Financial Results of Selection Forest Enterprises with High Proportions of Valuable Timber – results of an empirical study and their application

Marc Hanewinkel

Key words: Selection forestry, operational analysis, financial results

1 Introduction

As the most renowned form of a permanent forest, the selection forest is expected to have advantages compared to even-aged forests. Besides low logging and planting costs, a high percentage of large timber yield and a low risk is expected in selection forests (Mayer, 1968, Schütz, 1981). However, the actual data base regarding these expectations especially concerning empirical data is rather small. Forest enterprise-related data, as a result of long-term operational analysis, are lacking. For the area of Germany one explanation could be that there are almost no forest enterprises entirely operating the selection forestry system. In particular, the state forest service has almost no selection forests. The national forest inventory shows that only 2% of the public forest (state and community forests) in the South-West of Germany are selection forests. Also, in the small private forests where the percentage of selection forests amounts to 7%, little information is available for an economic analysis.

2 Goal of the Investigation

The goal of the present investigation is to analyse the financial situation of forest enterprises with a high percentage of selection forests (for a definition of 'selection forest' see Schütz, 1989, p.2) and a high proportion of valuable timber in order to evaluate forest enterprises characterised by the "selection forestry" management system from an economic point of view. The economic indices that are investigated in the present study can thereby only reflect the individual situation of the surveyed enterprises and the revenue/cost relation of the investigation period. However, the results of the study for the selection forests may be used for a benchmarking approach or as the database for modelling approaches of uneven-aged forests. The detailed questions that are linked to this investigation are :

- What are the financial results of these selection forest enterprises compared to other forest enterprises (the average forest enterprise) with different management regimes in the study area ?

- What is the role of risk in these selection forest enterprises ? Does it affect timber quality ?
- How high is the percentage of valuable timber in the selection forests and which assortment yield (percentage of stem-wood) can be expected in these forests?
- What is the reason for the detected timber quality ? Is it linked to disproportionate high costs – e.g for pruning or young growth tending – today ?

For the investigation two study-enterprises, a private selection farm forest of 100 hectares (in the following called: 'farm forest Y') and a selection forest district of 100 hectares ('district XVII') as part of a community forest of 600 ha ('community forest X') in the central Black Forest, were chosen. The selection forests are investigated by an operational analysis over a 15-year period using a detailed set of indices. Both of the forests are – due to their management tradition – characterised by a very high percentage of valuable timber in the annual cut, which puts them on top of forest enterprises comparable in sites and typology. Thus, the economic potential of large-timber selection forestry can be depicted with the data presented here.
To clarify the results of the selection forest enterprises they are compared to the indices of neighbouring state forest enterprises or groups of state forests, which are dominated by age class forests.

3 The Study- Enterprises

The study enterprises are located in the coloured-sandstone area of the central Black Forest. The natural wood association here is the montane beech- silver fir forest (Abieti Fagetum). In an altitude zone between 700 and 850m with a mean annual temperature of 7,5 ^{o}C and mean precipitations of 1500 mm per year, the forests are located in the center of the extension of the silver fir (Abies alba, Mill.) and thus of possible selection forestry.

[Table 1a and b]

Table 1a and b show the main inventory data of the study enterprises and of two neighboured state forest enterprises and two state forest groups. Both of the study enterprises with high proportions of selection forests (community forest X and farm forest Y) have a standing

volume between 370 and 410m^3/ha with an excess of large timber in the stem distribution. However, in regard to the structure of the standing volume, they cannot be looked upon as 'hoarding enterprises' with an excessive amount of large timber percentage compared with the steady state for selection forests calculated with a model after Prodan (1944) for site index II. The 100-ha pure selection forest district XVII is today the center of high quality timber production in the community forest X. Due to intensive pruning in the past which led to an unusual concentration of highly valuable pruned large timber, this district is renowned beyond the region and achieves extraordinary high timber prices in auctions. In order to clarify the results of the operational analysis of the two study enterprises they are compared with the results of two neighboured state forest enterprises (state forests A and B) and the mean results of two groups of state forests (group I and II). Both of the state forests are located in the same growth region and have 90% of conifers with similar site classes for silver fir and Norway spruce as the selection forest enterprises. The state forest groups cover the area around the study enterprises and comparative enterprises. State forest B is a typical age class forest with a high percentage of Norway spruce and dominated by older age classes (>80 years). Both of the state forest groups can be designated as pure even-aged forests. They both have an excess in the older age-classes. The state forest group II has a higher percentage of deciduous trees than the other forest enterprises and groups (table 1b). Table 2 shows the classification of the different enterprises, districts and groups according to the proportions of the different management systems.

