Proceedings of the S4.04 Meetings on Forest Management Planning and Managerial Economics

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Virginia Polytechnic Institute and State University
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compiled by
W. David Klemperer

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PREFACE

This volume contains papers presented on August 11, 1995 at two sessions of Subject Group S4.04-00, "Forest Management Planning and Managerial Economics," at the 20th World Congress of the International Union of Forestry Research Organizations held in Tampere, Finland. Papers are in the order they were presented at the meetings and are reproduced in the camera-ready format as submitted by the authors.

I appreciate the organizational assistance of Division 4 Coordinator Axel Roeder and Subject Group S4.04-00 Leader Othmar Griess. We will miss the able leadership of Othmar Griess, who is stepping down after 13 productive years with our group. His parting comments appear below. Most of all, I appreciate the authors' efforts in preparing these excellent papers which made our meetings such a success.

W. David Klemperer
Chairman, S4.04-04
Virginia Polytechnic Institute & State University
Department of Forestry

MEMORANDUM

TO: Members of IUFRO Subject Group S4.04-00, Forest Management Planning and Managerial Economics

FROM: Othmar Griess

SUBJECT: IUFRO Congress and Farewell

DATE: August 20, 1995

The doors of the 20th IUFRO World Congress have now closed. It was an impressive event with many papers from around the world. The Subject Group S4.04-00 contributed 23 invited papers and 13 voluntary papers, held 9 meetings (including 2 business meetings), and about 150 colleagues participated. Three sessions were organized by S4.04-00, Forest Management Planning and Managerial Economics (O. Griess. Leader) and 4 sessions by S4.04-02, Accounting and Finance in Forestry and Timber Industries (H. Jöbstl, Leader).

My very special thanks to Dave Klemperer for publishing the proceedings of the S4.04-00 meetings.

In closing, during the presentation and discussion of the papers, I was impressed with the range of problems in the different regions of the world. We face widely varying questions in areas of data accuracy, sustainability, and applications of new technology. Because my duties as leader of S4.04-00 will close at the end of 1995. I have prepared the following report on my 13 year tenure and on possible future directions for our group.

Summary of my Tenure with S4.04-00

Since "Forsteinrichtung" -- the original term, or the loose English translation, "Forest Management Planning" -- was developed 200 years ago in Central Europe, the work of S4.04-00 was initially limited to Europe. From the start, Managerial Economics was closely linked with Forest Management Planning because forestry planning in the field is impossible without economic thinking.

When I was elected as leader of S4.04-00 in 1983, I started spreading the philosophy of "Forsteinrichtung" and related aspects of managerial economics in regions where sustainability is a concern. We have thus had meetings not only in Europe, but also in the Middle and Far East and on the American Continent.

As mentioned, "Forsteinrichtung" has a long tradition and is highly developed, but this does not obviate the need for future research. During the last 13 years, much of the work of S4.04-00 has involved modern computer-based inventory and planning systems including remote sensing, geographic information systems, and operations research applications as well as applied economic theory. Recent public interest in non-timber values has led us to address questions of environmental damage and evaluation of non-market outputs from forests.

Future Directions

Two major research directions which I feel belong under the umbrella of S4.04-00 are as follows:

First, we need closer contact with developing countries which are in transition from forest exploitation to forest management. We can play a crucial role in helping these countries adapt modern techniques of mapping, inventory, and planning to their special circumstances. In this context we need to think about expanded definitions of "sustainability" to meet the needs of all societies.

Second, our group should consider ways to adapt modern management planning techniques to develop more ecologically sensitive forestry which includes uneven-aged mixed stands and more effectively addresses problems of environmental damage, tourism, economic development, and non-timber outputs.

Non-industrial private forest landowners' choices of timber management strategies and potential allowable cut: Case of Finland

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ABSTRACT

In the study, the potential allowable cut in Finland - based on the non-industrial private forest landowners' (NIPF) landowners' choices of timber management strategies - was clarified. The choices of timber management strategies were solved by maximizing the utility functions of the NIPF landowners. The parameters of the utility functions were estimated using the Analytic Hierarchy Process (AHP).

The potential allowable cut defined in the study was 19% higher than the average of the realized drain during the years 1989-1994. Respectively, the potential allowable cut defined in the study was 13% lower than the NFI8-based greatest sustained allowable cut for the 1990s. Using the method presented in this study, based on the choices of timber managemet strategies, regular cutting budgets can be calculated more realistically than before.

Keywords: Analytic Hierarchy Process, non-industrial private forest landowner, potential allowable cut, timber management strategy, utility function.

1. INTRODUCTION

1.1 The sustained allowable cut in Finland

The roundwood removals from non-industrial private forests NIPF) in Finland have been 75-85% of the total roundwood removals during last ten years (Aarne 1993). Thus, the timber supply from NIPF lands is important for Finland's forest-based industries.

Generally, the regional allowable cut has been viewed on the basis of the inventory data provided by National Forest Inventories (NFI) and the cutting budgets derived by combining private forestry plans. Two major weaknesses that relate to the cutting budgets based on NFI data, are: 1) Both regional and national cutting budgets have been calculated assuming that all the country's forests are treated as a single forestry unit and 2) the variability with goals of NIPF landowners has been ignored.

Thus, considering the forest resources simply as one entity leads to an overestimation of NFI- based cutting budgets. In fact, the cutting budgets derived by combining private forestry plans can be more than 30% lower than those based on NFI data (FOREST 2000... 1985). On the other hand, forestry plans made for NIPF holdings are often deliberate underestimations of the actual cutting potential; the cutting budgets presented in private forestry plans can be nearly 20% smaller than the actual allowable cut based on sustained forestry (Pesonen & Räsänen 1993).

1.2 The strategic decisions in the management of non-industrial private forests

Strategic planning operates on the future production possibilities; the starting point of which is the convertability of the factors of production and their allocation (e.g. Kast & Rosenzweig 1974). When applied to NIPF management planning, the strategic view includes the production of alternative, strategic-level programmes for timber production and silviculture. Timber management covers a range of strategies from no cuttings at all to maximum cuttings within the limits of timber production possibilities. For instance, timber management strategies can be described by the intensity and the recurrence of cuttings.

Most NIPF landowners have long term perspectives and strategic views concerning forest management (Lönnsted 1989). It is important to understand the strategic decisions of NIPF landowners for several reasons: e.g. 1) when predicting of the timber supply from private forests for future investments by forest industries (Lönnstedt & Roos 1993), and 2) when planning the governmental forest policy in general.

In Finland, present-day NIPF management planning is basically tactical. Landowners lack information about the actual, strategic-level decision alternatives and their consequences. Furthermore, decision analysis; that is, giving recommendations about decisions and making decisions are often separated in planning. The importance of planning in the production of decision alternatives, and in defining landowners' preferences, is often ignored. Sometimes the presentation of even a single timber production program has been called planning (Kangas & Pukkala 1992). Due in part to the growing interest shown in the non-economic uses of forest property, there is an apparent need to include strategic aspects in NIPF management planning.

While strategic forest management planning is lacking in private forestry of Finland, landowners tend to underestimate their allowable cut. Furthermore, forestry plans are usually underestimates compared to the sustained allowable cut of forest holdings (Pesonen & Räsänen 1993). Moreover, 60% of the landowners have actually harvested even less than the cutting budget presented in forestry plans (Pesonen et al. 1994a).

Many studies on strategic forest management planning (e.g Wardle 1965, Kilkki 1968, Ware & Clutter 1971, Kangas & Pukkala 1992) have been done and several tools (Siitonen 1983, Johnson et al. 1986, Jonsson et al. 1993, Pukkala & Kangas 1993) have been developed for strategic forest management planning. However, few studies have been made concerning the regional cutting budgets derived from the strategic goals of NIPF landowners. Lönnstedt & Roos (1993) concluded that the cutting potential based on the objectives of NIPF landowners ensures an adequate supply of wood raw material for future investments by Sweden's forest-based industries.

1.3 Modelling the strategic decision making of NIPF landowners

Modelling the strategic decision making of NIPF landowners, like any other attempt at modelling human behaviour, is a complex and multidimensional task. Few studies have been made on the strategic decisions of NIPF management (Lönnstedt & Törnqvist 1990, Hansson et al. 1990, Pukkala & Kangas 1993) and the factors affecting these decisions have been, have received little attention.

One of the methods used in decision analysis is the Analytic Hierarchy Process (AHP). Recently, the AHP has been applied to several kinds of decision situations. Moreover, there have been studies on the applications of the AHP to forest management planning (Mendoza & Sprouse 1989, Kangas 1992, Kangas & Pukkala 1992).

The Analytic Hierarchy Process is a mathematical method for analysing complex decision problems with multiple criteria (Saaty 1977, 1980). Basically, the AHP is a general theory based on certain mathematical and psychological foundations. In the AHP, a hierarchial decision schema is constructed by decomposing the decision problem in question into decisions elements: goals, objectives, attributes and decision alternatives. The importances or preferences of the decision elements are compared in a pairwise manner with regard to the element preceding them in the hierarchy (Kangas 1992). In this study, the AHP was used to determine the NIPF landowners' choices of preferred timber management strategies.

1.4 The aims of the study

The aims of this study are to 1) produce alternative timber management strategies for the NIPF landowners, 2) find out their choices of alternative timber management strategies, and finally, 3) based on landowners' choices of timber management strategies, calculate the potential allowable cut from non-industrial private forests in the district of Pohjois-Savo. The potential allowable cut is calculated with TASO- and NFI-data to show, how reliable is to generate regional allowable cut with TASO-data.

In this study, *timber management strategy* is defined as an alternative for a NIPF landowner in the utilisation of his/her forest property and *potential allowable cut* means the regional cutting budget calculated for particular forestry area, and derived from the landowner's choices of timber management strategies.

The choices of timber management strategies are solved by maximizing the utility functions of NIPF landowners. The parameters of the utility function are estimated with the AHP. The potential allowable cut is derived from the NIPF landowners' choices of timber management strategies, and it is compared a) to the cutting budgets based on NFI7 and NFI8, b) to the combining of NIPF management plans, and c) to the realized cuttings from NIPF lands. The potential allowable cut is calculated using the same MELA system (Siitonen 1983) as has been used in the calculation of national cutting budgets. The frame of reference of this study is presented in Fig. 1.

Figure 1.....

2 THE UTILITY FUNCTION AND TIMBER MANAGEMENT STRATEGIES

2.1 Estimation of the utility function's parameters using Analytic Hierarchy Process

According to a generally accepted economic theory, rational decision-makers (such as forest owners) are supposed to maximize their utility when they make decisions (eg. Hirshcleifer 1984). In the theoretical utility approach, the preferences of a decision-maker are often modelled as a function called the utility function. Utility theory has been further developed to solve decision problems with multiple objectives in complex decision situations, i.e. the Multi-Attribute Utility Theory (e.g. von Winterfeldt & Edwards 1988, Kangas 1992, Mykkänen 1994).

The linear and additive utility function applied in this study, has been the one most commonly used. It is also considered to be the easiest to interpret (Pukkala & Kangas 1993). In the formulation of the utility function for determining the choice of timber management strategy, the overall utility obtained from the use of forest property consisted of the utility obtained from the economic and the non-economic benefits of the forest property. In this study, the *economic benefits* consisted of the utility of timber production and the *non-economic benefits* of other benefits. Therefore, the form of the additive utility function (Pesonen 1995) was (1)

$$\max\ U = a_1 u_{econ}\ (S_j)\ Z a_2 u_{non}\ (S_j) \qquad (1)$$

where

U	is the total utility obtained from the use of the forest property (i.e. the utility from the preferred timber management strategy)
$u_{econ}\ (S_j)$	is the utility obtained from the economic benefits of the preferred timber management strategy
$u_{non}\ (S_j)$	is the utility obtained from the non-economic benefits of the preferred timber management strategy
S_j	is the preferred timber management strategy
j	is the number of timber management strategy
$a_1,\ a_2$	are parameters describing the importance of the respective criterion

The parameters a_1, and a_2 of the utility function (1) were solved using the AHP.

2.2 The definition of timber management strategies

In order to solve the parameters of the utility function (1), five alternative timber management strategies were computed using the MELA system. MELA is a Finnish LP-based system for long-term timber management planning (Kilkki & Siitonen 1976, Siitonen 1983, 1993). The strategies were described for each landowner with the objective and constraint variables derived from the MELA parameters (Fig. 2). The planning period was 20 years, divided into four 5-year intervals. In the calculations, the forest-holding level development of several forest characteristics was described and illustrated for the landowners.

Figure 2....

Each landowner was provided with five alternative timber management strategies covering a planning period of 20 years. In principle, the main differences between the strategies can be described in terms of intensity and the recurrence of removals. The objective variable used in optimisations was the maximisation of the stumpage earnings for the first planning period (the constraints for each strategy are presented below). The applied timber management strategies were as follows:

S_1 "NO CUTTINGS"
- removals set to zero

S_2 "SAVING"
- removals set to half of the removals under condition "SUSTAINABILITY"

S_3 "SUSTAINABILITY"
- even flow of removals over the planning period
- even flow of stumpage earnings over the planning period
- even amount of clearcut areas over the planning period
- volume of sawtimber equal to, or greater, than at the beginning of period
- market value of growing stock at the end of planning period at least the same as at the beginning

S_4 "FINANCE"
- even flow of removals during the first two planning periods
- market value of the growing stock at the end of planning period at least the same as at the beginning

S_5 "MAX CUTTINGS"

- even flow of removals during the last three planning periods

The NIPF landowners were asked to prioritise the timber management strategies according to their personal goals and preferences for forest use. First, the NIPF landowners were asked to compare the importance of the economic and non-economic benefits of the use of their forest holdings. Second, pairwise comparisons were made between the management strategies, considering the economic and the non-economic benefits separately (Fig. 3). The AHP process resulted in the relative priorities for each strategy being scaled 0-1. For each landowner, the strategy with the highest global priority (i.e., one that maximises the overall benefit) thus represented the most preferred alternative.

Figure 3....

3 MATERIAL

The basic data consisted of non-industrial private forest holdings in southern Finland that had a forestry plan made during the years 1989-1993. The data were collected from the TASO planning system, which has been the system of forest management planning for non-industrial private forestry since 1987 (Ranta 1991). The basic material consisted of 66 706 forest holdings with a total forest area of 2 882 114 ha and an average holding size of 43.2 ha (Table 1a). According to the official register on Finnish farm holdings, the forest area in southern Finland was 8 466 100 ha (Table 1b). In the basic data small forest holdings were under-estimated and large forest holdings were over-estimated.

Table 1a-1d.....

The forest holdings were divided into four groups according to their forest area: 5-19.9, 20-49.9, 50-99.9 and over 100 hectares. Stratified sampling was made according to the sizes of the forest holdings, so that the number of holdings in each sample group was determined by assigning a 4% maximum standard error in the initial volume (m^3/ha) within the groups. The sample consisted of 4105 forest holdings with a total forest area 214 662 ha and an average holding size of 52.3 ha.

After sampling, background information on NIPF landowners, their forest property and forestry goals were collected in a two-phase mail inquiry. The two-phase inquiry was necessary because the landowners had to be asked in advance for their permission to use the data from their forestry plans. In the first inquiry, the landowners were asked some questions about their ownership characteristics, economy and educational background.

For the second inquiry, calculations were made and presented for each landowner about their timber management strategies and their choices of forest taxation basis. In the second inquiry, 1367 acceptable answers were received representing an average holding size of 57.2 ha (Table 1d), which was larger than the average of the entire population. The selection of material during the different phases of the study resulted in a situation where small holdings (under 20 ha and 20-50 ha) were underrepresented and large holdings (over 100 ha) overrepresented when compared to the corresponding proportions in the Official Register of Finnish Farms(Table 1b). There are least two reasons causing this bias: 1) the forest holdings with forestry plan were generally above-average in size, and 2) presumably, landowners with large forest holdings were more interested in participating the study. Due to this bias, all the results (distribution of choices of timber management strategies, potential allowable cut) were weighted with the area group distribution of the Official Record of Finnish Farms (Pihljerta 1994).

The reference material for the calculations consisted of the cutting budgets calculated on the basis of sample plot data provided by NFI8 (hereafter referred as the NFI data). The same timber management strategies were calculated for the NFI data, and the results were then compared to those of the TASO data. In the calculations of the potential allowable cut from NIPF lands, it was assumed that the timber management strategies based on the NFI data would represent the areal proportion of the choice of each strategy in the TASO-data. Main characteristics of the sample are presented in Table 2.

Table 2....

The growth and removals of both TASO- and NFI-data were updated to the beginning of the year 1994. Without updating the data sets, the comparison of information on the forest resources and timber management strategies would have been difficult because the TASO data originated from the years 1989-1993 and the NFI data from 1990. In addition, updating the data enables the use of materials that are as recent as possible. Updating was done using the MELA system. The constraints used in the optimisations were annual removals based on statistics according to timber assortments, and the harvest areas according to harvesting methods.

After updating growth and removals, the initial volume of the growing stock, (an average of the sample holdings) was 120.6 m^3/ha and in the NFI data 122.0 m^3/ha(Table 3). The mean initial volumes of both the TASO and NFI data sets were very close to each other. The TASO data included more pine and spruce but, less birch than the NFI data. Furthermore, there were more sawtimber, in the NFI data than in the TASO data.

Table 3...

4 THE POTENTIAL ALLOWABLE CUT

In the maximisation of the utility function (1), the most preferred strategy obtained was "sustainability" (chosen by 61% of landowners). The second in preference was "finance" (17%) and the third was "saving" (14%). "No cuttings" and "maximum cuttings" were the least preferred (4 % and 4%, resp.). When presented according to the number of landowners, the distributions of the most preferred strategies were slightly different than when compared to the forest area represented by each strategy (Fig. 4).

Figure 4....

Timber management strategies were compared at regional level assuming that all landowners would follow the same strategy. Comparison were made for both the TASO and the NFI data sets in order to verify the reliability of the TASO data in southern Finland. The average removals in both data sets were compared over the entire 20-year planning period.

In the sustainability strategy, the average harvest rate in the NFI data was 1.2% higher compared to the TASO data (Table 4a). In the "saving" strategy, the average harvest was, by definition, approximately half of the removals of the "sustainability" strategy. In the "finance" strategy, the average removals were smaller than in the "sustainability" strategy. With the "finance" strategy, the removals in the TASO data were 6.9% greater than those in the NFI data.

Table 4a-4c....

When assuming that all landowners would choose the "max cuttings" strategy, the average removals were considerably greater in the TASO data than in the NFI data. However, the difference had only a small effect on the potential allowable cut, since only 4.0% of the landowners had chosen the "max cuttings" strategy. The greatest cumulative removals were obtained in the TASO data with the "max cuttings" choice, and in the NFI data when choosing "sustainability" (Table 4 b). The results of northern Finland were presented only with NFI data, because the mail inquiry was enquired in southern Finland (Table 4 c).

As a generalisation of the results for the whole district of Finland, the potential allowable cut of the 20-year planning period was 46.5 mill. m^3/a for the TASO data and 46.3 mill. m^3/a for the NFI data (Fig. 5). During the first half of the planning period, the removals were heavier due to the accumulation of removals in the "max cuttings" and "finance" strategies. The proportion of sawtimber in the removals was somewhat higher in the TASO data than in the NFI data.

Figure 5....

In both data sets, the mean volume increased towards the end of the planning period (Fig. 6). In addition, the mean volume in the TASO data was a little higher, particularly concerning the proportion of sawtimber. This was due to the higher level of growth observed in the TASO data when compared to that in the NFI data (Fig. 7).

Figure 6....

Figure 7...

5 DISCUSSION AND CONCLUSIONS

5.1 Comparing the cutting budgets

The potential allowable cut determined in this study was 18.9% higher than the average realized cuttings during the years 1989-1994 (Fig. 8). However, during the recent economic boom, 1994-, the potential allowable cut is at the same level of removals. Compared to the greatest allowable cut (based on sustained yield) of NFI8, the potential allowable cut of this study was 12.7% smaller. Furthermore, the cutting budget based on combining the forestry plans was 12% smaller than the one presented in this study.

Figure 8.....

The differences between the cutting budgets based on combining forestry plans and the potential allowable cut as defined in this study are due to two reasons: the principle of discretion in NIPF planning and the older, NFI7-based growth models used in the TASO planning system. The underestimation of the actual cutting possibilities on sustained yield basis in the TASO forestry plans can be almost 20 % (Pesonen & Räsänen 1993). Forest planning of non-industrial private forests is still based on standwise propositions of treatments made by professional planners. The planners seldom have full knowledge of the sustained cutting possibilities at the forest holding level.

In comparing the NFI8-based, forest-resources oriented cutting budget and the potential allowable cut of this study, two main reasons for the difference can be outlined: ignorance of landowner-specific forestry goals in the former and the constraints caused by the requirement of forest-holding level sustainability in the latter. The fact that the owners of small forest holdings preferred the choices of "no cuttings" and "saving" strategies reduces the potential allowable cut from NIPF lands. The requirement of sustained yield at the forest holding level has been reported to decrease regional cutting possibilities by over 10% (Pesonen & Soimasuo 1994).

5.2 The reliability of the data and methods

The additive utility function, the function form used in this study, is the easiest to interpret (Pukkala & Kangas 1993). In several studies, it has been noticed that the additive utility function produces a utility index which best describes the preferences of the decision-maker (Tell 1976, Laskey & Fischer 1987). It has also been stated that landowners are utility-maximizers who consider both the economic and the non-economic benefits of their forests (Boyd 1984, Hyberg 1987).

Due to its simplicity, effectiveness and ability to deal with qualitative as well as quantitative criteria (this is also indicated by the results of this study) the AHP is well-suited to dealing with problems with forest management planning (e.g. Kangas 1992). When applied to the mail inquirys, the weakest point of the method is the question of whether all respondents are able to concentrate on the numerous comparisons required by the AHP. Therefore, the results would be improved by the application of personal interviews in conjunction with data collection.

The consistency ratios (CR) were slightly higher than was acceptable: 16.8% in economic and 15.2% in non-economic comparisons. This may be partly due to the fact that the inquiries used in the study were made by mail, and all kinds of landowners did tens of AHP comparisons. However, there is no unequivocal upper limit for the level of inconsistency in pairwise comparisons, and moreover, the inconsistency in comparisons can also be due to a conscious choice, and must therefore be accepted (e.g., Wedley 1993, Apostolou & Hassell 1993). It can thus be concluded, after all, that the majority of landowners did understand the differences between the strategies, and they were also consistent with their comparisons.

The AHP method and the use of mail inquiry in data collection limited the alternative choices of strategies to five. In spite of this, the alternative strategies and choices made by the landowners were based on the actual, forest-holding level development of cuttings, income from timber sales and other forest characteristics. Although few landowners chose the extreme alternatives- "no cuttings" or "max cuttings" strategies - these strategies were included in the comparisons in order to describe the whole range of timber production possibilities.

The objectives of the landowners may also vary according to the point of time, and/or region. Lönnstedt & Törnqvist (1990) stated that the choice of timber management strategy is affected by the needs and objectives of both short- and long term perspective. The goal structure of the landowners could have been clarified better. In this study, the landowners were able to compare only five precalculated timber management strategies. It would be possible to ask more specific questions about the objectives of the landowners in the first inquiry, and with that information in mind, calculate the strategies more individually.

The overall differences between the results from the two data sets (TASO and NFI) were small. Based on this study, the material from the standwise inventory is reliable enough to enable the definition of regional cutting possibilities, although considerable measurement errors have been reported in standwise inventories due to personal characteristics of the planners (Laasasenaho & Päivinen 1986).

The study material (the TASO data) was representative in comparison with the reference material (the NFI data) in regard to the forest resource information. No major differences between the data sets were found concerning the mean volumes, proportions of sawtimber and tree species, and age class distributions. The only substantial difference was caused by the greater growth given by the TASO data, which was partly due to the greater proportion of seedling stands in the TASO data compared to the NFI data. In "sustainability", for example, the growth in the TASO data was 14.8% greater during the whole planning period than in the NFI data.

Due to requirement of sustainability at the forest holding level, the removals resulting from the TASO data were smaller and led to the faster volume increase and higher growth rate. One reason for the difference could have been in the fact that in the NFI data, the diameter distribution was constructed using the measured sample trees, while in the TASO data, the diameter distribution was formulated using the theoretical, Weibull-distribution (Kilkki et al. 1989). The reliability of the results could have been further increased by selecting diameter distribution from the NFI data by using the standwise information of the TASO data.

5.3 Conclusions

The potential allowable cut presented in this study appeared to settle in the middle of the realized drain and the greatest allowable cut based on the National Forest Inventory. The results of this study indicate that the landowners' future harvesting intentions will ensure the availability of wood raw material for forest companies. Furthermore, the region's landowners could be activated to practise intensive management and harvesting by demonstrating to them the strategic alternatives in timber management. The results of this study may also help to direct the development of management planning on NIPF lands.

An interesting issue for future research would be to monitor the sample forest holdings - will strategic calculations affect the future harvesting behaviour of the owners? In addition, forestry plans based on the choices of timber management strategies could be made for the sample holdings and then proceed to monitor owner's harvesting behaviour.

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FIGURE CAPTIONS

Figure 1. Theoretical frame of the study.

Figure 2. Alternative timber management strategies described as the development of the removals and the total growing stock during the planning period (an example of calculations for each NIPF landowner, representing a sample case of the forest holdings).

Figure 3. Decision hierarchy for selection of the preferred timber management strategy.

Figure 4. Choices of timber management strategies by number of landowners, and actual forest area represented by each strategy.

Figure 5. Removals according to choices of preferred strategies during each five-year period, and average removals.

Figure 6. Total volume according to planning periods, and average volume during 20 years.

Figure 7. Increment according to time periods, and average increment.

Figure 8. Realized drain, and cutting budgets calculated with alternative methods.

TAB_1A.XLS

Table 1a Distribution of the basic data according to the area of the forest holding.

Size of holding	Forest area	%	Count	%	Average size
5-19.9 ha	291 754	10.1	23 320	35.0	12.5
20 - 49.9 ha	863 727	30.0	26 735	40.1	32.3
50 - 99.9 ha	795 919	27.6	11 598	17.4	68.6
100 - ha	930 714	32.3	5 053	7.6	184.2
Total	2 882 114	100.0	66 706	100.0	43.2

TAB_1B.XLS

Table 1b Forest area distribution of the official register on Finnish farm holdings.

Size of holding	Forest area	%	Count	%
5-19.9 ha	1 483 000	17.5	123 696	50.1
20 - 49.9 ha	2 962 225	35.0	84 635	34.3
50 - 99.9 ha	2 174 325	25.7	28 991	11.7
100 - ha	1 846 550	21.8	9 487	3.8
Total	8 466 100	100.0	246 809	100.0

TAB_1C.XLS

Table 1c. **Distribution of the sampling according to the area of the forest holding.**

Size of holding	Forest area	%	Count	%	Average size
5 - 19.9 ha	16 763	7.8	1 393	33.9	12.0
20 - 49.9 ha	37 281	17.4	1 157	28.2	32.2
50 - 99.9 ha	64 755	30.2	927	22.6	69.9
100- ha	95 863	44.7	628	15.3	152.6
Total	214 662	100.0	4 105	100.0	52.3

TAB_1D.XLS

Table 1d. Distribution of the sampling after mail inquiries according to area of the forest holding.

Size of holding	Forest area	%	Count	%	Average size
5 - 19.9 ha	5 459	7.0	439	32.1	12.4
20 - 49.9 ha	11 660	14.9	358	26.2	32.6
50 - 99.9 ha	21 502	27.5	310	22.7	69.4
100- ha	39 597	50.6	260	19.0	152.3
Total	78 218	100.0	1 367	100.0	57.2

Table 2. Main characteristics of the sample, based on owners' responds.

	Mean	SD
OWNER, %		
Farmer	51.4	
Non-farmer	48.6	
AGE, a	50.9	13.0
FOREST AREA, ha	57.2	58.7
ARABLE LAND	14.6	23.2
PRODUCTION ORIENTATION, %		
Agriculture	11.3	
Agriculture and forestry	41.7	
Forestry	34.5	
Recreation and residence	12.5	
TIMBER PRODUCTION POSSIBILITIES, %		
Good	43.2	
Fairly good	43.4	
Poor	13.4	
FUTURE CUTTINGS, %		
Extensive cuttings	32.0	
Sustainability	55.3	
Intensive cuttings	12.7	

TAB_3.XLS

Table 3. Volume of growing stock (m3/ha) according to tree species in the TASO- and NFI-data.

	TASO	VMI8
Average	120,6	122,0
Scotch pine	47,8	45,4
Norway spruce	58,3	54,4
Hardwood	14,5	22,2
Sawtimber	52,6	54,0

Figure 2.

Forest area: 50.8 ha   Initial growing stock: 5332 m³   Mean initial volume: 105 m³/ha

Average of the realized commercial cuttings during 1988-1992: 347 m³/a.

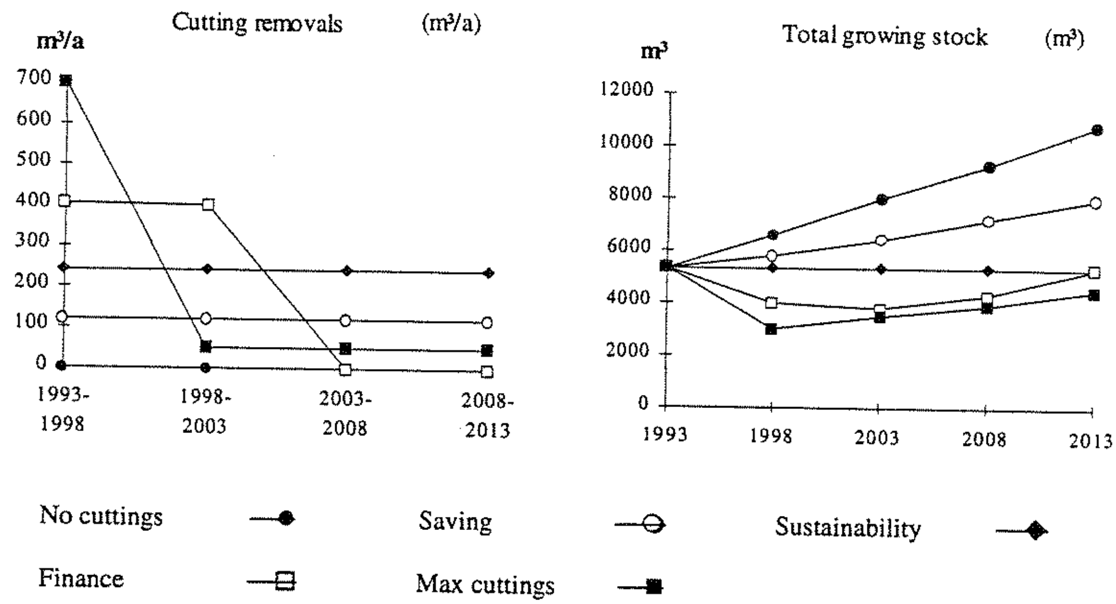


Figure 3.

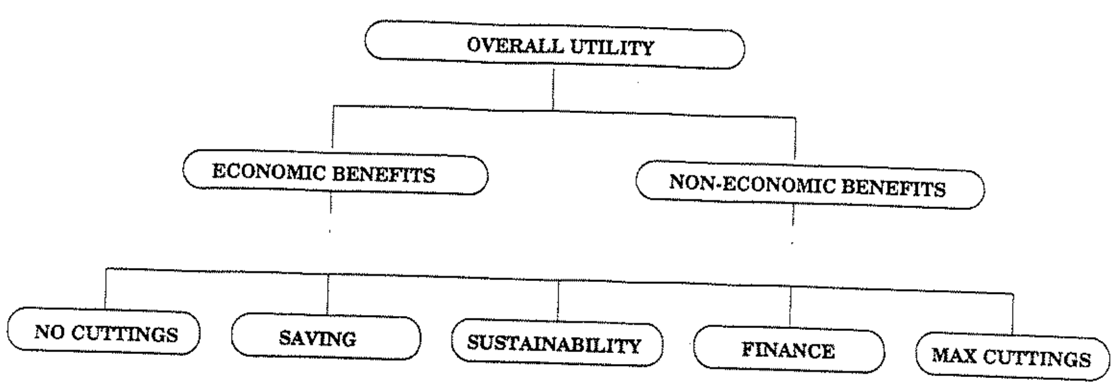


FIG_4.XLS Chart 1

Fig. 4.

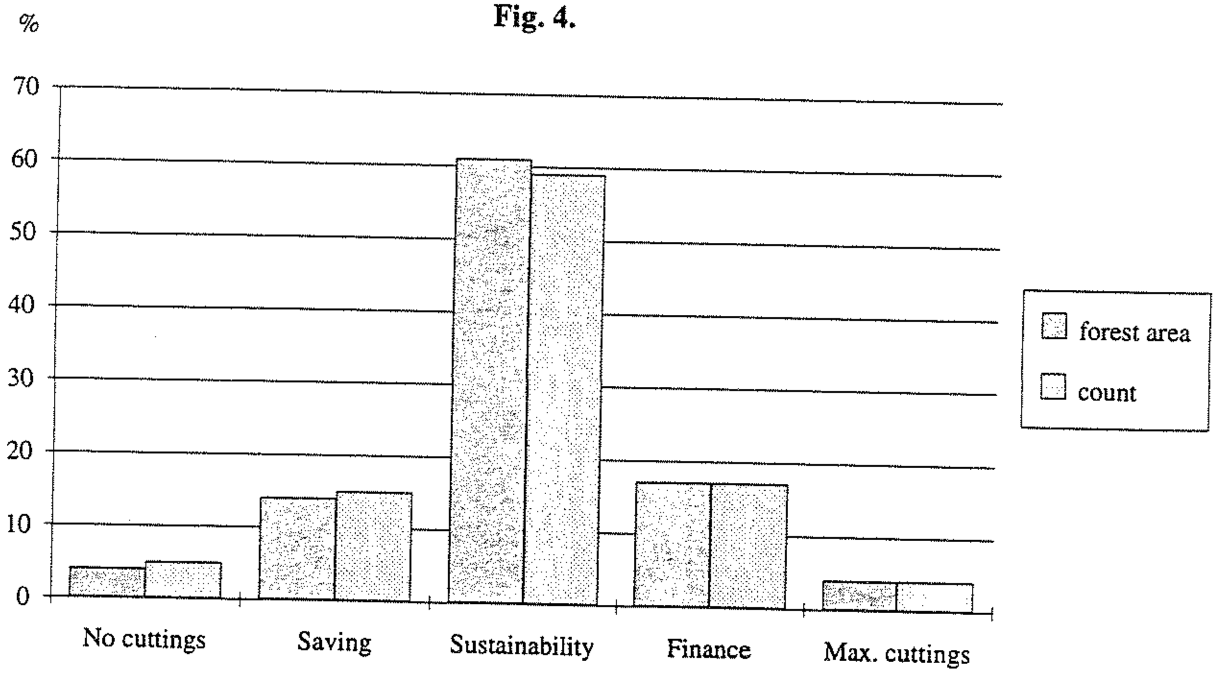


FIG_5.XLS Chart 8

Fig. 5.

