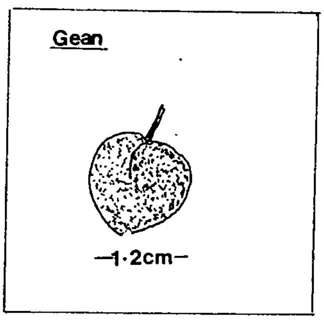
Berry trees with small inside seeds adapted to animal dispersal i.e. birds. Seed may pass through gut; seed small enough also to be carried long distance by birds.

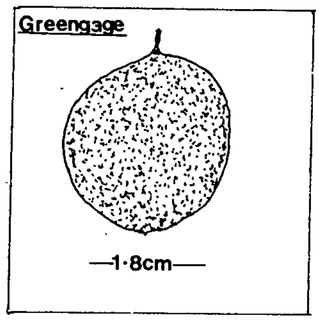
Fig 225 Guild Five - short or long distance dispersal

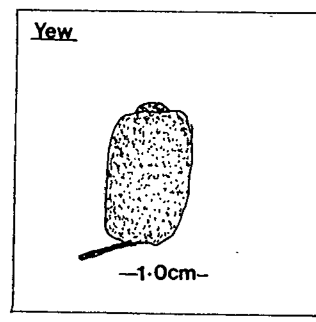


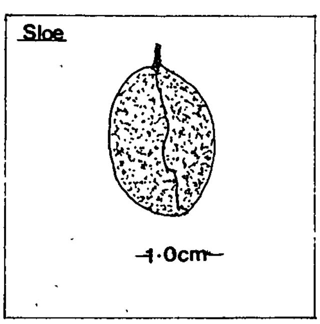
Guild Five are large fruits with small seed. Fruits cannot be carried far by birds but seed may be dispersed by birds. Seed may pass through animals' guts.

Fig 226 Guild Six - medium distance dispersal





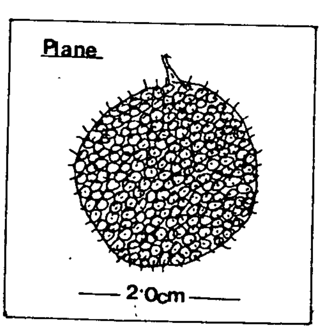


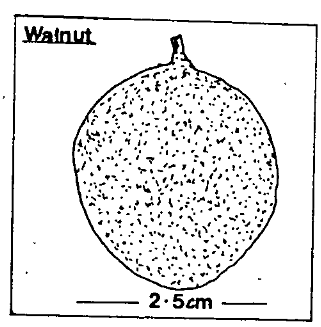


Large fruits

Large seeds less likely to pass through gut than guilds four or five. Seed protected by hard case. Seed too large to be carried far.

Fig 227 Guild Seven - Exotics, short range





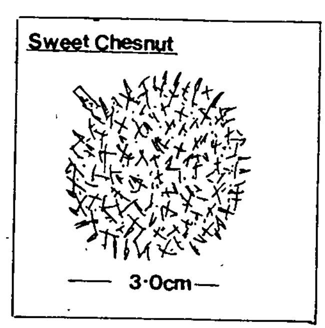
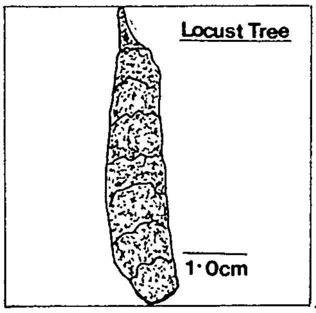
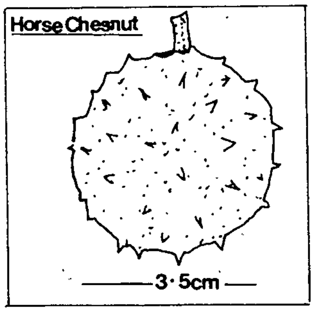


Fig 227 (contd)

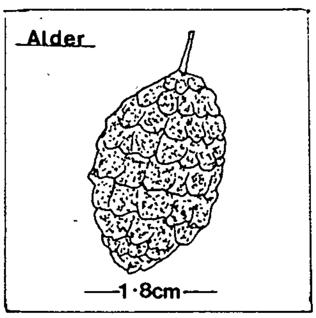




Large fruits or pods mostly large seeds.

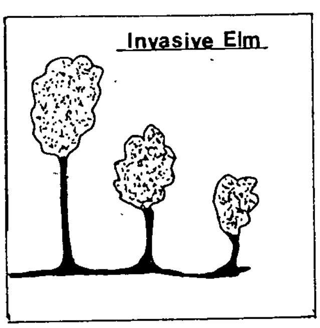
Protective adaptations

Fig 228 Guild Eight - long range to aquatic habitats otherwise short range



Adapted to dispersal by water

Fig 229 Guild Nine - short range



Does not seed disperse. Adapted to dispersal by suckering

Table 68 Occurrence of tree species in West Suffolk area hedge samples

Tree species in Guild groupings		30m Hedge Samples													
		1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1)	Sycamore	X	X			X	X	X		X	X		X		8
	Field Maple		X	X		X			X			X		X	6
	Norway Maple														
	Hornbeam														
	Lime														
	Ash				X	X			X					X	4
2)	Birch														
	Elm	X	X	X		X	X	X					X		7
	Pine														
	Willow														
	Poplar														
3)	Oak		X	X	X				X		X			X	7
	Hazel		X	X			X				X				4
	Beech														
4)	Elder			X	X		X	X	X	X	X	X	X		9
	Hawthorn	X	X			X		X	X	X	X	X	X		9
	Guelder														
	Wayfaring tree														
	Spindle											X			1
	Holly														
	Dogwood					X					X				2
5)	Apple														
6)	Cherry													X	1
	Greengage														
	Blackthorn			X		X		X							3
	Yew														
7)	Sweet chestnut														
	Horse chestnut														
	Locust														
	Walnut														
8)	Alder				X										
9)	Elm	X	X	X		X	X	X						X	7

Thirteen 30m samples of hedges were taken during the general survey (positions illustrated as (H) in fig 184).

Table 69 Analysis of guild occurrences

Tree species in Guild groupings		Numerical occurrences as totals of each woodland type								
		Individual Totals			Guild Totals					
		Hedge	Anc. Wd	Sec. Wd	Hedge WS	Hedge NS	Ancient WS	Ancient NS	Second'ry WS	Second'ry NS
	Sycamore	8	17	33						
	Field Maple	6	27	2						
1)	Norway Maple			1	18	10	94	77	59	26
	Hornbeam		8	1						
	Lime									
	Ash	4	43	22						
	Birch		11	6						
	Elm	7	15	15						
2)	Pine		2	1	7	7	35	35	35	35
	Willow			1						
	Poplar			1						
	Oak	7	48	27						
3)	Hazel	4	36	1	11	11	86	86	29	29
	Beech		2	1						
	Elder	9	10	22						
	Hawthorn	9	11	7						
	Guelder		8							
4)	Wayfaring tree		5		21	21	45	45	34	34
	Spindle	1	7	2						
	Holly		2	3						
	Dogwood	2	2							
5)	Apple			1					1	1
	Cherry	1	2							
6)	Greengage		1	1						
	Blackthorn	3			4	4	3	3	1	1
	Yew									
	Sweet chestnut		2	5						
7)	Horse chestnut		1	1						
	Locust		1	1			4	4	7	7
	Walnut									
8)	Alder	1	7	1	1	1	7	7	1	1
9)	Elm	7	15	15	7	7	15	15	15	15
	Total				69	61	289	272	182	149

Figures for cherry, greengage, apple, guelder rose, spindle, wayfaring tree taken directly from Record Card 2 of the general survey

Table 70 % occurrence within total sample for each vegetation type

Habitat types	Guild nos. 1	2	3	4	5	6	7	8	9
Hedge with sycamore	26.0	10.1	15.9	30.4	0	5.7	0	1.4	10.1
Hedge without sycamore	16.3	11.4	18.0	34.4	0	6.5	0	1.6	11.4
Ancient woodland with sycamore	32.5	12.1	29.7	15.5	0	1.0	1.3	2.4	5.1
Ancient woodland without sycamore	28.3	12.8	31.6	16.5	0	1.1	1.4	2.5	5.5
Secondary woodland with sycamore	32.4	19.2	15.9	18.6	0.5	0.5	3.8	0.5	8.2
Secondary woodland without sycamore	17.4	23.4	19.4	22.8	0.6	0.6	4.6	0.6	10.0

The percentage occurrence of each guild in the tree community sub-categories - hedge with sycamore, hedge without sycamore, ancient woodland with sycamore, ancient woodland without sycamore, secondary woodland with sycamore and secondary woodland without sycamore - are shown in table 70. The analysis of species occurrences (tables 18 - 21, see pp 78 - 81) recorded in the general survey provided the data for table 69 and the subsequent calculations of percentage occurrence (table 70). Percentage occurrence was considered to be :

$$\% \text{ occurrence} = \frac{\text{the number of occurrences of a dispersal guild in a woodland type}}{\text{the total number of occurrences of all dispersal guilds in that woodland community}} \times 100$$

