An analysis of the state of the forest and of some management alternatives for the

Östad estate

carried out by students at the Swedish University of Agricultural Sciences as part of a secondary course in Forest Management Planning 1997

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Swedish University of Agricultural Sciences (SLU)
Department of Forest Resource Management
and Geomatics
S-901 83 UMEÅ
Phone: +46 090 786 58 25 Fax: +46 90-14 19 15, 77 81 16

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Preface

This report is written by eighteen students as part of a course "Forest management planning" at the Swedish University of Agricultural Sciences (SLU), department of Forest Resource Management and Geomatics, Umeå. The subject is strategic and tactical forest management planning, using the system "The Forest Management Planning Package" and the GIS program ArcView. Each student group of two persons is responsible for one section of general interest, one strategic planning alternative and the corresponding tactical planning. The course instructors have only to a limited extent made modifications and additions to the text. Hence, any remaining heterogeneity with respect to typographical details, terminology and language has natural causes and is hopefully excused. Also, the same or similar theoretical expositions are sometimes found at several places, in different chapters.

All calculations and analyses are based on data from the Östad foundation estate, data collected by students during the five years 1993 - 1997, under teacher supervision. Each year a part of the estate has been covered by a sample. By the 1997 course the total sample covers the entire estate, including the Djurgården area. Some remarks and references, especially valid for the 1997 inventory and analyses, as well as for this report, immediately follow the preface.

The following students participated in the 1997 year course:

Jonas Björklund	Dzemal Imamovic
James Duggan (Canada)	Lars Johansson
Johan Eriksson	Thomas Karnestrand
Lars Fridh	Hans Larsson
Fredrik Granath	Cheryl MacKenzie (Canada)
Vegard Haanæs	Elke Meister (Germany)
Steffen Hartig (Germany)	Johan Strand
Johan Holmgren	Vanja Strand
Martin Holmgren	Maj-Britt Swartz

The Östad foundation has greatly supported by financial funds, lodging and other facilities. The foundation president, Mr. Patrik Alströmer has also, by his warm hospitality and great interest in the work, heavily contributed to the enthusiastic spirit in which the students have fulfilled the different phases of the course. For this, we are very grateful and we thank the Östad foundation and its staff for the fruitful collaboration since 1993. We hope for a long future continuation.

Umeå the 28th of May 1998

Sören Holm Tomas Lämås

Remarks

The 1997 population and sample

The 1997 sample of compartments was taken from a population consisting of the Djurgården peninsula (78 compartments, 163 hectares) and of compartments temporarily left the years 1994 - 96 (33 compartments, 90 hectares). The reason for leaving out some compartments previous years was mainly a problem to handle stands with Common oak (Quercus Robur L.). The Djurgården area also includes many stands with Common oak (and other valuable hardwoods), but also stands for pure timber production. The 1997 year sample consisted of 27 of the 111 compartments in the population.

The Oak problem

The system for strategic planning used, The Forest Management Planning System (Jonsson et al., 1993)[1], abbreviated FMPP, does not specifically treat Common oak. Instead, Oak is included in the class "other broad-leaves". The fairly large number of stands with Oaks on the Östad estate called for some action and research. There were essentially two problems requiring research: 1) The economic valuation of Oak timber, and 2) The thinning response of Oaks. These two problems have now been solved by two forestry students, Henrik Andersson[2] (granted by the Östad foundation) and Svante Claesson[3], in their examination theses. Their results have been implemented in a special version of the FMPP, used for the 1997 inventory, calculations and analyses.

It should be noted that the Oak problem is not yet completely solved. The generation of future forests in the FMPP does not separate Oaks from other broad-leaves. Thus, when studying diagrams showing the future standing volume development it is necessary to bear in mind that the class of broad-leaves includes Common oak.

An observandum

Each student group presents one strategic planning result and the corresponding tactical planning result. Hence, the chapters 7.1 and 10.1 are connected. In one case, a keyboard slip caused an erroneous strategic result, transmitted to the tactical planning. The strategic result was later on corrected, but the more time-consuming tactical was not. The chapters 7.2 and 10.2 are thus disconnected. (The erroneous strategic result was very similar to that of chapter 7.8, why the result in 10.2 and 10.8 are similar. The five year coupe in 10.2 should be realistic for 10.8, where it is missing!). A connected version of the alternative "normal price list, 2.5% rate of interest" is found in the chapters 7.9 and 10.9. The maps enclosed refer to the results in chapter 10.9.

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[1] Jonsson, B., Jacobsson, J. & Kallur, H. 1993. The Forest Management Planning Package. Theory and Application. *Studia Forestalia Suecica*. no. 189.

[2] Andersson, H. 1996. Taper Curve Functions and Quality Estimation for Common Oak (Quercus Robur L.) in Sweden. Arbetsrapport 10. SLU. Institutionen för skoglig resurshushållning och geomatik. (In English)

[3] Claesson, S. 1998. Thinning Response Functions for Single Trees of Common Oak (Quercus Robur L.) Arbetsrapport 35. SLU. Institutionen för skoglig resurshushållning och geomatik. (In English)

1. Introduction

This report contains strategic and tactical plans for Östad foundations forest estate. The plans are produced by means of the Forest Management Planning Package (Jonsson et al., 1993, see Remarks) and ArcView, a Geographical Information System (GIS).

The Östad estate is located 40 kilometers east of Gothenburg at lake Mjörn (58^0 N, $12^0$30´E). It comprises a total area of about 4600 hectares, of which roughly 3500 hectares are productive forest land. The dominant soil type is sandy moraine. The average site quality is moderate for southern Sweden conditions (the site quality is 8.1 m^3/ha/yr). More detailed data about the forest is found in chapter 4. The landscape has high scenic values, and is at many places broken by hills, steep cliffs and lakes. Large parts of the forest were intensively cut during the 1950-1960´s and efforts have been made during the last decades to increase the stocking. Close to the manor is a peninsula (about 160 hectares large), named Djurgården, with former pasture land which now is afforested, to a large extent by valuable hardwood. The Östad estate and foundation has an interesting history. From 1774, when the estate was donated by a wealthy merchant, N. Sahlgren, and until the end of Second World War, it served as a home and educational institution for youngsters from poor family conditions. Later it was the site for a forestry college. Since about 15 years the aim of the foundation is to support forestry and agricultural education and research, by providing both land for experimental activity and monetary funds. The estate is also famous for being once the home manor (in the 1750´s) of J. Alströmer, the man who “brought the potato to Sweden”.

The planning has been carried out by students at the faculty of forestry from SLU Umeå, during the course Forest Management Planning (SPLB 1).

The forest inventory was done from Sept. 24 to Oct. 3 1997 and the data was processed and analyzed from Dec. 1997 to Jan. 16 1998.

The report presents nine alternative harvesting plans on the strategic and tactical level. The alternatives differ with respect to interest rates and (future) price lists. Which alternative is to be considered as the optimal management plan is in the hands of the decision-makers for the Östad foundation. The planner is not supposed to take a standpoint on the interest rate or price development.

The purpose of the FMPP is to develop a strategic forestry plan for the estate analyzed. The FMPP contains the most important components for goal formulation, inventory, forecasts and optimization. The strategic result can then be used in the following tactical planning with help of statistical methods.

The tactical plans are produced using GIS. The goal of the tactical plan is to fulfil the results of the strategic plan, with regards to the cutting level and economical results for the next 5 to 10 years.

In the tactical planning other important factors are considered, such as co-ordination of the forestry activities, nature-conservation values and landscape-planning.

2. Description of the FMPP

The purpose of forest management planning is to attain the goal or goals formulated by the forest owner or administrator. That implies that every compartment should be treated in a way that implies optimality for the entire property.

Planning is usually divided into four steps: the normative, strategic, tactical and operative levels. During the normative planning the policies are set. For the Östad foundation the main normative goal is to give long-term financial support to education and research, obtained by a high and sustainable yield. Another goal that has been expressed is to raise the stocking from today's level (the figure180 m^3sk/ha has been mentioned as a goal). On the strategic level the aim is to find the management program and the amount of cuttings that best fulfils the long-term goals. On this level, the calculations needed are made on an objective sample of compartments. The next step is to extend the optimal program to all compartments. This is the tactical planning which is carried out on the entire property, resulting in a management proposal for the next 5 years. The final step in the planning process, called operative planning, is focused on the concrete execution of the management activities according to the tactical planning result. This planning step is beyond the scope of the present report.

In order to achieve this, the strategic planning needs methods for

- formulating the *goal* for the forestry
- making an inventory of the forest that gives proper data for different prognoses
- making prognoses of the result for different management alternatives
- optimizing the choice of management alternatives

The Forest Management Planning Package (FMPP) is an integrated, computer based system that fulfils these demands. It is primarily developed for inventory and calculations on the strategic level, but the results can also be implemented in the tactical planning stage. Calculations are made on single tree data obtained by an objective inventory from a sample of compartments.

The components of the FMPP and their interactions are briefly described in the following text.

2.1 Goal formulation

The forestry goal at Östad is to obtain a high and sustainable yield. For this reason, decisions can not only be made in order to maximize the net present value. Also the demand for an even income flow has to be considered. In the FMPP this is solved by using a goal function, that measures utility instead of present value. With the utility function used, the yearly marginal revenue is a decreasing function of the net income.

The FMPP goal function, to be maximized by choice of management alternative H, is

$$U_H = \sum_{p=1}^{\infty} e^{-rt_p} (N_{Hp})^b$$

Here

U stands for utility

H	treatment alternative (specified for each treatment unit)
p	period
t_p	time to period p (from the start)
r	interest rate
N_{Hp}	real net income for treatment alternative H in period p (for the entire estate)
b	evenness parameter ($0<b\leq1$)

The only parameter that differs between the FMPP goal function and a goal function which only considers net present value, is the evenness parameter, b. The greater the demand for evenness, the smaller value of b should be used. (Experience shows, however, that results are similar for different values of b, as long as b is clearly less than 1.) In this report, all calculations have been made using $b = 0.75$.

2.2 Inventory

The need for (inventory) data differs between the strategic and tactical level. In tactical planning, a complete description of all the treatment units is needed. Because of the cost, objective and accurate measurements can seldom be used. Subjective methods thus have to be applied, despite the risk of systematic and large random errors.

For the strategic planning, which concerns the entire forest estate, the demand for information covering the entire forest is less. Avoiding systematic errors is much more important, in order to get accurate results of the long-term calculations of the utilities of different treatment programs. Therefore, it is also very important that input data for the long-term growth prognoses is accurate. The FMPP solution to this is a two-step inventory.

2.2.1 The first step (Phase 1)

The estate is divided into compartments and a compartment register is created by a subjective inventory. If a register already exists, it should be controlled and updated. The strategic planning is only moderately affected by the data quality in step 1, as the calculations and prognoses are based on the objective data from step 2. However, the quality of the compartment register is of vital importance when implementing the results of the strategic planning for the tactical planning.

2.2.2 The second step (Phase 2)

In this step, the information is collected from an objective inventory. To make the inventory as efficient as possible, the stands are grouped into homogenous strata, with respect to age and stocking. The number of sample compartments from a stratum is determined (allocated). The within stratum sample of compartments is taken using a probability proportional to the compartment area (PPS-sampling). In this way, all area units within a stratum have an equal chance of being selected. Finally, the sampled compartments are objectively inventoried. Six to ten sample plots are arranged systematically (with random starting point) in each compartment. The inventory is performed using either sample plots with constant radius (10 m in old forests and 5 m in young forests) or a stem density method. If the stem density method is applied, usually the eight trees closest to the plot center are included, and the distance from the plot center to the eighth tree is the plot radius. All trees with a diameter of at least 5 centimeters (at breast height) are tallied. For forests in the thicket stage, and young forests, the height of the main crop plants and secondary plants are measured. For all plots, basal area weighted (BAW) mean age, butt log quality and site index are recorded. For the sample trees, chosen with probability proportional to basal area, thickness of the bark, height, live crown height, age and quality are noted. In this way data is collected for single trees, which leads to a high precision in prognoses and calculations. This system offers the possibility of presenting results in diameter classes and calculating realistic assortment distributions.

2.3 Forecasting

Söderberg's[1] functions for basal area growth of single trees are used in FMPP. The volume is calculated with Söderberg's functions for form height. The volume functions are calibrated by using the sample trees, for which the volumes also are calculated using the volume functions by Näslund[2] (Näslunds större) or those by Brandel[3]. In the forecasts, tree diameter, tree age, tree species, site index and other variables are used. There is also a function for natural mortality in FMPP.

For each compartment there is a possibility to test a large number of different silvicultural programs. A program is defined as a combination of thinning method, thinning grade and times for treatments. Fertilization can also be tested. Future net incomes are calculated from the volume forecast, a cross-cutting routine, a given price list and costs. The price

1 Söderberg, U. 1986. Funktioner för skogliga produktionsprognoser. SLU. Avdelningen for Skogsuppskattning och Skogsindelning. Report 14. (Summary in English)

2 Näslund, M. 1947. Funktioner och tabeller för kubering av stående träd. Tall, gran och björk I södra Sverige och I hela landet. Meddelanden från Statens Skogsforskningsinstitut 36(3). (Summary in English)

3 Brandel, G. 1990. Volymfunktioner för enskilda träd. SLU. Institutionen för skogsproduktion. Rapport nr 26. (Summary in English)

list can be modified according to prognoses about future prices. The costs are calculated from information about today's prices and performance rates. In the FMPP an (non-LP) optimization routine is applied for finding the optimal management program.

2.4 Optimization

When using the FMPP, the policy-maker influences the net incomes by setting the assumptions about prices and costs. He also affects the income flow by his choices of interest rate and evenness parameter. The optimization algorithm then selects the combination of silvicultural programs that provides the largest net present value on the estate level, given the evenness requirement. The FMPP gives a proposal for the management of the sample compartments. Without the evenness restriction, every compartment should be managed in an optimal way (net present value criterion), independently of the others. With the evenness restriction, optimality is sought for the entire estate, considered as one single unit. The two approaches in general leads to different solutions.

Because of the difficulty to prescribe adequate ("true") values for the interest rate and the evenness parameter, a number of different alternatives are tested and the one that best corresponds to the policy-makers ideas of net incomes and future timber volume development is chosen. In short, the policy-maker has an idea about the net income profile. The FMPP finds the optimal level for the desirable profile.

3. The sample of compartments

3.1 Stratification

The 1997 population, "Djurgården" plus some other compartments, was initially divided into five strata, in order to reduce the standard errors. The compartments in a given stratum were similar according to volume and age. The stratification is presented in Figure 3.1. The 1997 population of the forests of the Östad foundation completed the inventory covering the entire estate. The aggregated data set, from five years' inventories was used when applying the FMPP.

	volymklasser m3sk/ha								
åldersklasser	0-10	11-30	31-60	61-100	101-150	151-200	201-260	261-320	321+
3-10	0	4	1.6	0.7	0	0	0	0	0
11-20	0	1. 6	0	0	0	0	0	0	0
21-30	0	1.1	4.1	8.7	0	4.7	0	0	0
31-40	0	0	0	2. 2.1	8.8	7.4	5.4	0	0
41-50	0	0	0	0	15.6	21.2	6.6	3.3	0
51-60	0	0	0	0.5	3.5	18.6	7	0	0
61-70	0	0	0	3. 0	11.9	6.9	24.6	4.6	0
71-80	0	0	0	0	8.5	3.3	0	0	0
81-90	0	0	0	0	10.6	6.4	1.6	5. 0	0
91-100	0	0	0	1.1	3.2	0	1.6	4.1	0
101-110	0	0	0	4. 0	0	0	3	0	0
111-120	0	0	0	3	0.6	12	0.3	2.2	0.4
121-130	0	0	0	0	3.2	2.2	0	0	0
131-140	0	0	0	0	0	1.4	0	0	0
141-150	0	0	0	0	0	0	0	0	0
151-160	0	0	0	0	0	0	0	0	0
161+	0	0	1.8	1.5	1.8	0	0	0	0

Figure 3.1 The definition of the five strata used 1997 (age classes =" åldersklasser" horizontally and volume classes = "volymklasser" vertically).

3.2 Allocation

The division into strata was made subjectively, on intuitive grounds. The next step was to determine the number of compartments to be sampled from each stratum, that is, to allocate the sample. The aim was to take quite many samples in strata with stands that were soon to be harvested (final felling and thinning), because this would guarantee a high precision when estimating the net present value. This year's inventory covered 27 compartments , and the allocation chosen is shown in Table 3.1. Within stratum, the sample was taken with probability proportional to compartment area (PPS to area).

Table 3.1. The allocation of the 27 sampled compartments.

stratum	Area	no. of sample stands per stratum	Representative area (area/sample size)
1	26.2	4	6.6
2	59.8	5	12
3	72.2	5	14.4
4	43.7	6	7.3
5	50.8	7	7.3

3.3 Sampled compartments

The following compartments were sampled in the different strata:

Table 3.2. List of the compartments sampled

Strata	Compartment
1	827. 2012. 2015. 2043
2	746. 883. 2011. 2049. 2068
3	465. 893. 2005. 2027. 2057
4	112. 2002. 2013. 2024. 2054. 2060
5	196. 639. 807. 2019. 2021. 2026. 2040

Note: Compartments having numbers from 2001 (e.g., 2012) are located on the Djurgården area (2000 is added to the original forest map numbers).