[Table 2]

4 Methods and database

The purpose of the present investigation is a retrospective analysis of economically relevant indices of selection forest enterprises. The method chosen here was an operational analysis which was executed for the period of 1980 to 1994 and was limited to the most important cost centers "timber harvest", "planting" and "stand tending". The parameters of such an analysis are indices which numerically characterise the operational performance of a process or a working area. Within the present investigation an index catalogue was used which should on the one hand reproduce operational processes as exactly as possible and on the other hand answer the surveyed questions as much detailed as possible (table 3).

[Table 3]

Beginning with the financial results of the forest enterprises which were described as the operating profit (revenues minus expenses) and the input/ouptput – ratio (expenses in % of revenues) the surveyed indices were stepwise analysed in order to detect particularities of the selection forest enterprises that might have influenced their financial results and led to differences compared to forest enterprises dominated by other management regimes. The subsequent classification of the analysed indices with the help of neighbouring state forest enterprises can be – in terms of methodology – looked upon as a comparative analysis. Due to the differences in typology - mainly concerning the forest area and the organisation type - this comparison is only of restricted power.

The success of an operational analysis essentially depends on the quality of the investigated data recorded by the accounting system. As official index catalogues used by state forest administrations to analyse forest enterprises during the regular controlling process (Berger, 1997) are often not sufficient to answer detailed scientific questions, additional data sources had to be utilised. The data base for community forest X was the records of the volume felled, of the planting sites and the areas of pruning and young growth tending taken out of the regular accounting, and the management plans (the annual financial statements) for the economic indices. For a more detailed analysis of the cost center "Timber Harvest" (Table 3) this database was not sufficient. Thus, primary data - taken out of 'timber lists' (sales bills with detailed information of the sold logs), available for community forest X since 1984 - were additionally used. Altogether, 'timber lists' with a total of 35.000 m^3 of timber were evaluated. The data base for the farm forest Y was a 'farm forest test survey - net' maintained by the Baden-Württemberg Forest Research Station in order to get economic data from private forest owners in the South West of Germany. In addition to the data of the survey net, 'timber lists' with overall 10.000 m^3 of sold timber since 1983 were evaluated. The data for the comparative state forest enterprises and groups was taken from forestry statistics of the state forest administration.

5 Results

5.1 Operating profits

[Table 4]

Table 4 shows that the operating profits (revenue minus expense) of the survey enterprises are extraordinarily favourable compared to those of neighbouring state forest enterprises. Farm forest Y and community forest X reach between 450 and 500% of the operating profit of the state forest group I. An adjustment of these results on the annual planned cut (prescribed cut) does not substantially change the results. The higher operating profits are due to distinctly higher revenues. The expenses in community forest X is lower and in farm forest Y higher than in the other enterprises due to a high proportion of fixed costs linked to the small forest area of the farm enterprise. The input-output ratio (expense in % of the revenue) for farm forest Y and community forest X (no expenses are recorded for the district XVII and no revenues and expenses for the state forest group II) is between 48 and 53. The results from operations of the two enterprises have always - except in 1991 - been positive. Until the end of the 1980s the input/output-ratios of community forest X were constantly between 35 and 50, for farm forest Y between 40 and 60. After 1990 the ratios distinctly deteriorated due to the effect of the storm in 1990. Compared to that, the input/output ratios of the state forest enterprises are distinctly higher - between 78 and 83.

5.2 Incidental exploitations – assortment yield

In order to detect the cause for the differences in the operational results the main influencing factors – the annual harvested volume, the rate of incidental exploitations mainly due to snow and storm and the rate of stem-wood - were firstly analysed (table 5).

[Table 5]

Table 5 shows, that the planned annual cut and the harvested volume especially in district XVII are below the annual increment, which leads to a medium-term rise in growing stock. As a first conclusion of table 5, it can be seen that the investigation period was a 'calamity-period' where the forest management in the central Black Forest was highly dominated by external influences (mainly the snowbreakage in the early eighties and the storm and its consequences in 1990). This situation is expressed by extremely high percentages of incidental exploitations that reach more than 60% of the total harvested volume in state forest B and a high level of forced exploitations in the other forest enterprises.

The storm of 1990 is not the only reason for the remarkably high percentage of incidental exploitations that reached 43% of the 15-year mean total harvested volume for community forest X. Already in the years 1982, 1987 and 1988 more than 45% of the harvested volume

were incidental exploitations. Two main damaging events occurred: snowbreakage in the years 1981 to 1983 and 1987 to 1988 and windfall and its consequences after 1990.

In the pure selection forest district XVII the percentage of incidental exploitations was 29%, a value that was not to be expected in a pure selection forest. Here, the situation has - with clearly restricted harvesting indeed - dramatically deteriorated since 1990. For the farm forest Y the mean value for the years 1983 to 1994 was about 20% and thus below the value of the community forest. In this pure selection forest enterprise, classic calamities like windfall or snowbreakage were - apart from a few years - of little importance.

