The Management of Oak in Germany: A Silvicultural Note

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INTRODUCTION

The forests of Western Germany, in common with those of other European countries, have been greatly influenced by man.Over most of the country the indigenous forest was very different, both in species composition and structure, from that which exists today. A classification of the original forest types for the Federal Republic (Anon. 1962) shows the predominant position of pedunculate oak (Quercus robur L.) in the northern half of the country. From north-west Germany through Lower Saxony to the Basin of Münster and Cologne oak-hornbeam mixtures occupied the better sites with oak-birch on the poorer soils. Throughout the uplands of Hesse and towards the south-east in the Spessart oak-hornbeam forest covered the lower slopes with beech at the higher elevations. To the west in the Pfalzer Wald oak occupied the sunny slopes with beech on the north-facing shaded aspects.

These forest types have changed dramatically during the 19th and present century. Large afforestation projects have created the vast pine-dominated forests of northern Germany: spruce has advanced into Lower Saxony and Hesse and pine is spread widely in the Pfalz. Yet two regions still remain associated with the indigenous broad-leaved forest. These are the uplands of the Pfalz and the Spessart. Here the indigenous sessile oak stands have been subject to careful management over the centuries and are today considered to represent all that is best in quality oak production. They vary in composition from the irregularly distributed 250 year or more old specimen oak (Plate 1) through the more uniformly stocked middle-aged stands to the well planned closely spaced artificially regenerated young crops.Although silvicultural treatment and philosophy may vary somewhat between regions, the management objectives are ever the same — the production of a product whose value is epitomised in the phrase 'every tree a Volkswagen'.

SPECIES CHARACTERISTICS

Sessile oak (*Quercus petraea* Lieb.) and pedunculate oak

Plate 1 "Der Präsident". Johanniskreuz, Pfalzerwald.

Plate 2 Natural regeneration of *Q. robur* by Uniform System (Großschirmschlag). Biebertal, Hesse.

Adapted from "Forestry in the Federal Republic of Germany" (4th edition).

(*Quercus robur* L.) have many attributes in common. They are both light demanding and have the ability to reach a great age without deterioration in health or wood quality. By comparison with conifers both grow relatively slowly. Height increment of sessile oak culminates at 30 to 35 years for the best yield classes and at 40 to 45 years in poorer stands. Volume growth culminates later. In contrast to other light demanding species, both height and yield increment decrease very gradually after reaching the point of culmination. Both species retain the ability to react to increased growing space by crown development into old age. Beyond 150 years of age, however, they will often response to thinning by the production of epicormic branches in profusion. Thus heavy thinning after crops reach 150 years of age may mean a loss of increment and value (Petri, 1983).

The two species have highly contrasting preferences in regard to site. Sessile oak makes very little demand on the nutrient status of the soil and prefers the predominantly sandy soils (*Buntsandstein*) which occur in the upper regions of the Spessart and Pfalz. Pedunculate oak grows best on the nutrient rich, heavy, wet soils of the lowlands.It is particularly prominent in the meadow forests along the Rhine and on lower terraces where the soil water table is near the surface. The quality of its wood is, in general, not as good as that of sessile oak because of its coarse growth. Nevertheless, in the required dimensions and specified grades it is much in demand for veneer and saw timber.

The sessile oak of the Pfalz is reputed to be phenotypically homogenous and not inclined towards the development of epicormic shoots (Petri, 1983). The same is said to apply to the sessile oak of the Hessen Spessart (Langhammer, 1984). It is unclear if hybridisation occurs between the species in any region. Certainly it is not always possible to differentiate morphologically between the two. However, in the majority of cases, research has shown that it is possible to say with a high degree of probability that a foliar sample is either sessile or pedunculate.

Production Objectives

Because of the very long rotations involved and the relatively low volume yield, the establishment of oak can have no objective other than the production of high quality, high value logs for veneer and sawn lumber manufacture. Sessile oak stands with a pronounced veneer potential require a rotation of at least 240 years to reach an average 60 cm d.b.h.. Stands with a provisional potential for high quality log production need a rotation of 160 to 240 years, with the longer rotation yielding the greater proportion of veneer logs.

