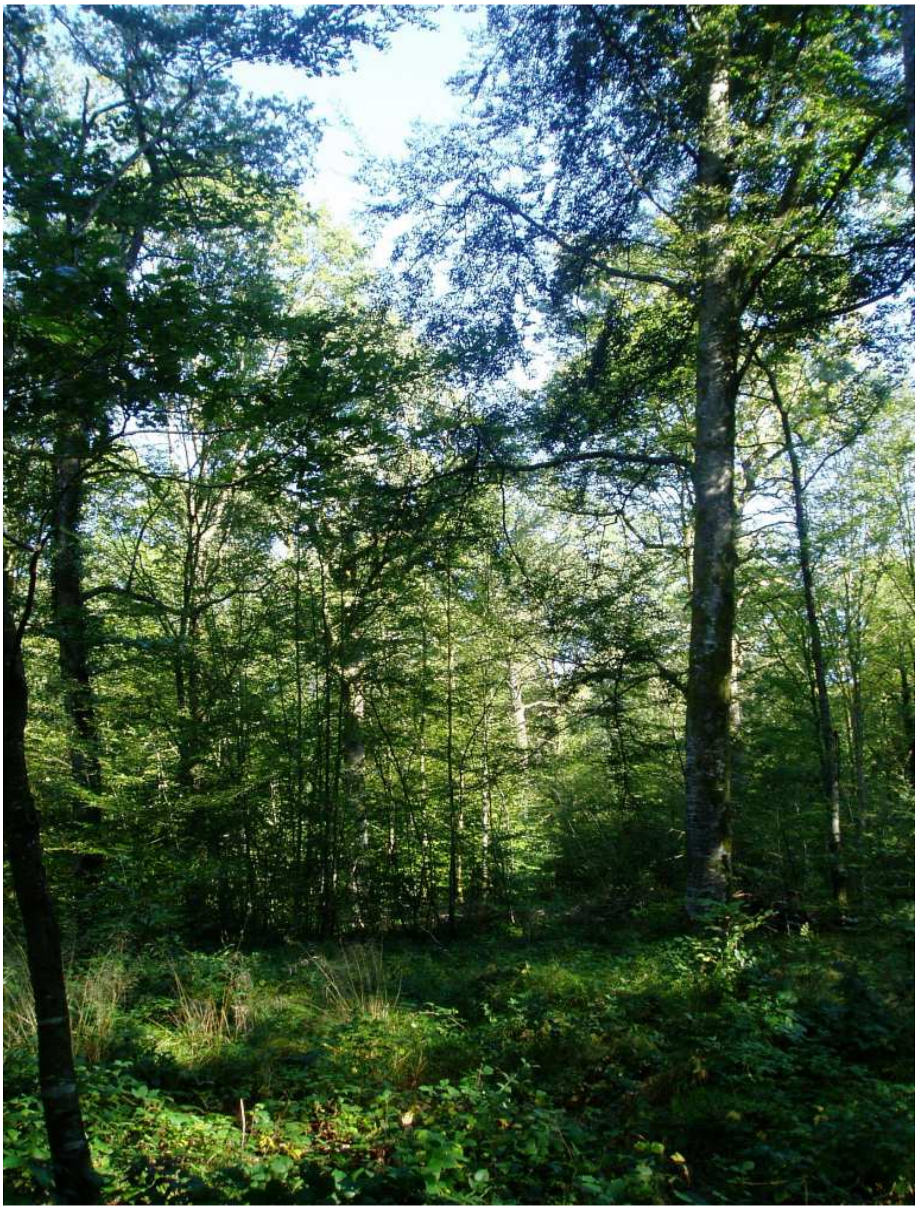
Continuous Cover Forest Management of Oak/Ash stands in the Lowlands: Stand Dynamics

Part 2: Continuous Cover Forest Management in France & the AFI Research Network: Implications for Continuous Cover Silviculture & Research in Southern England



A. Poore

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1. Introduction

The silviculture of mixed coniferous continuous cover stands in the Lowlands of the UK is now developing with the assistance of the large volume of experience and data available from central Europe and the increasing direct experience which is being gained in the UK. Data on stand structure and increment is beginning to be collected, at Stourhead (Western) Estate in Wiltshire, for example.

The situation with stands dominated by *pedunculate* oak and/or ash is very different. These stands, often on a range of soils from heavy clay soils and soils over chalk through to relatively fertile sands, are common in southern England and north-east and eastern France but are virtually absent from the areas of central Europe where CCF, and in particular selection systems, have been developed over the last 120 years.

Oak silviculture, and broadleaved silviculture in general, in France is highly developed but the classic oak forests of north central France are predominantly *sessile* oak stands growing on sandy sites and managed using the uniform shelterwood system. This approach involves the development of an even-aged mature stand that is removed completely by a series of interventions over a 15 to 25 year period. At the end of this process an even-aged pole-stage stand develops and this approach shares many of the features of a clear fell system except that it uses natural regeneration rather than planting.

The use of this approach has always been problematic on the richer sites due largely to weed competition when stands are opened aggressively. Since the 1980’s some French foresters in the private sector have been experimenting with the introduction of selection systems that would be more suitable on the richer sites and would avoid the problems associated with clear-felling. This process has been accelerated by the 1999 storm that began to undermine the French forester’s confidence in the conventional even-aged forest management approach, coupled with a growing need to adopt more cost effective silviculture in the face of falling timber prices and rising operational costs.

In the UK recent management of pedunculate oak and ash stands has consisted of neglect or the haphazard application of a small-scale clear-fell and re-plant approach. At Melbury and Rushmore Estates, however, the author has been undertaking transformations of oak and ash dominated stands by selection fellings on a range of soil types over the last 10 years.

The impetus behind the application of continuous cover principles in the UK Lowlands 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 that make up the majority of the resource.

The major question that this project aims to address is whether permanently-irregular structures produced by selection fellings can be created with oak and ash and what the transformation process and the developed structures would look like.

The aim of the first part of the project was to begin the establishment of a series of research stands which will produce information on stand structure and stand performance in terms of timber increment. There are few examples of systematically managed, irregular stands of these species in the UK, but as noted above, a range of stands on the Melbury Estate in northwest Dorset have been subject to interventions over the last 10 years designed to move the structure towards a structure likely to achieve permanent irregularity. Seven stands at Melbury were completely enumerated using the Check Method for the first time in winter 2003/4.

Part 2 of the project will consider the silviculture of continuous cover oak/ ash stands in detail in the light of recent experience and research in France.

In the late 1980's several pioneering private forest managers in France began to adopt continuous cover forest management principles in the silviculture of broadleaved stands where oak was the dominant or at least major stand component. Since then the application of these techniques has spread within the private sector and more recently in communally owned woodlands managed by the ONF, the state forest service.

Parallel with this a major research project has been developed by the Association Futaie Irrégulière (AFI), a group of private managers and owners, in association with the ENGREF, the leading forestry university and forest research centre in France based at Nancy. This project has established, since 1991, a network of research stands located within broadleaved forests with well-developed structures throughout eastern and northern France. All the managers and academics involved in the project have strong links with PRO SILVA, the European wide organisation promoting CCF.

A tour was undertaken in September 2005 of a number of these research stands organised and hosted by Max Bruciamacchie and Julien Tomasini, the scientific adviser and secretary of the AFI respectively and both academics at the ENGREF. A number of leading forest managers who have developed the silviculture of irregular broadleaves in France participated in the visit, including Roland Susse, President of AFI. This visit coincided with the publication of the second AFI report providing a synthesis of results from the AFI Research Network over the period 1991 to 2005[1].

This report considers the results of this research and its relevance to lowland England and particularly central southern and southwest England. The report further looks at the methodology of the AFI Network and considers whether a similar network might be extended to Britain.

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[1] Bruciamacchie, M., Susse, R. & Tomasini, J. 2005 *Gestion des peuplements irréguliers: Réseau AFI Synthèse 1991-2005.* AFI, Besançon

2. The background to continuous cover management in French broadleaved forests

The recent developments in irregular broadleaved silviculture in France have focused on the large area of mixed broadleaved forest that still exhibit a structure derived from coppice-with-standards. They are predominantly privately owned and oak commonly forms a major stand component. These stands, classified as 'mixed high forest-coppice' in the IFN (the National Forest Inventory), are still extensive and cover about 3.5 million hectares, which is over 25% of the forest area of France. In a large area of central northern and northeastern France this type of stand represents over 50% of the woodland area.

There are a number of important differences between these coppice-derived stands and those encountered in central southern England.

Firstly, the species composition of the coppice; in France the underwood has historically, and remains, a source of firewood and in northern and eastern France the coppice is often dominated by hornbeam with birch, aspen and lime as important associated species. Hazel does occur but as a minor component of the underwood. The 'coppice' species are, therefore, capable of reaching the canopy and are distinguished from the overwood by their multi-stemmed form and their short rotation. In southern England before the early 19th century, underwood was similarly managed for fuel production using the naturally occurring tree species. These mixed coppices, of ash, maple and hazel on calcareous sites with the maple and ash replaced by birch on more acid sites, were often converted to more or less pure hazel from the early 19th century. Despite the silvicultural effects of the decline of the coppice trades, coppice-derived stands today often retain an understorey dominated by hazel.

Given its species composition the French *taillis-sous-futaie* ('Coppice-under-high forest') is more robust in the face of neglect. Rotations in the coppice are long, normally around 25 years, and re-introducing cutting after a longer period is feasible in silvicultural and marketing terms. In France a steady increase in the density of the overwood of oak or even beech does not render the underwood unsaleable. In southern England, however, neglect in the form of both extended underwood rotations and increasing density of 'standards' lead very quickly to loss of viability in the underwood. Further, any silvicultural interventions in stands with a dense 'overstood' hazel understorey have to cope with the operational and financial problems it produces.

In France the conversion of coppice-derived stands to high forest has been a key object of management in the State Forests since the 1860's. The traditional approach has been to wait for a long period, undertaking light thinnings and singling to reduce the proportion of 'coppice' species, until a mature stand of oak and sometimes beech develops. Then the stand is regenerated using the uniform shelterwood system. This process can involve many decades during which virtually no income is forthcoming. Not surprisingly this prospect has not been very attractive either to private owners or in the large areas of community owned forest, although pressure from the State Service lead to the adoption of similar conversions here from the 1970's onwards[2].

This is the background to the large area of broadleaved woodland which retains its 'French coppice-standards structure'; a relatively low stocking of mature or maturing stems of the major canopy forming species, i.e. oak, beech and ash, mixed with multi-stemmed coppice last cut 20 to 50 years ago. Most stands also contain an element of maiden poles (termed '*perches'*) arising from the last or second last cut of the coppice.