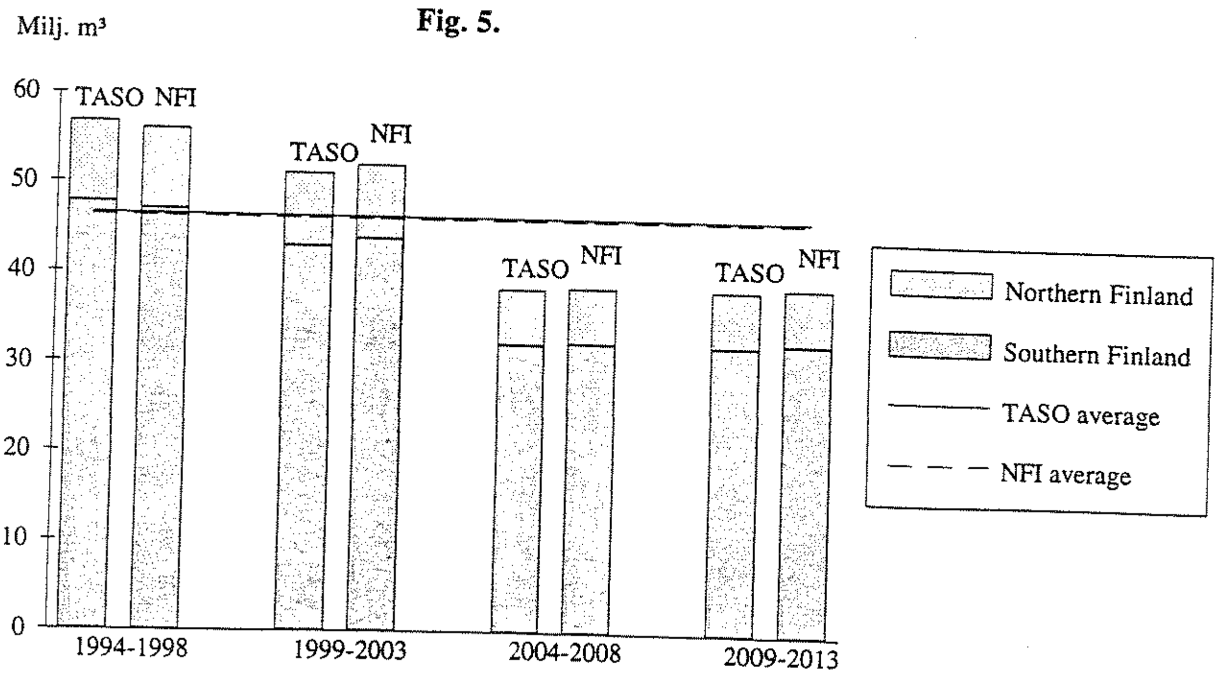


Fig. 6.

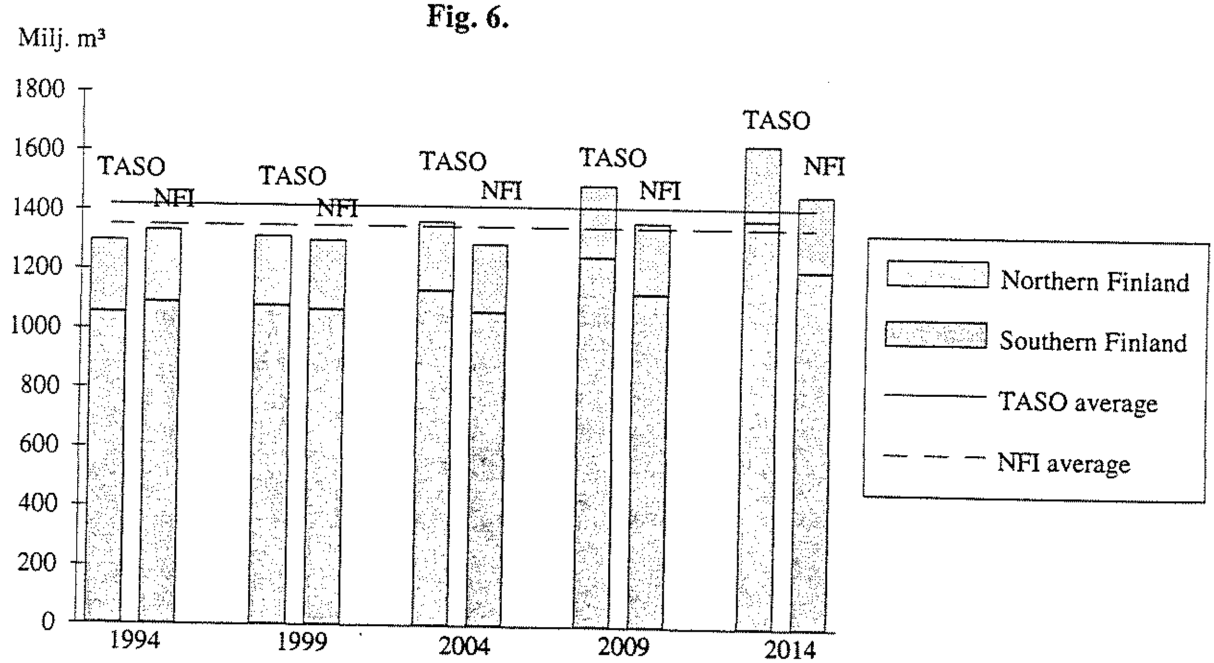
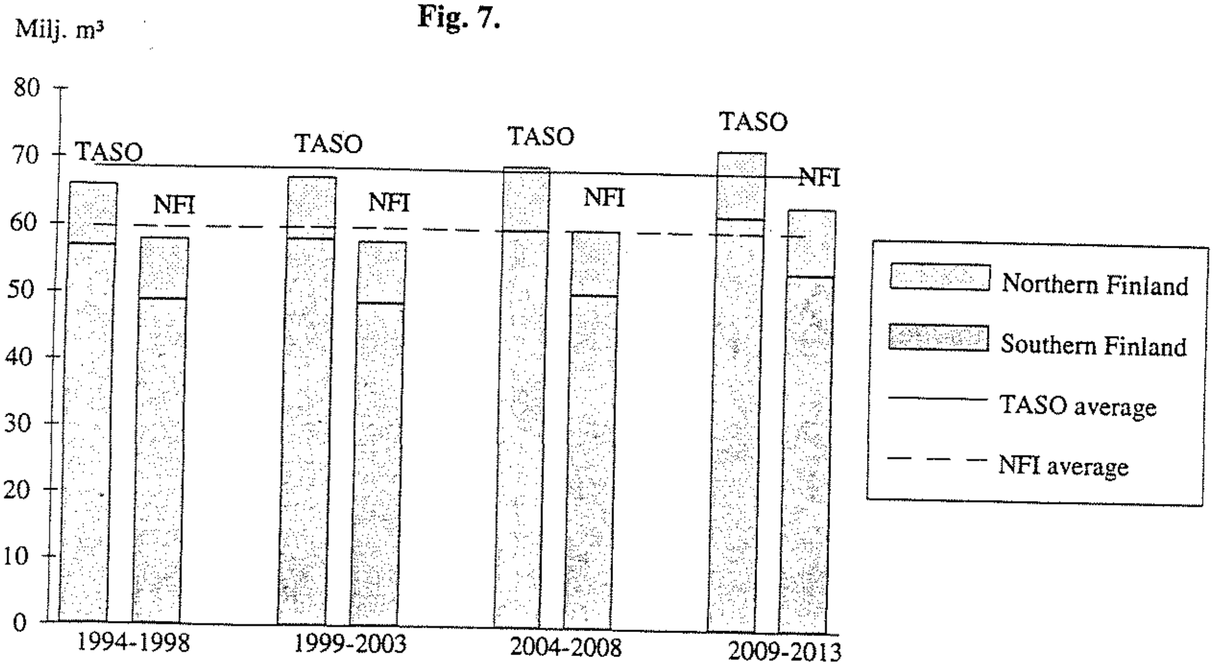

Milj. m³
1800
1600
1400
1200
1000
800
600
400
200
0
TASO
NFI
1994
1999
2004
2009
2014
Northern Finland
Southern Finland
TASO average
NFI average

Fig. 7.


Milj. m³
80
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40
30
20
10
0
TASO
NFI
1994-1998
1999-2003
2004-2008
2009-2013
Northern Finland
Southern Finland
TASO average
NFI average

Fig. 4.

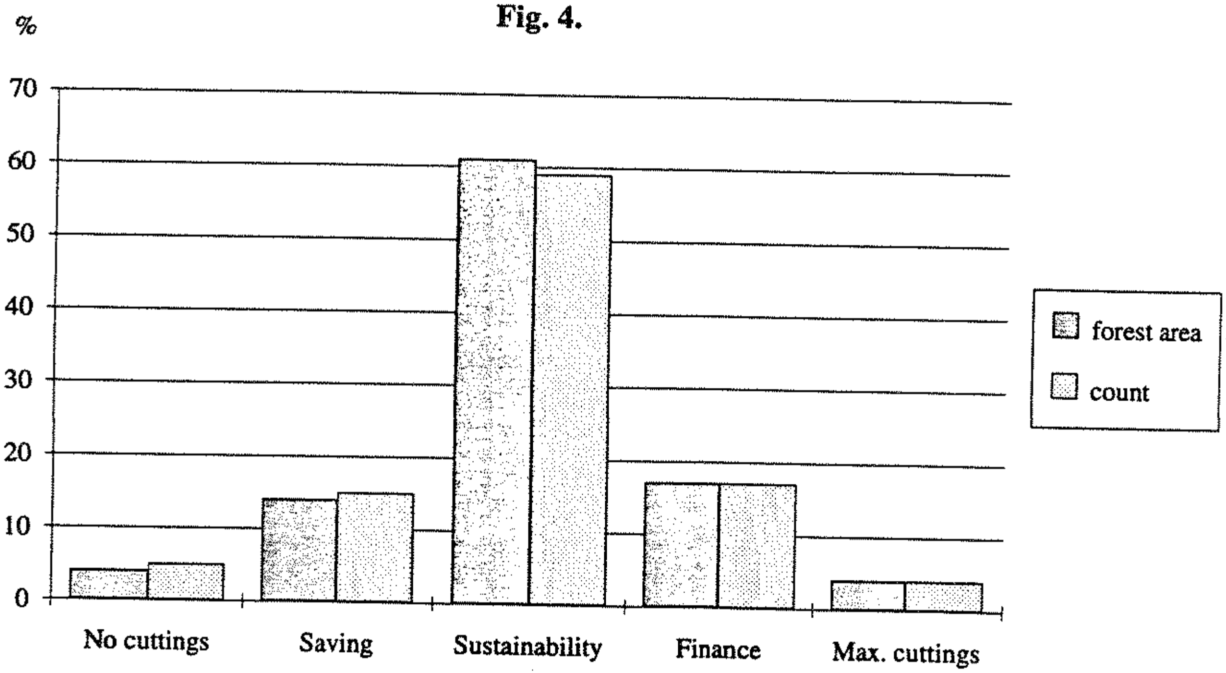
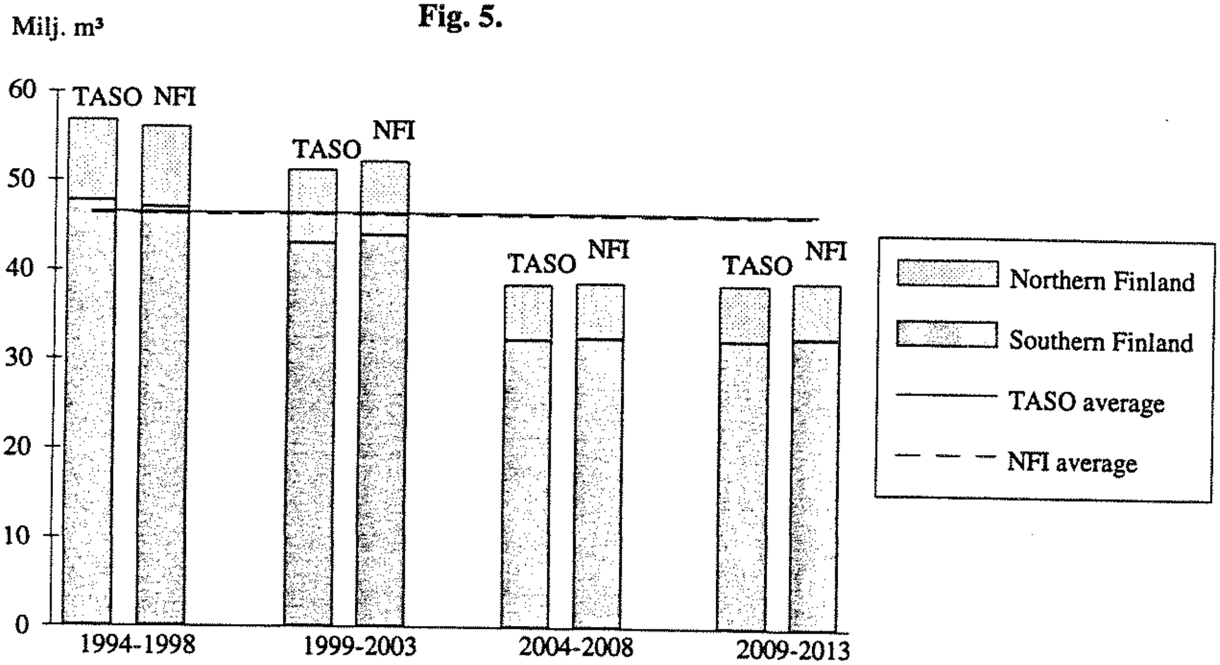

%
70
60
50
40
30
20
10
0
No cuttings
Saving
Sustainability
Finance
Max. cuttings
forest area
count

Fig. 5.


Milj. m³
60
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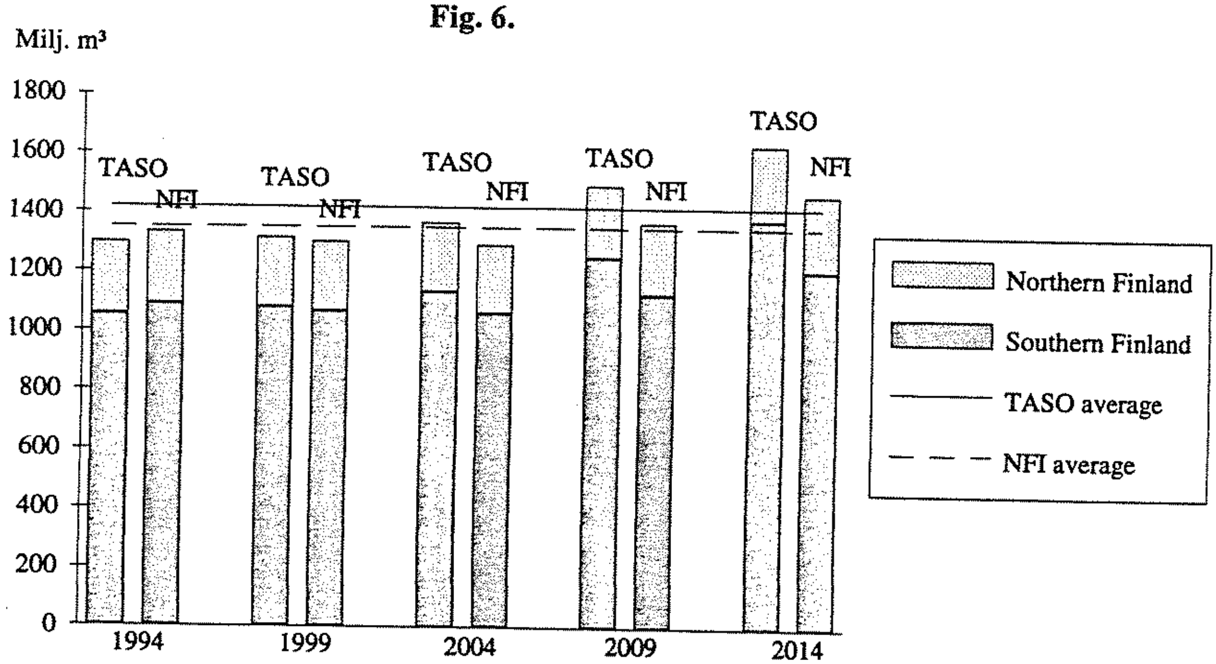
10
0
TASO
NFI
1994-1998
1999-2003
2004-2008
2009-2013
Northern Finland
Southern Finland
TASO average
NFI average

Fig. 6.



Milj. m³
1800
1600
1400
1200
1000
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600
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200
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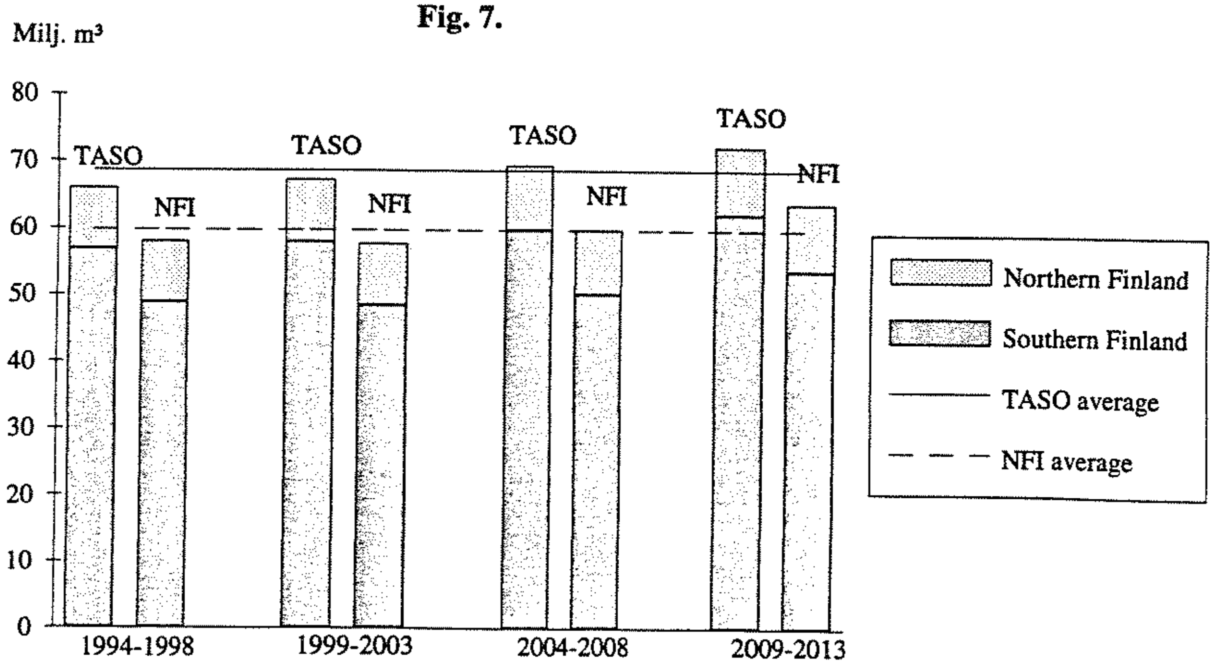
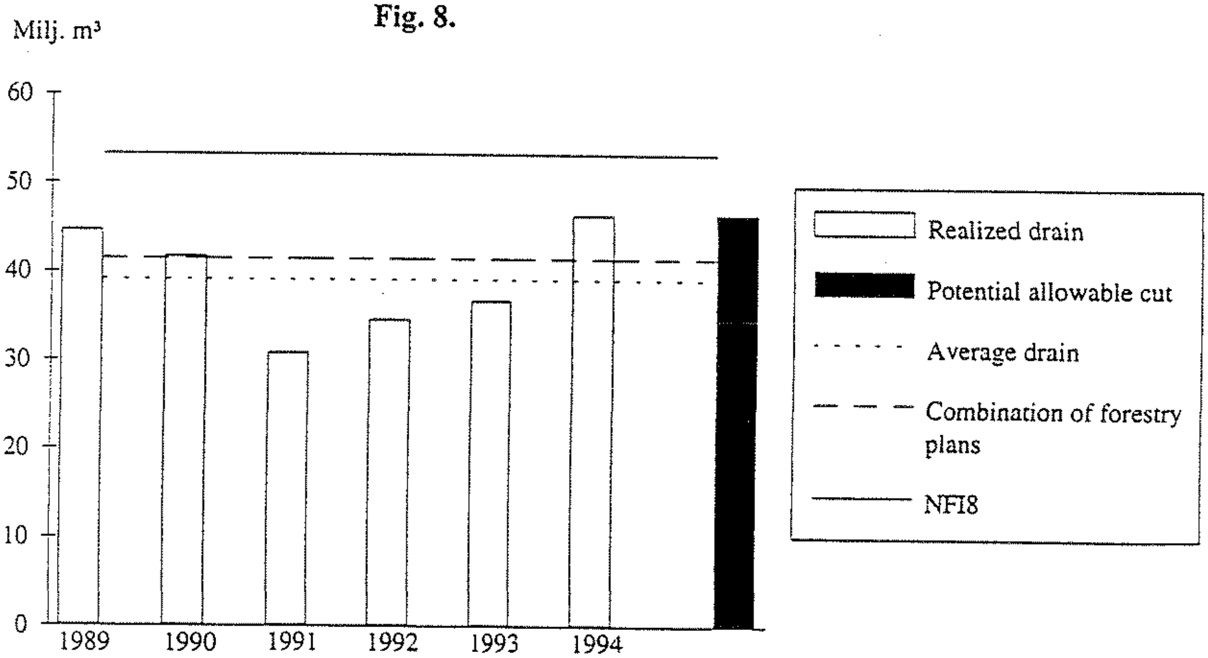
TASO
NFI
1994
1999
2004
2009
2014
Northern Finland
Southern Finland
TASO average
NFI average

Fig. 7.



Milj. m³
80
70
60
50
40
30
20
10
0
TASO
NFI
1994-1998
1999-2003
2004-2008
2009-2013
Northern Finland
Southern Finland
TASO average
NFI average

Fig. 8.


Milj. m³
60
50
40
30
20
10
0
1989
1990
1991
1992
1993
1994
Realized drain
Potential allowable cut
Average drain
Combination of forestry plans
NFI8

Making new Technologies user friendly for Foresters working on the roots.

PIERRE SCHRAM
CEPS / INSTEAD [1]
LUXEMBOURG

Abstract.

New technologies, especially technologies related to data processing or electronics cannot be introduced in forestry services without difficulty. They seldom reach the grass-roots. But it is exactly the person at the g.r. level who has the most detailed information about the forestry environment. We must give to this person who is normally no specialist in data processing, a simple tool allowing him to collect, to store, to treat and to transfer the data to a central data base.We only have to familiarise him with this special kind of work.

1.Introduction.

Sustainable forestry management cannot be achieved unless it is based on real and particularly on up-to-date information of all the stands, their surroundings included. A continuous monitoring of this major natural environment and a continuous feeding of the gathered data into a forestry information system is therefore indispensable.

This rather endless and very difficult job can only be realised on the basis of *modern technologies handled by people having best information of forest.*

Modern and efficient technologies and methodologies for capturing and storing data:

- Airborne and spatial remote sensing.
- Electronic relascope
- Electronic calibrator
- Electronic hight-meter
- Ultrasonic age detector
- G.P.S.
- Portable recorder
- Data processing
- G.I.S.

Unfortunately new technologies, especially technologies related to data processing or to electronics cannot be introduced in forestry services without difficulty. They seldom reach the grass-roots.

[1] Centre d'études de Populations. de Pauvreté et de Politiques Socio-Economiques / International Networks for Studies in Technology. Environment. Alternatives. Development.

newtec01.doc

But it is exactly the person at the g.r. level who has the most detailed information about the forestry environment. He/she knows the localisation of the hare's lair, can show you the nests and aries, leads you to the most beautiful oak in the region, gives you the most recent information about stands, soil, welfare or decline of biodiversity. He/she has best relationship to people depending on forest.

We must give to this person, who normally is no specialist in data processing, *a simple tool* allowing him/her to collect, to store, to treat and to transfer the data to the central data base. *We only have to familiarise him / her with this special kind of work.*

2. Data required for sustainable forest management and for forest research.

First of all data processing must be demystified. Data processing should not be any longer the privilege of a few important people.

The classes of data to be collected must be limited to basic variables. Unfortunately the « *Meeting on Minimum Data Requirements for Sustainable Forest Management held in Stellenbosch, South Africa, November 7-9, 1994* » could not present a definitive list of items to measure.

The methodology for the forestry data-base which we presented to UNEP in 1989 had been build upon 10 groups of data; most of the data had to be captured in the stands. Strange to say that a great part of the collected data had never been used.. Adopting the GIS system the number of primary data to be taken on the ground can be reduced to 5.

Additional descriptive information should be asked by a checklist indicating the possibilities of variables needed. All data should be introduced on site into a portable recorder running an appropriate hardware. All manual transfer must be avoided.

The unity for forest inventory is the stand. The capture of variables must be easy to realise even by a non-specialised staff. Data must be easily controllable and must come from actual measuring, and not from indirect derivation.

The primary data:
1) geographical information: localisation and area;
2) tree species;
3) volumetric components: diameter - height / length
4) age;
5) quality;.
6) management: structures of stands and past management system.

Most of the data of these 6 groups can be easily taken by rangers.
Most of the other information needed for management can be derived from this basic data.

Forest management as well as forest researchers need especially « to-day » data responding to the questions: •Where ist the forest ?
•What is the area of the forest ?
•What is the nature of the forest ?

3. Where is the forest ?

Many answers to this first question are given by aireborne and spatial remote sensing..

A short time ago managed forests were represented by so called « *island maps* » without indication of surroundings: other properties, roads, housings and so on. The local ranger was one of the few persons who knew handling these maps. Nowadays forest maps are filled with quite a lot of topographical informations; it was that the first step for GIS. into forest.
However this new kind of forest mapping is still depending on the « know-how » of the ranger. He/she knows the exact boundary line with its stones and marks of the different properties. He/she can show you the most recent changements of the property area by acquisition or selling.

He/she has no problems to delimit « his/her forest » on remote sensing pictures. It goes without saying that you recognise best on picture the objects that you have often seen before. The local ranger, who regularly passes through the forest, is therfore best informed to do photo-interpretation.

The reliability of colours of aerial photographs is not high. We take the pictures on black - and - white panchromatic film in the non-growing season[2]; they have a much lower price as the chromatics and they give us very good results.

These « unleaved » pictures show many details that are hidden by the leaves during summertime. They visualise quite a lot of geographical information which is very useful for identification.of forest type and tree species Each ranger recognises stands and trees species of « his » forest.

Satellite pictures go down very well. Everybody is enthusiastic to have a view of the forest from an altitude of more than 800 km and to have even a classification of the stands.

Nevertheless the satellite scenes must have a geometrical rectification before being useful on the ground. A hard-copy on glossy paper is of best use.

The interpretation is done by a simple overlay of the concerned georeferenced maps on the spatial scenes. The trained eye recognises whether a stand is still there or not, whether a stand has changed or not.
People who instantly know the reasons of these chages are not numerous. You can find them among those working in forest.

Most of the towns distribute to tourists maps or display on large panels photographs with referential coordinates allowing to find streets and monuments in an easy way. Why can we not complete our forest maps and satellite images with a similar system of coordinates ? It would be very simple to define trees, or stands, or marks on maps and satellite images. It would be a first practical application of GIS in forest.

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[2] Manuel of Photographic Interpretation by ASPRS / USA

3. What is the area of the forest ?.

On the basis of the above mentioned system of coordinates area calculation could be done on the roots with the formula

$$2\,S = \Sigma\,(\,x_n - x_{n+1}\,)\,(\,y_n + y_{n-1}\,)$$

The notion X/Y is already taught in primary school. There's no reason to neglect this kind of parameters for forest uses. The operator simply defines the trig points on the pictures completed with referential coordinates and enters their x/y values into a pocket recorder running the above mentioned formula, or better, he can use a portable running a special, but simple « forest hardware ».

Professionel land-surveyer certainly will not accept the precision of this kind of caculation of areas, but we have at least rapidly an overview of the areas of the stands.
Nevertheless by doing this simple kind of area calculation rangers are initiated in the work of digitising.

4. What is the nature of the forest ?

4.1 Tree species.

In managed forest tree species are known by date of forest inventory. Updating and especialy continuous updating of this basic information can be easily done at a low price(at least in our regions) by spaceborne remote sensing.

The interpretor of satellite information must be talented in the physiologie of forestry. On satellite imagery the reflectance[3] of the canopy is depending on a lot of external factors like season, dry or wet period, daytime and so on.
This facts are well known only to the ranger, who watches continously during his work the fare of the forest. It is indispensably to know the environmental conditions of the moment when the pictures were taken.

4.2 Volumetric components.

4.2.1 Diameter.

The diameter is the only parameter reflecting in a mathematical form the fare of the tree.It can be measured rather exactly in a very easy way on the tree. It is applied in square on volume evaluation.

Unfortunately this most important primary factor is very often neglected. Callipering trees is considered as a boring and time-consuming activity. This may change when the ranger is given an electronic calibrator[4] which allows automatic measuring of diameters and feeding collected data instantly into a portable recorder.

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[3] Schram: Revue Forestière Française 4 / 93
[4] Schöpfer: Moderne Kluppautomaten in der Forstwirtschaft / Allgemeine Forstzeitschrift 26/1978; Rondeux: Les encodeurs portables / Journal Foestier Suisse 1/1984

The calibrator, excepted the electronics, must be reduced to its classical form; it only must allow to store diameter and name of tree species. Our luxembourgish callibrator[5] was too sophisticated. It will be simplified soon.. All descriptive or supplementary data will be stored in a cordless recorder.

We must absolutely return to the former valuation of this most important factor: <u>the diameter.</u>

Diameter allows the calculation of the basal area,
the density of stands.
the relation diameter/age,
the relation diameter/hight

Diameters collected by the Bitterlich method indicate spatial distribution of species,
basal area of the stands,
and quality classes.

The basal area of the stemms choosen by the relascope, allows to verify the values defined by relascope measuring..

A new electronic relascope[6], communicating with the same cordless recorder as used for the the calibrator, will speed up inventory of stands enormously.

4.2.2 Height or length.

Theoretically it is easy to mesure height of the trees. Unfortunately that is only true for isolated trees or in stands with low density. An electronic hight-meter[7] stores the values of the height measurements of standing trees.

Measuring the length of cut timber gives a rather exact value of the height of the stands. Besides cut timber allow stem analysis
evaluation of the form factor,
calculation of th relation mean-diameter/age.
mesuration of the crown diameter

The capture of this data can be taken during the normal felling and can be considered as a normal job of each ranger.

4.3 Age

Stumps allow determing age and monitoring the way of life of trees and stands They are the link to dendrochronology. Study of the annual rings can be done by the ranger together with the felling operations. An ultrasonic age detector is being tested. It should allow to

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La mesure des arbres et des peuplements forestier / Presses Agronomiques de Gembloux 1993
La saisie des données sur le terrain / Revue forestiüre Française, nr. spéciale 1993.
Pardé: Manuel de Dendrometrie / ENGREF Nancy 1988
[5] Schram: Revue Forestière Française 5/1970 - 5/1987;
Forst und Holz 8/1988
[6] Leiss Berlin 1995
[7] Leiss Berlin 1995

determine the number of the annual rings at any hight of the stem. First results obtained on ash, spruce and pine are very encouraging.

4.4 Quality.

Quality criteria should be standardised and should be reduced to a minimum. The ranger who is always involved in felling and logging activities and who has good relationship with the users of woods products, has best information of the technological qualities of timber.

4.5 Management: structure of stands and past management system..

Changes of the structure of stands can be detected by spatial monitoring. This uncertainty assessment can be controlled by continuous visits of the stands.

5. Conclusion.

Until now forest management, and even forest policy, are based on periodical inventories. These are quite independent activities which are repeated only every ten or twenty years: they are planned, executed and analysed. They are very onerous an they give only a global information about the recent past period..

Nowadays environment and forest fare are changing continuously and nobody knows exactly why. The continuous monitoring on ground realised by the ranger during his daily work can certainly help to to find an answer to this « modern » problem. Management is independant from onerous inventories.

The new technologies will fill him/her with enthusiasm for this new and supplementary work. They will encrease the general sense of responsabiliy.