Occurrence of dispersal guilds

Fig 230

Ancient woodland without sycamore

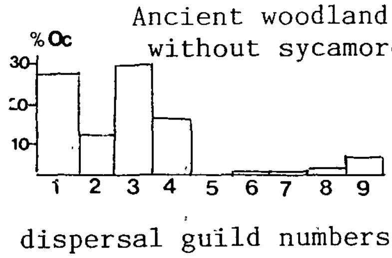


Fig 231

Ancient woodland with sycamore

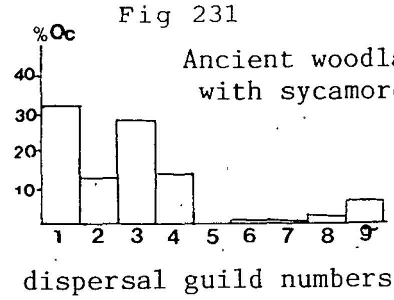


Fig 232

Secondary woodland without sycamore

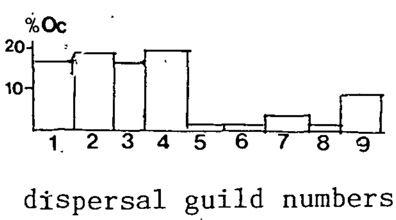
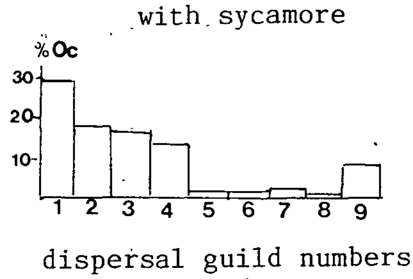


Fig 233

Secondary woodland with sycamore

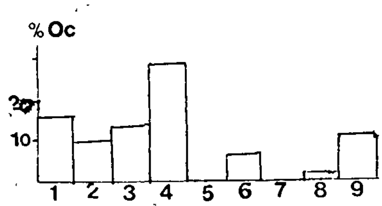


Ancient woodland without sycamore (fig 230) and with sycamore (fig 231) indicates a predominance of guilds 1 and 3: large wind dispersed seeds and large nut seeds with fewer small seeded berries (guild 4) and small wind dispersed seeds (guild 2). However, eight out of ten dispersal guilds are represented. The great age of ancient woods implies that, in terms of natural ecological succession, they should be stable woodlands. The diversity of dispersal guilds refutes the hypothesis that stability favours a certain seed phenology. It would seem more likely that the diversity of phenological adaptations to dispersal present in ancient woodland has contributed to the diversity of species present at woodland sites. There is a greater proportion of guild 1 in ancient woodland with sycamore. This is due to the presence of sycamore. If the ancient woodland without sycamore is considered to be representative of stable woodland based on an equilibria of seed types, woodland stability for ancient woodland with sycamore will only be achieved by the replacement by sycamore of a guild 1 species. Ash is regenerating in ancient woodland and it is, therefore, likely that sycamore is replacing field maple.

Secondary woodland is more recently colonized woodland than ancient woodland. It is therefore likely to be a less stable environment. Fig 234 illustrates that the large wind dispersed seeds guild (guild 1) in secondary without sycamore is less well represented than it is in both forms of ancient woodland. Dispersal to secondary woodland has favoured guild 2, small wind dispersed seeds and small berry bird transported species. This suggests more rapid dispersal of guilds 2 and 4 than guilds 1 and 3. The abundance of guild 2 in secondary woodland confirms the theory that unstable woodland favours small seeds. Presuming that ancient woodland, in its early stages of colonization, had a guild distribution similar to that of secondary woodland without sycamore, it is likely that species of guild 1 and guild 3 are actually likely, in some cases, to be invaders of existing woodland rather than colonizers. The abundance of guild 1 in secondary woodland with sycamore illustrates this invasion of woodland by sycamore, a guild 1 species.

Fig 234

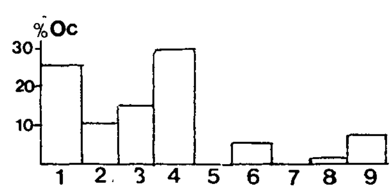
Hedges without sycamore



dispersal guild numbers

Fig 235

Hedges with sycamore



dispersal guild numbers

The distribution of dispersal guilds for hedgerows suggests a greater proportion of guild 4 berry trees than at woodland sites. The presence of exotic trees, guild 7, is relatively infrequent in all woodland categories.

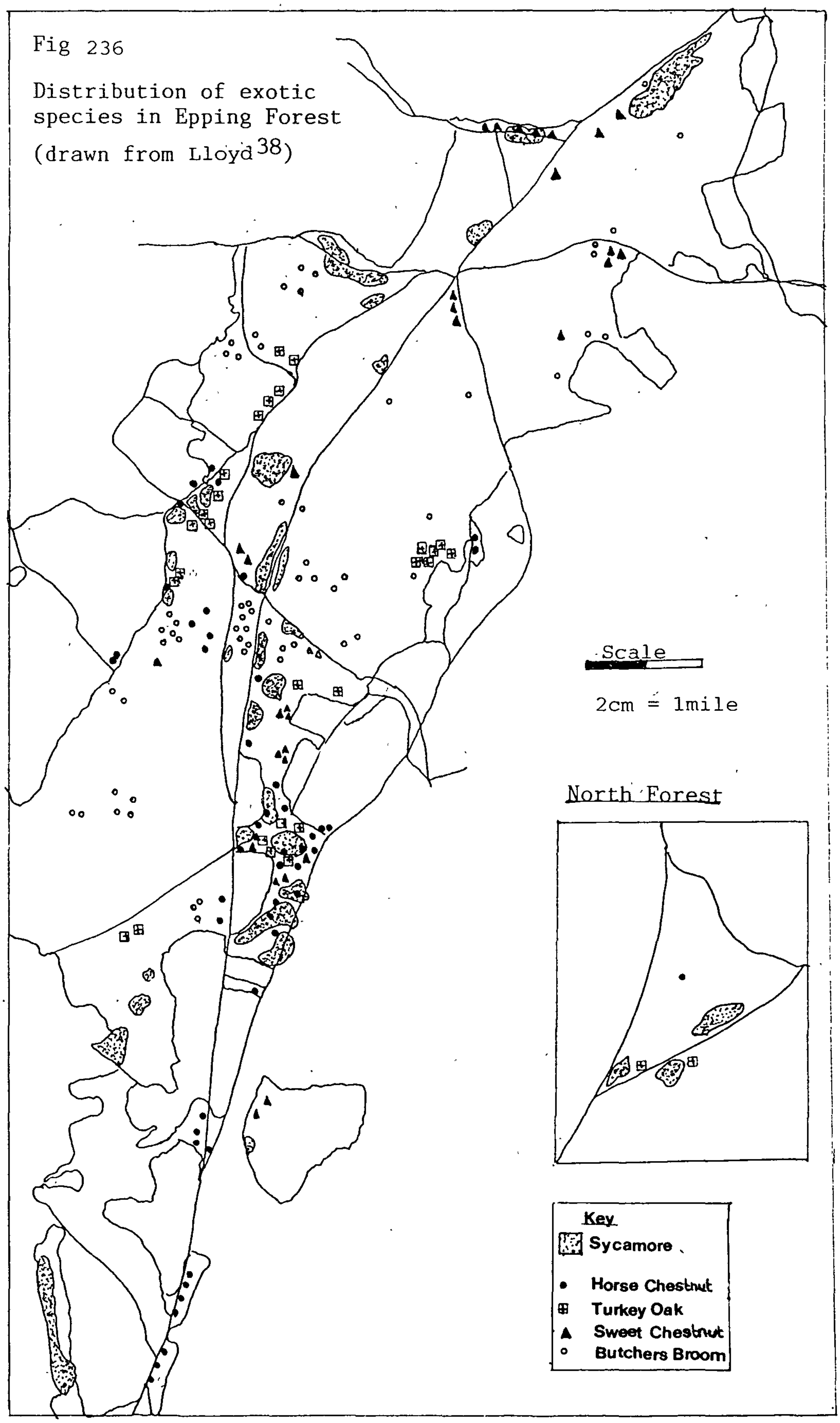


Fig 236
Distribution of exotic species in Epping Forest (drawn from Lloyd38)
Scale
2cm = 1mile
North Forest
Key
Sycamore
Horse Chestnut
Turkey Oak
Sweet Chestnut
Butchers Broom

Fig 236 illustrates the distribution of invasive exotics in Epping Forest. Butcher's Broom which would be in guild 4 has penetrated the wood pasture to the greatest extent. Naturalization of exotics other than sycamore may be limited to some extent by their dispersal adaptation. From the dispersal guild analysis it could be suggested that Macarthur and Wilson's [39] model of adaptive strategies should be modified to include invasive species. It has been shown that sycamore has a limited potential to disperse and colonize isolated sites before other more readily dispersed species, such as those of guild 2 and guild 4. However it would seem to be ideally adapted to invasion of existing woodland, although it is probable that anthropogenic factors have increased sycamore's ability to disperse and colonize potential secondary woodland sites.