In central southern England conversion to broadleaved high forest has taken place largely through conversion to oak plantations in the 19th century or through long-term neglect. In the latter case the end result is rather like the traditional French approach in that a one-storeyed stand of oak, often with some ash, arises through the growth of the standards. Underneath is a remnant understorey of hazel, which often also occurs in stands subject to plantation management either through chance or design.

In summary, neglected coppice-with-standards stands in northern and eastern France tend to have a relatively low stocking of larger 'timber' trees. Mixed with this is a relatively diverse, and relatively sparse, accompanying stand of multi-stemmed stems which can obtain some height and which can be managed at low cost as firewood, selectively if necessary. In contrast, neglected 'central southern English coppice-with-standards' tend to have a relatively uniform structure with a closed canopy, highly stocked, over-storey. The understorey is relatively dense, often dominated by hazel. It has no financial value, rendering it expensive to manage and almost impossible to treat selectively. This contrast is very significant silviculturally.

On more acid soils in central southern England birch becomes a more dominant component and the decline in coppicing and increased deer populations are favouring birch generally on soils over chalk as well. Structurally stands with birch and no hazel are closer to the French model. A few fragments also survive of 'unconverted' stands on heavy acid soils with lime, aspen and birch similar to those seen in eastern France. In other parts of the Lowlands stands similar to the hornbeam dominated French stands occur in eastern and southeastern England.

[2] Jacobée F. 2000 Converting coppice-with-standards into close-to-nature forests in the hill country of France. In Pro Silva Europe 3rd International Congress Report.

3. The AFI Network

The AFI is a constituted association that was officially registered in July 1991 by a group of private managers in order to promote the silviculture of irregular forest stands. Since then, much of the effort has been directed towards broadleaved forests, in part motivated by a wish to redress the traditional weighting towards conifers in irregular silviculture. The approach was closely allied to that of Pro Silva and to that of the leading players in the AFI, such as Roland Susse and Brice de Turckheim, who were also prominent in the development of 'close-to-nature' forest management at a European scale.

Since 1991 the group of managers within the AFI have refined the overall management approach and the silvicultural techniques of irregular silvicultural systems. In order to advance this process and to disseminate information, the AFI decided to put in place a network of 'reference' stands to demonstrate how managers were working and what was successful. A key principle of the network is that there is no overall prescribed management; *the network observes and chronicles the operation of experienced practitioners in well-structured forests owned by a range of private forest owners across a range of site types.*

As at the December 2004 there were 61 reference stands, normally on the basis of one stand per participating forest, each stand being a compartment between 5 and 15 ha in size. It should be noted that French forests, broadleaves included, tend to be large and relatively uniform. This stands in marked contrast to the extreme heterogeneity exhibited by the larger southern English forests, the product of 200 hundred years of dramatic changes in silvicultural practice, mixed with neglect and /or over-exploitation.

The AFI network consists primarily of broadleaved-dominated stands with a well-developed structure that are regarded as 'showcases' ('*vitrines*'). These forests have largely developed out of 'French coppice-with-standards' as described in Section 2. In addition, stands have been added because they are addressing specific silvicultural issues such as the early stages of transformation or the conversion of coniferous plantations. Overall, about 50% of the reference stands are oak dominated, of both species, and 20% are complex mixtures including oak. The other broadleaved stands are dominated by beech, ash and chestnut respectively plus four coniferous dominated stands (Douglas fir, silver fir and pine).

Site-type varies considerably and the network has specifically been constructed to investigate the AFI's contention that irregular silviculture is applicable to all site-types. A very wide range of sites is included in the network both with regard to nutrient status and moisture regime. The interaction of site, species and management is often subtle and in interpreting the mensurational data, and deriving the silvicultural implications, stands are grouped by site-type. Results are illustrated across several concrete examples rather than seeking to generate average values.

Climate also varies considerably across the network, particularly with regard to the summer moisture deficit that can be very severe in eastern France. Results are therefore also categorised by climate particularly with regard to the drier site-types where higher deficits have a significant effect on production.

The criteria for inclusion within the network has been, therefore, dominated by the need to include stands with well-developed structures under skilful and committed management across the full range of site and climatic types. From its beginnings in northeastern France the network has now spread to central, northern and western France. This expansion has allowed in particular the examination of the response of oak to selection systems across different climatic conditions with regard to seed year frequency, growth rates and light variables. The inclusion of Picardy has introduced stands on rich sites dominated by ash, cherry and sycamore. Expansion allows existing results to be affirmed and 'calibrated' with regard to climate and site.

A number of other stands have been established outside the network by various organisations (in particular stands set up by the ONF, the French state forest service, in different regions). These are designed and treated with the same AFI methodology, and are monitored by the AFI.

Further expansion of the network will be because a stand represents a novel site type or geographic situation or is representative of stands with particular problems relevant to the wider application of irregular silviculture.

The development of the research methodology adopted by the network and the actual data collection and analysis has been undertaken by the ENGREF (*L'Ecole Nationale du Genie Rural, des Eaux et des Forests*) at Nancy, the premier forestry university in France. The funding for the network has come from regional government, regional timber and forestry organisations.

The data are collected using repeated measurements on permanent sample plots, generally ten in number, across each reference stand. The plots are nested, with a wider range of measurements, e.g. seedling and sapling regeneration, being taken in the inner plots. The location of all stems measured is plotted so that their removal between measurements can be detected.

Two types of mensurational data are collected:

- **overall stand data**: the procedure incorporates the 'Check Method' and provides stand level information on the size and increment of the growing stock and its components. Measurements include the trees within the main stand (here defined as being over 17.5 cm diameter at breast height (dbh)) and the smaller stand elements including regeneration and multi-stemmed trees (*le taillis*).
- **individual tree data**: these relate to mensurational data, e.g. height, crown dimension, and also to quality.

It should be noted here that the management of most of these forests is strongly directed towards the production of quality hardwood timber. Both mensuration and silviculture is focused on this issue and the classification of growing stocks and removals by simple quality classes is ubiquitous.

These measurements are repeated on a five yearly basis irrespective of the felling cycle. By 2005 10 reference stands had been measured three times and 38 twice. 12 or more parameters had been recorded on over 10,000 individual trees.

In addition to mensurational data, information is also collected about the **economic performance** of the stands over time. These data cover the revenue account items; timber, sporting and grant income and detailed costs involved with harvesting, tending, maintenance and management as well as other costs such as taxes and insurance. In addition to these data the mensurational data is used to generate information on the evolution of the capital value of the stands. The value increment of each species and size category is calculated and this, when combined with a constant discount rate of 4%, produces a measure of the potential value of the stands, a form of ‘expectation, value.

A very succinct and informative global economic picture of each reference stand is then produced by combining the average annual profit/loss and the average annual change in the capital value (in terms of actual standing value) and a measure of the overall economic return. This latter is expressed in two ways; one uses the sum of the profit/loss accounts and the change in *actual standing* value over the 10 year period and the other uses the sum of the profit/loss accounts and the *potential, or expectation,* value. This allows an evaluation of the actual economic production and changes in the productive capacity of the stand. The analysis then groups stands with similar characteristics and economic strategies and then relates these to the silvicultural issues.

The rest of this report will consider the main silvicultural issues raised in the 2005 Synthesis Results publication[3], illustrated by some of the stands actually visited. The potential implications for continuous cover management of broadleaves in England are then considered.

[3]Bruciamacchie, M., Susse, R. & Tomasini, J. 2005 *Gestion des peuplements irréguliers: Réseau AFI Synthèse 1991-2005.* AFI, Besançon

4. The silviculture of French irregular broadleaved stands as demonstrated by the AFI Network

4.1 The management of the growing stock & its interrelation with regeneration

The choice of the level of growing stock is regarded as of fundamental importance and corresponds with the prominence which regeneration has within even-aged forest management.

One of the key aims of the AFI Network is to provide managers with guidance on the appropriate level of growing stock which permits continuously optimal production for different species mixes across different sites and climatic conditions. *This optimal production level is achieved by distributing the available timber increment onto the quality stems and by creating a sustainable framework in which an appropriate distribution of size groups is combined with sufficient regeneration and recruitment***.** This succinctly defines the structural timber production aspirations of the manager of permanently-irregular stands of all species.

Growing stocks across the network are described in terms of basal area rather than volume in order to aid comparisons by avoiding the effect of the variation in local volume tables on the conversion to volume. As the development of an irregular structure proceeds and stand structure becomes more stable, the relationship between basal area and volume over time also becomes stable and so basal area becomes an even more effective measure of overall stand density.

Individual trees from seedling to mature stems are classified by size as shown in Table 1.

Main Category	***Sub Category***	***French Term***	***Diameter Range at breast height (cm) unless stated otherwise***	***5 cm Diameter Classes***
Measurable Trees (>17.5 cm dbh	Large Trees	*Gros Bois (GB)*	>47.5	50+
	Medium Trees	*Bois Moyen (BM)*	27.5-47.5	30-45
	Small Trees	*Petit Bois (PB)*	17.5-27.5	20-25
Poles (maidens)		*Perches*	7.5-17.5	10-15
Coppice (multi-stemmed trees)		*Taillis*	7.5-17.5	10-15
Recruitment & Regeneration (<7.5 cm dbh)	Large Saplings	*Gaules*	2.5-7.5	
	Small Saplings	*Grand Semis*	>1.5 m height–2.5 cm dbh	
	Seedlings	*Semis*	50cm height–1.5 m height	

Table 1: Classification of trees in AFI methodology

The ‘measurable’ trees, *les précomptables*, correspond to those stems forming the main body of the stand. These are the stems that would be included in repeated enumerations under the Check Method. The French convention is to use 5 cm diameter classes with a minimum of 17.5 cm (Dbh Class 20) whilst the Swiss use 4 cm classes with a minimum of 16 cm (Dbh Class 18). It was the latter that was used in the enumerations in Part 1 of this project.

However, the network is also interested in the smaller sizes and there is often a significant number of larger multi-stemmed trees between 7.5 and 17.5 cm dbh in size. These, together with the maiden poles, make up the ‘*le sous-étage*’, or understorey in direct translation. The overall amount of understorey, and particularly the distribution between maiden and multi-stemmed trees, is important silvicultural issues as the transformation from coppice-with-standards to irregular high forest proceeds.