4. State of the Forest

The state of the forest was calculated using data collected from 1993 to 1997. Forest state estimates were projected upon the compartments of the estate that have not been inventoried by using information from both sample, and register data.

Estimated total area (FMPP):	3601 ha
Productive area:	3407 ha
Total volume:	500 150 m^3sk
Volume per hectare:	146.8 m^3sk
Net yearly volume growth per hectare:	6.96 m^3sk/ha/yr

Of the total productive area, 30% has a site index between T20 and T24, and 63% has a site index between G28 and G32.

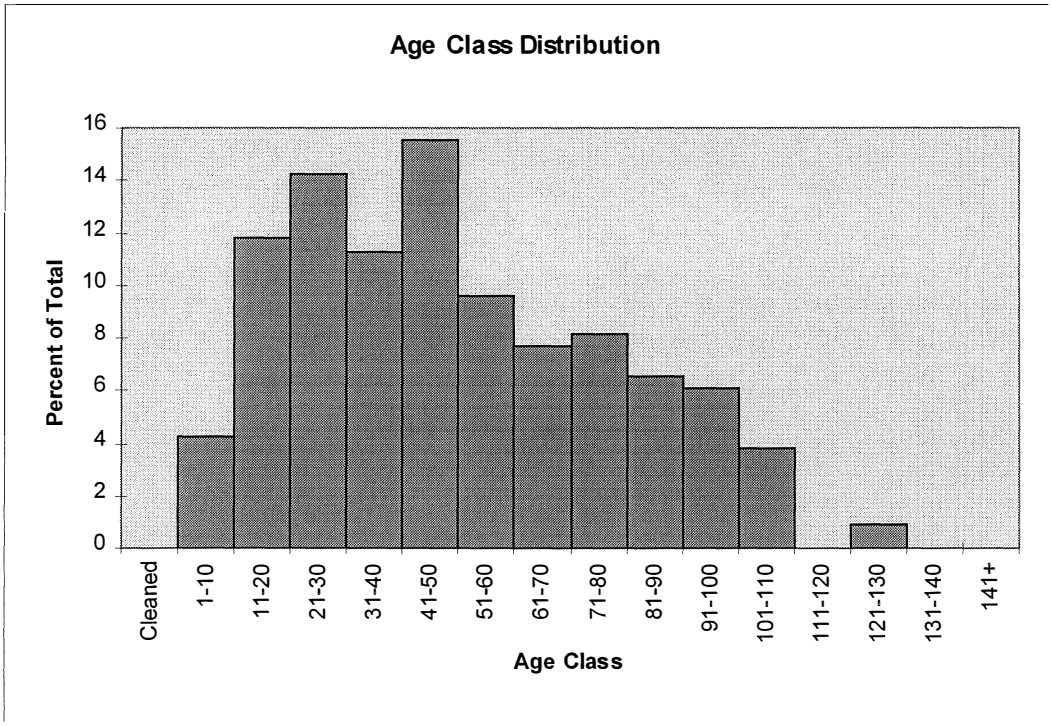

Figure 4.1 Percentage of the total productive area within compartment age classes.

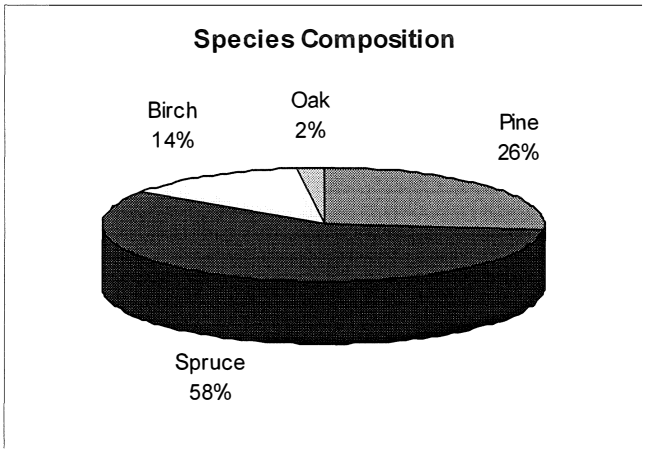

Figure 4.2 Species composition in volume percentages.

Table 4.1 Estimated estate characteristics, per age class.
(Per productive area. All trees, without lower diameter restriction.)

Age Class	Volume-weighted Age	Total Area (ha)	Aver. Height (m)	Average Volume (m3/ha)	Average Stems per Ha	Average Stem (dm3/tree)	Net Growth (m3/ha/yr)
Cleaned	0.	0.	0.0	0.0	0.	0.	0.00
1-10	9.	145.	25.9	1.1	2533.	0.	1.17
11-20	15.	403.	25.7	13.4	2180.	6.	4.33
21-30	27.	486.	29.2	80.2	1679.	48.	10.37
31-40	36.	384.	27.7	116.4	1393.	84.	9.33
41-50	45.	529.	28.8	178.4	1128.	158.	8.70
51-60	54.	328.	29.3	209.3	1148.	182.	8.27
61-70	64.	261.	28.5	188.8	694.	272.	6.49
71-80	75.	278.	27.2	213.9	714.	299.	5.76
81-90	86.	224.	28.7	261.5	709.	369.	5.04
91-100	95.	207.	26.0	239.8	668.	359.	4.47
101-110	106.	131.	25.4	190.0	641.	296.	3.26
111-120	117.	1.	31.5	321.9	188.	1709.	1.68
121-130	123.	30.	19.3	195.2	1054.	185.	2.89
131-140	0.	0.	0.0	0.0	0.	0.	0.00
141+	0.	0.	0.0	0.0	0.	0.	0.00
Total	**63.**	**3407.**	**27.7**	**146.8**	**1281.**	**115.**	**6.96**
Seed trees (+)	125.	4.	6.				

Note: With a diameter lower limit of 5 cm the estimated average number of stems is 983 and the average stem volume 149 dm^3.

5. Calibration of the compartment register

Information about the forest in the compartments is needed at several stages of the planning process. Some information is found in the compartment register of Östad. In order to save time and money, the information in the compartment register is collected using subjective methods. Because of this, both systematic and random errors can be found in the register.

The register can be calibrated if an objective survey is performed, allowing comparisons between the two surveys and thus a possibility to eliminate the systematic errors. The objective survey is taken as a random sample of compartments (PPS to area), resulting in data without systematic errors. It is assumed that all compartments in the register have been measured with the same systematic error, allowing us to correct the entire register. (Different systematic errors for different subsets of the register could originate from different surveyors for example.)

The calibration method can only correct for the systematic error. Thus, the random error remains after the calibration.

The calibration of the subjectively measured register data is performed using regression analysis. A mathematical function is fitted to data, in a way that makes the sum of the squared deviations as small as possible. The function values predict the objective values from the existing, subjectively measured, register data.

A linear model, and the method named the *inverse method* was used as follows:

Estimated objective value = a + b * X + c * Y + … ,

where a, b, c, … are constants and X, Y, … are register values.

5.1 Calibration of volume

A systematic error could be found when the volume figures in the compartment register were compared with the objectively inventoried compartment values. Therefore, the register compartment volumes were calibrated with the following function:

Estimated true volume = C * register volume + 2.0811 * register age –
– 0.01219 * register age * register age

where C = 0.70565 for inventory year 1993, 1995 and 1997
C = 0.88620 for the inventory 1994
C = 0.5481 for the inventory 1996

Note: The calibration was done to correct the register for systematic error *at the time for the inventory*. This explain the different values of C (here and below).

5.2 Calibration of age

By the same methods, the register compartment (total) ages were calibrated through the function

Estimated true age = 1.333 * register age – 0.153 * register age * ind(97)
– 0.004017 * register age * register age + 0.1613 * percentage broad leaves +
+3.616 * ind(pine)

where ind(97) = 1 if inventory year is 1997, otherwise zero, and
ind(pine) = 1 if site index species is pine, otherwise zero.

5.3 Calibration of site index

For site index species spruce, no realistic calibration function was found. Due to large random deviations the best regression resulted in almost constant calibrated values. Therefore no calibration was made for site index species spruce.

For site index pine (H100, m) the following function was found:

Estimated true site index pine = 5.68 + 0.745 * register SI (pine) + 2.42 * ind(96)

where ind(96) = 1 if inventory year is 1996, otherwise zero.

For register site index species birch or oak, the estimated true SI (spruce) has been calculated as

Estimated true site index spruce = 32.30 – 0.0489 * percentage pine

5.4 Calibration of volume growth

The volume growth (m^3sk/ha/yr) compartment values were calibrated through

Estimated true volume growth = 20.07 + C * register volume growth – 0.1728 * register age + 0.1634 * percentage pine

where C = 0.9970 if inventory year is 1994, 1996 or 1997
C = 0.6149 if inventory year is 1993
C = 0.7693 if inventory year is 1995

For some compartments, volume growth data was missing in the register. For those

Estimated true volume growth = Exp(0.09 + 0.78135 * ln(age) + 0.03598 * SI * ln(age) – – 0.001653 * age * S

5.5 Calibration of diameter

In 62 (out of 160) cases the diameter was missing or clearly erroneous in the register. For the other the following calibration function was obtained (basal area weighed mean diameter at breast height in mm):

Estimated true diameter = – 269.6 + 74.258 * ln (register diameter) +
+ 4.124 * register SI + 1.012 * percentage broad leaves except birch +
+ 0.6542 * register age – 18.415 * ind(SI species pine)

For the compartments lacking diameter information, the function used was:

Estimated true diameter (mm) = – 169.5 + 3.537 * register age + 7.739 * register SI +
+ 0.5835 * register volume growth

6. Prices and costs

6.1 Prices

The prices for timber and pulpwood used in the calculations are derived from two basic ones, the *normal* price list and the *optimistic* price list. From these, two alternatives for the future price development have been tested:

A. The normal price list has been applied throughout.
B. A continuous by time linear transition from the normal to the optimistic has been assumed. The time for the complete transition was set to 25 years.

The normal price list reflects the prices of today and is shown in Table 6.1. The optimistic price list differs from the normal by increased prices for spruce timber by 10%, for pine timber by 20% and for pulpwood by 20%.

There is also a pessimistic price list alternative (chapter 7.7). Here, all prices are reduced by 20% in period two and by 40% in period 12 (both reductions relative the normal price list).

It should be observed that optimal cross-cuttings are derived for each of the two basic price lists. For alternative B above, the value of a tree during the transition phase is obtained by linear interpolation between the two basic price list values.

Broad-leaves are by the FMPP supposed to give only pulpwood. However, in 1997 a special routine for calculating realistic values of oak trees has been developed and implemented. (The routine is in much based on the work and the data collected by Henrik Andersson (1996), financed by the Östad foundation.)

6.2 Costs

Costs for final felling, thinning and regeneration (including cleaning) have been considered. The costs are mainly given as certain functions, as described below, and the functions include indirect costs for planning and administration.

The cost functions have been derived in two steps:

1. For each measure taken (e.g., thinning) the actual costs for a sample of stands have been determined by using cost information given by the local forest management company (Skogssällskapet).

2. Cost functions have been estimated through regression analysis, by connecting the costs above (as dependent variables) to variables describing the harvests and the harvested stands (independent variables). The general form of each function follows an FMPP standard, but the coefficients estimated are unique for Östad.

Table 6.1 Normal price list, Östad 1997

Saw logs (SEK/m3top)

PINE

Diam. top end inside bark (cm) (log length 43 dm)

Grade	12	14	16	18	20	22	24	26	28	30
S	420	430	475	580	610	650	670	680	700	720
O/S	420	430	490	533	548	558	578	588	598	608
V	420	430	475	485	503	513	523	533	543	548
VI	380	380	380	380	380	380	380	380	380	380

Correction for log length:

Log length (dm)	31	34	37	40	43	46	49	52	55
Correction (%)	92	94	96	98	100	102	104	108	110

Pulp wood (SEK/m3solide)

Pine:	230
Spruce:	270
Broad leaf:	250

SPRUCE

Diam. top end inside bark (cm) (log length 46 dm)

Grade	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44
S	440	460	480	525	556	576	600	630	660	690	690	690	670	650	630	600	500
O/S	440	460	480	525	556	576	600	630	660	690	690	690	670	650	630	600	500
V	430	440	460	470	470	470	470	470	470	470	470	470	460	455	455	450	440
VI	332	332	332	332	332	332	332	332	332	332	332	332	332	332	332	332	332

Correction for log length:

Log length (dm)	31	34	37	40	43	46	49	52	55
Correction (%)	87	89	91	95	97	100	103	104	106

Costs for final felling

Cost = 1901 + 54.5 * V + 5.71 * S

where Cost is the cost (in SEK) per hectare, V is the harvested volume in m^3sk per hectare and S is the harvested number of stems per hectare.

A lower cost limit restriction was set to 60 SEK per m^3sk harvested.

Costs for thinning

Cost = 731 + 79.5 * V + 5.83 * S

where Cost is the cost (in SEK) per hectare, V is the harvested volume in m^3sk per hectare and S is the harvested number of stems per hectare.

A lower cost limit restriction was set to 100 SEK per m^3sk harvested.

Costs for regeneration

The costs for regeneration are periodized into several five year periods after final felling. The cause is naturally to simulate reality, since costs for beeting (restocking of blanks) and cleaning appear at different periods during the regeneration phase. The costs also cover expenditures for scarification. The costs are differentiated on different site quality classes and regeneration method, as shown by Table 6.2.

Table 6.2 Regeneration methods and costs (for not yet planted forests).
T stands for pine, G for spruce (T20 stands for dominant height, pine, at 100 yrs' age).

Site quality class	**Percentage of area regenerated through**			**Periodized cost in SEK per hectare and 5 year period**			
	Pine plant.	Spruce plant.	Natural regen.	Per. 1 (yr 0)	Per. 2 (yr 5)	Per. 3 (yr 10)	Per. 4 (yr 15)
T18/G16	0	0	100	1500	0	0	2600
T20/G18	0	50	50	6500	1600	0	3100
T22/G20	0	60	40	7700	1600	3200	0
T23/G23	0	75	25	7700	2000	3700	0
T24/G26	0	75	25	7700	2000	3700	0
T25/G29	0	95	5	11800	3600	3700	0
T26/G32	0	95	5	11800	3600	3700	0
T27/G35	0	95	5	11800	3600	3700	0

13 of the 160 sampled compartments have been regenerated with broad-leaves, to the same costs as for T27/G35 to simulate expensive Oak regeneration.

For compartments already in state of regeneration at the time of the inventory (already planted), the costs are determined by the surveyor's proposals concerning the needs for beeting and cleaning. The costs for beeting and cleaning are here:

Beeting: 5200 SEK per hectare
Cleaning: 3700 SEK per hectare

7. Strategic planning results

7.1 Normal price list with 1% interest rate

The analysis presented in this chapter is based on a demand for 1% rate of interest and a normal price list.

7.1.1 Net income

With demand for 1% rate of interest the income varies significantly over time if there is no evenness requirement (b=1). The peak in period 5 and 6 reflects many cuttings at that time, a consequence of today's age distribution, the forest growth and the rate of interest.

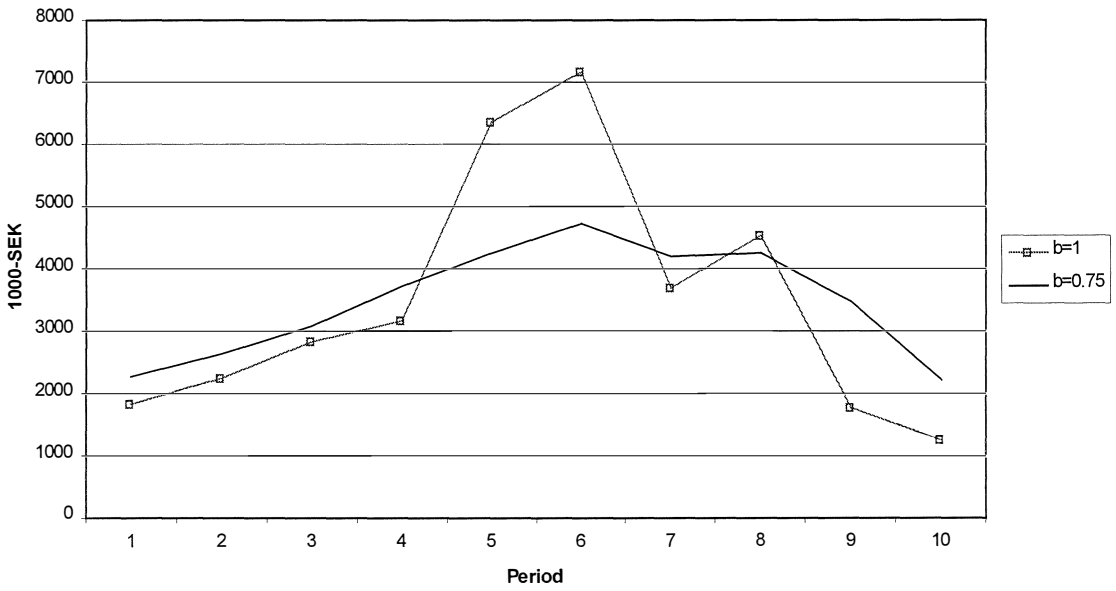

Figure 7.1.1 Annual net income with and without demand for evenness. Interest rate 1%.