Factors that enable sycamore to compete as an invasive species

It has been suggested that sycamore is specialised for an invasive strategy. This is not a unique strategy. Elms are often invasive, using stolons to expand their populations in woodland. Sycamore has several characteristics that make it an effective invader. Helliwell [30] states that :

> "there are few native species that are more shade tolerant than sycamore."

Sycamore in the West Suffolk area and in Epping Forest was found regenerating beneath many different canopy types. This supports the hypothesis that shading does not, in most circumstances, exclude sycamore invasion. In its native range, sycamore grows in association with silver fir. Silver fir is more shade tolerant than most native species (Helliwell[30]) with the possible exception of beech. It has been suggested (Rose [65]) that sycamore in its native range has to compete with silver fir and therefore produces mixed species associations. Sycamore, in Britain, may therefore be exploiting an ecological niche as an invader beneath existing canopies with no competition from a native species. The broad belt invasions (see p240) suggest that in many cases invasion is not related to the pattern of shading of woodland canopies.

Preliminary observations indicated that sycamore saplings and poles have considerably larger leaf sizes than mature sycamore.

Large leaves on mature trees would be likely to be disadvantageous by reducing the light reaching all levels of an individual tree's canopy. A small lower branch was removed from a mature canopy standard tree at Great Barton Wood and a pole tree was felled. The lengths and widths of all leaves on each sample were measured according to fig 237 . The results were put into 5cm classes and are illustrated on histograms fig 238 and fig 239 , for both leaf width and leaf length. The data from which these histograms were extracted can be seen in table 71.

Fig 237

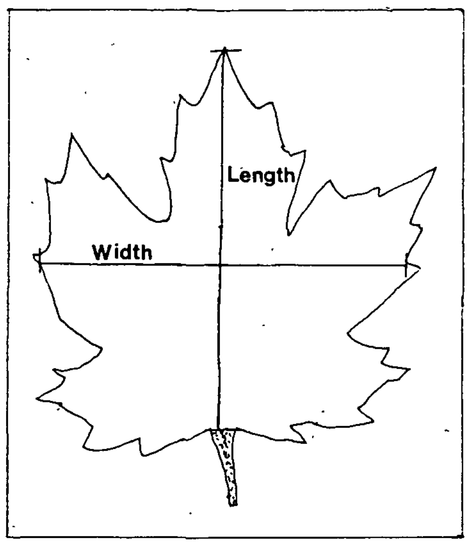


Diagram illustrating the technique used to measure leaf length and leaf width

Fig 238

Histogram illustrating distribution of leaf widths for Po and CnSt

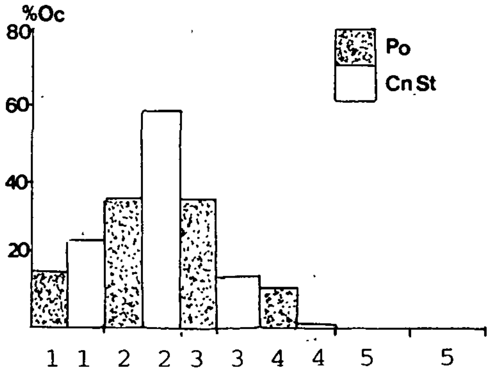


Fig 239

Histogram illustrating distribution of leaf lengths for Po and CnSt

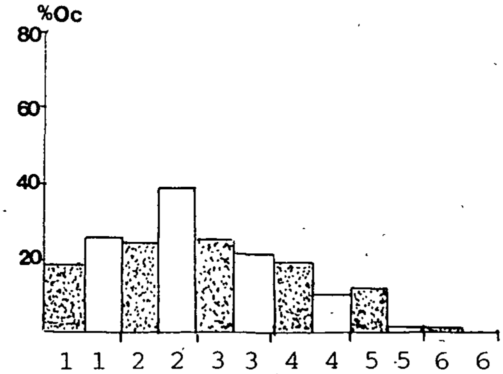
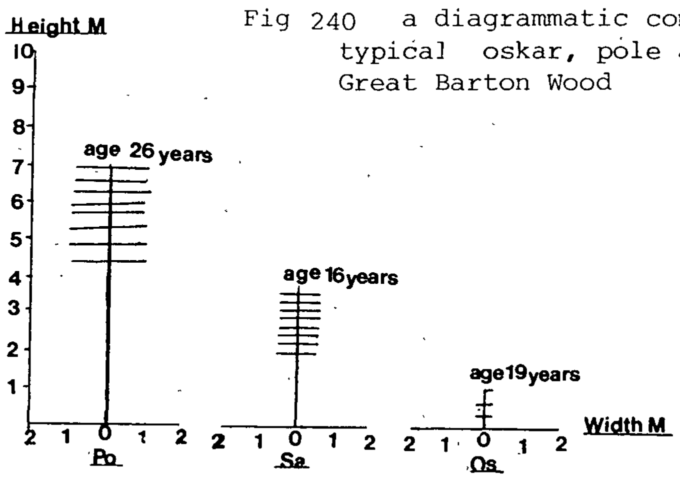


Table 71 Leaf lengths and leaf widths of canopy standard and pole trees in Great Barton Wood

Leaf of Tree type	1 0-4.9	2 5-9.9	3 10-14.9	4 15-19.9	5 20-24.9	6 25-29.9	Total
	5cm classes						
Pole width	36	48	49	39	20	4	196
Mature width	32	47	26	13	3	0	121
Pole length	35	69	70	22	0	0	196
Mature length	30	71	18	3	0	0	122
	percentage occurrence						
Pole width	18.3	24.4	25	19.8	11.2	2.0	
Mature width	26.4	38.8	21.4	10.7	2.4	0	
Pole length	17.8	35.2	35.7	11.2	0	0	
Mature length	24.7	58.6	14.8	2.4	0	0	

The canopy tree had leaves tending towards smaller size than for pole trees. Whilst this is not conclusive proof of sycamore saplings and poles having larger leaves than more mature sycamore, it does indicate that such a relationship might exist. Large leaves could be advantageous to invasive sub-canopy sycamore, by shading the seedlings and saplings of existing species and by maximising the sycamore's photosynthetic effort. If these factors are related to the photoperiod of sycamore saplings and poles (see text p 280) then it can be seen that sycamore can be particularly competitive at sapling and pole stages in native woodland.

Fig 240 a diagrammatic comparison of a typical oskar, pole and sapling at Great Barton Wood

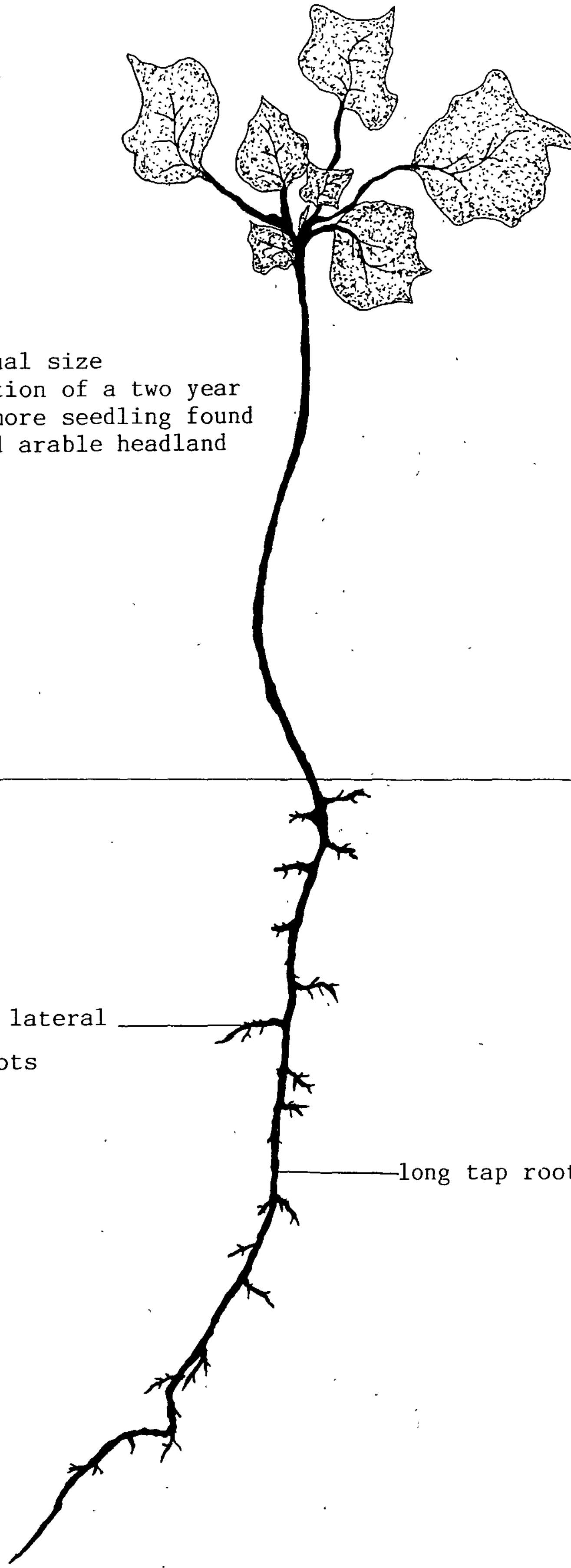


structural class

A typical oskar, pole and sapling were also drawn to scale (fig 240). Each tree had a very narrow lateral branch width. This may allow higher densities of saplings in a given area, such as those noted in the sapling clumps at Pakenham Wood and Longham Hills Wood. The number of branches would not seem to increase between sapling stage and pole stage. Growth is achieved by stem elongation producing an 'etiolated' form. The fast growth rate of sycamore in comparison with native tree species (Stern [78]) undoubtedly contributes to sycamore's invasive potential. There is a clear phenological difference between oskar and sapling forms. This could represent a difference in the invasive strategy of the two forms. Sycamore appears to have some flexibility in its invasive form that may allow it fully to exploit changes in the native canopy structure that may occur subsequent to an initial sycamore invasions. Rackham [64] has illustrated that masting has had a significant effect on the species composition of a disturbed site on disused commons in Hertfordshire. Sycamore is, in other ways, a highly flexible ecological strategist. Invasions and colonizations occur in a wide variety of habitats in the West Suffolk area.