The assortment yield for the selection forest district XVII (since 1984) and community forest X (since 1984) shows that over 15 years, 88% of the total harvested volume of community forest X and the district XVII were stem-wood. With the extreme years 1984 and 1992 excluded, 90% of the harvested volume in district XVII are stem-wood. In both cases the assortment yield can be looked upon as extremely favourable. In farm forest Y almost 94% of the total harvested volume are stem-wood. Hence, it must be taken into account, that the investigation deals with forest enterprises dominated by coniferous species, where 80% of stem-wood are reached in age-class forests (state forest A and B, group I) as well (table 4).

5.3 Quality classes - percentage of high quality timber - index figures

[Table 6]

Table 6 reveals that the predominance of the selection forest enterprises is mainly the result of very high revenues due to high percentages of high value timber. High quality timber of district XVII and community forest X is sold as full - (or part-) veneer wood, resonant (sounding) timber and rotary (peeled) veneer wood. Since 1992 full- and part-veneer- wood is sold as A-quality wood (s. subtitle of table 5) at specialized high-quality-timber auctions. To prove that these high quality logs are branchless, in an expensive procedure the stems at the last visible branch whorl - from the stemfoot - are cut in order to show the limbless outer radius of the log to the customer.

Except in the years 1987 and 1994 the high quality timber of community forest X came exclusively from district XVII. The percentage of high quality timber achieved there has not been equalled by any other public forest enterprises in the Black Forest region. A quality distribution of about 75% of B-quality, 20% of C-quality and 5% of D-quality of Norway spruce / silver fir stem-wood would be typical for the average state-forest enterprise in the

survey region. Almost no A-quality timber is harvested in the state forest group II. The exceptionally high percentage of high value timber in the district XVII is based on the long tradition of pruning in this selection forest. In community forest X the percentage of B-quality timber is very high, whilst a special kind of timber sorting in farm forest Y where pruning is also practised leads to unusually high percentages of A- and C-quality timber. The amount of C-quality timber in community forest X and in district XVII is very low despite a high percentage of silver fir which normally results in a lower quality of the harvested timber.

The mean index figures (as direct indicator for the dimension of the harvested trees - s. table 5) for the pure selection forest areas are substantially higher than in the age-class forests (group II) or in the enterprises partly consisting of age-class forests (community forest X). The average harvested log with B- or C-quality in the state forests of the group II has a mid-diameter (diameter in the middle of the logs that are mainly sold as long logs with up to 20m of length) of around 30cm whilst the logs of these quality classes in the pure selection forests reach mid-diameters of more than 40cm. According to the index figures, the average mid-diameter of the A- quality class is between 50 and 60 cm or even higher.

5.4 Revenues per quality class

[Table 7]

Table 7 provides an overview of the revenues per m^3 in the survey- and comparative enterprises. Revenues per quality classes were only recorded for the state forest group II. Table 7 shows that the highest average revenues per m^3 of all enterprises are achieved in the district XVII with more than 160 € per m^3. These unusually high revenues are based on very high prices achieved for high valued A- and B-quality timber. Due to a very high diameter of the logs (index figures >48 s. table 6) the revenues for C- quality timber in district XVII are distinctly higher than in group II (index figure 41.7 for C-quality). The prices for C-quality timber in farm forest Y are – with 75 € per m^3 – exceptionally high. Here, the mean index figure for C-quality (47.3) is more than 20% higher than in group II (41.7 – see table 6). Therefore the price for C-quality timber in farm forest Y excels B-quality in the group II. Due to lower prices for B- and C- quality timber the revenues for timber in community forest X are below of those in district XVII and farm forest Y. The revenues in the state forest enterprises A and B and the group II are distinctly lower than those in the selection forests. This emphasises the outstanding position of the survey enterprises, which reach unusually high

revenues due to high percentages of high quality timber and a very large diameter of the average log in the harvest. In the selection forests the harvesting is concentrated on few large trees.

5.5 Planting sites - young growth tending

[Table 8]

Planted areas are only investigated in detail for the district XVII (for the mean values of the community forest X - see table 8). Data for farm forest Y were not recorded.

Tab. 8 shows that planting is of no importance in district XVII. From 1980 to 1988 no planting at all was carried out. Mainly after the storm of 1990 planting on very small scale level took place. The total planted area in the 100 ha - forest in 15 years was below 2 ha. Thereby altogether 2100 plants were used (140 per year). This equals to a yearly percentage of 0,13% of the total forest area with less than 1100 plants per ha planting site (1,4 plants per ha total forest area per year). No preparation of planting or tending of plantations was executed.

Areas of young growth tending and pruning are analyzed for community forest X and district XVII. Data for farm forest Y were not recorded. The average area of young growth tending in farm forest X was 2,3 %/yr of the total forest area. Particularly in 1989, and in the years after 1990, intensive young growth tending was executed. In district XVII young growth tending took place on 1,7%/yr of the total forest area. Except in 1986, no young growth tending was carried out until 1989. The intensity distinctly rises after 1990.

