Continuous Cover Forest Management of Oak/Ash Stands in the Lowlands: Stand Dynamics

Part 1: Stand Enumerations

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Contents

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Finally I would like to thank Ilchester Estates for providing the opportunity to implement this research project on the Melbury Estate.

Summary

In the UK and Europe the application of Continuous Cover Forest Management (CCF) to stands dominated by oak and ash is relatively poorly understood when compared with its application to other forest types.

An opportunity for increasing understanding of the application of CCF to oak/ash woodlands exists at Melbury and Rushmore Estates, where Andy Poore of SelectFor has been undertaking transformations in these forest types on a range of soil types over the last 10 years.

The major question which this project aims to address is whether permanently irregular structures can be created with these species and what such structures might look like.

The objectives of **Part 1** of the project are to establish a series of research areas that will produce information on stand structure and volume increment, to assess the research areas for various measures of stand structure and record the costs of doing this and to examine the spatial distribution of trees in the research areas.

Part 2 of the project will combine the information from Part 1 along with consideration of the experience of managing similar stands in northern France.

Enumerations were undertaken in the Melbury Estate woodlands which cover 378 ha in north-west Dorset. 265 ha of the forest are broadleaved dominated stands of which around 80 ha are in active conversion to Continuous Cover at present.

Seven research stands were established covering a range of site types, species compositions and management histories. These varied from 0.89 to 6.11 ha in extent with a total area of 22.3 ha. All of these areas, except one, have been in active transformation for some time. Stand enumerations were undertaken within these areas which involved measuring the dbh of **all** stems over 16 cm dbh. This produces a snapshot of stand structure and when this process is repeated, after around 8 years in this case, the results will also produce detailed information on timber increment, by species and size-classes.

Whilst it is these repeated enumerations which produce the full range of information, the initial measurements have produced very interesting data regarding the structure of different stands during the course of transformation. This will also allow comparisons between these stands and French silvicultural recommendations and experience which will be explored in Part 2.

Further measurements were made to explore the spatial distribution of stems with the aim of deriving a simple parameter to describe the degree of aggregation, or ‘clumpiness’, which in itself has important silvicultural and management implications. Some progress was made with the determination and interpretation of this parameter(s) and this will be explored further in Part 2. Finally the cost of undertaking these enumerations was recorded and discussed.

1. Background

The silviculture of mixed coniferous continuous cover stands in the lowlands of Britain is now developing with the assistance of data from central Europe and increased understanding amongst forest managers. Data on stand structure and increment is beginning to be collected, for example, at Stourhead (Western) Estate in Wiltshire. However, the situation with stands dominated by pedunculate oak and/or ash is in stark contrast to this. These stands, often on heavy clay soils or soils over chalk, are common in southern England and north-east France but are virtually absent from the areas of central Europe where continuous cover forestry (CCF) has been developed. The classic oak forests of north central France are very different: these are mainly sessile oak stands growing on sandy sites regenerated naturally under the uniform system so essentially even-aged in structure. There is, therefore, much less European experience of continuous cover management of oak and/or ash stands and recent management of such stands in the UK consists either of neglect, or the haphazard application of small-scale clearfelling and replanting.

An opportunity for increasing understanding of the application of CCF to oak/ash woodlands exists at Melbury and Rushmore Estates, where Andy Poore (SelectFor) has been undertaking transformation in these species on a range of soil types over the last 10 years.

The impetus behind the application of continuous cover principles to these stands are many:

- The need to achieve cost-effective regeneration; current small scale plantation techniques are very expensive.
- A desire to improve stand performance; closed mature oak and ash stands often have very low timber increment.
- The need to create more structurally diverse stands for biodiversity objectives incorporating the use of natural regeneration and low to moderate degrees of change.
- The necessity of regenerating these stands without major disruption to the landscape or to the sporting value of the woods. This is a particular challenge with small stands which make up the majority of the resource.

There are a number of possible approaches to the transformation of these stands. At a simple level they could be managed using a shelterwood system which would maintain at most two canopy layers. Another option would be an irregular shelterwood system where different parts of the woodland are at different stages of the transformation.

However, considering the climate, the site-types at Melbury and the above wider management issues, a decision has been taken to attempt transformation to a permanently irregular structure, i.e. one that would have three or more canopy layers. A judgement has been made that such structures would deliver a wider range of benefits and hence achieves management objectives.

2. Aims of Project

The major question which this project aims to address is whether permanently irregular structures can be created with these species and what such structures might look like.

The objectives of **Part 1** of the project are:

1. To establish a series of research areas that will produce information on stand structure and volume increment.

2. To assess the research areas for various measures of stand structure and record the costs of doing this.

3. To examine spatial distribution of trees in the research areas.

Part 2 of the project will combine the information from Part 1 along with experience of similar stands in northern France. This part of the project will be done in consultation with Forest Research and some refinements of the initial work in Part 1 will also be considered.

However, it must be made clear that the real value of the research areas, and this project, will only be realised when the second assessment takes place. This will allow volume increment to be calculated and comparisons between stands with different structures.

3. Methodology

3.1 Site Selection

Melbury Estate woodlands cover 378 ha, of which 265 ha are broadleaved dominated stands. Of this area around 200 ha is likely to be brought into active Continuous Cover (CC) High Forest management in the next 20 years. **Of these potential CC broadleaved high forest areas, around 80 ha are in active conversion at present.**

The research stands will generate information for 2 purposes:

- to guide the management of CC oak/ ash stands on the Melbury Estate itself
- to provide information on the general application of this type of silviculture to these stand types.

With regard to the first purpose the ideal would be to have a series of research stands covering all the main species compositions and the main site types on the Estate.

With regard to the second purpose the ability to randomly select sample areas and to have a replicated sampling system would allow the application of more statistically rigorous techniques.

All the stands at Melbury in transformation are, however, in their early stages and the areas with more developed structures are few. The overall area of relevant stands is also quite small. This means that the stands selected as research areas have effectively chosen themselves. Fortunately the range of site-types and species compositions which this has produced is good and the selected areas will serve the purpose of 'Estate' research stands. It has not been possible, however, to produce a random, replicated sampling system but despite this the information generated by the project will produce useful results which will have wider applicability.

The sites selected on the Melbury Estate cover a range of variation in:

- Stand composition: mostly ash dominated or oak dominated with a significant ash component.
- Site type: heavy clay soils and thin soils over chalk
- Origin: ancient semi-natural; plantation and naturally regenerated on open land.

A summary of site details is as follows:

Research Area Name	**Area (ha)**	**Major Species**	**Subsidiary Species**	**Site Type**	**Origin**
Parsonage Copse	0.89	oak		Surface water gley	Ancient semi-natural subject to mid 19th century plantation
Annesley's Plantation	4.00	oak	ash	Impeded brown earth	Plantation c 1840 partly on ancient site.
Brickyards Plantation	2.84	oak	ash	Surface water gley	Plantation on open ground, c 1835
Rag Copse	4.34	oak	ash	Impeded brown earth	Ancient semi-natural
Evershot Plantation	6.11	oak	sycamore, ash, beech	Sandy head over chalk	Plantation on open ground 1820-30
Woolcombe Folly	0.98	ash	sycamore, beech, oak	Rendzina	Plantation on open ground 1792. Felled c. 1918 & replaced by largely naturally regenerated stand.
Hill Plantation	3.13	ash	sycamore, beech	Rendzina	Arose naturally on open ground in mid 20th c.

All but Parsonage Copse have had one or more interventions designed to begin the transformation within the last 10 years. The differing origin and stand histories had produced stands of varying structural diversity before these interventions took place. In general, however, the stands were relatively uniform with regard to age, but showed varying degrees of diversity with regard to spatial distribution, diameter distribution and species composition.

As the main aim of the Project is to evaluate transformation and the response of these stands to more open structures, actively managed stands have been included. Parsonage Coppice was included to evaluate the earlier stage of transformation and to record the structure of an example of a uniform, closed canopy oak plantation before transformation begins.

A map showing the location of the enumeration areas is attached at Appendix 1.

The climate at Melbury is noteworthy for a number of reasons:

- It is located within a region where the continental and Atlantic influences meet and where its relative proximity to the coast may also be influential. Annual rainfall is high for the region.
- The average annual precipitation for 1996 to 1999 was 1088 mm. (43 inches); the figure for 2000 was 1544 mm (61 inches)!
- This compares with an overall average of 896 mm (35 inches) per annum for the Wessex Water region as a whole for 1996 to 1999.

3.2 Silviculture & Mensuration

In determining what parameters to measure in Part 1, the following silvicultural issues were taken into consideration:

Overall Stand Structure.

In permanently irregular stands, the regeneration of seedlings and the recruitment of stems into the upper canopy takes place without major gaps. The differing light requirements of different species are accommodated by having different overall levels of growing stock (measured in cubic metres per ha of standing volume or square metres per ha of basal area). Given the correct amount of overall growing stock and a suitably irregular structure which allows light to penetrate to the floor from different directions, regeneration and recruitment should occur in relatively small gaps of under 0.1 ha. With oak other silvicultural considerations may warrant more concentration of regeneration into groups of up to 0.25 ha. It should be noted, however, that eventually these groups lose their identity and in developed structures mature stems are likely to be present in the upper canopy as singletons, sometimes accompanied by smaller stems.

Light requirements suggest that low overall growing stocks will be required for oak/ash dominated stands. Present knowledge suggests that developed structures are likely to be in the range of 15-20 sq m of basal area. This compares with growing stocks of up to twice this for closed even-aged mature stands of these species.

In determining the structure of stands during and after transformation to permanent irregularity, therefore, measures of stand density, composition and distribution in terms of diameter and spatial arrangement are required.

Timber Increment & Stand Performance

Whilst we can describe structures through the above parameters we must link these descriptions to measures of performance in order to determine whether a particular structure is meeting the aims of management. The normal parameter used to judge performance is timber increment and preferably this measure should apply to the components of the stand, individual species and stem size categories, as well as the stand as a whole.

In addition to increment, the sustainability of the structure is dependent on appropriate levels of regeneration and recruitment and some measure of regeneration success is required, particularly as the transformation process becomes further advanced.

Clearly in some cases timber increment is not a suitable performance indicator and others, linked to say biodiversity, might be more appropriate. However, the measurement of regeneration and recruitment would still be required. In many cases both timber increment and biodiversity indicators are required.

In this study timber increment will be used initially as the main parameter and the measurement of regeneration/ recruitment will be introduced when a suitable stage has been reached.

An additional aspect of the development of a workable, permanently-irregular structure is the spatial distribution of the stems. One of the key benefits of the development of **permanently irregular** structures is the abandonment of the need for relatively regular spacing between stems. Experience shows that 'clumpiness' naturally develops where continuous cover principles are applied but such clumpiness has two very desirable, probably essential, results for permanently irregular stands:

- it allows the light available to the forest floor, and hence the regeneration, to be somewhat concentrated. This is most important for light demanding species.
- it makes selective harvesting easier with regard to access to the stems themselves and it makes undertaking such fellings without causing major damage to the rest of the growing stock, and particularly the smaller 'recruitment' stems, much more feasible.

For research purposes it would be desirable to be able to define simple parameters which allow the degree and type of 'clumpiness' to be described so that in due course the appropriate levels, or ranges, of these parameters which are associated with successful transformation can be determined.

Transformation

Most current stands dominated by oak and/ or ash have developed as uniform stands either from plantations, from large-scale regeneration events or through a gradual development from coppice-with-standards to high forest. The transformation from these even-aged structures to permanently irregular ones, is likely to take some time and will be linked with other silvicultural factors such as vegetation management and mammal grazing control. Even when developed structures are achieved, the monitoring of timber increment, or any other performance indicator, in relation to stand structure is a long-term process. However, the process must be started and this is aim of Part 1 of the project.

Both oak and ash are intolerant of side competition and existing closed stands are likely to be growing slowly and much more slowly than even-aged management tables indicate. Of particular interest is the effect of more open diverse structures on the timber increment of these stands and this should be evident during the earlier stages of transformation.

3.3 The Measurement of Increment

The common means of measuring timber increment in Europe is the Check Method, or la 'Méthode du contrôle', developed by Gurnard and Biolley in the late 19th century. This involves the repeated measurement, or 'enumeration', of the diameter of all the trees in a stand over a predetermined size limit on a cycle of around 7-10 years **and** the recording of the diameter of all trees removed between enumerations. This method has been applied as part of the regular management of forests on a large scale in areas such as Neuchâtel in Switzerland. The historic use of this method in the UK is limited to the Ipsden Estate in the Chilterns where enumerations have been undertaken since the early 1950's. Recently, however, the method has been introduced by Andy Poore and David Pengelly into well developed, irregular conifer stands at the Stourhead (Western) estate in Wiltshire.

The Check Method produces 'snapshots' of the stand structure at each enumeration and also provides increment information from the second enumeration onwards. While 'snapshots' can be obtained by other methods, repeated enumeration is the only means of producing increment information on any scale. This increment information applies to the whole stand and to individual elements, i.e. different size classes and individual species. It has proved itself a very robust method of producing the essential information required to direct the management of permanently irregular stands once a substantial degree of structural diversity has been achieved. It has also been the basis of the substantial body of research information developed in countries such as Switzerland.