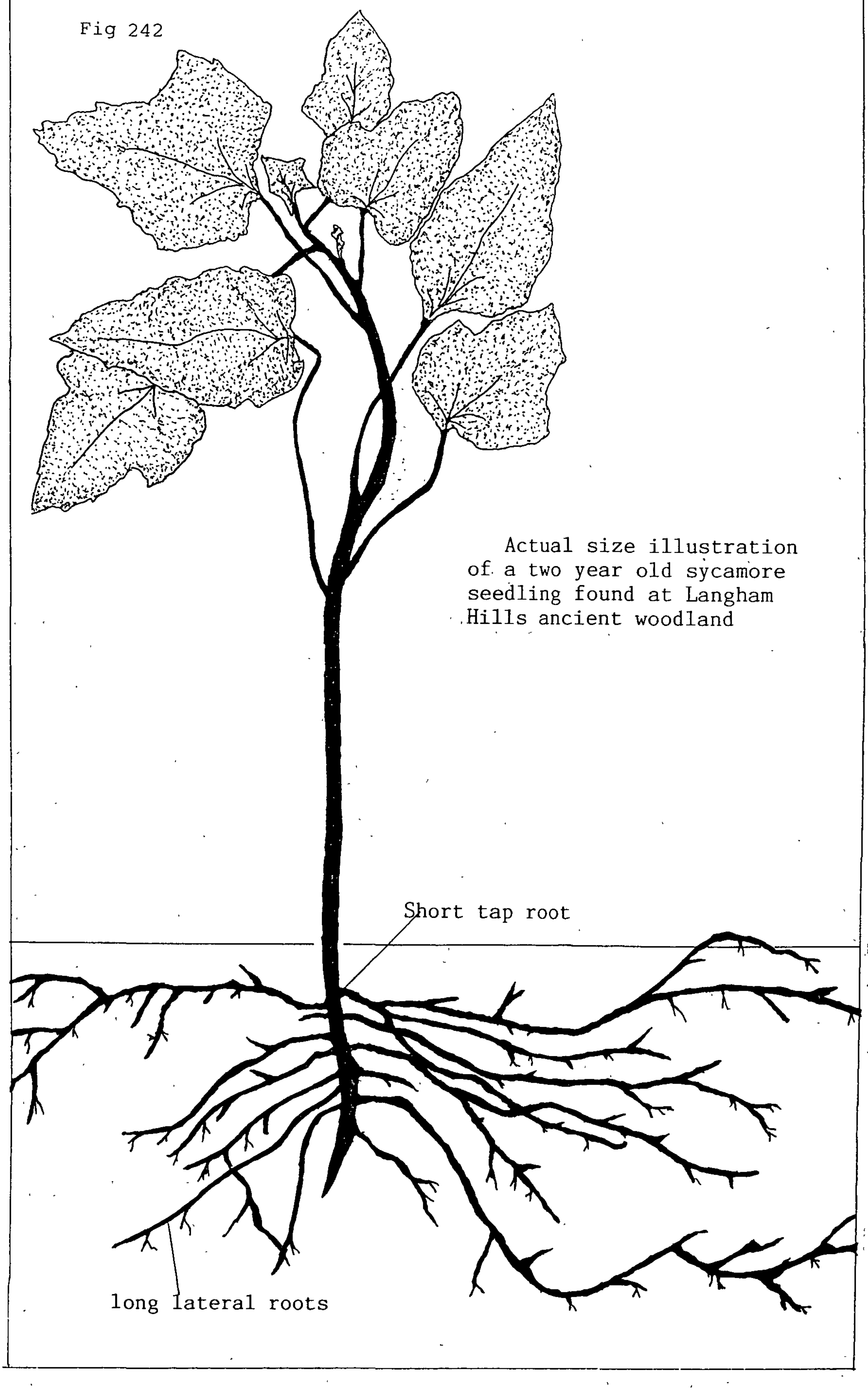
Sycamore invasion of woodland might be assisted by the seed producing potential of sycamore. Some of the common native tree species have a habit of not seeding every year (Matthews [44]). Sycamore seeded abundantly in the years 1983-1986 indicating seeding in most years. Silvertown[71] and Janzen [34] suggest a positive survival value for masting trees. This may be so for colonizing species or climax type tree communities but invasive species such as sycamore are likely to be favoured by seeding every year. Suitable regenerative conditions, such as those produced by coppicing, disturbance or the death of an existing tree, might only be temporary. Therefore a yearly seed yield would seem more likely to capitalize on the regenerative niche created. The ability of sycamore to seed every year might be a function of its tolerance to the British climate. The yearly seeding could represent a greater fitness (Silvertown [70]) than for native species in the British climate. Matthews[44] has found various climatic factors to be related to masting. Holmsgaard [90] and Eis, Garman and Ebel [14] propose that seeding can reduce growth in some tree species. It may be that non-invasive species gain a competitive advantage from growth rather than seeding.

Fig 241



Actual size illustration of a two year old sycamore seedling found on unused arable headland

Fig 242



Actual size illustration of a two year old sycamore seedling found at Langham Hills ancient woodland

Phenotypic flexibility can also be seen in the rooting structure of sycamore. Fig 241 illustrates a two year old colonizing seedling found at Stanton Grundle in unused arable headland. The tap root penetrates far deeper than the invasive seedling of Langham Hills Wood (fig 242). However, the lateral roots of the Langham Hills seedling have a greater spread than for the Stanton Grundle seedling. This could be a competitive strategy to minimise root competition in the woodland soil environment or a response to the different environmental conditions at each site.

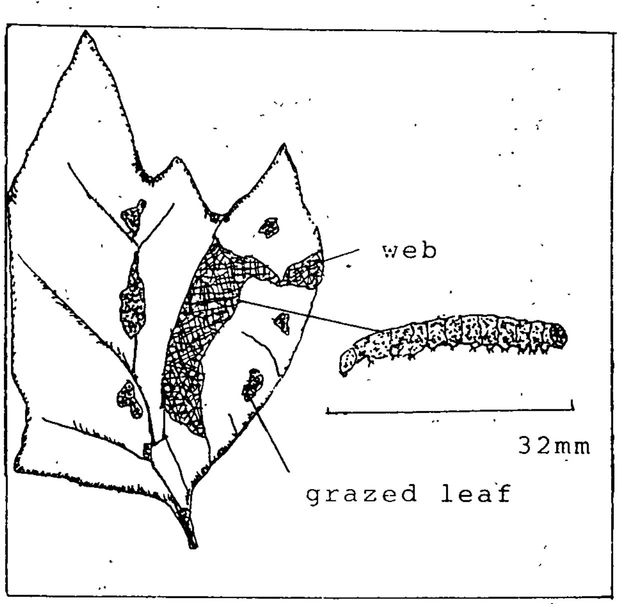
Conservationists have proposed that sycamore supports far less wildlife than native species. This might be expected, for native wildlife has had only a relatively short period to become adapted to utilizing the sycamore as a food resource. If this is indeed the case, the invasive potential of sycamore will have undoubtedly been increased by its immunity from predation.

The most commonly quoted source for this argument is Southwood [73,74]. He suggests that invertebrate fauna to tree association is dependent on the duration of existence in Britain of a particular tree species following glacial retreat and its accumulative abundance thereafter. Sycamore is suggested to have from only 5-10% the number of associated insects as early British immigrants oak and birch. Southwood's [73] 1984 figures increase sycamore's associated invertebrates to between 10-15% of birch and oak. Southwood has concentrated particularly on the primary consumer insects.