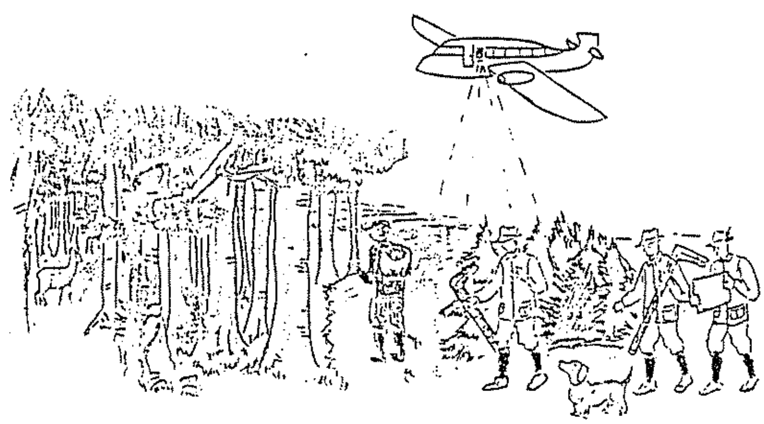
IUFRO WORLD CONGRESS
Tampere / Finland August 1995

INVENTORY OF STANDS

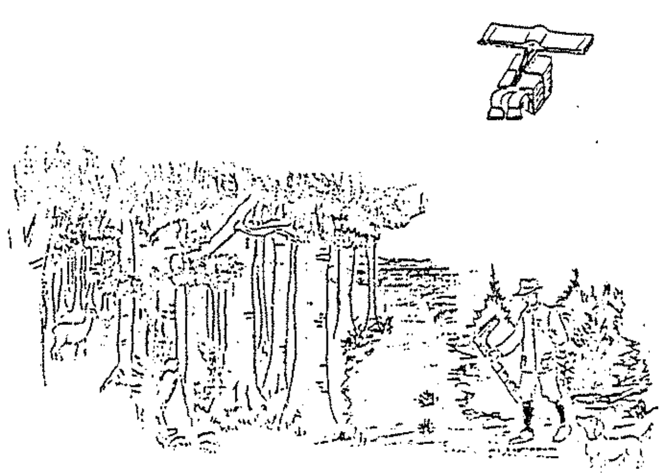
FORMERLY

YESTERDAY

TODAY



TOMORROW



APPLIED AGROFORESTRY

IN THE CENTRAL COAST OF CALIFORNIA

By

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Cal Poly
San Luis Obispo, California 93407

Submitted

IUFRO, XX World Forestry Congress
Tampere, Finland

August 1995

Abstract

APPLIED AGROFORESTRY IN THE CENTRAL COAST OF CALIFORNIA

Most agroforestry in the Central California is based on a combination of fuelwood and beef production. Since 1772, when the padres established the San Luis Obispo Mission, cattle grazing has been an important use of the local oak-woodland. At the same time, the oak resource was also an essential source of high quality fuelwood. Early Mission papers indicate that the padres recognized the value of this combined resource use.

However, the enlightened resource management was not continued. In the early 1900's local cattle herds were increased, due to improved markets. At that time, high grazing pressure reduced the extent of the local oak resource, in favor of increased forage production. Until about 1950, this area was the major state production center for charcoal. As a result, heavy oak removals were made to provide raw materials for the kilns.

Since the 1973 oil crisis, there has been a growing interest in wood fuel, locally. As a result, many cattle ranchers are again practicing agroforestry based on a combination of fuelwood and cattle gazing. During periods of low beef prices, the production of fuelwood has been economically attractive.

Earlier, in 1981, under a joint program with CDF, the NRM Department at Cal Poly established an experiment dry-land eucalyptus energy bio-mass plantation. The purpose of this work was to evaluate eucalyptus seeding survival, without irrigation. Also at that time some local ranchers were beginning to develop a few eucalyptus bio-mass energy plantations.

At present, throughout the Central Coast area of the State, much of the cattle grazing business is combined with oak fuelwood production. There is increasing interest in this agroforestry application-forage + fuelwood + wildlife. Woodland owner education programs have been developed jointly by the NRM Department, Cal Poly, with CES, and CDF.

Currently, there are two major oak- woodland management problems that restrict further agroforestry, technically and socially. The technical or biological problem is a lack of oak seeding regeneration and the social/political problem is fragmentation of oak-woodland for residential housing. The continued development of applied agroforestry, as a suitable management system for the local oak-woodlands will require further research and education to solve these problems.

Applied Agroforestry
In The Central Coast of California

Introduction:

Agroforestry is a system of growing a stand of forest trees, in association with a food or domestic animal crop, on the same area, and at the same time. The key concept is a systems approach for cultivation of food and fiber, on the same land, and in the same time-frame.

As an integrated system, agroforestry provides an integrated approach to complex land use questions that is both productive, and also environmentally sensitive. Clearly, there are both advantages and disadvantages to the practice of agroforestry. Some of the advantages include:

1. increased biodiversity
2. better site utilization, from sub-soil, root systems to under and over story canopy structure.
3. production transition or link, as land use changes
4. reduce soil erosion and improved water management

Some of the disadvantages include:

1. more complex management
2. may reduce short-term food yields
3. resistance from traditional production forestry/agriculture

In the past, agroforestry, in the form of alley-cropping, has been most widely used in tropical forestry situations. However, over the past decade, temperate agroforestry applications have been growing rapidly. Locally, in Central California, agroforestry programs have been applied in some unique systems, for private land owners.

The Central California coast environment is characterized by a Mediterranean climate-- cool wet (about 20" annual rainfall) winters, and hot, dry summers (with some daily temperature, in excess of 100º F). The topography ranges from wide river bottoms with highly productive soil to steep , brush covered hillsides. Most of the vegetation is oak-woodland,[1] mixed with grass land and chaparral brush lands. The Salinas River system is the main drainage that flows into the Monterey Bay, south of San Francisco.

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1 oak-woodland blue oak, Quercus douglasii; coast live oak, Q. agrifolia, etc.

The riparian vegetation [2] represents a very important part of the full area ecosystem. Originally, this oak-woodland provided a wide range of wildlife habitat, that was the foundation for very high biodiversity. Fire was and still is, a very significant element that has shaped the local ecosystem. In addition, drought and floods also impact this land area on an irregular cycle. High-damage earthquake are not common in this area. During long droughts, water supply may be limited, particularly as population (currently about 205,000 in San Luis Obispo County) continues to grow.

Historically,the Mission era (about 1772 in San Luis Obispo) was an initial point of land use change. The Franciscan padres introduced cattle and sheep to this area, and with these animals, the Mediterranean annual grasses. These exotic grasses soon replaced the less aggressive native bunch grasses. Until the turn of the century, cattle ranching was the major land use in this area. At present, other forms of agriculture, such as wine grapes, walnuts and dry- land grains have reduced the amount of grazing. Until the middle of this century, large volumes of oak were cut for firewood, and for charcoal. The Paso Robles area was, until about 1950, a statewide, leading producer of quality charcoal.

Currently, local population -particularly retired seniors- is growing rapidly in this area. As a result of this growth, there is a rapidly increasing demand to convert prime agriculture land into home sites, that range in size from one-fourth to fifty acres. The layout for most homes represent maximum landscape sprawl and maximum habitat fragmentation. This fragmentation, continued overgrazing, and decline in bunch grasses has led to lack of oak regeneration. In addition, with the rapid "sub-urbanization" of the oak -woodland, the risk of devastating wildfire has also increased significantly in the past decade.

Most of southern California is a naturally arid environment. Limited water is also a human management problem. As population[3] levels increase, water resources will be heavily impacted. California ground water supply is now in overdraft by about 2 MM acre feet per year. Agroforestry has the potential to conserve these limited water resources.

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2 reparian sycamore, Plantanus sp.; willow, Salix sp.; cottonwoods, Populus spc., etc.

3 currently California population is about 32, and projected to the year 2,000 it will be about 38 mm.

Temperate Applications:

Generally, over the past ten years, there has been a growing interest in temperate application of agroforestry. At this point, it is important to distinguish between the newer concept of agroforestry, and the older idea of "tree farming." As a management concept, the tree farm idea has been successfully practiced for 20 years or more. Tree farming is often practiced in many different ways. However, the most common application of tree farming is the development of a single species plantation, managed on an even-age basis. Although some agriculture practices are used in tree farming, it is not agroforestry, in any way.

Historically, in Central California, most agroforestry applications have been primarily developed for fuelwood, or as a livestock mixture. For example, in 1981 the Natural Resources Management Department, Cal Poly received a State grant to investigate the possibility of establishing an un-irrigated eucalyptus trial, in association with controlled grazing. The eucalyptus was intended for eventual firewood. However, lack of funds has curtailed the experiment. The initial results did show that there was some agroforestry potential. Last August, a large local area was burned over in the Highway 41 wildfire, that scorched about 48,000 acres of oak-woodland (and about 19 expensive homes). As a result of that fire a number of local sheep faced a lack of forage. About 30 mature sheep were then pastured for about a month in a 3 year old Monterey pine (Pinus radiata), Christmas tree plantation. The sheep gained weight and grass competition was removed from the plantation under this improvised, emergency agroforestry system.

Over the past five years, there has been a prolonged drought in this Central California area. Lack of rain has made it more difficult for many local ranchers to realize their usual livestock profits, as beef prices also declined. For this reason, some ranchers have entered the fuelwood business; using either the native oak, or eucalyptus as a raw material. In a few cases, the low rainfall and low beef prices have forced ranchers to shift their priorities to fuelwood. Thus, trees and cattle have become an economically attractive agro-silvi-pastoral system.

In recent years, some ranchers have recognized the value of agroforestry for wildlife habitat. Some landowners have planted trees (and wildlife food plants) to improve wildlife food and cover.

Land owner assistance programs, that will cost-share wildlife improvement, are available from both state and federal agencies.

As a means to provide maximum wildlife habitat benefit, there has been some limited planning, on a regional basis, to use some agroforestry wildlife plantings, as a mitigation for habitat fragmentation caused by large, unplanned and under-regulated construction.

During this past winter and spring, the annual rainfall exceeded all records, and broke the drought. Unfortunately, after last year's large fire, these heavy rains also caused heavy local flooding and soil slippage. As one particular solution, the Central Coast Resources Conservation and Development Council sponsored a trial agroforestry project, on a community basis. The federal/state Stewardship Incentives Program (SIP) has a provision for using cost-share funding to support agroforestry projects. However, many of the land owners in this fire area did not own sufficient land-minimum 10 acres and maximum 1,000 acres---to qualify for an individual SIP agroforestry project. Many of these small landowners represent the growing interface population in the area that is buying subdivided land for individual home sites. Thus, in order to apply the SIP agroforestry system to this area, a special community management program was established--on a trial basis--to include a number of small, adjacent landowners, on a cooperative basis.

The initial results of this experimental community agroforestry program does seem to be very productive. One positive element that has resulted from this community agroforestry effort is the development of a strong source of shared concern about improved land-use. Tree planting plans are being developed to meet multiple-goals, such as:

1. slope/soil stabilization
2. wildlife habitat enhancement
3. improved community aesthetics
4. wind breaks/ riparian filters

Most of this tree planting has been laid out as strips with grass filters. Later thinning in the strips will yield fuelwood, and some limited grazing may also be done in the future.

Unrelated to fire and flooding, there has been an increase in agroforestry for wind breaks, both community wide and for individual residential areas. Many local creekways, heavily damaged by overgrazing and irresponsible recreation (ORV) use, have been under going rehabilitation, by planting trees as a filter-strip along damaged creekways. Planting trees for creekway filter-strips has also benefited local wildlife by improving habitat, and reducing the impacts of habitat fragmentation. Local creekways are important migration routes for different wildlife species. It has been estimated that there is now about 30 miles of local windbreak, and filter-strip plantings.

The use of exotic species of trees, such as eucalyptus in agroforestry has raised some significant questions. Clearly, exotics may be invasive, and may cause soil/site problems. However, for certain uses, such as short-rotation, bio-mass energy fuel, some exotics, again like eucalyptus, may be relatively efficient. Otherwise, the use of native tree species is usually most desirable, in local, temperate agroforestry.

Future:

As it has been applied in Central California, agroforestry is still a relatively small operation. However, in the future, it seems clear that as traditional (timber based) forestry declines, there will be a growing need for agroforestry as a social/ecological link. This agroforestry link will serve as a connection between the old traditional--timber based--forestry, and a new, community based system of ecosystem management. Agroforestry can also serve as a link between extractive commercial forestry and a non-commodity interface, land-use system.

A sound agroforestry system will also contribute to a production shift away from large-scale wood processing facilities. Smaller volume of interface wood can now efficiently be processed in local, small-scale facilities, and by portable mills.

In addition, agroforestry will contribute to a productive system of social/community forestry. Local people will be able to see and understand the ecosystem implications of greater biodiversity, and more sustainable systems provided under an agroforestry model. Agroforestry provides not only a biologically more productive environment, but also an ethically more responsible system. As Aldo Leopold said, "the first rule of sound tinkering is to save all the parts."

Agroforestry will also serve as a means for conflict-resolution. In many local areas, the community is split between traditional, production-at-any cost individuals and a group of more environmentally sensitive citizens. The old-guard ranchers and foresters still consider any natural resource useful, only as it is converted into a market product. For example, "the only good tree is a board," and "the only good cow is a hamburger." And, from a development viewpoint the only good piece of land is one that is now, or about to become, a home site. Thus, agroforestry, as an environmentally sensitive, production system may function as an acceptable bridge between the traditional community approach to land-use and the growing group of citizen advocating a non-commodity approach.

Historically, much of our forest resource management has been developed on a short-term, high profit system of resource exploitation. Agroforestry can provide a bridge to help individuals and rural communities move from a short-term, non-sustainable process of resource exploitation, to a new ecosystem management process that includes commodity values, but also places the management focus on biodiversity, within the framework of long-term sustainability. In 1854, a wise American Indian Chief, Seattle said, "remember that man is only a strand in the web of life; whatever we do to this web we do to ourselves."

Agroforestry progress will also require a significant change in traditional forestry education. Many traditional forestry programs are still based on out-moded concepts of short-term, forest exploitation. Although a few professional forestry programs are now talking about ecosystem management and forest health, most of this learned discussion is lip-service only--- the heart of these programs remain in timber exploitation. Agroforestry can fulfill its potential as a transition science only when forestry students learn the importance of social/community forestry, as well as traditional regulation and silviculture.

Traditional forestry education has generally been very slow to change and some old-guard foresters still resist the idea that ecosystem management has any part in a professional forestry education program. A full forestry education system--hardware, students, faculty, and concepts-- all require measured change, for progress in agroforestry. Most educational change has thus far concentrated on the easiest element--changing hardware and delivery. The most difficult elements to change are the faculty and learning concepts. It is in this area of education where agroforestry will meet success or failure, as a direct response to change in forestry faculty and concepts.

In addition to formal education, it is essential to develop an informal education network. Successful application of agroforestry will require a well motivated group of trained land owners who support the agroforestry concept. This will also require some significant socio-political re-education to move from a rabid "private-property" view into a broader community values view of land use. Economically, agroforestry is a very cost effective use of scarce tax dollars.

In the past few years, continuing education in agroforestry has been successful in Central California using an extension type seminar mode. In the future, there will be a growing interest in developing a more formal system of university certificate courses, that may be sponsored by different community organizations, or public agencies.

The future development of agroforestry in Central California will require:

1. community support, and landowner outreach
2. change in forestry emphasis from commodity exploitation to non-commodity ecosystem values
3. some major changes in professional forestry education and educators
4. additional applied research on systems integration of both food and fiber elements in agroforestry

Agroforestry, research centers, such as the new Forest Service Agroforestry Center in Lincoln Nebraska, have made a major contribution.

In general, as the oak woodland environment in Central California comes under increasing development pressures, the importance of agroforestry will increase. Land-use and water conservation will be the most significant elements for increased application of agroforestry, in Central California.

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NEUE WEGE ZUR PLANUNG UND STEUERUNG DER ÜBERWIRTSCHAFTLICHEN WALDFUNKTIONEN

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SUMMARY

In the following article, the author describes new approaches to forestry land use planning. With the help of some concrete examples of the Austrian forestry planning practice, already available experiences are demonstrated, above all in the field of the planning to improve the protection forest. Due to a general „change in values" in forestry (multifunctional multipurpose forestry, ecology with lasting effects), people are working at present on planning and controlling systems for the lasting protection of all forest functions. The respective present knowledge is described in a survey.

SOMMAIRE

Dans l'article suivant, l'auteur décrit de nouveaux points de départ pour la planification de l'aménagement du territoire forestier. Au moyen de quelques examples concrets de la pratique de la planification forestière en Autriche, des expériences déjà présentes sont démontrées, surtout dans le domaine de la planification en ce qui concerne l'amélioration de la forêt de protection. En raison d'un changement des valeurs qui peut être observé généralement dans la foresterie (foresterie multifonctionnelle à usage multiple, efficacité écologique), on travaille aux systèmes pour la planification et le contrôle afin de constamment protéger les fonctions de la forêt. Des constatations trouvées jusqu'à présent sont présentées dans un résumé.

ZUSAMMENFASSUNG

Der Autor befaßt sich im folgenden Artikel mit der Beschreibung neuer Planungsansätze für die Forstliche Raumplanung. Anhand von einigen konkreten Beispielen aus der Österreichischen Forstlichen Planungspraxis werden bereits vorliegende Erfahrungen vor allem im Bereich der Schutzwaldverbesserungsplanung demonstriert. Auf Grund des allgemein in der Forstwirtschaft auftretenden „Wertewandels“ (Multifunktionale Mehrzweckforstwirtschaft, Ökologische Nachhaltigkeit) wird derzeit an Planungs- und Steuerungssystemen für die nachhaltige Sicherung aller Waldfunktionen gearbeitet, entsprechende bisherige Erkenntnisse werden überblicksmäßig dargestellt.

EINLEITUNG UND PROBLEMSTELLUNG

Die durch die verfallenden Holzpreise verursachten ökonomischen Probleme der Forstbetriebe einerseits, die steigende Nachfrage der Gesellschaft nach überwirtschaftlichen Waldfunktionen (Infrastrukturleistungen des Waldes) andererseits bedingen einen notwendigen Umdenkprozeß bei der forstlichen Planung. Vorhandene und bis jetzt eingesetzte Methoden der Forsteinrichtung, die primär an der Massen- bzw. Wertleistung der Waldbestände orientiert sind, können die durch diese Situation aufgeworfenen Fragen nicht hinreichend beantworten.

Zur Lösung der - zwar nicht neuen, aber neu priorisierten - Fragestellungen ist es notwendig, einen (finanziellen) Ausgleich zwischen den Produzenten (Anbietern, Waldbesitzern) und den Konsumenten (Gesellschaft) der Leistungen herzustellen (BAUMGARTNER 1883). Je nach der politischen Struktur einzelner Staaten wird die staatliche Verwaltung dieser Aufgabe nachkommen und entsprechende „Umverteilungssysteme“ einsetzen müssen.

Für die spezifische Situation in Österreich (Großer Anteil an privatem Waldbesitz) sind dafür im Rahmen der entsprechenden Gesetze (vor allem Forstgesetz 1975) praktisch nur die Anreizsysteme der Forstlichen Förderung sinnvoll einsetzbar. Das Gesetz schafft zwar ausdrücklich mit dem Bannwaldbegriff eine „Zwangsmaßnahme“, die es den zuständigen Stellen erlaubt, direkt auf die Waldbewirtschaftung durch Vorschreibung der Bewirtschaftungsform Einfluß zu nehmen, diese Maßnahme wird jedoch nur sehr restriktiv eingesetzt (Anteil der Bannwaldflächen unter 5% der Gesamtwaldfläche!)

Für die Durchsetzung, Dokumentation und Kontrolle der forstpolitischen Zielsetzungen ist die Forstliche Raumplanung zuständig. Die derzeit in Österreich hauptsächlich zur Verfügung stehenden diesbezüglichen Instrumentarien (Waldentwicklungsplan, Gefahrenzonenplan) sind aus verschiedenen Gründen nicht mehr im vollem Umfange in der Lage, die gestellten Anforderungen zu erfüllen. Die Firma STUGES hat daher im Auftrage des und in enger Zusammenarbeit mit der Forstsektion des Bundesministeriums für Land- und Forstwirtschaft (BMLF) in einer Reihe von Pilotprojekten entsprechende Modelle und Planungsansätze entwickelt, die vor allem auf eine Verbesserung der Situation bei der Schutzfunktion abzielen (SCHABL, FLASCH, 1993; FLASCH, 1994).

Die hier präsentierten Aufgaben wurden vor allem auch mit Blickrichtung der Erfüllung internationaler Vereinbarungen (z.B.: Alpenkonvention, Bergwaldprotokoll) durchgeführt. Als wesentliche Voraussetzung zur Erreichung der dort festgelegten Ziele wird der Aufbau entsprechender Planungsinstrumente gefordert.

Die gemeinsamen Überlegungen (STUGES und BMLF) gehen mittlerweile über die Schutzfunktion hinaus und verfolgen den Aufbau eines umfassenden Planungs- und Steuerungsmodells zur nachhaltigen Sicherung aller Waldfunktionen (Nutz-, Schutz-, Erholungs- und Wohlfahrtsfunktion).

Die rasante Entwicklung auf dem Gebiete der Geoinformationssysteme (GIS) und der Datenbanken bietet für die beschriebenen Aufgaben ideale Voraussetzungen. Erst dadurch ist die umfassende und sowohl zeitlich auch finanziell vertretbare Verarbeitung der großen Datenmengen mit Raumbezug möglich geworden.

ANALYSE DES ISTZUSTANDES UND ABLEITUNG DER ZIELVORGABEN DER FORSTLICHEN RAUMPLANUNG

ANALYSE DES ISTZUSTANDES DER FORSTLICHEN RAUMPLANUNG

Zusammengefaßt ist der derzeitige Stand der Forstlichen Raumplanung durch folgende Charakteristika gekennzeichnet:

- statischer Planungsansatz
- Planungsunterlagen basieren auf terrestrischen Erhebungen
- analoge Grundlagen (Kartendarstellungen und entsprechende Tabellenwerke)
- kleinmaßstäbliche Darstellungen (1:50000 oder kleiner)
- nur periodische Revisionen der Planungsunterlagen

Mit den oben angeführten Charakteristiken sind folgende Nachteile verbunden:

- geringe Aktualität der Datengrundlagen
- Planungsgrundlagen sind oft subjektiv gefärbt und kaum nachvollziehbar
- inhaltliche Einschränkungen aufgrund des kleinen Maßstabes
- Unhandlichkeit durch analoge Führung
- Informationsfluß nur von „unten nach oben“

ZIELVORGABEN

Ziel ist es, entsprechende Modelle und Werkzeuge für die Planung der Waldfunktionen zu entwickeln. Auf der Grundlage der Integration verschiedenster Daten über die forstliche Umwelt soll ein naturraumbezogenes Informationssystem auf der Basis modernster Technologien zur Verfügung stehen, das Grundlage für eine effektive Planung und Steuerung hinsichtlich der Infrastrukturleistungen des Waldes ist.

Zur Erreichung der definierten Ziele sind folgende Teilaspekte besonders zu berücksichtigen:

- eine Operationalisierung der Infrastrukturleistungen des Waldes, d.h. Beurteilung und Beschreibung der Waldfunktionen nach objektiv erfaßbaren Kriterien und Definition eines Maßstabs zur Messung und zum Vergleich der Waldwirkungen

- Qualitätsverbesserung bei der Erhebung der Grundlagendaten durch den Einsatz modernster Fernerkundungsmethoden

- Einsatz eines naturraumbezogenen Informationssystems zur Be- und Verarbeitung aller umweltrelevanten Daten

- Qualitätsverbesserung bzw. Qualitätssicherung der Grundlagendaten durch Bearbeitung des Gesamtkonzeptes unter den Vorgaben eines TQM-ISO 9000

Durch die Umsetzung dieses Konzeptes soll schrittweise ein neues Gesamtsystem für die Forstliche Raumplanung entwickelt werden, welches gegenüber dem derzeitigen Stand folgende Neuerungen und Vorteile aufweist:

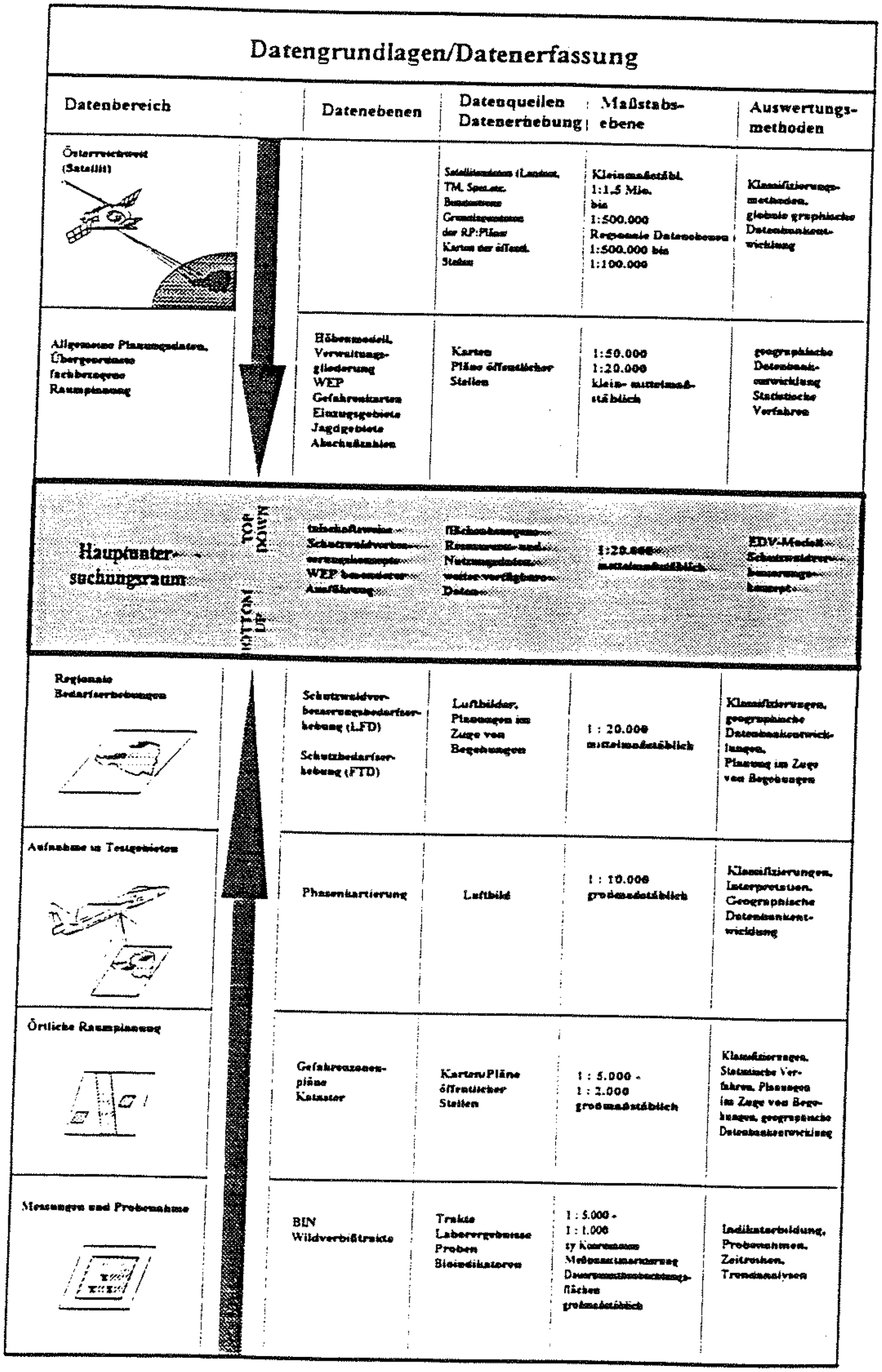
- dynamischer Planungsansatz
- hohe Aktualität
- Planungsgrundlagen basieren auf objektiv nachvollziehbaren Grunddaten
- Mehr Informationen durch größeren Planungsmaßstab (1:10000 bzw. 1:20000)
- durch digitale Führung besser handhabbar
- gemeinsame Datenbasis über alle Hirarchiestufen, daher verbesserter Informationsfluß
- Basis für die Festlegung von Waldfunktionen
- meßbare Zielsetzungen als Basis für den Regelkreis
- leicht übertragbares Modell

DAS BEISPIEL KÄRNTNER WALDINFORMATIONSSYSTEM

Die nachfolgend angeführten Beispiele wurden in den letzten Jahren von der STUGES in enger Zusammenarbeit mit der Forstsektion des BMLF, dem Forsttechnischen Dienst der Wildbach und Lawinenverbauung bzw. mit der Landesforstdirektion Kärnten erarbeitet. Es handelt sich dabei ausschließlich um Arbeiten mit Pilotprojektcharakter, d.h. die Entwicklung neuer Methoden stand im Vordergrund. Die dabei erzielten Ergebnisse werden im Rahmen des Forstlichen Fachinformationssystems der Kärntner Landesregierung erfolgreich eingesetzt (FLASCHBERGER, FLASCH, 1993).

Für das Bundesland Kärnten wurden im Zuge mehrerer Projekte die entsprechenden Daten und Methoden aufgebaut und werden laufend aktualisiert und vervollständigt. Im wesentlichen sind dadurch die Voraussetzung für ein effektives Planungs- und Steuerungssystem für die Landesforstdirektion - zumindest für die Schutzfunktion - geschaffen

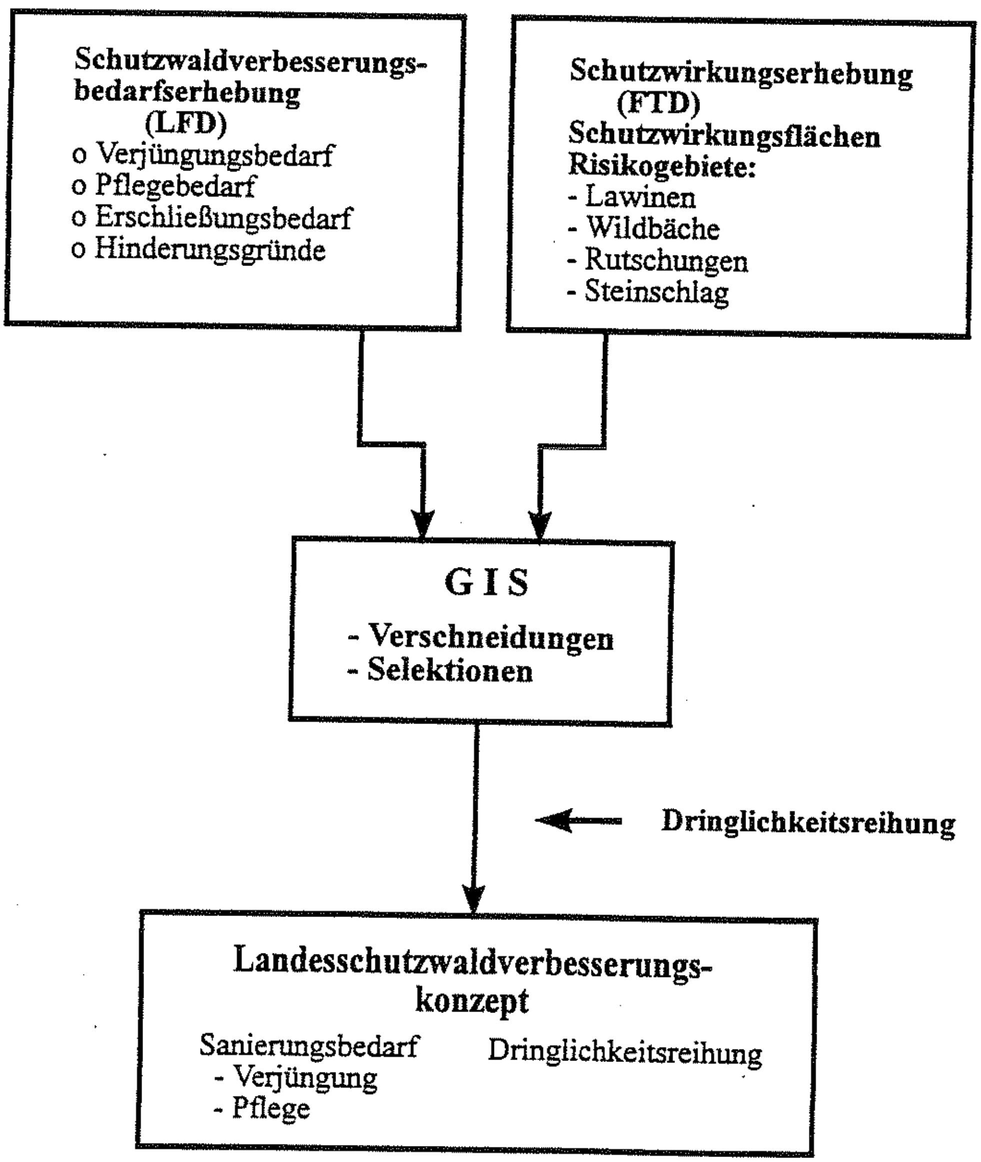
Das entwickelte und bereits erfolgreich eingesetzte System bedarf je nach Genauigkeitsanforderungen der zu treffenden Aussagen jeweils unterschiedlich genauer Grundlagendaten und Analysemethoden (siehe Abbildung 1). Die bis jetzt vorliegenden Ergebnisse sind Modelle, die entsprechende Grundlagen für politische Entscheidungsträger liefern können.



(Abbildung 1: Daten und Methoden im Kärntner Waldinformationssystem)

LANDESSCHUTZWALDVERBESSERUNGSKONZEPT

Das entsprechende Projekt „Pilotstudie Erweiterung Drautal" (SCHABL, FLASCH, LANCSAK, 1993) umfaßt die Erarbeitung einer kurzfristig verfügbaren, flächendeckenden Gesamtübersicht für das Bundesland Kärnten als Grundlage zur Abschätzung von erforderlichen Planungsmaßnahmen im Bereich der Schutzwaldverbesserung und die Reihung dieser nach Prioritäten. Die folgende Abbildung 1 zeigt dabei das zugrundeliegende Vorgehenskonzept.