The disadvantage of the Check Method is that it is expensive if large areas are measured. In Switzerland sampling methods have been devised for its application in general forest management but these are suited to large, state managed forests where forest inventory is undertaken by different personnel from the management itself. With respect to its application in guiding site specific forest management, an alternative approach is to limit complete enumeration to a series of sample stands within a forest estate which cover the major site types and species combinations and then apply this information to other comparable stands. This is the approach taken at Stourhead (Western) and this will also be the approach adopted in this Project. The costs of this approach to enumeration will also be evaluated as part of this Project.

3.4 The Application of the Check Method at Melbury

Detailed information regarding the principles and application of the Check method exists elsewhere[1,2]

The main elements of the application at Melbury are similar to those recently introduced at Stourhead (Western):

- Define enumeration areas with fixed, permanent boundaries. These are not necessarily coincident with compartment boundaries.
- Record the diameter of all trees over 16 cm dbh by species using one *calliper* measurement where possible.
- Diameter is recorded in 2 cm classes. (These could if necessary be aggregated into 4 cm classes which is one of the standard formats used in continental enumerations).
- For broad comparative purposes diameter classes are aggregated into Diameter Groups as follows:
  Small: (16-31.9 cm)
  Medium: (32 –51.9 cm)
  Large: (52 cm –79.9cm)
  Super Large (80 cm +)
- Scribe a mark at the point of measurement so that future enumerations will determine the diameter parameter in exactly the same place and alignment.

However, with regard to method of recording the information the stands at Melbury differ somewhat from those at Stourhead (Western) in having fewer stems per hectare and having a higher proportion of larger stems. This led to an adaptation of the normal method of recording using 2 measurers and 1 recorder using a clipboard. At Melbury only one technician was used and recording was done initially using a dictaphone which was then transcribed onto paper at a later date. The largest pair of callipers available (up to 100 cm) was obtained to avoid the time consuming use of girth tapes. The full field procedure is given at Appendix 2.

This approach produces data for stem diameter, stem numbers and basal area. Once repeated, a direct measure of basal area increment is also obtained. In order to convert this to volume a local tariff table must be produced. This can take some time and the volume parameter is most relevant when increment is being considered, i.e. from the second enumeration onwards. **At this stage therefore we shall consider the growing stock and its components in terms of basal area and average diameter rather than volume.**

The first application of the Check Method provides information on the composition of the growing stock according to diameter class and species. It does not say anything about the spatial distribution of the stems.

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[1] Knuchel (1953) Planning and Control in the Managed Forest, Oliver & Boyd, London.
[2] Reade, M.G. (1989) Chiltern Enumerations, Quarterly Journal of Forestry 84(1), 9-22.

The use of the lower diameter limit of 16 cm means that the measurements will slightly underestimate the stocking density compared with the normal lower limit of 7 cm. In more developed stands, however, the contribution of the smaller stems to overall density is low and the relevance of these stems to increment is even less when the process is repeated.

3.5 Measurement of Spatial Distribution of Stems

Spatial distribution does not figure in the classical literature on irregular silviculture. Research literature has considered this aspect to some extent, particularly with respect to whether spatial distribution is regular or random[3]. None of these descriptive statistics meets the current purpose of a simple description of how far a stand has moved from regularity towards a clumpy or 'semi-aggregated' condition, the question of the degree of randomness being irrelevant.

A new approach has been used here in which the distance between sample stems and their nearest neighbour is measured and the mean and distribution of these measurements is considered in relationship to the average spacing of stems in the stand derived from complete enumeration. The ratio of the distance from the nearest stem to the average spacing in the stand will be called the '**Normalised Neighbour Distance Ratio**'.

In a plantation in which all plants have survived the value of the mean of these Normalised Neighbour Distance Ratio (NNDR) measurements will be one. In a clumpy structure, however, this ratio would be less than 1 and possibly substantially so.

This ratio alone, however, would not tell us how dispersed the clumps were since one large clump surrounded by open space would have a similar NNDR ratio to a structure where clumps were dispersed. In order to consider the dispersion of the clumps we need to consider the frequency distribution of the NNDR measurements. More spread, i.e. a higher standard deviation, in this distribution would suggest more dispersion in the clumps. Given that we are using these measures to compare stands of different characteristics a relative measure of variation is appropriate and so the coefficient of variation is suggested as the desired measure in this case.

In permanently irregular stands the desired structure would be some form of dispersed, semi-aggregated, i.e.clumpy, structure as discussed in Section 2.2 above.

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[3] see for example Duchiron M-S. (2003) Structure Forestieres Auto edition. ISBN 2-9506866-2-1

The following combinations of these two parameters are therefore possible with some preliminary suggestions as to possible values:

	Normalised Neighbour Distance Ratio	
	Mean	**Coefficient of Variation**
Fully stocked plantation planted on the square	1	0%
Fully aggregated structure (one large clump)	<1: could be Low < 0.5	Low less than 25%
Dispersed semi-aggregated structure with many clumps of different sizes and some individuals	**<1: probably rather Low <0.7**	**High probably near to 0.50%**
Semi-regular, non aggregated structure	<1: probably rather high > 0.8	Rather Low

The sample trees were selected by a systematic sampling method designed to cover the whole enumeration area with the aim of sampling around 10% of the stand. The diameter and species of each sample tree was noted and the distance to its nearest neighbour.

This procedure was undertaken on two of the more spatially diverse stands, Rag Copse and Hill plantation, neither of which have a plantation history; and on the even aged stand of plantation origin, Parsonage Copse.

Dr Geoff Morgan, Principal Statistician for Forest Research, has had a preliminary look at the above statistic and its interpretation. His initial, tentative, conclusions are that:

- **The statistic does give a reasonable distinction between regular, random and aggregated distributions.**
- **The coefficient of variation does not add a significant amount of further information.**
- **The interpretation of the statistic needs to be improved.**

The usefulness and application of this statistic will be considered further in Part 2 of the Project.

3.6 Measurement of Regeneration

The Check Method is concerned with increment and ignores smaller diameter classes which, in developed structures, contribute very little increment and are expensive to measure. The common lower limits are 16 or 20 cm. Between enumerations stems grow into the smallest measured class, called the 'passage à la futaie' in French. The increment of this class is used in Switzerland as an indicator that conditions are appropriate in the lower parts of the stand with regard to the recruitment of pole stage stems. This is useful for monitoring recruiting but does not provide information on the contemporary conditions at forest floor level and the disadvantage of relying on the Check Method alone is that there is a long lead time between problems with regeneration occurring and the evidence appearing in the enumeration. Some direct monitoring of the sapling, and seedling, regeneration is therefore often desirable.

In the UK a monitoring procedure for regeneration has been devised by Gary Kerr and his colleagues in Forest Research which is combined with sampling designed to produce 'snap shots' of stand structure[4]. The procedure with regard to seedling and sapling regeneration will be used during Part 2 of this study on stands where transformation is far enough advanced to have entered into the regeneration initiation stage (see Part 2 for discussion on stages within transformation).

[4] Kerr G., Mason B., Boswell R. & Pommerening A. (2002) Monitoring transformation of even-aged stands to continuous cover management

4. Results

4.1 Stand Enumerations

The following information from the complete enumerations is given below for each area in turn:

- Stand history
- Chart showing overall stand parameters for stocking density (basal area and stems per ha) and the species composition by basal area.

The stands are presented with the most uniform structured stands first, then in order according to increasing structural diversity.

Then the stand structure of each stand is considered, stands being listed again in increasing order of structural diversity. The data presented are:

- Chart showing the frequency distribution of stems per ha by diameter class and species, the so-called 'reverse- J curve'.
- Histogram showing the distribution of basal area by Diameter Group.

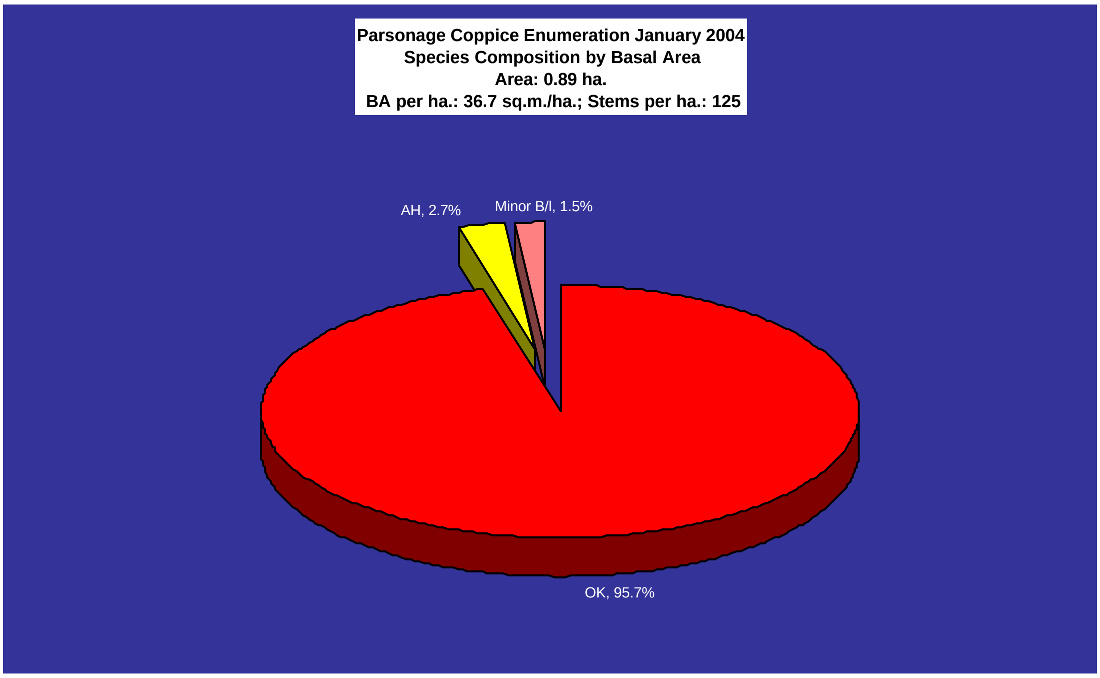
It should be noted that all enumerations have a lower diameter limit of 16 cm. These measurements, therefore, slightly underestimate the stocking density compared with the normal lower limit of 7 cm. In more developed stands, however, the contribution of the smaller stems to overall density is low and even lower when increment is considered after repeated measurements.

4.2 Site History & Main Stand Parameters

Parsonage Coppice

The stand is oak over hazel on Oxford Clay. It is recorded as 'coppice' in 1839 but was subsequently planted through with oak and a conifer nurse (largely Scots pine), probably before 1858.

Little obvious management has taken place since then although a more open structure in part suggests a felling or windblow event in the last 50 years.



Annesleys Plantation

Oak and ash over hazel, field maple & *Sorbus torminalis* on Forest Marble Clay.

- Part planted on open ground with OK/SP 1810-1835.
- Part ASNW (Pickets Copse) planted through with OK/ SP 1810-1835.
- Part less modified ASNW (failed plantation).

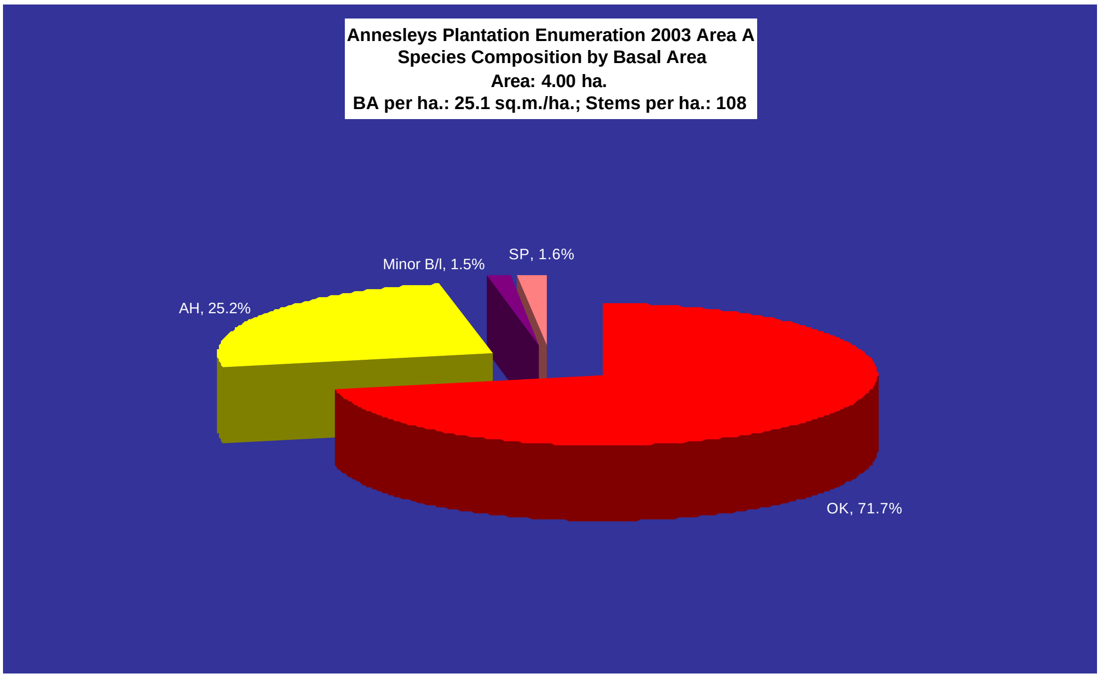
The whole site was part of a larger woodland area cleared in mid 16th century. The wood is sub-divided east/west into chain wide sections by low banks. Underwood last cut for gads c 1955.

