Effect of Alternative Thinning Intensities on the Financial Outcome in Silver Birch (*Betula pendula* Roth) Stands: a Case Study Based on long-term Experiments and MOTTI Stand Simulations

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We examined the financial aspects of alternative thinning intensities in silver birch stands in Finland. We compared alternative thinning intensities with respect to the net present value (NPV) and the equivalent annual income (EAI). The data set was derived from successive inventories (measurement period 10 to 20 years) in 13 different experiments comprising a total of 56 sample plots on medium-fertile and nutrient-rich site types. The tree characteristics at the time of the last measurement on each sample plot were fed into the MOTTI stand simulator as inputs; the stands were projected for the rest of the rotation. Financial calculations were conducted using inflation-adjusted discount rates of 2% to 6%. On the nutrient-rich sites a thinning intensity lighter than the current silvicultural recommendations outperformed the other thinning intensities, while on the medium-fertile site types a thinning intensity corresponding to the silvicultural recommendations resulted in the best profitability, regardless of the discount rate or calculation method. The financial outcomes on the average were clearly higher on the nutrient-rich than on the medium-fertile sites, as expected.

Key words: profitability, silver birch, MOTTI stand simulator, thinning intensity, net present value, equivalent annual income

Introduction

The effect of different thinning intensities on stand and tree characteristics of silver birch (*Betula pendula* Roth) after the first commercial thinning have been well documented in Finland (Oikarinen 1983, Niemistö 1991, 1997). However, much less effort has been made on the financial aspects associated with alternative thinning intensities, although the financial attractiveness of forestry investments in general continues to be a subject of major interest in forest economics. A common topic in corporate finance is capital budgeting (see, e.g., Thomson 1989, Megginson 1997), i.e. how to choose investments that are in the best interest of the company. By analogy, we can examine at the stand level which thinning intensity is financially the most rewarding from the private forest owner's point of view.

During recent years a large number of permanent birch sample plots have been re-measured and provided us with a data set that is suitable for large-scale financial analysis. In addition, several stand simulators are currently undergoing development, and they have now reached a level enabling long-term stand projections of relevant accuracy for both practical decision-making and scientific assessments (Nuutinen & Kellomäki 2001, Matala *et al*. 2003). We can increase, with the aid of up-to-date measurements and the latest advances in stand simulators, our knowledge of the economic feasibility associated with alternative harvesting regimes.

The main emphasis of the present study is on examining the impacts of alternative thinning intensities on the financial outcome in silver birch stands in south-central Finland. A supplementary objective of the study is to determine the sensitivity of the results with respect to the chosen calculation method. The underlying idea is to compare whether the different methods (the net present value, NPV, and equivalent annual income, EAI) affect the ranking between the alternative thinning intensities.

Material and methods

Data were collected from 13 silver birch stands located in south-central Finland (Fig. 1). The stands were originally planted, and they were measured at five-year intervals during a 10- or 20-year study period (Niemistö 1997). The initial data set used in the analyses consisted of 56 successively measured permanent sample plots. The average sample plot size ranged from 700 to 1250 m^2, and the sample plots had been managed by the Finnish Forest Research Institute (METLA). Each plot had a ca- 5 m-wide buffer zone surrounding it in order to avoid border effects. Each buffer zone was treated with the same thinning intensity as the measurement plot.

The experimental design and measurement standards for silver birch are described in detail in Niemistö (1997). In general, the distance and direction from the center of a sample plot and the diameter at breast height (mm) for each tree were measured. Furthermore, 40 sample trees were selected and the following characteristics were measured: diameter at 6 m height of the tree (mm), tree height (dm) and the crown ratio (total tree height minus the height of the first living branch, dm). Tree characteristics and growth on the sample plots were calculated by KPL software developed by METLA for compartmentwise computations (Heinonen 1994). Some of the original sample plots (< 5% of the original number of sample plots) had to be rejected due to inconsistencies. These inconsistencies were mainly caused by changes in the management regimes. For instance, some control plots were thinned during the measurement period. Basic information on the experimental stands is presented in Table 1.

Calculation principles

Alternative thinning intensities were determined according to the latest silvicultural recommendations applied in Finland (Anonymous 2001a). First, we determined the thinning intensity of each sample plot at the time of the first measurement. The thinning intensity was based on the basal area removal, and it was expressed as per cent (%). Then we compared this thinning intensity to the silvicultural recommendations (Anonymous 2001a) where thinning intensities are tabulated against dominant height (i.e. for each dominant height there are two tabulated values of thinning intensity: an upper and a lower limit). Altogether there were two different thinning intensity classes on nutrient-rich site types (former agricultural land or the *Oxalis-Myrtillus* site type) and three different thinning intensity classes on medium-fertile site types such as the *Myrtillus* site type (Figure 2). Both the nutrient-rich and medium-fertile site types are considered to represent typical birch habitats in Finland. On the nutrient-rich sites there were two thinning intensities: “control” (i.e. no thinnings), and “light” (lighter than the silvicultural recommendations) (Figure 2). The thinning intensity classes on the medium-fertile sites were: “control”, “light” and “silvicultural recommendations”. Sample plots from different experimental stands could be included in the same thinning intensity class even though the stands were located relatively widely over south and central Finland (Figure 1). However, they were still considered to be growing under similar macro-climatic conditions (Kuusipalo 1996), and thus representing south-central Finland. After dividing the sample plots into different thinning intensity classes