Below this come the seedlings and saplings classified into three groups. Multi-stemmed trees below 7.5 cm dbh are classified in with these categories and most of southern English ‘understories’ would be classified as regeneration in France. This again shows this important distinction between French and southern English stands.

Figure 1 shows the basal area of all the reference stands at their first measurement and the concurrent density of seedlings and saplings in terms of number per hectare by species. The basal area is divided between the measurable trees, poles and ‘coppice’. The sites are grouped by site type along a nutrient gradient. 59 of the 61 stands illustrated are broadleaved dominated.

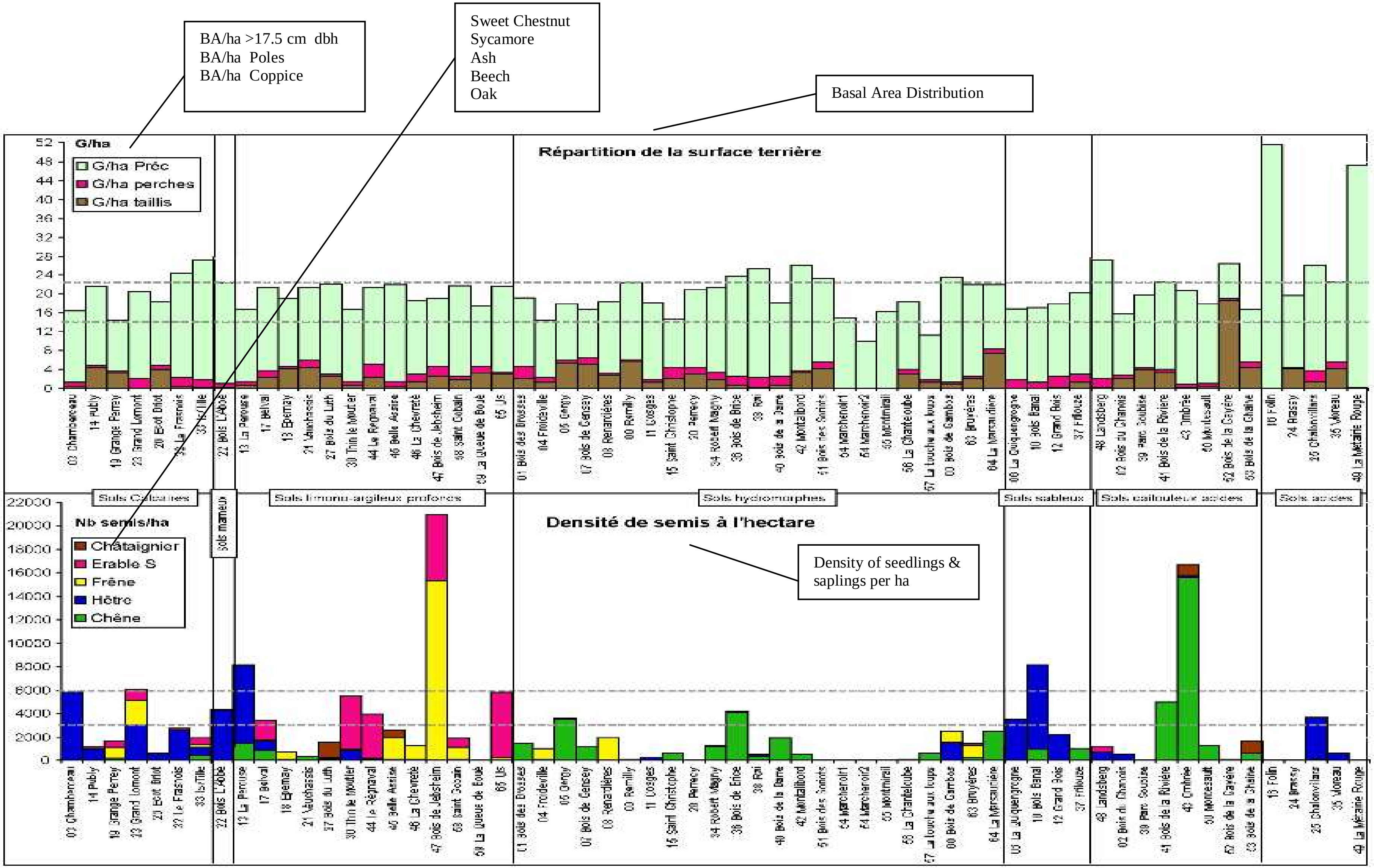

Figure 1: Relationship between growing stock size and regeneration across all AFI research stands (after Bruciamacchie, M. Susse, R. & Tomasini, J. 2005 ob cit, fig 4, p 11).

The first broad point which the authors make here is that, despite the lack of direction from the AFI, the 9 forest managers involved have developed growing stocks within a relatively narrow range of 14 to 22 square metres per hectare for all trees over 7.5 cm dbh and 12 to 20 for those over 17.5 cm. The two stands with high basal areas are coniferous stands in the early stages of transformation.

Relating basal area to regeneration and recruitment in *oak* stands on the lower nutrient, more acid and gleyed sites, growing stocks of 12-15 square metres per hectare for the 'measurable' trees plus 3-5 in the understorey permits a suitable level of regeneration. This regeneration is diffuse but spasmodic and is *sometimes* concentrated in small holes formed by the removal of one large mature tree. Of the 3-5 square metres per ha in the understorey it is preferable if less than 3 are 'coppice'.

With regard to the climatic range covered by the network it is felt that this level of growing stock is particularly appropriate to the west where higher levels of luminosity allow the use of slightly denser stands.

We visited 3 stands of this type at Forêt de Gergy (AFI Stand No 5), Bois du Château (AFI Stand No 15) and Forêt de Fresnoy en Bassigny (a communal woodland managed by the ONF). These stands are situated in eastern France in Burgundy and the Haute Marne. The growing stocks of these three stands at their last inventory are shown in Table 2.

The diameter distribution of the AFI research stands is given in terms of stems per hectare by diameter class but also in terms of the proportion of basal area falling within broad diameter size groups (see Table 1). This latter parameter is used in overall stand assessments and as a framework for considering how removals have been conducted. The diameter distribution is *not* used specifically as a guide to marking.

Forest	*Location*	*Site*	*Species*	*Basal Area (sq m/ha)*				*% of BA in Diameter Size Groups (as defined in Table 1)*			*Density of seedlings & saplings per ha*	
				Total	*Measurable (>17.5 cm dbh)*	*Poles*	*Coppice*	*Large*	*Med.*	*Small*	*Total*	*Of which oak*
Forêt de Gergy (AFI)	Burgundy	Mildly acid silty clay gley.. 800 mm rainfall p.a..	pedunculate & sessile oak + lime & aspen	**17.6**	15.0	1.4	1.2	41	35	24	2782	1791
Forêt de Fresnoy (ONF)	Haute Marne	Fertile sandy silty loam.	oak, beech + ash, cherry & service.	**17.9**	15.4	c. 2.5		69	31		?	?
Bois du Château (AFI)	Burgundy	Mildly acid silty clay gley.. 760 mm rainfall p.a..	pedunculate & sessile oak + hornbeam, aspen, birch and cherry.	**20.2**	16.5	0.7	3.0	29	43	28	7403	2452
Forêt de Vivey (ONF)	Haute Marne	Calcareous soil over limestone.	beech & sessile oak plus 9 other species including ash sycamore and 2 sorbus spp.		20.2 (>12.5 cm dbh)	?		56	33	19	?	?
Le Régnaval (AFI)	Picardy	Deep, neutral, silty soil over clay loam. 880 mm rainfall p.a.	pedunculate oak, ash, sycamore + 8 other species	**21.3**	16.3	2.8	2.2	53	21	25	8346	(sycamore 4008/ash & beech 188)

Table 2: Stand details at last inventory for five stands visited.

The general feeling amongst the AFI staff concerning these 3 oak stands was that the growing stock levels here were about right but that the density of poles, particularly of oak, was too low (see Photos 1-3). Within the main stand, the proportion of small trees was about right. At Gergy and Bois du Château the managers were endeavouring to increase the proportion of larger trees whilst at Fresnoy the aim was over time to replace some of the larger beech with larger oak with a concurrent small decline in the amount of large trees overall.

In all cases oak regeneration was evident spread throughout the stands with saplings developing as individuals and groups ranging up to 0.05 ha in extent. At Gergy small gaps of 0.01 ha appeared to be sufficient to allow the survival of groups of oak seedlings and saplings (see Photo 4) although saplings also appeared as individuals. At Bois du Château, oak regeneration and sapling density had risen from1084 plants per ha in 2001 to 2452 per ha now. At Fresnoy there were abundant large seedlings and poles of beech, ash and service (see Photos 5 & 6). Oak was present as dense seedlings in holes created by the removal of large beech (see Photo 7). *However, in none of the stands visited were significant gaps in the canopy created for the express purpose of creating a specific cohort of regeneration.* The obtaining of oak regeneration and regeneration in general, was not regarded as a problem on any of these sites.

With beech dominated stands, regeneration of beech comes easily on all soils, except for the gleyed site types, with growing stocks of 14-17 square metres per hectare. Over 20 square metres per hectare regeneration is much more uncertain and sparse. Surprisingly, given the usual perception of the 'shade-tolerant' beech and the 'light-demanding' oak, the difference between the growing stocks developed for irregular stands of beech and oak by the AFI managers is small, with slightly denser stands being preferred for beech.

Two stands on richer sites were visited (see Table 2). The communal forest of Vivey is in the Haute Marne in eastern France and is part of a very large forest block on a limestone plateau. The stands on calcareous soils have both a wide range of tree species and great floristic diversity. Tree species include the very valuable wild service, whitebeam and cherry. The Forest of Le Régnaval is again part of a huge forest situated in North-east France near the Belgian border. The deep silty loams are regarded as the most productive in France and are ideal for ash, cherry and sycamore. Wild service is not present but *Sorbus domestica* was seen. Here, as on richer sites generally, oak regeneration was more fragile with ash and sycamore being easier to obtain. The AFI staff felt that at Le Régnaval current stocking was a little on the high side given the importance of ash and cherry on the site and this is demonstrated by the relatively low level of ash regeneration. The distribution across diameter groups appears good at Le Régnaval, however (see Photo 9). At Vivey the local ONF staff considered that a major issue was to redress the imbalance between medium and small trees (see Photo 8).

