Dynamic silviculture – an alternative approach to traditional oak silviculture

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Introduction

France has a long tradition in the production of high quality hardwood timber, particularly from oak. Recently in France, the various forestry organisations involved in oak silviculture, including the association representing the private forest owners, the Centre National de la Propriété Forestière (CNPF), in cooperation with the Institut pour le Développement Forestier (IDF) and the state forestry organisation, Office National des Forêts (ONF), have through the establishment of a national oak working group, been examining ways to reduce rotation lengths while still producing the highest quality timber. While in the UK the "Free Growth" method has been explored through research trials commenced in the 1950s by Hummel (1951), by Jobling and Pearce (1977) in the mid 1970s and again by Kerr (1996) in the 1990s. In order for foresters working with oak to explore these methods two field trips were organised by Woodland Heritage, the first to Central France in November 2015 and the second to southern Britain in April 2016. This report provides a record of these trips and background on some of the newly developing production methods for high quality oak production, specifically dynamic silviculture -a new and rapidly changing oak silviculture.

Overview of traditional oak production in Central France

Forests cover approximately one-quarter of the land area of France – about 14 million ha, of which about two-thirds are broadleaved. Oak forests occupy about 34% of the total forest area (Teissier du Cros, 1987). A number of different species of oak are native to France. However, of them all, only pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* (Matt.) Liebl.) are important economically. They form a major component of the forests on the plains and lower hills of France, and in many other parts of Europe including Britain and Ireland. In fact, they constitute the major part of productive European broadleaved forests. Both species exhibit wide tolerance of ecological conditions and have many attributes in common. Both species retain the ability to react to increased growing space by crown development, even in old age (Joyce and Gardiner 1986). Sessile oak tends towards more mild and oceanic climatic conditions, so its share of the range diminishes in Northern and Eastern Europe. It is found at higher elevations than pedunculate oak. With less requirement

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for water, sessile oak is considered more suitable for drier sites, whereas sites for pedunculate oak are becoming more limited in France, and in the Central region the species is now considered to be at its ecological limit, due mainly to regular seasonal moisture deficits. Pedunculate oak is essentially a valley-bottom tree which performs best on deep, rich soils with ample moisture (land that is now mostly cleared for agriculture). Where moisture is lacking at crucial times during the growing season it will perform poorly and may even suffer dieback. On good sites both species can perform outstandingly well, provided the trees are given early and adequate space which suggests a requirement for early and heavy thinning. A critical consideration is that crowns of the best and most vigorous trees need to be given full sunlight as early as possible to allow complete development of the individual tree.

The traditional production cycle for high quality oak has been recognised in France for over a century and has been defined as the Méthode Française (Pardé 1986). This traditional silviculture usually extends over a rotation of at least 180 years, and sometimes up to 250 (Figure 1). While such long rotations are economically difficult to justify, even with the production of such high quality oak timber, they are still generally practised in both the public and private forestry sectors.

Because of the long rotation and the relatively low volume production, oak growing has only one objective: the production of the highest quality, high value logs for veneer and sawn timber for furniture-making, as well as for cooperage. Furthermore, the uses of oak timber has changed, and while stems with very narrow rings are still sought for particular products, wider regular rings are now used for joinery, sliced veneers, barrel staves and many other uses. Indeed, it appears that oak growing in France is going through something of a crisis, as traditional rotations are so long that the timber for cooperage is becoming increasingly hard to find. This is greatly exacerbated by the increase in demand for oak cooperage from wine growing regions other than France (for example Australia, Chile and New Zealand), all of which want French oak barrel material. Foresters in France have concluded that it is possible to grow high-quality oak in under a century – not a new discovery they say but a verification of past practices where oak was grown as standards over coppice. Lemaire (2010) concluded that a good approach is to modify the silviculture of open-grown crops to achieve such results.

New methods for the production of high quality oak wood in France

Up to the 1990s most of the forest sector in France made little or no distinction between the two oak species despite their different ecological requirements. The silviculture for both was identical, and restocking always by natural regeneration. However, today more stands are planted and new afforestation projects, such as farm woodlands, are generally established by planting or by sowing acorns. This is