Table 1. Mensurational characteristics of the original data set at the time the experiments were established. Standard deviations (S.D.) for stand mean height, stand dominant height and stand basal area in each experiment are presented in parentheses.

Experiment Number	Location (municipality)	Number of sample plots	Site Type[1)]	Age, in years	Stand mean height, meters (S.D.)	Stand dominant height, meters (S.D.)	Stand basal area, m^2/ha, over bark (S.D.)
832	Kannus	4	FAF	22	11.0 *(0.4)*	15.1 *(0.4)*	12.9 *(0.9)*
833	Lestijärvi	4	FAF	21	13.3 *(0.4)*	14.6 *(0.8)*	20.0 *(0.6)*
834	Kivijärvi	6	FAF	18	12.5 *(1.0)*	13.7 *(0.9)*	15.2 *(1.7)*
835	Uurainen	1	MT	22	16.7 *(0.0)*	17.2 *(0.0)*	16.9 *(0.0)*
836	Kuopio	1	FAF	19	15.8 *(0.0)*	16.9 *(0.0)*	19.6 *(0.0)*
837	Konginkangas	7	MT	21	13.9 *(0.9)*	15.2 *(1.2)*	18.3 *(1.1)*
838	Konginkangas	6	MT	22	12.2 *(0.9)*	14.0 *(0.7)*	15.0 *(0.9)*
839	Uurainen	3	FAF	15	11.1 *(0.7)*	12.2 *(0.6)*	13.0 *(0.3)*
840	Juuka	3	OMT	19	13.7 *(0.2)*	15.4 *(0.9)*	19.5 *(0.8)*
841	Perho	2	FAF	21	12.8 *(0.4)*	13.6 *(0.5)*	12.3 *(0.0)*
842	Suonenjoki	5	FAF	19	11.9 *(0.7)*	13.4 *(0.8)*	13.8 *(1.7)*
845	Vesijako	6	OMT	21	11.9 *(0.6)*	13.3 *(0.7)*	13.8 *(1.5)*
846	Lammi	8	MT	23	12.3 (1.1)	14.0 *(1.1)*	14.4 *(1.7)*

[1)] Former agricultural fields (FAF) and corresponding site types (e.g., Oxalis-Myrtillus type, OMT), and Myrtillus type (MT) were included into the study

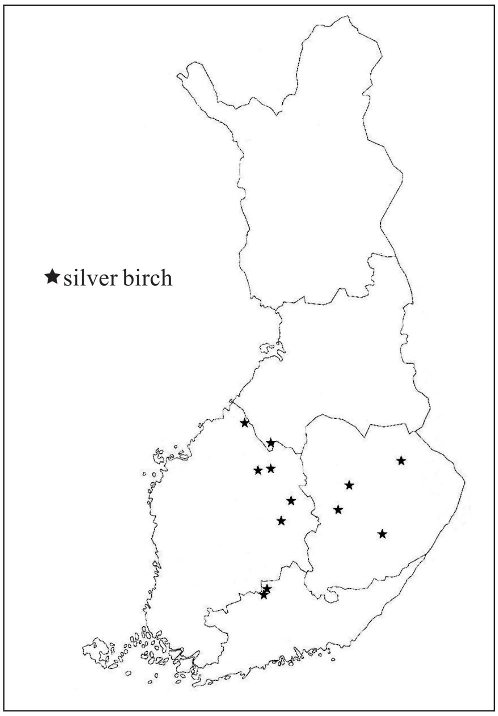

Figure 1. Map of Finland and the locations of the silver birch experiments.

we simulated the later growth of the stands on the sample plots by the MOTTI stand simulator (Figure 2, Table 2). MOTTI is basically a stand-level simulator, which includes specific tree-level models for e.g. natural regeneration, growth and mortality. Technically, MOTTI is classified into distance-independent non gap tree models (Porte & Bartelink 2002). It is designed to simulate stand development under alternative management regimes and growth conditions in Finland. So far, it has been used in growth forecasting (Matala *et al*. 2003) and assessments of alternative management regimes (Hynynen *et al*. 2004, Salminen *et al.* 2004). We needed to use a stand simulator because *a)* the sample plots at the time of the last measurement were too young to represent mature stands, and *b)* because the measurement period was too short, in many cases only 10 years. The simulations were based on the following criteria:

1) The input data for the MOTTI simulations were derived from the tree characteristics (age, basal area, mean height weighed with the stand basal area, mean diameter at breast height weighed with the stand basal area and stem number) of the remaining stock at the time of the last measurement.