Pruning is traditionally one of the most important activities in district XVII. In community forest X an average of 3,4% of the total forest area are pruned yearly with 410 trees per ha pruned. In district XVII, almost 5,7%/yr of the total forest area are pruned, thus more than 85% of the total area within the survey period of 15 years were subject of pruning activities. Thereby almost 420 trees per ha were pruned, 70% of them (300/ha) up to a height of 5m, and 30% (120/ha) to more than 5m. This is obviously more than would be pruned in an age class forest with a full stocking of future crop-trees. However, it must be considered that the unusual concentration of high quality timber in district XVII today is the result of a similar pruning intensity in the past.

The interpretation of these indices is difficult. Basically, indices linked to the total forest area of forest enterprises with a distinctly different size are hard to analyse. This is especially valid for planting and young growth tending, where a minimum size for each activity should be

observed for economic reasons. In addition, it has to be considered that for young growth tending an index that characterises the intensity of the activities like the labour intensity (labour hours per ha for young growth tending) is lacking.

In the pure selection forest district XVII the volume of planting and young growth tending and the intensity of planting – expressed as number of trees planted per ha of forest area – is distinctly lower than in the other surveyed enterprises. Beyond that, Community forest X, despite having 60% selection forest, hardly differs from the two comparative enterprises and the state forest group I. The number of pruned trees is for historical reasons very high in district XVII and community forest X. Here, the pruned area is 3 to 10 times higher than in the comparative enterprises.

6 Discussion

The economic performance of uneven-aged forests has often been subject to an economic analysis (Hall, 1983; Nautiyal, 1983; Haight, 1985; Bare & Oppalach, 1988; Buongiorno et al. 1994; Buongiorno et al. 1995; Volin & Buongiorno, 1996).

The European literature on natural and economical productivity of selection forests as opposed to age-class forests displays controversial discussion. In regard to productivity as volume increment of the two management systems, various authors hold different views (Assmann, 1961; Ammon, 1951). The supremacy of one of the systems is very difficult to prove (Kern, 1966). As far as economic profitability is concerned, the superiority of selection forests seems to be definite: Almost every study (Ammon, 1951; Mitscherlich, 1952; Mayer, 1968; Roches, 1970; Siegmund, 1973; Schütz, 1981; Leibundgut, 1975,1983; Schütz, 1997; Knoke, 1998) – regardless of whether an empirical or a model-oriented approach was chosen – shows that selection forests yield higher financial results than comparable age-class forests. A critical view of the methodology of these studies seems to be essential (Hanewinkel & Willmann, 1996; Hanewinkel, 1998).

Statements concerning the economic performance of selection forests are mainly based on aspects of 'timber harvesting'. The favourable structure of the harvested timber (high percentages of stemwood and large timber - Schütz, 1981) and low logging costs (Roches, 1970; Leibundgut, 1975,1983) are mentioned. Leibundgut (1975,1983) shows that the number of plants required in selection forests is much lower than in age class forests with distinctly lower expenses for planting and young growth tending and a clearly better input/output ratio.

Schütz (1997) calculates the productivity in value of selection forests up to 40% higher than in age class forests. A model study (Hanewinkel, 1998) using the indices of the present paper as a framework shows that, without taking risk influences into consideration, selection forests and age class forests of equal timber quality and volume increment can reach similar net revenues. However, taking risk-influences into considerations, the net revenues of age-class forests can dramatically decrease.

The results of the present study are rare in the sense that they include parameters (e.g. timber quality, area of pruning, area of planting, incidental exploitations) that are usually not reported in such studies due to the lack of a database. Thus, the study can contribute to a more objective evaluation of the economic potential of selection forest management. The results show clearly that, given a certain intensity of pruning, selection forests can achieve extremely high proportions of highly valuable timber and consequently high revenues. Looking at these results, opinions assuming a general lower timber quality in selection forests compared to age-class forests (e.g. Assmann, 1961) are untenable. The revenues are diminished by the costs for pruning. However, looking at the operating results of community forest X (table 3) where the intensity of pruning is clearly higher than in neighboured state forests, one can consider that this does not necessarily lead to on overall higher level of expenses. Compared to the cost center "timber harvesting", "pruning" is of little importance. In addition, the intensity of planting in the pure selection forests observed is – with less than 1.5 plants per year and ha of forest area – extremely low.

The expectations towards a very low or even negligible influence of risk in selection forests (Leibundgut, 1983, Mayer, 1968) can not entirely be met by the present investigation. Almost 30% of incidental exploitations in a pure selection forest district and more than 40% in a forest that is mainly composed of selection forests are unexpected results. Mohr and Schori (1999) found higher incidental exploitations in selection forests than in the compared age-class forests but on a distinct lower level of risk induced harvesting. The results of the present study nevertheless show that the impact of risk on the financial output of the selection forests is limited. There are obviously no severe damages on the trees that might affect the timber quality and the cost of "repairing" the damage by planting is not important.