Recent Interventions

The wood east of stream is sub-divided into 4 sections. The northern section is ash dominated, with remnant large SP. The southern 3 sections subject has been subjected to staggered thinnings and then selection/ transformation fellings in FY’s 89,93,95,00 and 03.

Volumes removed:

	Area (ha)	Volume	Vol/ha (cu.m.)
FY88/99	1.6	63.6 cu.m. timber 63 cu.m. firewood	79
FY95	0.7	525 Hft timber (26.4 cu m) _26.4 cu.m. firewood	75
FY2000	0.8	763 Hft timber (27.5 cu.m.) c 30 cu.m. firewood	72
FY2003	0.9	844 Hft timber (30.4 cu.m.) c 40cu.m. firewood	78

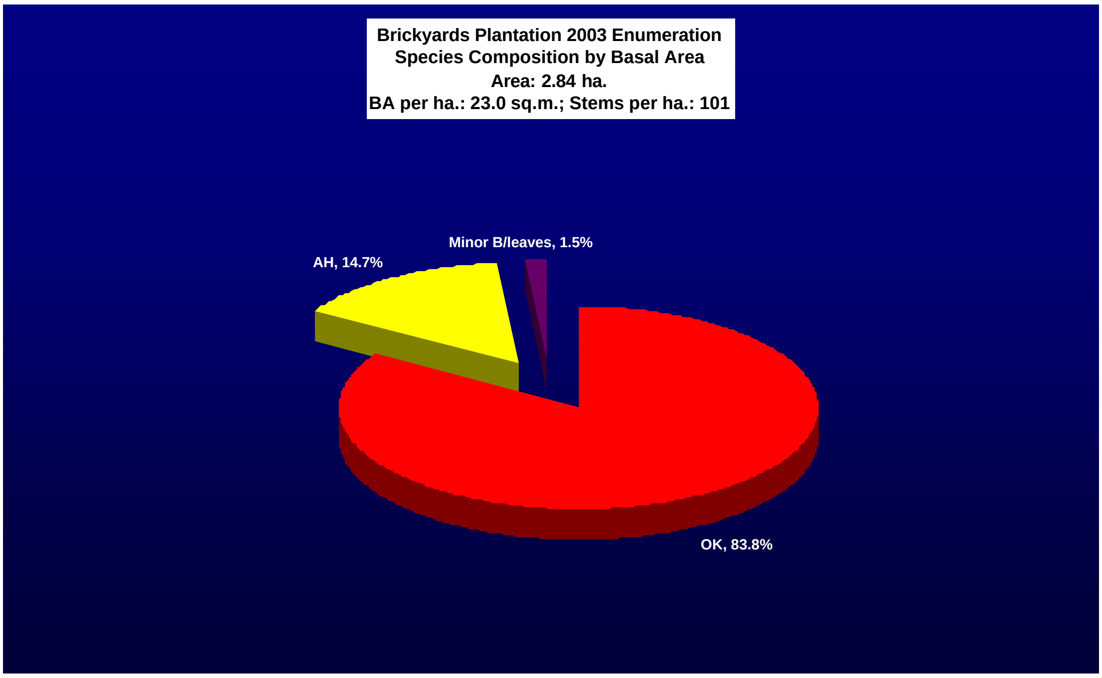


Brickyards Plantation

The stand comprises oak and ash over hazel and field maple on Oxford Clay. The stand was planted on open ground between 1803 and 1839, probably in 1830's with conifer nurse.

Recent interventions:

FY88 &89	Underwood Cut	
	Selective Fell	Total Volume Removed: . 4109 H ft 148 cu.m (= 52.8/ha.) Timber 1430 Firewood 2676
		Ave BHQG trees removed: 12 in (39 cm.)
FY98 & 99	Underwood Cut	
FY 2000	Selective Fell	Total Volume Removed: .3579 H ft (129 cu.m = 46.1 /ha.) Timber 1554 Firewood 2025
		Ave BHQG trees removed: 20.25 in (66 cm.) Basal Area 8/01: 20 sq.m./ha.

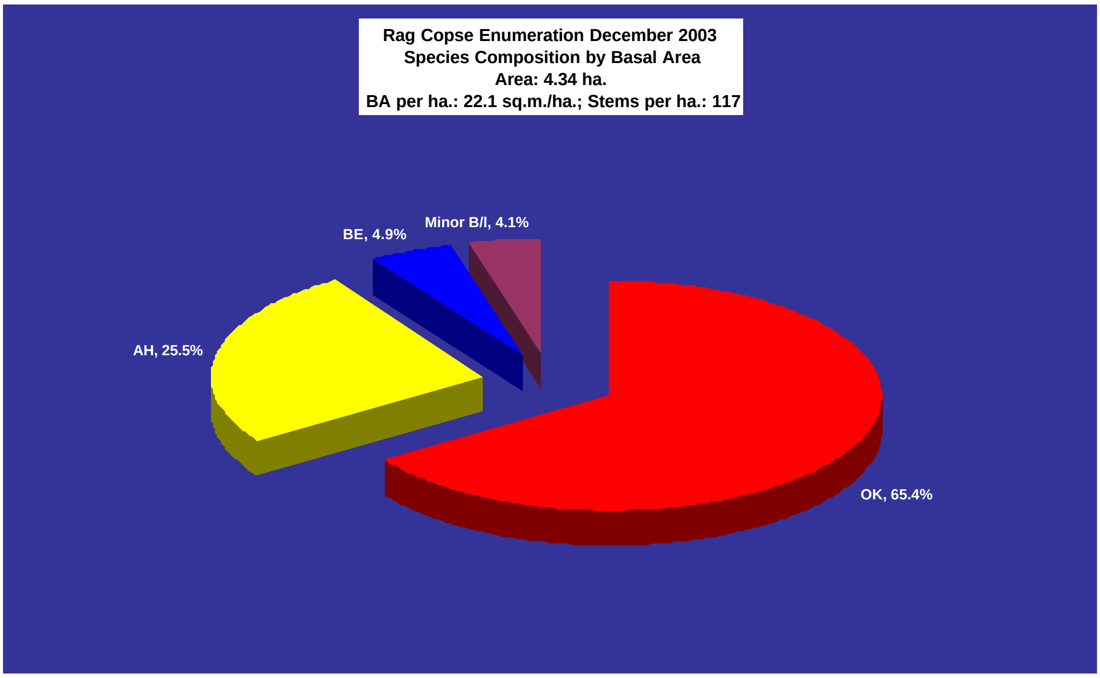


Rag Copse

Oak and ash over hazel, field maple & *Sorbus torminalis* on Forest Marble Clay. An ancient semi-natural stand not subjected to 'improvement' in 19th century but with a low underwood density.

Recent Interventions

1999: Selective felling/ transformation cutting: c. 885 Hft timber (31.9 cu.m.) + 146 cu.m..(37.1 cu.m. /ha). Underwood cut where fellings occurred. Centre of larger gaps planted with oak.



Evershot Plantation

Stand comprises oak, ash, sycamore, beech on sandy head over chalk.

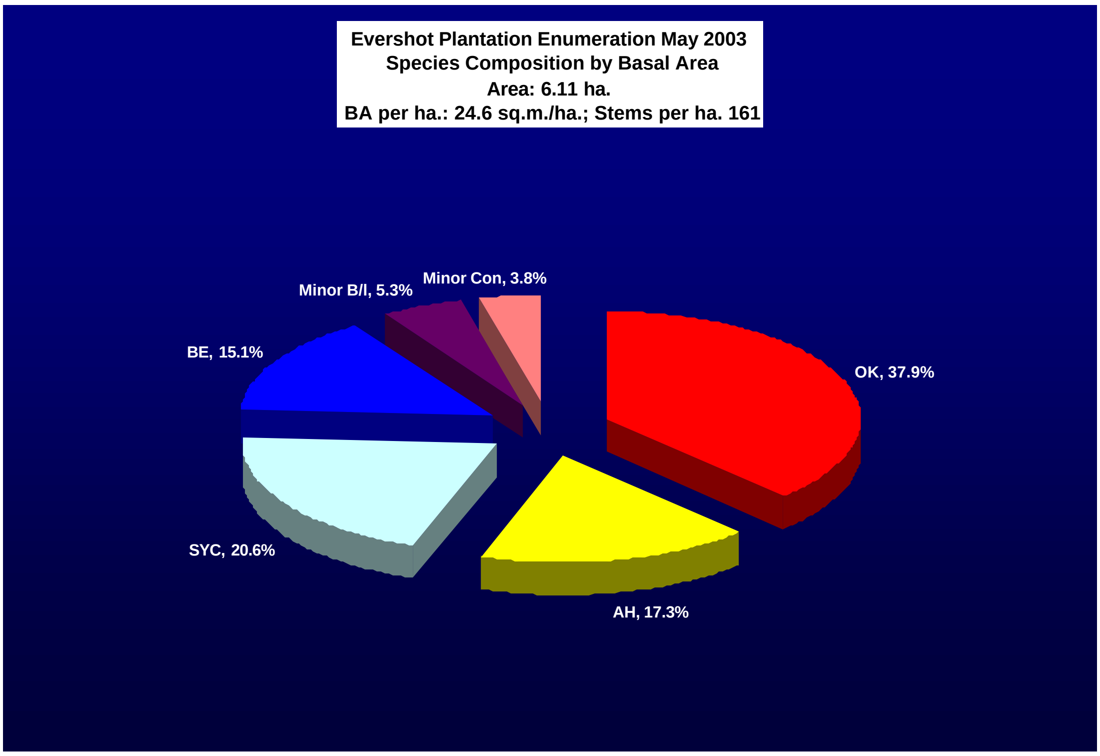
This stand is part of a major planting on open land around the top of the Hazel Farm valley undertaken from 1798 to 1850 and part of the Registered Designed Landscape at Melbury. The southern part, including the enumeration area, was planted in 1807-9 and 1814-20 on land previously enclosed from Evershot Common in 1786.

The stand was established as oak, beech, sycamore (plus ornamentals along track: Turkey oak, cherry, *Cupressu spp.s*) plus mixed conifer nurses (EL, SP & NS).

Heavy conifer thinnings were undertaken around 1880 & in the early 1900's with a possible further intervention in the 1940's. Little management occurred thereafter until effect of 1990 storm and introduction of formal management to transform stand to continuous cover.

Stand elements:

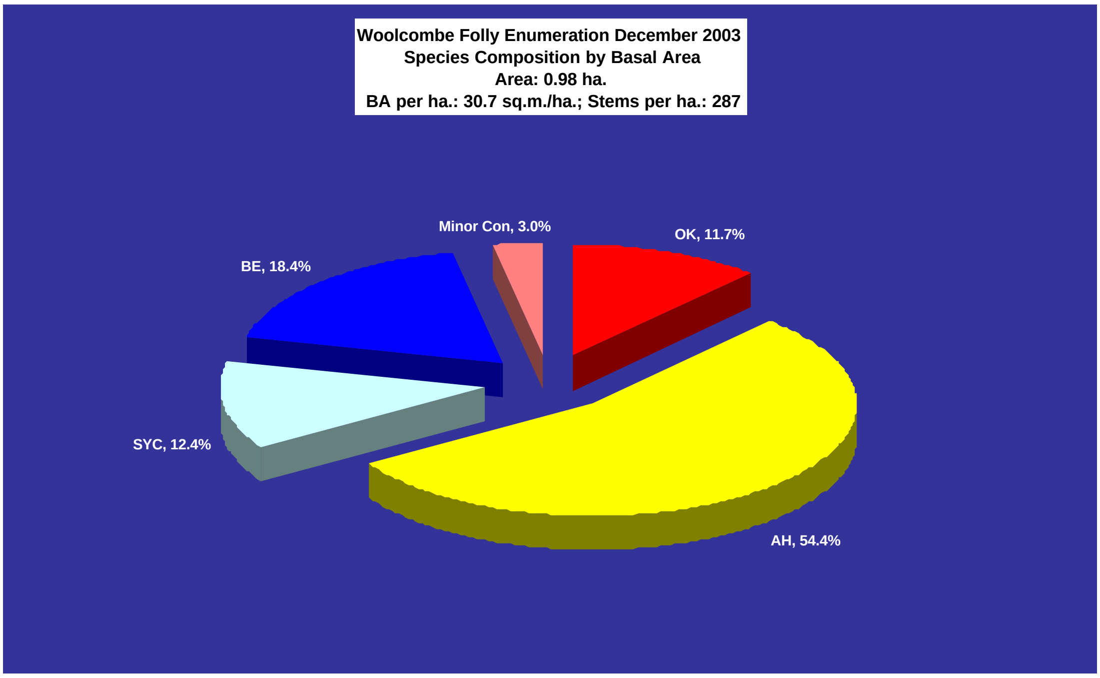
	Species	**Age (yrs)**
1	Original Plantings: OK TOK BE MC	180-190
2	AH SY arising from natural regeneration following 1880-1900 interventions	100-120
3	SY	c. 50
4	AH WCH SWC SY & OK SWC planted in groups	1995-97



Woolcombe Folly

Planted between 1792 and 1811 on open downland as beech and conifer mixture. The enumerated area appears to be a small area felled in 1914-18 and allowed to regenerate naturally. In the early 1950's the 'ash coppice', as the stand was described in 1951, was thinned and underplanted with beech and Norway spruce. This underplanting was largely a failure and the current stand is dominated by ash and sycamore.