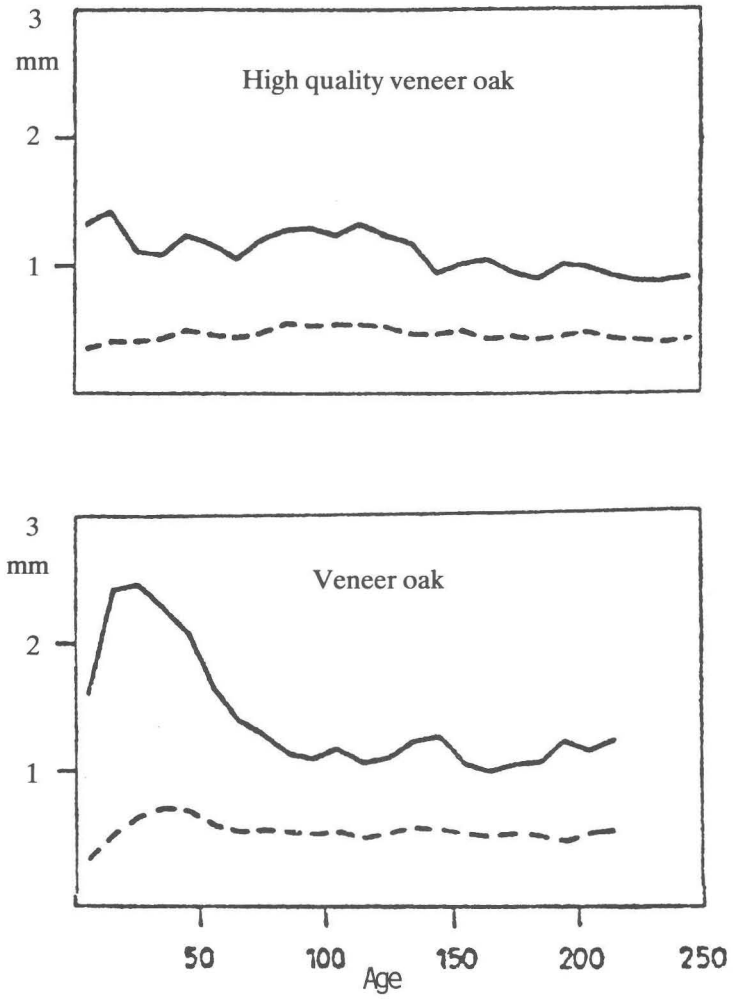

Fig 1 Average width of ring and early wood in two veneer quality groups.

(*Source:* H. Schulz, "Untersuchung uber Bewertung und Gütemerkmale des Eichenholzes aus verschiedenen Wuchsgebieten", Schriftenreihe der Forstlichen Fakultät der Universitat Gottingen, Band 23).

According to Fleder (1981) veneer quality logs must be between 55 and 75 cm in diameter; they must be free from knots and have a regular, uniform growth pattern with ring width between 1 and 2 mm. In addition, the wood must be of a light clear colour and must have good workability properties. Figure 1 shows the annual ring width and early wood growth patterns for two grades of veneer oak.

Stand Establishment

Regeneration operations are heavily concentrated in mast years which occur on average once or twice each decade. Stands are prepared well in advance, in order to take full advantage of each seed year and to make maximum use of the mast available. In general, the regeneration areas range from a minimum of one hectare to a maximum of three hectares.This upper limit is determined by a number of factors such as the availability of seed or plants, the location of the area in the felling coupe and the facilities available for wood storage and utilisation.

Natural regeneration is more the exception than the rule, particularly for sessile oak. When practised in accordance with the prescriptions of the Uniform System it can lead to very successful crop establishment (Plate 2). For optimum natural regeneration conditions, the ground should be free of weeds. Seed trees of birch and aspen should be removed from the site and the immediate environs. It is also good practice to scarify or lightly rotovate the ground at time of seed fall to curtail the growth of grass. A number of the oak seed trees should be retained for 2 - 3 years to give a light shade which checks weed growth and protects the seedlings from sun-scorch. The danger from late frost during the young growth phases should not be underestimated. Destruction of the unfolding primary leaves causes loss of increment and results in prolonged competition from grass and weed growth. Sessile oak is more sensitive to this kind of damage than pedunculate. The likelihood of damage can be counteracted by establishment under shade.