With the evenness requirement the peak is largely flattened out, especially due to earlier more cutting before the time of the peak.

7.1.2 Harvested volume

The annual cutting levels will increase the first periods to the peak at 60 years from today, and then fall slightly. This is explained by the large number of middle aged compartments on Östad today, and by the low rate of interest.

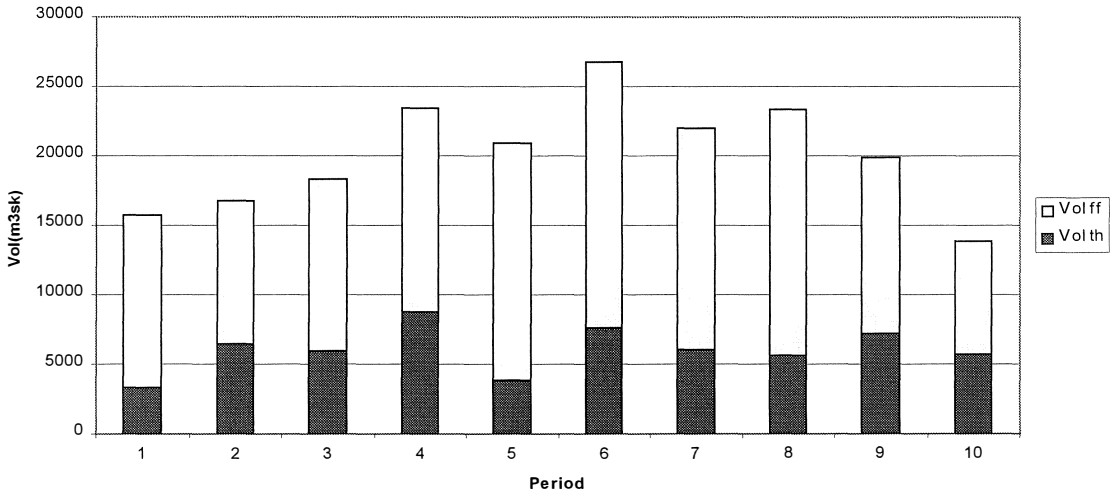

Figure 7.1.2 Mean volumes for final felling and thinning per10 year period. (With an evenness requirement). Interest rate 1%.

7.1.3 Stocking

The initial low cutting levels builds up the standing volume the first 50 years. A level over 200 m3sk/ha is soon reached, a value that seems to be the long-term average. The proportion of spruce is increasing every period and both the proportions of pine and oak are decreasing (future oak is included in the broad-leaves).

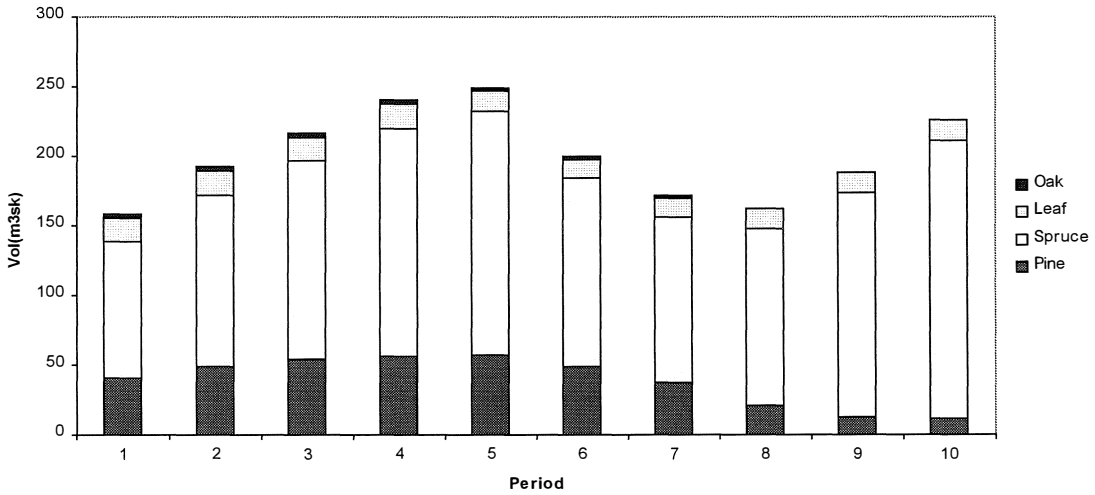

Figure 7.1.3 Standing volume. Ten yr periods (evenness requirement). Interest rate 1%.

7.2 Normal price list with 2.5 % interest rate

7.2.1 Annual net income

The annual net income varies between 1 800 kSEK and 5 200 kSEK without an evenness requirement and between 2 400 kSEK and 3 900 kSEK using an evenness parameter of b=0.75. With the evenness requirement, there is a decrease in the annual income between the sixth and eighth periods due to a decreasing harvest volume. The volumes are harvested in the ninth period instead. The lower harvested volumes in the first periods, both with and without evenness restriction, are the results of a rather low interest rate. (Figure 7.3.1)

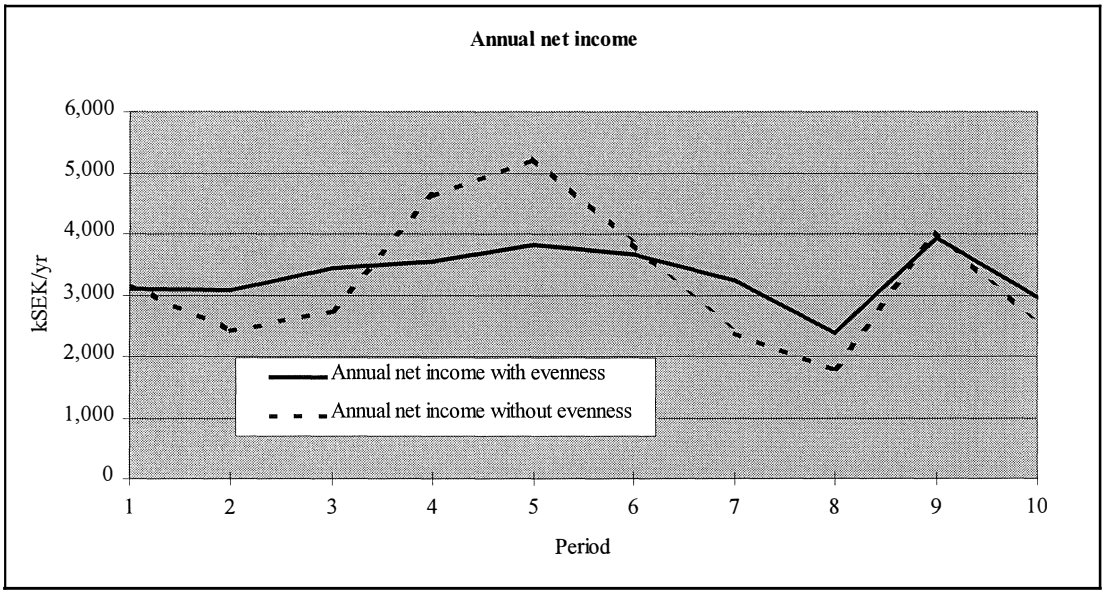

Figure 7.2.1 Net income profiles, with and without evenness, per10 year period. Interest rate 2.5%

7.2.2 Harvested volumes

The decrease in harvested volume as observed in figure 7.2.2, from the sixth to eighth periods, is what causes the decrease in income shown in figure 7.2.1 for the same period.

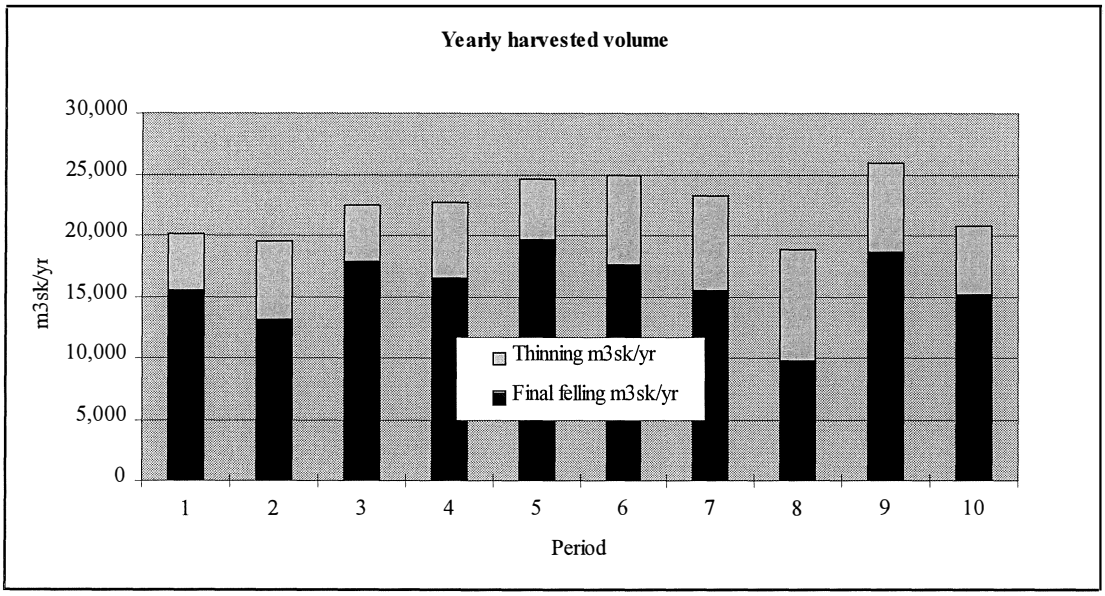

Figure 7.2.2 Annual harvested volume, with evenness, per10 year period. Interest rate 2.5%

7.2.3 Standing volume

There is only a small fluctuation in standing volumes throughout the ten-year periods. The standing volume reaches a high of 180 m3sk/ha in the ninth period. (Figure 7.2.3)

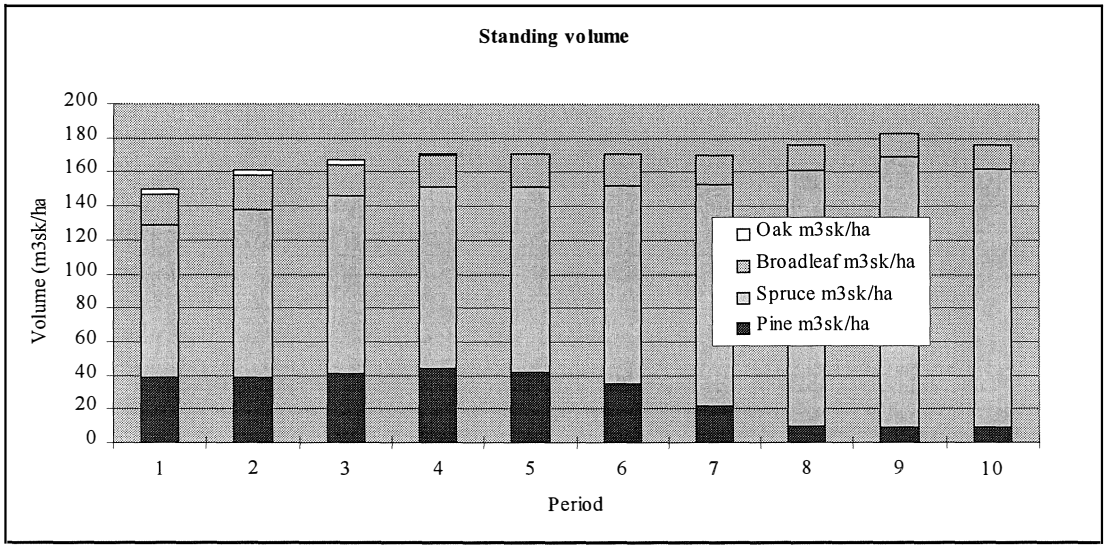

Figure 7.2.3 Standing volume, with evenness, per10 year period. Interest rate 2.5%

7.3 Normal price list with 4% interest rate

7.3.1 Annual net-income

The annual net income decreases during the hundred years' period from four thousands to three thousands kSEK, given the evenness requirement. The same decreasing trend can also be observed without this requirement. The slightly decreasing trend (mainly in the two first periods) is a cause of the high interest rate.

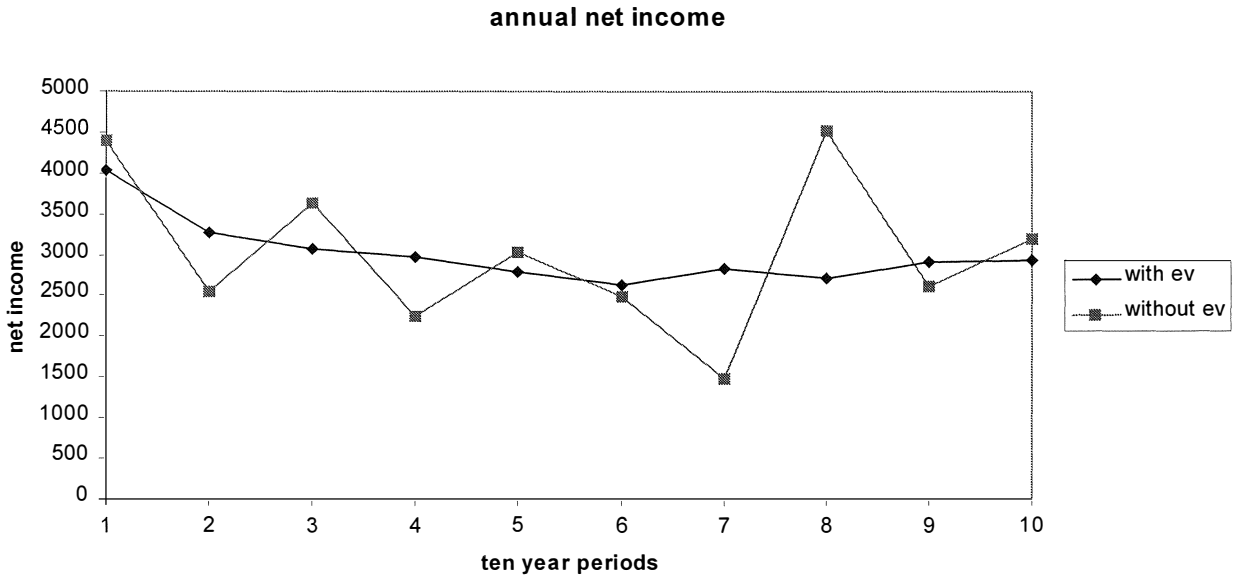

Figure 7.3.1 Annual net income(kSEK) profile with and without evenness restriction. Interest rate 4%

7.3.2 Harvested volume

The amount of annual harvested volume varies between 20000 and 25000 m^3sk.
The varying contribution from thinning depends on the state of the forest rather than on the interest rate.

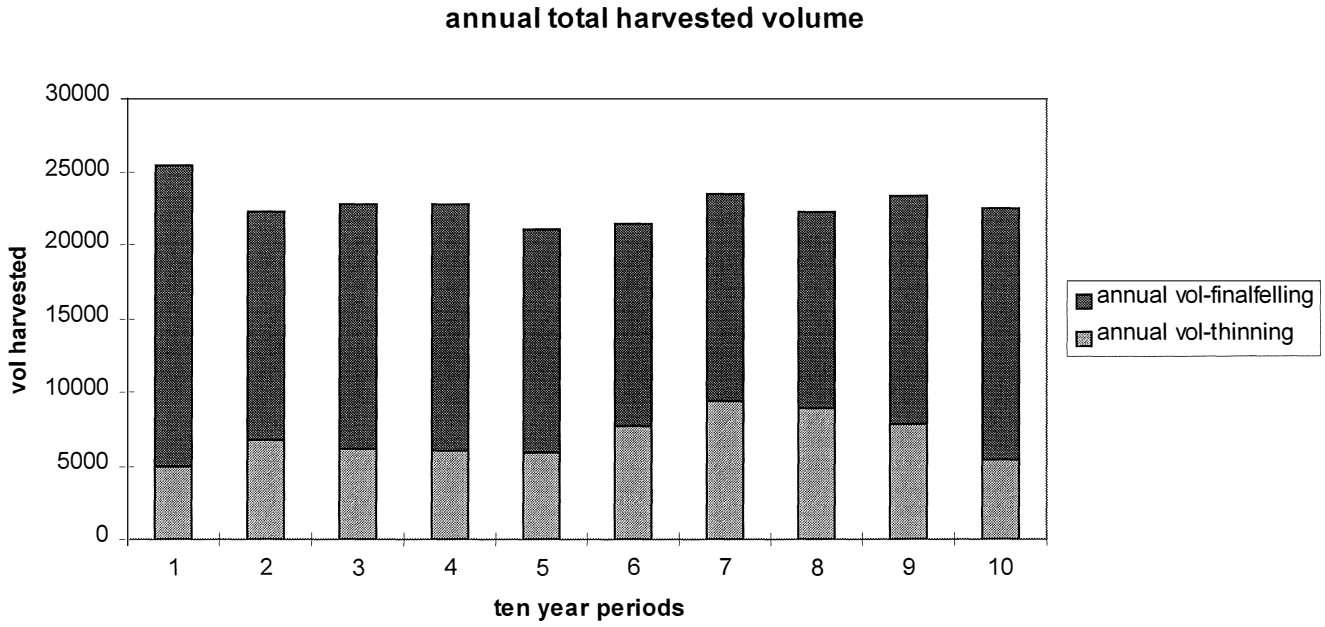

Figure 7.3.2 Annual harvested volume with eveness restriction. Interest rate 4%

7.3.3 Standing timber volume

The development of the standing volume, quite naturally, is a consequence of the harvested volumes in previous periods. The hard cuttings in the first periods make the timber volume decrease. The timber volume increases again with new generations.