The development of the growing stock over time has differed across these forests. At Gergy the present growing stock has stabilised after a period where capitalisation has taken place since the move away from coppice-with-standards began in 1971. Here the main removals were directed at steadily reducing the amount of coppice, particularly lime, and removing poor quality medium sized stems. A similar situation pertains at Bois du Château where a heavy wartime felling removed the larger trees. At Fresnoy, however, the current growing stock is an 'after felling' level at 2004 following 2 coupes since the previous inventory in 1998 when the basal area of measurable trees over 17.5 cm dbh had been 21.8.

Information on this development across eight of the AFI research stands, including Gergy, and more detailed information on regeneration is given in Figure 2. In this Figure the stands are grouped into three oak dominated stands on gleys, three beech dominated on reasonably well drained acid and calcareous sites and two ash/ oak sites.

The data show that with regard to the understorey, the three oak stands show a reduction in the amount of coppice over time whilst the level of poles has stayed more or less the same; the level of 'measurable' trees has increased despite removals. The AFI stresses the importance of appropriate management of the understorey in improving timber quality and managing light conditions for regeneration and Figure 1 also shows that in general there is a higher level of understorey and more coppice in oak stands. In beech stands the poles take over the role of 'educating' the regeneration and maintaining the quality of the main canopy trees. This is clearly shown in Figure 2, particularly in the well-developed irregular stands at La Quinquengrogne. Again it should be remembered that French 'coppice' will be much taller on average than southern British coppice dominated by hazel and has a more beneficial and more easily managed role in natural tending of the main stand. Another clear point made by the authors is that as the understorey density rises, regeneration density declines.

Both Figures 1 and 2 show that the relationship between the density of oak regeneration and growing stock density can be undermined by high deer populations and the infrequency of seed-years. At Gergy, the sharp decline between the second and third inventory was due to increasing deer numbers. *Even when the forester creates suitable light conditions throughout the stand, the obtaining of sufficient and well distributed oak regeneration remains at the mercy of '..the gift of acorns and the teeth of the deer'.*

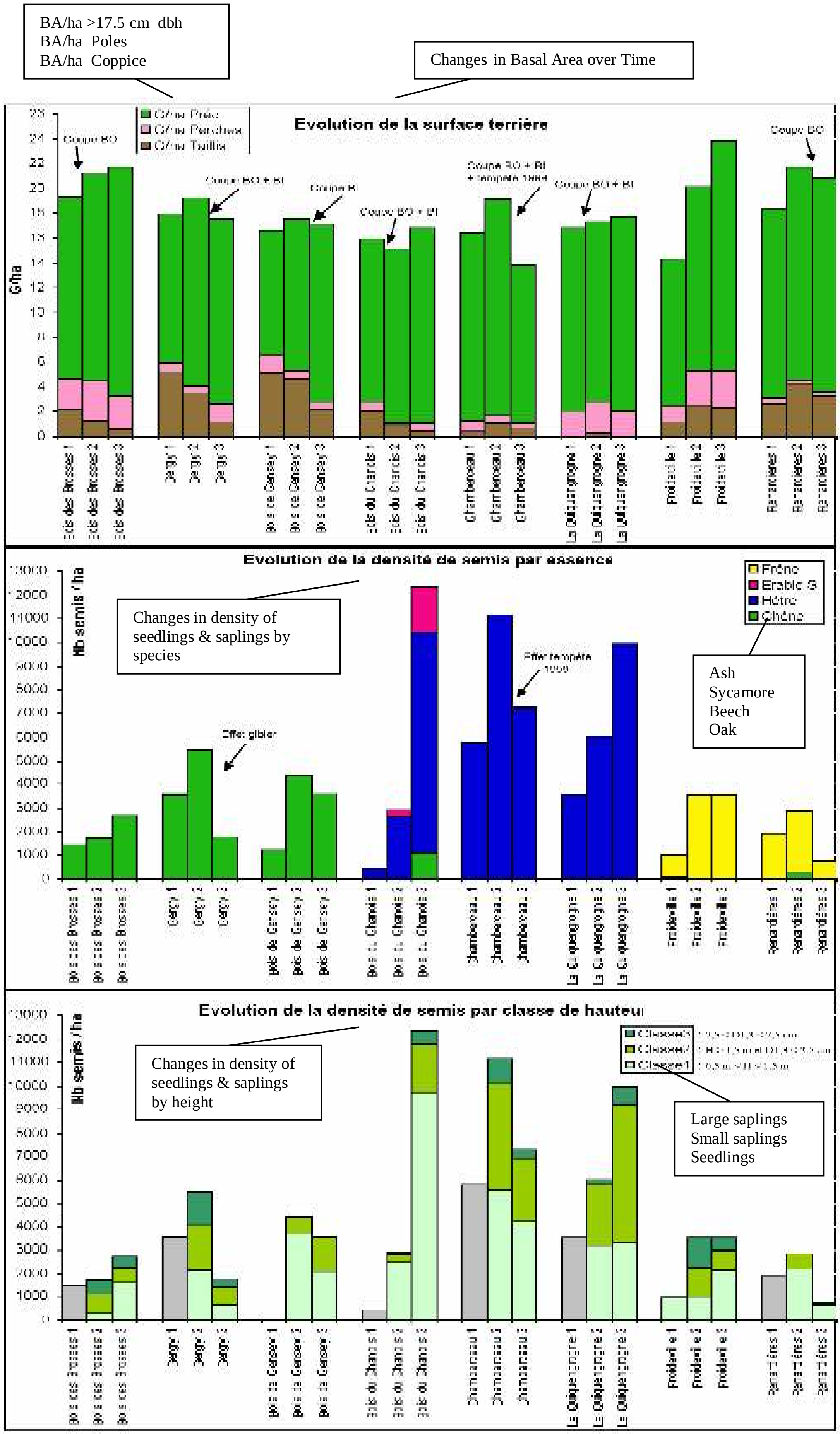

Figure 2. The evolution of the growing stock and levels of regeneration over 3 inventories on 8 selected research stands (after Bruciamacchie, M, Susse, R. & Tomasini, J. 2005 ob cit, fig 5, p 13)

Figure 2 also shows that despite the preferred overall growing stocks of oak and beech dominated stands being broadly similar, the *amount* of regeneration, particularly seedlings, is higher in the beech stands.

Finally, the lower section of Figure 2 shows how the proportion of seedlings and small and large saplings changes over time. One basic point is that as seedlings develop into saplings their number declines naturally so that global figures of all the regeneration classes per hectare may be misleading.

4.2 Production: Fellings and Increment

The felling cycle for cutting timber in broadleaved stands varied between 7 and 15 years depending on the type of stand and the owner's objectives. The percentage of basal area removed during the cycle under normal conditions was between 15 and 25% of the initial stand density. Fellings in the understorey, or to remove windblow after the 1999 storm, took place outside of this cycle.

Where decapitalisation is taking place to achieve levels of growing stock compatible with sustained regeneration and recruitment, shorter cycles are preferred rather than heavier interventions at longer intervals. This is to maintain stability and to avoid detrimental effects on timber quality. However, under French coppice-with-standards management felling of timber were often on a 20 to 25 year cycle and there has been some reluctance by owners to reduce the felling cycle dramatically; hence the variability in cycles across the network.

Stands with a well-developed structure had cycles around 10-12 years and these also showed a close relationship between removals and increment when expressed in terms of annual percentage change in basal area. Stands in earlier stages of transformation were not being managed to bring felling in line with increment and comparing these two parameters produced groupings of stands according to their stage of development and past treatment as follows:

Removals well below Increment	Lower Initial Growing Stock	Capitalisation from coppice-with-standards with lower timber stocking.
Removals somewhat below Increment	Higher Initial Growing Stock	Stands with a Growing Stock Volume approaching equilibrium level but where quality considerations and need to develop diameter group distribution are constraining removals
Removals well below Increment	Higher Initial Growing Stock	Removals are too low
Removals similar to Increment	Higher Initial Growing Stock	Stands near to equilibrium in overall terms and diameter group development proceeding

Increment is considered in terms of both average diameter, expressed in centimetres of diameter per annum, and basal area.

The first point made is that for any particular period climatic effects can have a significant effect on increment. Only as long series of data develop does this effect even out and underlying site and silvicultural factors begin to become clear. Despite this, the information coming from sites measured twice and three times (i.e. for 5 and 10 year periods respectively) shows some interesting features.

A key result that is shown clearly by the data is that diameter increment does <u>*not*</u> *vary with size and that this is true of both less and more fertile sites and irrespective of the actual level of increment;* the graph of increment against diameter class is remarkably flat. This is a surprising result since in irregular conifer stands there is a strong trend for diameter increment to *increase* as trees get bigger and for this increase to continue up to large sizes. In even-aged coniferous stands diameter increment also increases with size but levels off at moderate diameter sizes around 40-50 cm. This distinctive result for irregular broadleaved stands almost certainly relates to the fact that their growing stocks are significantly lower than coniferous stands, however managed. *It may be that the independence of diameter increment and tree size could be regarded as a feature of a good structure in irregular broadleaved stands.*

The range of diameter increments across the 38 research stands measured twice and three times is shown in Figure 3. This shows the wide range of some species with sessile and pedunculate oak ranging from below 0.2 cm to above 0.8 cm of diameter per year. Ash shows almost as wide a range. Beech, on the other hand, shows a generally higher increment with almost all stands over 0.5 cm and some around 0.9 cm per annum.

Figure 3 also shows an overall lack of correlation between increment and dominant height and this illustrates how past stand management can affect increment. Irrespective of site, stands with a history as denser high forest will produce lower diameter increments than those with a recent history of coppice-with-standards. In this regard the species data reflect the varying ability of beech, on the one hand, and oak and ash on the other, to cope with denser conditions.

When the research stands are grouped by site type, relationships are clearer. On the gleyed soils sessile oak consistently outperformed pedunculate oak in terms of diameter increment. In the AFI sites these gleyed soils tend to be less fertile and this may contrast with southern English sites where gleyed sites tend to have relatively high nutrient status. Beech out-performed oak on the sandy and more acid soils and produced increments at levels equivalent to the best stands on the deeper silty loams. On the latter sites increment varied considerably, again due to different past management, but those showing higher increments over 0.7 cm per annum included stands dominated by ash, beech and both oak species and show that these sites are optimal for a wide range of species. The calcareous sites tended to have lower increments from 0.6 cm per annum down to 0.2 cm.