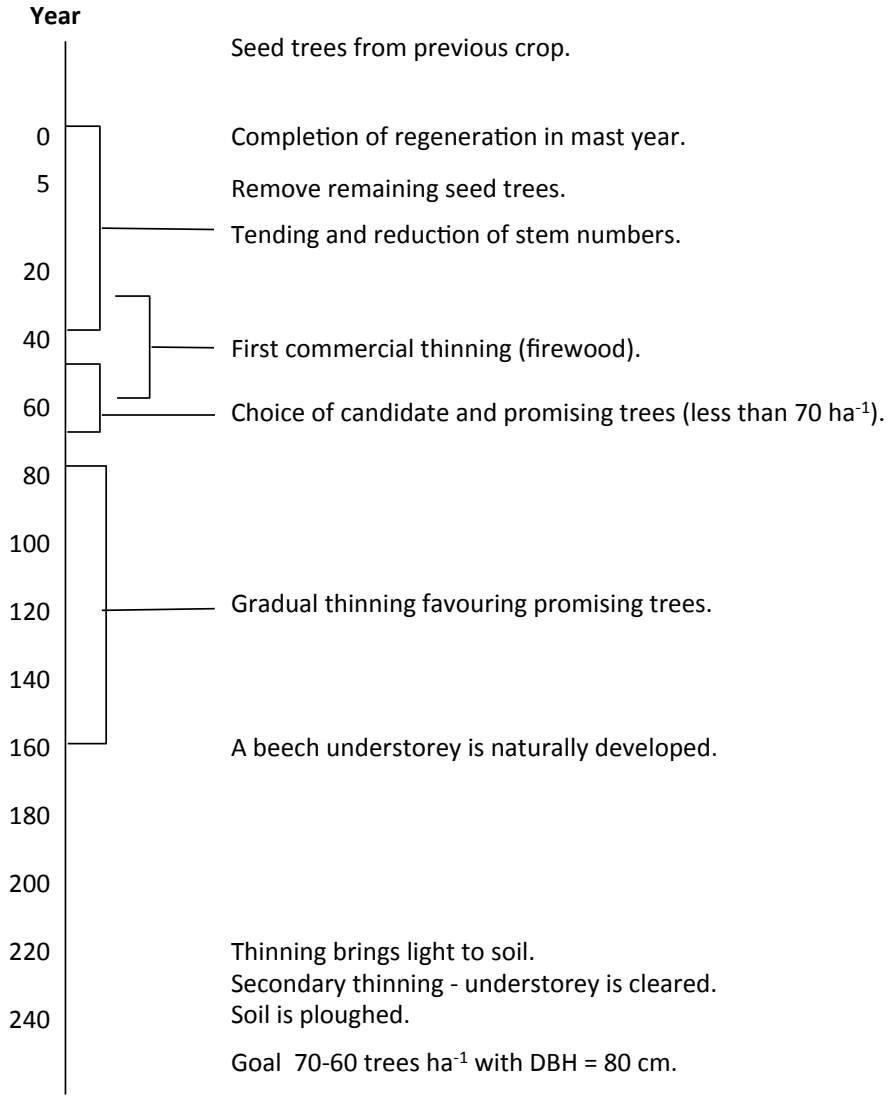


Figure 1: *Diagrammatic representation of the traditional French oak rotation, extending over more than 200 years (adapted from Teissier du Cros 1987).*

mainly due to the unsuitability of one or other oak species to features of certain sites, for example pedunculate oak was previously established where moisture deficits developed. Furthermore, where artificial regeneration was practised in the past, seed was often introduced from inappropriate sources, e.g. from outside France. Many of these were from locations such as the Netherlands or, surprisingly, even Britain. However, around ten to fifteen years ago extensive dieback and even some mortality

of mature oaks were observed by forest owners which caused a great deal of alarm (Figure 2). When the cause was investigated it was found to be related to seasonal moisture deficiencies. This was especially the case with pedunculate oak stands. This led to a re-examination of the requirements and the differentiation of both species as well as an examination of both species specific site requirements.

The various forestry organisations involved in oak silviculture, including the association representing the private forest owners in France, the Centre National de la Propriété Forestière (CNPF), in cooperation with the Institut pour le Développement Forestier (IDF) and the state forestry organisation - Office National des Forêts (ONF) - have, through the establishment of a national oak working group, been examining ways to reduce rotation lengths while still producing the highest quality timber.

In the 1980s, an oak study group was formed in the central region of France, the main area for the production of high quality oak. The study group has undertaken an extensive series of field trials, organised seminars along with regional meetings and facilitated a number of local and regional groups to examine ways of achieving a substantial shortening of the traditional oak rotation. The culmination of their work has been a far-reaching report on a method of silviculture based on the individual tree, and termed "dynamic silviculture", containing a suite of recommendations which if implemented lead to a substantial reduction in rotation length. The report

Figure 2: *Pedunculate oak in France showing the effects of water stress. (Photo: Bede Howell.)*

was published in 2010 as *Le chêne autrement: Produire du chêne de qualité en moins de 100 ans en futaie régulière* (Lemaire, 2010). It was translated and published by the Future Trees Trust in 2014 (with support from Woodland Heritage, UK and the Department of Agriculture, Food and the Marine in Ireland). The translation was undertaken by Bede Howell OBE, an eminent forester with extensive experience with oak silviculture in Britain as well as having worked on oak management in France, and published as *Oak: fine timber in 100 years - Growing high-quality oak within a century* (Lemaire 2014).