Ward [85] and Claridge and Wilson [9] have observed that the geographical size of species communities is closely related to the abundance of phytophagous fauna. The large scale expansion of sycamore populations, which has been shown to be relatively recent in the West Suffolk area, may be encouraging a greater abundance of phytophagous fauna. Mason and Macdonald [43] have recorded a far greater abundance of phytophagous fauna than Southwood [74] 1984 records. Sycamore is an insect pollinated species unlike many native species. It is probable that this encourages association with insect fauna. Jones' [35] records of insect flower visitors include greater abundance and diversity of *hemiptera*, *homoptera* and *hymenoptera*. In fact, there is considerable evidence to suggest that the invasion of native woodland by sycamore has not been effected by an immunity of sycamore to the exploitation of native macro or micro fauna and fungi. Species that have been recorded in association with sycamore by various authors are : Diamond Bark disease - Bevercombe and Rayner [3], Gregory and Waller [22] ; Sooty Bark disease - Pearce [56], Pawsey [55], Rawling [67] ; unidentified fungus - Gregory [21] ; *Helix aspersa* - Macintosh [40] ; deer species - Urquart [86] ; grey squirrel - Burgess [6], Shorten [68], ; leaf mining insects - Opler [50] ; Thylocobine leaf hopper - Whittaker [84] ; brown tail moth larvae, *Euproctis chrysorrhoea* - N.London Polytechnic [91]; field mice and voles - Ashby [2] ; sheep - Linehart and Whelan [37] ; pheasants - Mowat [92] and the leaf black spot, *Rhytissima acerinum*.

Sixty two percent of the sapling, pole and oskar leaves recorded at Great Barton Wood (see p 267) had leaf black spot. Sixty eight percent of the leaves of the three trees showed signs of predation. Considerable numbers of the leaves were covered with raised red nodules. These are common on sycamore. They may be formed as a result of the egg laying of leaf hoppers or other insects. They must surely interfere with the photosynthetic effort of sycamore leaves. Sawfly larvae were found on the Great Barton trees (fig 240).

Fig 243



Saw fly larva on sycamore leaf

The species mentioned feed directly from sycamore and are therefore likely to be inhibitors of sycamore's invasion. Their presence does, however, illustrate that native biota are capable of exploiting sycamore as a food resource.

Sycamore produces considerable quantities of sugary sap from leaves and bark. This may be a protective mechanism to encourage organisms to eat the sap rather than the leaves themselves. Aphids were present in large numbers on the canopy standard sycamores at Great Barton Wood and these are the probable source of food for secondary consumers, such as arachnids and ladybird larvae which were found in considerable numbers in association with the Great Barton trees. Whether species are becoming adapted to the sycamore more than to other native species will be the true test of the degree to which sycamore can become fully naturalized in the British Isles. An immature green bush grasshopper,(fig 244), found on the mature sycamore canopy standard at Great Barton Wood was identical in colour and of very similar form to unripe sycamore seeds on which it was found.

Fig 244

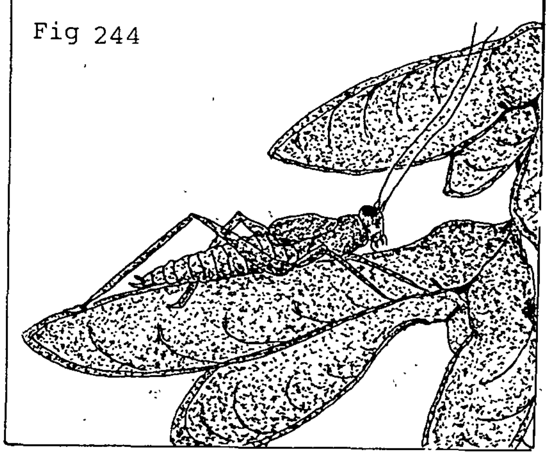
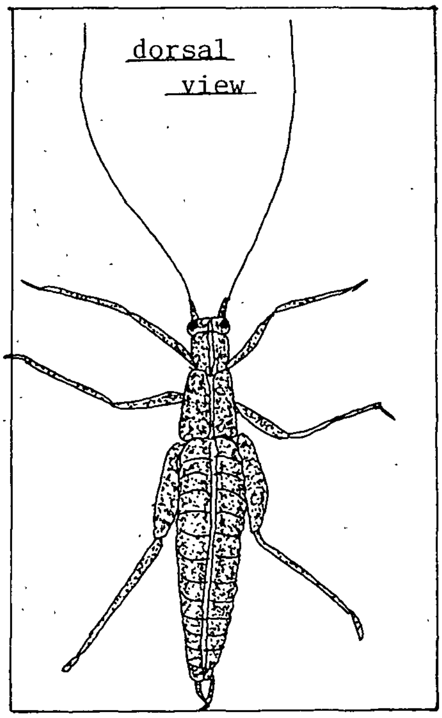


Fig 245



An immature green bush grasshopper Its colour was identical to unripe sycamore seed. Its adult form even more strikingly resembles the form of a sycamore seed.

Perring[58] and Hartley[26] suggest that invertebrates found on sycamore are often used as a food resource for tit species, *(species Parus)*. It may therefore be argued that sycamore's expansion of population is not entirely due to its status as an exotic and therefore an alien to native tree population regulating organisms. The tree would appear to be becoming fully naturalized. Even its litter has been found to be suitable for the wood ant (*Formica rufa*), (Skinner[75]). However this does not rule out the effect of changes in predation or disease of other species that may encourage sycamore.

A final consideration that might have encouraged sycamore invasion is the formation of sycamore sub-species. Watt, Tansley and Godwin[82] have concluded that sub-species of native trees such as *Quercus petrae* and *Quercus robur* or *Crataegus monogyna* and *Crataegus oxyacanthoides* may have evolved in post-glacial times in accordance with adaptation to different environmental pressures. Preliminary observations have suggested that sycamore can show remarkable variability and flexibility in form, such as in leaf size and shape and seed size and shape. Sycamore has the ecological flexibility to invade or colonize a wide variety of different habitats. The possibility that sycamore is adapting and forming ecologically segregated sub-species to meet the demands of an environment beyond its native range should not be ruled out.

Summary

1. The sycamore's seed adaption for dispersal is comparable to field maple, Norway maple, lime, ash and hornbeam.
2. Ancient woodland tree species contain a wider diversity of seed adaptation than secondary woodland.
3. Seed adaptation of sycamore and native tree species may relate to their ability to colonize or invade.
4. Sycamore is a shade tolerant species.
5. Sycamore changes its leaf form as it develops to maturity. This may relate to its ability to compete as a sapling.
6. Sycamore appears to show flexibility in its growth form which may enable it to exploit a variety of niches.
7. Sycamore is unlikely to be less limited by predator pressure than native tree species, although in the past, this may not have been so.
8. Sycamore could have the genetic flexibility to form sub-species or, at least, ecologically differentiated species.

Chapter 11

CLIMATE - A possible clue to Sycamore's Competitiveness in the British environment

In order to analyze the competitive relations of sycamore with other native trees, one must be sure to take the evidence that can be gained from present distribution in the appropriate context. For instance, in ancient woodland (a large portion of the West Suffolk survey area) up to a thousand years of anthropogenically managed tree selection has taken place. The woodland classifications of Rackham [64] and Peterken [59] are largely based on such woodland.

Ancient woodland management has without doubt affected any natural competitive balance between native species. Trees have been selectively planted and felled. Others have been coppiced which prolongs their natural life and reduces their seeding capability, whilst the actual environmental conditions for regeneration may have been distinctly affected by ancient woodland management. More recently, the effect of other woodland management practices, the dereliction of ancient techniques and the destruction of considerable amounts of woodland has also interfered with the natural competitive balance between species in British woodland.

The expansion of sycamore populations will also interfere with this natural balance. The study of the West Suffolk survey area attempts to provide an impression of this interference based on existing woodlands. However, the dereliction of ancient woodland and the formation of small areas of secondary woodland suggest that, at least in the rural environment of West Suffolk, a return to the dominance of natural limiting factors rather than anthropogenic limiting factors, as may be the case in ancient woodland, might be significant, despite the working conservationists' attempts to reintroduce traditional ancient woodland management techniques.

Therefore, it has been considered necessary to conduct a brief review of the status of native trees in British woodland beginning at a stage prior to the full scale ancient management of woodlands. This review also addresses itself to the interesting question of why sycamore has actually been absent from the British native tree flora/

throughout

its post glacial history, but yet it appears to flourish in the twentieth century. The answer to this question might only come from studying woodland sites no longer being constrained, in terms of the competitive balance of their constituent species, by woodland management techniques.

A hypothesis that accounts for the comparatively recent success of sycamore might also give a much clearer indication of the existing competitive relationships of native species. Sycamore provides an almost unique example of the large scale naturalization of an exotic tree species. Sweet chestnut and rhododendron have also had some success but on a localized scale. It has not been possible to gain sufficient environmental data from sycamore's native range which would have provided greater support to this section. However, it has at least been possible to form a hypothesis that relates climate to interspecific tree competition following glacial retreat and to use this hypothesis to estimate the status of tree species and, in particular sycamore, under the present climatic conditions.

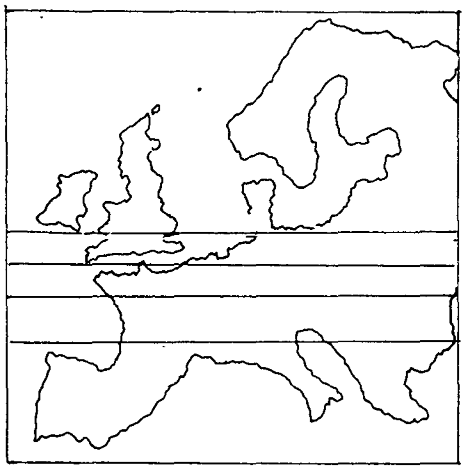
From the moment the last(Weichselian) ice age retreated, the wildwood of Britain represented the northerly extension of the continental virgin forest. It is possible to present a strong correlation between climatic fluctuations since this time, 10,000 b.c. and the competitive status of each species; a correlation that may be critical to our understanding of the present day success of sycamore and the apparent demise of other native species.