Little management was undertaken subsequently until the stand was thinned as part of the transformation process in FYs 1995 and 2001.

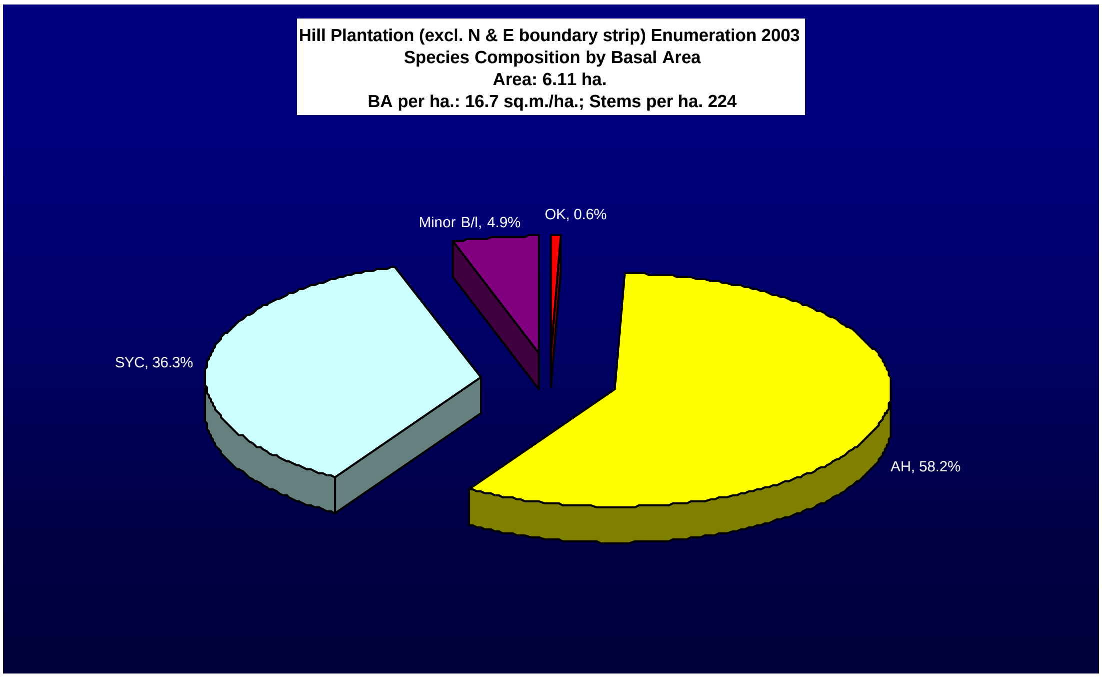


Hill Plantation

Ash and sycamore on thin soil over chalk.

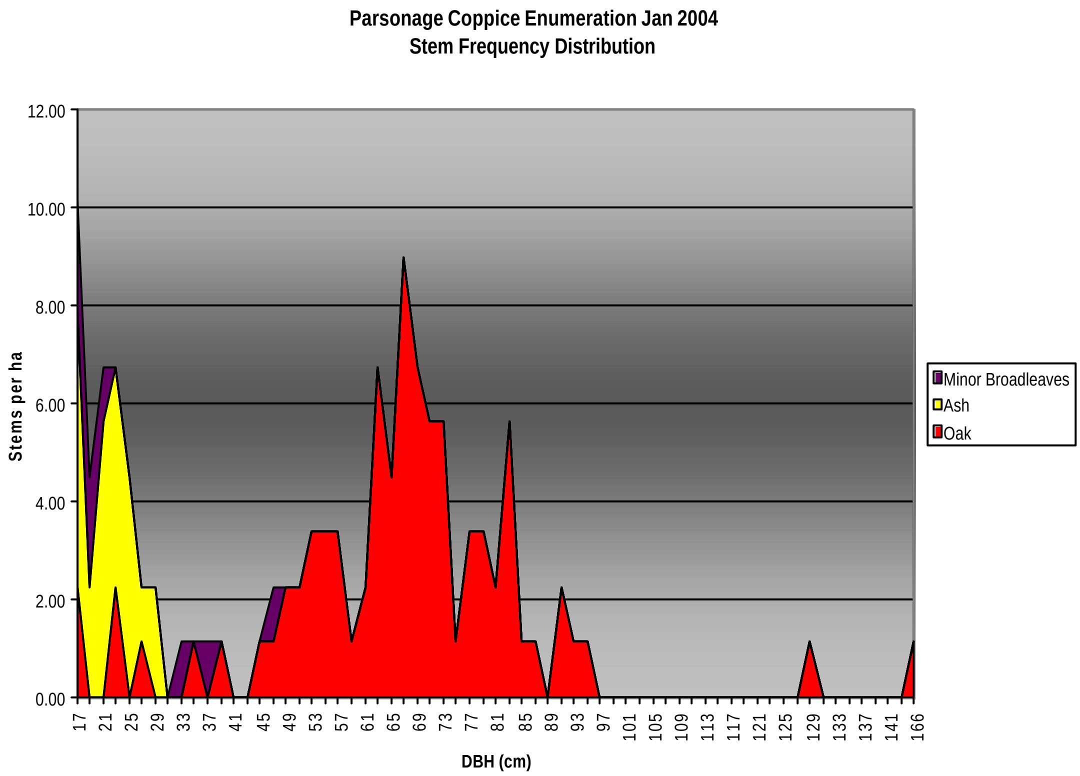
The area to the north of the enumerated area was planted before 1860 apparently with beech, sycamore, oak and conifer nurses and then felled for the Ministry of supply in 1946. The northern and eastern boundaries of the enumerated area incorporate an extant beech/ sycamore belt which was part of this original planting and which was not felled in 1946.

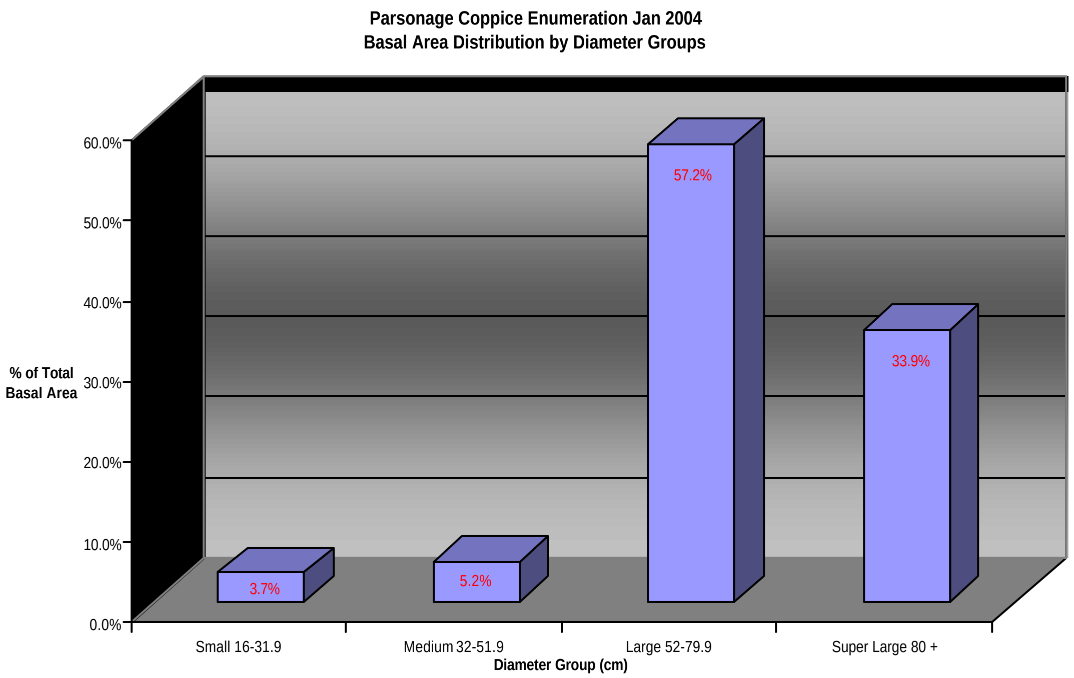
The rest of the enumerated area arose on abandoned farmland after 1900 (probably after 1930). Some trees were 'inherited' from the fields and these were felled in the 1960's. Apart from this the stand received no management until a thinning was undertaken in FY 2001.