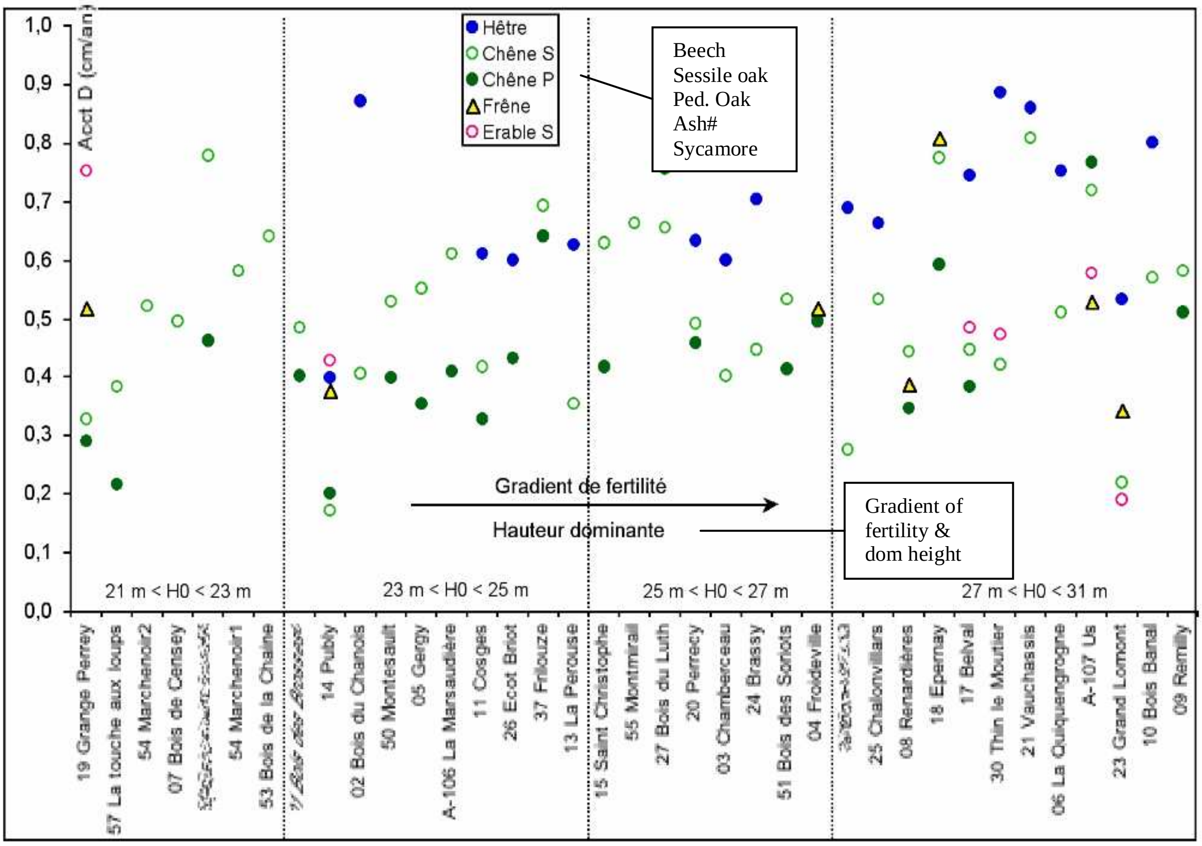

Figure 3: Average diameter increment by site fertility in terms of the principal species[4].

In considering the change in overall growing stock size, basal area increment is preferred to volume increment in the AFI network, again to allow easier comparison between sites by avoiding the vagaries of the conversion to volume. Within a given period, total basal area increment comprises the increment arising from the stand measured at the beginning of the period *and* the increment attributable to those stems that have grown into the lowest measurable size category during the period. This latter is called in French *le passage à la futaie (PF)*. This latter can be a significant proportion of the total, particularly when the stand is in a capitalisation phase.

Overall, total basal area increments for the broadleaved stands varied between below 0.3 to over 0.7 square metres per hectare per annum. The figures for the 3 AFI research stands visited are shown in Table 3. (Across the central range of site types the equivalent volume increment was 5.5 to 6.5 cubic metres per year of which 4 to 4.5 cubic metres was timber).

At Gergy the annual basal area increment was 0.58 square metres per ha for the 10-year period whilst at Bois du Château it was 0.71. The PF contributed 33% and 27% respectively. In terms of stem numbers around 8 stems per hectare were recruited into the 'measurable' stand every year for the 10-year period in both stands.

[4] after Bruciamacchie, M. Susse, R. & Tomasini, J. 2005 ob cit , fig 9, p 17

This information can be relevant in a number of ways:

- eventually removals will be related to increment. In both the above stands removals are well below increment at present at 0.28 square metres per ha per annum for Gergy and 0.06 at Bois du Château.
- an appropriate level of PF is a good indication that the key recruitment of saplings into the main stand is occurring at a rate that will sustain the stand.
- the detail species breakdown will ensure sufficient of the key species are recruited.

Another way of describing increment is as a percentage of the initial stand volume or basal area (the PF is ignored). This increment percentage or ratio varied over 10 stands measured three times, i.e. over 10 years, from 2.5 to 5.6% per annum. At Gergy it was 4.8%. However, the ratio for sessile oak alone was 2.6% and that of pedunculate oak even lower at 1.8%. This result with regard to the oak species is often replicated across the network. Here then we have a direct measurement of the performance of the stand and its constituent parts.

It should be noted, however, that during the long transition towards a quasi equilibrium structure differences in increment ratios may occur due to changing growing stock size and the distribution of sizes across the diameter groups and species composition. Climate will also play its part. This is illustrated in Figure 4 where the relationship between increment and growing stock size (in terms of 'measurable' stems only) for 10 stands measured three times is shown, as well as the change in increment across the 2 five year periods. The second period has a generally lower increment with climatic differences playing a leading role. The particularly sharp drop in the oak dominated stand at Bois des Brosses is also the result of the growing stock rising *and oak increment may be especially sensitive to growing stocks rising above key threshold levels.*

Overall, Figure 4 shows that varying types of structural development prevent an easy correlation between growing size and increment. *It does show, however, that increments of 0.5 to 0.7 square metres per ha per annum are achievable with levels of basal area of 'measurable' stems of 13-17 square metres per ha for a range of broadleaved species.*

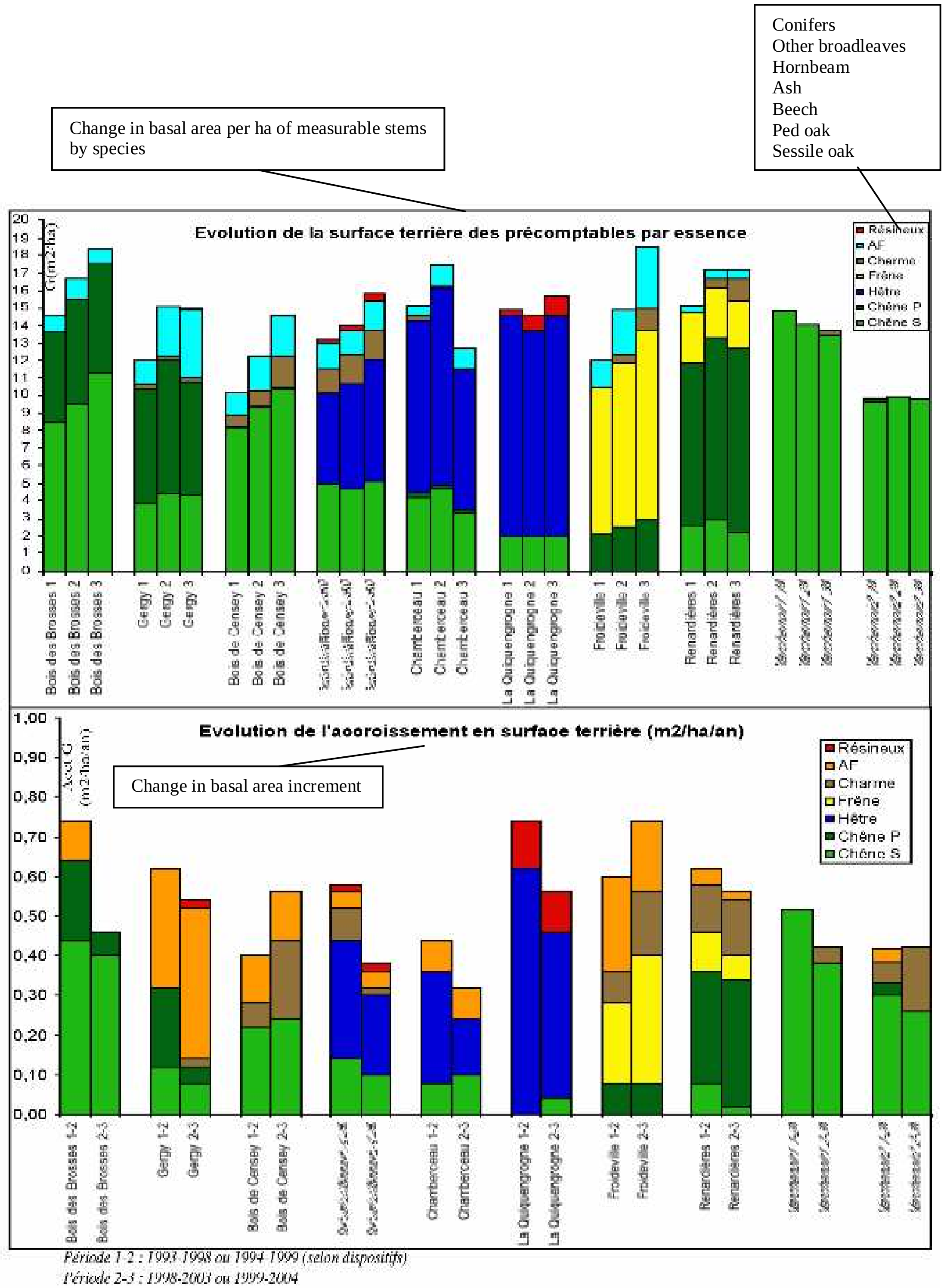

Figure 4:Change in the basal area per ha of 'measurable' stems (>17.5 cm dbh) and their increment (after Bruciamacchie, M. Susse, R. & Tomasini, J. 2005 ob cit, fig 13, p 21

4.3 Management for Timber Quality

The managers and owners of the forests within the AFI network are very focused on the production of quality timber. Silviculture aims at concentrating the timber increment onto the best quality stems and at the production of a supply of high quality poles and small trees to sustain the population of quality stems in the main stand. According to site the production of larger diameter oak, good quality ash and sycamore and ‘precious’ species, primarily cherry and wild service, is promoted.