(a) The Pfalz and Bavarian Spessart

In the Pfalz and Bavarian Spessart, sessile oak for the production of veneer quality logs are almost exclusively established by means of seeding. This procedure is regarded as the most effective and surest method of regeneration. Broadcast seeding is generally ruled out because of the cost of subsequent cleaning and tending. Hence, direct sowing of acorns in rows or drills is the preferred method of plantation establishment.The following outline, provided by Nusslein (1984) for *Forstamt Rothenbuch* in the Bavarian Spessart typifies the general procedure. The area to be regenerated is reduced to 0.5 stocking density and fenced against deer. Seed is

collected in October, taken to the site where it is to be sown and spread out on the ground. A disc plough is used to cut furrows at one metre intervals. Ploughing cuts through the humus layer and penetrates to the mineral soil. The seed is bagged as required and distributed along the plough lines. Autumn sowing is carried out in October-November and up to the 20th of December or first snow fall. Sowing density is in the range 750-850 kg/ha^{-1}. The acorns are then covered to a depth of 5cm with mineral soil and firmed in. Sowing at this density usually results in about 200,000 seedlings per hectare (Plate 3). Many factors including felling of the overstory, subsequent extraction, mice, deer and jays contribute to a reduction in this number. The overall objective at this stage is to have sufficient trees for natural pruning to occur and to have a stocking density which ensures small annual growth rings.In this early stage the overhead canopy provides protection against frost and suppresses the growth of grass and weeds. Suppression of grass growth is important as mice cause much greater damage where grass exists.

The presence of some beech in the overstory is desirable because it will provide natural regeneration of this species, without which it is impossible to grow veneer quality oak. If no natural regeneration of beech (hornbeam, lime) occurs, approximately 5000 are planted per hectare, when the overhead canopy is removed. Oak is a strong light demander and although the seedlings will survive for 10 years under the 0.5 density of canopy, they will not grow well. The deer fence usually remains effective for about 12 years. With normal growth the oak should then be two metres in height and safe from deer damage. Variations on this Bavarian Spessart approach include spring sowing and a greater distance between the rows. Spring sowing entails storage of the acorns in such a way as to avoid self-heating and mould growth. Drying out of the acorns may lead to lower germination. In the Pfalz, the distance between the rows is generally 1.20m to 1.50m. In practice 1.5m spacing and a sowing density of 600 kg./ha^{-1} gives approximately 15 to 20 acorns per linear metre.

(b) The Hessen Spessart

Although the production objectives remain exactly the same in the Hessen Spessart, regeneration practice and the philosophy of oak establishment are entirely different. The main differences are described by Langhammer (1984) as follows: (1) regeneration areas are completely clear-cut; (2) establishment of the new crop is by planting rather than by sowing; (3) in subsequent cleaning operations, final crop trees (Z-stems) are identified (Plate 4). In this

operation planting stock is generally 2+0 or 3+0 undercut seedlings. The distance between the planted rows is usually 1.2m to 1.5m and plants are spaced at intervals of 30cm to 50cm in the rows. Results from spacing experiments in Hesse suggest that the optimum spacing is 2m between the rows and 50cm within rows.

Grass-cleaning and Weeding

Grass cleaning measures are similar to those applicable to other species. It is strongly recommended that old, seed bearing, birch be removed from the neighbourhood of young oak stands and that young birch growing in the area be wrenched out (not cut). Herbicides are useful for the control of grass and weeds in sessile oak stands, but care is necessary to apply the correct amounts and to use appropriate application techniques.

Weeding out of inferior oaks begins for all yield classes at about 25 years of age, when the crop height is about 8m. The purpose of the operation is to ensure that the growth potential of the final crop trees will not be impaired by competition from 'wolf trees' or unwanted species. Dominant stems of unwanted species are removed or topped back. Subdominant broadleaves, where they occur, are retained. Timely intervention is particularly important on sites susceptible to damage by snow break. The weeding process should provide growing space for the good stems which will later form the population from which the final crop stems will be selected. These stems should, at the commencement of thinning, have branch-free stem lenghts of 8m to 10m. Weeding should also admit sufficient light into the stand to ensure survival of the understory. One intervention per decade should be sufficient under normal circumstances. The weeding phase ends for all yield classes when the crop reaches 50 years of age.

Thinning

The integration and continuity of weeding/thinning phases is more critical for future value production in sessile oak stands than for any other species. Thinning begins where weeding ends and when the stand top height is in the range of 14m to 18m. First thinnings should be light and the cycle should be short. The aim should be a gradual diminution of the high stem numbers, through a selective form of crown thinning. Some 140 to 300 final crop trees per hectare are selected from the predominant and dominant classes. These should have good straight leaders, good crowns and healthy, undamaged, branch-free boles. These are the Z-stems which are of potentially high quality and value. They should be capable of sustained, vigorous, uniform growth. They are usually

marked for identification and to protect them from damage during forest operations. As in the 'Scottish Eclectic' thinning method, (McDonald, 1961), thinning should give preference to the development of those stems. Suppressed trees should be gradually and carefully removed. The objectives of this thinning are not only to develop a well formed crown, but also to avoid the formation of epicormic branches. The danger of epicormic branch development is most acute when the crowns are small and slender. Thus the maintenance and development of a uniform understory of beech, lime or hornbeam is essential, as is the promotion of volume increment. When a broadleaved understory does not exist at the beginning of the thinning phase, a heavy thinning is needed to facilitate its development. However a great deal of caution is necessary in order to achieve a balance which will prevent epicormic formation and at the same time promote understory development.