This method of silviculture, based on the requirements of the individual tree, consists of selecting the best trees for the future – referred to as "winners" – the most vigorous, well-formed trees; all effort is concentrated on bringing these trees to a marketable size in 100 years or less. Work includes re-spacing, thinning, pruning and other management. Selection of the individual trees is made as early as possible, usually at time of first thinning when the top height is between 9 – 12 m. Sometimes it may be necessary to re-space, especially in naturally regenerated stands, at a height of 3 m and possibly again at 6 m. If necessary, the winners are pruned when they have been selected.

Free growth is not a new idea. It was evaluated in Great Britain by Forest Research through silvicultural research trials in the 1950s (Hummel 1951). However, coniferous forestry was much more important at that time and there was little emphasis on broadleaves which resulted in little if any follow-up of this silvicultural system. More recently Jobling and Pearce (1977) revisited the method in the mid 1970s but again at that time conifers dominated and the method remained overlooked. Evans (1984) also presented a diagrammatic response of diameter increment to free-growth. Later Kerr (1996) undertook a further evaluation of this system. A summary of findings at the time showed that:

- there is a close relationship between the average crown diameter and DBH (basal area) in oak and all other species, irrespective of age and the rates of height and radial growth (Dawkins 1963, Hemery et al. 2005, Kerr 1996).
- timber height in free-grown oak is usually low. To obtain a satisfactory length of clean bole, green pruning is usually necessary.
- free-grown oak has a substantially faster rate of radial growth than oak in traditional high forest.
- the crop parameter least affected by free-growth is total tree height.
- by contrasting the information on the relationship between crown diameter and DBH with rate of growth (age/height and age/DBH) a preliminary yield table can be constructed.
- a very small number of young trees, no fewer than 1,600 ha^{-1}, is considered adequate to achieve complete stocking at maturity.

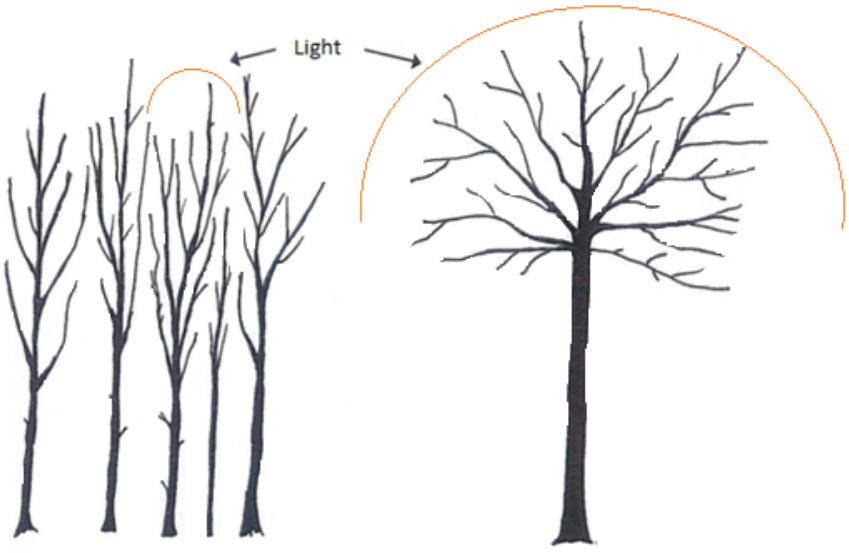
More recently in Ireland the free-growth silvicultural system has been evaluated by Short (2013) in the context of poorly performing pole-stage broadleaf stands and he has recommended that the system be considered for a number of broadleaf species including oak. These findings concur with new findings from a recent French study (Le Nail 2015) and are the basis of much of the shorter, production cycles that are now practised in new dynamic French oak silviculture. Despite this the free-growth approach for oak has been questioned due to the additional labour required to control epicormic shoots and may be more suited to species such as ash or sycamore (Kerr 1996). However, a study by Beinhofer (2010) modelled the free-growth system, with and without pruning, and compared it with conventional management. Results from the modelling excercise showed that oak grown under the free-growth system and pruned, provided better financial returns than conventionally grown oak or un-pruned free-growth oak (Short 2013).

The close relationship between average crown diameter of free-grown oak and DBH, irrespective of age and the rates of height and radial growth, are very important. French researchers have focused entirely on this particular aspect (Figure 3). Of course, because the stand density is much reduced, total production over the rotation is also reduced, but the economics of the enterprise might be greatly improved due to a much shorter rotation.

Today the accepted standard is to have an initial stocking of 1,600 trees ha^{-1} at time of establishment. The initial stocking of the stand illustrated in Figure 4 was 15,000 ha^{-1} but it was reduced to 10,000 ha^{-1} at the end of first year due to natural mortality and predation. Further reductions were achieved by removing unwanted stems, cutting at approximately 1.5 m in height. At a top height of 3 m the stocking was further reduced to 1,600 ha^{-1}. The stand is now 19-years-old.