The general distributions of native trees will be interpreted under the headings of each accepted geological phase. Lamb [36] has been used as the source of the climatic information.

Fig 246 illustrates the continental distribution of tree dominance in the Old Dryas period 10,000 - 9,000 BC. Birch has reached England; oak, elm and hazel are in Southern France. The climate was slowly warming following glaciation.

Fig 246

Old Dryas



Birch

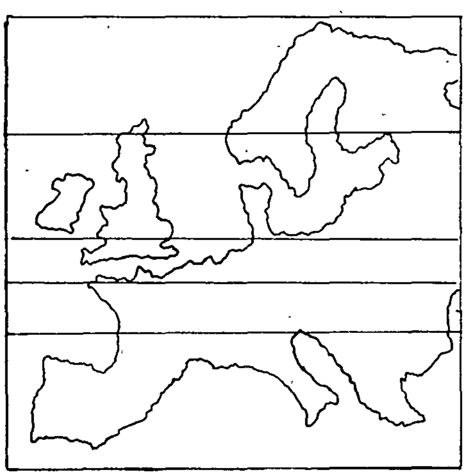
Pine

Alder, Oak, Hazel, Lime

Following the Older Dryas there was a colder period, 9,000 - 8,000 BC known as the Allerod which possibly pushed back the birch northerly tree line to Germany and pine further back to South Germany. Following the Allerod, the climate again continued to warm through the Young Dryas and Pre-Boreal phases, 8,000 - 7,000 BC. Birch, by this time, had reached and was dominant in Northern Britain whilst pine was dominant in the South; juniper was also noted to have a northerly distribution, especially in Denmark. Oak, elm and hazel have pushed north to Germany by this time. Fig 247 illustrates these latitudinal zonations.

Fig 247

Young Dryas-Pre-Boreal



Birch

Pine, Juniper

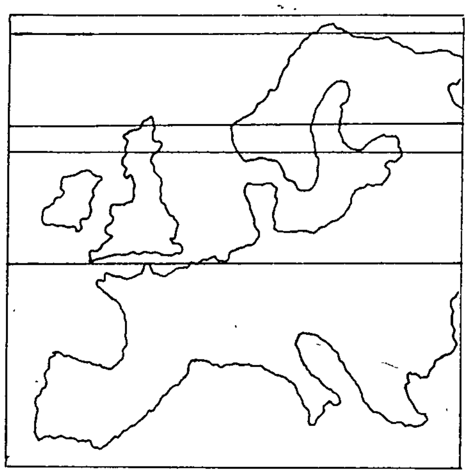
Oak, Hazel, Elm, Lime, Alder

Beech, Ash, Hornbeam, Field maple

Subsequent to the Pre-Boreal was the Boreal 7,000 - 6,000 BC. Perhaps the most significant species migration in this time was that of hazel. The Boreal epoch again represented increasing climatic warmth and retreat of glaciers. Hazel spread northwards as far as Sweden. Mixed oak woodland also began to spread to Britain (see fig 248).

Fig 248

Boreal



Birch

Pine

Oak, Hazel, Lime, Alder,/ Elm

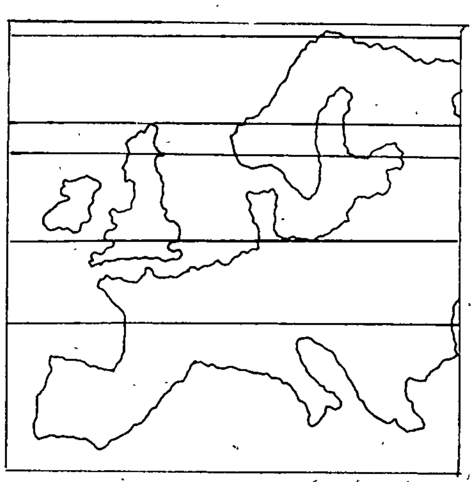
Beech, Ash, Hornbeam, Field maple

Following the Boreal, the climate warmed to what has been considered to be a climatic optimum. The Flandrian period 6,000 - 3,000 BC possibly represents a phase of optimum conditions for the British deciduous wildwood. Lime was particularly widespread during this period as was elm, oak and hazel. Importantly, during the Flandrian, the British Isles became isolated from the continental forest blocks. Beech, ash, hornbeam and field maple were the last species to colonize the British mainland significantly later than the species already mentioned. Any climatic deterioration following the Flandrian climatic optimum could no longer be translated entirely into migrations of species southwards in accordance with their climatic range. Fig 249 illustrates the Flandrian period.

Towards the end of the Flandrian there was a decline in temperature which corresponded to a major change in the composition of the Flandrian wildwood, notably the large scale reduction of elm and lime populations.

Fig 249

Flandrian



Birch

Pine

Oak,Hazel,Elm,Lime,Alder

Hornbeam,Beech,Ash,Field maple

Following the dip in temperatures 3,500 - 3,000 BC the climate again warmed, although not to the Flandrian optimum. This period is known as the Sub-Boreal, 3,000 - 1,000 BC. From the Sub-Boreal records of oaks in Fenland deposits (Godwin[19] p203), it would seem that oaks may once have grown significantly larger than they do today achieving 27.5m before the first branch. This could suggest that the climate was more favourable to oak growth than the present day.

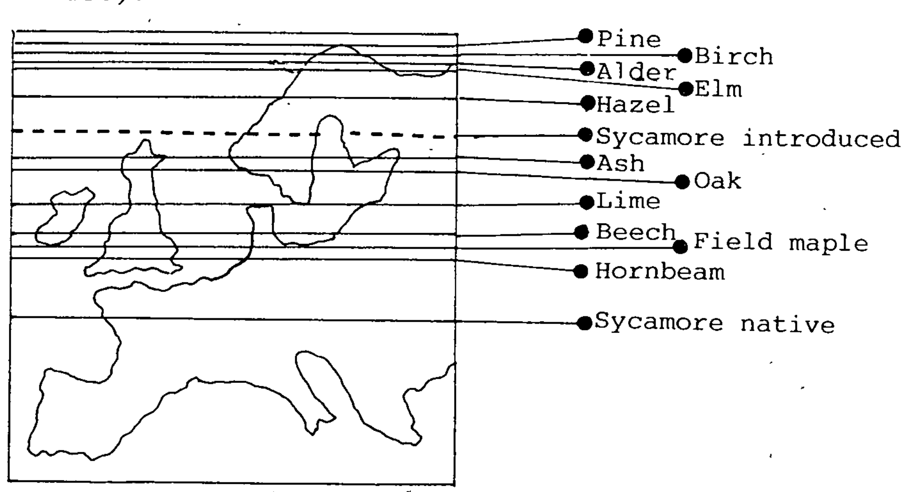
Again, following the Sub-Boreal, the climate became colder and West[83] quotes evidence of a wildwood retreat from its northern limits, again in accordance with individual species temperature tolerance. This period, known as the Sub-Atlantic, was between 1,000 - 500 BC. From this stage in the bioclimatic history of the British Isles, the analysis can be carried out at a micro chronological level. From the climatic deterioration of the Sub-Atlantic the temperature increased to an optimum at 1300 AD. This period represented the beginning of woodland management in Britain and corresponds to a Middle Ages warm epoch. From 1300 to the period 1550 - 1750, 'the Little Ice Age', the climate again cooled. British woodlands at this time were nearly completely managed. From 1840 - 1945 a slight warming of the climate may have occurred but from this time cooling may be taking place.

How these climatic changes have affected the evolution of the British tree flora is difficult to assess for there are many other variables that may affect woodland composition. However it appears that there was firstly a distinct zonation in time and space of trees as they recolonized the British mainland. Each map illustrates the basic associations of tree species at each stage of recolonization. (see figs 246 - 250).