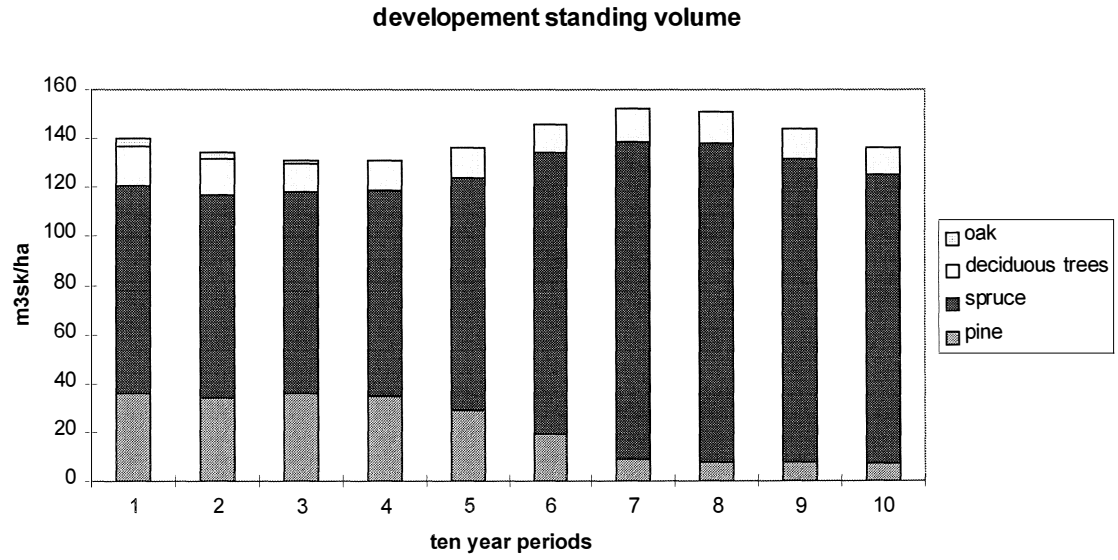

Figure 7.3.3 Development of the standing volume. Interest rate 4%

7.4 Optimistic price list with 1% rate of interest

7.4.1 Net incomes

Figure 7.4.1 shows the development of the annual net income over time. It varies between -61 kSEK and 10 399 kSEK. With an evenness requirement, a more even flow of revenues is obtained; the variation is now between 1478 kSEK and 5621 kSEK. Still, the income is low in the first period. This is explained by the low rate of interest and the optimistic price list (gradually reaching the highest level in the fifth period), which favors delayed cuttings and do not cause negative reactions to initial investment costs.

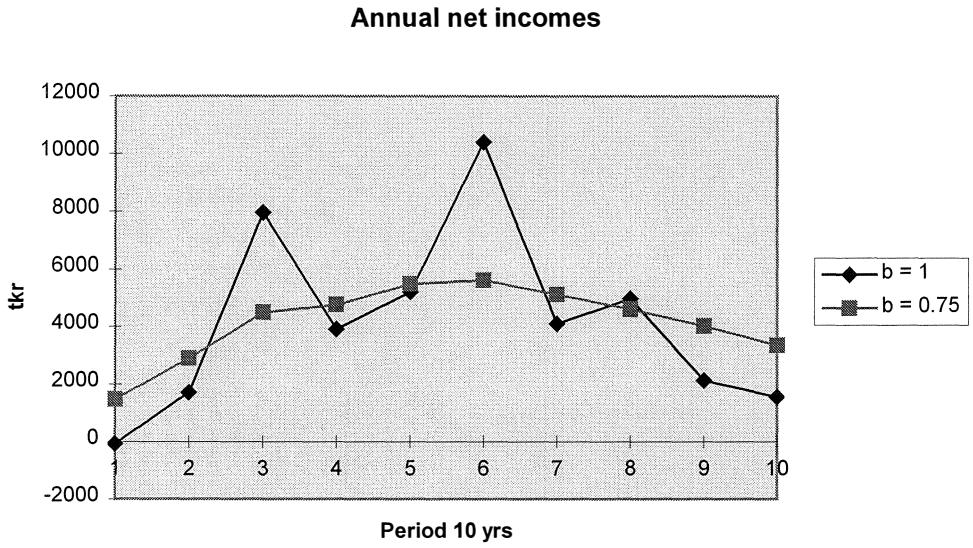

Figure 7.4.1 Development of annual net incomes over time. Optimistic price list. Interest rate 1%.

7.4.2 Cuttings

The cuttings increase until the fourth period, and after a decrease in the fifth period they reach the highest level in the sixth period (Figure 7.4.2.). In general, the diagram of cuttings follows the diagram of net incomes, which is to be expected. The harvested volume varies between 9 937 m3sk/ha and 26 507 m3sk/ha. The percentage of thinning as a part of the total harvested volume varies over time.

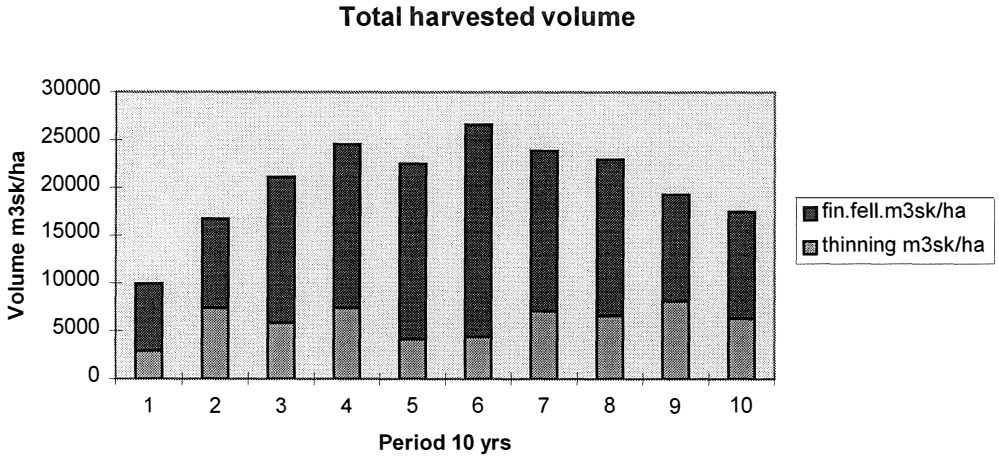

Figure 7.4.2 Profile of total harvested volume, under evenness constraint. Optimistic price list. Interest rate 1%.

7.4.3 Standing volume

The low cutting in the first period causes the standing volume to increase until the third period, where it decreases slightly because of a high cutting level. From the diagram it is seen that the percentage of spruce volume is increasing over time as a result of the high extent of regeneration by spruce. The percentage of pine decreases over time, although (or due to) the price of pine timber will increase faster than the prices of spruce timber. The relatively site index on the forest holding could be the reason for the decline of the pine percentage.

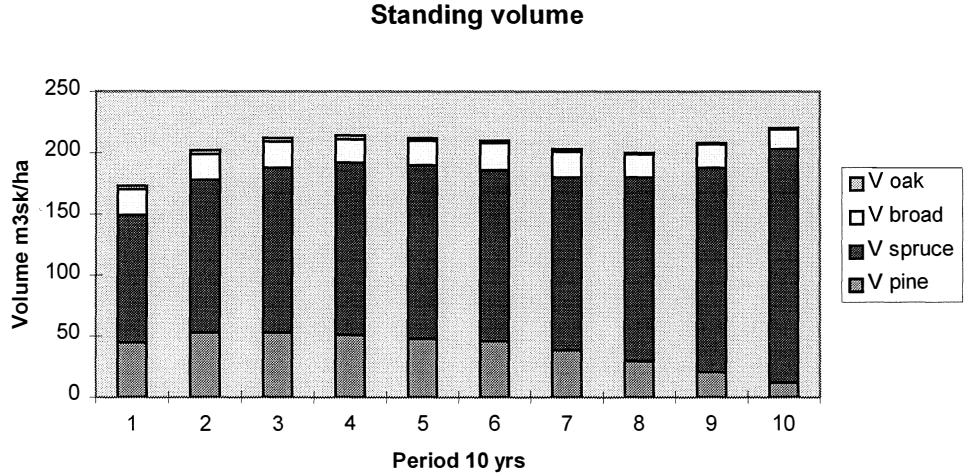

Figure 7.4.3 Profile of standing volume, under evenness constraint. Optimistic price list. Interest rate 1%.

7.5 Optimistic price list with 2.5% rate of interest

The analysis presented in this chapter is based upon a 2.5% rate of interest and an optimistic price list (see chapter 6.1).

7.5.1 Net income

With a 2.5% rate of interest, the net income varies significantly over time if no evenness requirement in the goal function. The peak in period three is a cause of the optimistic price list. Many cuttings are postponed till that period because they will be more profitable then. The net yearly mean income varies between 800 kSEK and 11100 kSEK for the different ten-year periods. With an even revenue requirement, the variation in net yearly income decreases and the values fluctuate between 2700 kSEK and 5100 kSEK.

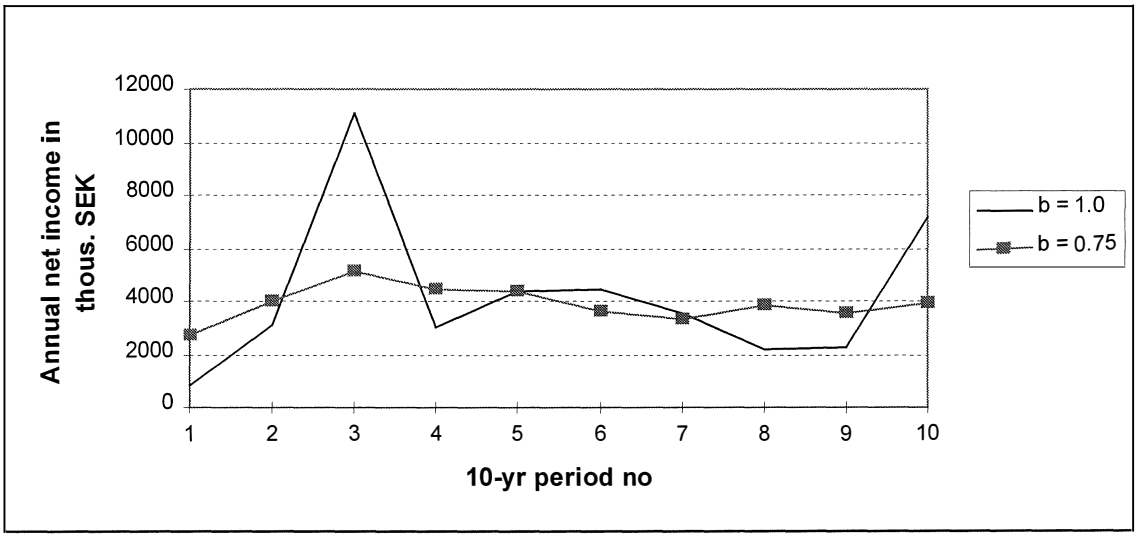

Figure 7.5.1 Annual net income profile, with and without an evenness constraint. Optimistic price list. Interest rate 2.5%.

7.5.2 Cuttings

The annual cutting level is about 17 000 m^3sk/yr in the first period and increases to a peak of 26 000 m^3sk/yr in the third period. In the following periods the amount of cutting falls slightly and stabilizes around 22 000 m^3sk/yr.

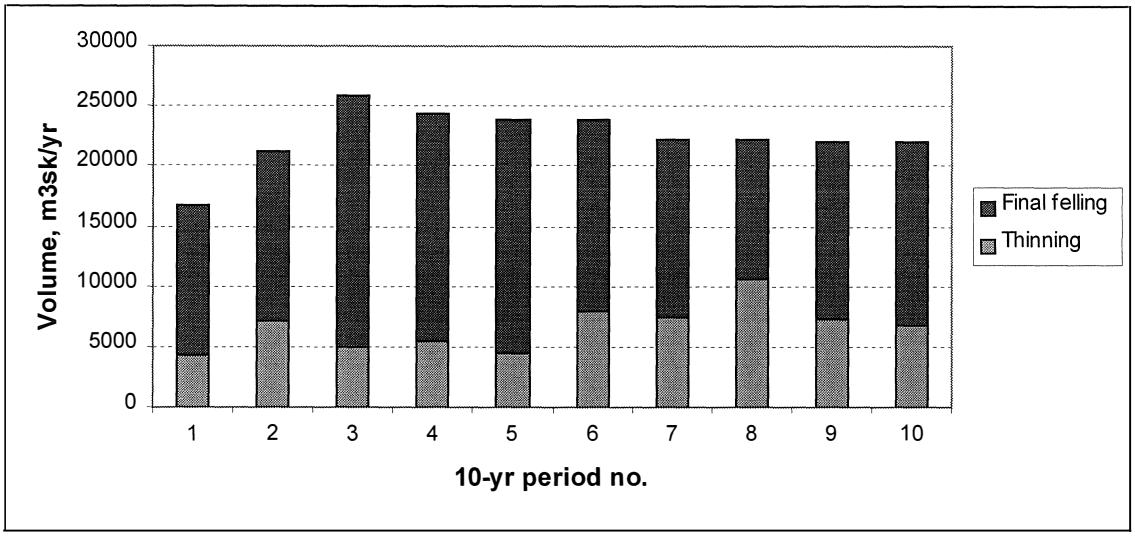

Figure 7.5.2 Mean annual cutting levels for final felling and thinning, in 10 years' periods. Optimistic price list. Interest rate 2.5%.

7.5.3 Standing volume

The standing volume increases from 155 m^3sk/ha to 170 m^3sk/ha during the first two periods. During the following periods, the stocking varies between these levels. The relationship between different species changes over time. The spruce volume percentage increases from 65% to 85%, at the expense of pine, for which a decrease from 25% to 5% is noted. The standing volume of broad-leaves remains fairly constant over time.

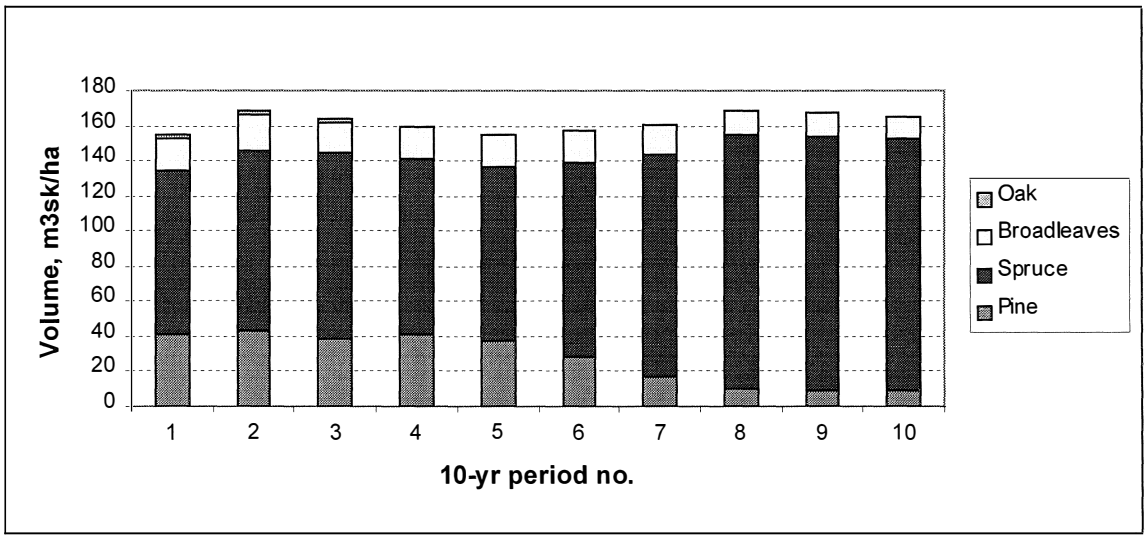

Figure 7.5.3 Standing volume development, distributed on species, over time. Optimistic price list. Interest rate 2.5%.