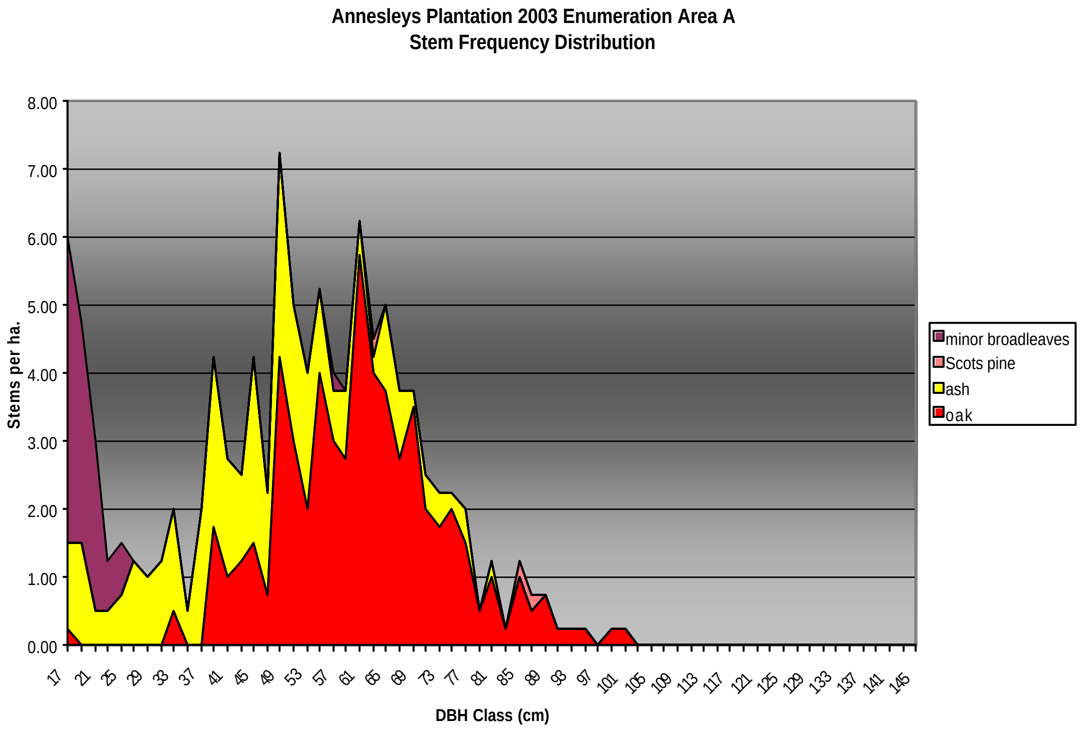
4.3 Stand Structure

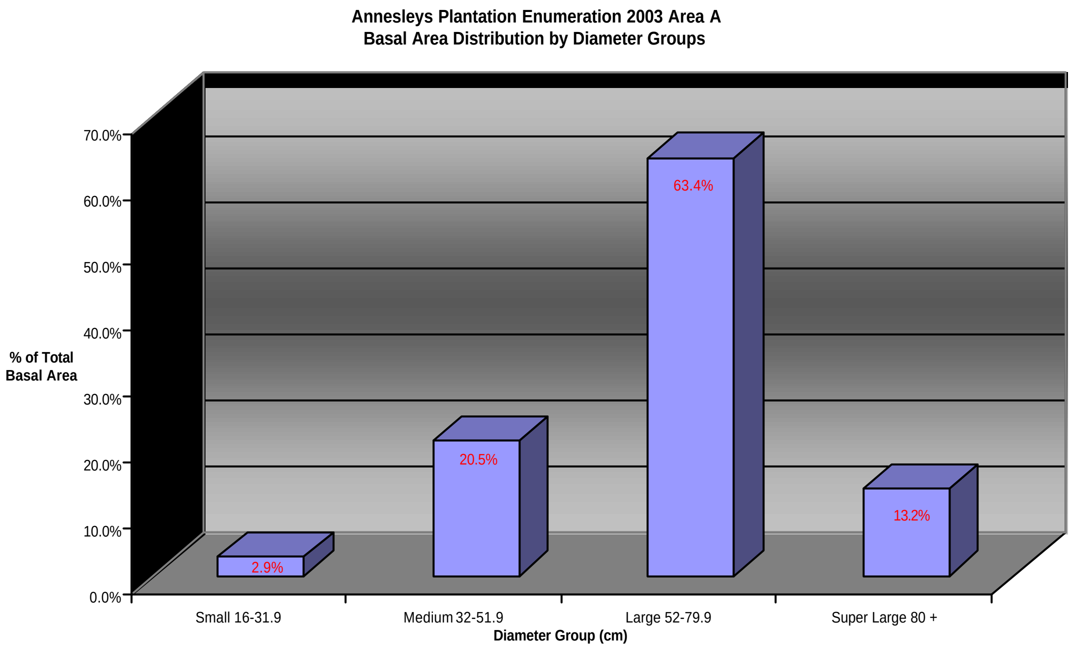
Parsonage Copse



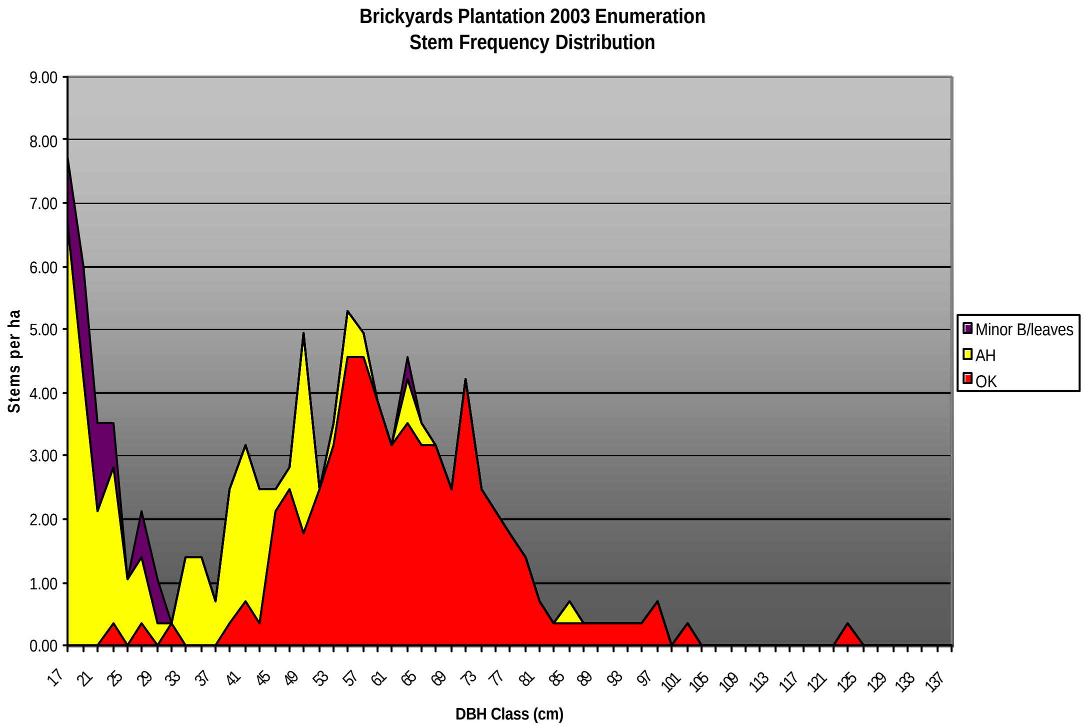


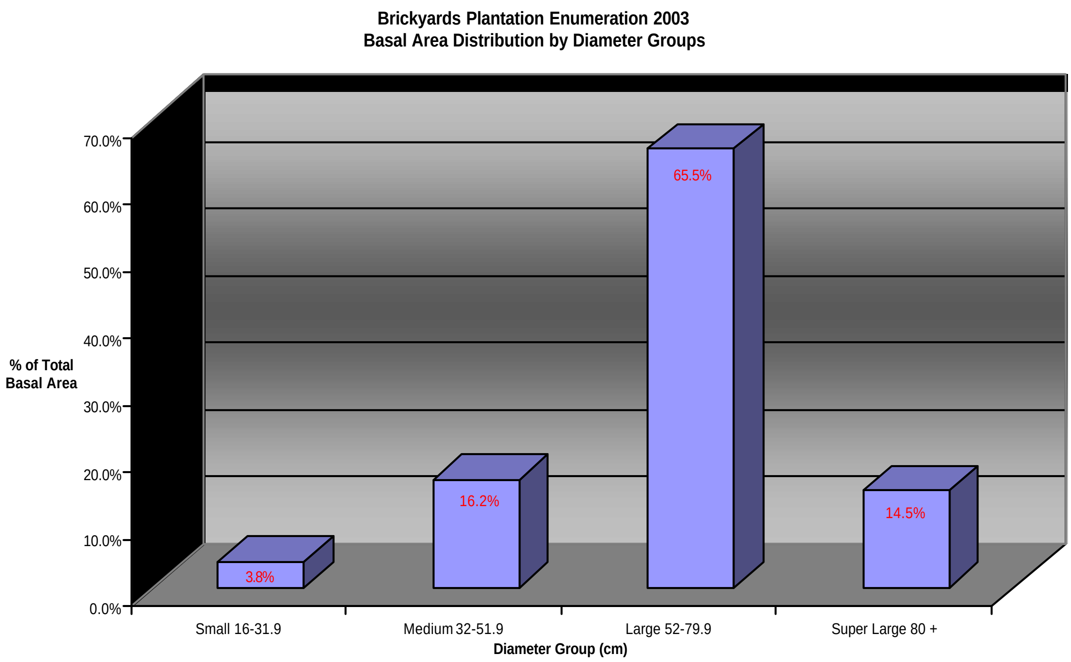
Annesleys Plantation



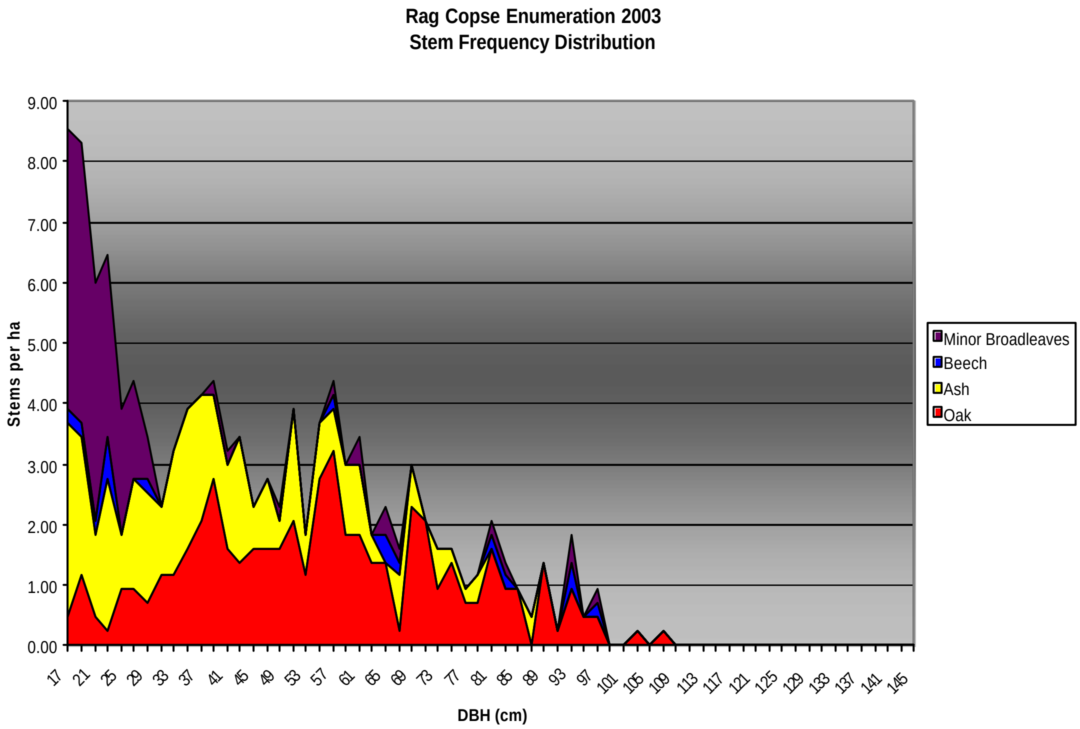


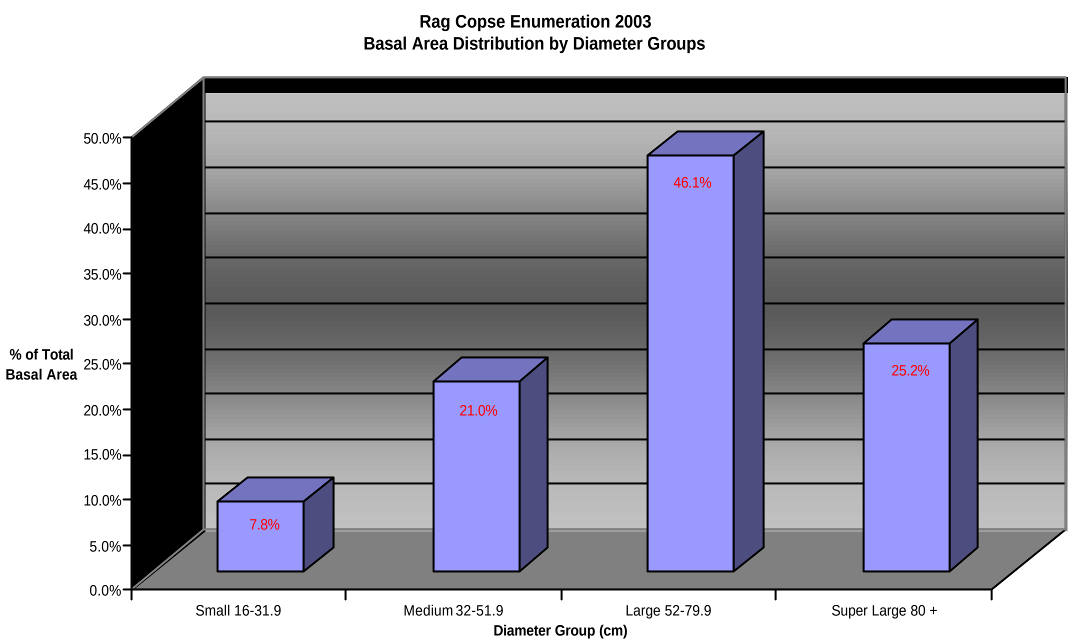
Brickyards Plantation



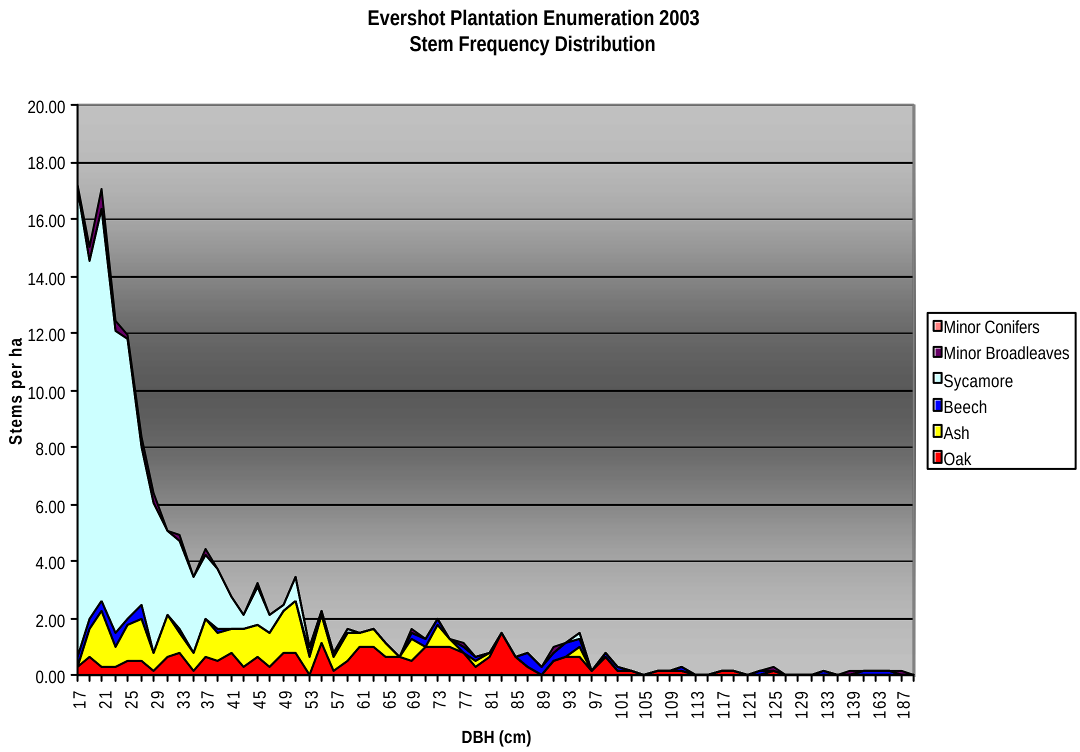


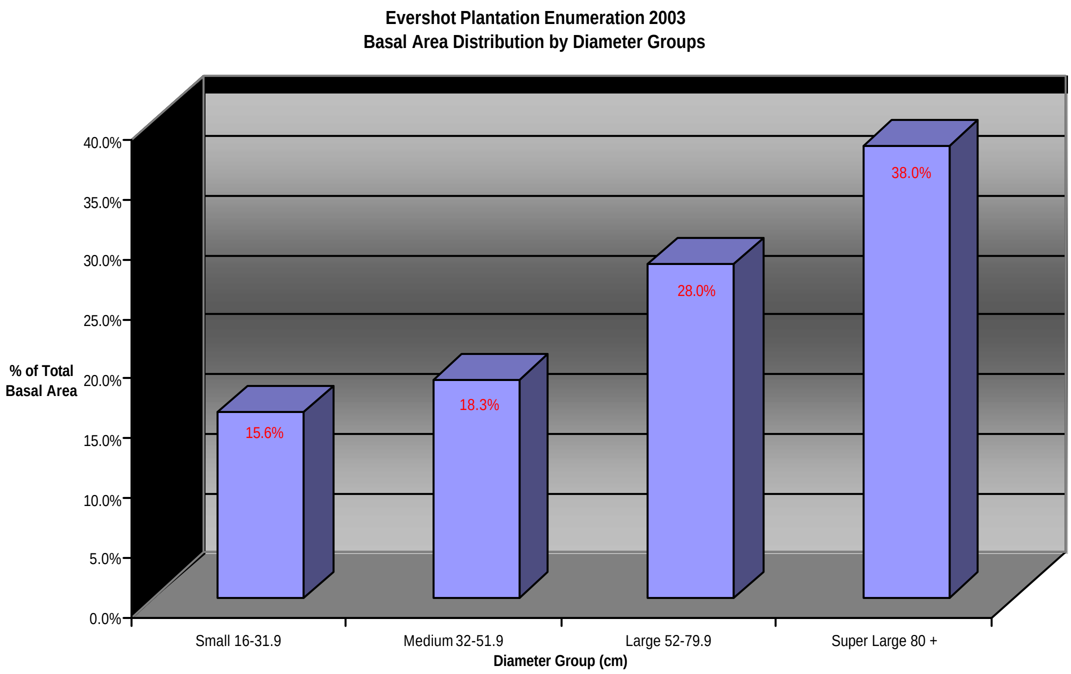
Rag Copse


Rag Copse Enumeration 2003
Stem Frequency Distribution
Stems per ha
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101 105 109 113 117 121 125 129 133 137 141 145
DBH (cm)
Minor Broadleaves
Beech
Ash
Oak