Looking at the overall results of the different forest units of the present investigation one might come to the conclusion that there is a general supremacy of selection forests compared with age-class forests. However, the investigation reveals clear differences in typology mainly concerning forest area, history and organisation form of the different enterprises. Thus, the

results should not be used to compare age-class forests and selection forests in a general way. Such a comparative empirical analysis would require much more similarities between the forest units that are surveyed. It is unlikely that it is possible to find two forest enterprises that are 'equal' in a way that differences in economic indices that can be detected by a scientific investigation can really be assigned to the different management systems.

7 Conclusions – how to use the results of the present study ?

Schori (1999)[1] discusses the possibility to use the results of empirical studies on different management systems as a benchmark for other forest units (for the results of the study see Mohr & Schori, 1999). Benchmarking seems indeed to be a more sensible way to use the results of empirical studies like the present one. A forest owner who is willing to convert his forest from an even-aged to an uneven-aged status for economic reasons is better supported in his decision if he knows what each of the different management systems can yield under favourable conditions than with a comparison of some more or less arbitrarily chosen forests. The results of the present investigation concerning the selection forest (especially of district XVII) can serve as a benchmark for a silver fir / Norway spruce-type of selection forest in the montane zone of the Black forest area. A similar benchmark for an even-aged forest of the same type has still to be detected. Merker (1997: 159) discusses central elements of substantive goals for near-to-nature forestry. The selection forest – despite his high percentage of conifers and his artificial structure – is often used as an ideal model for near-to-nature forestry. The results of the present study may be used as an example for the economic possibilties if this ideal uneven-aged structure is reached. Another possible approach to use the results of this study is to get a new and more complete database for modelling selection forests (Hanewinkel, 1998).

In order to be able to find such benchmarks, a formalised and complete catalogue of indices is required. The indices (table 3) used in the present investigation are obviously not complete

[1] Schori, C. (1999). Analyse von Plenterwaldstrukturen anhand wichtiger betrieblicher Kennziffern. Diploma – thesis (unpublished), ETH Zürich.

due to the restricted database provided by the booking system. Berger (1997) discusses how such an index catalogue for the controlling of forest enterprises should look like. Among the 'process-based' indices (Berger, 1997:197ff), those of the process-sectors "timber-harvesting", "stand establishment" and "forest tending and protection" are the most important. What is obviously lacking in table 3, is a more detailed analysis of the harvesting costs and separate indices for felling and skidding. For the sector "forest tending", the intensity of young growth tending should be recorded by an index. Indices of the process-sector "forest roads" are important to control whether selection forestry requires higher costs for road construction and road maintenance. The production of highly valuable timber requires a high value of the growing stock. Thus, the interest costs linked to this type of selection forestry are certainly higher compared to other management regimes. Ideally, these interest costs should be documented by an index. However, the appraisal of the value of the growing stock is usually not exact enough due to methodological problems and a lack of inventory data.

8 Abstract

The goal of the investigation is to analyse the financial situation of forest enterprises with a high percentage of selection forests and a high proportion of valuable timber. In the centre of the investigation are two study-enterprises, a private selection farm forest and a selection forest district as a part of a community forest in the central Black Forest. The selection forests are investigated by an operational analysis over a 15 year-period using a detailed index catalogue. The results are compared to those of two neighbouring state-forest enterprises and two state forest groups. The two surveyed enterprises exhibit clearly favourable economical indices - due to high revenues linked to a very high proportion of valuable timber in the annual cut. It is discussed in which way these results can be interpreted in respect of decision support for forest managers. A benchmarking approach is thereby preferred to a comparative approach between even-aged and uneven-aged management systems.

9 Zusammenfassung

Ziel der Untersuchung ist die finanzielle Analyse von Forstbetrieben mit hohen Anteilen an Plenterwald und Wertholz. Im Zentrum der Untersuchung stehen zwei Untersuchungsbetriebe, ein Bauernplenterwald und ein Plenterwalddistrikt als Teil eines Gemeindewaldes im

Mittleren Schwarzwald. Die Plenterwaldbetriebe werden im Rahmen einer Betriebsanalyse über 15 Jahre mit Hilfe eines detaillierten Kennzahlenkataloges untersucht. Die Ergebnisse werden mit denen zweier benachbarter Staatswaldbetriebe sowie zweier Staatswaldkollektive verglichen. Die beiden Untersuchungsbetriebe zeigen deutlich günstigere ökonomische Kennzahlen aufgrund hoher Einnahmen, die auf sehr hohe Anteile an Wertholz im jährlichen Einschlag zurück zu führen sind. Es wird diskutiert, in welcher Weise diese Ergebnisse im Hinblick auf eine Entscheidungsunterstützung für Forstbetriebsleiter interpretiert werden können. Dabei wird einem "benchmarking"-Ansatz der Vorzug vor einem vergleichenden ökonomischen Ansatz zwischen Alterklassen- und Plenterwaldsystemen gegeben.