Study visit to forests in Central France

In November 2015, Miles Barne of Sotterley Estate, Suffolk, England, and Peter Goodwin of Woodland Heritage arranged for an invited group of Irish and British foresters and forest owners to visit the main French oak-growing region to examine the new oak silvicultural system at first-hand, meet the researchers and to visit some of the field-trials. The visit also presented an opportunity to meet some of the French forest owners who advocate and now practice the new system. During the visit it was possible to contrast the new system with the traditional French production method. The visiting group consisted of foresters, researchers, students and forest owners from Great Britain and Ireland who are actively involved in oak silviculture and provided them with a valuable opportunity to spend a few days in this important oak-growing region as guests of the Centre National de la Propriété Forestière (CNPF). The group assembled on Sunday afternoon (1st November 2015) in Tours in the Loire valley where the visit was based.



Left – small crowns of plantation oak

- 25-year-old trees, not thinned and crowded;
- Many defects e.g. forks and knots;
- Profuse epicormics shoots when thinned;
- Wood production of very poor quality;
- Likely rotation: 150 – 180 years at least, if not more.

Right – large crown of "free-grown" oak

- 25-year-old tree in a plantation and thinned 2 – 3 times;
- Bottom log of 5.5 – 7.5 m length, without defects;
- No or slight risk of epicormics shoots;
- High quality timber, particularly the bottom log;
- Likely rotation: 80 - 100 years.

Figure 3: *Idealised contrast and comparison of development of constrained (in plantation) and non-constrained (free-growth) crowns of oak (adapted from Le Nail 2015).*

Monday 2nd November -morning

The group met French forestry colleagues including Eric Severin (Deputy Director, CNPF in Pays de Loire) who arranged the programme, provided leadership for the group and acted as tour leader for the duration of the visit. The group travelled north towards Le Mans and from there to private oak plantations close to Chémeré-le-Roi and Saint-Loup du Dorat. Here the group visited a private forest owned by M. Le Nail, who was on site to welcome the group and to discuss his forest stands and their management issues. M. Bruno Longa and M. Christian Weben, both colleagues of Eric Severin at CNPF, also joined the group at the site.

In the 1980s, agriculture in France was experiencing low prices for most products

combined with over-production and generally poor economic returns, similar to the situation in Ireland and the UK at the time. This resulted in some farmers like M. Le Nail deciding to change from the traditional agriculture of mainly corn tillage (maize) to an alternative enterprise. He converted his estate to forest, with particular emphasis on the production of high quality oak. M Le Nail's experience with maize production also guided him at the time of establishment of his new forests and suggested that the best time to sow acorns would be in the spring rather than the autumn; with reduced predation establishment rates would be improved. Early findings from a number of trials supported this and sowing in April/May at a rate of 100 kg acorns ha^{-1} resulted in the establishment of 15,000 plants ha^{-1}. There were many variations to this method, depending on the owner, but they all had the same objective: to shorten the very long traditional French oak rotation (see Figure 1).

First stop

Pays de Loire are renowned for the high quality of oak produced there. The conventional rotation is generally at least 180 (and sometimes up to 250) years. This is now considered much too long and uneconomic by private owners as well as by the state foresters, so other methods had to be explored to seek to shorten such a long production cycle. One area focused on was the very fast growth of individual

Figure 4: *Stand stocking reduced from very high numbers to the current 1,600 stems ha^{-1}.*

oak trees in traditional oak silvicultural systems such as coppice-with-standards and also oak established in hedgerows. Various studies have suggested that in hedgerow conditions, it was possible to produce large trees over a much shorter rotation and the oak produced had a lighter and flatter branching habit. This was especially the case where individual trees were allocated fully open area for crown development without impediment. It suggested that free-grown oak could produce large trees in a much shorter time. Studies also established that, when compared with conventionally thinned oak, the basal area (BA) of open-grown trees could be as much as double that of traditional oak trees of the same age.

Second stop

The second stop was also on Mr Le Nail's estate, again at a 19-year-old oak stand produced from acorns sown as at stop 1. The stocking of that stand had been reduced to 2,200 trees ha^{-1} at 3 m height. The second reduction to 1,200 stems ha^{-1} occurred

Figure 5: *Selected "winners" (potential final crop trees marked with red paint bands) at 120 stems ha^{-1}. Note the openness of the stand and low the stocking at 24 years of age.*

when a top height of 5 m was attained. The stand now has only 120 trees ha^{-1} and will be thinned every four years. After the first thinning a high pruning was also undertaken. It is anticipated that by age 45 the stocking will be approximately 60-70 trees ha^{-1}, with an anticipated rotation of about 90 years.