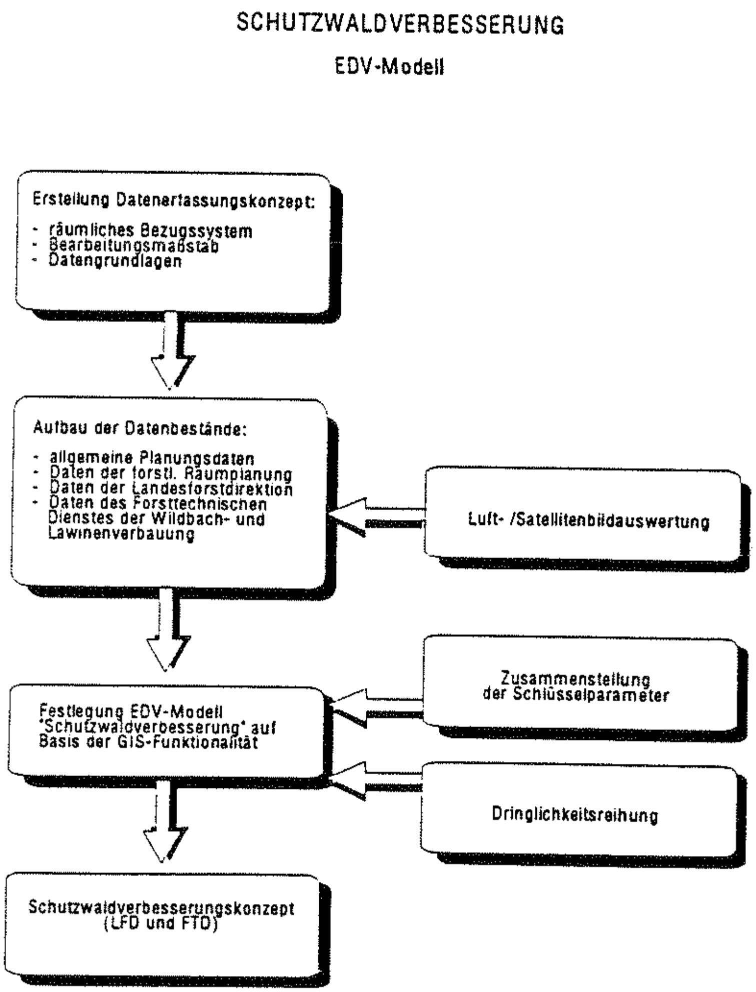


(Abbildung 1: Landesschutzwaldverbesserungskonzept, Vorgehenskonzept)

Die Landesforstdirektion selbst ist damit in der Lage, landesweite Fragestellungen (wie z.B.: die Ausweisung von Förderungswürdigen Gebieten laut EU-Verordnungen, Beispiele: Förderung nach EU-VO 2078 und 2080) schnell und basierend auf jeweils aktuellen Daten zu lösen.

TALSCHAFTSPLANUNG

Auf der Basis der Vorgaben des BMLF war ein EDV-unterstützter Lösungsansatz zu entwerfen, mit dem in einem kurzem Zeitraum auf einer hinreichend breiten Datenbasis vielfältige und interdisziplinäre Lösungen zu aktuellen Fragen des Hochwasser- und Lawinenschutzes und der Forstlichen Raumplanung erreicht werden. Dafür wurde das in Abbildung 2 generalisert dargestellte EDV-Modell „Schutzwaldkonzept“ erarbeitet.



(Abbildung 2: EDV-Modell „Schutzwaldkonzept“ für die Talschaftsplanung)

Im Zuge dieses Projektes (Pilotprojekt Drautal; SCHABL, FLASCH, 1992) wurde auch ein Vergleich zwischen der herkömmlichen Planung im Schutzwaldbereich und den hier eingesetzten neuen Methoden im Hinblick auf die Aussagegenauigkeit angestellt. Durch die viel kleinflächigere Ansprache der entsprechenden Parameter werden die neuen Methoden als wesentlich treffsicherer eingestuft. Bei der Feststellung des Sanierungsbedarfes im Schutzwald wurde etwa mit herkömmlichen Methoden (terrestrische Kartierung) bei gleich großem Einzugsgebiet eine Fläche von etwa 1700 Hektar als dringend sanierungsbedürftig ausgeschieden, während aufgrund der neu zur Verfügung stehenden Daten und Methoden nur ca. 450 Hektar als solche ausgewiesen wurden. Eine Überdeckung fand man nur auf etwa 120 Hektar. Die Ergebnisse wurden vor Ort verifiziert, wodurch die neueren Ergebnisse als zutreffend bewertet werden können.

Weitere wesentliche Ergebnisse dieses Projektes sind zum Beispiel GIS-unterstützte Methoden zur Einzugsgebietsanalyse für die Wildbach- und Lawinenverbauung mit Gefahrenzonenausscheidung (SCHABL, FLASCH, 1994).

SCHLUSSFOLGERUNGEN UND AUSBLICK

Auf Grund der geänderten Anforderungen kann basierend auf den bisherigen Erfahrungen angenommen werden, daß der eingeschlagene Weg der richtige ist. Die Weiterentwicklung der gesamten Forstlichen Raumplanung zu einem dynamischen Panungs- und Steuerungssystem muß im wesentlichen durch den Aufbau eines permanenten Monitoringsystems erfolgen, das die Möglichkeit bieten muß, die Entwicklung des Waldzustandes durch kostengünstige Datenerhebung (Fernerkundungsmethoden) laufend aktuell zu dokumentieren. Der so abgebildete IST-Zustand kann laufend mit dem SOLL-Zustand (wird durch verschiedene Einflüsse vorgegeben, bzw. kann aus anderen Vorgaben abgeleitet werden) verglichen werden. Aus den Abweichungen können die notwendigen Maßnahmen abgeleitet werden. Somit steht durch den Einsatz modernster Techniken der Geodatenverarbeitung in Verbindung mit noch zu verfeinernden Modellen ein „fachliches Controllingsystem" zur Verfügung, durch welches eine der Voraussetzungen zur nachhaltigen Sicherung aller Waldfunktionen geschaffen ist.

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NACHHALTIGE FORSTLICHE BEWIRTSCHAFTUNGIN POLEN

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ZUSAMMENFASSUNG

Der Begriff "Forstliche Nachhaltigkeit" wird geschichtlich gesehen verschieden definiert und verstanden. Die Ansprüche der Gesellschaft an den Wald sind dem Wandel unterworfen worden. Nachhaltige forstliche Bewirtschaftung wird in Polen gegenwärtig als Nutzung des Waldes verstanden, die den künftigen Generationen möglichst gleichwertige, vielseitige Nutzungsmöglichkeiten sowohl im Bereich Holznutzung als auch hinsichtlich der Wohlfahrtswirkungen (Schutz- und Erholungsfunktionen) des Waldes gewährleisten. Nachhaltigkeit kann als langfristiges Ziel der Forstwirtschaft nur in einer multifunktionalen Forstwirtschaft erreicht werden auf der Basis eines ökologischen, naturnahen Waldbaues. Die Erhaltung bzw. Wiederbegründung ökologisch stabiler, artenreicher und möglichst mehrstufiger Mischbestände ist eine unentbehrliche Voraussetzung zur Sicherung und Erweiterung der vielfältigen Funktionen des Waldes.

Laut Forstgesetz muß der Wald in Polen planmäßig und nachhaltig auf der Basis der Forsteinrichtungswerke bewirtschaftet werden. Als langfristige Ziele nachhaltiger Forstwirtschaft, die in Forsteinrichtungswerken berücksichtigt werden, gelten vor allem:
- Exakte Standortserkundung, d.h. die Erfassung der aktuellen und potentiellen Produktionsmöglichkeiten,
- Standortgerechte Baumartenwahl, die auch den Ansprüchen der biologischen Vielfalt entspricht,
- Verzicht auf Kahlschlag wo es möglich und sinnvoll ist, bzw eine wesentliche Begrenzung der Abtriebsflächen,
--Förderung der Naturverjüngung,
- Intensive Bestandespflege,
- Zielbewußte und immissionsbedingte Waldumwandlung.

Eine multifunktionale Forstwirtschaft, d.h. die Sicherung der vielfältigen Funktionen des Waldes, kann keineswegs ein Verzicht auf Holzproduktion zufolge haben. Die primäre Aufgabe des Waldes als nachhaltige Rohstoffquelle hat aus ökologischen und ökonomischen Gründen nicht an Bedeutung verloren, obwohl die materiellen und immateriellen Leistungen des Waldes gegenwärtig und in der Zukunft stetig und optimal gewährleistet werden müßen.

NACHHALTIGE FORSTLICHE BEWIRTSCHAFTUNGIN POLEN

1.Ziele und gesetzliche Grundlagen nachhaltiger forstlicher Bewirtschaftung

Die Walderhaltung ist aus ökologischen und ökonomischen Gründen zweifelsohne eine vorrangige Aufgabe der Forstpolitik und Forstwirtschaft. Der Begriff Nachhaltigkeit wurde geschichtlich gesehen verschieden definiert und verstanden - immer aber galt die Walderhaltung und dessen Leistungen als vorrangiges Ziel.
Nachhaltige Forstwirtschaft wird in Polen gegenwärtig als Nutzung des Waldes verstanden, die den künftigen Generationen möglichst gleichwertige, vielseitige Nutzungsmöglichkeiten sowohl im Bereich Holznutzung als auch hinsinchtlich der Wohlfahrtswirkungen (Schutz - und Erholungsfunktionen) des Waldes garantieren. Nachhaltigkeit im Forstbetrieb bedeutet also im Grunde genommen die Sicherung der natürlichen Bedingungen der Reproduktion des Waldes und seiner vielseitigen Leistungsmöglichkeiten (Funktionen) mit Berücksichtigung der Ansprüche der Gesellschaft, die sehr oft dem Wandel unterworfen sind. Die Sicherung des Nachhaltigkeitsprinzip, d.h. die Sicherung der vielseitigen Leistungen (Funktionen) des Waldes in allen Besitzarten ist eindeutig im polnischen Forstgesetz (1) geregelt. Aufgrunddessen ist der Waldbesitzer verpflichtet seinen Wald zum Wohle der Allgemeinheit nach forstlichen und landespflegerischen Grundsätzen nachhaltig, ordnungsgemäß, sachkundig, möglichst naturnah und planmäßig auf der Basis der Forsteinrichtungswerke (mittelfristige Forstplanung) im Staatswald bzw. Betriebsgutachten im Privatwald zu bewirtschaften und zu schützen.
Das staatliche Eingreifen im Privatwald hat bestimmte Grenzen, die das Waldeigentum respektieren, anderseits aber kann ein uneingeschränktes Bewirtschaften nicht in Frage kommen.

Die eindeutig im polnischen Forstgesetz formulierten Ziele der Forstwirtschaft können nur durch eine möglichst naturnahe Waldwirtschaft realisiert und erreicht werden. Eine wesentliche und unentbehrliche Voraussetzung zur Sicherung der vielseitigen Leistungen (Funktionen) des Waldes ist also die Erhaltung bzw. Wiederbegründung standortgerechter, ökologisch stabiler, artenreicher und möglichst mehrstufiger Bestände.

2.Voraussetzungen nachhaltiger Forstwirtschaft

2.1.Erfassung der aktuellen und potentiellen Produktionsmöglichkeiten - exakte Standortserkundung

Die Erfassung der gegenwärtigen und potentiellen Produktionsmöglichkeiten sowie der natürlichen Umweltbedingungen ist eine wesentliche Entscheidungsgrundlage für eine rationelle und umweltbewußte Forstwirtschaft. Die Standorterkundung und

Standortkartierung - für einen Zeitraum von 50 Jahren - wird von Spezialisten durchgeführt aufgrund von Analysen mechanischer und chemischer Eigenschaften entsprechender Bodenschichten und mit Hilfe von Bestockungs - und Vegetationsanalysen unter Berücksichtigung des Geländewasserhaushaltes.
Die Ausscheidung des aktuellen und potentiellen Standortstyps erfolgt also aufgrund der Standortsmerkmalsanalyse (Lage, Klima, Boden, Bestockung, Vegetation und Wasserhaushalt). Die Kenntnis ökologischer Produktionsgrundlagen ist eine unentbehrliche Voraussetzung für eine optimale Erfüllung der vielfältigen Funktionen des Waldes und jede zielgerichtete Planung und Realisierung waldbaulicher Maßnahmen.

Die Ausscheidung potentieller Standorttypen (Produktionsmöglichkeiten) gilt auch als praktischer Hinweis zur Umwandlung nicht standortgerechter und leistungsschwacher Bestockungen (Bestände)

2.2 Standortgerechte Baumartenwahl

Eine standortgerechte Baumartenwahl gilt als vorrangiges Ziel bei Walderneuerungen und Waldumwandlungen. Sie ist zweifelsohne ein Schwerpunkt betrieblicher und überbetrieblicher waldbaulicher Planung. Die Baumartenwahl muß aber außer Standortsgerechtigkeit die landespflegerischen Bedürfnisse berücksichtigen. Das immer wachsende Umweltbewußtsein der Öffentlichkeit hat dazu beigetragen, daß die standorts - und waldfunktionsgerechte betriebliche Einzelplanung auch die großräumigen Zielvorstellungen und planerischen Überlegungen verwirklichen muß.

Die ökologischen Gesichtspunkte bei der Baumartenwahl stehen nicht - langfristig gesehen - im Gegensatz zu den ökonomischen,denn Ökologie ist kultivierte Ökonomie. Im Leistungsbereich verschiedener Standorttypen können vorgegebene waldbauliche Ziele in Bestandesstruktur und Bestandesaufbau erreicht werden. Meist stehen mehrere standortgemäße Baumarten und Mischungen aus ökologischen und ökonomischen Gründen zur Auswahl (z.B. Buche oder Eiche).

Bei waldbaulichen Maßnahmen, die von schaderregenden Faktoren diktiert werden, besonders aber bei immissionsbedingter Wiederaufforstung und Waldumwandlung aufgrund großer Immissionsbelastung, wird die Baumartenwahl den konkreten Verhältnissen angepaßt. Die Palette der im Rahmen der immissionsbedingten Wiederaufforstungen und Waldumwandlungen angebrachten Baumarten - vor allem Laubbaumarten - wird bewußt möglichst groß gehalten um das Produktionsrisiko abzuschwächen.

Eine standortgerechte bzw. immissionsbedingte Baumartenwahl erfüllt zweifelsohne die Ansprüche biologischer Vielfalt.

3. Die wichtigsten Aufgaben einer nachhaltiger forstlicher Bewirtschaftung

3.1 Verzicht auf Kahlschlag

Die ökologischen Nachteile - besonders bei größeren Kahlschlägen - sind bekannt, denn sie verursachen drastische Veränderungen im

Wasser - und Strahlungshaushalt und führen zu einer schnellen Humusmineralisierung. Ein Verzicht auf Kahlschlag kann aber nicht gesetzlich geregelt und schematisch realisiert werden. Bei bestimmten Standort - und Bestockungsverhältnissen ist ein Kahlschlag unentbehrlich (z. B. Kiefermonokulturen auf armen Standorten). Eine besonders Rolle spielt aber die maximale Kahlschlagfläche. Sie darf in Wirtschaftswäldern nicht 6 ha überschreiten, in Schutzwäldern dagegen 2 ha.

Die Zwangsnutzungen, die von Schadfaktoren diktiert werden, d.h. bei immissionsbedingten Nutzungen, bei Schneebruch, Waldbrandschäden usw. wird und muß der Kahlschlag angewendet werden und deren Größe (Fläche) wird vom Schadausmaß bestimmt. Verzicht auf Kahlschlag - obwohl es ökologisch sinnvoll ist - kann also praktisch genommen nur dort realisiert werden wo es möglich ist. Jede Nutzungsform muß eine natürliche oder künstliche Verjungung gewährleisten. Die praktische Realisierung des Kahlschlagverzichts ist also nicht immer einfach. Die Nutzung der gleichaltrigen, einstufigen Bestände auf relativ schwachen Standorten, die in Polen vorwiegend vorhanden sind, kann nur allmählich - wo es Standort - und Bestockungsverhältnisse erlauben - auf kahlschlaglose Verjüngung umgestellt werden. Es muß unbedingt im Einzelfall entschieden werden wie man gleichaltrige, für den Schirmschlag im lockeren Verband nicht vorbereitete reine Nadelbaumbestände (vor allem Fichte) kahlschlaglos verjüngern kann. Ein schematisches Generalkonzept kann keinesfalls in Frage kommen. Langfristig gesehen muß der Kahlschlagverzicht aus ökologischen und ökonomischen Gründen ein vorrangiges Ziel beim ökologischen Waldbau sein.

3.2 Föderung der Naturverjüngung

Wo immer es möglich und sinnvoll ist wird Naturverjüngung bevorzugt. Verzicht auf Kahlschlag und konsequente Anwendung der Naturverjüngung sind langfristig Ziel der nachhaltigen Forstwirtschaft in Polen. Der dadurch bedingte ökologischer Vorteil entspricht auch einem ökonomischen Vorteil aufgrund der größeren Stabilität der naturverjüngten Bestände.

Die Naturverjüngung ist mit Verjüngungsmethoden ((-verfahren) verbunden die Zeiträume von 20-50 und mehr Jahren beanspruchen. Die Form und die Intensität der Nutzung der Altbestände, die die Naturverjüngung ermöglichen soll, darf keinesfalls schematisch durchgeführt werden. Außerordentlich wichtig, als rationelle Vorraussetzung einer Naturverjüngung, ist die autochthone Herkunft und technische Qualität der Altbestände.

Viele Möglichkeiten - wie bereits praktisch bewiesen wurde - bietet die Naturverjüngung der Kiefer bei unterschiedlichen und relativ kurzen Verjüngungszeiträumen. Die Naturverjüngung der Kiefer wird konsequent gefördert, denn die Kiefer als Hauptbaumart in Polen nimmt 71% der gesamten Fläche des Staatswaldes ein (im Privatwald ca 80%) auf relativ schwachen Standorten.

Kahlschlaglose Verjüngung wird gegenwärtig auf 30% der gasamten Waldfläche realisiert. Als langfristiges Ziel gilt eine kahlschlaglose Bewirtschaftung auf 60-70% der gesamten Waldfläche. Auf ca 30% der Waldfläche kann ein Kahlschlagverzicht aus standort - und immissionsbedingten Gründen sowie aufgrund der vorhandenen Bestockungen und Gefährdung der Wälder durch Schaderreger (Insekten, Pilze, Schneebruch, Waldbrände usw) nicht realisiert werden.

Die eindeutige Förderung der Naturverjüngung entspricht den Bedingungen des ökologischen Waldbaus und läßt eine höhere Betriebssicherheit erwarten.

3.3 Intensive Bestandespflege

Ein wichtiger Faktor nachhaltiger Forstwirtschaft ist eine intensive Bestandespflege. Zielgerechte Bestandespflege ist zwar - insbesondere in jüngeren Altersklassen - eine kostspielige Maßnahme auf die aber aus Gründen der Ökologie, vor allem aber der Betriebssicherheit, nicht verzichtet werden kann. Trotzdem aber sind relativ große Rückstände bei der Durchforstung jüngerer Bestände (vorwiegend in der II Altersklasse) zu verzeichnen, die besorgniserregend sind und katastrophale Konsequenzen haben können (z.b. großflächiger Schneebruch - und Schneedruck). Als Ursache der pflegerischen Rückstände gelten vor allem die Schwierigkeiten bei der Vermarktung von Schwachholzsortimenten und davon abhängigen finanziellen Schwierigkeiten, die sich bei der Selbstfinanzierung der Forstwirtschaft aus waldbaulicher Sicht aufgrund des großen Pflegebedarfs besonders ungünstig auswirken.

Besonders wichtig und unentbehrlich ist eine intensive Jungbestandespflege in den von Immissionsschadstoffen bedrohten Beständen. Je stabiler der Einzelbaum, desto stabiler der Bestand.

Die Bestandespflege wird im Rahmen der Vornutzung realisiert. Alle im Forsteinrichtungswerk geplanten Pflegemaßnahmen (Läuterung, Durchforstung) sind flächenmäßig obligatorisch für einen 10-jährigen Zeitraum, der Vornutzungshiebsatz dagegen kann nicht als verbindlich betrachtet werden. Eine exakte Herleitung der Masse bei Pflegemaßnahmen für einen 10-jährigen Planungszeitraum ist am Anfang der mittelfristigen Planungsperiode praktisch unmöglich. Die jährliche Planung der Vornutzung muß also den konkreten pflegerischen und forstschutzlichen Bedürfnissen der Bestände entsprechen.

3.4 Genressourcenerhaltung und Saatguternte

Genressourcenerhaltung und Saatguternte ist eine wichtige Voraussetzung eines ökologischen, naturnahen Waldbaus und nachhaltiger Forstwirtschaft. Die wertvollsten Populationen (Bestände), deren Herkunft eindeutig nachgewiesen wurde, wurden als "Anerkannte Samenbestände" ausgewiesen. Außerdem wurden "Wirtschaftsamenbestände" ausgewiesen, die zwar eine relaliv gute Qualität (Vitalität, Schaftform usw) ausweisen aber nicht den strengen Kriterien der "Anerkannten Samenbeständen" entsprechen. Das Ziel aller in "Anerkannten- und Wirtschaftsamenbeständen" durchgeführten Wirtschaftsmaßnahmen ist eine Förderung der Fruktifizierung. Die Saatguternte in Wirtschaftsamenbeständen ist mit der Endnutzung verkoppelt. In "Anerkannten Samenbeständen" sind Plusbäume ausgewählt worden die vor allem zur Propfreisergewinnug dienen.

Um die sehr oft vorkommenden Engpässe bei der Saatgutversorgung zu vermeiden wurden für die Hauptwirtschaftsbaumarten Erhaltungssamenplantagen, d.h. Klonsamenplantagen mit gepropften Pflanzen sowie auch generative Samenplantagen angelegt. Außerdem wurden technische Möglichkeiten zur mehrjährigen Saatguteinlagerung der Buche, Eiche und anderen Baumarten geschaft.

Die bisher durchgeführten Maßnahmen zur Genressourcenerhaltung entsprechen den Bedürfnissen der polnischen Forstwirtschaft und sind folgende :

Merkmale	Bezeich -nung	Inge-samt	Davon Hauptwirtschaftsbaumarten							
			Ki	Fi	Ta	Lä	SEi	Bu	Bi	RErl
Anerkannte Samenbestände	ha	13350	5500	1910	1120	360	1780	1740	170	365
Plusbäume	Zahl	4890	2550	401	130	778	35	25	150	118
Klonsamenplantagen	ha	528	280	28	-	156	-	-	22	-
Generative Samenplantagen	ha	370	200	-	-	114	-	-	7	-
Erhatungsbestände in situ und ex situ	ha	15300	12190	1500	177	244	609	295	-	23
Wirtschaftsamenbestäne	ha	225100	163775	13990	5050	634	14145	16652	2600	6700

3.5 Holznutzung

Eine multifunktionale Forstwirtschaft, d.h. die Sicherung der vielseitigen Leistungen (Funktionen) des Waldes kann keineswegs ein Verzicht auf Holzproduktion zufolge haben. Die primäre Aufgabe des Waldes als nachhaltige Rohstoffquelle hat aus ökologischen und ökonomischen Gründen nicht an Bedeutung verloren, obwohl die materiellen und immateriellen Leistungen des Waldes gegenwärtig und in der Zukunft stetig und optimal gewährleistet werden müßen. Holz ist und bleibt - dank seiner Eigenschaften - aus technischen und gesundheitlichen Gründen ein begehrter, erneuerbarer und umweltfreundlicher Rohstoff, der auch zur Ernergiegewinnung genutzt werden kann.

Die Menge und Struktur der Holznutzung (End - und Vornutzung, Sortimente) wird laut Forstgesetz im Forsteinrichtungswerk auf Forstamtsebene bzw. im entsprechenden Gutachten im Privatwald für einen 10-jährigen Zeitraum festgelegt. Verbindlich bei der jährlichen Planung der Endnutzung ist der 10-jährige Endnutzungshiebsatz. In den einzelnen Jahren der mittelfristigen Planung kann der Hiebsatz vom jährlichen, durchschnittlichen Hiebsatz abweichen zwecks Berücksichtigung der Holzmarktentwicklung und Zwangsnutzungen infolge antrophogener, biotischer und abiotischer Schäden. Auf dieser Weise ist die Flexibilität bei der jährlichen Endnutzungsplanung garantiert. Eine größere Vornutzung als die, die schätzungweise im Vornutzunghiebsatz empfolen wird, die aber den waldbaulichen, forstschutz - und immissionsbedingten Bedürfnissen entspricht, muß bei der Nutzung hiebsreicher Bestände berücksichtigt (kompensiert) werden.

Der Anteil der gesamten Nutzung (Vor - und Endnutzung) beträgt ca 65% des laufenden Derbholzzuwachses. Das garantiert die Sicherung der natürlichen Bedingungen der Reproduktion des Waldes und seiner vielseitigen Leistungen.

3.6 Waldumwandlung

Eine Wiederbegründung ökologisch stabiler, artenreicher und möglichst mehrstufiger Mischbestände kann im Grunde genommen nur im Zuge der Waldumwandlung erreicht werden. Bei der Waldumwandlung unterscheiden wir einen beschleunigten, immissionsbedingten und einen langfristigen Waldumbau der nicht standortgerechten Bestände.

3.6.1 Immissionsbedingte Zwangswaldumwandlung

Die relativ starke Immissionsbelastung, (SO_2, NO_x, u.a.) insbesondere in den Gebirgshochlagen, verursacht ein großflächiges Waldsterben. Die Wiederaufforstung erfolgt zwangsweise in äußerst extremen klimatischen Voraussetzungen und ungünstigen Bodenverhältnissen. Die Palette der angebrachten Baumarten - vor allemLaubbaumarten wie Buche, Bergahorn, Birke, Eberesche, Grauerle u.a. wird bewußt möglichst groß gehalten. Auch die Fichte autochthoner Herkunft wird gefördert (30-40%). Als besonders geeignet bei der Umwandlung immissionsgeschädigten Gebirgswäldern hat sich die Lärche (Larix europea) bewiesen. Die biologische Vielfalt der eingebrachten Baumarten bei immissionsbedingten Wiederaufforstungen ist besonders in Gebirgshochlagen ein wesentlicher Faktor zur Risikominderung der Wiederaufforstung. Die Versuche, durch gezielte Auslese und Züchtung die Immissionstoleranz der Baumarten zu steigern haben bisher nur sehr begrenzte Erfolge gebracht und sind bei hoher Immissionsbelastung als problematisch zu bewerten.

3.6.2 Immissionsbedingte, vorbeugende Waldumwandlung

Der Gebirgswald ist nicht nur in den Hochlagen gefährdet. In den mittleren Höhenlagen (600-800 m), die großflächig in den Sudeten mit gleichaltrigen, vielfach hiebsreichen und vorwiegend nicht autochthoner Fichtenbestände bestockt sind, sind Symptome des Waldsterbens schon eindeutig erkennbar. Ansichtlich diesen Tatsache ist eine vorbeugende Waldumwandlung aus zeitlichen und räumlichen Gründen zweckmäßig um einem großflächigen Waldsterben vorzubeugen und seine Konsequenzen so viel wie möglich zu mildern.

Die Umwandlung der großflächigen Fichtenbestände in den mittleren Höhenlagen wird in verschiedenen Verfahren durchgeführt, u. a. im Blender - und Saumschlag. Die Säume werden nach sorgfältiger Bodenbearbeitung mit standortgerechten Baumarten aufgeforstet. In den verbliebenen Bestandesteilen wird intensiv durchforstet und an aufgelichteten Stellen werden standortgerechte Laubbaumarten gepflanzt bzw gesät (z. B. Birke). Nach ca 10 Jahren werden die Säume im Sinne der räumlichen Ordnung fortgesetz. Die mikroklimatischen Bedingungen und Lichtverhältnisse der unter dem Schirm des Altbestandes gepflanzten Laubbaumarten werden durch gezielte und individuell gesteuerte Bewirtschaftungsmaßnahmen (Durchforstung) geregelt. Dieses experimental angewendete Verfahren hat bisher positive Ergebnisse gebracht; es ermöglicht eine begrenzte, aber notwendige Gestaltung des Waldgefüges und die Umwandlung der real gefährdeten reinen und nicht autochthoner Fichtenbestände.

3.6.3 Waldumwandlung nicht standortgerechter Bestockungen
Sie wird langfristig mit verschiedenen waldbaulichen Verfahren - vor allem aber durch Voranbau und Unterbau realisiert. In die infolge von biotischen, abiotischen und anderen Schaderregern verlichteten Bestände verschiedener Altersklassen werden standortgerechte, vor allem Laubbaumarten wie Buche, Eiche, Linde unter Schutz des vorhandenen Bestandes eingebracht. Bei stark verlichteten Beständen älterer Altersklassen gilt der Unterbau als gezielte Maßnahme zur standortgerechten Walderneuerung.

4. Beispiele praktischer Förderung der naturnahen, ausgewogenen Waldwirtschaft

Obwohl die Forstwirtschaft in der Vergangenheit und auch gegenwärtig im Grunde genommen als ökologisches Handeln bewertet werden muß, wurden in den Staatsforsten praktische Maßnahmen eingeleitet zwecks komplexer Realisierung einer naturnahen Waldwirtschaft. Auf Erlaß des Generaldirektors der Staatsforsten vom 19.11.1994 wurden 7 Wald-Förderungskomplexe, d. i. möglichst naturnahe Waldkomplexe, ausgeschieden.(2) Sie gelten als Musterbetriebe einer naturnahen Waldwirtschaft und haben folgende Ziele und Aufgaben :

1) Vielseitige Erkundung des Ökosystems Wald und seines Entwicklungstrends
2) Erhaltung bzw. Wiederbegründung eines möglichst naturnahen Waldes auf der Basis einer ökologischen Waldwirtschaft
3) Harmonisierung der Bedürfnisse und Interessen der Forstwirtschaft und des Naturschutzes
4) Förderung einer multifunktionaler Forstwirtschaft mit Hilfe von Förderungsmitteln aus dem In- und Ausland
5) Realisierung entsprechender Versuchs- und Forschungsprogranmme und Verbreitung deren Ergebnisse in den Staatsforsten
6) Aus- und Fortbildung des Forstpersonals und Aufklärung der Bevölkerung im Bereich Ökologie

Die Verteilung und Fläche der 7 ausgeschiedenen Wald - Förderungskomplexe ist folgende :

Lfd Nr	Lokalisation	Fläche - ha
1	Białowieża Heide	56452
2	Tuchola Heide	82475
3	Waldkomplex Gostynin - Włocławek	49589
4	Kozienice Heide	46065
5	Waldkomplex Janów Lubelski	31348
6	Niederschlesische Heide	32020
7	Waldkomplex Schlesische Beskiden	39763
Insgesamt		333712

In allen Wald - Förderungskomplexen wurden Beratungsausschüße ins Leben gerufen in denen Wissenschaftler, Forstleute, Komunalpolitiker, Vertreter der Naturschutzverbände u.a. vertreten sind.

Zusammenfassend kann festgestellt werden, daß eine ökologische, naturnahe und ausgewogene Waldwirtschaft alle Erwartungen einer nachhaltigen Waldwirtschaft erfüllt.

Quellennachweis

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Heuristics for Financially Rationalizing Forest Management

Abstract Proceedings of the XX IUFRO World Congress *

Ben Holtman

Formulation of a single stand optimum prescription in an industrial forest is a complex task and includes consideration of forest growth, harvest/conversion plans and non-timber or public values. Total property conditions may also play a significant role. For example, deviations from single acre optimum strategies may be required because of wood flow and/or financial requirements over time. Finally, external events provide additional opportunities/ challenges to development of the forest management plan, e.g., product price or substitution trends, regulatory changes, etc. Therefore, the optimum forest management strategy at any point in time includes a wide range of possible paths -- depending on how events external to the forest may unfold. In this paper, heuristics useful in adjusting forest treatment and harvest prescriptions are described.

* Paper not available

CHARACTERISTICS OF WELL-FORMULATED DYNAMIC PROGRAMMING NETWORKS

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SUMMARY

Dynamic programming is a well established technique for solving the optimal rotation length and stand density problem. However, dynamic programming suffers from the need to discretize the solution network. This is due to the fact that most implementations of dynamic programming use transformation vector and return functions, that are, either separately or in combination, non-differentiable. Thus, discrete stage and state dynamic programs are used to approach the problem. As the stage and state intervals become smaller, and thus better approximate a differentiable solution network, the entire formulation suffers from the need to model intractably large numbers of states and the formulation is unsolvable with current computational technology. In standard forward-recursive dynamic programming formulations that use state neighborhoods, all entering paths to a particular state neighborhood or interval are compared and the entering path with the greatest accumulated value is the only one stored. Using such a discretized dynamic programming network, paths with potentially higher future values may be discarded. This investigation examines behavior of dynamic programming formulations, with special emphasis on intra-neighborhood selection of "winning" paths. The intra-neighborhood behavior will be related to the overall problem formulation, and can provide indication of poorly defined discrete solution networks.

Keywords: Dynamic programming, forest economics, optimization

INTRODUCTION

Dynamic programming (DP) has been a useful numerical analysis tool in forest management. One of its more common uses is determining optimal stand management strategies such as thinning timing, thinning intensity, and final harvest rotation length (Brodie and Kao 1979, Kao and Brodie 1980, Haight et al. 1985, Arthaud and Klemperer 1988, and Valsta 1990). Although both forward and backward recursion methods are both valid, forward recursion has been most often used due to its ability to consider multiple rotation lengths with one iteration, non-generation of infeasible nodes, and growth of the network in parallel with growth of the stand. Also common in the aforementioned articles is discretization of nodes. Although it may be possible to develop a truly continuous state DP formulation (Chen et al. 1980) creation of discrete node spaces, "neighborhood storage" per Brodie and Kao (1979), is a useful method to decompose the DP network into separable sub-problems. The overall DP is then solved through step-by-step solution of the sub-problems (stages).

Problems associated with discretization of the response network may lead suboptimality from artifacts. As long as neighborhood storage is used, then there are going to be cases of where paths that may have produced quality solutions are discarded. The principle of optimality states that decisions made at one point in the DP will remain optimal at future states (Bellman and Dreyfus 1962). With decisions in forward recursion DP being made based only on accumulated value, there is no guarantee that chosen paths will remain globally optimal in future states.