10 References

Ammon, W. (1951). Das Plenterprinzip in der Waldwirtschaft: Folgerungen aus 40 Jahren schweizerischer Praxis, 4.Ed., (1995, by L. FAVRE) Haupt, Bern-Stuttgart-Wien, Switzerland.172 p.

Assmann, E. (1961). Waldertragskunde, BLV, München-Bonn-Wien, Germany. 490 p.

Bare, B.B. & Oppalach, D. (1988). Determining Investment-Efficient Diameter Distributions for Uneven-Aged Northern Hardwoods. For. Sci. 34: 243-249.

Berger, M. (1997). Controlling mit Kennzahlen im Forstbetrieb –Entwicklung eines forstspezifischen Kennzahlensystems zur operativen Betriebssteuerung. Aachen, Shaker-Verlag, 281 pp.

Buongiorno, J.; Dahir, S.; Lu, H.-C. & Lin, C.R. (1994). Tree Size Diversity and Economic Returns in Uneven-Aged Forest Stands. For. Sci. 40: 83-103.

Buongiorno, J. ;Peyron, J.-L.; Houllier, F. & Brucciamacchie, M. (1995). Growth and Management of Mixed-Species, Uneven-Aged Forests in the French Jura: Implications for Economic Returns and Tree Diversity, For. Sci. 41: 397-429.

Haight, R.G. (1985). A Comparison of Dynamic and Static Economic Models of Uneven-Aged Stand Management. For. Sci. 33: 908-931.

Hall, D.O. (1983). Financial Maturity for Even-Aged and All-Aged Stands. For. Sci. 29: 833-836.

Hanewinkel, M. & Willmann, U. (1996). Ökonomische Leistungsfähigkeit zweier Plenterwaldbetriebe mit hohen Wertholzanteilen im Mittleren Schwarzwald.

Arbeitsbericht 25-96, (Research paper) Institute of Forestry Economics, University of Freiburg, Germany. 54 p.

Hanewinkel, M. (1998). Plenterwald und Plenterwaldüberführung - Modellstudien zu planungstechnischen, waldbaulichen und ökonomischen Aspekten am Fallbeispiel des Wuchsgebietes Schwarzwald. PhD-Thesis, Univ. of Freiburg, Germany. 252p. (English summary).

Kern, K.G. (1966). Wachstum und Umweltfaktoren im Schlag- und Plenterwald, Schriftenreihe der forstlichen Abteilung der Universität Freiburg, Germany 5, 119 p.

Knoke, T. (1998). Analyse und Optimierung der Holzproduktion in einem Plenterwald. Forstliche Forschungsberichte, München, Germany. 182 p.

Leibundgut, H. (1975). Über den Arbeitsaufwand für Holzernte, Kulturen und Waldpflege im Plenterwald, SZFW 126: 901-903.

Leibundgut, H. (1983). Führen naturnahe Waldbauverfahren zur betriebswirtschaftlichen Erfolgsverbesserung ? Forstarchiv 54: 47-51.

Mayer, H. (1968). Langfristige waldbauliche Betriebsrationalisierung, AFZ 23: 687-689; 711-713; 725-728; 742-743; 754-757; 770-771.

Merker, K. (1997). Ein Controllingsystem 'Naturgemäße Waldwirtschaft'- Schriften zur Forstökonomie, Band 17. Sauerländer's, Frankfurt/Main, 212 pp.

Mitscherlich, G. (1952). Der Tannen-Fichten-(Buchen)-Plenterwald, Schriftenreihe der Badischen Forstlichen Versuchs- und Forschungsanstalt, Freiburg, Heft 8, 42 S.

Nautiyal, J.C. (1983). Towards a Method of Uneven-Aged Forest Management Based on the Theory of Financial Maturity. For. Sci. 29: 47-58.

Prodan, M. (1944): Zuwachs und Ertragsuntersuchungen im Plenterwald - Ein Beitrag zur Methodik der Ertragsuntersuchungen im Plenterwald dargestellt anhand der Ergebnisse der badischen Plenterwaldversuchsflächen, Diss. Universität Freiburg, 135 S.

Roches, D. (1970). Etude comparative des prix de revient d'une récolte en forêt régulière et en forêt jardinée, SZFW 121: 215-238.

Schori, C., Mohr, B. (1999). Femelschlag oder Plenterung – Ein Vergleich aus betriebswirtschaftlicher Sicht. SZFW 150: 49-56.

Schütz, J.-P. (1981). Que peut apporter le jardinage à notre sylviculture?, SZFW 132: 218-242.