Third stop

The third and final stop of the morning was also on Mr Le Nail's estate (Figure 5). The stand, which was 24 years-old, was first thinned at 6 m top height. The final crop will be 70 trees ha^{-1} at age 90 when the expected DBH will be 60 cm, though some trees may be up to 80 cm DBH.

It is also planned that this stand would be thinned every four years, in contrast to the original plan which was to thin every 8 to 10 years, as the increased production requires much more frequent thinning. At that site M. Le Nail hopes to have a stand reflecting an "active" silviculture approach by 40 years of age.

Monday 2nd November –afternoon

For the afternoon the group travelled to another private forest in the vicinity of Sablé-sur-Sarthe where a number of adjoining stands of oak were visited. The first was planted at 2 × 2 m in 1983/84 and was aged 31 years. It was first thinned in 2000, with further thinning in 2004 and 2008, and most recently in 2013. Current spacing is between 8 and 12 m between selected "winners". Again this stand was quite impressive for its age and was also responding well to the early and frequent thinning.

The next stop was in an oak stand which was planted in 1993. It contained an experimental area where two contrasting treatments were being tested. The first was a stand managed using active silviculture (Lemaire 2010) and the second where no thinning had taken place. While the performance of the selected "winners" was impressive, it was not as outstanding as the stands visited in the morning, however the overall performance was still outstanding.

Tuesday 3rd November -morning

The group travelled along the valley of the Loire passing the town of Vouvray with its fine château en route to the 4,000 ha Forêt D'Amboise, one of the oldest oak forests in France. This area is considered one of the most suitable areas for high quality oak production; the oak forest is recognised as the finest in all of France. While much of the oak was pedunculate in the past, today the species is only planted on a limited scale as it is now considered to be at its limit due to seasonal droughts.

First stop

At the first stop the group was introduced by Eric Severin to the local leaders for the day, Mme Laurence Degoul (UNISYLVA) and Franck Masse (CNPF) along with

M. Laurent Borel (Forester-in–charge) and M. Renaud. A short introduction to oak production in the forest was provided. Despite having a long tradition of growing high quality oak, the traditional cycle, as was also highlighted on the previous day, is now considered too long from an economic viewpoint, and so methods to shorten it are now being introduced.

Second stop

Our next stop was in a 33-year-old oak plantation. The original spacing was 1.5 × 1.5 m in small gaps. The plants used were seedlings collected in the locality (where the genetic quality was considered excellent). The height of seedlings varied between 25 and 40 cm. The rotation there was 120 years. A naturally regenerated hornbeam nurse had been used, which is considered an economically valuable understorey. Current heights range between 15 and 18 m and selected "winners" were spaced wide apart (Figure 6).

Figure 6: *Selected final crop trees – the "winners" marked with green bands.*

Near this site we also saw a naturally-regenerated 15-year-old oak stand which had a number of gaps, but where two very large gaps existed, acorns had recently been sown to achieve full stocking. Establishment costs varied between €3,000 and €5,000 ha^{-1} for oak whether by natural regeneration or planting. Natural regeneration generally results in faster establishment but if the site is considered unsuitable for the species than replanting is the only option. For instance where naturally regenerated pedunculate oak is unsuitable due to developing water deficits (Figure 2) the trend is to replant these areas with sessile oak. During the very early stages it is also important to maintain competition. At this time the most vigorous individuals ("winners") begin to develop dominance.

Other stops

During our visit to the Forêt D'Amboise the importance of "dynamic silviculture" in the production of high quality oak was demonstrated. It involved:

- planting at least 1,600 stems ha^{-1} and allowing the most vigorous individuals to express their potential, sometimes even disregarding straightness and overall quality.
- selecting 70 to 80 vigorous, well formed "winners" ha^{-1} at the time of first thinning, when the stand reaches between 9 to 12 m. Selected trees are bigger than average, where girth is approximately 20% greater than the mean of the surrounding trees.
- trees selected should be free from defects such as broken crowns, stem damage or pronounced curves in stem.
- there should be not more than three large branches on the first five metres of stem.
- allowing full crown development of the winners through regular "halo" thinning.
- at first thinning stage removing between 35 and 40% of the standing volume.

The ultimate target was 70–80 trees ha^{-1} at 90 years – which was the anticipated end-point of the shortened rotation.

Methods for sale of oak logs in France

Having seen many different sites where dynamic silviculture of oak was now the norm, the group then visited a site where logs were being prepared for a roadside log auction (Figure 7).

Since the 1990's the demand for small oak barrels, commonly known as barriques with a capacity of 59 gallons (225 l) has increased substantially (Dominé 2001). In most of the world's wine producing countries, an ever increasing number of winemakers are using these barrels as vessels to vinify white and red wines. Oak from a number of sources is used to make these barrels but French oak is considered the very best material to use.