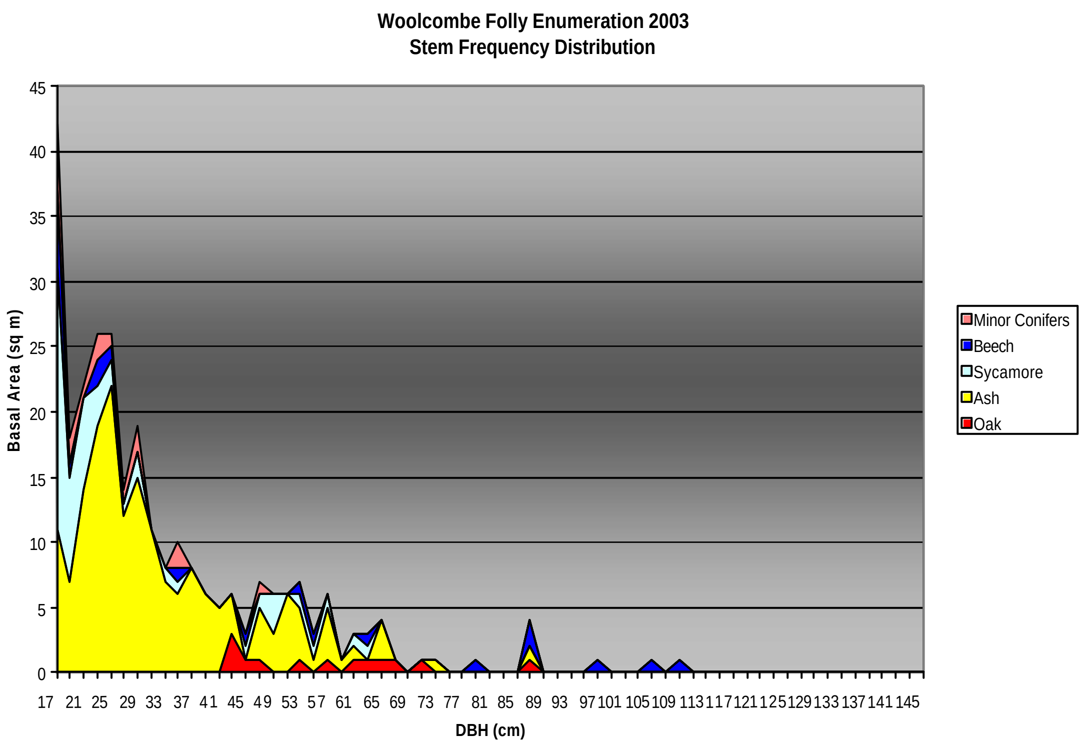

Rag Copse Enumeration 2003
Basal Area Distribution by Diameter Groups
% of Total Basal Area
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
7.8%
21.0%
46.1%
25.2%
Small 16-31.9
Medium 32-51.9
Large 52-79.9
Super Large 80 +
Diameter Group (cm)

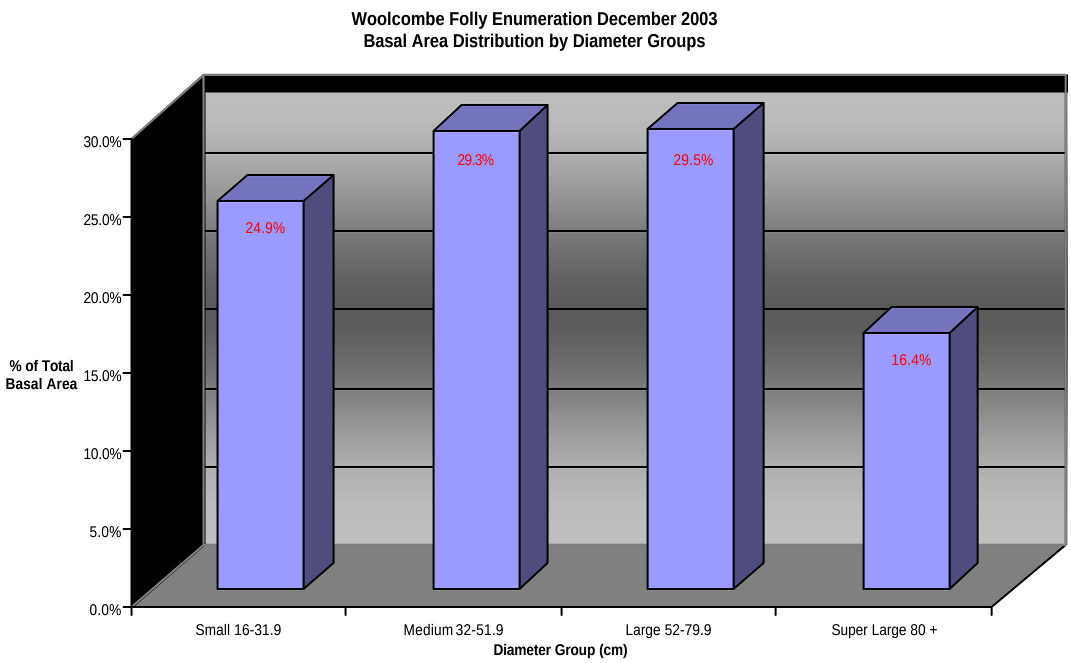
Evershot Plantation





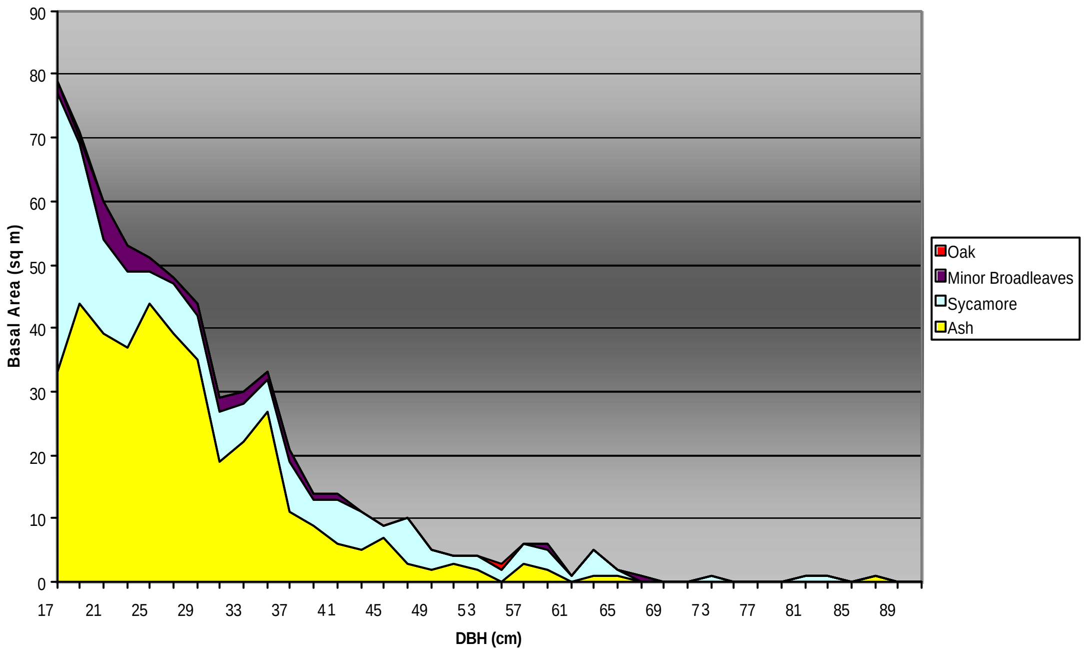
Woolcombe Folly



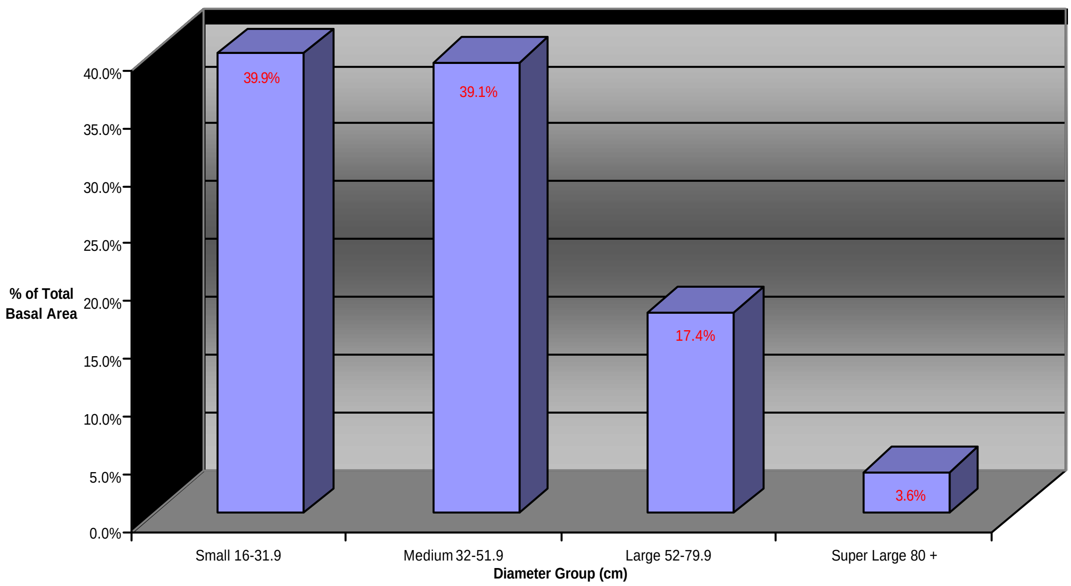


Hill Plantation

Hill Plantation (excl. N & E boundary strip) Enumeration 2003
Stem Frequency Distribution



Hill Plantation (excl. N & E boundary strip) Enumeration 2003
Basal Area Distribution by Diameter Groups