7.6 Optimistic price list with 4% interest rate

7.6.1 Annual net income

A fixed interest rate without any evenness constraint (b=1) lead to a widely varying net income over periods. The incomes vary from 1 830 kSEK to 7 968 kSEK. With an evenness requirement, the incomes vary from 2 293 kSEK to 5 053 kSEK. We start with a normal price list but gradually an optimistic price list is applied. That explains the first peak in Figure 7.6.1. The second peak is related to the first peak; it is the cuttings of the next generation that are seen.

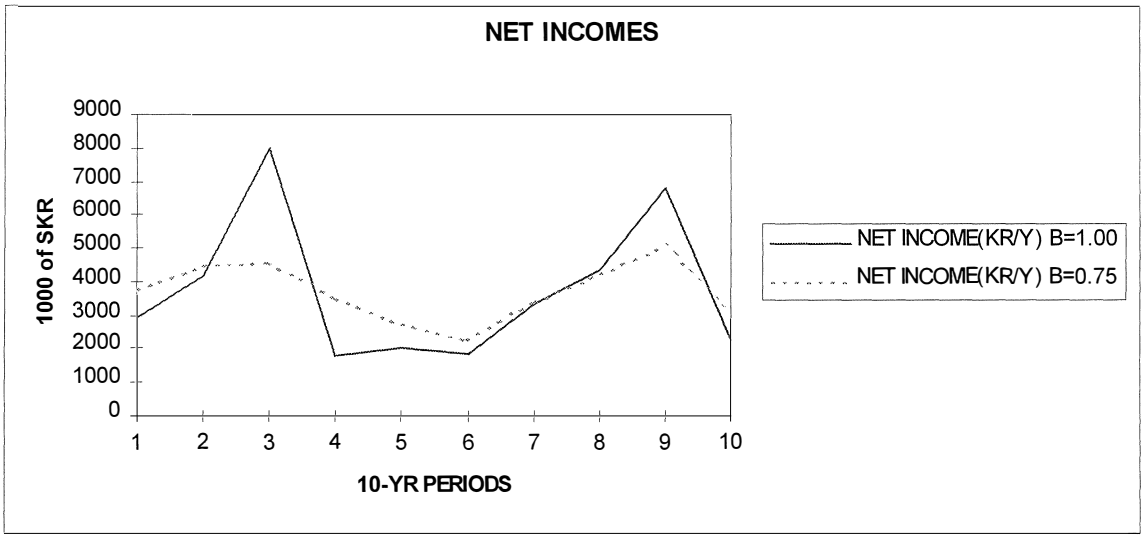

Figure 7.6.1 Annual net incomes based on an optimistic price list with 4% interest rate, with and without evenness constraint.

7.6.2. Annual cuttings

The peaks in the annual cutting levels (diagram 7.6.2) are explained above. The large amount of final felling is explained by the high interest rate and the optimistic price list. Eventually, the amount of thinning increases because the state of the forest is changing.

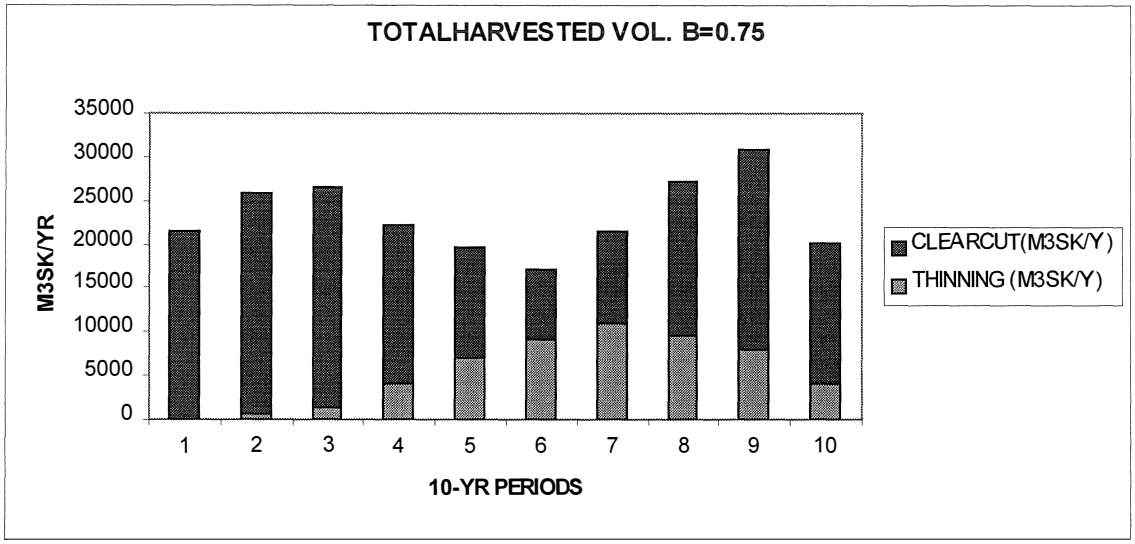

Figure 7·6.2 Annual cutting levels based on an optimistic price list with 4% interest rate and an evenness requirement.

7.6.3 Standing volume

A large percentage of pine and some broad leaves are lost over time (Figure 7.6.3), while the spruce increases. The share of broad-leaves is almost constant after period three and the share of pine is constant after period six. The standing volume reaches a minimum in period four (114 m^3sk/ha) and a maximum in period seven (170 m^3sk/ha).

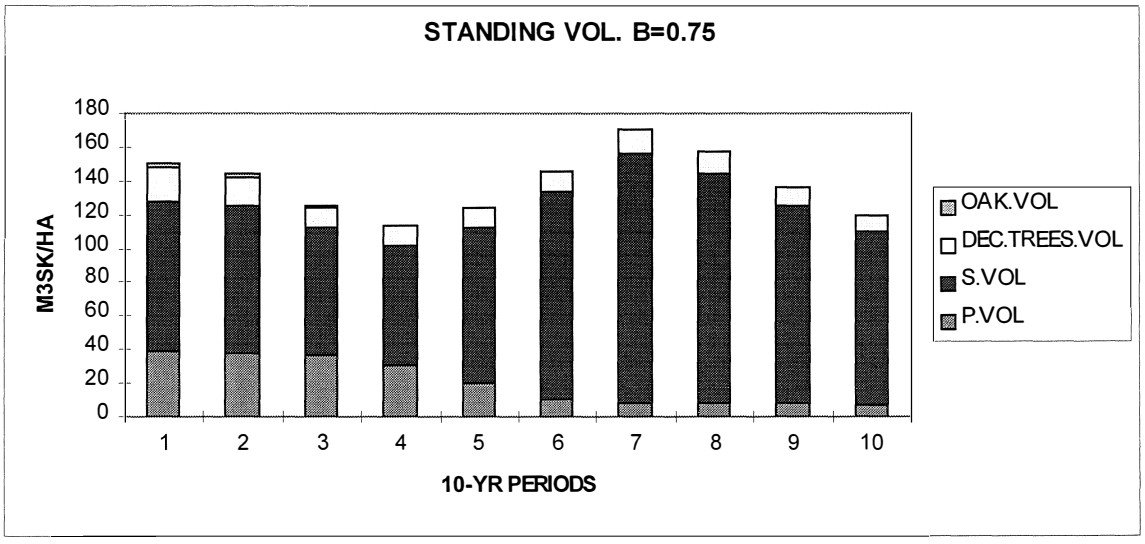

Figure 7·6.3 Development of the standing volume based on an optimistic price list with 4% interest rate and an evenness requirement.

7.7 Pessimistic price list with 2.5 % rate of interest.

7.7.1 Net incomes

This alternative is derived for the pessimistic price list, described in chapter 6.1.

The pessimistic price list results in a very high cutting level in the first period, before the drastic price decay in the next period. The negative net income, occurring in period two, is a consequence of the very high cutting amount in the first period, thus creating high expenses for regeneration. (The negative net income only pertains to the alternative without an evenness restriction.). The high cutting level in the first period is reflected in a small cutting level peak also in the tenth period (even flow alternative), corresponding to the harvest of the next generation. However, in the evenness requirement alternative we get a very even income flow after the first period. For the alternative without an evenness restriction there are humps in the fourth and the eighth periods, caused by large cuttings before decreases of the price list.

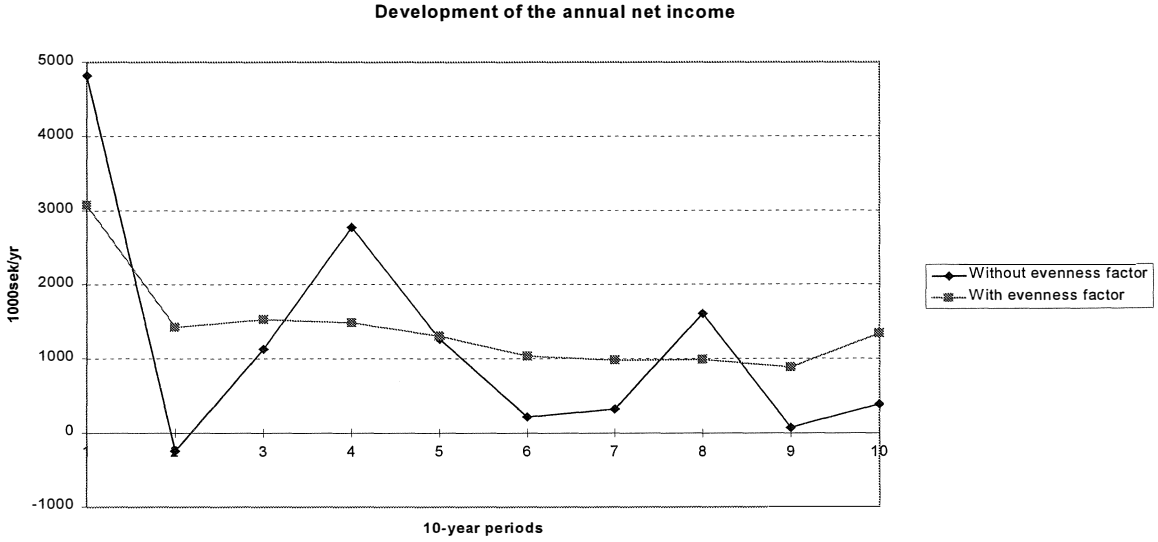

Figure 7.7.1 Net income profiles with and without evenness constraint. Pessimistic price list. Interest rate 2.5%.

7.7.2 Cuttings

The profile for the cutting, under evenness restriction, will in general correspond to the annual net income. We make a lot of felling in the first period with less thinning, since the thinning would reduce our net income per m^3sk compared with the final felling. The relationship between thinning and final felling will stay on the same level for the rest of the hundred year planning period.

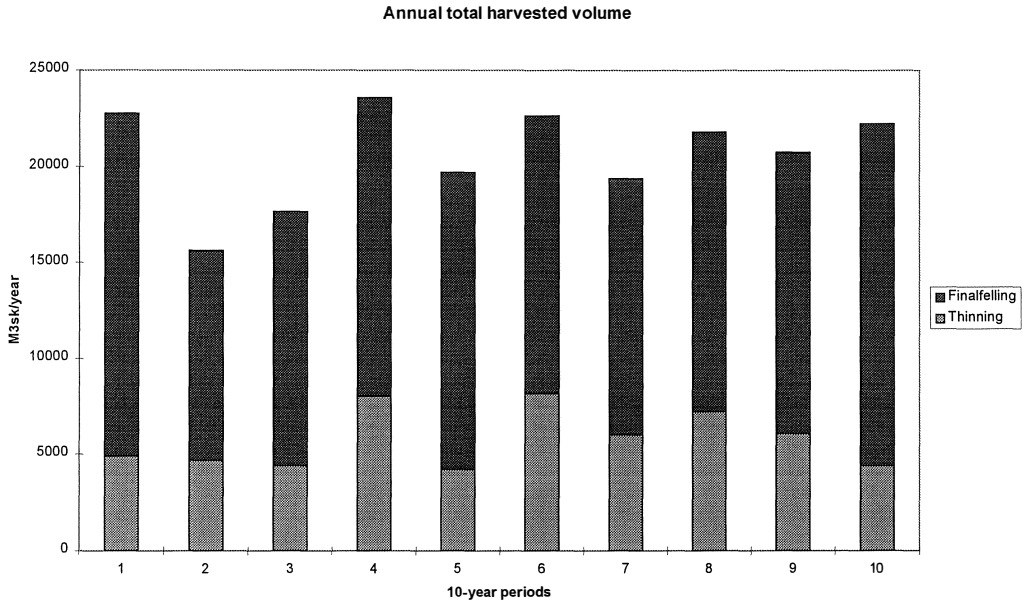

Figure 7.7.2 Harvested volume for final felling and thinning under evenness constraint. Pessimistic price list. Interest rate 2.5%.

7.7.3 Standing volume

Since the regeneration with spruce is given a higher priority than pine, we will have an increasing volume of spruce at the expense of pine. The oak stands seem to disappear since no regeneration with oak is included. However, oak regeneration is included in broad-leave regeneration, why future broad-leave stands also contain Oak.

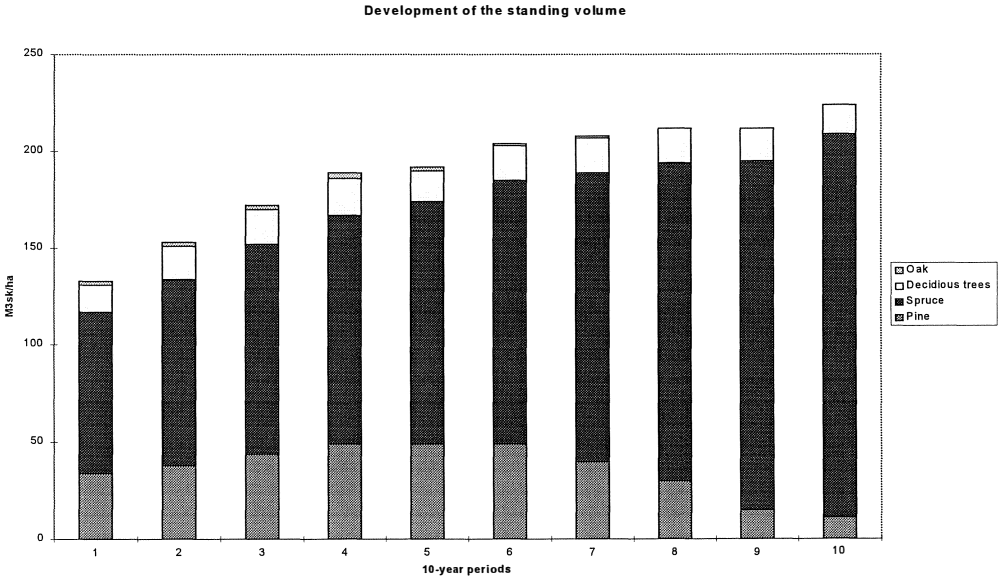

Figure7.7.3 Standing volume under evenness constraint. Pessimistic price list. Interest rate 2.5%.

7.8 Thinning from above, 2.5% interest rate, normal price list.

The analysis presented here is based on a 2,5% interest and a normal price list. The major interest in this analysis is that all thinning is made from above, that is, the larger the tree, the larger the probability to be cut when thinning.

7.8.1 Net income

The annual net incomes are shown in Figure. 7.8.1. They vary between 1959 kSEK and 5287 kSEK without an evenness restriction and between 2163 kSEK and 3821 kSEK with an even flow requirement. In both cases, the net income will be lower in the last three periods.

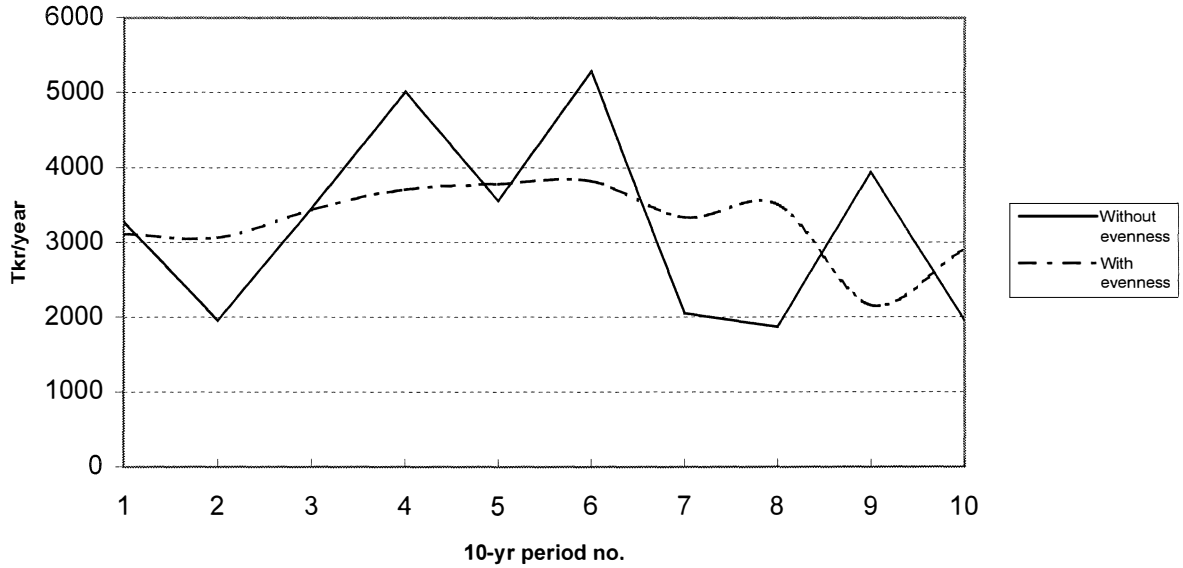

Figure 7.8.1 Development of annual net incomes over time. Thinning from above. Interest rate 2.5%

7.8.2 Cuttings

The cuttings increase until and including period six, after which they decrease a little and reach the lowest level in period nine. The harvested volume varies between a lowest level of 16591 m3sk (per. 9) to the highest level 24907 m3sk (per. 6). The percentage of thinning as a part of the total harvested volume varies over time, and is highest in period 2 and lowest in period 5.