The possibility of growing high quality hardwoods in selection systems, particularly oak, has been questioned. The orthodoxy is that phenotypic variation in oak is large plus its lack of apical dominance, leads to a need for large numbers of oak saplings in order to allow selection and to promote natural pruning. The high numbers of young stems of sessile oak arising from the uniform shelterwood system in Northern France is often seen as the ideal despite the high cost of tendings. This has lead to a belief that selection systems are not suitable, or that within selection structures regeneration of oak must be encouraged in sizeable groups.

In the UK few have dared to question this view with the noticeable exception of the late Talis Kalnars who suggested that the light regime within a selection system encourages a different type of tree architecture within the regeneration/ sapling size classes in which side branching is discouraged and finer form favoured.

The leading forest managers within the AFI, and the academics, strongly concur with this view and are beginning to demonstrate it within their stands. In their view a selection structure with densities similar to those described in the above sections, and with an appropriate proportion of tall mature stems, produces a diffuse light regime that encourages fine branching, lack of stem sinuosity and apical dominance. *They are suggesting that the poor form found in many individuals in young, even-aged broadleaved stands, and particularly oak, is caused as much by too much direct overhead light as by genetic variation.*

We saw good evidence that this radical idea has foundation at the Forêt du Régnaval, which has the reputation of being one of the foremost producers of quality hardwoods in France. Here we saw small stems of ash, cherry and sycamore growing as individuals under a tall stand formed by a very open upper canopy of mature poplar which had been selectively removed over the previous 20 years, the current overall basal area being around 21 square metres per ha. There were no significant defined gaps as such in the upper canopy. The quality of the ash in particular was excellent with long, clean, straight stems; no pruning at all had been undertaken.

At Gergy we saw groups of oak saplings, of the order of 50-80 individuals, growing closely under irregular, small gaps in the open upper canopy. To our eyes these seemed to be a very successful demonstration of oak regenerating within a selection structure. The manager, Roland Susse, stated however, that he was striving to move away from these ‘groups’ and had begun to promote single oak stems under more diffuse light conditions by avoiding large gaps in the upper canopy. In his view the ‘groups’ of 50-80 trees contained too many poor quality trees due to higher direct light levels and required expenditure on pre-commercial thinning that he would like to avoid.

The growing stock, removals and increment data are recorded according to 4 quality classes (A-D) that are combined into 2 (A+B & C+D) for the purposes of analysis. Through this changes in the quality composition of the stands are charted over time and comparisons made between stands on similar site types. The absolute levels are dependant on past management, and in some cases on site factors, but changes over time and across similar sites can be instructive. Comparison across diameter classes gives an idea of whether the ‘machinery’ to produce quality large trees is being sustained.

Another interesting way of showing these parameters is shown in Figure 5 where the initial growing stock size is shown split into the two quality classes together with the increment percent of the A+B class only. *Financially this latter parameter is the key one given the large price differential between high and low quality hardwoods. Many stands, including Gergy, have increment percents of 3 to 4.5% per annum in the A+B category.*

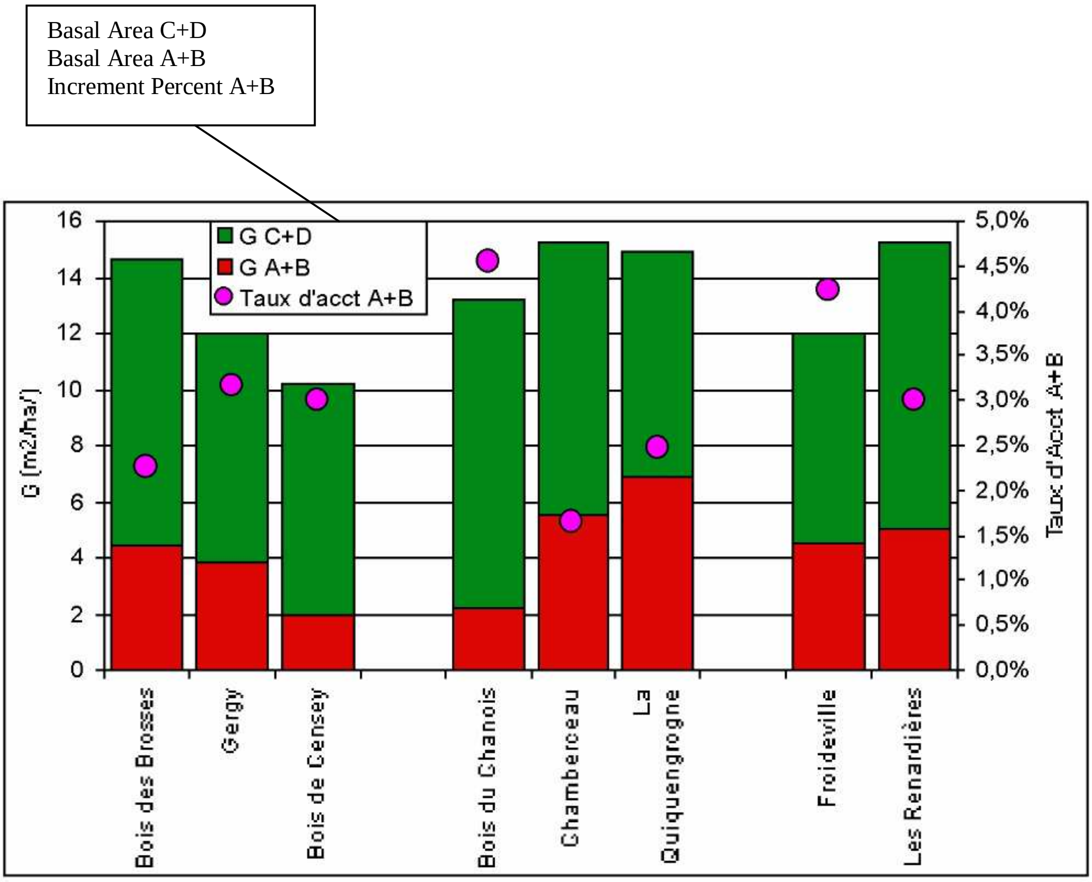

Figure 5: Distribution of basal area of initial stand by quality and the increment percentage for quality class A+B[5].

[5] after Bruciamacchie, M. Susse, R. & Tomasini, J. 2005 ob cit , fig 19, p 24

With regard to removals it is not surprising that the large majority are in the C+D quality class given that many stands are in a phase of timber quality improvement following the cessation of coppice management; the proportion can be from 75 to 100% in these cases. The more even-aged stands often have a high proportion of removals in the lower class, medium diameter size group. In the more developed stands, a higher proportion of larger trees are removed as well as a higher proportion of higher quality trees (48% of removals from La Quiquengrogne were in Class A+B).

In all the stands we visited special care was given to the young stand (poles and the small diameter size group) during the selection and harvesting process. This involved the removal of medium sized trees to favour key, younger elements and care was taken to protect these stems during felling. In several stands visited, poles and small diameter group oak and precious species such as cherry and wild service were marked with a blue band to ensure that they were avoided during harvesting operations. The overall density of such marked trees was low. The other key element of this process is the management of the under-storey, particularly the coppice. Selective thinning in the coppice element is undertaken, rather than the complete cut of the coppice system, in order to favour poles and large saplings without overexposing the stems in the main stand.

4.4 Measurements of Crowns

Another focus of investigation is the architecture of crowns. Three parameters are measured and recorded according to stem diameter and species: total height of crown, the maximum diameter of crown in a horizontal plane (canopy cover) and the height at which this maximum crown diameter occurs.

The two height parameters allow the vertical profile of the crown to be described. Total height varies with the fertility of the site and stem diameter, as one would expect. However, the height of maximum crown diameter, the ‘floor’ of the crown in effect, varies much less with regard to stem diameter and rarely varies more than 4 metres between the small tree and large tree diameter classes. This ‘floor’, therefore, rises only slowly as the tree develops. In oak the floor averages around 15 metres and varies from 12 to 20 across the range of sites. For beech it revolves around 18 metres and in ash around 19 metres.

The managers and academics who we met were clear that individual broadleaves generally should be encouraged to grow in height in the pole and small tree sizes and then given progressively more room to stimulate diameter growth. This was regarded as particularly important with cherry that requires a large crown to achieve fast diameter growth. The profiles presented by the research stands give some indication of when this change of approach should take place; once the ‘floor’ height has been reached the diameter expansion phase should begin.

The other important silvicultural feature of crown architecture is the relationship between maximum crown diameter/ canopy cover and basal area. It turns out that for a *given* stem diameter, different species have markedly different amounts of canopy cover and hence deliver a different amount of light to the lower parts of the stand.

This is particularly important in irregular stands where light manipulation is the key tool of the forester.

The ratio of the projected ground area of the crown to its basal area is called the 'Coefficient of Cover'. The distribution of this ratio by species across the diameter classes is shown in Figure 6. Having obtained these ratios it is possible to easily convert basal area into canopy cover percentages, canopy cover being a difficult parameter to quickly assess directly.