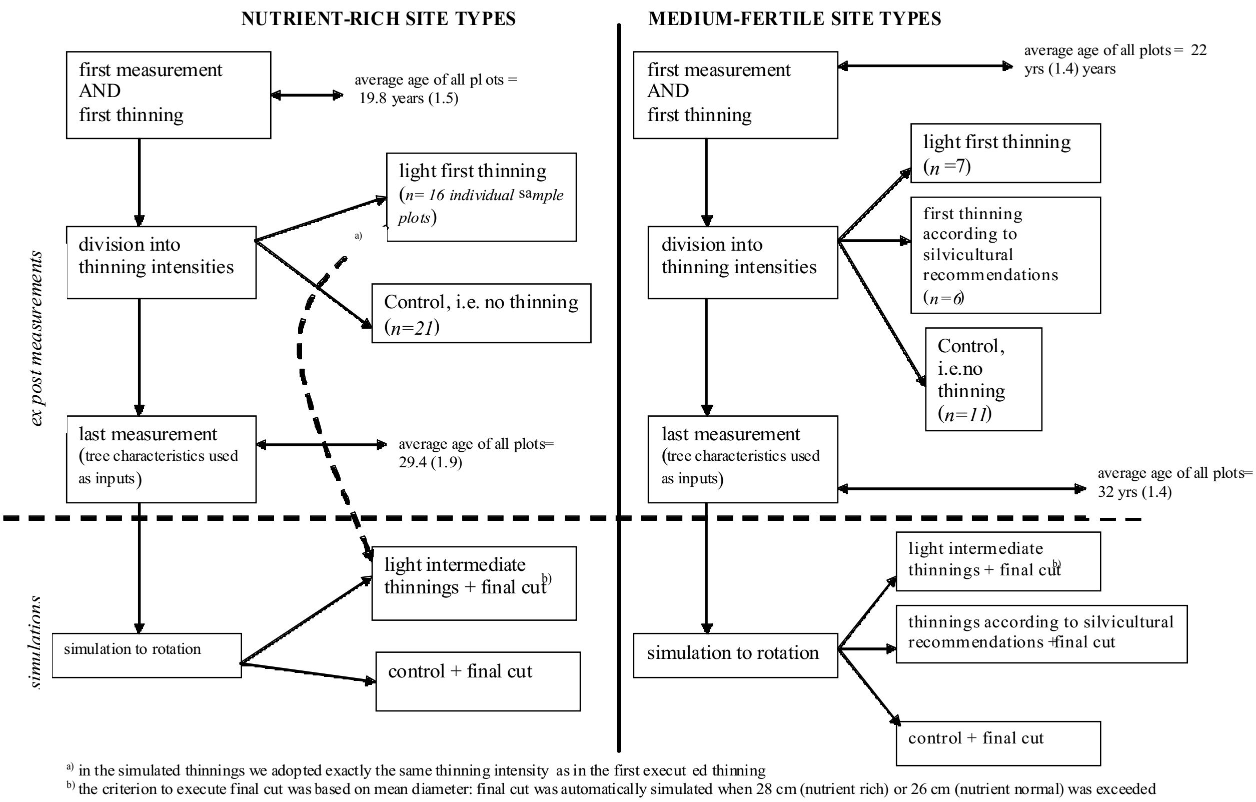

Figure 2. A flowchart on the division of thinning intensity classes and simulations for silver birch on nutrient-rich and medium-fertile site types.

Table 2. Averages and standard deviations (in parantheses) of the thinnings on the experimental plots (ex post measurements) and simulated thinnings (simulations).

	Characteristics	*NUTRIENT-RICH SITE TYPES* Thinning intensity class		*MEDIUM-FERTILE SITE TYPES* Thinning intensity class		
		Light	Control	Light	Silvic. Rec.	Control
ex post measurements	Age, years	20 *(1.4)*	19 *(1.6)*	22 *(0.8)*	22 *(1.0)*	21 *(2.2)*
	Thinning intensity, %	34 *(8.5)*	0	24 *(5.6)*	36 *(6.9)*	0
	Stand basal area, m^2/ha	16 *(3.4)*	16 *(2.4)*	16 *(0.8)*	16 *(2.4)*	15 *(2.1)*
	Removal of pulpwood, m^3/ha	23 *(12.6)*	0	9 *(5.4)*	22 *(16.6)*	0
	Dominant height, m	14 *(1.3)*	13 *(1.4)*	15 *(1.3)*	15 *(1.1)*	14 *(1.3)*
simulations	Number of simulated thinnings	1.6 *(0.5)*	0	1.4 *(0.8)*	2.7 *(0.5)*	0
	Total removal of pulpwood, m^3/ha	230 *(24.8)*	177 *(13.3)*	254 *(18.1)*	269 *(32.5)*	179 *(15.3)*
	Total removal of sawlog, m^3/ha	155 *(14.8)*	140 *(10.9)*	156 *(11.8)*	157 *(19.9)*	143 *(15.7)*
	Rotation, years	64 *(7.3)*	87 *(6.4)*	74 *(3.8)*	77 *(6.2)*	85 *(3.1)*