Fig 250

The present day northerly limits of trees

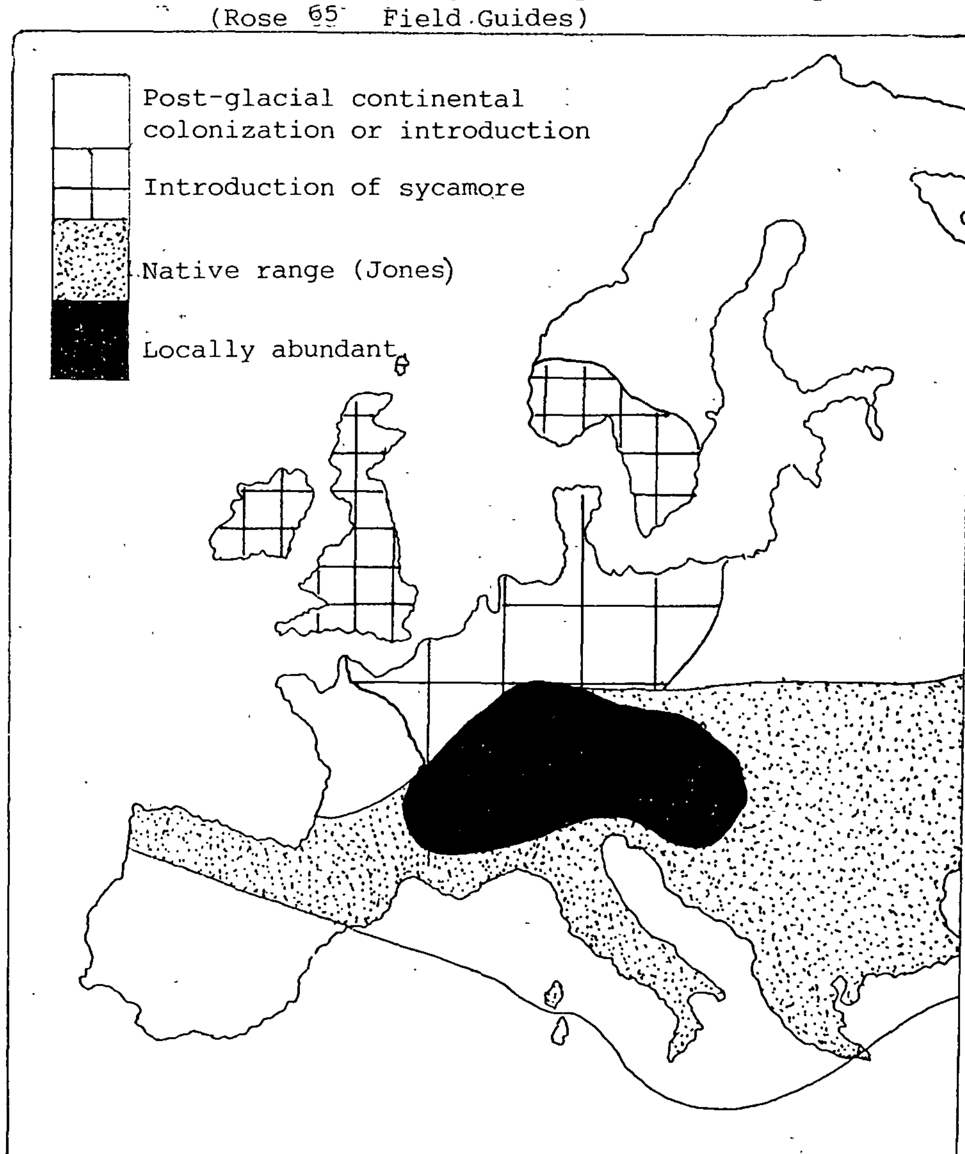
(Rackham)



The present day distribution depicted by the latitudinal northerly limits of tree species suggests that there are distinct climatic limitations to most native tree species that restrict further northerly colonization.

Sycamore did not arrive in Britain following glaciation. Its present native northerly limit is far south of the native British associations (see fig 250). It appears to be mainly restricted to mountainous regions of Southern and Central Europe (see fig 251) although it has extended its range by introduction.

Fig 251 Map illustrating native, colonized, locally abundant and introduced ranges of sycamore in Europe (Rose 65 Field Guides)



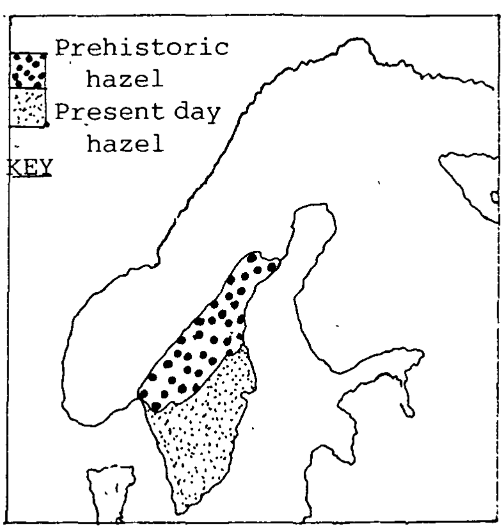
Cooper[10] suggests that the only area in Europe where sycamore produces pure forest is in the Thuringian Forest where it grows to 4,400 ft. It may also grow at 5,000 ft above elm in France and Switzerland.

Much of the investigation carried out in the West Suffolk area has given clues to reasons why sycamore failed to colonize Britain, Northern France and the Low Countries following glacial retreat. These are based on its success at colonizing a variety of woodland habitats within the survey area. The most obvious hypothesis might be based on climatic limitations. Sycamore may once have found the British climate less favourable than it does today or, as the evidence suggests, that native trees were once more competitive in the British climate than they are today and hence excluded sycamore by way of competition.

To analyze completely this hypothesis would be difficult given that climate is made up of many factors that may affect individual tree species in different ways and it would appear that since post-glacial recolonization there have been significant variations in the climatic regime. However, perhaps most importantly, it can be recognised that there has been a fall of 3°C in the annual mean temperature since the Flandrian period. Lamb (36) It could therefore be contended that this fall in temperature has created climatic conditions that are more comparable to sycamore's native range in upland communities in Mid and Southern Europe and climatic conditions that are less favourable to many native species.

Table 72 demonstrates some of the available evidence to support the theory that it is climatic alterations that have given sycamore the competitive edge in present day Britain.

Fig 252



Fossil distribution of hazel redrawn from West illustrating southerly retreat from prehistoric post-glacial distribution

Table 72 Relationships between Tree Distributions and Climate in Post Glacial Britain

Species	Post Glacial Recolonization	Flandrian Distribution	Post Flandrian	Present day distribution and physiology
Birch	Early colonizer	Northerly upland		Northerly upland i.e. Scotland some secondary sites
Pine	Early colonizer	Northerly upland		Northerly upland i.e. Scotland some on impoverished sites
Hazel	Mid colonizer	All of lowland Britain except North	Hazel may have grown taller in historic times (Rackham [64] p203)	Poor regeneration last 40 years (Rackham [64] p209) Thrives in cool oceanic climate (Lamb[36] p79) Present distribution more southerly than in Flandrian (West [83]) see fig 252
Alder	Mid colonizer	All of lowland Britain but particularly wetland sites		Wetland sites, plateaux, valleys Can bear viable fruit at -49°C (Macvean [42])

Table 72 (contd)

Relationships between Tree Distributions and Climate in Post Glacial Britain (contd)

Species	Post Glacial Recolonization	Flandrian Distribution	Post Flandrian	Present day distribution and physiology
Elm	Mid colonizer	Most of lowland Britain	Declining in numbers	Invasive elms no longer seed Susceptible to disease
Lime		Dominant tree in lowland Britain	Declining	Does not produce viable seed, very infrequent masting Relict in ancient woodland Seeded after very hot summers of 1976 and 1983 (Rackham[64]) Absent from Scotland (see fig 253) Oak then beech replace lime (Tubbs[80])
Oak	Mid colonizer	Abundant except in far north Grew much larger in Sub-Boreal (Godwin[19])	Beech replaces it in southern lowlands It seeded more in middle age warm epoch but lessened in little ice age - historic recording (Rackham[64])	Quercus petrae common in uplands Quercus robur - lowland but a lot of mixing with Q.petrae and hybridization Limited regeneration-mast seeding 3-5 year intervals Widespread distribution Possible slow growth rate Does not open leaves until June

Table 72 (contd)

Relationships between Tree Distributions and Climate in Post Glacial Britain (contd)

Species	Post Glacial Recolonization	Flandrian Distribution	Post Flandrian	Present day distribution and physiology
Ash	Mid - late colonizer		More common after elm decline	Freely regenerates, seeds every year - seed takes two years to germinate opens leaves late Montane species on the continent Widespread but common in some upland in Derbyshire Fast growth rate
Field maple	Mid - late colonizer			Southerly distribution
Beech	Late	Very southerly	May have been more northerly than today	Masts after warm summers (Matthews[44]) Southerly distribution (see fig 253)
Hornbeam	Late Always late Colonizer in previous inter-glacials (Rackham [64])	Very southerly	More northerly in Anglo-Saxon times after elm decline (Moxey [47]) (Giling [17])	Southerly - some relict population in East Anglia and Midlands in ancient woodland (see fig 253)

Fig 253 Map illustrating some present and past distributions of native tree species