The ability of the sessile oak crown to respond to thinning ends at about 120 to 150 years of age. Up to 120 years of age the aim of each thinning must be towards good crown formation in the selected stems. Thus, thinning proceeds in the following sequence:

From 50 to 80 years: average, two thinnings per decade.
From 80 to 100 years: one thinning per decade.
From 100 to 150 years: less than one thinning per decade.

Pruning

Pruning of sessile oak is not considered necessary, although epicormic branches may be knocked off. The initial high stocking density and the subsequent cultural operations are intended to ensure a good selection of branch-free, final crop stems at a relatively early age. However, it is now proposed to prune the selected Z-stems in the recently planted thicket stage stands of the Hessen Spessart. This will be done before formation of heartwood.

Mixtures and Other Factors

For ecological reasons, for soil protection and, particularly for the production of high value produce, it is imperative that sessile oak is grown with a nursing mixture of broadleaves. Generally these consist of groups of either beech, lime of hornbeam. They may constitute 15-20% of the upper canopy, in addition to the middle story and understory trees.The mixture of beech (lime or hornbeam) is generally introduced artificially, since it is rarely possible to achieve the desirable mix of species through natural regeneration from a shelter-wood. The subordinate species may be introduced either immediately after establishment or at the pole

stage. In the former case, beech may be introduced through enrichment (*Nachbau*), some 3 to 5 years after establishment of the oak. Strong beech plants (1+1 or 1+2) can be planted at wide espacement (2m x 2m to 3m x 3m) in existing open spaces. An irregular arrangement rather than line planting is recommended. Technically underplanting at the pole stage should follow a thinning, to ensure that sufficient light reaches the ground for the survival of the young beech. Beech planted at the pole stage generally survive until the oak is mature. A disadvantage of underplanting at the pole stage is the necessity to fence against deer. Fencing at this stage restricts thinning and may lead to the neglect of cleaning operations.

The Economics of Oak Growing

Even in present-day terms, the establishment of sessile oak is a capital intensive operation. The cost of ground-preparation, sowing, fencing, protection and cleaning has been estimated to be about 10,000 DM (IR£3,350) per hectare. Positive returns from thinnings do not begin until after the trees have reached 80 years of age. Material extracted at this stage may be sold for the manufacture of parquet flooring and other relatively low value products. Thinnings from middle-aged stands command better prices and the value of the wood increases steeply as the trees grow into veneer sizes. The best price obtained in the Spessart in recent years was 42,000 DM (IR£14,000) per m^3 for the very highest quality veneer logs. Many stems, however, are sold for around 5000 DM (IR£1,700) per m^3. The final yield of about 350 m per hectare is small for the length of rotation required and only a proportion of this yield may meet the standard needed for quality veneer. Although individual logs may realise exceptional prices, the combination of low yield and long production period militates against profitability if the high establishment costs are compounded even at low interest rates. Yet, in the Spessart and Pfalzerwald, oak takes precedence over other species in reforestation wherever the site is suitable.

There are two general viewpoints of maximising returns from an operating forest and both of those have their origins in German forestry. One is the *Bodenerwartungswert* (land expectation value) developed by Faustmann; the other is *Waldreinertrag* (forest rent) which measures the average annual net revenue. In the long established regulated forests of Germany forest rent is deemed to be the more appropriate measure. The forest property is viewed as a single entity, organised for continuous production and not as an independent series of age classes.

Plate 3 *Q. petraea* regeneration by sowing. Rothenbuch, Bavarian Spessart.

Plate 4 'Z' stem selection. Bad Soden-Salmünster Hessen Spessart.

Applied to the management of oak, forest rent carries implications of continued supply and a responsibility to maintain a good forest structure. It is argued that oak is available today because of the efforts of previous generations of foresters. To harvest without sowing would be tantamount to exploitation. It would conflict with the principle of sustained yield, the forestry precept of *Nachhaltigheit.*

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