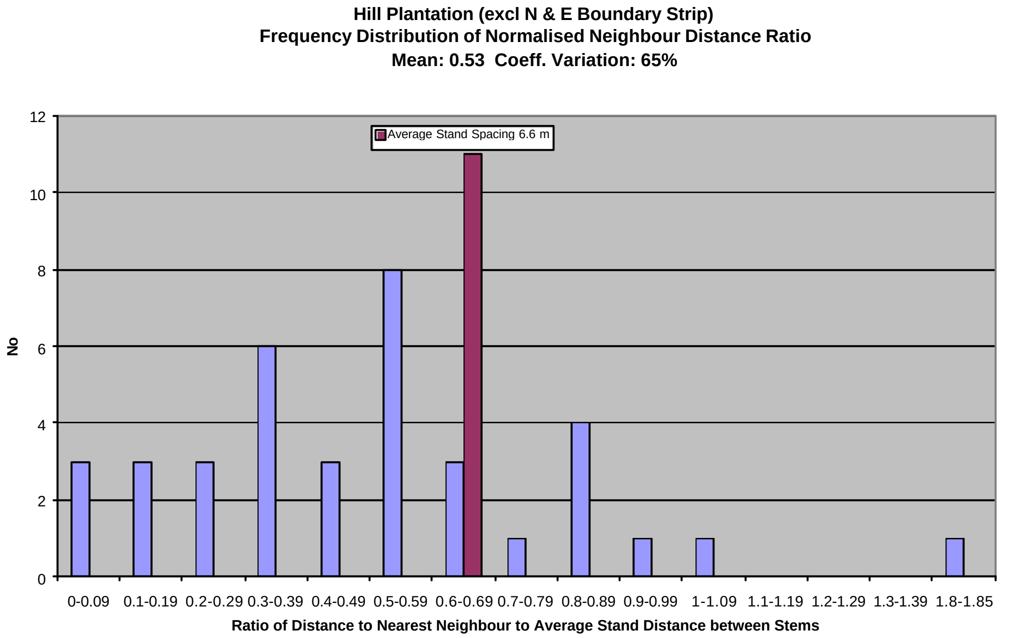
4.4 Spatial Diversity

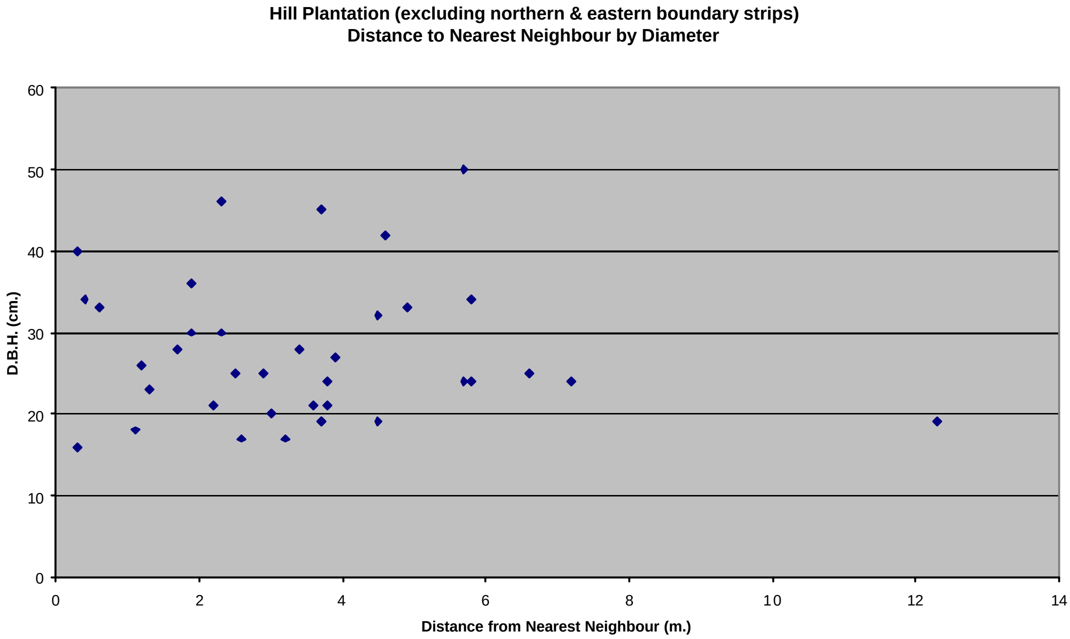
Information on spatial distribution was obtained from two of the more spatially diverse stands, Rag Copse and Hill Plantation, neither of which have a plantation history and on the more uniform stand of plantation origin, Parsonage Copse. The aim was to explore how useful the parameters described in Section 2.4 above were in practice and whether the a priori interpretation of the Normalised Neighbour Distance Ratio sample measurements was broadly correct.

Given below for each stand is the following data:

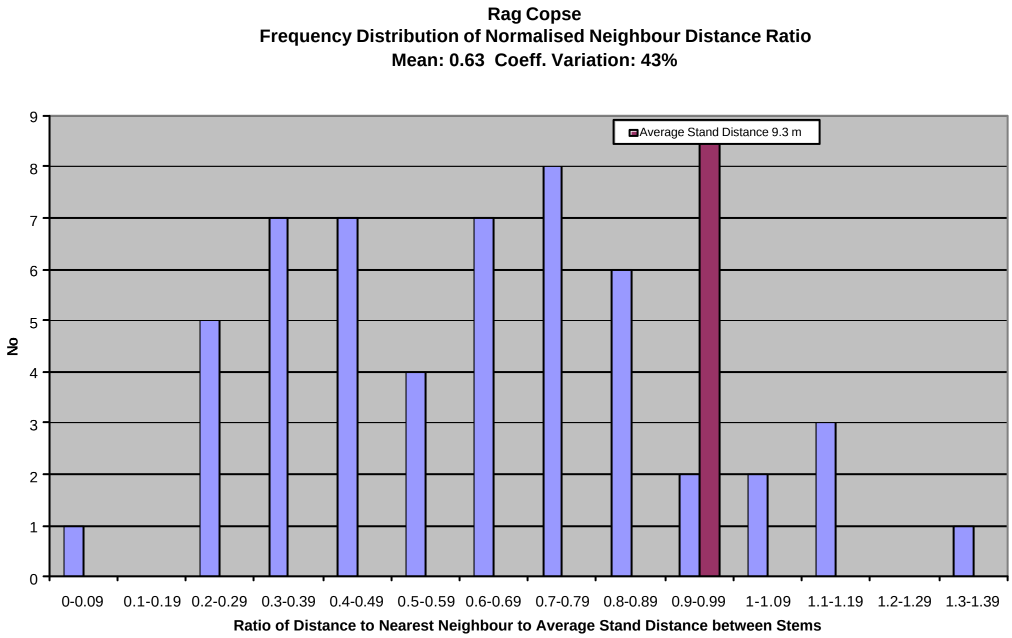
- A chart showing the frequency distribution of the measurements of the Normalised Neighbour Distance Ratio. The mean NNDR is also shown together with the coefficient of variation.
- A chart showing the scatter of actual distances to the nearest neighbour shown against the dbh of the selected tree.

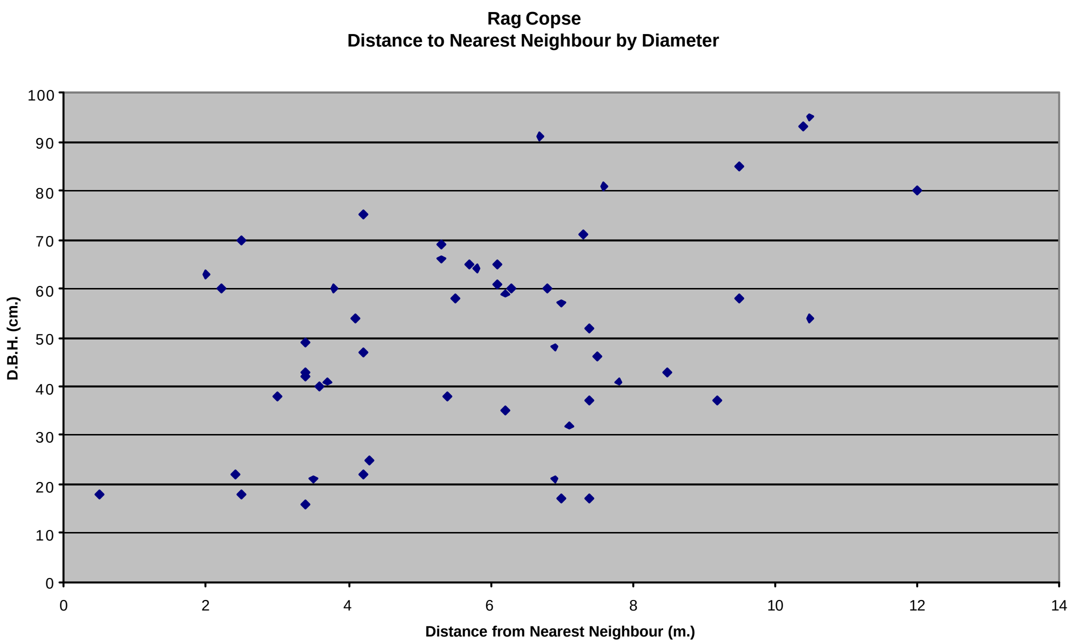
Hill Plantation



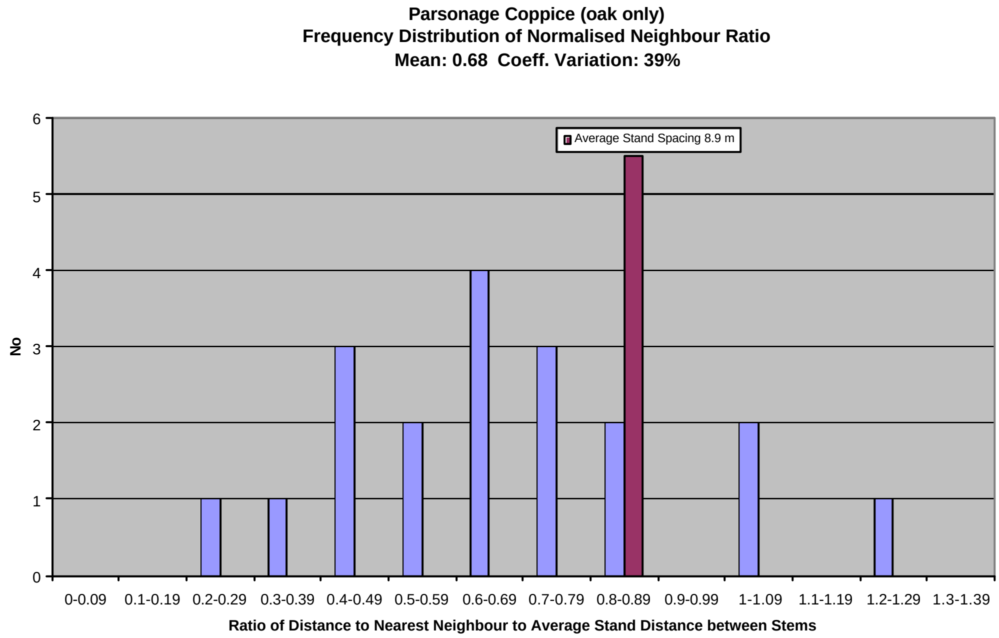


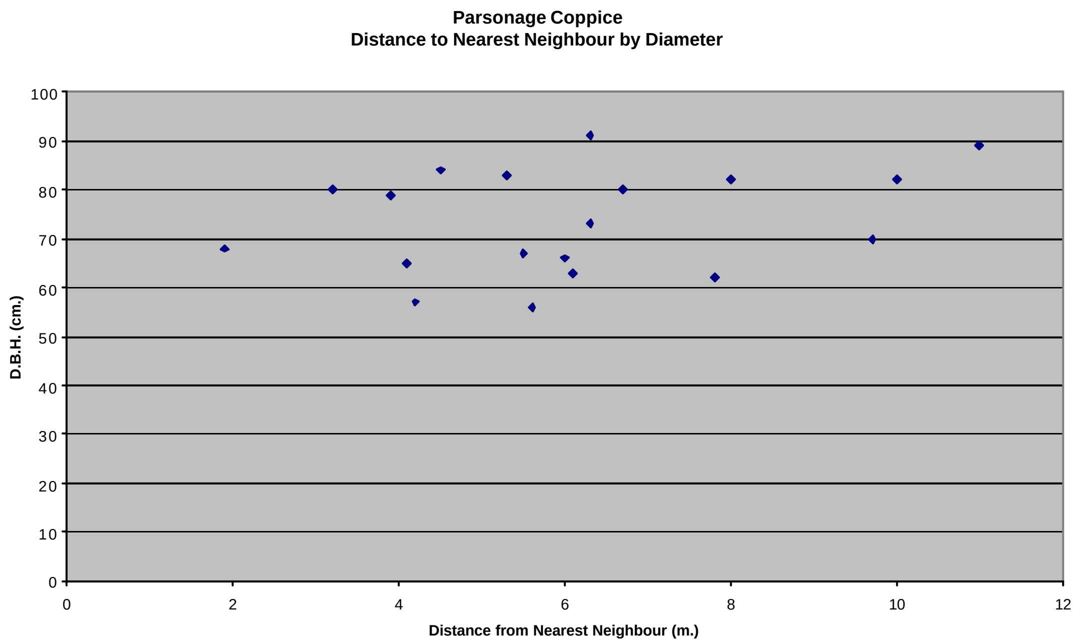
Rag Copse


Rag Copse
Frequency Distribution of Normalised Neighbour Distance Ratio
Mean: 0.63 Coeff. Variation: 43%
Average Stand Distance 9.3 m
No
0
1
2
3
4
5
6
7
8
9
0-0.09
0.1-0.19
0.2-0.29
0.3-0.39
0.4-0.49
0.5-0.59
0.6-0.69
0.7-0.79
0.8-0.89
0.9-0.99
1-1.09
1.1-1.19
1.2-1.29
1.3-1.39
Ratio of Distance to Nearest Neighbour to Average Stand Distance between Stems


Rag Copse
Distance to Nearest Neighbour by Diameter
D.B.H. (cm.)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
Distance from Nearest Neighbour (m.)

Parsonage Coppice





4.5 Cost of Enumeration

The time taken on the full enumeration was recorded and is given below.