2) In the subsequent thinnings we adopted the same thinning intensity as in the first thinning. Subsequent thinnings were simulated if the basal area (m^2/ha) exceeded the limit of the silvicultural recommendations at a particular dominant height.

3) Final cut was simulated when the mean diameter at breast height (weighed with basal area) exceeded the recommendation limits, 28 cm for *Oxalis-Myrtillus* or corresponding site types, and 26 cm for the *Myrtillus* site type (Anonymous 2001a)

Item 2) in the above list needs more detailed explanation. In the simulated subsequent thinnings we had to adopt exactly the same thinning intensity of the first thinning so as not to violate the original experiment design. The original experiment design was based on the comparison of alternative thinning intensities, which are determined according to the thinning intensity of the first thinning. For each sample plot the idea was to keep the thinning intensity (basal area removal, %) constant every time the thinning was executed.

Because we used a stand simulator (MOTTI) for growth predictions, the validity of the stand simulator needed to be tested. We tested the validity by comparing the simulated values to the observed values at the time of the last measurement. This was done in the following way. First, we used the tree characteristics (stand age, basal area, mean height, mean diameter at breast height and stem number) of the remaining stock at the first measurement as inputs for the simulations. Then we simulated the tree growth on each sample plot to the time of the last measurement. The sample plots did not represent all the sample plots, but only two different thinning intensity classes on both site types. However, these two different thinning intensity classes were considered to represent alternative management schedules divergent enough with respect to validity testing under various conditions. The analysed combinations of management and site type were: lighter than the silvicultural recommendations and a control on both medium-fertile and nutrient-rich site types. The variables to be tested with respect to model validity were the mean diameter at breast height weighed with the basal area and the financial value of the stock. The financial value was based on simulated and observed pulpwood and sawlog volumes and on the average stumpage prices of the felling season 2002 (METINFO database search; birch pulpwood = 13.63 €/m^3, birch sawlog = 45.43 €/m^3, unpublished). We plotted the residuals (i.e. observed – simulated) of the two test variables: mean diameter at breast height weighted with the basal area and the financial value of the stock against the initial value (i.e. value representing the first measurement) of the mean diameter at breast height weighed with basal area and growing stock, respectively.

Financial outcomes and statistical analyses

Two methods were applied in the financial calculations. In the first approach the financial outcomes were calculated according to the traditional net present value (NPV) method. The starting point of the calculations was chosen to represent the time of the first thinning, which was implemented in the original experimental design (Niemistö 1997). Formally (modified from Raunikar *et al*. 2000) the NPV approach can be presented by:

$$NPV = \sum_{i=0}^{I} \frac{H_i}{(1+r)^i} + \frac{V_t}{(1+r)^t} - V_0 \qquad (1)$$

where: NPV = net present value of cutting incomes valued at stumpage, in euros/hectare, V_0 = the commercial value of the stand (growing stock) valued at stumpage, excluding land, at the time of the first measurement, V_t = the commercial value of the simulated final cut valued at stumpage, excluding land, at rotation, and H_i = the value (at stumpage) of the thinning. The economical feasibility associated with each management alternative was thus based on the values reflecting stumpage prices. During the past years approximately 75-85% of all roudwood trade in non-industrial private forests of Finland has been standing sales, where forest owners sell wood at stumpage, and forest companies pay the roundwood prices and also logging costs (Anonymous 2003). In this study the first thinning was executed in the same year as the first measurement, and the other thinnings were simulated by the MOTTI stand simulator, i = years after the first measurement, t = years between the first measurement and simulated final cut ($i, I < t$), and r = discount rate (here within a range of 2% to 6%, which can be considered to be relevant for a large proportion of forest owners (Hyytiäinen & Tahvonen 2001). The NPV calculations were focused on investigating which thinning intensity yields the highest return on the investment, which, in this case, was the initial growing stock. Similar investment approaches have been used widely in the forest economics literature (Hseu & Buongiorno 1997, Braze & Bulte 2000).