Schütz , J. P. (1989). Le jardinage - Script - Sylviculture III, EPF- Zürich, 54 p.

Schütz , J. P. (1997). Sylviculture 2, Presses Polytechniques et Universitaires Romandes.

Siegmund, E. (1973). Aufwand und Ertrag bei waldbaulichen Betriebsformen, PhD – thesis. Universität München, Germany. 108 p.

Volin, C.V. & Buongiorno, J. (1996). Effects of Alternative Management Regimes on Forest Stand Structure, Species Composition and Income: A Model for the Italian Dolomites. For. Ecol. and Manage. 87: 107-125.

Address of the author

Dr. Marc Hanewinkel
Institute of Forestry Economics
University of Freiburg
Tennenbacherstr. 4
D- 79104 Freiburg, Germany
Tel : ++49-761-203-3686, Fax : ++49-761-203-3690
Email : hanewink@uni-freiburg.de

11 Acknowledgements

I want to thank Ulrike Willmann (Freiburg) for assistance with data-collection and analysis, Prof. Dr. G. Oesten (Institute of Forestry Economics, University of Freiburg) and Prof. Dr. J. Ph. Schütz (chair of sylviculture at the Swiss Federal Insitute of Technology, Zurich) for discussions and useful hints and the local State Forest officers, the communal and private forest owners for their readiness to allow the investigaton and let the data. In addition, I want to thank Dr. Anton Bürgi (WSL) and one anonymous reviewer for their useful comments.

List of tables:

Table 1: Inventory data of the study enterprises
Table 2: Classification of the different study and comparative enterprises according to their management system
Table 3: Catalogue of indices used in the operational analysis
Table 4: Profit and Loss (Operating Profit in % of group I and Input/Output Ratio).
Table 5: Planned annual cut, harvested volume, percentage of incidental exploitations and stemwood in the investigated survey- and comparative enterprises and groups.
Table 6: Distribution of quality classes and mean index figures of the quality classes (stem-wood of Norway spruce and silver fir). Weighted mean of the years 1984 - 1994 .
Table 7: Revenues per ha (per m3 of harvested timber) in % of group I, and per quality class of stem-wood
Table 8: Comparison of the indices for planting, young growth tending and pruning.

Table 1a: Inventory data of the study enterprises. Source : Forest Management Plan 1986 (Y) and 1988 (X).

	Comm. Forest X	Distrikt XVII	Farm Forest Y
Species composition			
% of Norway spruce	45	41	37
% of Silver fir	55	59	63
Growing stock			
m^3/ha – effective	367	412	405
m^3/ha – normal (steady state*)	401	415*	415*
% of Norway spruce	45	40	36
% of Silver fir	55	60	64
Volume increment			
m^3/ha/yr – long term average	7.9	-	-
m^3/ha/yr – periodical	7.5	6.6	6.7

* calculated with a steady state model after Prodan (1944; Site index II, upper limit)

Table 1b: Inventory data of the comparative enterprises. Source : Forest Statistics , 1994.

	State Forest A	State Forest B	Group I	Group II
Species composition				
% of Norway spruce	50	70	58	40
% of Silver fir	38	21	20	13
Growing stock				
m^3/ha – effective	497	390	362	331
m^3/ha – normal	--	--	--	--
% of Norway spruce	56	72	63	47
% of Silver fir	37	22	22	15
Volume increment				
m^3/ha/yr – long term average	8.0	6.7	7.0	6.6
m^3/ha/yr – periodical	9.0	7.4	--	--

-- = not calculated or recorded

Table 2 : Classification of the different study and comparative enterprises according to their management system

District, Enterprise, Group (+)	Area (ha)	Percentage of (%)			11.1 Classification
		SelF	ConF	ACF	
District XVII (D)	100	100	-	-	pure selection forest
Farm Forest Y (Y)	100	97	-	3	pure selection forest
Community Forest X (X)	600	62	22	16	selection forest with conversion- and age-class forest
State Forest A (A)	1400	12	19	69	age-class forest with conversion- and selection forest
State Forest B (B)	3250	-	-	100	pure age class forest
State Forest Group I (GI)	53250	1	-	99	pure age class forest
State Forest Group II (GII)	92000	-	-	100	pure age class forest

(+) = in parentheses : abbreviation of the different enterprises/groups (Table 3)
area = total forest area, SelF = Selection Forest, ConF = Conversion Forest,
ACF = Age Class Forest