CHARACTERISTICS OF STATES, STAGES, AND THE ENTIRE NETWORK

In formulating a dynamic programming network, it is imperative to initially analyze the biological aspects and management constraints of the problem. Questions need to be considered, such as:

> What type of growth model is being used? What are the important parameters needed to move the stand state from one stage to the next? What types of management activities will be modeled? Are all biologically feasible options being considered? Are there aspects of the problem that can help eliminate the consideration of certain options, thereby decreasing the complexity of the overall network?

If the DP problem is discrete, decisions on state and stage interval sizes will need to be made. State intervals should be small enough in size that paths competing for the node are similar enough to be considered equally. Stage size should track the timeframe of decision-making. If harvest schedules are set to occur annually, then single-year stage intervals may be appropriate. If the type of stand being modeled is a slow-growing, long rotation type then larger stage intervals may be suitable.

To illustrate these concepts, and upcoming discussion of states, stages, and overall formulation it is helpful to use an example. Consider the case of a forward recursion, discrete-state, DP network for loblolly pine (*Pinus taeda*) in the southern United States. Loblolly pine is a fast growing species with financial rotation ages varying between 20 and 50 years depending upon financial assumptions and type of product being produced. Financial assumptions, model parameters, and model constraints for a base case are found in Table 1. This is a problem that will find the optimal timing and level of stand thinning, and optimal rotation age for the given site conditions. This problem is formulated as a two state (basal area and stem density), one stage (age interval) DP. Discounted net present value (NPV) is the criteria being used to compare alternatives. Note that stage interval is set at 1 year. For a short-lived investment this may be quite appropriate. State are of a fixed size and represent a small increments of the expected range of values. Thinning is done from below and has certain minimum constraints on time of first thin, state variables, and thinning removals.

Table 1. Economic parameters, model parameters, and model constraints for base case.

Parameter or constraint type	Parameter or constraint value
Alternative rate of return	4%
Thinned wood price	90% of complete harvest price
Fixed thinning cost	\$124/ha
Establishment cost	\$124 plus \$0.03/seedling
Pulpwood price	\$11.70/m^3
Sawtimber price	\$59.00/m^3
Site index	18.3 m at age 25 yr
Planting density	1730 trees/ha
Stage intervals	1 year
State intervals	1.15 m^2/ha basal area and 12.4 trees/ha
Thinning increments	1.15 m^2/ha basal area
Thinning type	low (from below)
Minimum thinning removal	8.5 m^3 and 10% of total stand volume
Allowed post-thinning states	minimum of 247 trees/ha and 4.61 m^2/ha basal area
Minimum age for first thin	10 years

Figure 1 illustrates how the network expands and contracts over the stages. Higher (2220 trees/ha) and lower (1240 trees/ha) planting densities are also shown. As the stand grows, basal area increases and the possible valid thinning options increase. This leads to an increase in the number of network nodes. At some point (around stage 25) the network begins to decrease in size. This is due to tree mortality reducing the number of possible stem density states, while the number of possible basal area states has peaked. The decision to set minimum retention values, particularly for trees per acre, will influence at what point this DP problem size reduction occurs. In this particular case, the minimum level for trees per acre was instituted to remain within the range of data from which the loblolly pine growth algorithm was developed. These growth dynamics also impact the number of paths competing at nodes, as seen in Figure 2.

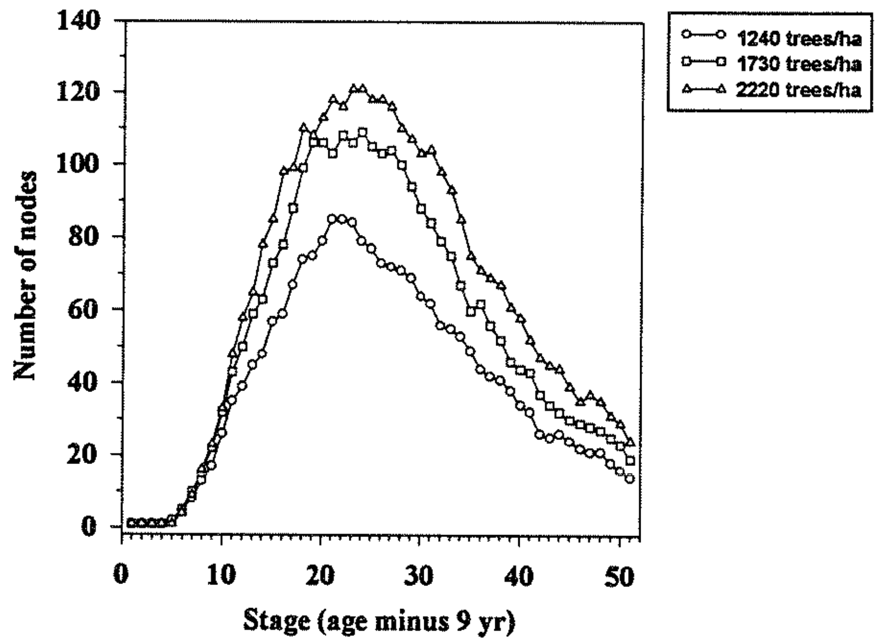

Figure 1. Number of nodes, over time, for differing planting densities.

Similar patterns for number of nodes, and paths per node can also be observed with increases or decreases in state or stage interval sizes. Obviously, larger state or stage intervals will reduce the problem size. As discussed earlier, the interval sizes should be determined appropriate for the given problem. Because interval size impacts may vary over the network, variable size classes should be considered. For example, if a difference of 1 m^2/ha basal area (BA) at stage 10 had a larger impact on eventual NPV than at a later stage (such as 30), then state interval size could increase as stage increased. Further work is needed to understand such relationships.

The example presented does not guarantee an optimal solution. In fact, the solution for the DP presented has a resulting NPV ($1615.69/ha) that is lower than one found when the stage interval was changed from 1 year to 5 years ($1635.90/ha). Figure 3 illustrates the node were the two solutions deviated. At the node (stage 14), only two paths competed for the node in the single year stage formulation. In the 5 year stage formulation, there was only one path that led to the node (the upper entering path in the figure). Because the lower entering path has a higher accumulated value ($190.98), then it is chosen to represent the node in future stages. If these two paths were allowed to grow to the optimal rotation age (35 years) the upper node would generate an overall NPV (as stated) of $1635.90. This would exceed the $1615.69 NPV of the lower node. In this case, the NPV found in the single year stage solution is at least 1.3 percent below the truly optimal solution. Accumulated value, as used in the forward-recursion DP, may be a small component of overall stand NPV. Making decisions on path selection based on this small portion can impact the overall NPV solution.

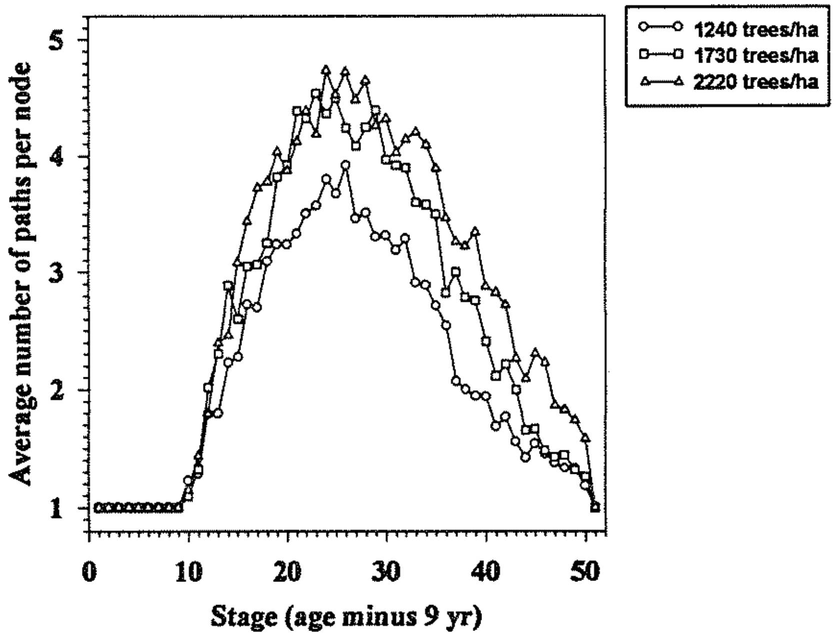

Figure 2. Number of paths per node, over time, for differing planting densities.

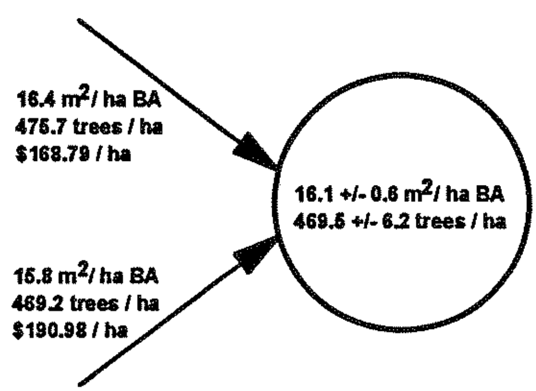

Figure 3. The competing path for a node at year 23 (stage 14) for the base case assumption DP network.

If the position within node was insignificant, we might expect the chosen path position within the node to be evenly distributed across the node neighborhood. Figure 4 shows the proportion of paths entering the node over 5 classes (each representing 20% of the neighborhood range). A proportional number of paths seemed to enter each class. There seemed to be some bias for selecting nodes with fewer trees per acre (chosen) when compared to all entering paths (all). A Wilcoxon rank-sum test on the two data set found significant difference between the distribution of all paths and those chosen at α=0.05. For all paths, 51% were below node center while 54% of those paths chosen were below node center. This might make sense since paths with fewer trees would be the result of a relatively heavier thinning at some time. Heavier thinnings would likely generate larger profits and result in larger accumulated NPV's.

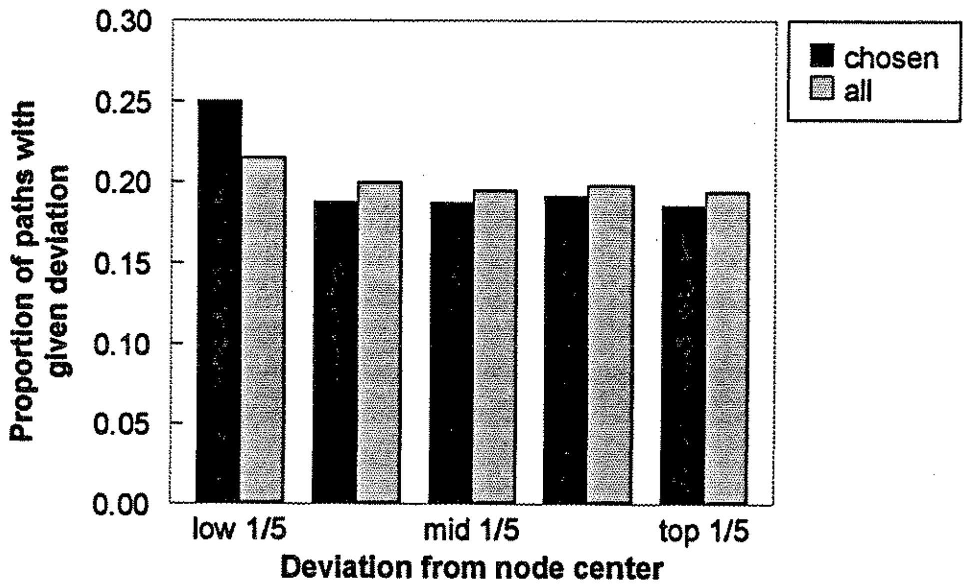

Figure 4. Proportion of paths falling within node stem density neighborhood range quintiles, both all nodes competing and those chosen to represent nodes.

In Figure 5, the large number of paths that enter the center of the node neighborhood is quite apparent. This is due to the fact that thinnings are applied to the center of the node BA neighborhood. A lesser proportion of paths with center values is chosen compared to those present. This is likely explained by the fact that many paths are generated through multiple thinnings that may not be very desirable (lower NPV's). While there seems to be some skewness in all paths entering towards higher BA's, the chosen paths tended to be biased towards choosing lower BA paths (the ratio of chosen paths to all paths at lower BA's is much larger than at higher BA's). A Wilcoxon rank-sum test on all paths and those chosen found significant differences between the data sets at α=0.01. For non-node center values, 36% of all paths fell below node center, while 52% of chosen paths were below node center. As with stem density, this is most likely due to heavier thinnings (more BA removal) generating larger accumulated NPV's.

As was shown in Figure 3, a node path with a larger BA might be expected to produce a larger value in later stages of the network. Fewer trees might also be beneficial. Given the choice of two possible states within a node, one having the largest acceptable BA and lowest acceptable stem density, the other having the lowest acceptable BA and highest acceptable stem density, we might expect the former to have a higher value at final harvest than the latter. The appropriate choice at a node then would seem to rest, not only on the accumulated NPV of paths, but on the NPV potential of paths in future stages.

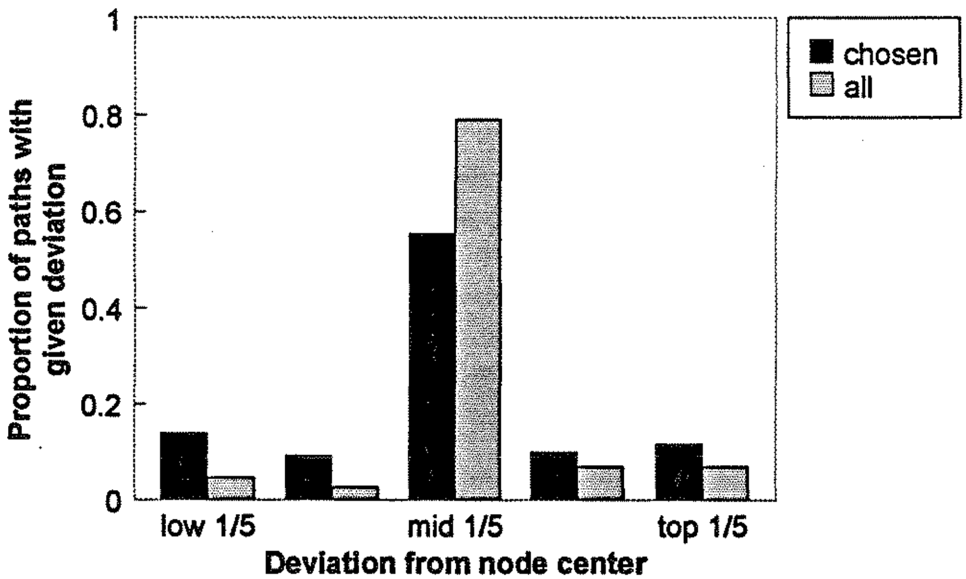

Figure 5. Proportion of paths (all nodes competing and those chosen) falling within node basal area neighborhood range quintiles.

CONCLUSION

Dynamic programming is a valuable tool for optimizing forest stand treatments. Care should be taken to configure the individual application to minimize problems associated with state class intervals, "neighborhoods." In the application presented here, when compared to all entering paths, both lower basal area and lower trees per acre were selected as continuation paths in the DP formulation. To overcome this problem, future value can be considered. Methods such as PATH (Yoshimoto et al. 1988) and A* (Arthaud and Pelkki 1995) present valid alternatives to traditional forward recursion DP. In the end, well formulated DP networks come about from knowledge of incorporated growth and yield models, understanding of intra-nodal dynamics, and sensitivity analysis of model parameters.

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EVALUATING PINE PLANTATION RESPONSES TO MANAGEMENT USING DYNAMIC PROGRAMING

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SUMMARY

The dynamic programing software NESTER (NEighborhood STate EvaluatoR) determined optimal management schemes for shortleaf pine (*Pinus echinata*) in the Central United States. NESTER uses the GROW subroutine from the TWIGS growth projection system to project individual tree lists in a discrete-state, discrete-stage, forward-recursive dynamic programing network. Sensitivity to planting density, site quality, thinning types, intensity, thinning costs, stage interval and stumpage prices are examined under deterministic stumpage prices. Multiple simulations under stochastic stumpage prices are investigated to determine if robust management schemes can be developed that do well under a variety of conditions.

Key words: stochastic dynamic programing, timber management

INTRODUCTION

Shortleaf pine (*Pinus echinata*) is the most widely distributed of all southern yellow pines in the United States with a range of more than one million square kilometers (Lawson and Kitchens, 1983). Shortleaf pine consists of over one-fifth of the southern pine growing stock in the United States (McWilliams, 1987).

Field studies of shortleaf pine have found its growth to be responsive to changes in density (Brinkman et al, 1965; Rogers and Brinkman, 1965; Gingrich et al, 1965), even quite late in the rotation. Both thinning from above and thinning from below are biologically and economically feasible. Economic questions related to different thinning strategies have not been completely resolved by field studies; therefore, a simulation approach is well suited for this species.

METHODS

The NESTER (NEighborhood STorage EvaluatoR) software uses a discrete-state, discrete-stage forward recursive dynamic programing search technique (Dykstra, 1984) to explore a network of possible stand states defined through various combinations of state variables and state neighborhoods (Brodie and Kao, 1979). Stand age is the stage variable. The objective function seeks to maximize stand soil expectation value (SEV). The variables that define the network are not restricted to including state variables for every constraint relating state and decision variables. Thus, the neighborhoods must be carefully tested to avoid violating the principle of optimality (Nemhauser, 1966). The growth projections are made through an individual-tree growth model (Miner et al, 1988). A complete description of NESTER can be found in Pelkki (1995).

Six initial stand states for planted shortleaf pine were obtained through Bailey and Smalley (1974). Planting densities ranged from 1854 to 4942 trees/ha in 618 trees/ha intervals. Parameters for a seventh planting density of 1236 trees/ha were extrapolated to test densities that have become more common in southern pine plantations today (Caulfield, et al, 1992).

Planting and site preparation costs were estimated from regionwide averages (Belli, et al, 1993). Stumpage prices for sawtimber and pulpwood were determined using reports from Timber Mart South and set at $125 per MBF International ¼ inch rule (~ 36.25/m^3) and $22 per standard cord (~ 9.84/m^3). Harvest costs were modeled using a $98.84/ha fixed entry cost for all harvests. Thinning stumpage prices were penalized 15%, and pre-merchantable stems were cut at a "cost" 10% of their pulpwood stumpage price. The baseline case assumed no real stumpage price changes in the future and a 4% interest rate was applied to future cash flows.

The state network was defined using basal area and average stand diameter variables. The state intervals for these variables were set at 0.23 m^2/ha and 0.51 cm, respectively. From previous research (Pelkki, 1995), smaller state intervals did not increase the value of the objective function.

NESTER simultaneously simulated thinning from above, below, and mechanical thinning of a stand. The baseline case examined five levels of each thinning type at intensities ranging from 10 to 50 percent of initial basal area.

The stage interval for the baseline case was 2 years. Site quality for the baseline case was 15.24 m at 25 years.

Sensitivity analyses were completed via departures from the baseline case. Site quality was varied from 9.14 m to 18.29 m at 50 years. Planting density was varied to measure the opportunity costs of planting at densities other than the optimal density found in the baseline run. The stage interval was varied from 1 to 10 years to determine sensitivity to the timing of actions. Thinning strategies were tested to see how the objective function responded when forced to thin using only one or two of the three available strategies. Sensitivities to interest rates from 2% to 10% were tested. A real price increase of 1.25% per year on all products was tested. Sensitivity analysis for sawtimber stumpage prices was done. Finally, simulations using stochastic prices with a real price increase of 1.25% per year were completed.

RESULTS

The baseline case determined an optimal planting density of 1236 trees/ha and a rotation length of 44 years. Two thins were included in the rotation, a thin from below at age 20 (30% of the basal area), and a thin from above at age 28 (30% of the basal area). The soil expectation value (SEV) of this management scenario is $541.1/ha. Comparing volume production to an unthinned simulation (Figure 1) we see that total cumulative net volume production declines with thinning, but SEV increases ~25%.

In all simulations, planting at the lowest density tested was found to yield the highest SEV. Increasing density to 1854 trees/ha reduced the SEV by $103.3/ha, and increasing density beyond 3706 trees/ha resulted in a negative SEV (Figure 2).

In the baseline case, both thinning from above and below were used. When the simulation was restricted from using thinning from below, the SEV dropped to $537.4/ha(-1%). The rotation length increased to 60 years. When the simulation was restricted from thinning from above, the SEV dropped to $534.0/ha (-1.3%), and the rotation was shortened to 42 years. Restricting the simulation to only mechanical thinning resulted in an SEV of $502.6/ha (-7.1%). In this case, there was no thinning at all, and the rotation was shortened to 34 years. Thus, the best combination of thinning increased SEV 7.7% ($502.6 to $541.1).

While the elimination of thinning did not severely affect SEV, it did change the distribution of products derived from the rotation. At all site indices, elimination of thinning reduced mean annual production of sawtimber from 9% to 37% per year. In unthinned stands, the volume production shifted to pulpwood.

Returns are insensitive to timing of actions within 5 years. A stage interval of 1 year resulted in an SEV of $541.4/ha, and a 5-year stage interval resulted in an SEV of $540.4/ha. Even a 10-year range on management actions only resulted in an SEV of $519.4/ha(-4%). In each case, the rotations were identical, only the timing of the actions changed.

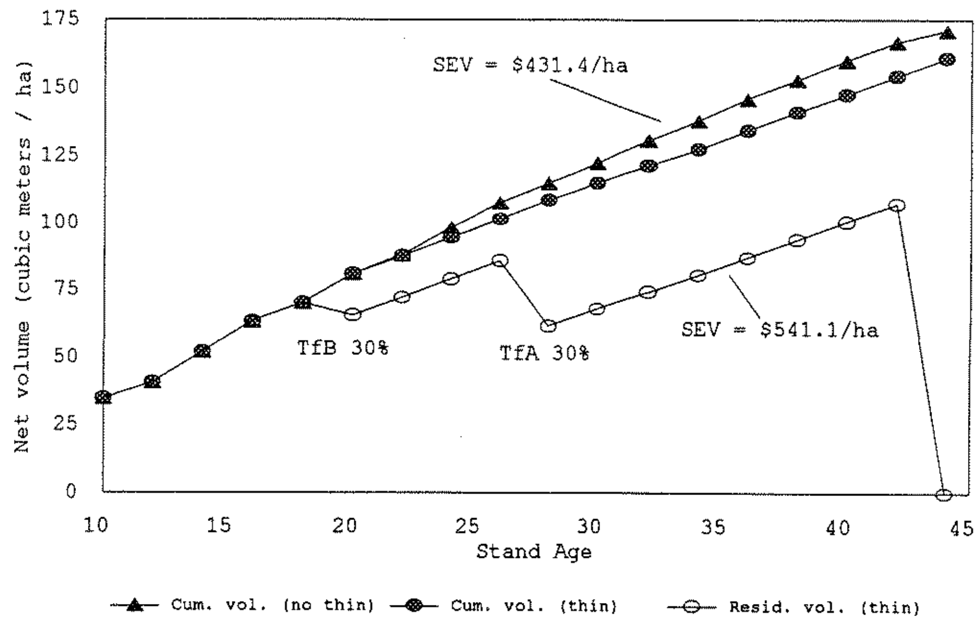

Figure 1. Volume production for shortleaf pine baseline run vs. unthinned rotation, SI = 15.24 m

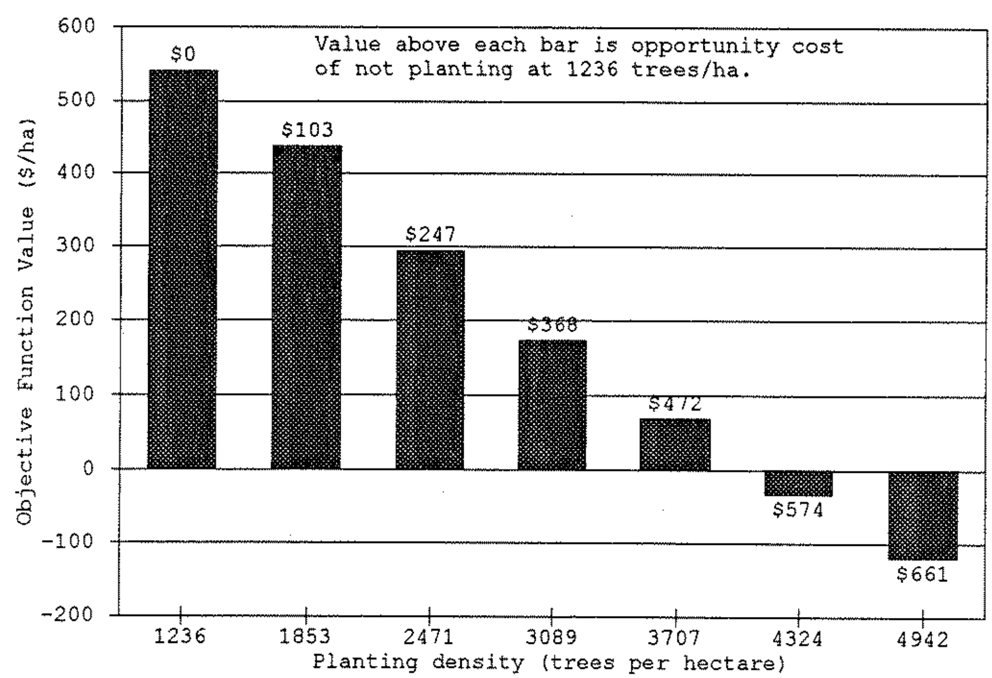

Figure 2. Sensitivity of objective function to planting density (SI = 15.24 m)

SEV was very sensitive to site index(figure 3). Lower site indices resulted in longer rotations and a change in thinning strategy to thinning only from above. High site indices resulted in shorter rotations and thinning only from below.

Sensitivity to interest rates is show in figure 4. At rates greater than 9%, no management scheme was found to produce a positive SEV. Increasing rates from 2% to 10% shortened rotation lengths from 48 years (ARR=2%) to 22 years (ARR=7% to 10%). At interest rates greater than 5%, there was no thinning.

Sawtimber prices were varied to determine the effect on the management scheme and SEV (figure 5). Varying sawtimber prices from \$34.5 to \$46.4/m^3 had no effect on the baseline management scheme. Increasing the stumpage price beyond \$46.4/m^3 lengthened the rotation to 60 years and changed the thinning strategy to multiple thinnings from above. Decreasing the sawtimber stumpage price below \$34.5/m^3 changed the timing of the thinnings slightly, but did not change the rotation length. Decreasing prices further first changed the thinning strategy to only one thin from below (\$32.5/$m^{3)}$ and finally to no thinning (\$29/m^3). Further decreases result in shorter rotations, eventually to a rotation length of 24 years(\$21.8/m^3).

When a real price increase of 1.25% per year was applied, the SEV rose to \$959.5/ha. The rotation length increased to 66 years. If thinning from above is not allowed, the rotation is shortened to 48 years, with an SEV of \$882.6/ha.

The timber prices for the ten stochastic price simulations are shown in figure 6. The heavy black line is the deterministic 1.25% per year real price increase, and the other price series are the price series used by each of the stochastic simulations. The average rotation age for the simulations was 62 years (52 - 74 years). The average SEV returned was \$1047.7/ha (\$741.3 to \$1448/ha). The stochastic simulations had no "future knowledge" of the increases or decreases in the sawtimber prices: the decisions made at each stage were based on stand conditions and current prices. In all the cases, thinning from above was used extensively, a few cases did utilize thinning from below, but those were associated with temporary declining or level price trends. Thinning intensity centered in the 20%-30% range, with a few thins as high as 40% of the basal area.

DISCUSSION/CONCLUSION

For shortleaf pine management, lower planting densities appear to yield the highest returns. The strategy of thinning from above appears to be worthwhile as previous research has shown response to release even in mature stands. However, thinning from above extends the rotation length, while no thinning or below thinning maintains a much shorter rotation with

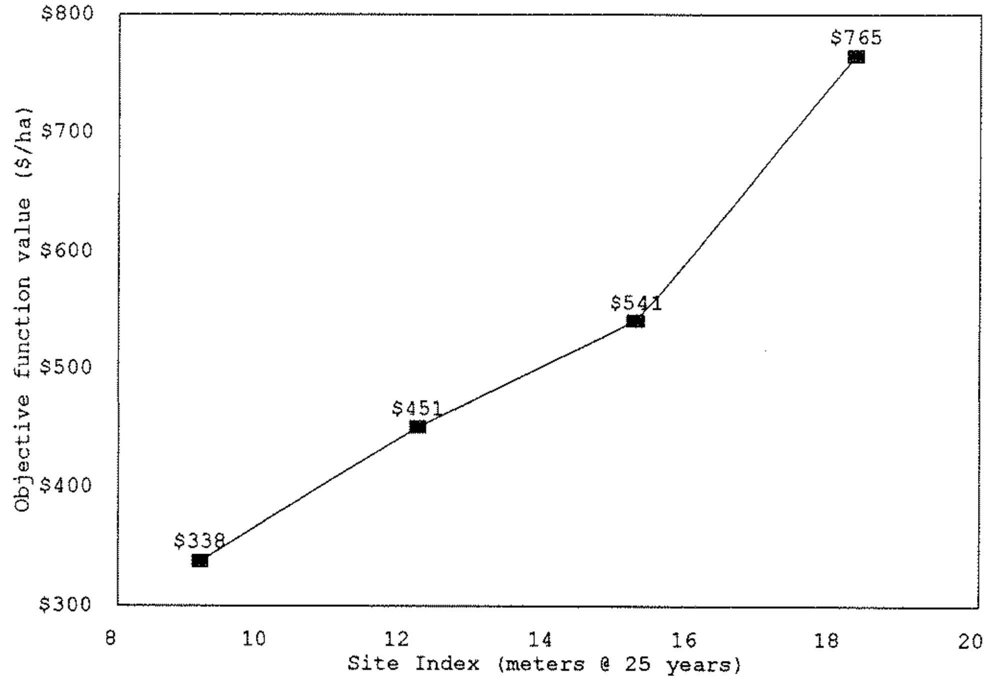

Figure 3. Sensitivity of objective function to site index

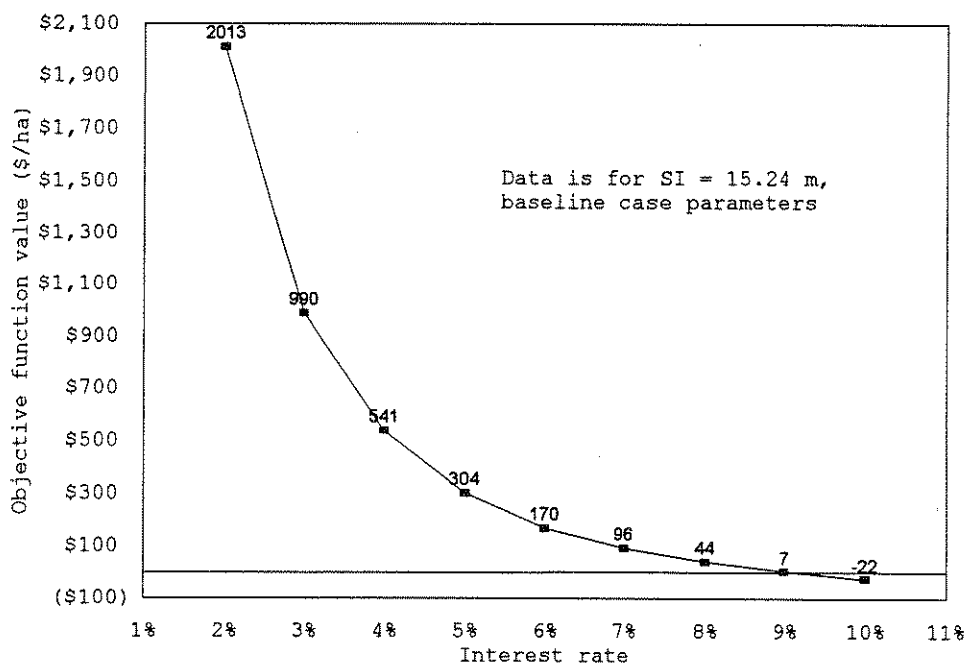

Figure 4. Sensitivity of objective function to interest rate

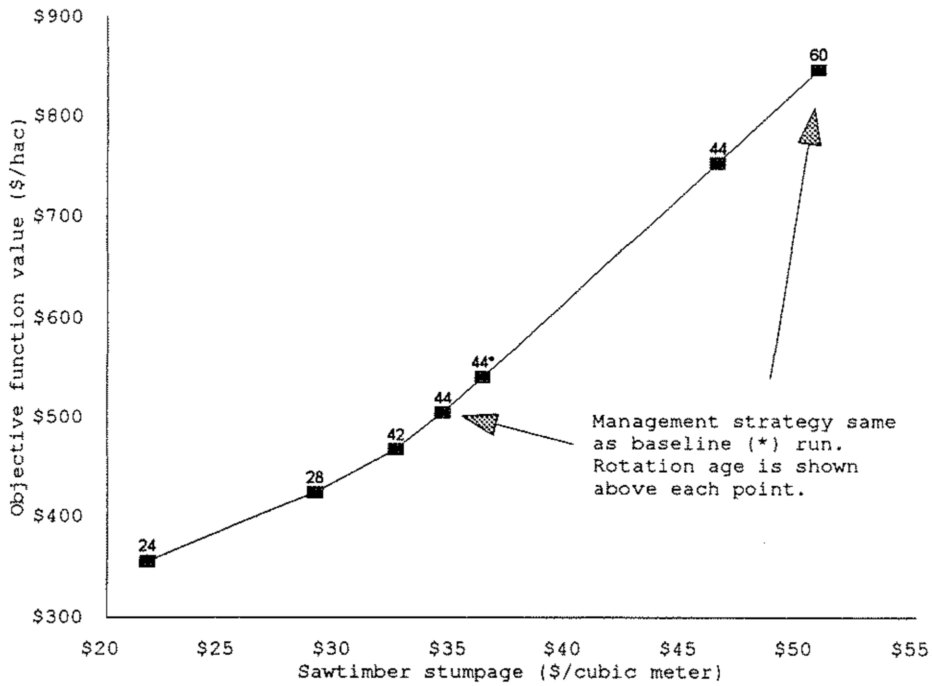

Figure 5. Rotation sensitivity to sawtimber

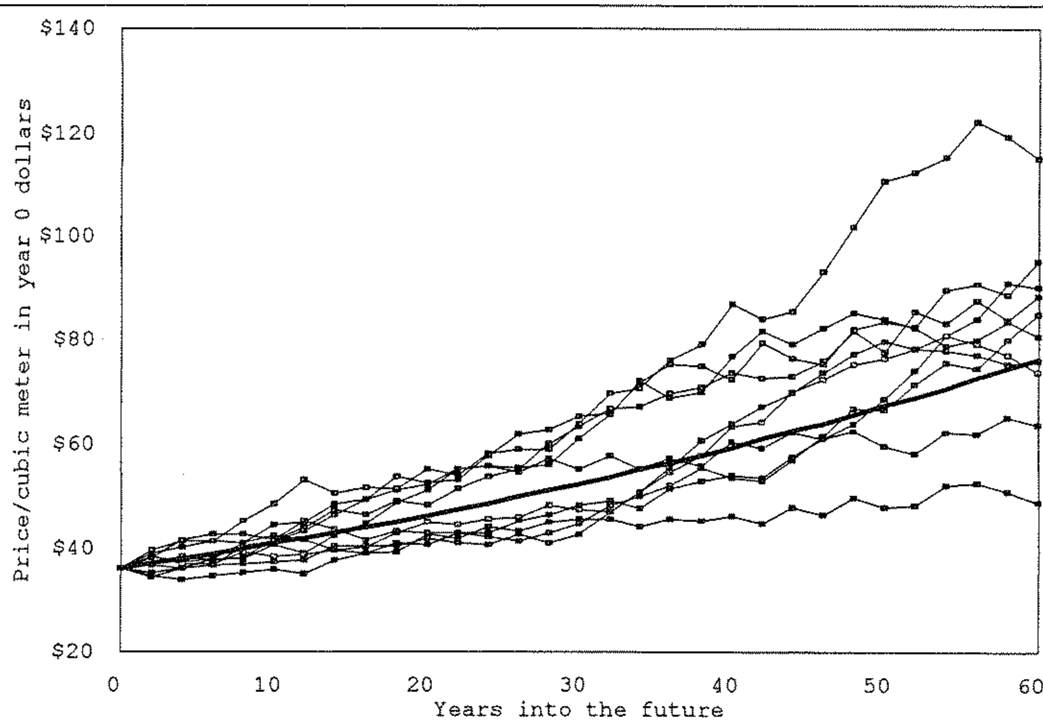

Figure 6. Simulated sawtimber stumpage prices
(mean 1.25%/year real price increase)

only a minor impact on the SEV. However no thinning does reduce sawtimber yields, especially on high quality sites.