As another calculation method we applied the equivalent annual income (EAI) approach, which determines the constant annual income that would yield the same NPV over *t* years (Raunikar *et al*. 2000). The main advantage of this method is that it allows unbiased comparison of experimental plots that have been measured over different time intervals. Furthermore, it provides an annual measure of the relative return on stand management, and this measure can be compared to alternative capital assets. Formally, the relation between NPV and EAI can be presented by the following:

$$EAI = NPV \frac{r(1+r)^t}{(1+r)^t - 1} \qquad (2)$$

where: EAI = equivalent annual income valued at stumpage, in euros/ hectare, NPV = net present value of cutting incomes (see formula [1]), r = discount rate (see formula [1] for details), t = time span (here: from the first measurement to the simulated final cut). The underlying idea in applying these two methods was to examine whether the methods (NPV and EAI) affected the statistically significant levels and ranking of the thinning intensities with respect to the financial attractiviness.

Stumpage prices were used instead of delivery prices in the calculations. The stumpage value is generally seen as an economic rent, a value excess of the total costs of bringing trees to the market as logs or wood products, including the cost of attracting the necessary investment (Repetto 1988). Economic rent, on the other hand, reflects the strength of market demand, which is ultimately determined by the global demand for wood products, e.g. pulp and sawn timber. We applied real, net of inflation stumpage prices, because they are preferred to nominal prices in capturing the actual financial performance of the alternatives. In other words, under a perfectly informed rational expectations assumption, real prices are the prices used by decision makers (Raunikar *et al*. 2000). Each thinning intensity class consisted of a number of sample plots (in most cases even from different experimental stands) in which the time of the first thinning actually occurred in different calendar years. We used deflated (Anonymous 2000) stumpage prices in order to constitute a uniform average stumpage price for the first thinning. The idea of using a uniform average between different thinning intensities was to abolish the effect of business cycles in order to be able to determine the real effects of thinning intensities on the financial outcome. For the first thinning (and for the first measurement; see formula [1]) the deflated average stumpage price of sawlogs was 48.4 euros/m^3 and for pulpwood 14.7 euros/m^3. The averages were derived from deflated stumpages prices in the actual calendar years of 1974, 1980, 1983, 1989, 1990 and 1994. For the subsequent thinnings and final cut (which were simulated) we used another uniform stumpage price set reflecting the average stumpage prices of the 2002 felling season: birch pulpwood = 13.63 €/m^3 and birch sawlog = 45.43 €/m^3 (METINFO database search, unpublished).

The first step in the statistical analyses was to execute univariate analysis of variance for both site types and each discount rate. In the univariate analyses we calculated type III sum of squares, mean squares, F-values and significance levels for the corrected model, intercept, experiment and thinning intensity. Furthermore, we tested separately each thinning intensity class against the control with respect to both the NPV and EAI (Dunnett's t test), and in the medium-fertile site types each thinning intensity class against another thinning intensity class (LSD tests) (Anonymous 2001b). The main goal in the univariate analyses was to find out whether the thinning intensity had a statistically significant effect on the NPV

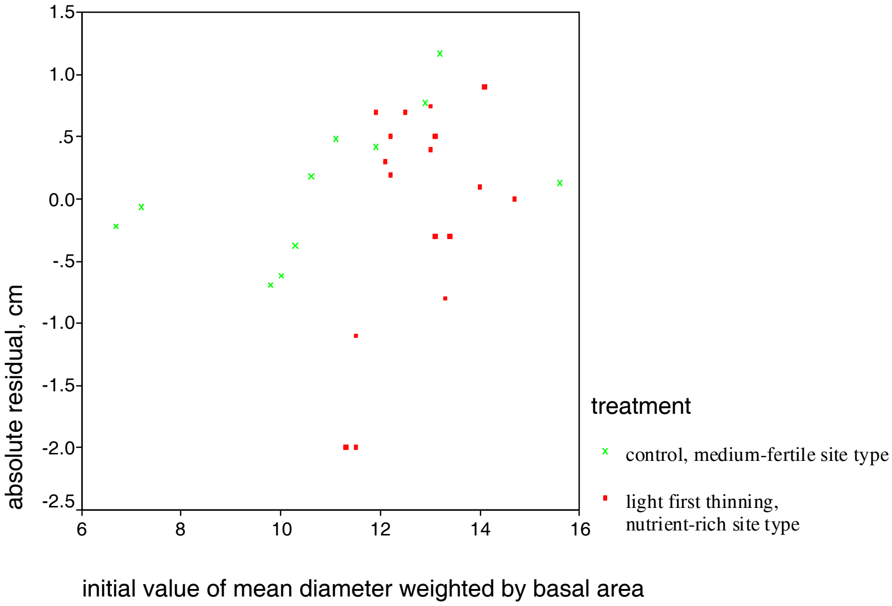

Figure 3 Absolute residuals (observed-simulated) plotted against the initial mean diameter at breast height weighted by the basal area and three different thinning intensities (treatments).