Figure 7: *Oak logs prepared for an auction in the Forêt D'Amboise. Each log was marked to identify the specific sale lot.*

In France logs are usually sold at auctions held regularly throughout the year. The quality of oak depends on (1) colour, (2) ring width and (3) length of log. Another factor considered for barrel-making is the tannins which impart a particular taste to wine. From their experience in sourcing oak wood in the region, certain stands are noted by buyers for their desirable wood tannin characteristics, imparting a sweet taste to the wine, while others are noted for wood which imparts a bitter taste. The most desirable stands are well known in the trade. The wood lots with the desirable taste are much sought after by timber merchants. For cooperage a log of at least 40 cm in diameter and free of defects is required and with a length of 1.1 m. Prices vary quite considerably but on average the highest quality logs sell for between €400 – 600 m^3, second quality for €300 – 500 m^3 and the lowest quality for €150 – 250 m^3 (L. Degoul, 2015, pers.comm.) A detailed catalogue is prepared for each auction and extensive details of each log are provided. The quality of the logs on display in the forest varied considerably. Many were fairly crooked and had what appeared to contain several defects, nevertheless one got the impression that they were prime logs from a timber quality point of view. The quality of logs seen in the sawmill which the group visited later was also quite variable. This was somewhat reassuring for the group as we expected to see only premium quality logs in France and not such a wide range of grades and types.

Tuesday 3rd November -afternoon

After lunch the group visited a specialist oak sawmill, Scierie Besson at Beaumont. This mill produced green oak beams, air-dried oak beams, square-edged oak, oak boules, oak railway sleepers and boule logs. It saws approximately 10,000 m^3 per annum, mostly oak, with some smaller quantities of Douglas fir also.

Wednesday 4th November -morning

During the final morning the group visited another private forest in the vicinity of Vallières-les-Grandes with a stop in a stand of sessile oak planted in 1994/95 at 1,736 plants ha^{-1}. The site had been excellent agricultural land which grew corn in the recent past. The stand had been planted in strips 4 m wide, each with six rows within strips. Planted strips alternated with 3 m wide unplanted strips (Figure 8).

In an adjoining part of this stand the group (divided in two) performed a hands-on exercise. The purpose was to get a feel for the practical application of "dynamic silviculture". The first group were given the task of selecting "winners" while the other group were required to mark the "halo" thinning around the selected trees. The general tendency was for the groups not to mark enough trees for removal. For an example of halo thinning see Figure 9.

Figure 8: *A young stand of sessile oak on former agricultural land close to Vallières-les-Grandes.*

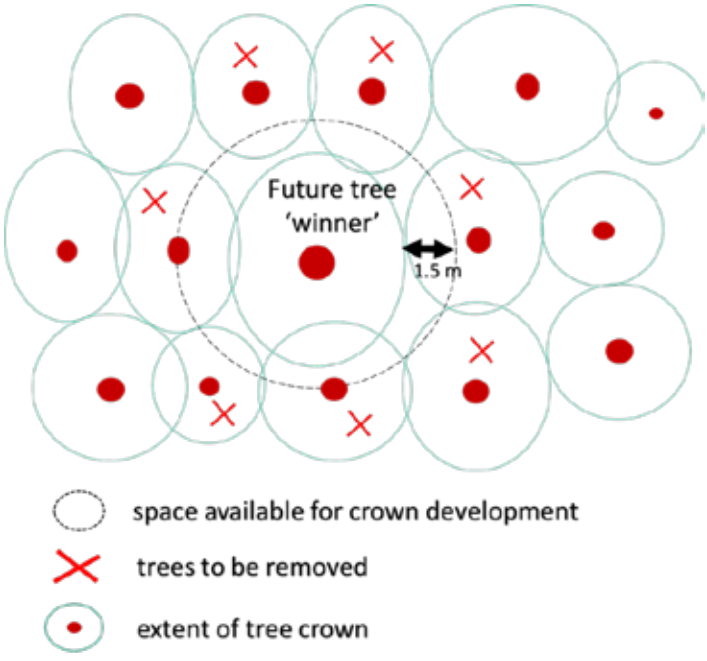


Figure 9: "*Halo*" *thinning (adapted from Anon. 2015).*

UK free growth oak study tour - April 2016

A follow-up tour took place on the 20th and 21st of April to the UK, organised by the Woodland Heritage. The aim of this tour was to expand on the lessons learned in France and discuss the merits of "free grown oak" and "active silviculture" in a British and Irish context. The tour took in two sites, the first a Forest Research experimental site at Crumbland, Wales and the second, a visit to the Cranborne Estate in southern England where a somewhat similar thinning regime as per the Lemaire (2014) methodology had been implemented.

Day 1: Crumbland, Gwent, Wales.