If long rotation lengths are desirable from an ecosystem management viewpoint, and the risk from fire, insects, and disease is acceptable, thinning from above is a strategy that appears to protect financial returns in long rotations.

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IMPACT OF LOCAL GOVERNMENT FORESTRY-RELATED ORDINANCES AFFECTING HARVESTING IN THE EASTERN UNITED STATES

Christopher E. Martus, Harry L. Haney, Jr. and William C. Siegel[1]

Abstract. --In three northeastern and three southern states 748 loggers and consultants were surveyed. In the Northeast, the importance of regulation is limited by low levels of forest activity and small forested acreage. But in the South, large timber acreage and active markets magnified the importance of local regulation. Loggers and consultants reported examples of costly requirements, but most local laws were not viewed as burdensome. The results show that local forestry laws currently impose less of a burden than their absolute number would suggest.

INTRODUCTION

Local governments[2] have become increasingly active in regulating forestry activities in the United States over the last decade. Several important studies have been conducted on this subject, but most have focused on the scope and distribution of local forest laws, and have provided little insight into their impact on loggers, pulpwood operators and forest landowners. A study concluded in August of 1992 identified 493 local governments who had enacted over 520 local forestry-related ordinances (Martus 1992). The ordinances cover a wide variety of activities ranging from harvesting and silvicultural operations to hauling forest products on local roads.

The benefits and costs of local forest ordinances have received little formal analysis. Most, if not all, of the information on this subject is anecdotal in nature. By many accounts, the cost of local regulation to loggers and landowners can be significant, and in some cases, extremely burdensome (Pennsylvania Township News 1990, Salazar 1985). Similarly, improperly conducted forestry activities can represent significant costs to local governments

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[2] Local government applies to all levels of political administration below the state level, such as, counties, cities, towns, townships, boroughs and some forms of special government

in terms of environmental degradation or destruction to local roads (Hill 1990, Wolfgram 1984). Unfortunately, most of the analysis on this subject provides little empirical evidence on the magnitude of these values.

Several noteworthy studies have estimated the cost of compliance with federal environmental legislation and state forest practice regulation. These studies have little applicability, however, for determining the cost of compliance with local forestry ordinances. State regulations are, for the most part, consistent and uniform within geographic regions. By contrast, local regulation generally implies a large number of dissimilar forest laws, which differ greatly in their regulatory provisions, levels of enforcement and tenure (Goodfellow and Lea 1985, Harberger 1986, Perschel 1984, Provencher and Lassoie 1982, Sheay 1985, Smith 1991, Youell 1984). The prospect of learning the nuances of dozens of local laws within an operating area may impose a greater psychological burden on loggers and landowners than actually complying with the laws' provisions.

Some authors have suggested that the impact of local timber harvesting ordinances will not be borne by the logger, but exclusively by the landowner who receives reduced timber prices. Higher operating cost to loggers, it is argued, will eventually be translated into lower stumpage prices (Pennsylvania Township News 1990, Goodfellow and Lea 1985, Provencher and Lassoie 1982, Smith 1990). This argument assumes certain elasticity conditions. For the landowner to bear the entire burden, stumpage supply must be perfectly inelastic or timber demand must be perfectly elastic in the regulated areas. The validity of these assumptions has not been fully examined.

Communities must also consider that they may realize unwanted costs, if forestry activities are unregulated. Improperly conducted forestry operations can result in environmental degradation or the destruction of public property which undoubtedly imposes a cost on society (Brinson 1990, Cubbage 1989, Hill 1990, Pollack 1987, Wolfgram 1984). Theoretically, regulation should only act to bring such forestry operational costs in line with the unfavorable costs that these operations impose on society, that is, internalize the diseconomies. Moreover, the cost of local forest laws to loggers and landowners must be examined in the context of the benefits they cause to accrue to society. This point has been conspicuously overlooked by virtually all of the literature on this subject, perhaps due to the difficulty of estimating the benefits.

In many cases the impact of local forestry laws has been equated with their number, irrespective of the level of forestry activity or the quality or quantity of the forest resource. Although this conclusion seems intuitive, it may be false. The number of ordinances, regardless of their requirements, will have little relevance if concentrated in areas containing small quantities of merchantable timber or weak resource markets. The purpose of this paper is to describe the regulatory variables affecting forestry and to place their values in the proper context.

METHODS

Mail surveys of loggers and forest consultants were the primary tool used in this study. The survey of loggers, pulpwood operators and forest consultants was distributed to 748 individuals in six states.

The surveyed states were Connecticut, New York, and Pennsylvania in the Northeast and Georgia, Louisiana and Virginia in the Southeast. These states contained a large number of ordinances and were generally representative of other states within their respective regions. Participants were chosen on the basis of the ZIP code of their business address. The ZIP codes of all local governments having laws enumerated in the 1992 study (Martus 1992) were collected to create a list of postal delivery zones which contained forestry ordinances. ZIP codes of counties and municipalities with multiple delivery zones were determined using the U.S. Postal Service's National Five-Digit Directory (National Address Information Center 1992). ZIP code information was matched to the addresses listed for "timber harvesters" in the Directory of the Forest Products Industry (DFPI 1990) to create a list of loggers and pulpwood operators who may have been exposed to local forestry-related ordinances. All timber harvesting professionals with business ZIP codes matching those of regulated localities were included in the sample.

A sample of forestry consultants was similarly constructed using lists obtained from state forestry or natural resource agencies (Eastern Connecticut Landowners Association 1991, Pennsylvania Department of Environmental Resources 1991, New York State Department of Conservation 1990, Georgia Forestry Commission 1990, Virginia Department of Forestry 1991).

The survey of loggers and forest consultants contained several sections. In the first, participants were asked to rank "common" regulatory provisions on an ordinal scale of "costliness". Requirements identified in at least twenty percent of the ordinances in each region were considered "common". A different set of requirements was created for each region based on differences in the included states' statutes.

Participants estimated the costliness of complying with each of the listed requirements. The scale of "costliness" ranged from one to four as follows: (1) extremely difficult or costly to implement; (2) difficult or costly to implement; (3) moderately difficult or costly to implement and (4) easily implemented at little cost. A fifth category permitted responses of no opinion or no comment. The number of responses by rank were collapsed to two rankings to facilitate analysis. Categories (1) and (2) were combined to create a category of "high" cost or difficulty of compliance. Categories (3) and (4) were combined to indicate a "low" cost or difficulty of compliance. "No opinion" rankings were omitted. This dichotomy was used to determine whether a significant number of respondents viewed each common requirement as "costly" or "not costly". The rankings did not represent financial costs per se but rather reflected the relative burden of complying with regulatory provisions. In the second section, participants were asked if they had actually encountered each common requirement. Finally, in the third section, they were requested to comment on the scope and importance of state and local forest regulatory laws.

The methodology for the mail survey was based on the principles outlined by D.A. Dillman (Dillman 1978). An initial mailing containing a survey and cover letter was sent to each participant. One week after this mailing a postcard was sent to the participants reminding them of the survey and asking them to complete it, if they had not yet done so. The final mailing was distributed to non-respondents three weeks after sending the post card. This mailing consisted of a more adamant cover letter and an additional survey form.

Surveys were distributed to 254 loggers and pulpwood operators and 188 forest consultants in the South and to 191 loggers and pulpwood operators and 115 consultants in the northeastern United States. Surveys were returned from seventy-five (30%) loggers and pulpwood operators and 119 (63%) consultants in the South and from seventy-five (39%) loggers and pulpwood operators and seventy-four (64%) consultants in the Northeast.

RESULTS AND DISCUSSION

The surveys sampled the attitudes of the forestry community toward local forest regulation. They were designed to obtain an estimate of the "perceived" cost of the most common regulatory provisions. The purpose of the survey instrument was not to determine the benefits and costs of local forest regulation, but to define some of the factors which characterize these variables. Survey results are presented by region.

Northeastern Region

Survey results based on responses from loggers and pulpwood operators in the Northeast are shown in Table 1. The number of respondents who ranked the regulatory provisions as extremely difficult or costly to implement, or difficult or costly to implement are shown in column one by rank category. In column two number of the respondents are shown who ranked the regulatory provisions moderately difficult, or costly or easily implemented at little cost. The chi-square test of significance is shown in column three and in the fourth column are responses arranged into three categories: requirements are ranked as "high" cost by a significant number of respondents; requirements are ranked as "low" cost by a significant number of respondents; and requirements are indeterminate, in which case counts of rankings did not differ significantly.

Requirements for harvesting permits, restrictions on the time of operations, and guidelines for the use of culvert and bridges were viewed as "high" cost provisions by a significant number of respondents. Local notification, requirements for performance bonds, buffer standards and management plans were ranked as "high" cost provisions by a majority of respondents; however, these relationships were not statistically significant. Similarly, requirements for road clearing, best management practices and road retirements were viewed as "low" cost provisions by a significant number of respondents.

Of the eleven common provisions identified, only six were statistically significant, with three ranked in the "high" cost category (Table 1). For the most part, common requirements in the Northeast are not viewed as overly burdensome by a majority of loggers and pulpwood operators. One reason for this may be that many of the provisions of local laws are consistent with common operating procedures. Loggers who adhere to best management practices, clear roads of debris, and retire forest roads as a matter of practice will not view ordinances which impose these requirements as costly. Although unreasonable and costly provisions do exist, many requirements simply reinforce common practices. The most "costly" provisions are those which are peculiar; such as, obtaining harvesting permits which can take up to thirty days to be approved, or restrictions on operations during certain times of the day.

The percentage of logger respondents who have actually encountered these provisions are surprisingly low, particularly because the surveys were targeted at individuals residing in areas subject to local forest ordinances. Requirements for the posting of performance bonds, the retirement of forest roads, the use of culverts at road crossings, and the clearing of roads and rights-of-way were the more frequently encountered provisions. They were experienced by seventy-two, sixty-seven, sixty-four and fifty-three percent of logger respondents, respectively. Most regulatory provisions were encountered by less than 60 percent of the logger respondents.

Forestry consultants viewed six categories of regulatory provisions as significantly "low" cost requirements (Table 2). Permit requirements and harvest selection guidelines were the only provisions associated with a "high" cost of compliance by a majority of consultants. However, neither of these relationships were statistically significant. Consultants generally viewed the provisions of local laws as being much less burdensome than did loggers. This is a fairly logical finding, since consultants generally do not have to adhere to these provisions. Forestry consultants may have a vested interest in local regulation when forest management plans and permit processes developed by professional foresters are required. That is, local laws may be perceived as creating business opportunities for forestry consultants. Similar results have been identified in California. California's Z'berg-Nejedly Forest Practice Act requires the participation of consultants in all stages of the management process (Shaffer 1991). The idea that forest consultants benefit from the adoption of local laws is reflected in the following comment of a consultant from New York, "...regulation helps the private consultants, but will be the end of the mom and pop logging operation".

The proportion of forest consultants who have experienced these provisions is similar to the proportion of loggers. Requirements for performance bonds, forest road retirement and the use of culverts were cited by both groups as the most frequently encountered local requirements. The remaining provisions were encountered of less than sixty percent of all respondents. The percentage of consultants was slightly higher, which is most likely due to the fact that many local laws require their services.

Southern Region

Logger and pulpwood operator rankings for the South are shown in Table 3. Six categories of common requirements were identified as "high" cost provisions by a significant number of respondents. These included harvesting permits, performance bonds, local notification, and management plans. Buffer zones and best management practice requirements were the only provisions ranked as "low cost" by a majority of loggers. Neither of these rankings were statistically significant.

The most commonly experienced provisions involved best management practices, retirement of forest roads, prohibitions on hauling during wet periods, buffer requirements, gravel mat requirements and performance bonds.

Several of the most commonly encountered local provisions such as adherence to best management practices, road retirement, and buffer requirements were ranked as "low cost" provisions by a majority of respondents. Presumably, these requirements are familiar and consistent with common operating procedure; therefore, they can be implemented at relatively little cost.

Fundamentally different conclusions can be drawn by comparing responses of loggers in the Northeast and the South. With regard to the provisions which are common to both regions (best management practices, performance bonds, permits and management plans), larger proportions of southern loggers ranked them as "high" cost requirements than did northern loggers. This is most likely attributable to the differing traditional attitudes toward land use and regulation in the two regions. The northern United States has a much longer tradition of environmental activism and regulation as compared to the South (Roland 1975). Northern loggers accustomed to higher levels of environmental regulation will generally perceive local forest laws as less burdensome than would a southern logger who has typically experienced little regulation.

The cost rankings for common provisions for forest consultant respondents in the southern region is shown in Table 4. Requirements for management plans, performance bonds, the installation of culverts, and the notification of local governments of operations were viewed as "low" cost provisions by a significant number of consultants. These same provisions were ranked as "high" cost requirements by a significant number of loggers and pulpwood operators. In addition, the requirement of a management plan, approved by a professional forester, was viewed as a "high" cost provision by sixty-nine percent of loggers surveyed. This same provision was ranked in the "low" cost category by sixty-four percent of forest consultants. Provisions for adherence to best management practices, prohibitions against hauling, and requirements for stream crossings are the most commonly encountered provisions reported by southern consultants. In most cases less than 60 percent of southern loggers and consultants have experienced these provisions.

SUMMARY AND CONCLUSIONS

The impact of local forest ordinances on loggers and forest landowners is determined by a large number of factors, including the stringency of the regulatory provisions, and local resource and market conditions. This impact can only be evaluated within the context of the benefits that these laws accrue to society. Forest ordinances should act to internalize social costs which are not accounted for by the market (negative externalities); however, estimating these values was beyond the scope of this analysis. Rather the study examined the costliness of certain common local regulatory provisions.

Most common requirements of local ordinances were not viewed as costly by a significant number of respondents. Requirements for forest road retirement, adherence to best management practices, and buffer zones were not viewed as overly burdensome. Many of these requirements simply reinforce commonly conducted practices. Although examples of costly requirements do exist, most provisions are not singularly burdensome.

Perceptions of costliness by loggers and forest consultants differ dramatically. Loggers consistently ranked common requirements as more costly to comply with than did forest consultants. Consultants generally do not have to adhere to the requirements of local laws. In addition, consultants may actually benefit from local ordinances which require their participation in management plan or harvest permit review processes. Attitudes of respondents in the northeastern and southern regions also differed. Southern respondents consistently ranked requirements as more costly than did their northern counterparts. Differing traditions of environmental regulation and contrasting methods of production are the primary reasons for this variation.

The impact of local forestry ordinances is determined by many factors, including the stringency and the distribution of regulation, and the market and resource conditions of regulated areas. The influence of local forestry laws is also defined by the quantity and quality of the resource, the burden of requirements, and the level of forestry activity. This study indicates that local forestry ordinances generally impose less of a burden than their absolute number would suggest.

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Table 1. Survey results for loggers by rank category, northeastern region[a]

Common regulatory provisions	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square (X^2)	Rank category
Harvesting permits required, approval of which can take up to 30 days	61	12	32.89	"High" Cost
Forest activities cannot be conducted between 5 p.m. and 7 a.m.	53	18	17.25	
Stream can only be crossed with culvert	49	24	8.56	
Local officials must be notified 48 hours before operations begin or end	40	31	1.14	indeter-minate
Performance bonds required	40	35	.33	
Buffers of 100 feet required along roads, streams, lakes and property lines	40	35	.33	
Management plans approved by a professional forester required	39	35	.22	
Harvesting must be by selection, openings cannot exceed 7500 square feet	38	27	1.86	

[a] $X^2_{df=1} = 3.838379; \alpha = .05$

Roads and rights-of-way must be cleared of debris daily	29	46	3.85	"Low" Cost
Best management practices required	15	50	18.85	
Forest roads must be properly retired	7	68	49.61	

Table 2. Survey results for consultants by rank category, northeastern region[b]

Common regulatory provisions	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square (X^2)	Rank category
Harvesting permits required, approval of which can take up to 30 days	40	27	2.52	indeter-minate
Harvest must be by selection, openings cannot exceed 7500 square feet	31	35	.24	
Stream can only be crossed with culvert	28	44	3.56	
Buffers of 100 feet required along roads, streams,lakes and property lines	25	46	6.21	"Low" Cost
Forest activities cannot be conducted between 5 p.m. and 7 a.m.	22	40	5.23	
Roads and rights-of-way must be cleared of debris daily	15	58	25.33	
Performance bonds required	14	59	27.74	
Local officials must be notified 48 hours before operations begin or end	13	56	26.8	
Best management practices required	6	62	46.12	

[b] $X^2_{df=1} = 3.838379;\ \alpha = .05$

Management plans approved by a professional forester required	6	65	49.03	
Forest roads must be properly retired	3	70	61.49	

Table 3. Survey results for loggers by rank category, southern region[c]

Common regulatory provisions	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square (X^2)	Rank category
Harvesting permits required, approval of which can take up to 30 days	62	6	46.12	"High" Cost
Performance bonds required	51	21	12.5	
Local officials must be notified 48 hours before operations begin or end	51	23	10.59	
Management plan approved by a professional forester required	50	22	10.89	
Hauling is prohibited when roads are muddy	49	26	7.05	
Culverts must be used to cross streams and ditches	47	26	6.04	
Roads and rights-of-way must be cleared of debris daily	42	33	1.08	indeterminate
Gravel must be installed on haul roads 15 to 25 feet before the intersection with any public road	39	33	.5	
Forest roads must be properly retired	38	37	.013	

[c] $X^2_{df=1} = 3.838379; \alpha = .05$

Buffers of 25 and 50 feet required along roads, streams, lakes and property lines	31	41	1.39	
Best management practices required	30	45	3.0	

Table 4. Survey results for consultants by rank category, southern region[d]

Common regulatory provision	"High" cost rankings (#)	"Low" cost rankings (#)	Chi-square (X^2)	Rank category
Harvesting permits required, approval of which can take up to 30 days	89	21	42.04	"High" Cost
Hauling is prohibited when roads are muddy	63	50	1.45	indeterminate
Buffers of 25 and 50 feet required along roads, streams, lakes and property lines	51	67	2.17	
Roads and rights-of-way must be cleared of debris daily	45	70	5.43	"Low" Cost
Performance bonds required	44	71	6.34	
Local officials must be notified 48 hours before operations begin or end	42	69	6.57	
Forest roads must be properly retired	41	74	9.47	
Culverts must be used to cross streams and ditches	41	77	10.98	
Management plan approved by a professional forester required	41	77	10.98	

[d] $X^2_{df=1} = 3.838379; \alpha = .05$

Gravel must be installed on haul roads 15 to 25 feet before the intersection with any public road	36	75	13.7	
Best management practices required	14	102	66.76	

Easy evaluation of establishment treatments*

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Abstract

The obvious approaches to comparing profitability of competing tree establishment techniques or treatments would require much data on growth, costs, and revenues. This in-depth knowledge is frequently unavailable or unreliable. A simple alternative is presented that often can determine economic viability with little detailed information. Specifically, assuming that an improved method shortens stand development time by δ years, it is shown that a break-even additional relative cost can be computed knowing just δ and the discount rate or internal rate of return.

Introduction

It is frequently necessary to evaluate alternative tree planting or regeneration methods, or soil preparation treatments such as plowing, fertilization, and weed control. The profitability of a "new" technique or treatment has to be compared with that of a "standard" one. An obvious approach would: (a) estimate/simulate the development of a stand under the new and standard treatments using an appropriate model; (b) estimate/calculate the respective costs and revenues; (c) compute the net discounted value, land expectation value, or internal rate of return as a profitability measure; (d) compare, and carry out a sensitivity analysis.

Such an approach, however, requires a great deal of knowledge and detailed data, which may be unavailable or unreliable. In addition, the validity of the conclusions is obscured by the complexity of the procedure. It may be difficult to assess the impact of the various assumptions and estimation errors.

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An alternative is presented here that often can determine the economic viability of a new establishment technique or treatment easily, and with little detailed information on growth, cost, and revenues. The assumptions are discussed first, followed by the main result and an example. The proof and further discussion of the growth assumptions are presented in the Appendices.

An earlier version of this paper was published in Spanish (García 1994a).

Assumptions

Growth

We assume that the *new* establishment method, compared to the *standard* one, causes a temporary increase (or decrease) in the rate of stand development. The magnitude of this change in growth rate may vary in an arbitrary manner over time, provided that the direct effect has vanished before reaching the cutting age. Specifically, let the net revenue in dollars per hectare with the standard method be some function $R(t)$ of the cutting age t. Then, for ages around the optimal rotation, the net revenue with the new method is

$$\overline{R}(t) = R(t + \delta) , \tag{1}$$

where δ is a certain *time gain*. The function $R(t)$ needs not be known, but we assume that an estimate of δ is available.

This model seems reasonable, at least as a first approximation, for treatments that affect the early growth of the trees but do not cause a permanent change in site quality. Initially the growth curves with and without treatment diverge, but when the direct treatment effect disappears trees of similar sizes will have similar growth rates. Note that this does not rule-out a persistent "indirect" effect of the establishment treatment; at any given age the trees will have different sizes and may grow at different rates because of that. The equal growth rates for equal sizes imply that the later portion of the growth (and revenue) curves will differ only by a horizontal time shift δ. A more formal discussion is included in Appendix 2.

Economics

Given an interest rate i, treatments may be compared through the net present value, or the land expectation value (LEV). This is the discounted cash flow, assuming constant prices and not including the land cost, over an infinite number of rotations of optimal length:

$$L = \max_t\{\sum_{k=0}^{\infty} \alpha^{kt}[\alpha^t R(t) - C]\} = \max_t\{\frac{\alpha^t R(t) - C}{1-\alpha^t}\} \qquad (2)$$

(for the standard method), where C is the establishment cost, and $\alpha = 1/(1+i)$ is the discount factor (Faustmann 1995, Leuschner 1990, for example).

Alternatively, the comparison may be in terms of the internal rate of return (IRR), which is the value of i for which the LEV equals the land cost (more precisely, the largest of these i, in case of multiple solutions.) The same equation (2) applies, where now i is interpreted as the IRR, and L as land cost.[1]

As is customary in the textbooks, to simplify the presentation intermediate costs and revenues have not been indicated explicitly in (2). Some care in their treatment is needed to preserve the validity of (1). Ongoing costs and revenues that do not depend of the rotation age (overheads, protection) are considered included in L, as a present value. Those occurring once in the rotation, independently of its length (e. g. respacing), would be discounted and included in C. Those affected by the time gain δ (production thinning) would be capitalized and included in R.

Results

Define the *break-even cost* $\overline{C}$ as the establishment cost for the new method that would give the same LEV (or IRR) as the standard method. Then,

$$\frac{\overline{C} - C}{L + C} = (1+i)^\delta - 1 \; . \qquad (3)$$

This is the break-even additional cost, relative to the value of a just-established stand. The proof is in Appendix 1.

Some values from (3), expressed as percentages, are shown in Table 1. In many instances the information available would be sufficient to make decisions about proposed treatments. At any rate, the simplicity of this relationship makes it easy to explain and to explore through sensitivity analysis the impact of various estimates.

[1]The IRR may not deserve all the "bad press" that it often receives (e. g. Leuschner 1990, Chap. 9). Under the usual assumptions of constant prices, etc., maximizing the LEV maximizes the return per unit area, as would be appropriate if land is the limiting factor. Maximizing the IRR might be preferable if the limiting factor is capital.

Table 1: Break-even relative additional cost (%)

Time gain (years)	Discount rate or IRR (%) 4	6	8	10	15	20
1	4	6	8	10	15	20
2	8	12	17	21	32	44
3	12	19	26	33	52	73
4	17	26	36	46	75	107

Example

It is estimated that certain treatment would result in a gain of two years, compared to current practice. Then, for a discount rate of 8%, Table 1 shows that the new treatment would be profitable if costs do not increase more than 17% of the stand value (land value plus establishment cost).

On the other hand, if it is estimated that the additional cost does not exceed 8% of the value of the stand, it is seen that for the treatment to be profitable it would be sufficient to gain one year in its development.

Appendix 1. Proof

Because of the time invariance assumption, it is clear that the LEV can be written as a sum of the net revenue from the first (optimal-length) rotation and the LEV of the stand left after that, with all quantities discounted to the present. For the standard method:

$$L = \max_t\{\alpha^t R(t) - C + \alpha^t L\} = \max_t\{\alpha^t[R(t) + L]\} - C\,. \qquad (4)$$

(Note that solving for L gives an alternative derivation of (2).) This is valid also for the IRR, with a change in interpretation of L and α (or i).

The break-even cost $\overline{C}$ is the value that gives the same L with the new method (or the same α under the IRR interpretation):

$$\begin{aligned} L &= \max_t\{\alpha^t[\overline{R}(t) + L]\} - \overline{C} = \max_t\{\alpha^t[R(t+\delta) + L]\} - \overline{C} \\ &= \max_t\{\alpha^{t-\delta}[R(t) + L]\} - \overline{C} = \alpha^{-\delta}\max_t\{\alpha^t[R(t) + L]\} - \overline{C}\,. \end{aligned}$$

Solving for $\overline{C}$, and using (4) to eliminate the term containing $R(t)$,

$$\overline{C} = \alpha^{-\delta}(L + C) - L\,,$$

and

$$\overline{C} - C = (\alpha^{-\delta} - 1)(L + C) ,$$

which proves (3).

Appendix 2. Relative growth rates

As in any dynamical system, the development of a forest stand can be modelled by a (local) *transition* function

$$\frac{d\mathbf{x}}{dt} = \mathbf{f}(\mathbf{x}, \mathbf{u}) , \tag{5}$$

and an *output* function

$$\mathbf{y} = \mathbf{g}(\mathbf{x}) \tag{6}$$

(Padulo and Arbib 1974, García 1994b). The *state* vector $\mathbf{x}$ describes time-varying characteristics relevant to the stand development. Its elements can range from a few aggregated variables such as basal area, trees per hectare, and top height, in stand-level growth models, to a list of all the individual tree sizes and spatial coordinates, in distance-dependent models. The *control* vector $\mathbf{u}$ represents silvicultural treatments and other inputs. The *output* vector $\mathbf{y}$ corresponds to quantities of interest such as crop volume and value. Difference instead of differential equations may also be used.

We assume that the effect of the improved establishment method is to alter the initial development rate by some factor, not necessarily constant, and that the (direct) effect vanishes some time before any potential rotation age. That is, (5) becomes

$$\frac{d\mathbf{x}}{dt} = h(t)\mathbf{f}(\mathbf{x}, \mathbf{u}) ,$$

where $h(t)$ can be any function of time such that $h(t) = 1$ for t equal to or greater than the rotation age. We assume further that any silvicultural treatments or other inputs are linked to the state of the stand, so that $\mathbf{u}$ may be a function of $\mathbf{x}$ but not of t.

With these assumptions, the effect of the new (improved) method can be seen as a deformation of the time scale in the early years through the mapping $dt \to h(t)\,dt$. Integration shows that the state of an improved stand at time t equals the state of the standard at an equivalent "physiological time"

$$\int_0^t h(s)\,ds = t + \int_0^t [h(s) - 1]\,ds .$$

The second integrand vanishes before rotation age, its integral reaching some final value δ. Clearly, any outputs from improved and standard stands at rotation age, being functions of $\mathbf{x}$, are related through the substitution $t \to t + \delta$.

Perhaps the most questionable assumption here is that the rates of change of all state variables are altered by the new method in the same degree, through the common factor $h(t)$. In reality, height growth might react differently than diameter growth, for example (Carson and García 1995). However, the approximation is probably sufficient for this type of analysis.

Incidentally, sustained growth differences from genetic improvement, periodic fertilizing, or other treatments causing permanent or long-term changes in site quality, are often modelled as percentage increases in yield and outputs. We would have then $\overline{R}(t) = kR(t)$, but this does not follow naturally from the system-theoretical considerations above. More satisfactory would be to use a constant gain factor $h(t) = k$, giving $\overline{R}(t) = R(kt)$ (García 1994b, Carson and García 1995). No results analogous to those for establishment effects have been obtained for this case.

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FOREST MANAGEMENT EFFICIENCY OF STATE FOREST ENTERPRISES IN LITHUANIA

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SUMMARY

This paper addresses the potential of improving cost effectiveness in the Lithuanian state forest system through analysis of forest management efficiency. During period of centrally planned economy there was not so much of real interest in measuring the efficiency of forest management in Lithuania. In the period of transition to market economy the relative efficiency of management in the state forest enterprises should be evaluated because of the state forest ownership will prevail in this country. Principle of Pareto optimality is introduced as a basic approach for measuring the efficiency of forest management. Such an approach will enable the Ministry of Forestry to decide on a scale of economies and to identify the sources of inefficiency. A system of inputs and outputs for evaluation of efficiency is proposed. The inputs include budget of forest enterprise (Litas, Lithuanian currency unit, per ha, area of forest enterprise, number of employees, growing stock etc.) and timber production (cu m/ha and Litas/ha), profit (Litas/ha) are considered to be outputs. As an illustration the model is applied to measuring the management efficiency of the forty three state forest enterprises in Lithuania based on quite reliable statistical data.

Key words: forest management, efficiency, state forest enterprise.

INTRODUCTION

According to Lithuanian Forest Act adopted 1994 state ownership on the forests shall prevail in Lithuania. It means that privatisation of forest land will not be carried out on a significant scale except the restitution of the property rights on it to the previous owners who managed 25-30% of total forest area in pre-war Lithuania. Meanwhile the process of the restitution is speeding-up as it may be seen from the Fig. 1. "Public owners are usually concerned about the production of recreation opportunity, wildlife habitat, or visual quality, goods and services that do not have well-defined market values, in addition to goods such as timber, that do have a market value" (Davis and Johnson 1987). Three important conditions must be satisfied to permit a particular problem solution declared the most efficient:

a) the problem is completely and uniquely specified in terms of objective function and a set of constraints;

b) all outputs included in the objective function of the problem have comparable units of value;

c) the full feasible region of solutions, including its boundary, is systematically searched to locate the most efficient solution.

A number of attempts have been made to evaluate the management efficiency in forestry. Theoretical background of the problem, conditions for and limitations of successful efficiency analysis in forest management planning are disclosed by Davis and Johnson (1987). Meanwhile mathematical programming has been extended for use as a planning aid to forest management. As a matter of fact this resulted in expanded possibility to start using a set of inputs and outputs instead of the average productivity of labour as the only criterion of efficiency. We were inspired by the idea of Chiang Kao and Yong Chi Yang (1991) that "an ideal method should take all inputs as well as all outputs into account" and that there is no necessity "to compare a weighted output with a weighted input". Concept of Pareto optimality expanded by Farell (1957) served as an approach for provisional study of the management efficiency in the state forest enterprises (SFEs) of Lithuania. The study has been carried out on the basis of numerous and quite reliable statistics from 1994 published by the Minisury of Forestry. This paper is the first attempt to deliver a tool for obtaining evaluations of the relative efficiency of the management accomplishments in the SFEs of independent Lithuania.

FOREST POLITICAL BACKGROUND

At the time being the crucial part of Lithuanian forests (1.8 Mil ha) is managed by 43 state forest enterprises (SFE) supervised by the Ministry of Forestry (Fig. 2). The average area of a SFE is close to 40000 ha.