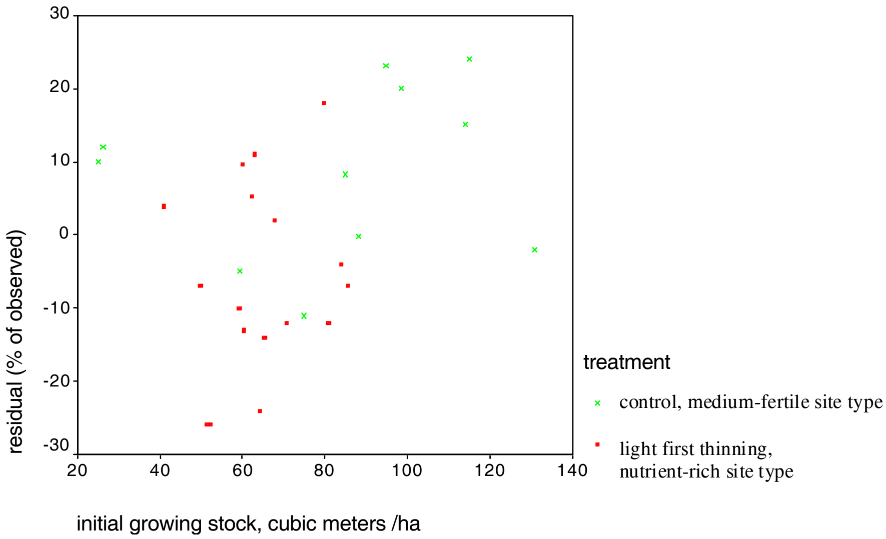

Figure 4. Relative residuals (%) plotted against the initial growing stock and three different thinning intensities (treatments).

or EAI. Further, each discount rate needed to be analysed separately due to the nonlinear relationship between the initial biological data and the discount rates. In other words, the discounting process is log-linear with respect to time, and this alters the distributional properties (Binkley 1981). This may finally result in different statistical significant levels for different discount rates even though the underlying biological data (e.g. measured removal volumes and stem dimensions) remain exactly the same. Another goal in the analyses was to test whether the statistically significant levels differ between NPV and EAI when applying the same discount rate.

Results and discussion

Model validity

The reliability of the stand projections executed by MOTTI was examined by testing model validity. As can be seen from Figures 3 and 4, the residuals show no pattern with respect to either thinning intensity or the initial values for the diameter at breast height and growing stock. In this respect the applied stand simulator seems to be unbiased, and thus suitable for the stand projections applied in this study. For instance, the simulated financial outcome on average overesti-

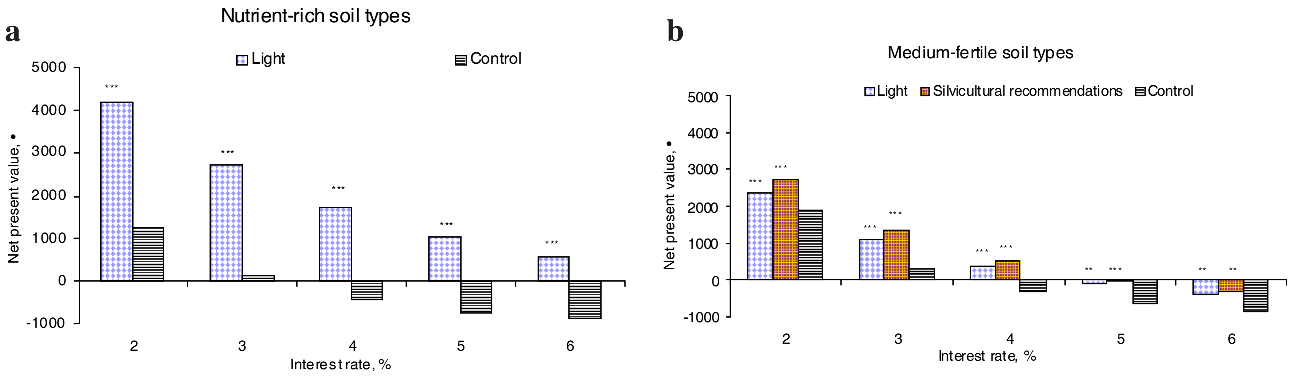

Figure 5. Net present value (NPV) for silver birch on nutrient-rich (a) and medium-fertile (b) site types. Asterisks above the bars indicate statistical significance levels when compared to the control, *** $p < 0.001$, ** $p < 0.01$ and * $p < 0.05$ (*Dunett's t test)*.

mated the observed financial outcome by only 7.2%, let alone the fact that the residuals showed no clear pattern with respect to either the site type or thinning intensity class (Figure 4).