Table 3 : Catalogue of indices used in the operational analysis

Indices	Units	
(I)	(II)	(III)
PROFIT AND LOSS		
(1) operating profits		
revenues	€/haF	
expenses	€/m^3	
(2) input-output ratio		%
TIMBER HARVEST		
(3a) Regular Exploitations		%
(3b) Incidental Exploitations		%
(4) Assortment yield		%
Percentage of Stem Wood		%
(5) Degrees of Quality - Distribution		%
Percentage of High Quality Timber		%
(6) Index Figures	€/m^3	
(7) Revenues Per Quality Class	€/m^3	
PLANTING		
(8a) Planting Sites (ps)	ha(ps)	%
(8b) Number of Plants	n/ha(ps)	
	n/haF	
STAND TENDING		
(9) Young Growth Tending	ha(ygt)	%
(10) Pruning	ha(pru)	%
	n/ha(pru)	

haF = ha of total forest area,
ha(ps) = ha of planting sites,
ha(pru) = ha of pruning,
ha(ygt) = ha of young growth tending;

units in % are related in :
(1), (2) to the total harvested volume
(3) to the harvested volume of stem wood
(5),(6),(7) to the total forest area

Table 4: Revenues, expenses, operating profit and input/output ratio. Revenues without grants. Expenses without expenses for administration and depreciation for roads. Mean of the years 1980 to 1994. (Data not recorded for District XVII and Group II).

Enterprise/ Group II	Revenue	Expenses	Operating profit	Input/Output Ratio
	€/ha (€/m^3)			%
Farm Forest Y	814(108)	434 (58)	380(51)	53
Comm For. X	682 (95)	329 (46)	352(49)	48
State Forest A	479 (73)	387 (59)	92 (14)	81
State Forest B	543 (66)	420 (54)	123(13)	78
Group I	450 (62)	373 (52)	77 (10)	83

Table 5: Planned annual cut, harvested volume, percentage of incidental exploitations and stem-wood in the investigated survey- and comparative enterprises and groups. Weighted mean of the years 1980 (1984) to 1994. (Data not recorded for Group II).

	Ratio			
Enterprise/Group	Planned Annual Cut (m^3/ha * a)	Harvested Vol. (m^3/ha * a)	Incidental Exploitations (%)	Stem-wood (%)
District XVII	6,1	6,1	29,0	87,8
Farm Forest Y	6,7	7,5	20,4	93,8
Community F. X	6,2	7,2	43,0	88,0
State Forest A	7,5	6,6	32,3	85,2
State Forest B	7,5	8,2	62,2	82,3
Group I	7,1	7,2	44,3	74,7

Table 6: Distribution of quality classes and mean index figures of the quality classes. (Stem-wood of Norway spruce and Silver fir). Weighted mean of the years 1984 – 1994. (Data not recorded for State Forest A and B and Group I).

	Ratio							
Enterprise/Group	**%-of Quality Class :**				**Mean Index Figure :**			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**
District XVII	10,1 (58,7)*	79,0 (30,4)*	10,7	0,2	53,6	48,5	48,1	49,5
Farm Forest Y	20,9	42,9	33,0	3,3	-	46,2	47,3	46,5
Community F. X	1,7 (11,2)*	86,1 (76,6)*	12,0	0,3	53,6	45,0	44,7	48,1
Group II	0,03	76,5	19,2	4,3	52,5	41,2	41,7	43,4

( )* = Total amount of high quality timber (part-veneer, resonant wood, ...) assorted as A-quality.
- = No information recorded

Quality classes for stem-wood : A-excellent quality without defects; B- normal quality with small defects; C- - With defects... but fully utilisable; D-quality : heavy defects.

Index figures (depending on the mid-diameter of the harvested log): s. explanations in the text
Small size stem-wood: < 35
Medium size stem-wood: 36 - 43,
Large size stem-wood: > 43

Table 7: Revenues per quality class of stem-wood. (Data not recorded for Group I, for State Forests A and B no data for revenues per quality class recorded).

Enterprise/Group	Revenues per m^3 and Quality Class of Stem-wood				
	€/m^3				
	A	B	C	D	∅
District XVII	352	152	59	39	162
Farm Forest Y	230	89	75	36	112
Community For. X	352	87	56	39	88
State Forest A	-	-	-	-	68
State Forest B	-	-	-	-	65
Group II	170	69	53	33	60

- = no data recorded. Weighted mean of the years 1984 to 1994 (Farm Forest Y : 1983 to 1994). Assortment: Norway spruce / Silver fir stem-wood.

Table 8: Comparison of the indices for planting, young growth tending and pruning. (Data not recorded for Farm Forest Y, Group II).

	Ratio					
Enterprise/Group	**Planting**			**Yg. Gr. Tend.**	**Pruning**	
*	% ps	N/ha (ps)	N/haF	% Ygt	%Pru	N/ha(pru)
District XVII	0,13	1100	1,4	1,7	5,7	420
Comm. Forest X	0,9	1040	9,6	2,3	3,4	410
State Forest A	0,6	3203	19	2,3	0,5	144
State Forest B	0,8	1384	11	1,9	1,0	378
Group I	0,7	3079	21	2,3	0,6	199

* : % = yearly area in % of the total forest area (F). ps = planting sites, Ygt = young growth tending, pru = pruning