There are several reasons for keeping state ownership on the forests as a leading property type in Lithuania:

1) traditions of private forestry have been lost during 50 years of Soviet power;

2) current recession in Lithuanian economy, seeking to get "easy-money" on the European roundwood market and neglective attitude to the young native legislation may bring devastative consequences for private forests;

3) forest officers in state forestry managed to sustain and enhance forest resources for diverse benefits in perpetuity;

4) state forest enterprises are aggregated management entities (forest protection + regeneration + fellings + timber extraction + partial timber processing) and that's they are self financing;

5) once privatised the forest land would need a hardly available state funding to set it for public use again in recreational areas to be developed if the welfare of Lithuanian population hopefully were raised.

Forestry Act proclaims the sustainable management and multiple use as the two leading principles in Lithuanian forestry. It means that the timber production is not the only management goal the SFEs are striving on. There are four forest protection classes (FPC) in Lithuanian forests characterised by different management goals and silvicultural systems (Fig. 3). No fellings are permitted in FPC 1 and 2 and the timber production is mainly concentrated in FPC 4 (industrial forests). Forests in Lithuania must produce multiple outputs to meet different demands mostly common to all the countries: timber production, soil conservation and recreation.

All the forest parts (FPCs) must contribute to efficient forest management and vice versa - forest management must promote efficient allocation of leading forest functions and that of budget and work force. "Therefore, an evaluation method which takes this into consideration is needed to identify efficient and beneficial management programs for managing forests, and to enable the top management to know how far a given forest can be expected to increase its output by simply increasing its efficiency" (Chiang Kao and Yong Chi Yang 1991). This is exactly what Lithuanian forestry needs in this transition period to market economy. Under the conditions of centrally planned economy inputs and outputs were subjects to strict planning and so there was not so much of real sense in measuring the efficiency of forest management. The main shortage of forest management plans which used to be delivered to the SFEs by Forest Inventory and Management Planning Institute on a regular basis (every 10 year) was the absence of management efficiency measurement and that of its prediction. Now we still have and we are going to have in the future SFEs but the economical surroundings are quite different and because of that SFEs must change their attitude to the management efficiency to improve resources allocation and to maintain sustainable profitability.

MEASURING EFFICIENCY

The forest managers are mostly interested to estimate the resources to be allocated to promote the highest level of outputs in the management unit concerned. It is not so much complicated task in the case the production frontier $y=f(x)$ is known. Let's suppose there are x inputs describing the situationin a decision making unit (DMU). Maximum output will be $y=f(x_o)$. It means that the efficiency of the point A on the production frontier would be equal to 1. If a DMU was able to reach just point B below the ideal production frontier by x_o inputs its management efficiency might be evaluated as a ratio $E_{Bo} = Bx_o/Ax_o$ and $E_{Bo} < 1$. In this way the efficiency of two management approaches (x_o ; A) and (x_o ; B) might be compared in connection with an output level.

The problem is that the production frontier $y=f(x_0)$ is not given usually, that's why empirical data from DMU and the concept of Pareto optimality is one possible way to evaluate the management efficiency. This is so called technical efficiency of DMU. Besides that the scale efficiency might be evaluated and an approach different from that used by Chiang Kao and Yong Chi Yang has been implemented. An ellipsoid method for solving a task of linear programming enabled us to take into account the weights of all scale curve segments when calculating technical efficiency. When making a solution the biggest number of constraints meeting the optimality requirements is taken into consideration. As a result each SFE might be characterized as being situated in a zone of intensive (i), extensive (e) or non-effective development (n) according to the position of its point of technical efficiency on or under the production frontier. The third type of efficiency is called aggregate one and it is based on the ratio between two efficiency types mentioned above.

EFFICIENCY EVALUATION MODELS

The models for technical efficiency evaluation are:

$$E_o(r) = \max \sum_{k=1}^{t} V_k*Y_{rk}/(U_o+ \sum_{j=1}^{s} U_j*X_{rj}),$$

$$\text{subject to} \sum_{k=1}^{t} V_k*Y_{ik}/(U_o+\sum_{j=1}^{s} U_j*X_{ij}) \leq 1,\ i=1, \dots , n \qquad (1)$$

$U_1, \dots , U_s ;\ V_1, \dots , V_t \geq \varepsilon > 0$
Uo - unconstrained in sign ;
n - total number of DMU;
t - number of outputs ;
s - number of inputs.

$$E_i(r) = \max \sum_{k=1}^{t}(V_k*Y_{rk}-V_o)/ \sum_{j=1}^{s} U_j*X_{rj},$$

$$\text{subject to } (\sum_{k=1}^{t} V_k*Y_{rk}-V_o)/\sum_{j=1}^{s} U_j*X_{rj}) \leq 1 \qquad (2)$$

$U_1, \dots , U_s ;\ V_1, \dots , V_t \geq \varepsilon > 0$;
Vo - unconstrained in sign ;
ε - infiniterimal non-Archimedean quantity .

The dual of model (1) may be written as:

$$E'_r = \min (W_o - \varepsilon(\sum_{j=1}^{s} S_j^- + \sum_{k=1}^{t} S_k^+))$$

$$\text{subject to } \sum_{i=1}^{n} W_i Y_{ik} - S_k^+ = Y_{rk}, \; k=1, \dots, t; \qquad (3)$$

$$W_o - \sum_{i=1}^{n} W_i = 0;$$

$$W_o * X_{rj} - \sum_{i=1}^{n} W_i * X_{ij} - S_j^- = 0, \; j=1, \dots, s;$$

$$W_i, S_j^-, S_k^+ > 0, \; i=1, \dots, n; \; j=1, \dots, s, \; k=1, \dots, t.$$

RESULTS

Data from the all 43 Lithuanian SFEs have been used to illustrate the efficiency measurement approach described earlier. The inputs were classified into the following categories: growing stock, m3/ha; technicians, number of persons/ha; staff members, number of persons/ha; workers, number of persons/ha; machinery, units/ha; capital, litas/ha; costs, litas/ha. Concerning outputs we selected the following four ones: forest plantation, litas/ha; timber extraction m3/ha; other silvicultural activities, litas/ha; and revenues, litas/ha. The advantage of the approach is that all those figures of quite different origin could be made comparable because all the inputs and outputs were calculated as an average per one ha of the SFE area. All the inputs and outputs should be discussed to achieve a total agreement among all the parties involved.

The results of these preliminary calculations are given in the Table 1. According to the aggregate efficiency (Kagr) 14 SFEs (one third) should improve the management. The last 13 SFEs on the list are situated in the zone of non-effective development. It is interesting that some SFEs are very high on the list of measured efficiency due to extensive (not efficient) expenditures (Zone "e"). The Ministry of Forestry should intervene to improve the situation. One half of SFEs are managing the forest efficiently (Kagr = 1,00) and they are driving in the direction of intensive (i) management.

Table 1. Efficiencies of the SFEs in Lithuania

District	Zone	K_{TO}	U_O	K_{SO}	K_{TI}	V_O	K_{SI}	K_{AGR}
35 - Tytuvenai	i	1.00	0.10	1.00	1.00	0.68	1.00	1.00
34 - Telsiai	e	1.00	-0.23	1.00	1.00	-1.00	1.00	1.00
7 - Jonava	e	1.00	0.34	1.00	1.00	-0.07	1.00	1.00
3 - Birzai	e	1.00	-0.13	1.00	1.00	-0.76	1.00	1.00
30 - Siauliai	e	1.00	-0.05	1.00	1.00	-0.08	1.00	1.00
16 - Kursenai	e	1.00	0.13	1.00	1.00	0.19	1.00	1.00
33 - Taurage	e	1.00	0.31	1.00	1.00	7.72	1.00	1.00
11 - Kaunas	e	1.00	0.25	1.00	1.00	1.32	1.00	1.00
31 - Silute	i	1.00	-0.25	1.00	1.00	-0.14	1.00	1.00
5 - Dubrava	e	1.00	0.41	1.00	1.00	0.14	1.00	1.00
1 - Alytus	i	1.00	0.10	1.00	1.00	0.10	1.00	1.00
43 - Zarasai	i	1.00	-0.30	1.00	1.00	0.01	1.00	1.00
12 - Kazlu Ruda	e	1.00	-0.16	1.00	1.00	-0.60	1.00	1.00
6 - Ignalina	i	1.00	-0.14	1.00	1.00	0.14	1.00	1.00
4 - Druskininkai	i	1.00	-0.20	1.00	1.00	-0.50	1.00	1.00
36 - Trakai	i	1.00	-0.52	1.00	1.00	-0.38	1.00	1.00
10 - Kaisiadorys	i	1.00	-0.12	1.00	1.00	0.00	1.00	1.00
22 - Plunge	i	1.00	-0.06	1.00	1.00	-0.67	1.00	1.00
42 - Vilnius	i	1.00	-0.49	1.00	1.00	-0.27	1.00	1.00
18 - Mazeikiai	i	1.00	-0.90	1.00	1.00	-0.07	1.00	1.00
41 - Veisiejai	i	1.00	-1.70	0.99	1.00	-0.57	1.00	1.00
2 - Anyksciai	i	1.00	-0.28	0.99	1.00	-0.62	1.00	1.00
39 - Valkininkai	i	1.00	-1.04	0.99	1.00	-0.08	1.00	1.00
40 - Varena	i	1.00	-3.77	0.99	1.00	-0.60	1.00	1.00
25 - Raseiniai	i	1.00	-0.11	0.99	1.00	-0.11	1.00	1.00
21 - Panevezys	i	1.00	-0.20	0.99	1.00	-0.17	1.00	1.00
26 - Rietavas	i	1.00	-0.72	0.99	1.00	0.79	1.00	1.00
38 - Utena	i	1.00	0.00	0.99	1.00	-0.43	1.00	1.00
20 - Pakruojis	i	1.00	-0.91	0.99	1.00	-0.41	1.00	1.00
17 - Marijampole	i	1.00	-0.10	0.99	1.00	0.09	1.00	1.00
14 - Kretinga	i	1.00	-0.10	0.98	1.00	-1.00	1.00	0.99
23 - Prienai	n	0.97	-0.20	0.99	0.97	-0.16	1.00	0.98
19 - Nemencine	n	0.94	-0.19	0.99	0.95	-0.19	1.00	0.97
9 - Jurbarkas	n	0.94	0.05	1.00	0.94	0.06	1.00	0.97
27 - Rokiskis	n	0.90	-0.55	1.00	0.96	-0.63	1.00	0.96
29 - Salcininkai	n	0.91	-0.33	0.99	0.93	-0.25	1.00	0.96
32 - Svencionys	n	0.87	-2.66	0.99	0.96	-0.74	1.00	0.95
24 - Radviliskis	n	0.92	0.18	1.00	0.90	0.17	1.00	0.95
13 - Kedainiai	n	0.90	0.00	0.99	0.91	-0.21	1.00	0.95
44 - Average	n	0.88	-0.06	1.00	0.89	-0.21	1.00	0.94
37 - Ukmerge	n	0.86	-0.24	0.99	0.90	-0.40	1.00	0.94
8 - Joniskis	n	0.88	0.58	0.98	0.83	-0.40	1.00	0.92
15 - Kupiskis	n	0.80	-0.56	0.99	0.88	-0.66	1.00	0.91
28 - Sakiai	n	0.82	-0.02	0.99	0.83	-0.08	1.00	0.91

CONCLUSIONS

The first attempt to measure the management efficiency of Lithuanian SFEs on the basis of relative productivity opens a new control and analysis possibility. The sources of inefficiencies may be disclosed and appropriate measures may be taken to improve the management policies, and thus the best performance by the SFEs might be promoted. Economic framework of efficiency developed by Farell (1957) got a meaning of an objective mathematical tool for forest management analysis in Lithuanian SFEs under the conditions of market economy. To avoid misunderstandings when measuring management efficiency the Ministry of Forestry should agree on a list of inputs and outputs to be evaluated in a forest management plan of a SFE. The research work on this field should be continued.

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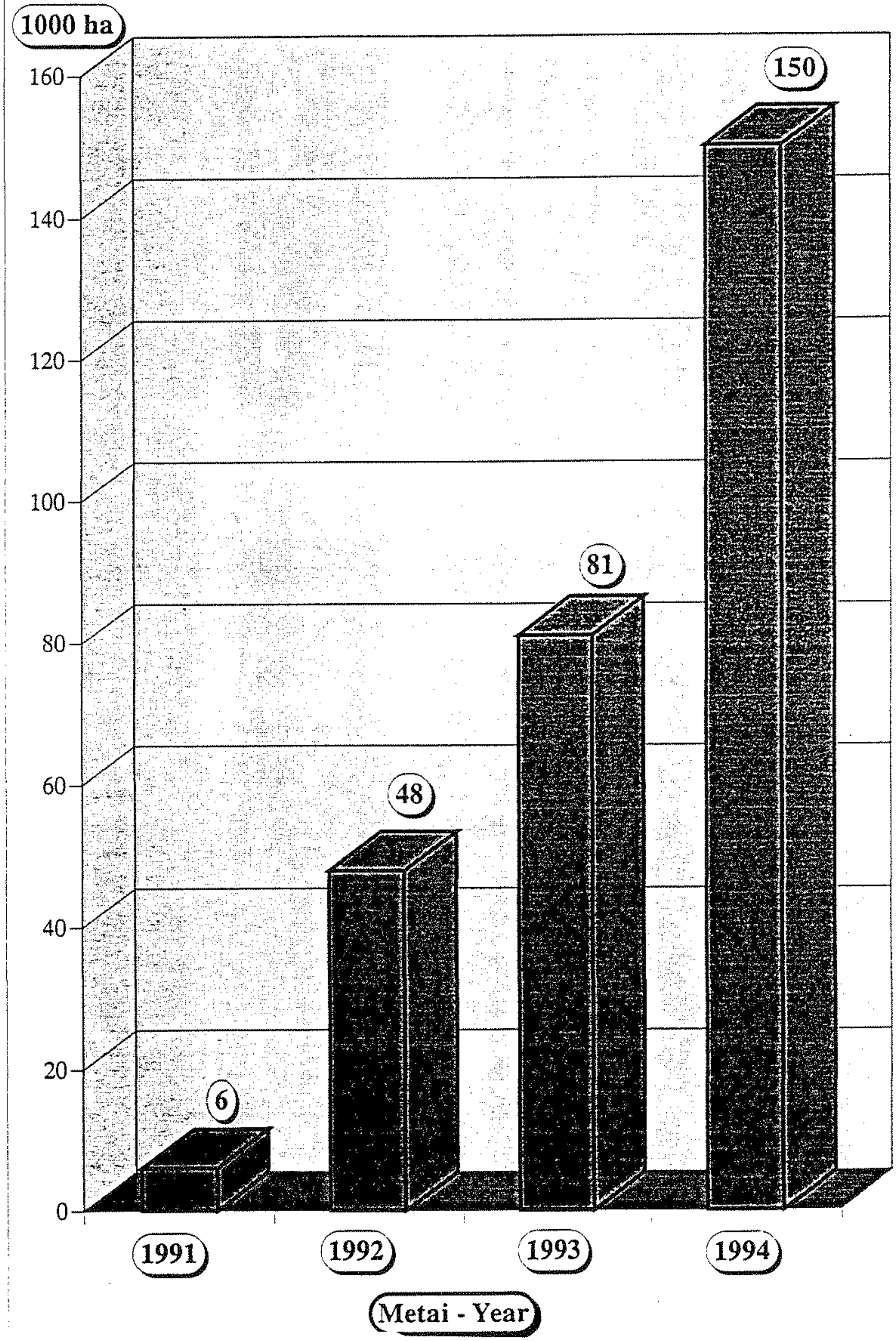
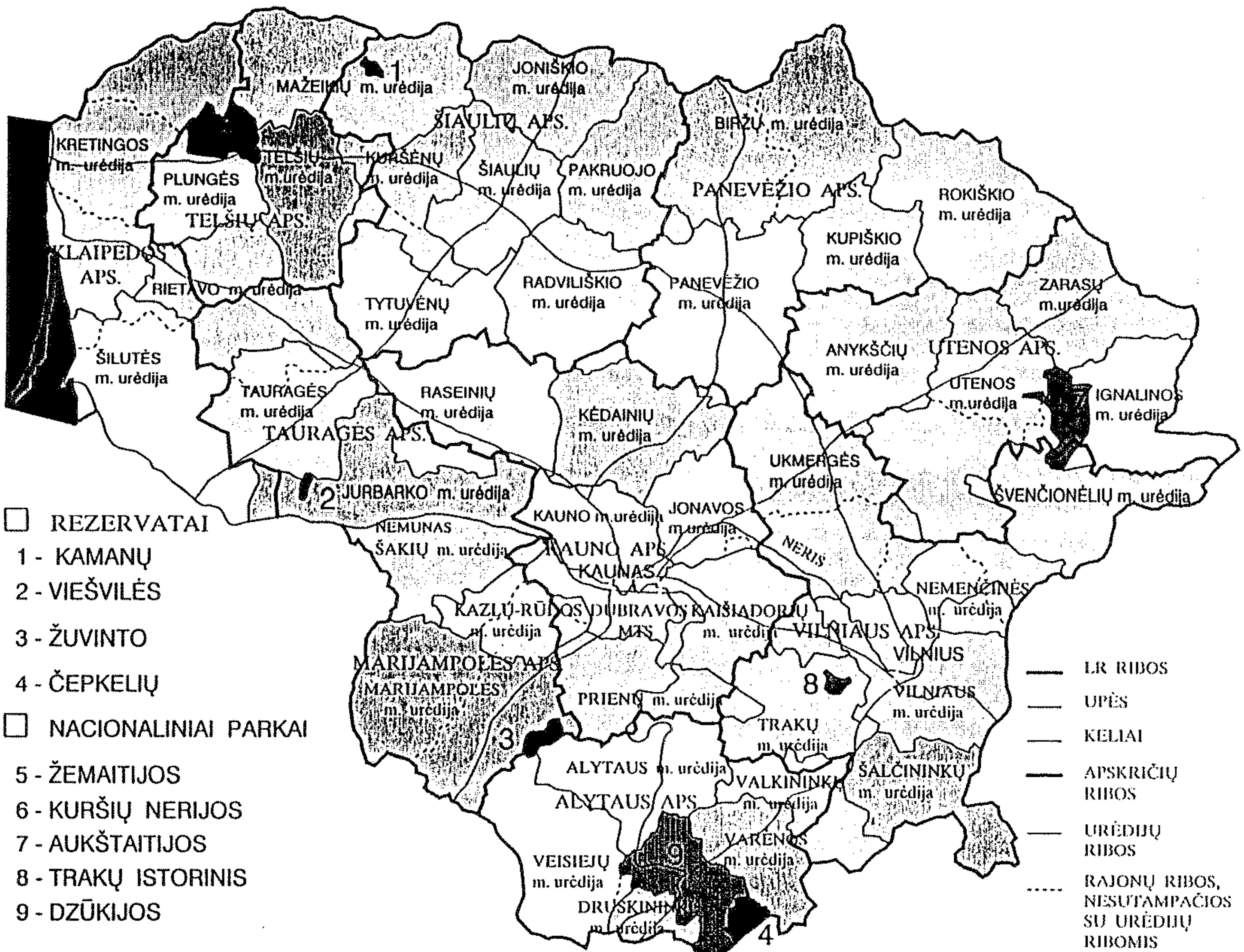
MIŠKŲ GRĄŽINIMO EIGA
RESTITUTION OF FOREST HOLDINGS

Vidutinis valdos dydis - 6 ha - Average forest holding
Miško savininkų skaičius - 22 000 - Number of forest owners

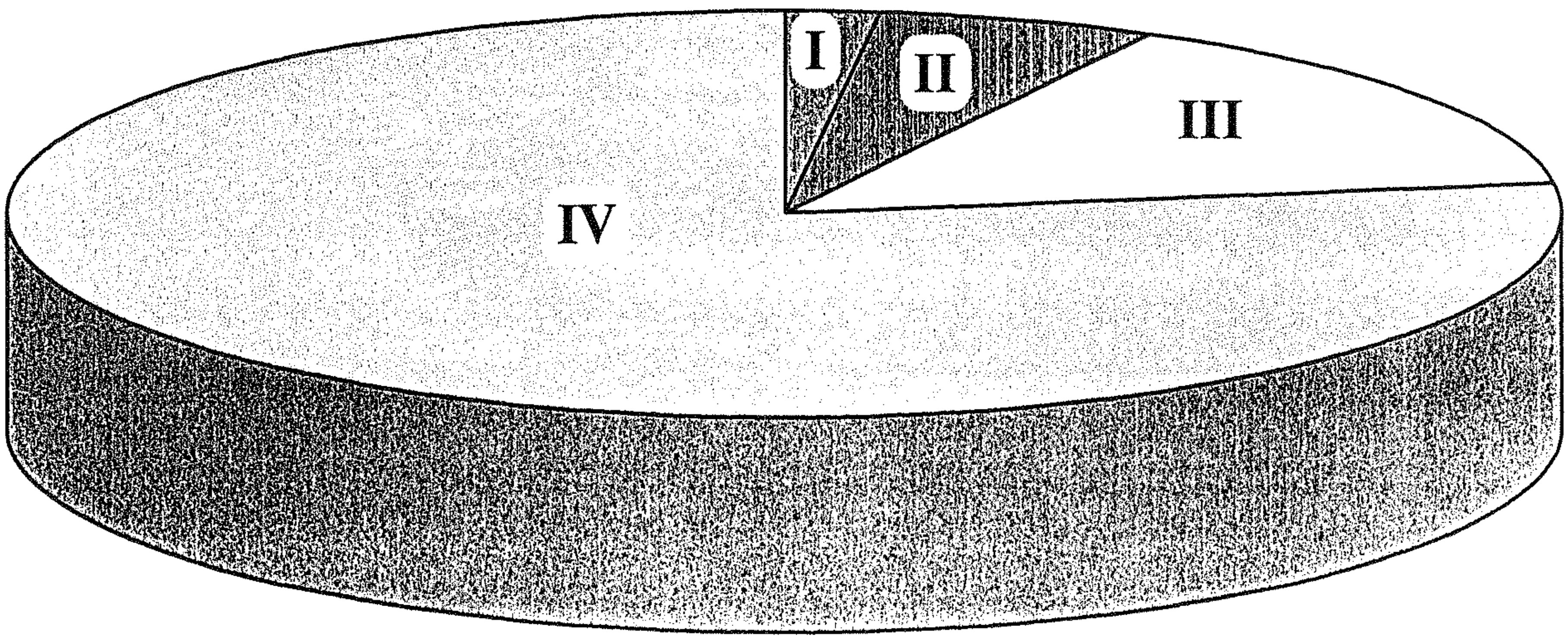


LIETUVOS MIŠKO URĖDIJŲ, REZERVATŲ IR NACIONALINIŲ PARKŲ SCHEMA



MIŠKO GRUPĖS - FOREST PROTECTION CLASSES

I - Rezervatiniai miškai - **1,9%** - Rezerve
II - Specialios paskirties miškai - **5,8%** - Special
III - Apsauginiai miškai - **15,0%** - Protectional
IV - Ūkiniai miškai - **77,3%** - Commercial



AN APPROACH TO ANALYZING RISKY FORESTRY COSTS

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ABSTRACT

One way to handle risk in discounted cash flow analyses is to increase the discount rate above the risk-free rate. Since most investors dislike risk, or variability in cash flows, a higher discount rate reduces the present value of risky revenues, thus reflecting the disutility from risk. But some analysts suggest that we should decrease the discount rate for risky costs, thus increasing their present value to reflect the disutility from variance in costs. Others support the standard practice of using the same risk-adjusted discount rate for risky revenues and costs.

This paper reviews theoretical arguments in cost discounting and shows why the standard practice of discounting net revenues with a single interest rate above the risk-free rate will often underestimate the present value of future costs.

INTRODUCTION

In calculating present values of future cash flows, most investors use a risk-adjusted discount rate (RADR) higher than the risk-free rate. While this approach raises many theoretical questions, it is widely used because usually not enough information is available to apply more sophisticated methods of risk analysis.

Cash flow risk is defined as variance in the cash flow, compared to a risk-free payment which occurs with certainty at a predictable level and time. In computing present values, the cash flow being discounted should be the "expected value" or the average amount which could be expected with many repetitions of the investment. Following results of previous empirical research, this discussion assumes that most investors are risk-averse and would prefer a sure cash flow to a risky one of the same expected value (for example, see Halter and Dean 1971, Wilson and Eidman 1983, Litzenberger and Ronn 1986).

Risk-averse investors use RADRs above the risk-free discount rate, thus reducing present values of risky revenues to account for the dissatisfaction brought by risk.[1] Following this reasoning, a risky *cost's* present value should be made *larger* to account for disutility from risk. Thus, some authors have suggested that risky costs should be discounted with RADRs *lower* than the risk-free rate. Risk-free costs -- for example, loan payments -- should be discounted with a risk-free rate.

Lewellen (1977, 1979) noted that costs which have a perfect positive correlation with revenues or with the market in general, can simply be offset by revenues in the year they occur, assuming that revenues exceed costs. In such cases, net revenues can be discounted with a RADR above the risk-free rate, which is the standard approach of discounting costs and revenues with the same RADR. But Celec and Pettway (1979), argue that perfect correlation of costs and revenues (for example income taxes and income) is the exception rather than the rule. They thus recommend that in most cases, risky costs should be discounted with RADRs lower than those used for revenues. This conclusion is now common in finance texts (for example, see Brigham and Gapenski 1991) and is mentioned in the forestry literature by Price (1993) and Klemperer (1996), although it is not widely recognized among forest economists.

In the environmental economics literature, Brown (1983) suggested that not only should the RADR for risky costs be below that for risky revenues, but risky cost RADRs should actually be less than the risk-free rate. Prince (1985) responded by maintaining that Brown's conclusion was consistent with the standard practice of subtracting costs from revenues and discounting net revenues with a single RADR exceeding the risk-free rate. But Prince failed to note that his conclusion only holds for the special case where revenues and costs are perfectly correlated and revenues exceed costs. There is a danger in interpreting Prince's analysis to mean that we can safely continue computing net present values (NPV) of future benefits and costs with standard formulas using a single risk-adjusted discount rate. Under risk-aversion, when costs are risky and uncorrelated with revenues, this paper shows that it will not always be mathematically possible to use standard net present value formulas to arrive at correct net present values.

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[1] Samuelson (1964) suggests that the large numbers of government projects and taxpayers provide a risk pooling effect where extraordinary losses and gains offset one another in any year. That view supports a risk-free discount rate for risky government projects. But decision makers or groups within government agencies often behave like risk-averters. Moreover, Hirshleifer (1966) notes that setting the public discount rate below the private rate is like charging different prices for the same commodity. In that case, shifting dollars from public to private investment could improve welfare (Arrow and Lind 1970). While the issue of a government risk premium is unresolved, this paper assumes that public and private investors use the same risk premiums and follows Hirshleifer's (1964) view that public investors should behave as if they were risk-averse. This approach is further justified because most public agencies simulate risk-averse behavior by using discount rates which substantially exceed the risk free rate.

NOTATION

c_r =	cost/revenue ratio, or $E(C_t)/R_t^s$
C_t^* =	certainty equivalent of $E(C_t)$ -- a sure cost bringing the same utility loss as the risky cost
$E(C_t)$ =	the expected value of a risky cost in year t with a known probability distribution
$E(R_t)$ =	the expected value of a risky revenue in year t with a known probability distribution
NPV =	net present value (present value of revenues minus present value of costs)
q_r =	certainty equivalent ratio for expected values of risky costs. $q_r = C_t^*/(E(C_t))$, and $C_t^* = q_r\, E(C_t)$
RADR =	risk-adjusted discount rate
r_f =	real risk-free discount rate/100
r_c =	real risk-adjusted discount rate/100 for expected costs
r_n =	real risk-adjusted discount rate/100 for expected net revenues
R_t^s =	a sure revenue in year t
t =	the number of years from the present that the future revenue and cost occur

ASSUMPTIONS

All values and discount rates will be in constant dollars. For simplicity, cash flows will be one revenue and one cost at one time t, but conclusions apply to multi-period cases. Initially, to model the case of uncorrelated costs and revenues, the cost will be risky, and the revenue will be certain. Investors will be risk averse so that, other things equal, increasing cash flow variance reduces utility from revenues and increases disutility from costs.

NET PRESENT VALUES OF RISKY CASH FLOWS

Correct Discounting of Risky Cash Flows

The correct net present value (NPV) of future expected cash flows in year t will be the sum of their certainty-equivalents discounted with the risk-free rate.[2] This is shown in equation (1) and set equal to the separate discounting of expected revenues and costs (R_t^s and $E(C_t)$) with separate risk-adjusted discount rates (r_f and r_c). Since R_t^s is risk-free, it is both an expected value and a certainty-equivalent, and its risk-adjusted discount rate is the same as the risk-free rate r_f.

[2] The certainty-equivalent of an expected revenue (cost) is that sure sum which would yield the same utility (disutility) as the risky revenue (cost).

Correct net present value =

$$\frac{R_t^s}{(1+r_f)^t} - \frac{C_t^*}{(1+r_f)^t} = \frac{R_t^s}{(1+r_f)^t} - \frac{E(C_t)}{(1+r_c)^t} \tag{1}$$

Since $E(C_t)<C_t^*$, the risk-adjusted discount rate for expected risky costs must be less than the risk-free rate, for the equality to hold.[3] The reasoning is as follows: With a zero variance in positive or negative cash flows, a risk-free discount rate, r_f, will yield the correct present value. Under risk aversion, to reflect the disutility from variance in an expected *revenue*, a risk-adjusted discount rate$>r_f$ will give the required reduction in present value (not used here, since revenue is sure). To reflect the disutility from variance in an expected *cost*, its negative present value must be *greater* than it would be if variance were zero. To achieve this, Brown (1983) correctly reasons that the r_c for risky costs must be *lower* than the risk-free rate.

Problems with the Standard Net Present Value Approach

The standard approach discounts net expected revenues with the following NPV formula using one risk-adjusted discount rate $r_n>r_f$:

Standard NPV formulation

(will not always yield correct NPV) =

$$\frac{R_t^s-E(C_t)}{(1+r_n)^t} \tag{2}$$

The numerator expresses the risky cash flows in any year as the expected value of revenues minus the expected value of costs, or expected net revenues. Prince (1985) maintains that since the expected net income (R_t^s-$E(C_t)$) in equation (2) exceeds its certainty equivalent (R_t^s-C_t^*) in equation (1), then r_n must exceed r_f, if both equations are to yield the same NPV. Prince thus concludes that "discounting the net *benefits* of risky projects at a rate higher than the riskless rate (r) is consistent with discounting the *costs* of risky projects at a rate lower than r" (Prince, 1985, p. 180). However, the following analysis reveals that equation (2) will not always yield the correct present value given by equation (1).

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[3] For risk-averse investors, the certainty-equivalent of a risky revenue is less than the expected revenue because the utility of a greater-than-average revenue is more than offset by the disutility of a less-than-average revenue (Robichek and Myers 1966). In absolute value terms, the certainty-equivalent of a risky cost exceeds its expected value because the utility of a lower-than-average cost is more than offset by the disutility of a greater-than-average cost.

The most obvious problem with the standard NPV formula in equation (2) occurs when expected revenue equals expected cost, in which case the numerator is zero. However, when $R_t^s=E(C_t)$, the correct NPV must be negative, as in equation (1), since C_t^* will then exceed R_t^s. In equation (2), there is no solution for r_n which can convert a zero numerator into a negative NPV. These and other problems are revealed by setting the left side of equation (1) equal to the right side of equation (2) and solving for r_n:

$$\frac{R_t^s-C_t^*}{(1+r_f)^t} = \frac{R_t^s-E(C_t)}{(1+r_n)^t} \tag{3}$$

To provide for different certainty-equivalents, let $C_t^*=q_r\, E(C_t)$, where q_r is the certainty-equivalent ratio for risky costs:

$$\frac{R_t^s-q_r\,E(C_t)}{(1+r_f)^t} = \frac{R_t^s-E(C_t)}{(1+r_n)^t}$$

$$(1+r_n)^t = \frac{[R_t^s-E(C_t)](1+r_f)^t}{R_t^s-q_r\,E(C_t)}$$

Solving for r_n,

$$r_n = \sqrt[t]{\frac{[R_t^s-E(C_t)](1+r_f)^t}{R_t^s-q_r\,E(C_t)}}\;-1$$

Letting the cost/revenue ratio be $c_r=E(C_t)/R_t^s$, and setting R_t^s equal 1, then $E(C_t)=c_r$, and

$$r_n = \sqrt[t]{\frac{(1-c_r)(1+r_f)^t}{1-q_r\,c_r}}\;-1 \tag{4}$$

Equation (4) thus gives the r_n that should make equation (2) yield the correct NPV given by equation (1). Table 1 shows values of the risk-adjusted rate, r_n , for discounting expected net revenues, using equation (4), assuming t=10 years, a 3% risk-free discount rate (r_f=.03), and a range of values for q_r and c_r. To reflect risk aversion, q_r values exceed 1. Problems exist when c_r=1: When c_r=1, r_n is always -1, which would give division by zero in equation (2). This is the problem mentioned earlier; when $R_t^s=E(C_t)$, no solution for r_n exists that will make equation (2) yield the correct negative NPV. The error messages in Table 1 occur when the expected value $R_t^s-E(C_t)$ is positive and the correct NPV is negative, in which case, no value for r_n exists which, for all t, will discount a positive expected value to the correct negative NPV. Also note in the lower half of Table 1 (where costs exceed revenues or where c_r >1), the risk-adjusted discount rate r_n *is less than* the risk free rate of .03 --

TABLE 1. **Risk-adjusted Discount Rates/100 [or r_n from equation (4)] which will Discount Expected Net Revenues [equation (2)] to the Correct Net Present Value [equation (1)].**

Year of cash flows, (t) = 10
Risk-free discount rate/100, (r_f) = 0.03

$c_r =$ $E(C_t)/R_t^s$	Certainty-equivalent ratio for costs, $q_r = C_t^*/(E(C_t))$				
	1.2	1.4	1.6	1.8	2.0
0.2	0.035	0.041	0.047	0.053	0.060
0.4	0.045	0.062	0.084	0.112	0.150
0.6	0.067	0.129	0.297	error#	error#
0.8	0.210	error#	error#	error#	error#
1.0	-1.00##	-1.00##	-1.00##	-1.00##	-1.00##
1.2	-0.048	-0.089	-0.116	-0.136	-0.152
1.4	-0.023	-0.056	-0.080	-0.099	-0.114
1.8	-0.008	-0.034	-0.054	-0.071	-0.085
2.0	-0.004	-0.029	-0.048	-0.064	-0.077

Error occurs when correct NPV<0 and $[R_t^s - E(C_t)] > 0$, because no r_n exists which will discount a positive expected net revenue to a correct negative NPV for all t.
$r_n = -1$ is infeasible, since it results in division by zero in equation (2).

directly opposed to the standard guide. Thus, it is not always possible to use standard NPV formulas where $r_n > r_f$ [for example, equation (2)] to compute correct net present values when costs are risky.