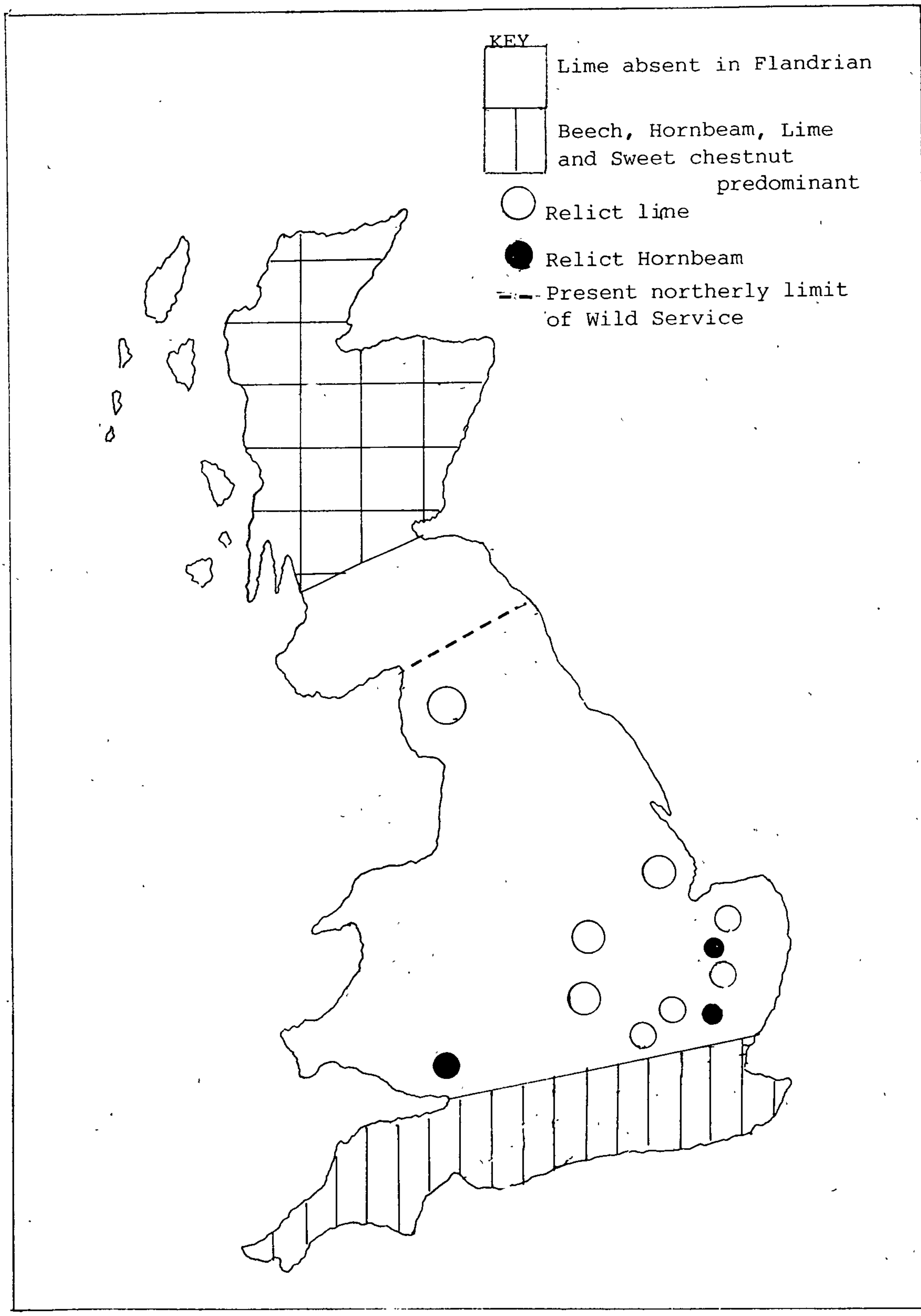


Table 72(contd)
Relationships between Tree Distributions and Climate in Post Glacial Britain (contd)

Species	Post Glacial Recolonization	Flandrian Distribution	Post Flandrian	Present day distribution and physiology
Sweet Chestnut			Introduced by Romans far to the north of normal range Possibly once produced viable seed Expanded in medieval warm epoch Disappeared from Forest of Dean 1565-1686 - corresponding to little ice age	Southerly distribution Rarely produces viable seed
Wild Service		Never in Scotland		Very rare southerly distribution (see fig 253)
Black Poplar		More common in this period		Very rare
Sycamore			Introductions	Does not form pure woodland on Continent Very fast growth rate - seeds every year - opens leaves early Only deciduous tree to grow in Orkneys (Burroughs [7]) Forms upland woodland with silver fir on continent Last tree in tree line W.Yorks (Gillingham)[18]

Table 72 gives some clear indications of the response of native tree species to changes in climate. It is apparent that oak, field maple, lime, elm, hornbeam, beech and sweet chestnut are at present at the northerly and altitudinal limits of their climatic range. They may be responding in various ways, such as having slow growth rates, or reduced seeding capabilities or limited demographic distributions in Britain. Only ash would seem to be capable of successfully seeding every year and capable of having a relatively fast growth rate in comparison with sycamore. It is interesting to note that both species are thought to be commonly montane species on the continent. It can be contended that sycamore did not migrate to Britain with other native species as it was simply outcompeted by these species which both grew and regenerated more successfully in the slightly warmer than present post glacial climate. Other sections of the text have sought to analyze the dispersal potential of sycamore which may have also contributed to its inability to colonize the new habitat created by the last retreating ice sheet. Importantly, it has been seen that sycamore is slow to invade large unbroken woodland and it may not be able to traverse great distances between isolated woods. Britain's physical isolation from the continent has not been responsible for sycamore's absence from Britain. Sycamore is not found naturally in Northern France, Rose [65]. However, the relatively slow potential for this rate of change of tree communities combined with the long history of woodland management in Britain has probably helped to maintain species that would not continue to be successful in a fully natural ecosystem under present climatic conditions. Without using the predictors of the survey of West Suffolk woodland, it could be argued that ash and sycamore appear to have the most favourable responses to present day climate, whilst oak, field maple, hornbeam, hazel, sweet chestnut, beech, lime and elm may not be favoured by the present climate.

Summary

1. Tree immigration to the British Isles following the retreating ice sheet occurred in a series of broadly defined zones and did not include the natural immigration of sycamore.
2. Subsequent zonation and success of species may be broadly defined in response to changing climatic conditions.

3. Climate may have a significant effect on factors such as growth rate and seeding of tree species and resistance to disease.

4. Sycamore and ash would appear to be the most tolerant species to the present British climate. The present climate regime may be similar to montane habitats in which sycamore is commonly successful in its natural range.

5. Factors such as a sycamore dispersal potential may also be involved with its failure to colonize post-glacial Britain.

6. Ancient woodland management will have significantly affected the natural competitive balance between species and could have helped maintain otherwise uncompetitive species.

POSTSCRIPT

Sycamore is probably exploiting niches in woodlands that are being created by the change in woodland structure that has occurred since the decline of ancient woodland management. The many native species are not seemingly able to exploit these changing conditions.

Sycamore dispersal appears to have been vastly aided by woodland fragmentation and the construction of routeways. Sycamore does not appear to disperse at a rapid rate or over long distances when not within relatively close proximity to routeways. Sycamore appears to be a methodical but relatively slow invader of woodland. These factors and its environmental tolerances in relation to native species are likely to be the reasons for its absence from the prehistorical tree flora of Britain.

Ancient woodlands have some inherent resistance to invasion, probably caused by their ability to reduce wind velocity, the agent by which sycamore seed is dispersed. Secondary woodland is often likely to be invaded by sycamore. The sycamore appears not to have to compete with many ancient woodland native species, at least in the early stages of secondary woodland development.

Sycamore is a flexible ecological strategist able to exploit a wide variety of different niches and habitats as an invader or a colonizer. It is likely to become more dominant in all woodland types in the West Suffolk area. Its major competitor is likely to be ash. Oak may also remain as a significant contributor.

Sycamore is already widely distributed throughout woodland in the West Suffolk area. Its demography is predictable so that,if conservationists required its total removal, this could in all probability still be achieved. At least certain woodlands or areas could be safeguarded from invasion. However, conservationists would be unwise to base their anti-sycamore vociferations on the premise that a sycamore dominated ecosystem would be unlikely to be rich in flora or fauna. The native biotic community will have to adapt to sycamore. Selection and expansion of populations of plants and animals that are compatible with sycamore will obviously take time. The difference in seasonality of leafing of sycamore from that of most native species is a striking example of change in a major ecological factor that will not necessarily limit ground flora but will certainly be selective in favour of a vastly different ground flora community. This,again,will take time to develop.

Conservationists may also have to look beyond the puritanical view that 'nativeness' is what is most desired. The woodlands of a rural ecosystem owe their very existence mainly to land economic factors, partly to aesthetic factors, but, in essence, they owe very little to their desirability as representatives of the native flora. The woods of West Suffolk have already been severely depleted. In the three years of the survey, three woods were removed from the area completely and four hedges were removed. Rural conservation is as much about saving woodland as saving particular species. For this reason, sycamore could be seen as a saviour; its fast growth rate rapid regeneration and ability to develop beneath a variety of canopies make it an ideal timber resource. The owner of one of the largest estates in the survey area has already seized upon the opportunity presented to him through the invasion of many of the estate's woods by sycamore. Sycamore is now being managed to produce a timber crop; it is often left to grow amongst conifer plantations producing a double crop of trees. The estate has won, in 1986, an important new award for combining farming with conservation.

What is, in fact, natural has to be argued. Lowland woodlands have been drastically interfered with by man for at least a thousand years. Although sycamore will undoubtedly oust some native species from their existing ranges, it is, I think, unlikely that the diversity of species and woodland structures that exists now would persist for many generations to come given that there was no large scale return to ancient woodland management techniques.

If blue tits can adapt to milk bottles, then the British conservationist could possibly adapt to sycamore. The rural ecosystem is losing trees by the dozen. It might seem stupid to be too proud to accept a tree from abroad that will grow anytime, anywhere. It actually seems to like being in Britain more than the natives.

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The Landowners of West Suffolk

"May *Acer pseudoplatanus* no longer be dominant in their lives"