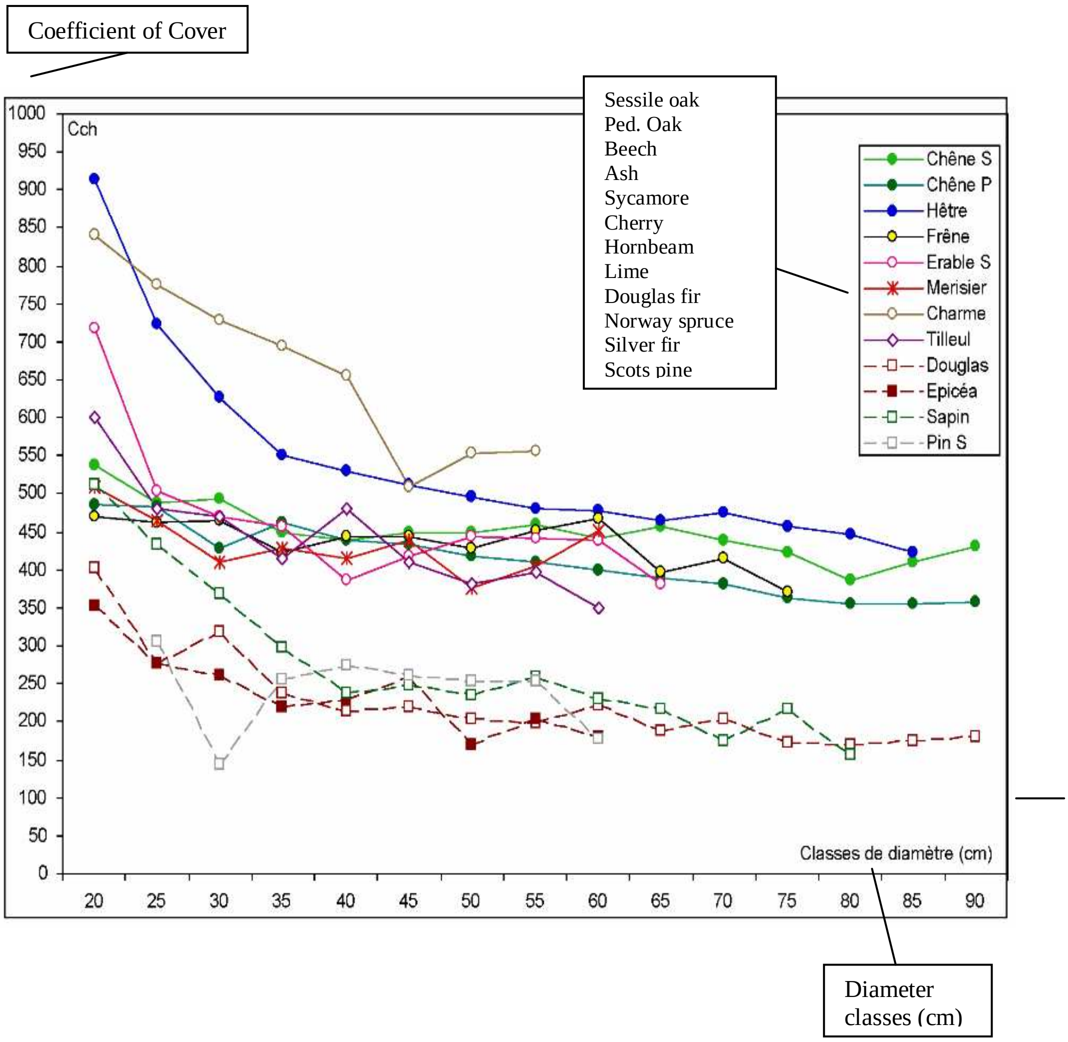

Figure 6: Distribution of coefficient of cover by species and diameter[6].

[6] after Bruciamacchie, M. Susse, R. & Tomasini, J. 2005 ob cit , fig 21, p 26.

This diagram shows a number of important features:

- Coniferous species have a lower ratio than broadleaves, i.e. they take up less space and caste a lower amount of shade for a given diameter/ basal area. (Note, however, that larch is not included in this analysis)
- In some species there is a marked difference between smaller trees and larger trees (beech, hornbeam, lime, sycamore and silver fir); the smaller trees are considerably less ‘efficient’ in terms of canopy cover per unit of basal area. Other species (oak, ash, and pine) show much less difference between trees of different diameter.
- With beech, hornbeam and silver fir the high ratio, low ‘efficiency' extends into the medium sized trees.
- The most ‘efficient’ trees are the larger ones and over about 50 cm conifers on the one hand and broadleaves on the other converge around ratios of 225 and 450 respectively.

These fundamental differences between the crown architecture of coniferous and broadleaved species, coupled with the generally taller dominant heights of coniferous stands, are two of the key reasons why ‘equilibrium’ growing stocks for broadleaves will be significantly below those for Norway spruce, silver fir and Douglas fir.

Further, ‘efficient’ growing stocks, in species other than oak, ash and cherry, should have an appropriate amount of larger trees and not too many smaller trees which occupy a lot of space for a given proportion of basal area. In stands of beech, hornbeam, silver fir and sycamore the detrimental effect of having too many smaller diameter trees was a particular concern and this had specifically influenced the marking in the stand visited at Vivey.

In **summary** a basal area of 20 square metres per hectare will produce a different degree of canopy cover depending on species and the diameter distribution between small, medium and large trees.

5. Conclusions & implications for continuous cover forest management of broadleaves in southern England

The *first major conclusion* to be drawn from the French experience, as chronicled by the AFI, is that selection systems can be successfully applied to a wide range of broadleaved species, including oak and ash, and across a wide range of site types in different climatic regions.

Stand structures that deliver favourable light conditions for regeneration, recruitment of saplings into the main stand and the development and sustension of large trees are well demonstrated across the AFI Network and were seen at first hand in the 5 stands visited in eastern and north eastern France. Timber increments were reasonable on the poorer and less developed stands and on some of the better sites with consistent good management the results are impressive: a 4% annual increment on the higher quality elements of an oak stand with some ash and cherry produces a very attractive financial yield.

The key silvicultural factors that produce success are:

- A growing stock of the appropriate size.
- An appropriate balance between small, medium and large diameter trees.
- A well managed understorey *and*
- A deer population in reasonable balance with available food resources.

With regard to oak managed under selection systems both species are well represented within the AFI Network, and in all the more developed stands oak regeneration was occurring without major problems.

The *second major conclusion* is that management directly focused on the production of high quality hardwood timber is compatible with permanently-irregular, selection stands. Their view is that growing trees under the diffuse light conditions which pertain in these rather open selection stands is the most effective way of achieving high quality timber production on sites with reasonable existing genetic resources of the target species.

The *third major conclusion* is that setting up long term monitoring of well-managed stands, similar to the AFI methodology, produces a very valuable source of practical information which can quite quickly begin to provide key insights into the application of these techniques and are able to define good practice across a wide range of species and sites.

The AFI Network is also producing a large amount of economic data, analysed in innovative ways. This has been outside the scope of this report to describe but the results have already provided similar insights and overviews of the financial characteristics of CCF stands. This is real data based on real timber revenues and real costs of silviculture and management. A striking, simple, statistic is that *all* 61 reference stands have made a profit over the whole period of the study to date.

In applying the research and practice from the AFI Network to southern English broadleaved stands we should consider the following differences between the two locations:

In climatic terms northwestern France is not dissimilar to southwest England. The information discussed above, however, relates to eastern France and here light conditions and the degree of summer moisture deficit may differ somewhat from southern English conditions.

As described above, the **existing stand structure** of southern English stands is often different from the French stands. The structure of the understorey, particularly the dominance of hazel in southern England, is important silviculturally and the fact that many stands enter the transformation process with a high stocking of large trees will result in a different kind of transformation, often with a longer time period, in the English stands.

Finally, the **scale** of woodlands in the two regions is different. In eastern France the broadleaved forests are large, blocks of 500-1000 ha are not unusual and are more homogeneous than in the UK. They have not suffered from the either the neglect or the drastic changes which have often left larger woods as a mosaic of relict over-stocked broadleaved stands amongst plantations of exotic species.

The similarities are such, however, that we can draw some initial lessons for current practice of Continuous Cover Forest management in southern England.

With regard to the key aspect of the appropriate density of ***Growing Stock*** it is likely that *for oak, equilibrium levels for total basal area over 7 cm dbh will oscillate within boundaries of around 15 and the low 20's square metre per ha.* In France this would relate to levels of basal area of the main stand (over 17.5 cm dbh) of around 12 to 18 square metres per ha. French experience would suggest that equilibrium levels for ash might be a little lower than oak and beech a little higher.

In transforming broadleaved stands French practice suggests two distinct phases: an initial phase where overall basal area is brought nearer to an equilibrium level and a second phase where this overall level is maintained, in terms of the level halfway through the felling cycle, whilst an appropriate balance between small, medium and large diameter groups is developed along with appropriate densities of regeneration and saplings.

Most stands in central southern England will be approaching these suggested overall levels from 'above', often with too low a level of large saplings and a coppice layer of hazel which does not contribute to over 7 cm dbh basal area. Virtually all the measurable basal area will be in the main stand (over 16 or 17.5 cm dbh) and within this there will be a surfeit of large and medium trees. It seems probable that *phase one* of the transformation here will involve reducing the main stand basal area to below 20 square metres per ha. The *second phase* would focus on shifting some of the growing stock into the large sapling and small tree categories, which would eventually lead to basal areas for the main stand approaching French levels.

In stands with hazel dominated **understorey,** an associated change would be the replacement of a lot of the hazel by large saplings and poles. This would allow the understorey to serve the dual function of controlling ground vegetation and shading the lower stems of the trees in the main stand. This latter is given great emphasis by French practitioners and leads to selective and gradual interventions in the understorey. With hazel domination, following a number of year's experience on the Melbury and Rushmore Estates, the author considers that this approach is all but impossible; most of the hazel has to be cut to allow safe felling of the timber trees and truly selective cutting of part of stools is largely impractical. There is also the danger that partial cutting of the understorey will render cut stools more vulnerable to death by browsing and localised shade. This complete cutting of the understorey may not be silviculturally optimal for the stems in the main stand, but this should be largely a symptom of the earlier stages of the transformation. As the understorey becomes largely composed of maiden poles and saplings, selective treatment becomes more feasible.

On the more fertile sites, the heavy, mildly acid to mildly calcareous clays in particular, and with open structures based on basal areas below 20 square metres per ha, the hazel understorey is crucial to maintaining control of the seedbed. The interrelationship between main stand density, understorey and bramble is also crucial since low level patchy bramble allows all species to survive 'reasonably low' deer populations. It will be interesting to see whether a 'developed' understorey will have the same characteristics in this regard to pure hazel.

Returning to the main stand growing stock; what might be an appropriate distribution of basal area between the 3 main diameter groups? This is more difficult to judge from the existing French data and there may well be a wider degree of tolerance here than for the equilibrium level for the overall growing stock. As an initial guide we should probably be looking for 50-60% in the large tree category, and 20-30% in both the medium and small tree classes.

At this point it is worth reviewing the basic stand data from the stands at Melbury enumerated in Part 1 of this study. These data are given in Table 3.

Since the Melbury enumerations used 4 cm diameter classes, the 'measurable' trees start at 16 cm dbh and the diameter classes have somewhat different ranges than those used in the AFI Research Stands. In effect if the French system were used the Melbury stands would have slightly higher proportions in the large category.

Also the stand between 7 and 16 cm dbh was not measured. Generally, however, the Melbury stands had a very low density of stems of this size. A multi-stemmed understorey existed in the form of hazel in the four oak dominated stands but this would not have produced measurable basal area under the AFI methodology. This means that in terms of the overall growing stock, the 'measurable' basal area in the Melbury stands is broadly equivalent to the total basal area from 7.5 cm dbh upwards of the French stands.