Effect of thinning intensity with alternative discount rates

Because the main emphasis was to test whether thinning intensity had a statistical significance in our univariate analysis of variance model, we therefore only tested the significance level (criterion set to $p < 0.05$) of the thinning intensity with respect to alternative discount rates. This was done for both site types and financial calculation methods. We ended up with 20 univariate analyses of variance test (2 site types* 5 discount rates * 2 financial calculations methods). The results showed that thinning intensity in the univariate model was significant at the probability level of 0.005 in both medium-fertile and nutrient-rich site types with all discount rates (2% to 6%).

For instance, when discounting 3%, the average NPV on the nutrient-rich site type for the light thinning intensity was approximately 2720 €/ha, whereas for the control only 139 €/ha (Fig. 5a). This value (2 720 €/ha) differed statistically significantly from the control at a significance level < 0.001 (*Dunnett's t test*). Furthermore, in the medium-fertile site type, the NPV (discount rate 4%) for the light thinning intensity was 347 €/ha, for the control –314 €/ha and, when thinned according to the silvicultural recommendations, the NPV was as high as 501 €/ha (Figure 5b). A noteworthy outcome of the NPV results was that the NPVs on the nutrient-rich site types had distinctively higher values than those on the medium-fertile site types (Figure 5a vs. Figure 5b), especially when the discount rates were higher or equal to 4%. In the medium-fertile site types all the NPVs were negative when discounting with 5%, whereas on the nutrient-rich site types the NPVs for light thinning intensity was positive even when discounting with 6% (Figure 5a). In the medium-fertile site types LSD test procedure showed that there were no statistically significant differences (p<0.05) between "light" and "silvicultural recommendations" thinning intensities.

The EAI results were similar to the NPV results with respect to statistical significance and differences between the site types (Figures 6a and 6b). In this respect the results were relatively insensitive to the calculation method. Further, the ranking (i.e. the best – the worst financial performer) between the thinning intensities remained the same regardless of the calculation method (NPV or EAI). This result implies that the financial ranking is robust – we could find the best thinning strategy for each discount rate. In nutrient-rich site types the equivalent annual income, EAI, was distinctly higher than the corresponding value in the medium-fertile site types. For instance, when discounting with 3%, the EAI for light thinnings was 115 €/ha in the nutrient-rich soil type, whereas the EAI for light thinning in the medium-fertile site type was as low as 42 €/ha. If we consider thinning intensity as an investment strategy, we could obtain over 2.7 times higher returns with the same strategy in nutrient-rich than in medium-fertile site types when applying a 3% discount rate. With a higher discount rate (4%) the relative difference between site types even increases, let alone the fact that in the medium-fertile site types the EAIs become negative when discounting with 5% or 6%. There were no statistically significant differences between "light" and "silvicultural recommendations" thinning intensities with respect to EAI (p < 0.05).

In general, there seems to have been a lack of research results on the financial performance associated with alternative management regimes of silver birch, at least in Finland. New information on the financial as-

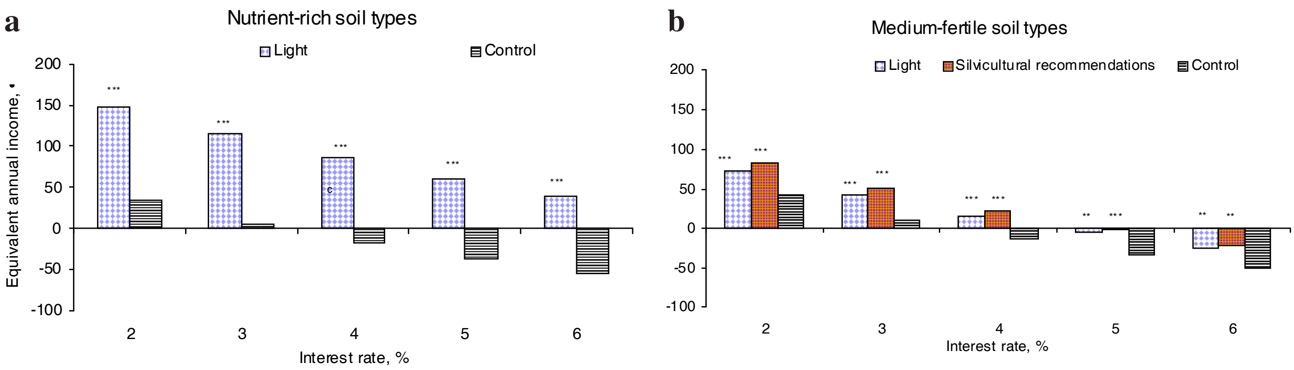

Figure 6. Equivalent annual income (EAI) for silver birch on nutrient-rich (a) and medium-fertile (b) site type. Asterisks above the bars indicate statistical significance levels when compared to the control, *** $p < 0.001$, ** $p < 0.01$ and * $p < 0.05$ (*Dunett's t test*).