The Crumbland plantation is located in Tintern Forest, Gwent in Wales where the soil may be described as a well drained loamy brown earth over old red sandstone. Slope was slight to moderate with a south easterly aspect, moderate exposure and rainfall of approximately 960 mm per year. The stand was established by planting in 1931 with the plants raised from seed of an unknown origin. It was originally planted at a very high spacing of 1.2 × 0.6 m (13,888 ha^{-1}). The experiment was established in 1950, at age 19 with three original treatments applied and 10 replications of each treatment. These included: A) no thinning, B) crown thinnings, and C) free-growth. The objective of the experiment was to establish by how much the girth increment of

selected predominants could be increased, above that obtained under conventional thinning following customary practice. However, due to the small size of the plots the treatments began to overlap and in 1964 it was decided to abandon treatments A and B and convert them to free-growth treatment (C). The free-growth approach involved selecting approximately 80 final crop trees evenly spaced throughout the stand, carrying out a very heavy first thinning and second thinning (Figure 10).

The benefits of the free-growth approach were reported as:

- trees producing a high value crop on shorter than normal rotation lengths have been shown to more than compensate economically for the reduction in yield;
- following thinning to allow free-growth, crown diameter increases, and there follow substantially enhanced rates of stem diameter increment compared with trees in conventionally stocked plantations.

Figure 10: *Selected final crop tree in the foreground being measured for DBH. Note the cleanness of the stem and the size of the crown. The "free grown" oak is high pruned to 5 m and given full space for crown development, which in turn leads to rapid radial growth.*

Non timber benefits:

- "more aesthetically pleasing";
- increased light on the forest floor resulting in a more prolific shrub and small tree layer;
- Lower bole may be rendered less susceptible to squirrel damage since without branches there is nowhere for them to perch;
- The percentage of heartwood produced by free growth treatment was not significantly different to that of a crown thinning (Kerr 2008).

The reduction in number of stems per ha results in more light being made available along the trunk and thus the likelihood of epicormic branches forming (Figure 11). As only a few stems are selected as the winning final crop, it is essential that they are of a very high quality, i.e. veneer or planking quality. Epicormics seriously reduce this potential. The importance of maintaining the remaining matrix trees and not pruning

Figure 11: *Selected final crop tree. Note the presence of epicormic branches.*

them was identified as being important to increase the possibility of shade along the trunk, as was the encouragement of an under-storey.

Final crop trees are selected and favoured at 8 m. Basel area of the stand is thus decreased to such an extent that revenue from intermediate thinning will be forgone later on in the rotation. Therefore in order to make the approach viable a quality product must be produced at the end of rotation.

A discussion took place around the amount of sap wood and whether faster grown oak would result in a reduction in quality. The consensus appeared to be that, 1) fast grown timber was not an issue, rather variation in growth rates could be problematic; leading to irregular growth rings and increased flow in sap which in turn may increase the probability of squirrel damage. 2) A "slow down" period was suggested by a number of attendees. That for a target diameter of 60 cm DBH, a further 10 -15 cm in DBH may be required to allow the heartwood to develop; and result in more planking or indeed veneer quality timber being produced.

Day 2: Crichel Down and Cranborne Estate, England

On the second day the focus switched to the active silviculture system as described by Lemaire (2014). The first stop was at the Crichel Down Estate where we saw a very impressive 7.3 ha block of sessile oak with a hazel understory, planted in 1954 (Figure 12).

Figure 12: *Sessile oak (62 years), originally planted in a mixture with Corsican pine. Elite oak trees were selected at year 16. Pine was thinned and finally removed at year 29. Oak was high pruned to approximately 5 m. The mix proved to be successful. Key to this success was appropriate thinning and final removal of pine. Also note the development of a hazel understory.*

The area was originally planted in four regular blocks and four mixture types according to Table 1 below. Conifers were thinned normally and oak was regularly pruned until eventually all conifers were removed.

Using conifers as a nurse species proved to be a relative success. However, this was attributed to the active management on the site. Without this the likely result is that the oak would have become suppressed. Thinnings were carried out regularly and oak were high pruned. Maintaining a basal area of between 15 and 18 m^2 was deemed optimum in order to encourage even growth and the development of an understory. Indeed the stand has a well developed understory of hazel which shades the most valuable part of the stem, thus preventing epicormic shoot development. The site management was therefore largely in line with that proposed by Lemaire (2014).

A very interesting graph was presented by the forest manager, Andrew Poore where the "active silviculture" thinning prescription was presented alongside that of the "free growth" prescription (Figure 13). This graph demonstrated effectively that key to the active approach is the careful management of stand basal area. According to the active approach stand basal area is maintained at between 15 and 18 m^2. This is achieved by re-spacing the stand to between 1,100 and 1,500 stems ha^{-1} at a height of 6 m and then by thinning every six years up to 16 m, every 8 years from 16 to 22 m, every 12 years from 22 to 26 m, and every 15 years thereafter. At each stage, the basal area is reduced to keep it within the prescribed range. This approach provides a steady stream of income while maintaining ground conditions such that the understory of hazel is developed. While the free growth approach prescribes a heavy first thinning in the early life of the crop and progressively reducing the basal area to 6 m^2 through a series of thinnings to age 50, or a top height of approximately 19 m. At this point no further thinning is carried out and the stand is managed to clearfell. There are clearly drawbacks to this both in terms of the management of epicormics, and in terms of cash flow for the remainder of the rotation.