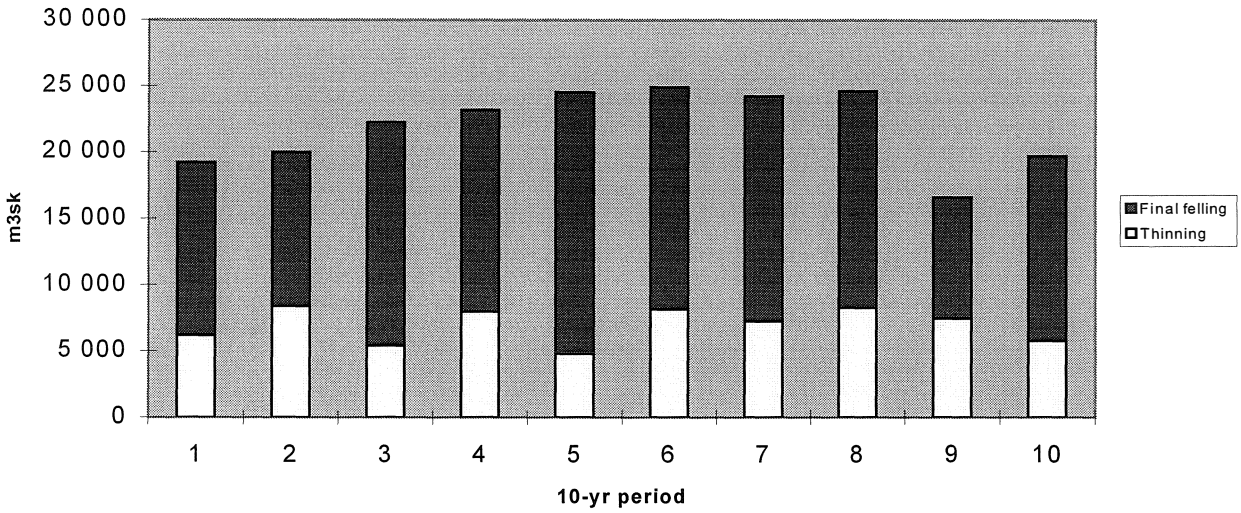

Figure 7.8.2 Profile of total harvested volume, under an evenness constraint. Thinning from above alternative. Interest rate 2.5%.

7.8.3 Standing volume

The low cuttings in the first periods causes the standing volume to increase up to the fifth period. Then the volume decreases for three periods and ultimately starts to increase again. The percentages of oak, pine and broad leave trees are decreasing from period one to period ten.

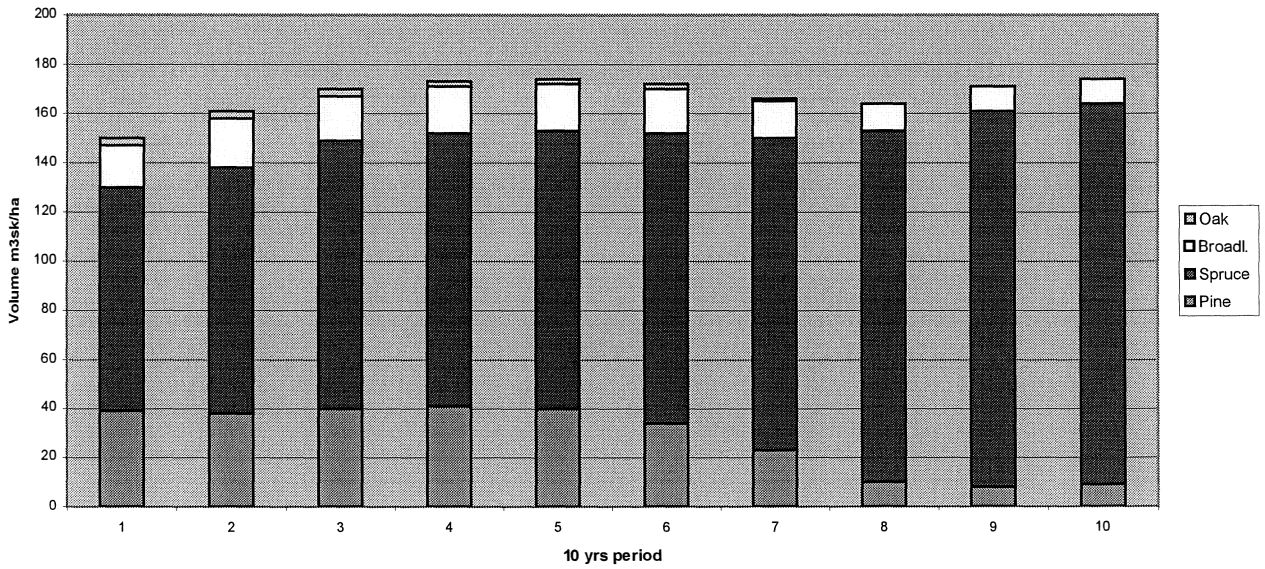

Figure 7.8.3 Profile of standing volume, under an evenness constraint. Thinning from above. Interest rate 2.5%.

7.9 Normal price list with 2.5% rate of interest

We have in our results presented here used 2.5% rate of interest and the normal price list. This is seemingly the same alternative as that in chapter 7.2. The two alternatives, however, are not identical since many other parameters (except the interest rate and the price list), like thinning intensity definitions, might differ.

7.9.1. Net income

If the goal function is not forced to generate an even net income over time (if b=1), the net income will fluctuate widely over the 100 years period. It varies between 2000 and 3000 kSEK during the first three periods. After that, in period four and six, two peaks occur with annual incomes of more than 6000 kSEK. The peaks are natural consequences of the age distribution of the forest.

With evenness requirement (b=0.75), the annual income variations are smaller, only between 2200 and 3900 kSEK. Except for the drop in period eight, the net income stays steadily between three and four million SEK.

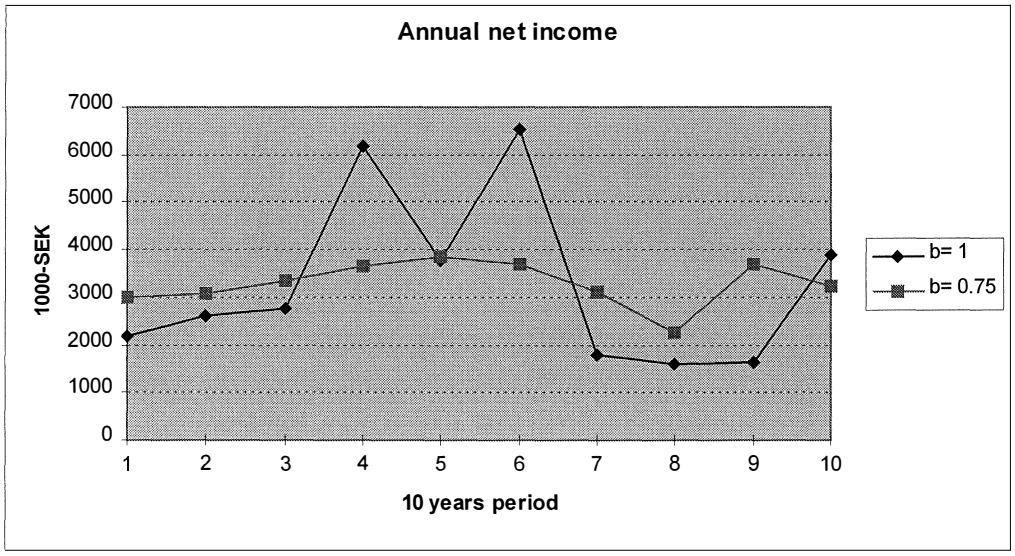

Figure 7.9.1 Annual net income with and without an evenness requirement. Interest rate 2.5%.

7.9.2 Cuttings

The annual harvesting level calculated with the evenness constraint follows the same trend as the annual net income. This seems very reasonable, since no drastic price changes are expected. The yearly cutting levels vary roughly between 1800 and 2500 m^3sk. The thinning proportion varies and it is difficult to see or explain any trend. The

thinning percentage is largest in period eight and lowest in the first period.

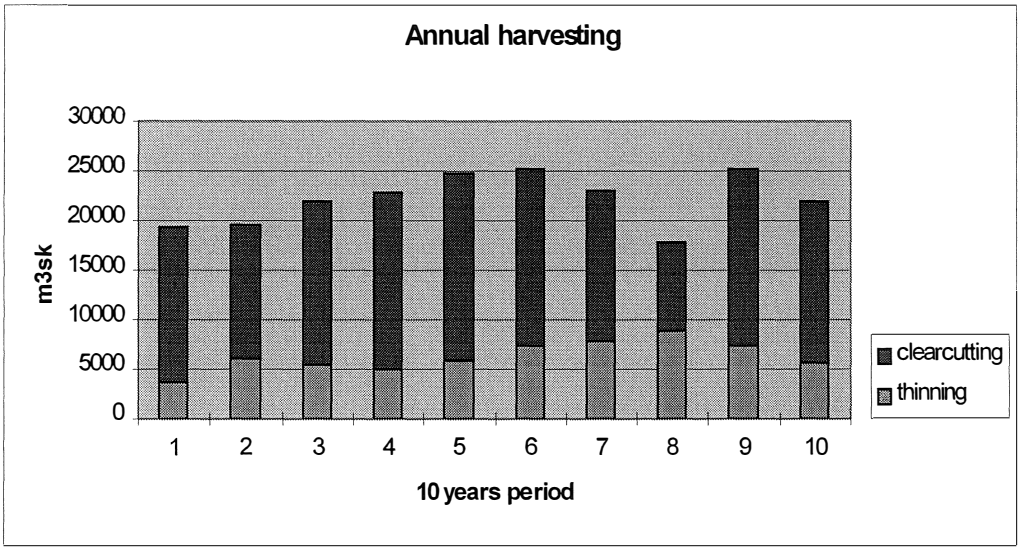

Figure 7.9.2 Mean annual harvested volumes for a 100 years period, under an evenness constraint.Interest rate 2.5%.

7.9.3 Standing volume

The relative low initial cutting levels during the first 30 years generates a high stocking of the future forest from today's 150 m3sk/ha to 170 m3sk/ha, where it stabilizes. A small drop in period seven is expected though, due to the high harvesting level in the previous periods. However, there are no great changes in stocking and the growth is clearly greater than the harvest over the hundred years period. Without doubt, the proportion of spruce will increase and the proportion of pine decrease.

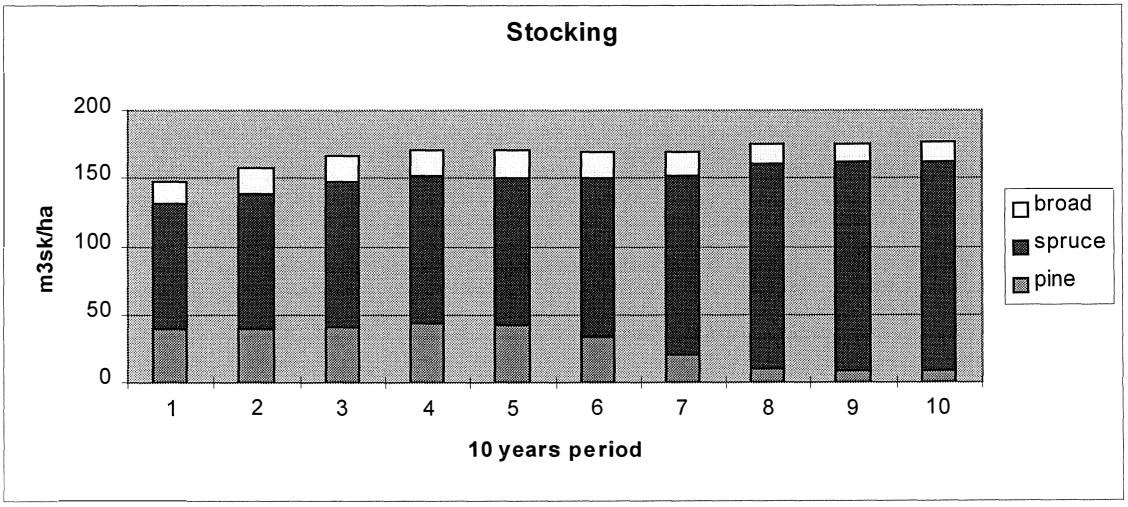

Figure 7.9.3 Standing volume for a 100 years period, with evenness requirement. Interest rate 2.5%.

8. Tactical planning

The tactical planning is the third level in the planning process. The role of the tactical planning stage is explained by:

- The strategic planning is performed on a sample of compartments, objectively inventoried. The result is a set of accurate estimates of the optimal levels of a range of management actions. Optimal actions are only obtained for the sampled compartments. The motivation behind using a *sample* is the relatively high inventory costs.

- It has not been possible to use all available information in the strategic planning. For example, spatial aspects and logistics have not been considered.

The objective of the tactical planning is thus to find the best choice of compartments for different treatment alternatives for the next five years, *the five year coupe set*, within the restricted levels of the strategic planning result. The tactical planning results have a direct impact on the forestry within the near future, but in principle the planning horizon is infinite also at the tactical stage (future consequences of decisions are considered).

The basis for the tactical planning work is the strategic result, furnishing general levels but also information about the kind of compartments to treat during the first five year period, and more specific information about the forestry conditions on the estate. The latter information is in large given by a stand register and a map (GIS), but also softer information concerning, e.g., specific compartments or total area to be treated for nature preservation.

The connection between the strategic and tactical planning is obtained through the estimated in-optimality losses for single compartments, calculated by the FMPP. The in-optimality losses are transformed into priority functions, by means of regression analyses (see chapter 9), with register values as independent variables. Priority functions are estimated for clear-cutting and thinning (and “no activity”), and they can be applied on all compartments.

Ideally, the priority functions both rank the compartments in order of precedence and give high priority to compartments similar to those of the sample chosen for treatment by the FMPP.

The concrete selection work was performed with help of the GIS product Esri ArcView combined with the data base system Microsoft Access. In Arcview a script-program was used as a tool to get information for the selection of the final felling and thinning compartments for the next five years period. Beyond this, other information like the compartments’ locations, road net, requested concentration of the cuttings, nature conservation, available resources etc. were used to govern the choice of compartments.

The tactical planning results in a suggested set of compartments to clear-cut and to thin in the coming five years. Naturally, the suggestion is dependent not only on the planner’s

skill but also on the prices, costs and rate of interest, in the same way as is the strategic planning result. Finally, the choice of compartments becomes the foundation for the operative planning, the fourth and last planning level, in which schedules for the concrete measures (cuttings) are worked out.

9. Priority functions

In the planning process we have to make some decisions, which lead to some activity in order to reach a given goal. For a good decision we must have good information about treatment units. To get information about the forest we could measure all trees, but that would be too expensive, so we use a sample method to collect data. The data is used for a compartment description, serves as basis for forecasts and as data for constructions of priority functions.

The calculations in the strategic planning are only based on the sample, but the compartments to be treated have to be found over the whole forest holding. Using the FMPP we find the optimal solution for the sample and we know how much to thin and to clear-cut, but still we do not know where. The FMPP optimal solution provides us with an in-optimality loss for each sampled compartment. The in-optimality loss is the loss (in SEK per hectare) that an in-optimal decision would cause. In-optimality losses are calculated for each decision (clear-cut, thin, do nothing). The in-optimality losses (for the sampled compartments) are used to derive priority numbers for all compartments and different treatments. The basis for this work is the register compartment data (stand averages and site variables), existing for all compartments.

The first step consists in constructing priority functions, one for thinning and one for final felling. To find the relationship between in-optimality losses and the compartments characteristics we used regression analysis.

IL = f (sample register data)

The function is estimated with data from the sampled compartments.

The function can be applied to every compartment, to get estimated in-optimality losses (priority numbers) for all compartments. The priority functions are then used to find the optimal treatment decision for each compartment. The compartments with the lowest values (lowest expected losses) have the highest priority, but we also have to consider other conditions such as environmental values and geographical considerations.