pects of alternative thinning intensities at the stand level has been urgently needed by, e.g. non-industrial private forest owners. In this study the initial growth and yield results, projections by a stand simulator and financial calculations were comprised in order to determine the financial attractiveness of alternative thinning intensities of silver birch. However, our study context included some reservations, which deserve further attention prior to drawing any conclusions on the main results. First, the later development of the stand in the rotation was based on simulations. There is always some uncertainty associated with stand simulations, but in this case the validity of the underlying growth and yield models of the MOTTI stand simulator seemed to be relatively unbiased with respect to e.g. diameter increment predictions. Second, in the practical forestry carried out in Finland the minimum level of removal volume is more or less above 30-35 cubic meters per hectare. In this study the light thinning intensity alternative included the first actual thinning which had a lower removal volume, mainly due to the original research design, which was to achieve a larger range of thinning intensities. Due to the simulation approach applied here we adopted exactly the same thinning intensity (expressed as removal of the basal area) in the subsequent thinnings, which were simulated by the MOTTI stand simulator. This led to relatively low thinning removals in the light thinning intensity alternative compared to the normal practice in Finland. Thirdly, in the simulated thinnings we had to adapt the exact thinning intensity of the first executed thinning so as not to violate the original experiment design.

The main results suggest that thinnings more or less according to the present silvicultural recommendations (i.e. "good silviculture") clearly outperform the alternative in which the stand is left unmanaged. This applies to both site types (medium-fertile and nutrient-rich) and for all the discount rates ranging from 2% to 6%. However, if we draw an analogy between a corporate investment strategy and a thinning intensity, then the two site types (nutrient-rich and medium-fertile) are quite different regarding the possible returns on the investment. In the nutrient-rich site type the best investment strategy (thinning intensity) can yield returns as high as 6%, whereas on the medium-fertile site types even the best strategy fails to have returns higher than 4%.

Conclusions

The main results of this study have clear implications for practical forestry in Finland. First, both in silvicultural and economic sense there is always a need to thin in silver birch stands. Second, it seems that current silvicultural recommendations for silver birch (Anonymous 2001) provide a good base for executing thinnings with respect to economic feasibility. However, with the normally applied discount rates (3% to 4%) there are relatively small differences in the financial outcome between the "light" and "silvicultural recommondations" alternatives, regardless of the site type and applied discount rate. This can be interpreted as meaning that we have more choices with respect to thinning intensity than earlier pure growth and yield studies might have suggested. In other words, the results imply that there is a wide range of alternative thinning intensities that can be applied, and that these alternatives have no significant effect on the financial performance. We can add more case-sensitivity to birch stand management without losing too much financial attractiveness.

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РЕЗУЛЬТАТЫ РАСЧЁТОВ РЕНТАБЕЛЬНОСТИ АЛЬТЕРНАТИВНЫХ ВАРИАНТОВ ИНТЕНСИВНОСТИ ПРОРЕЖИВАНИЯ БЕРЁЗЫ БОРОДАВЧАТОЙ (*BETULA PENDULA* ROTH): АНАЛИЗ ДОЛГОСРОЧНЫХ ЭКСПЕРИМЕНТОВ И ИСПОЛЬЗОВАНИЯ СИМУЛЯТОРА «MOTTI»

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Резюме

Целью исследования было определение рентабельности альтернативных вариантов интенсивности прореживания березняка (берёзы бородавчатой) в Финляндии. Альтернативные варианты сравнивались относительно чистой текущей стоимости (NPV) и эквивалентной годовой прибыли. Материал был получен на основе 13 различных долгосрочных экспериментов, проведенных выборочно на 86 опытных делянках, на которых цикл измерений колебался от 10 до 20 лет. Опытные делянки по условиям произрастания относились к рощам или влажным борам. Характеристики древостев, полученные при последнем измерении на каждой делянке, были обработаны на симуляторе ”MOTTI”, с помощью которого было смоделировано развитие сохранившегося древостоя до конца цикла. Экономические расчёты (чистая текущая стоимость и эквивалентная годовая прибыль) выполнялись с учётом реальной ставки дисконтирования 2% - 6%. На лесных участках типа рощи наибольшую рентабельность показали рубки прореживания, интенсивность которых ниже ныне действующих лесохозяйственных рекомендаций. С другой стороны, в местах, сходных по плодородности с влажными борами, наиболее рентабельным оказалось прореживание, соответствующее современным рекомендациям, независимо от расчётной дисконтной ставки и метода расчёта (чистая текущая стоимость и эквивалентная годовая прибыль). В среднем, показатели рентабельности были явно выше на лесных участках типа рощ по сравнению с участками типа влажных боров.

Ключевые слова: рентабельность, бородавчатая берёза, симулятор древостоя ”MOTTI”, интенсивность прореживания, чистая текущая стоимость, эквивалентная годовая прибыль.