Stand Name & Date of Measurement	*Description*	*Basal Area (over 16 cm dbh) Sq m /ha*	*% of Basal Area in Diameter Groups*		
			Small (16-31.9 cm dbh)	*Medium (32-51.9 cm dbh)*	*Large (56+ cm dbh)*
Parsonage Copse (2003/4)	Oak plantation 1840's with hazel. Unthinned for at least 40 years in 2003. Full mature stocking.	36.7	3.7	5.2	91.1
Brickyard's Copse (2003/4)	Oak plantation 1830's with ash, hazel & maple. In transformation since 1998.	23.0	3.8	16.2	80.0
Annesley's Plantation (2003/4)	Oak plantation 1830's with ash, hazel & maple. In transformation since 1995.	24.6	2.9	20.5	76.6
Rag Copse (2003/4))	ASNW oak, ash, maple, wild service, hazel: coppice-with-standards until 1940's. In transformation since 1999.	22.1	7.8	21.0	71.2
Evershot Plantation (2003/4)	Mixed broadleaved plantation 1807-1820 with elements from c 1900. In transformation since 1995. Oak, sycamore, ash, beech.	24.6	15.6	18.3	66.0
Woolcombe Folly (2003/4)	Plantation from 1800 clear felled in 1914-18. Regenerated naturally with little intervention before 1995. In transformation since 2001. Ash, beech, oak, sycamore.	30.7	24.9	29.3	45.9
Woolcombe Folly (2005)	After further felling in 2005 (increment 2003/4 to 2005/6 ignored).	25.4	29.0	28.4	48.1
Hill Plantation (2003/4)	Ash & sycamore stand arose on abandoned farmland in 1930's. Intervention in 2001.	16.7	30.9	39.1	21.0

Table 3: Growing stock data from 7 stands at the Melbury Estate, Dorset.

Table 3 shows that the three essentially regular oak stands at Brickyard's Copse, Annesley's Plantation and Rag Copse are being 'de-capitalised' and are beginning to approach overall levels of growing stock seen in France. These levels have now diverged significantly from the levels of the untreated stand at Parsonage Copse which in 2003/4 was still a fully stocked single storey of oak over low density hazel.

The proportion of large trees has diverged less although the medium size group is developing well at Annesley's Plantation and Rag Copse. Clearly there is a major shortage of small trees. There is also a lack of recruitment in the form of saplings. Seedlings, still predominantly of ash, are now appearing in parts of Annesley's Plantation and Brickyard's Copse.

What we do not know is how the silvicultural conditions produced by the hazel dominated understorey of these stands will compare with those of the French stands. The light conditions in a hazel understorey, low in height and relatively dense where it occurs, will be significantly different from a French understorey of tall hornbeam coppice and poles. The positive aspects of hazel on controlling ground floor vegetation on rich sites is now being clearly demonstrated at Melbury and it may be desirable to maintain in perpetuity a patchy distribution of hazel as the understorey develops an admixture of poles.

The other three stands are rather different. They have not developed out of coppice-derived stands and are on less fertile site-types. Evershot Plantation is more diverse structurally and in species composition. In broad terms it is closer to the French model in terms of diameter class distribution and there are younger elements, both planted and natural. Here there is a legacy of large trees that may not be able to respond fully to a more open structure. Increment information will in due course probably show a significant difference between medium and larger diameter classes.

The other two stands are younger, having developed from open/ felled ground naturally over a 70 to 90 year period, with ash as the major component rather than oak. A hazel dominated understorey is replaced by low density sycamore.

At Woolcombe Folly it should be feasible fairly soon to produce a main stand not dissimilar to the range of values shown in the AFI Network. However, sapling and seedling regeneration and recruitment are still lacking.

Hill Plantation is the only stand that at the moment lies within the AFI Network ranges for the main stand in terms of overall basal area and is the only stand which has not required significant decapitilisation; it requires increasing capital accumulation in terms of the proportion of larger trees.

It appears from the French data and experience that these stands are moving in the right direction and it is intended that, with the exception of Hill Plantation, the growing stock will be gradually brought down below 20 square metres per ha using removals of around 15-20% on around an 8 year cycle. Sycamore appears to have great potential in these stands to provide a 'developed' understorey.

The actual trees to be felled will be determined in the stand on a tree-by-tree basis according to felling rules designed to remove the weaker elements of the stand and to harvest a proportion of larger trees as appropriate whilst retaining vigorous stems below the target diameter. The diameter class group distribution will be used in a strategic way, particularly with regard to the large diameter classes, but there will be no direct use of stem diameter frequency distributions (‘J’ curves) in determining which stems to remove. This latter approach risks the removal of good quality elements of the stand in order to produce an ideal J curve which will have dubious basis in fact and may not exist at all in a precise form. The use of broad targets related to diameter class groups as a framework for the marking process, as used by the French managers, is a much more satisfactory approach.

We shall have to wait and see at what levels and structure of growing stock satisfactory regeneration and recruitment cohorts are produced and how easy it will be to achieve ‘developed’ understories in stands currently dominated by hazel.

In conclusion, the AFI Research Network has demonstrated that by quantifying, describing and sharing good, effective practice across the widest possible range of situations, one can provide detailed insights into the effects of different species composition, stand development and site type.

Also the French experience suggests that there is no silvicultural reason why continuous cover forest management cannot be applied to broadleaves in lowland England and the experience on the Melbury Estate is beginning to corroborate this contention. The challenges lie in the small-scale and fragmented nature of our broadleaved resource, the poor infrastructure, both practical in terms of access, and in terms of human resources; the contractor base is declining.

The AFI’s objective is to promote and to refine silvicultural techniques and define optimal management for irregular forest systems. It is also providing managers with a range of effective tools to deal with all the eventualities they may face. The trip certainly demonstrated how worthwhile this is; all those who came were convinced of the effectiveness of what they had seen.

There are sufficient differences between the French stands and their English counterparts for it to be worthwhile establishing a similar research stand network to that of the AFI in Britain. Although this might begin in southern England in order to maximise the comparison with the French network it would be valuable to extend it into the rest of Britain and Ireland as more sites travel further down the road of transformation to permanently-irregular structures. The wealth of practical silvicultural information and the confidence that is derived from comparing and contrasting different experience would be invaluable to the development of continuous cover forest management in Britain and Ireland.

It should also be noted that the collating of economic data following the AFI Network methodology, which has only been touched on in this report, would begin to fill a major gap in current data relating to this aspect of continuous cover forest management in Britain.

Photo 1: Bois du Château, St Christophe en Bresse

Julien Tomasini AFI

Photo 2: Forêt de Gergy 1

Photo 3: Forêt de Gergy 2

Photo 4: Forêt de Gergy 3

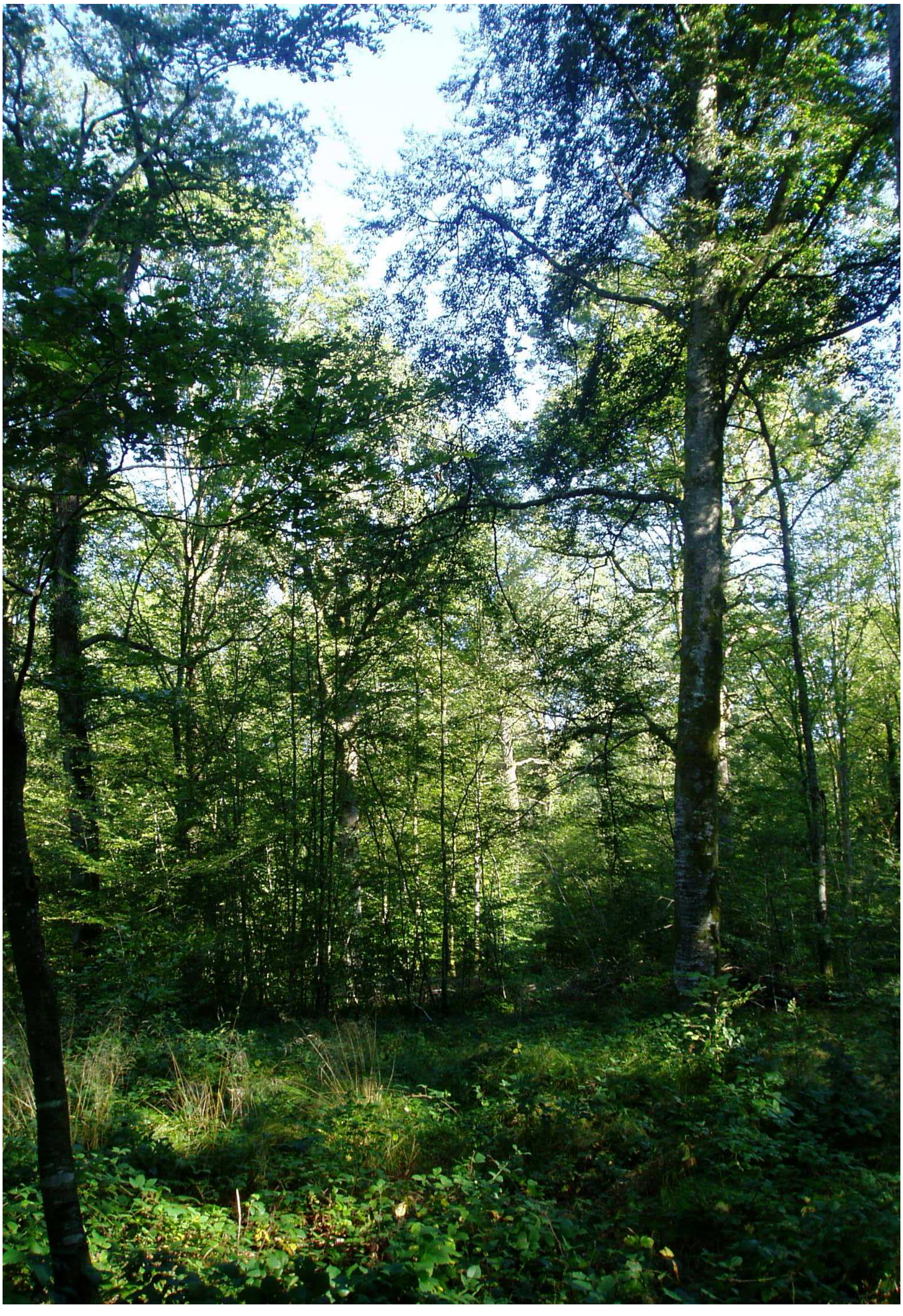

Photo 5: Forêt de Fresnoy 1

Photo 6: Forêt de Fresnoy 2

Photo 7: Forêt de Fresnoy 3

Photo 8: Forêt de Vivey

Julien Tomasini AFI

Photo 9: Forêt du Régnaval