Here we have to point out that the priority functions are based on register data, which are sometimes uncertain or crude, and this is especially marked for the priority functions for thinning. Also, usual register data is not collected with the aim to be well adapted for constructing priority functions, why many variables that could be important in this work are lacking in the register.

Sections 9.1 and 9.2 shows, as an example, the priority functions for the optimistic price list with 1 % rate of interest. The other alternatives (chapter 7.1 – 7.9) result in their specific set of priority functions.

9.1 Priority function for final felling

ILSLU = 67298.663326 - 637.9583O5 * ALD - 23. 709677 * VOL -
-267.252997* PROCB

where

ILSLU denotes the value of the priority function (for final felling)
ALD Total age in years,
VOL Volume in m3sk/ha and
PROCB Percentage birch

9.2 Priority function for thinning

ILGA = -23.678177 -14.980372 * VOL + 0.039353 *VOL2 - 0.008566 * DIAM2 +
+0.345260 * ALDSPEC + 151.253688 * SI + 9.638028 * PROCL -2.011972 *PROCB

where
ILGA denotes the value of the priority function (for thinning)
VOL Volume in m3sk/ha
VOL2 The square of the volume in m3sk/ha
DIAM2 Diameter (mm) - square

ALDSPEC = $\begin{cases} (ALD - 55)^2 \\ 0 \end{cases}$

where ALD is the total age in years

SI Site quality index
PROCL Percentage other broad-leaves (including Oak)
PROCB Percentage birch

10. Tactical planning result

10.1 Normal price list with 1 % rate of interest

The choice of compartments is based on the estimated in-optimality losses that are given by the priority functions and also on the volume levels that are given by the FMPP system. For the decision also the geographical locations of the compartments have been considered. Single small compartments, which are situated far away from selected compartments and therefor have high cutting (transport) costs, have been excluded. These compartments will be treated in the future when nearby compartments are mature for treatment. Nature conservation aspects also have been considered in the decision of compartments for clear-cutting and thinning.

List of five years' amount (five years' coupe)

Area (ha)
- Total : 3569
- Productive : 3491
- Final felling : 291
- Thinning : 272
- No treatment : 3006

Volume (m^3sk)
- Initial volume : 544 540
- Final felling : 73 608
- Thinned : 12 786
- Final volume : 555 823

Gross incomes (SEK)
- Final felling : 21 608 500
- Thinning : 3 075 030

Cutting costs (SEK)
- Final felling : 5 319 080
- Thinning : 1 630 390

Net incomes (SEK)
- Final felling : 16 289 500
- Thinning : 1 444 640
- Total : 17 734 140

Net income per m^3sk (SEK)
- Final felling : 221
- Thinning : 113
- Total : 205

Final felling is suggested for the following 77 compartments in the next five years, in order of priority:

1701, 1702, 671, 177, 585, 424, 523, 1171, 11017, 566, 178, 448, 4070, 414, 264, 269, 350, 258, 381, 71150, 1150, 710, 32, 855, 236, 461, 591, 845, 654, 1061, 158, 1018, 702, 703, 957, 701, 399, 147, 712, 657, 1515, 713, 7713, 174, 63, 118, 1511, 296, 136, 140, 909, 445, 686, 334, 696, 7696, 388, 685, 12013, 550, 428, 522, 938, 933, 969, 851, 4050, 306, 297, 39, 4060, 143, 906, 7736, 7185, 71049, 7369

Thinning is suggested for the following 98 compartments in the next five years, in order of priority:

4390, 1055, 4100, 1042, 1037, 930, 4360, 1703, 1712, 1038, 681, 1064, 115, 459, 1073, 4540, 953, 4030, 1066, 11052, 1006, 238, 356, 873, 1072, 170, 1003, 1103, 10, 1074, 4110, 403, 1109, 1015, 145, 931, 11056, 1067, 4020, 493, 1043, 556, 1110, 120, 538, 182, 151, 11018, 4190, 465, 960, 1122, 345, 1059, 533, 537, 4530, 149, 1044, 1113, 320, 395, 1071, 746, 4120, 1050, 1051, 1177, 4430, 558, 959, 531, 163, 155, 1193, 152, 902, 339, 1023, 351, 315, 371, 353, 1049, 1509, 181, 1047, 323, 119, 348, 4480, 966, 961, 978, 1058, 462, 330, 265

10.2 Normal price list with 2.5% interest rate

This management alternative is based upon a realistic price list for 1997, and an interest rate of 2.5%.

The tactical planning relies upon choices made using estimated in-optimality losses for every compartment. The estimated in-optimality losses are estimated for all compartments when implementing the strategic planning level (the FMPP result), and are based upon the register data and true in-optimality losses from the sampled compartments. When choosing which compartments to treat, we considered species composition, road distances, and various environmental concerns. We also tried to minimize cost, and losses, and to maximize revenues.

(See remarks, explaining the disconnection between the strategic and tactical planning for this alternative.)

List of five years' amount (five years' coupe)

Area (ha)
- -Total (prod.) : 3490.5
- -Final felling : 232.3
- -Thinning : 757.8
- -No treatment : 2500.4

Volume (m^3)
- -Initial volume : 544 540
- -Final felling : 55 474
- -Thinning : 35 599
- -Final volume : 550 133

Gross incomes (SEK)
- -Final felling : 16 376 940
- -Thinning : 7 095 080

Cutting costs (SEK)
- -Final felling : 4 065 715
- -Thinning : 4 709 880

Net incomes (SEK)
- -Final felling : 12 311 225
- -Thinning : 2 385 199
- -Total : 14 696 424

Net income, SEK per m^3

-Final felling	: 221.9
-Thinning	: 67.0
-Total	: 161.4

The following is a list of compartments scheduled for final felling in the first five-year period in order of priority:

483, 424, 1171, 874, 575, 202, 523, 3107, 414, 513, 710, 454, 448, 264, 269, 258, 671, 1158, 177, 51, 967, 654, 957, 502, 933, 15, 71150, 1619, 1511, 585, 3118, 929, 969, 938, 945, 332, 63, 1080, 4070, 350, 3120, 3117, 503, 306, 1515, 3102, 3113, 296, 970, 965, 7696, 7713, 7369, 7185, 7736

A total of 55 compartments are suggested for final felling the following five years.

The compartments scheduled for thinning are, in order of priority:

3114, 3116, 4100, 3119, 1701, 1033, 3105, 4360, 277, 4110, 642, 3108, 888, 115, 11051, 175, 236, 21, 3104, 4390, 903, 3111, 950, 1061, 1185, 1194, 1093, 845, 893, 826, 11004, 1026, 3112, 5, 906, 921, 96, 408, 825, 24, 1180, 883, 11049, 909, 4540, 11071, 131, 4030, 471, 161, 243, 834, 661, 549, 480, 1103, 388, 935, 1095, 2580, 1081, 1085, 832, 737, 107, 84, 736, 153, 11061, 1032, 688, 371, 4090, 955, 573, 11005, 68, 963, 821, 4490, 875, 479, 4320, 215, 528, 70, 1018, 4350, 558, 4450, 2090, 109, 4500, 4020, 3110, 887, 4410, 2020, 11008, 156, 4130, 82, 855, 11017, 178, 2511, 216, 219, 10, 566, 1113, 983, 4370, 11068, 11046, 1069, 4200, 149, 11033, 4190, 718, 657, 120, 1509, 1064, 956, 4430, 4510, 1165, 821, 1122, 1702, 4230, 976, 2080, 961, 703, 400, 4060, 1073, 2011, 379, 4470, 1060, 1072, 2070, 1177, 11038, 1178, 425, 11069, 988, 413, 942, 1708, 74, 537, 723, 99, 846, 11003, 210, 1070, 4010, 4530, 1154, 493, 353, 697, 1118, 104, 1021, 351, 1506, 11054, 916, 1097, 707, 677, 481, 1029, 151, 4180, 1078, 2550, 4380, 939, 866, 103, 2560, 11043, 1712, 86, 1068, 160, 4161, 152, 11039, 712, 451, 1015, 841, 1057, 1703, 1110, 4521, 242, 4170, 644, 705, 30, 1049, 1706, 361, 1059, 1101, 535, 2551, 1020, 31, 694, 981, 359, 1094, 98, 4440, 436, 1187, 1044, 1608, 672, 839, 975, 4400, 700, 847, 432, 4420, 1038, 26, 11042, 2040, 419, 4520, 14, 2110, 722, 844, 725, 4361, 673, 1098, 902, 2541, 1088, 510, 71049, 403, 2410, 4460, 428, 532, 1707, 936, 1116, 2570, 659, 701, 870, 1037, 579, 1196, 496, 675, 28, 136, 1183, 140, 719, 4480, 431, 1077, 658, 692, 704, 1076, 1023, 77, 139, 456

A total of 290 compartments are suggested for thinning in the following five years.

10.3 Normal pricelist 4% interest rate

In the tactical planning the priority functions from the strategic planning are used when selecting the set of compartments for treatment. We have also taken in consideration the nature conservation perspective and the spatial distribution of the cuttings.

List of five years' amount (five years' coupe)

Area (ha)		
-Total (productive)	:	3 491
-Final felling	:	461
-Thinning	:	88
-No treatment	:	2 942
Volume (m3sk)		
-Initial volume	:	544 540
-Final felling	:	124 209
-Thinned	:	3 072
-Final volume	:	506 206
Gross income (SEK)		
-Final felling	:	36 339 796
-Thinning	:	454 802
Net income (SEK)		
-Final felling	:	27 642 376
-Thinning	:	67 471
-Total	:	27 709 847
Net income, SEK per m^3		
-Final felling	:	223
-Thinning	:	22
-Total	:	218

According to our alternative, final felling in the next five-year period is suggested for the following 110 compartments, in order of priority:

3102, 585, 3117, 258, 264, 414, 269, 671, 523, 3104, 3107, 3110, 713, 7713, 63, 654, 177, 350, 296, 686, 710, 51, 32, 3112, 483, 874, 270, 12013, 370, 354, 334, 306, 933, 3101, 674, 369, 7369, 297, 503, 3108, 189, 587, 702, 895, 11019, 3118, 550, 202, 551, 714, 71150, 1150, 7696, 696, 295, 685, 965, 518, 39, 332, 9036, 957, 967, 448, 657, 591, 428, 502, 275, 582, 945, 406, 938, 424, 1171, 4170, 11007, 666, 855, 174, 322, 319, 11026, 446, 236, 703, 158, 720, 244, 3113, 399, 461, 16, 11059, 435, 716, 381, 929, 221, 415, 363, 318, 816, 897, 522 , 970, 969, 7185, 7736, 71049

According to our alternative, thinning in the next five-year period is suggested for the following 38 compartments, in order of priority:

4100, 4360, 4390, 4070, 2580, 2511, 1033, 115, 1103, 4080, 921, 1093, 11052, 918, 1194, 170, 1026, 1085, 1081, 3109, 11003, 4110, 888, 10, 192, 4510, 11056, 11024, 4340, 120, 4500, 1072, 11005, 388, 21, 408, 149, 11010.

10.4 Optimistic price list with 1% rate of interest

This forest management plan is based on an optimistic price list and 1% rate of interest. In the tactical planning some information from the strategic planning level is used, namely:

-The amounts of final felling and thinning.
-The in-optimality losses, transformed into priority functions.

To select compartments that should be treated in the next five years we have considered:

- Economical aspects.
- Biological aspects.
- Geographical (spatial) aspects.

A set of compartments with old forests or with broad-leaves has been excluded from the set of compartments to be treated. Small compartments situated far from the roads are left for future treatment.

List of five years' amounts (five years' coupe)

Area (ha)	
-Total	3 490.5
-Final felling	233.8
-Thinning	209.8
-No treatment	3 046.9
Volume (m3sk)	
-Initial volume	544 540
-Final felling	53 349
-Thinned	9 666
-Final volume	584 172
Gross incomes (SEK)	
-Final felling	14 606 165
-Thinning	2 349 685
Cutting costs (SEK)	
-Final felling	3 852 557
-Thinning	1 159 401

Net incomes (SEK)

-Final felling	10 753 608
-Thinning	1 190 284
-Total	11 943 892

Net incomes, SEK per m3sk

-Final felling	201.4
-Thinning	123.1
-Total	189.6

Final felling in the next five years is suggested for the following 58 compartments, in order of priority:

1701, 1702, 575, 483, 202, 255, 140, 438, 174, 52, 414, 874, 3101, 573, 4070, 1271, 258, 284, 585, 558, 566, 269, 10, 513, 3117, 381, 15, 332, 654, 710, 236, 3102, 448, 3110, 177, 71150, 1150, 51, 3104, 957, 933, 1103, 4060, 350, 296, 3118, 967, 502, 1061, 63, 855, 824, 32, 7713, 7696, 9369, 7185, 71049.

Thinning in the next five years is suggested for the following 76 compartments, in order of priority:

371, 528, 353, 718, 351, 14, 379, 345, 419, 361, 3114, 661, 425, 1512, 537, 4110, 697, 11054, 356, 3120, 77, 1032, 136, 479, 291, 970, 701, 703, 445, 104, 942, 1612, 1703, 68, 481, 432, 950, 3113, 516, 712, 323, 4160, 372, 1509, 437, 216, 1113, 436, 521, 315, 312, 916, 28, 401, 277, 4400, 3105, 155, 403, 4430, 3, 163, 493, 2511, 938, 1015, 1618, 1115, 961, 1603, 219, 164, 333, 1712, 1607, 1605.

10.5 Optimistic price list with 2.5% rate of interest

The analysis presented in this chapter is based upon a 2.5% rate of interest and an optimistic price list. The optimistic price list was created by raising the prices of the normal list, equally every period, for five periods (25 years). The ultimate price levels, compared to the basic prices, are 10% higher for spruce timber, 20% higher for pine timber, and for pulpwood, 20% higher than today.

The strategic planning provides recommended cutting levels for the first five-year period. Calculated target volumes were 12 534 m^3sk for thinning and 65 801 m^3sk for final felling. These values are relatively small because of the optimistic price list, that is, the cuttings are delayed until the prices are increasing.

List of five years' amount (five years' coupe)

Area (ha)		
- Total	:	3 491
- Final felling	:	241
- Thinning	:	258
- No treatment	:	2 992
Volume (m^3sk)		
- Initial volume	:	544 540
- Final felling	:	65 907
- Thinning	:	12 535
- Final volume	:	565 456
Gross incomes (SEK)		
- Final felling	:	20 233 359
- Thinning	:	3 115 774
Cutting costs (SEK)		
- Final felling	:	4 615 534
- Thinning	:	1 553 510
Net incomes (SEK)		
- Final felling	:	15 617 826
- Thinning	:	1 562 263
- Total	:	17 180 089
Net income (SEK per m^3sk)		
- Final felling	:	237
- Thinning	:	125
- Total	:	219

The following 42 compartments are suggested for final felling during the next five-year period, in order of priority:

585, 414, 269, 177, 258, 264, 296, 710, 51, 63, 350, 32, 933, 306, 483, 686, 334, 713, 7713, 370, 1150, 71150, 270, 965, 967, 297, 189, 957, 295, 9036, 39, 448, 1171, 9224, 696, 7696, 685, 587, 7369, 7185, 71049, 7736

Thinning is proposed for the following 89 compartments, in order of priority:

11022, 11001, 4080, 4320, 1511, 4500, 969, 2550, 332, 4480, 4520, 1618, 930, 4450, 112, 4230, 1607, 4521, 1613, 1005, 982, 1515, 170, 4510, 1617, 1514, 1602, 1605, 4370, 1504, 1619, 970, 4470, 1611, 1006, 4410, 1043, 140, 136, 1042, 1003, 1614, 11014, 158, 1047, 1512, 1505, 2512, 681, 1066, 1712, 960, 1168, 1074, 592, 15, 1612, 11013, 1603, 1071, 1037, 1029, 1077, 1034, 143, 77, 1051, 11025, 1711, 1038, 4360, 1616, 376, 1050, 992, 118, 14, 1109, 522, 1023, 11010, 953, 1049, 1110, 1044, 2040, 959, 1703, 139

10.6 Optimistic price list with 4% interest Rate

The following treatment alternative is based on a price list valid in 1997, and assumes a continuous increase in prices for pine saw timber and pulpwood of 20%, and 10% for spruce saw timber up to the year 2017.