Enumeration Area	Hrs	Hrs/ha	Stems/ha	Hrs/100 stems	Comments
Rag Copse	26	6.0	117	5.1	More open structure: less understorey more bramble
Annesleys A + B	40.5	8.2	141	5.8	More open structure: less understorey more bramble
Brickyards Plantation	10.5	3.7	101	3.7	More open structure: more understorey less bramble
Evershot Plantation	38.5	6.3	161	3.9	
Hill Plantation	25	8.0	224	3.6	Less fertile
Woolcombe Folly	9.75	9.9	281	3.5	Less fertile
Parsonage Copse	4.5	5.1	125	4.0	

The hours spent per hectare varied considerably from 3.7 to 9.9 hours. The main factors which determined the time spent was the number of stems per ha and when the time per 100 stems is considered the results are uniform for two classes of site; sites with easy access between stems taking between 3.5 and 4.0 hrs per 100 stems and sites with more bramble, rank herbaceous growth taking 5.1 to 5.8 hours

The degree of bramble etc. is dependant on:

- the degree of openness in the stand and
- the site type.

In terms of costs the measurement cost per hectare varied from £35 to £92 per ha with an average of £62.

5. Discussion

5.1 Stand Enumerations

These first stand enumerations give a snapshot of the stands which with repeated measurements will yield increment information as well.

The results provide some interesting information with regard to stands in the course of transformation.

In terms of *overall growing stock size*, stocking densities as expressed by basal area varied from 36.7 sq. m per ha (>16 cm dbh) in the more or less closed even-aged stand at Parsonage Coppice to 16.7 sq .m. per ha at Hill Plantation which has arisen spontaneously and has had one intervention. It has been suggested in France that stocking densities of around 17 sq .m. per ha (>16 cm dbh) might be appropriate for developed structures of ash and oak[5]. Hill Plantation, therefore, gives an idea of what this level of growing stock might look like. The basis for this French recommendation and its relevance to southern Britain will be explored in Part 2.

The actively managed, oak dominated stands at Brickyards Plantation, Annesley's Plantation and Rag Copse had stand densities of 22.6 to 25.1 sq .m. per ha suggesting that further reduction in overall stocking will be required during the transformation process. These stand densities have, however, allowed the commencement of largely ash seedling regeneration although the recruitment of saplings has yet to take place.

The mixed species stand at Evershot Plantation has a basal area of 24.6 sq .m. per ha and it may be that given a higher proportion of sycamore and beech the appropriate overall density may not be as low as 17 sq .m. per ha. Sycamore seedling regeneration is now occurring in this stand but little ash or oak has developed yet[6].

The final stand at Woolcombe Folly stands at 30.7 sq .m. per ha and represents an ash dominated stand in an earlier stage of transformation with no regeneration appearing as yet.

Stand density expressed as stems per ha varied from 101 stems per ha at Brickyards Plantation to 281 at Woolcombe Folly.

Stand structure, as measured by the distribution of stems by diameter and basal area by diameter group, varied considerably.

The two stands of plantation origin with a more active management history, Annesley's Plantation and Brickyards Plantation, have a somewhat more diversified structure with a smaller, predominantly ash, size cohort present when compared with the uniform, unmanaged Parsonage Coppice; the stem frequency distribution of the

[5] F. Jacobee (2000) Converting coppice-with-standards into close-to-nature forests in the hill country of France. Congress Report, Pro Silva 3rd International Congress p166-177. Pro Silva
[6] see Kerr (2002) Forestry, 75:227-243.

oak in all three stands is rather similar. Once the data is considered by basal area rather than by stem numbers, however, it can be seen that the distribution by Diameter Groups of Annesley's Plantation and Brickyards Plantation has begun to diverge from the undifferentiated Parsonage Coppice.

At the other extreme, Hill Plantation presents a more classically irregular stem frequency distribution. However, it's relatively young age and predominance of smaller diameter stems, is shown in the basal distribution by diameter groups. The 40:40:20 ratio of small:medium:large/super large compares with a more developed structure which might be more like 30:30:40.

In terms of the distribution by basal area Woolcombe Folly is further advanced and the stem frequency distribution is also quite good. Here stand density reduction is the issue, and lack of recruitment, rather than the structure per se.

Evershot Plantation has an interesting structure with a wide spread of size-classes but with too many stems in the large sizes and with the smaller cohorts dominated by sycamore. The former point is demonstrated by the basal area distribution with 54% in the large/ super large category and almost 40% in the super large category alone.

Finally Rag Copse is an interesting example of a relatively uniform stand which has developed naturally from a coppice-with-standards structure rather than by plantation. The basal area distribution is strongly dominated by the larger size groups and the stem frequency distribution shows that much of the smallest size cohorts have high proportions of minor species, ie field maple, alder etc. The size range of oak is quite wide, however, and together with ash shows a significantly different structure from the plantation derived stands in transformation at Annesleys Plantation and Brickyards Plantation.

5.2 Spatial Diversity

The overall results in terms of the mean Normalised Neighbour Distance Ratio and the coefficient of variation of the distribution are as follows:

	Mean	Coefficient of Variation
Hill Plantation	0.53	65%
Rag Copse	0.63	43%
Parsonage	0.68	39%

The differences in the mean NNDR is not great although the more differentiated Hill Plantation has a lower value. The Coefficient of Variation is more variable with Hill Plantation having a considerably wider distribution of values.

Although these stands have different origins the two actively managed stands have only begun to be transformed and Parsonage Coppice is an old plantation where some differentiation has occurred naturally. The parameters do seem to behave in a manner similar to that described in Section 2.5 above and it would be interesting to assess these parameters firstly, in stands which were more structurally developed and secondly, which are nearer to the original plantation event.

The scatter diagrams give an impression of to what extent diameter is related to the NNDR. In a well structured permanently irregular stand one might expect a **lack** of correlation between these two parameters, particularly with regard to the larger diameter sizes. In addition ideally with oak and ash it might be desirable to have some aggregation of the smaller sizes to promote natural pruning and this would also show in the scatter diagram.

In the event the scatter diagrams of the sampled stands emphasise the differences between the stands to a greater degree than the NNDR distribution:

- Hill Plantation has some aggregation in the smaller sizes and a reasonable spread of larger sizes.
- Parsonage Coppice has a surprising degree of spread in the larger sizes but no aggregation in the smaller.
- Rag Copse has aggregation in the middle sizes and considerable spread in the larger pointing to an intermediate position between the other 2 stands.

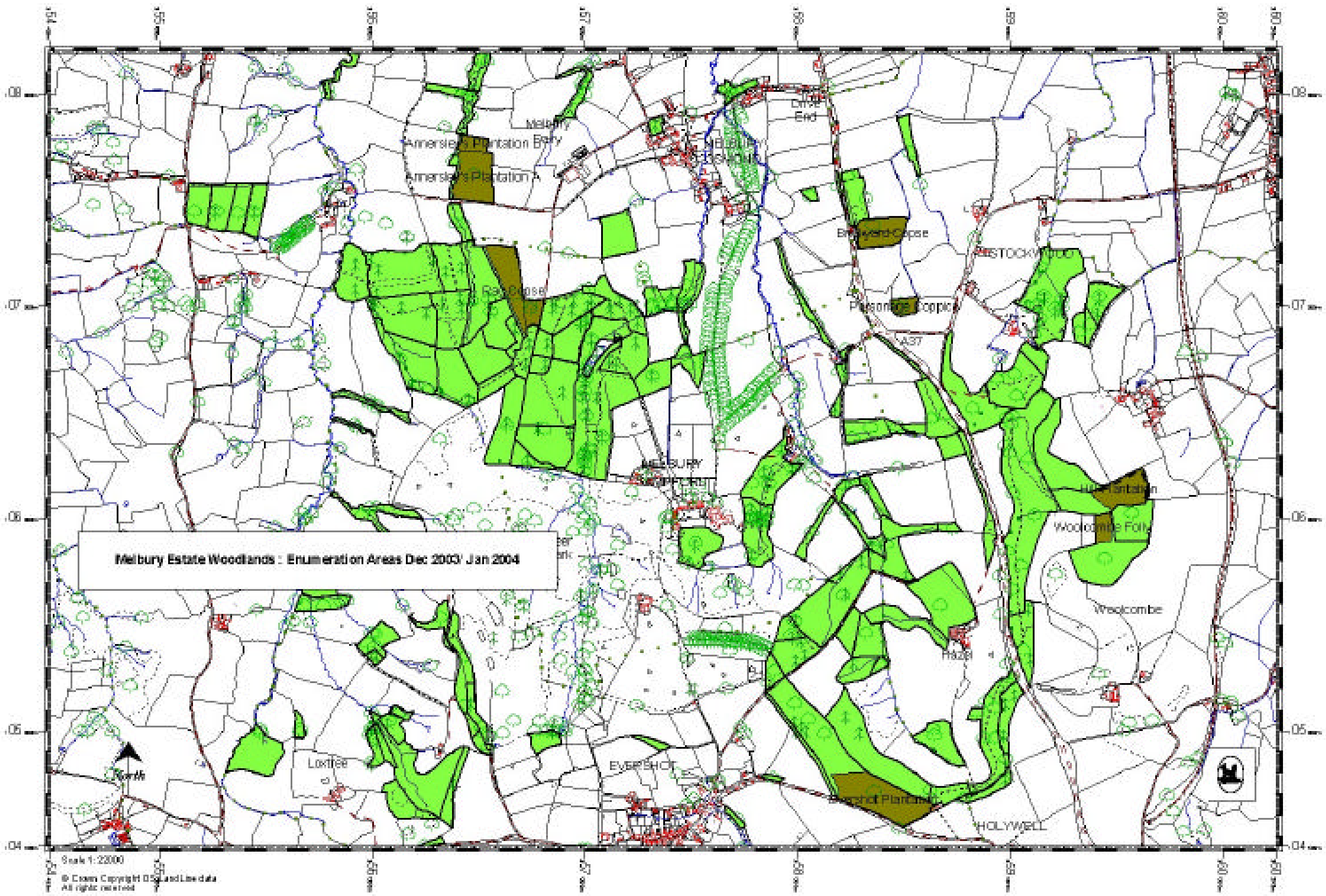
5.3 Cost of Enumeration

Overall the new approach with one operator and the use of callipers and Dictaphone has proved efficient and where stems numbers per hectare was low and access good the cost per ha fell below £50. However as the stands proceed through the transformation process growing stock levels will decline and access will become more difficult. Counterbalancing this stem numbers per ha will also decline as the stands develop to around the 150 per ha.

The average direct measurement cost of around £60 per ha encountered across all stands is likely to be similar to that applicable in developed structures. Adding 10% for supervision and data input this equates to £66 per ha. Assuming a felling/ enumeration cycle of 8 years this represents around £8 per ha per year for the sample stands. If 10% of the forest area lies within these sample stands then the overall mensurational cost is less than £1 per ha per year.

The effect of stem number per ha on the enumeration cost reinforces the point that this approach should not be introduced until stands have proceeded someway down the road to an irregular structure.

Appendix 1: Map of Enumeration Areas


Melbury Estate Woodlands : Enumeration Areas Dec 2003/ Jan 2004
Annersley's Plantation B
Annersley's Plantation A
Rag Copse
Parsonage Coppice
A37
STOCKWOOD
Hill Plantation
Woolcombe Folly
Woolcombe
Hazel
Evershot Plantation
HOLYWELL
EVERSHOT
Loxtree
MELBURY
North
Scale 1: 22000
© Crown Copyright OS Land Line data
All rights reserved

Appendix 2: Enumeration Field Procedure

Melbury Estate
Enumerations 2003/2004

ENUMERATION FIELD PROCEDURE
One operator recording & measuring.

- .Determine Permanent boundary to area being enumerated.
- Start at one corner at the bottom of any slope and proceed in staggered line uphill. At the top of each 'run' return to the bottom and start again. Apply the same procedure on flat ground. This is to enable measurers to see easily which trees have been measured.
- Measure the diameter of each tree at 1.3m. above ground (attach a safety pin to clothing at this height) **with callipers wherever possible**.
- Measure trees on the far side of the line of walking (this will be on the top side on slopes). If using callipers measure in one direction only at right angles to position of measurement. Trees forking below 1.3m are treated as two trees.
- Only measure trees **above** 16 cm. dbh. Measure all stems above this limit which have any chance of being still standing at the next enumeration or of being removed as marketable timber before the next enumeration.
- When using callipers and girth tapes the following should be noted:
  - **Callipers**
  - In order to ensure that the measurements taken in subsequent exercises match with the technique used in the 2003 enumeration the following points should be noted.
  - The shaft of the callipers should seat in the scribe mark/s as much as possible.
  - The callipers should be held level, at 90 degrees from the body of the recorder.
  - Where stems are not straight the scribe mark may appear to be at an angle. In this case the first point above is still essential but the recorder will have to alter the angle of the callipers accordingly.
  - The callipers should not be forced and the shaft must be kept clean and dry for ease of use.
  - In most cases the scribe mark will be on the uphill side of the stem but where this is not possible the mark can appear anywhere but 99% will be at, or close to, breast height.

  - **Quartergirth Tape**
  - The following points should be noted.
  - The tape should be at an even height around the stem, avoiding twigs and burrs etc.
  - Ensure that the tape is not twisted.
  - Take the reading from the furthest extent of the steel loop at the tapes end.

- Mark each measured tree with a small line at breast height at point of measurement. (i.e. on top side on slope ground). At subsequent enumerations mark at 2 cm. above previous line.

- Record the species and diameter of each stem on a dictataphone worn around neck. There is a danger that the record button is inadvertently switched off. To avoid losing data the operator should:

    - Say the words ‘end of run’ at the end of each pass.
    - At each break transfer information onto field data sheet.