Table 1: *Overview of species, planting arrangement and management prescription used at the Crichel Down Estate, UK (Poore 2016). SO = sessile oak.*

Species	Arrangement	1st thinned & oak pruned	Conifer removed	Age
Norway spruce (NS)	3:3 row NS 6ft × 6 ft; SO 3ft × 4 ft	1968	1996	42
European larch (EL)	Matrix of EL at 5 ft × 5 ft l SO in groups of 13, groups at 30 ft spacing (120 ha^{-1})	1965	1979	25
Corsican pine (CP)	4:2 row CP 5ft × 5ft; SO 3ft × 4ft	1965	1983	29
Japanese larch (JL)	Matrix of JL at 5 ft × 5 ft; SO in groups of 13, groups at 30 ft spacing	1965	1983	28

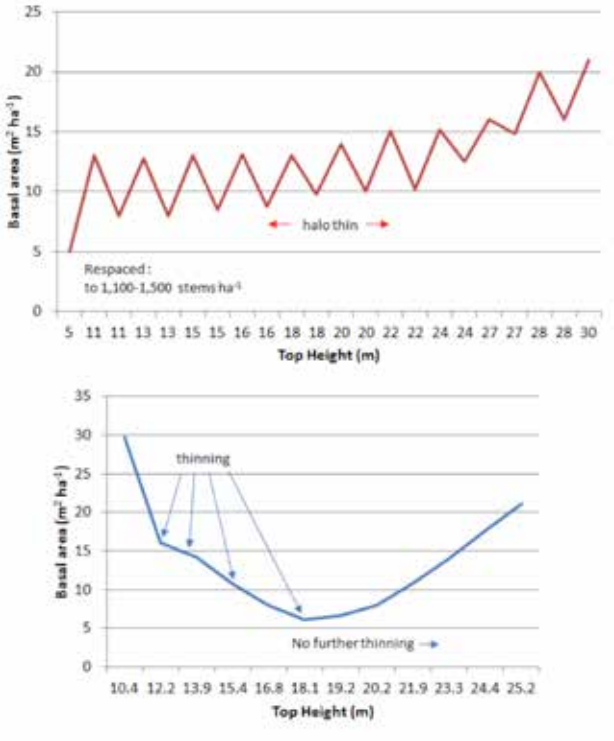


Figure 13: *Thinning regime of active silviculture (top) vs. free growth (bottom). Adapted from Poore (2016).*

Conclusion

The dynamic system of growing oak in France is one which merits greater attention by British and Irish oak growers. The findings of studies undertaken by Forest Research in the UK since the 1950's would also support this. The main elements of these findings are:

- at first establish whether a potential site is suitable for the oak species proposed – pedunculate or sessile oak depending on availability of soil moisture. This issue may not be as important for British or Irish oak growers as moisture deficits are relatively infrequent, but in parts of France, seasonal moisture availability is now becoming a very important and decisive issue regarding oak species suitability;
- plant at least 1,600-1,700 stems ha^{-1} at time of establishment using the very best and most suitable provenance available. Where stocking is high the stand is thinned at three metres to reduce to the previously stated stocking;
- stand allowed to develop until it reaches a height of 9 – 12 m. Manual cleaning carried out during this time depending on site conditions;

- identify the "winners" at as early a stage as possible;
- between 9 and 12 m the canopy closes and natural pruning takes place. Even at this stage oak may naturally re-absorb some forks and large branches. However, some of the potential crop trees (winners) may need to be pruned;
- choose only the most vigorous trees as "winners". If they are slightly crooked remember that oak has capacity for straightening to some extent during early growth;
- allow the selected "winners" complete crown space by "halo" thinning;
- remove heavy branches from the winners and even occasional forks where necessary;
- aim for a rotation of 90 - 100 years.

The dynamic system which is now being applied in certain areas of France, especially in the private sector, merits greater review, analysis and possibly a new research programme to test such methods in Britain and Ireland. This is a task of such importance for future oak silviculture in this region that the Oak Group of Future Trees Trust must now consider, discuss and possibly look to the establishment of similar trials in both countries in the near future.

The free-growth method may also prove useful for other broadleaf species such as sycamore and ash, as has been suggested by Kerr (1996, 2008) and Short (2013). However, for oak it would appear that the opening up of the stand to the degree prescribed at such an early stage of the rotation, will result in a significant issue of epicormic branching which will limit its viability.

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