List of five years' amount (five years' coupe)

Area (ha)
- -Total :3490
- -Final felling :318
- -Thinning :346
- -No treatment :2826

Volume (m^3sk)
- -Initial :544 540
- -Final felled :91 386
- -Thinned :16 176
- -Final :553 058

Gross incomes (SEK)
- -Final felling :27 740 109
- -Thinning :3 853 103

Cutting costs (SEK)
- -Final felling :6 264 565
- -Thinning :2 059 126

Net incomes (SEK)
- -Final felling :21 475 543
- -Thinning :1 793 977
- -Total :23 269 520

Net income, SEK per m^3sk
- -Final felling :235
- -Thinning :111
- -Total :216

The following 76 compartments are proposed to be final felled in the next five-year period, in order of priority:

71049, 7185, 547, 816, 363, 310, 221, 322, 319, 3118, 158, 1171, 244, 666, 720, 332, 4151, 202, 275, 502, 295, 1619, 550, 582, 9224, 696, 7696, 71150, 1150, 518, 4170, 714, 3108, 702, 895, 483, 297, 551, 503, 587, 3101, 369, 7369, 674, 306, 334, 874, 370, 354, 3112, 270, 51, 32, 296, 686, 710, 3110, 350, 654, 177, 63, 3104, 523, 713, 7713, 671, 3107, 269, 1702, 414, 3117, 258, 264, 585, 3102, 1701

The following 118 compartments are proposed to be thinned in the next five-year period, in order of priority:

1070, 1160, 10, 252, 542, 1067, 821, 368, 91, 708, 1611, 34, 531, 254, 903, 583, 485, 242, 533, 84, 402, 429, 863, 282, 860, 722, 360, 430, 407, 430, 360, 905, 227, 336, 525, 22, 1044, 678, 845, 1071, 214, 1021, 413, 642, 662, 216, 667, 859, 538, 731, 526, 320, 129, 339, 314, 388, 12, 824, 400, 218, 211, 434, 669, 672, 119, 1617, 348, 848, 1038, 707, 139, 1074, 208, 524, 659, 839, 851, 579, 844, 1020, 109, 151, 107, 210, 516, 68, 345, 660, 24, 1711, 1037, 1055, 220, 875, 425, 1073, 1058, 537, 265, 737, 238, 681, 1023, 341, 1032, 371, 401, 315, 31, 1064, 1042, 356, 437, 1712, 661, 169, 697, 701

10.7 Pessimistic price list with 2.5 % interest rate.

This alternative is based on the pessimistic price list that is described in the strategic planning chapter 7.7. To decide which stands to be cut or thinned, we calculated the in-optimality losses in the sampled compartments and then applied expressions that described the losses as functions of register data. When choosing stands to cut, the intention was to be careful with compartments containing natural values, like broad-leaves and forests in maturity classes 51-53 (nature preservation). Also, cuttings suggested in stands situated far from other high priority objects were suppressed. In this decision process, the age of the forest was an important characteristic (especially for thinning).

List of five years' amount (five years' coupe)

Area (ha)	
- Total	:3 490
- Final felling	:326
- Thinning	:689
- No treatment	:2 475
Volume (m3sk)	
- Initial volume	:544 540
- Final felling	:89 500
- Thinned	:24 623
- Final volume	:522 169
Gross incomes (SEK)	
- Final felling	:27 199 643
- Thinning	:5 550 387
Cutting costs (SEK)	
- Final felling	:6 235 153
- Thinning	:3 754 083
Net incomes (SEK)	
- Final felling	:20 964 489
- Thinning	:1 796 304
- Total	:22 760 793
Net income, SEK per m^3	
- Final felling	:234
- Thinning	:73
- Total	:199

The following 68 compartments are suggested for final felling during the next five-year period, in order of priority:

414, 3107, 3117, 3102, 258, 264, 523, 585, 671, 269, 483, 3101, 3110, 3112, 710, 3104, 424, 177, 350, 63, 296, 713, 7713, 32, 306, 3118, 558, 334, 686, 1171, 503, 270, 967, 370, 354, 566, 381, 3120, 71150, 1150, 297, 550, 236, 674, 957, 502, 3113, 448, 189, 591, 295, 551, 15, 518, 1061, 39, 275, 9036, 369, 7369, 428, 587, 714, 7696, 582, 7185, 7736, 71049.

The following 198 compartments are suggested for thinning, in order of priority:

4100, 11052, 921, 4360, 21, 1093, 1194, 4390, 120, 149, 153, 151, 1081, 96, 277, 388, 4110, 1067, 1085, 4540,1042, 1055, 1109, 1103, 1193, 1185, 11056, 909, 238, 182, 731, 1177, 4430, 665, 175, 1026, 538, 1074, 651, 531, 1064, 1044, 655, 84, 1616, 403, 960, 1164, 119, 82, 959, 681, 400, 243, 11061, 586, 471, 1183, 906, 161, 4020, 556, 646, 24, 1160, 980, 978, 954, 320, 956, 131, 4190 , 883, 252, 910, 1091, 1170, 1162, 1071, 873, 348, 1611, 339, 1111, 1113, 395, 107, 28, 218, 211, 434, 308, 326, 1617, 644, 1608, 1703, 1070, 485, 440, 533, 467, 67891, 198, 76, 11043, 737, 1094, 254, 525, 242, 299, 1173, 287, 511,512, 156, 966, 4480, 205, 1712, 422, 642, 4490, 992, 1068, 137, 186, 1154, 34, 903, 30, 279, 4420, 1602, 103, 1180, 356, 1708, 1097, 33, 335, 505, 1610, 746, 1062, 284, 1037, 11114, 109, 963, 1057, 282, 1084, 273, 11051, 875, 1028, 1029, 552, 73, 142, 4030, 208, 396, 57, 430, 407, 430, 371, 534, 4530, 26, 139, 314, 346, 1072, 672, 988, 1058, 351, 17, 1165, 977, 4120, 360, 71, 1038, 955, 1089, 192, 496, 219, 183, 1604, 888, 950, 333, 11042, 11068

10.8 Thinning from above

In the tactical planning, the priority functions from the strategic planning are used when selecting the set of compartments for treatment. We have also taken in consideration the nature conservation perspective and the spatial distribution of the cuttings.

List of five years' amount (five years' coupe)

Area (ha)		
-Total	:	3 491
-Final felling	:	226
-Thinning	:	836
-No treatment	:	2429
Volume (m3sk)		
-Initial volume	:	544 540
-Final felling	:	63 606
-Thinning	:	35 896
-Final volume	:	445 038
Gross income (SEK)		
-Final felling	:	8 514 538
-Thinning	:	18 318 733
Net income (SEK)		
-Final felling	:	14 031 045
-Thinning	:	1 092 325
-Total	:	15 123 370

10.9 Normal price list with 2.5 % interest rate

This treatment program is based on the normal price list for 1997 and with an interest rate of 2.5 %. In the strategic planning in-optimality losses are calculated for each sampled compartment, for thinning, for clear-cutting and for "doing nothing". The in-optimality losses are described as functions of stand data, which implies that they can be applied on all compartments, thus providing a priority system for the tactical planning. A geographical information system has also been used as a tool for the tactical planning. Besides the effort to keep the in-optimality losses as low as possible, also natural conservation values have been taken into account. For example, compartments with a great proportion of broad-leave trees (birch excepted) have not been selected for harvest. Also, some compartments are set aside from harvesting because they have the maturity class E. This class includes forests that for different reasons are low productive, sparsely stocked or have high nature values. For example, the land may historically have been used for pasture or farming and is nowadays dominated by broad-leaved species. Usually, forests of this type have a high nature conservation value. Another aspect for the tactical planning has been the allocation of harvesting operation equipment. Due to the cost of moving equipment and personal, harvesting is not proposed for small isolated compartments.

List of five years' amount (five years' coupe)

Area (ha)
- Total (prod.): 3491
- Final cut: 291
- Thinning: 431
- No treatment: 2786

Volume (m3sk)
- Initial: 544 540
- Final felling: 83 316
- Thinning: 17 774
- Final: 537 981

Gross income (SEK)
- Final cutting: 24 014 166
- Thinning: 3 572 413

Harvesting costs (SEK)
- Final cutting: 5 696 062
- Thinning: 2 498 029

Harvesting net income (SEK)
- Final cutting: 18 318 054
- Thinning: 1 074 384

Harvesting net income per cubic meter (SEK per m^3)
- Final cutting: 291
- Thinning: 60

The following 70 compartments are recommended for final felling the next five-year period, in order of priority:

3102, 3104, 3107, 671, 3110, 585, 11030, 3112, 414, 258, 264, 713, 7713, 269, 523, 177, 12013, 3101, 654, 51, 63, 686, 573, 11017, 202, 350, 3108, 296, 334, 270, 32, 370, 558, 354, 483, 591, 874, 566, 710, 933, 702, 381, 895, 550, 855, 696, 7696, 369, 7369, 10, 15, 236, 685, 306, 674, 1150, 71150, 587, 1619, 189, 957, 1171, 428, 11053, 461, 551, 703, 12035, 11060, 518

The following 154 compartments are recommended for thinning the next five-year period, in order of priority:

4100, 3114, 3116, 2580, 4110, 371, 4360, 3119, 4540, 661, 4390, 950, 1032, 277, 4030, 642, 115, 479, 3105, 351, 1064, 5, 353, 1113, 175, 1180, 68, 1509, 4430, 1712, 425, 1095, 537, 2551, 4490, 219, 356, 403, 21, 4190, 826, 216, 4020, 24, 1122, 955, 1073, 1055, 718, 437, 1060, 96, 935, 921, 131, 736, 7736, 2090, 1097, 4530, 1015, 2011, 1708, 28, 1069, 1042, 413, 345, 956, 1038, 1061, 1165, 549, 932, 1037, 1044, 400, 963, 2080, 1187, 1154, 401, 395, 11069, 210,931, 481, 844,31, 4400, 1070, 1072, 1177, 1058, 432, 315, 2511, 4420, 692, 2040, 707, 672, 82, 436, 11054, 2560, 422, 1020, 839, 156, 1081, 1094, 673, 1183, 493, 516, 333, 677, 2510, 76, 4361, 14, 419, 182, 1023, 2070, 1021, 691, 669, 579, 1103, 4120, 1093, 689, 644, 966, 659, 348, 1194, 346, 1059, 4460, 4480, 1085, 1057, 525, 99, 2570, 2570, 2020, 218, 1185, 379, 4500

Final fellings in the first 5 yr period in the case of 2.5% interest rate and normal timber prices

Final fellings in the first 5 yr period in the case of 2.5% interest rate and normal timber prices

0 1 2 Kilometers

N

Thinnings in the first 5 yr period in the case
of 2.5% interest rate and normal timber prices

Thinnings in the first 5 yr period in the case
of 2.5% interest rate and normal timber prices

0 1 2 Kilometers

N

Serien Arbetsrapporter utges i första hand för institutionens eget behov av viss dokumentation. Rapporterna är indelade i följande grupper: Riksskogstaxeringen, Planering och inventering, Biometri, Fjärranalys, Kompendier och undervisningsmaterial, Examensarbeten samt Internationellt. Författarna svarar själva för rapporternas vetenskapliga innehåll.

Riksskogstaxeringen:

1995 1 Kempe, G. Hjälpmedel för bestämning av slutenhet i plant- och ungskog. ISRN SLU-SRG-AR--1--SE

2 Riksskogstaxeringen och Ståndortskarteringen vid regional miljöövervakning. - metoder för att förbättra upplösningen vid inventering i skogliga avrinningsområden. ISRN SLU-SRG-AR--2--SE.

1997 23 Lundström, A., Nilsson, P. & Ståhl, G. Certifieringens konsekvenser för möjliga uttag av industri- och energived. - En pilotstudie. ISRN SLU-SRG-AR--23--SE.

24 Fridman, J. & Walheim, M. Död ved i Sverige. - Statistik från Riksskogstaxeringen. ISRN SLU-SRG-AR--24--SE.

1998 30 Fridman, J., Kihlblom, D. & Söderberg, U. Förslag till miljöindexsystem för naturtypen skog. ISRN SLU-SRG-AR--30--SE.

34 Löfgren, P. Skogsmark, samt träd- och buskmark inom fjällområdet. En skattning av arealer enligt internationella ägoslagsdefinitioner. ISRN SLU-SRG-AR--34--SE.

37 Odell, G. & Ståhl, G. Vegetationsförändringar i svensk skogsmark mellan 1980- och 90-talet. -En studie grundad på Ståndortskarteringen. ISRN SLU-SRG-AR--37--SE.

38 Lind, T. Quantifying the area of edge zones in Swedish forest to assess the impact of nature conservation on timber yields. ISRN SLU-SRG-AR--38--SE.

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1995 3 Holmgren, P. & Thuresson, T. Skoglig planering på amerikanska västkusten - intryck från en studieresa till Oregon, Washington och British Columbia 1-14 augusti 1995. ISRN SLU-SRG-AR--3--SE.

4 Ståhl, G. The Transect Relascope - An Instrument for the Quantification of Coarse Woody Debris. ISRN SLU-SRG-AR--4--SE.

1996 15 van Kerkvoorde, M. A sequential approach in mathematical programming to include spatial aspects of biodiversity in long range forest management planning. ISRN SLU-SRG-AR--15--SE.

1997 18 Christoffersson, P & Jonsson, P. Avdelningsfri inventering - tillvägagångssätt och tidsåtgång. ISRN SLU-SRG-AR--18--SE.

7 Henriksson, L. The thinning quotient - a relevant description of a thinning? Gallringskvot - en tillförlitlig beskrivning av en gallring? Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--7--SE.

8 Ranvald, C. Sortimentsinriktad avverkning. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--8--SE.

9 Olofsson, C. Mångbruk i ett landskapsperspektiv - En fallstudie på MoDo Skog AB, Örnsköldsviks förvaltning. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--9--SE.

10 Andersson, H. Taper curve functions and quality estimation for Common Oak (Quercus Robur L.) in Sweden. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--10--SE.

11 Djurberg, H. Den skogliga informationens roll i ett kundanpassat virkesflöde. - En bakgrundsstudie samt simulering av inventeringsmetoders inverkan på noggrannhet i leveransprognoser till sågverk. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--11--SE.

12 Bredberg, J. Skattning av ålder och andra beståndsvariabler - en fallstudie baserad på MoDo:s indelningsrutiner. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--12--SE.

13 Gunnarsson, F. On the potential of Kriging for forest management planning. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--13--SE.

16 Tormalm, K. Implementering av FSC-certifiering av mindre enskilda markägares skogsbruk. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--16--SE.

1997 17 Engberg, M. Naturvärden i skog lämnad vid slutavverkning. - En inventering av upp till 35 år gamla föryngringsytor på Sundsvalls arbetsområde, SCA. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN-SRG-AR--17--SE.

20 Cedervind, J. GPS under krontak i skog. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--20--SE.

27 Karlsson, A. En studie av tre inventeringsmetoder i slutavverkningsbestånd. Examensarbete. ISRN SLU-SRG-AR--27--SE.

1998 31 Bendz, J. SÖDRAs gröna skogsbruksplaner. En uppföljning relaterad till SÖDRAs miljömål, FSC's kriterier och svensk skogspolitik. Examensarbete. ISRN SLU-SRG-AR--31--SE.

33 Jonsson, Ö. Trädskikt och ståndortsförhållanden i strandskog. - En studie av tre bäckar i Västerbotten. Examensarbete. ISRN SLU-SRG-AR--33--SE.

35 Claesson, S. Thinning response functions for single trees of Common oak (Quercus Robur L.) Examensarbete. ISRN SLU-SRG-AR--35--SE.

19 Ståhl, G., Ringvall, A. & Lämås, T. Guided transect sampling - An outline of the principle. ISRN SLU-SRG-AR--19--SE.

25 Lämås, T. & Ståhl, G. Skattning av tillstånd och förändringar genom inventerings simulering - En handledning till programpaketet "NVSIM". ISRN SLU-SRG-AR--25--SE

26 Lämås, T. & Ståhl, G. Om dektektering av förändringar av populationer i begränsade områden. ISRN SLU-SRG-AR--26--SE

Biometri:

1997 22 Ali, Abdul Aziz. Describing Tree Size Diversity. ISRN SLU-SRG-AR--22--SE.

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1997 28. Hagner, O. Satellitfjärranalys för skogsföretag. ISRN SLU-SRG-AR--28--SE.

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Kompendier och undervisningsmaterial:

1996 14 Holm, S. & Thuresson, T. samt jägm.studenter kurs 92/96. En analys av skogstillståndet samt några alternativa avverkningsberäkningar för en del av Östads säteri. ISRN SLU-SRG-AR--14--SE.

21 Holm, S. & Thuresson, T. samt jägm.studenter kurs 93/97. En analys av skogstillståndet samt några alternativa avverkningsberäkningar för en stor del av Östads säteri. ISRN SLU-SRG-AR--21--SE.

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1995 5 Törnquist, K. Ekologisk landskapsplanering i svenskt skogsbruk - hur började det?. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--5--SE.

1996 6 Persson, S. & Segner, U. Aspekter kring datakvaliténs betydelse för den kortsiktiga planeringen. Examensarbete i ämnet skogsuppskattning och skogsindelning. ISRN SLU-SRG-AR--6--SE.

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1998 40 Persson, M. Skogsmarksindelningen i gröna och blå kartan - en utvärdering med hjälp av riksskogstaxeringens provytor. ISRN SLU-SRG-AR--40--SE.

41 Eriksson, F. Markbaserade sensorer för insamling av skogliga data - en förstudie. ISRN SLU-SRG-AR--41--SE.

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1998 39 Sandewall, M ., Ohlsson, B & Sandewall, R.K. People´s options on forest land use. - a research study of land use dynamics and socio-economic conditions in a historical perspective in the Upper Nam Nan Water Catchment Area, Lao PDR. ISRN SLU-SRG-AR--39--SE.