Generality of the Correct Discounting Approach

One can show the simplicity and generality of the correct discounting approach by solving equation (1) for the risk-adjusted discount rate (r_c) for risky costs and performing a sensitivity analysis analogous to Table 1. First note that $C_t^* = q_r\, E(C_t)$, and $E(C_t) = c_r\, R_t^s$. Therefore, $C_t^* = q_r\, c_r\, R_t^s$. Substituting in the left side of equation (1),

$$\frac{R_t^s}{(1+r_f)^t} - \frac{q_r\, c_r\, R_t^s}{(1+r_f)^t} = \frac{R_t^s}{(1+r_f)^t} - \frac{c_r\, R_t^s}{(1+r_c)^t}$$

$$\frac{c_r\, R_t^s}{(1+r_c)^t} = \frac{q_r\, c_r\, R_t^s}{(1+r_f)^t}$$

$$(1+r_c)^t = \frac{c_r\, R_t^s (1+r_f)^t}{q_r\, c_r\, R_t^s}$$

Cancelling out $c_r R_t^s$ and solving for r_c,

$$r_c = \sqrt[t]{\frac{(1+r_f)^t}{q_r}} - 1 \qquad (5)$$

Using equation (5), Table 2 gives correct risk-adjusted discount rates for risky costs, given the same parameter values as Table 1. Although unnecessary, c_r values are given to show a comparison with Table 1. As expected, when $q_r>1$ (i.e., when costs are risky), all values for r_c are less than the risk-free discount rate of .03. Compared to Table 1, not only are all discount rate solutions possible in Table 2, but once the discount rate for revenues is given, selecting the appropriate rate for costs is far simpler than setting a different r_n for each value of c_r in Table 1.

Perfect Correlation between Risky Costs and Revenues

So far the discussion applies for the usual case where probability distributions of costs and revenues are independent, as initially assumed. Suppose simultaneous risky revenues $E(R_t)$ and costs $E(C_t)$ are perfectly correlated and revenues exceed costs, as with revenues and income taxes thereon. Since the perfectly correlated cost can be seen as a reduction in revenue for all bars of the revenue histogram, a positive expected net revenue will always have a positive but smaller certainty-equivalent under risk aversion. Thus, replacing R_t^s with $E(R_t)$ in equation (3), as long as $E(R_t)>E(C_t)$, r_n will always exceed r_f in equation (3), and the mathematical impossibilities that can occur with an uncorrelated cost and revenue in Table 1 would not exist. In that case, discounting revenues and costs with the same rate exceeding the risk-free rate is appropriate (see Lewellen 1977 and Prince 1985). But this is not the usual situation.

CONCLUSIONS

Discounting risky cash flows with risk-adjusted interest rates is at best a crude procedure -- ideally we should discount certainty equivalents with risk free rates. However,

TABLE 2. **Risk-adjusted Discount Rates/100 for Risky Costs, when Revenue is Sure [r_c from equation (5), for use in equation (1)]**

Year of cash flows, (t) = 10
Risk-free discount rate/100, (r_f) = 0.03

$c_r = E(C_t)/R_t^s$	Certainty-equivalent ratio for costs, $q_r = C_t^*/(E(C_t))$				
	1.2	1.4	1.6	1.8	2.0
0.2	0.011	-0.004	-0.017	-0.029	-0.039
0.4	0.011	-0.004	-0.017	-0.029	-0.039
0.6	0.011	-0.004	-0.017	-0.029	-0.039
0.8	0.011	-0.004	-0.017	-0.029	-0.039
1.0	0.011	-0.004	-0.017	-0.029	-0.039
1.2	0.011	-0.004	-0.017	-0.029	-0.039
1.4	0.011	-0.004	-0.017	-0.029	-0.039
1.8	0.011	-0.004	-0.017	-0.029	-0.039
2.0	0.011	-0.004	-0.017	-0.029	-0.039

lacking adequate data, public and private investors commonly apply risk-adjusted discount rates to evaluate projects. For example, the United States Office of Management and Budget (OMB) recommends that federal agencies evaluating investments should use a 7 percent real interest rate to discount expected values of risky benefits and costs (USOMB 1992). Based on Simon's (1990) long-term projected 3 percent real risk-free interest rate, OMB's 7 percent includes a 4 percent "risk premium." The foregoing analyses suggest that such risk premiums would underestimate the present value of future risky costs which are uncorrelated with revenues. Such costs should be discounted with interest rates lower than the risk-free rate.

One unresolved issue is how best to measure the degree of correlation between risky costs and revenues. In a given period, if revenues offset costs, and both are perfectly correlated, the same discount rate can apply to revenues and costs. As correlation diverges, say, by measure of the correlation coefficient, the discount rate for expected costs drops below that for expected revenues. We need to explore the implications of different degrees and measures of correlation between costs and revenues.

When risky costs include possible losses of unique ecosystems, the literature on the "endowment effect" may be relevant (Kahneman et al. 1990, and Shogren *et al.* 1994). This effect refers to people's resistance to giving up non-market goods which have no perfect substitutes. This provides an added rationale decreasing the discount rate for risky environmental costs in order to boost their present value.

The issue of discounting risky costs needs more examination in forestry. To what extent is incorrect discounting leading to inefficient decisions? How important are future risky costs in forestry, and what are the implications of standard discounting for evaluating various types of catastrophic forest damage?

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Development of Human Resources and Economic Growth Models for Sustained Forest Management, Planning for Multiple Benefits

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INTRODUCTION

The significance of forests can very well be understood for the simple reason that forests play vital role in the use of land for the following reasons :

(1) They provide natural climax vegetation of at least four to six billions hectares of land throughout the world (Mathews, 1983; U.N. 1992), while several billions hectare support open or dwarf woody vegetation.

(2) They provide wide range of products and services essential for human welfare.

It is well known fact that world's forests have been greatly reduced as a result of human action. By the mid twentieth century at least 30% to 50% of the original forest area had disappeared (Sommer, 1976; Myers, 1979). In 1980 closed forests were reported as covering some 2.7 billion ha. with a further 1.3 billion ha. supporting some kind of woody vegetation (UNEP, 1982). It is therefore essential that each nation must develop its own set of political priorities, taking into consideration the interests of its people. The involvement of local communities in the management of the resources amongst which they live and on which they depend is crucial for both sustainability of development and optimization of economic benefits.

The period from 1989 to 1992 has been very significant in the field of Indian Forestry. The directives of the National Forest Policy of 1988 have been operationalised. The concept of participatory forest management on usufruct sharing basis has been gaining momentum. The new approach includes active participation of the village communities, specially women, weaker sections, and voluntary agencies in strengthening the hands of the forest department for sustained forest management and regeneration initiatives.

Bio-diversity conservation has been made an integral part of forest conservation. Various conservation measures have been taken through strengthening of legislations as also through eco-development efforts. About 1,41,000 sq. km. of area comprising 75 national parks and 421 sanctuaries have been brought under Protected Area Network. This constitutes 4.26% of the geographical area of the country. Forestry Research and Education have been made more broadbased, the emphasis being on productivity, seed technology, planting techniques, forestry extension, wood substitution and wildlife. The methodology and content of forestry training programmes have been given new orientation in view of developing changes.

Sustained Forest Management for Multiple Benefits

In June 1992, at Rio de Janerio, the leaders of the World Communities collectively endorsed the fundamental principle that environment and development policies had to be seen as part of larger collective whole. Sustained development was defined by the Brundtland Commission as meeting the needs of the present without compromising the ability of future generations to meet their own needs. (WCED, 1987). The Convention of Biological Diversity also emphasized that this pattern was such which every sovereign state should adopt for itself. It should be supported and helped by wider world community.

The reasons for managing forests sustainably has a logic. The principle of sharing the bounty of the forests by maximizing the number of benefits we can derive from it, has not only an ethical and egalitarian justification, but also makes economic and political sense. Invariably the maximisation of the number of benefits which can be derived from forests will ensure that the total value of the forest and the number of constituencies that support retention of the forest will be increased. Both UNCED and the Stockholm Conference of 1972 recognised that sovereign states have the right to develop their own resources in accordance with their own political judgements. At the general level, "Caring for the Earth: A Strategy For Sustainable Living (IUCN/UNEP/WWF, 1991) recommends priority actions such as :

1. Establishment of a permanent state of natural and modified forest in every nation and manage it to meet the needs of all sectors of society.

2. Establishment of a comprehensive system of protected natural forests.

3. Establishment and maintenance of adequate permanent state of modified forest.

4. Increased national capacity to manage forest sustainably.

5. Strengthening of community management of forests.

6. Expansion of efforts to conserve forest genetic resources.

7. Creation of a market for forest products from sustainably managed sources and use of wood more efficiently.

8. Setting up a stumpage price to reflect the full value of timbers.

9. Increasing the capacity of lower income countries to manage forests sustainably; and improvement of international cooperation in forest conservation and sustainable development.

The unifying element has been the recognition that forests deliver, and must continue to deliver, far more to humanity than timber (Poore and Sayer, 1991). The point has been well elaborated by Myers (1980) who sets out a spectrum of goods and services available from tropical moist forests. Among important international dimensions which affect sustainability is the way current world economic and trading system impede the sustainable development of many developing nations.

Sustained Management of Forests in India : Some Efforts

The major forest groups of India can be divided into the following four groups.

Sl. No.	Forest Group	Temp. conditions related to zone occupied by the group. (Mean Annual Temp.)
1.	Tropical	Over 24°C
2.	Sub-Tropical	17°C to 24°C
3.	Temperate	7°C to 17°C
4.	Alpine	under 7°C

India is a country with vast variations in climate and physical features so as to permit the study of its vegetation in various ways. It is equally convenient to divide the vegetation of the country primarily on the basis of rainfall, which is as follows: (i) Rain Forest, (ii) Monsoon Forest, (iii) Dry Forest, (iv) Xerophytic Forest, (v) Mangrove Forest.

The per capita forest cover is worked out to be 0.08 ha. where actual forest cover is estimated at 640107 sq km for total population of 84.6 crores. (Source SFR, 1993, FSI & Census of India, 1991). Realizing the significance of forests for human welfare, much attention has been given to this sector. There is a regular increase in budget allocation to achieve sustainability. The table below is an evidence.

Planwise (All India) Outlays Under Forestry Sector as Compared to total public sector outlays since 1st five Year Plan

Plan	Plan Period	Total public Sector (in crores)	Forestry Sector (in crores)	Percen-tage
1st	1951-56	1950	7.64	0.39
2nd	1956-61	4600	21.21	0.46
3rd	1961-66	8576	45.85	0.53
4th	1969-74	15778	89.42	0.57
5th	1974-69	40650	208.84	0.51
6th	1980-85	97500	692.49	0.71
7th	1985-90	180000	1859.10	1.03
8th	1992-97	434100	4909.98	1.13

Source : VIIIth Five Year Plan 1992-97. Vol I & Forestry Statistics, India - 1995.

To overcome various forestry related problems the National Forest Policy was revised in December, 1988. The new policy has identified constraints in Forest Management, set goals and devised strategy for achieving these goals. The new policy marks a major departure from the earlier policy which was primarily production oriented. It accords the highest priority to conservation of forests for environmental stability and maintenance of ecological balance. It also lays emphasis on meeting the local needs, in particular of the tribal population.

The Participatory Forest Management System being developed in India, points out towards a new and promising direction in forest management. In a country with multifarious socio-economic diversities, it is not possible to evolve a uniform model. This makes the task more challenging because depending upon the ground realities specific models need to be developed for specific areas.

The guidelines issued in the new policy also encompass a number of subjects including regularisation of old encroachments on forest lands, review of disputed claims over forest land, elimination of intermediaries to stop exploitation, conversion of forest villages into revenue villages, payment of compensation for loss of life and property due to predation and depredation by wild animals, etc.

Forest Management Techniques

During the last decade (1980 to 1990) India embarked upon the social forestry programme with the main objective of producing fuelwood, fodder, small timber and other products to meet the needs of rural communities by raising plantations on wastelands including community lands, degraded forests, other government wastelands and private marginal lands. This imbalance is sought to be rectified in the present forest management approach which aims at comprehensive and sustainable forestry development. Rehabilitation of degraded forests primarily through natural regeneration has been given priority. In the new forest management approach, bio-diversity conservation has become an integral part of overall forestry management. The assessment of the forest cover of the country, pertaining to the period 1987 to 1989 has shown that there has been an increase in the actual forest cover of the country at an annual rate of 28,000 ha. By a very conservative estimate, it is assessed that forest produce (including about 220 million tonnes of firewood, 200 million tonnes of fodder, 12 million cu.m. of timber and varieties of Non Wood Forest Products) worth Rs. 26,000 crore ($10,000 million) is withdrawn from the forests annually in the form of recorded and unrecorded removals.

Forest Administration

A new board called the National Afforestation and Eco-Development Board (NAEB) was set up in the Ministry of Environment and Forests which is responsible for promoting afforestation, tree planting, ecological restoration and eco-development activities with special attention to the regeneration of degraded forest areas and lands adjoining forest areas, national parks, sanctuaries and other protected areas as well as the ecologically fragile areas like the Western Himalayas, Aravallis, Western Ghats and the like.

Commonwealth Cooperation

Cooperation with commonwealth countries continues to grow. The Overseas Development Administration (ODA) has agreed to support environmental forestry projects in Himachal Pradesh and Uttar Pradesh. Financial assistance is also being considered under ODA for strengthening the Wood Science Institute (Bangalore), Forest Genetics and Tree Breeding Institute (Coimbatore), and establishment of Forestry Information and Record Service, Forest Research Institute (Dehra Dun). The Government of United Kingdom has been offering training to a large number of officers from India under Colombo Plan on Forestry and Environment.

National Forestry Action Programme

With the announcement of new National Forest Policy in 1988, it became necessary to orient all the on-going forestry practices and programmes to meet the objectives set by it. Consequently an integrated perspective programme for the long and mid-term development of forestry sector at National and State level, together with a short term priority action programme for the next five years is being prepared taking all aspects on forestry and people. This is being done under the project 'National Forestry Action Programme' as part of global 'Tropical Forestry Action Programme' with assistance from UNDP and FAO.

National Conservation Strategy

The Government of India, has adopted the National Conservation Strategy in June 1992. The Strategy has identified population control, conservation of natural resources including land, water, atmosphere, biodiversity and biomass as the priority areas needing specific concerted action. Integration of environmental considerations in the policies and programmes of development in various sectors like Agriculture, Irrigation, Animal Husbandry, Forestry, Energy, Industry, Mining, Tourism, Transport and Human settlements have been emphasised in the National Conservation Strategy. The strategy has also highlighted the role of international cooperation and need for support policies and systems for strengthening the institutional set up, legislative instruments and enforcement mechanisms, research and development, mobilisation of financial resources, creation of public awareness and training of professionals.

Human Resources Development

Development of human resources to optimum level is the key to achieve the aim of sustained development. Some of the basic qualities in the person linked with the management can be briefly summarised as :

1. He should be well grounded in the basic biological, physical and social science.

2. He should have a thorough grasp of the principle and practices involved in the application of basic knowledge in science, art and business of forest land management.

3. So far as existing knowledge permits, he understands not only how things happen but why they happen. He understands the relation between causes and effects.

4. He should be equipped to formulate forest policies, prepare plans for the integrated management of the forest various resources that give full consideration to biological, economic and social factors and to supervise the execution of these plans.

5. He has a comprehension of people and of human institutions that makes him at home as an individual, a citizen and a professional man in the community in which he lives and works.

6. He recognises that the objectives of his activities is the rendering services, which may take a wide variety of forms.

7. He is guided in all his activities by his professional code of ethics.

8. He joins with his fellow foresters in advancing the interests and maintaining the standards of the profession.

In order to have the best use of human resources, it is important to understand the Psychosocial Qualities of forest work. Mental work load has not been a major critical factor in forest works until the processing machines appeared. Reported mental fatigue at the end of a working day is quite common for operators of delimbing and debarking machines (Bostrand, L. 1978). Production and product qualities are likely to suffer from this.

Work Organisation, Supervision and Worker's Participation

Work organization forms an integral part of forest management. Organization of work depends on the level of education and competence of the workers, the wage system, organisational climate and the like. An important part of work organization is the allocation of the working hours. Shift work is often considered necessary in mechanized operations in order to achieve higher utilization of expensive machinery. According to Bostrand (1980 b) most machine operators prefer day work (only one shift) while management often prefers two or more shifts. A compromise called the overlapping shift is becoming increasingly common in Sweden. In this field, work has been done by Frykman (1980 a) and Kyttala (1980) which reports studies and experiences for Finland in this problem area. The selection of individuals and composition of a team is of particular importance in group oriented work forms (Frykamn 1980, Hachman and Suttle 1977).

Work supervision plays an important role in mobilizing human resource development for forest management. Frykman (1980 b) reports on recent studies of work demands and working conditions of supervisors in forestry. He also analyzes the present and future work role of forest supervisors. One conclusion is that the supervisor should be both productivity oriented and personnel oriented, another that the supervisor should be given opportunity to increase his knowledge, especially within the behavioural sciences area.

Regarding selection of individuals for work, Fibiger (1980 b) presents a general model how to establish health standard for a job and a set of desirable psychomedical features of the individual as a base for selection of individuals for a job. Rehschuh (1980) describes a model specifically designed for examination and classification of the individual fitness for forest work.

As far as workers participation in planning and control goes, recent researches have made it clear that the forests can be better maintained and managed with workers participation in planning and control of forest management. Frykman (1980), Kyttala (1980) and Aminoff and Lindstorm have given some methods for decision making. They conclude provisionally that :-

1. Machine operators and union representatives have in reality, little influence on the final decision.

2. Human criteria have only little weight compared with technical and economic criteria.

3. The decision process in selecting new machines in forestry cannot be described by any one of the general decision models.

An example of workers participation in forest management improvement programme on the branch level is given by Nugent (1980). In the province of Ontario in Canada workers, employees, researchers and others, cooperated in the development of a skill training programme for forest workers.

Reward System, Work System Design and Psychology of Workers

Introducing a Reward System in forest management and development of human resources have proved very fruitful. Some important studies in this field were done by Petterson et al (1980).

Work system design in forest management is of great significance. In work system design it is important to identify the objective of the system, to express them as operational (concrete) as possible and to assign priorities to them. It is also important to identify all possible means in system designs, to know how these means affect the objectives (and individuals) and to identify the interdependence between the means. In the design of the technical system and its influence on the psychosocial job qualities, one has to consider macroaspects as well as micro aspects. [Soderquist and Gyer (1980) and Harstela dn Piiranen (1980)].

Considering the psychology of forest workers and guards, when forest workers finds that the forester in-charge is deeply concerned about his safety, productivity, wages and his living conditions, he develops appreciation for the forester and for his aims in forest management. This in turn builds up self-respect in the forest worker that lends dignity to his job which is often missing in practical life. Forest worker schools have rather short training programmes that lay emphasis on how to work easily, safely and efficiently.

Forestry Research and Training in India

Taking into account the recent developments and the present requirements, forestry training in India has been given due importance. The existing training system lays emphasis on practical training. The trainees are taken to representative forest areas for practical field exercise in forest mensuration, surveying, road alignment, working plan preparation and the study of different forest types, nursery plantation practices, tending, thinning and other forestry operations and also field botany, including identification of different species.

The Indian Council of Forestry Research and Education (ICFRE), which was established in 1986 with a view to strengthening the research base and find technical solutions to the development of forests and the forestry sector. In order to make forestry education more broad based, and in pursuance of the recommendations of the National Commission of Agriculture, a number of agricultural and other universities have started Graduate and Post-Graduate Forestry Course. Since 1989, the Indian Council of Forestry Research and Education has been providing financial support to these universities for strengthening their forestry faculties.

The methodolgy and syllabus of Forestry Training Programmes for the professional foresters (include the officers of Indian Forest Service, State Forest Service and other field level officers) have been updated and reoriented. Indian Institute of Forest Management, Bhopal, offers two years Post-Graduate Programme in Forest Management and also short management development programmes for serving forest officers on various relevant topics. Wildlife Institute of India, Dehradun is responsible for the training in Wildlife Management. Amongst other short-duration courses that need to be mentioned are Social Forestry Diploma Course, Refresher Course and Reorientation course. Forest Research Institute, Dehradun has started conducting short duration course to meet the increasing demand of education and training facilities of manpower for forest based industries.

There are a number of forest based industries in the country. The primary processing operations such as logging and saw milling, employ more people than the industries engaged in secondary processing units. The training facilities in logging operation are created at Forest Research Institute, Dehradun. Broadly two types of education and training programmes are designed :-

a) Professional Education/Training, to provide professional and managerial staff.

b) Vocational Training for workers.

Introduction of forestry education in the State Agriculture Universities on a large scale and a very tight time-frame has been a unique effort in the history of Indian Forestry Education. It demanded a very careful planning, resource mobilization, and implementation strategies. The advice from the Ministry of Environment and Forests, India to establish undergraduate degree programmes in 14 State Agriculture Universities in the country has a massive faculty support to offer quality teaching programmes.

In order to cope with professional resources demand, Indian Council of Agriculture Research had to rely on facilities available within the country as well as abroad. Simultaneously under the existing Indo-U.K. agreement on Science, support to natural resources, it was agreed to provide slots every year for teaching orientation in forestry colleges in the Universities at Oxford, Edinburgh, Abordeen, Bogor, and U.K. Advantage was also taken of the UNDP Programme for establishment of advanced centre in Agro-forestry research and education. A few other numbers were trained under the fellowship programme with the Ministry of Human Resource Development, Govt. of India.

Forestry training in India aimed at training of forest managers for the management of national forests and it has served the purpose well. It has ensured that there is no unemployment among the forestry trained personnel. The foresters have to be good managers as well as good conservationists. We have to bring forward our products in such a way that it fetches us more and more revenue. The examples of the countries like Indonesia, Malasia, and Japan are worth noting who have banned export of timber in its primary form (Logs).

Keeping in mind all the factors, it is important to have training system, work design, training programmes and determination to have best human resources mobilization for forest management for the welfare of our country and the Universe at large.

Growth Models

The concept of a growth model is not new to forest management. More than a century ago foresters conceived their model of the ideal or normal forest. Linked with this idea was sustained yield of all products - tangibles and intangibles, which in turn became a management objectives in their working plans. From the beginning it was accepted that plans should be cost effective. In these plans every aspect of management is set forth in such a way that it would be possible to attain the objectives laid down at the minimum cost in the shortest time. (Knuckle, 1953). There was also a recognition of the multiple uses of forest and that one needed to know the comparative values of multiple objectives in order to arrive at an optimum solution. Often one contradictory claim on the forest has to be weighed against another. Some arrangement has to be sought which results in the working of the forest for the greatest benefit of all. (Kunchel, 1953). Growth models are becoming increasingly flexible, enabling a wide range of different management regimes or natural occurring conditions to be simulated. Models have been developed which can take account of such factors as land preparation, initial spacing, fertilization, pruning, thinning intensity, type and length of cycle. Similarly genetic and microsite effects and the effects of insects and pathological infestation have been modelled.

Experiments as a source of data for Growth Models

There is a need for silvicultural experiments to provide data for growth models. The development and use of growth models for both natural and plantation forests has been rapid for the last fifteen years. The advisory Group of Forest Statisticians at the meeting in 1965, concluded that in order to estimate the parameters of a model, it was important to have well designed, replicated experiments covering a sufficiently wide range of conditions including extreme treatments. Experiments can act as efficient information generators provided they are properly designed (Nelder, 1972). An attempt by O' Connor (1935) to provide Correlated Curve Trend (C.C.T.) techniques is a practical alternative to the replicated designs. More recently Grut (1970), Burgers (1971), Marsh and Burgers (1973) have used the CCT data for successful growth prediction in thinned stands. (H.L. Wrights).

Simulation

The techniques used in management planning models are usually referred to as either simulation or optimisation. The techniques of simulating or copying, the progress of an operation over a time period is extremely valuable in forest planning, since it permits evaluation of the consequence of events without having to wait for the event to occur in reality. From early times foresters recognised the advantages of simulation and consequently yield tables for use in management planning were developed (Spurr 1952). Such tables have been refined to high degree in recent years (Hamilton and Chriestie, 1973). Simulation has been applied to almost every aspect of forestry and forestry planning operations. Its most widely used application has been in the development of models which stimulate the growth of forest stands. This enables the forest managers to study the problems arising because of decisions to fell and helps him to compare the outcome of alternative strategies. Simulation has been extended to an examination of the physical, economic and environmental consequences of alternatives land use decisions by Bare and Schreuder (1975) in which they use a set of simulation models each of which describes a major components or sub system of a forest ecosystem.

A number of prepacked "models" have been developed for operational use in Timber Management Planning. Notable amongst these are MAX MILLION and TIMBER RAM MAX MILLION (Clutter, et al 1968). They are harvest scheduling model developed for a cooperative of industrial firms in the United States. An improved model, Max Million II (Cluster et al 19780 is currently in use and is being applied by several companies. TIMBER RAM (Resource Allocation Method) is a package for estimating the potential yield and the long term implications of harvesting on National Forest Lands. Although the model is intended for application on land under multiple use management only, the timber portion of the resource is modelled. The limitations of this model has been documented by Chappelle (1977).

Linear Programming Model for Planning Reforestation investments

Experiences with this model demonstrate that it is a practical, efficient method for selecting an optimal set of reforestation projects when there are multiple resource constraints. Indeed, the question of how to select a set of reforestation projects when resources limit the amount of work which can be undertaken arises in about the same form in forest area, throughout the world. A linear programming model was formulated to help reforestation planners select the set of projects and practices which maximise the present net worth of the reforestation program subject to constraints which specify resource available.

Data Processing Model

It is possible, of course, to combine an optimizing procedure such as linear programming with other data reduction or processing models which introduce considerable efficiencies in planning. A system called RPM has been developed as backup to the LP model (Buongiorno and Teeguarden, 1973). The system permits the user to supply data on the availability of characteristics of reforestable land to a model which will accomplish a number of task.

The benefits include both real gains in the efficiency of decision making, measured in terms of goal achievement, and increased understanding of the inter-relationships between goals, decision criteria, alternatives, resources and "efficient" programs.

CARP (Computer Assisted Resource Planning System)

A pilot study in 1971 indicated that forest management practices could be substantially improved through the use of CARP techniques of linear programming to develop long term harvesting schedules for forest lands. The fundamental component of the system is the LP model; the other modules link the LP Component to the forest inventory and multi resources data base and translate the LP analysis into relevant management information. The various modules are described in detail in the papers by Williams (1975) and Hegyi (1975).

An important aspect of the growth models is that they have been designed to utilize all the available inventory and growth data. In addition, the system analysis facilitates the testing of different approaches to growth modelling while using the same data base. The success and acceptance of the CARP System is due to its integrated approach and the total involvement and commitment of both the administration and the scientific community.

Models for Forestry Recreation Economics

The first major important work on recreation economic was by Strand (1967) who discussed different theoretical problems such a collection consumption, non - treatability and joint public and private supply of recreational goods, as well as the possibilities of a better allocation in the production of recreational goods. The intangible part is probably the section on "Measures for describing recreation". The chapter is very critical discussion of the travel cost method and the assumptions behind it. The first and the simplest model Strand describes is based on maximum travel costs as applied by Trice and Wood (1958) The consumers surplus can be expressed by

$$C_s = E_i \text{ (max } C_i - C_i) \times P_i \qquad \ldots\text{. (i)}$$

where
C_i = travel cost from zone it to the recreation area.
max C_i = the maximum travel cost spent to reach the recreation area.
P_i = number of people in zone i visiting the recreation area.

The idea of uniform willingness to pay was unacceptable, and the second model which Strand describes is a Clawson (1959) Zone method, which allows for differences between preferences.
A simple model can be written as

$$V = f\{p + t(r)\} \qquad \ldots\text{. (ii)}$$

where V = rate of visit
p = entrance fee
t(r) = travel cost from distance r to the recreation area

Travel Cost Method (Clawson model)

The basic method as described by Clawson and Knetsch (1966) is to establish the relationship between number of visitors from a given zone at a given site and their travel costs to get there, as in model (ii). This gives the so called trip demand curve or gross demand curve. The aggregated demand curve or the net demand curve for the site can be derived by imposing a hypothetical fee i.e. increasing the actual travel cost by range of fees and for each new cost finding the number of visitors who have that given willingness to pay. The recreational value of the area is then equal to the area under the net demand curve.

Since the above formulation of the travel cost method, further developments and refinements have evolved especially in the field of substitution, time bias and congestion. A formulation of the travel cost method including these factors could be (Dwyer et al 1977) :-

$V_{ij} = f(C_{ij}, P_i, S_{ij}, A_j)$ .... (iii)

where

V_{ij} = the number of site visits or trips for a population source from centre i to a recreation site j.

C_{ij} = Trip cost, the cost of travel between the origin i and the site j, plus entry fee at site j. (included in cost of travel is time)

P_i = population of origin i

S_{ij} = an index of the proximity of substitute recreation areas available to each population source.

A_j = the attraction of site j.

Models such as (iii) have been successfully applied both in linear form (Burt and Brewer 1971), and in non linear form (Cesario and Knetsch 1976).

IIASA Forest Sector Model

International Institute for Applied System Analysis Forest Sector Model is also referred to as Global Trade Model (GTM). This is a partial market equilibrium economic model cast in a nonlinear programming framework, with linear constraints and a partially non linear objective function. For any time period 't' the model finds the market equilibrium solution for all regions and all forest products so that demand and supply are equal for each forest product in each region, given that regional material flows (including timber supply) must balance and that restrictions on productivity capacity limits and interregional trade flows must be observed. The market equilibrium solution for period t is then updated to the beginning of the subsequent five-year period (t+1) by considering changes in timber supply, productive capacity, production, technology and costs, demands, and trade flow inertia. The solution for period t + 1 is then obtained using a non - linear programming alogrithim. In the manner, sequential market - equilibrium solutions are obtained for each five year period in the planning horizon.

The GTM is a partial market - equilibrium economic model that follows Hotelling (1932) and Samuelson (1952). In any time period, the model finds the market equilibrium solution for all forest products in all world region, without considering any possible influence of future time periods. There are 18 regions included in the final data base and GTM. The product categories used in the GTM are 16 in total.

TAMM (Timber Assessment Market Model)

This has been developed for long range planning by the United States Forest Service. The function of this modelling system is to provide long-term projection of consumption, production, and prices of forest products and the growth specified conditions on policy and the economic environment surrounding the forest sector. Since its inception in the late 1970s, the TAMM system has under gone a number of extensions and revision. Revisions to this basic structure complete within the past 5 years embraces 3 major areas (Haynes and Adams, 1985).

1. The pricing and outputs of sawn timber and pulpwood stumpage have been differentiated.

2. Recovery factors for the endogenous solid wood products have been consistently linked to residue generation factors.

3. Product supply relations were revised to include capacity as a shifter and capacity change models were revised to better reflect historical experience.

Some other efforts

Some progress has been made to incorporate the various decisions into forest planning processes. Chen, Rose and Leary (1980) have described a mathematical approach for arriving at the desired value of spacing/thinning options, considering stand treatments, production and risk, from the choice of a range of economic factors where the equations of the type can quantify discrete or continuous decision.

$Y_4 = B_3 = K_3 + aSK_3 - bK_3^m,$

where Y = decision, B = Crop variable, K = Growth, S = Site, a & b are constants.

Control of yield is also facilitated by detailed knowledge of the factors involved.

(2) Jose A. Aleix DA Silva, Bruce E. Borders, Graham H. Brister, 1994, estimated tree volume using a new form factor. The use of cylinder form factor in tree volume estimation is discussed together with the use of Girard form class and the normal and absolute form quotients. A new estimates of cylinder form factor is derived which uses two stem diameter measurement at 0.5 feet (15.2 cm) and 5.0 feet (1.52 m) above ground level. The estimated form factor f would be

$f = p\ (Vs/Vc)(TH/TH-h)$

This can be also expressed as.

$f = [0.25 + 0.25(D_u/D_1)][TH/(TH-5.0)]\ X\ 0.005454(DBH)^2(TH)$

where everything is as defined :

p = constant of proportionality
Vs= Volume of the first butt section (cu. ft) between D_L and D_u Calculated by Smalians formula.
D_1 = diameter at 0.5 feet (15.2 cm) from ground level in inches.
D_u= diameter at 5.0 feet (1.52 m) from ground level in inches.
Vc= Volume of the cylinder with diameter equal to D_1 and height equal to 4.5 feet (1.37) in cu. ft.
TH= Total tree height, in feet
h= height where the upper Diameter Du was measured (5 feet or 1.52m)

This produces very good estimates. This estimate & procedure involves the measurement of three lower stem diameters and total height of the tree. (CFR March p/6)

(3) Khanna, P.; and Mahindra, A.K.; studied the consumption behaviour of Fuel wood in Gujarat and developed two regression Equations.

(i) Rural areas having no forests :
$Y = 0.24369 - 0.02179\ X_1 - 0.00142\ X_2$

where, Y = Percapita fuelwood consumption,
X_1 = Population (Million), X_2 = Cattle (lakhs)

(ii) Rural areas having forests:
$Y = 0.02925 - 0.0266\ X_1 - 0.000259\ X_2 - 0.06063X_3$

where
Y = per capita fuelwood consumption
X1 = Population (Million)
X2 = Forest area (1985-86)
X3 = Cattle (in lakhs)

(a) It was inferred that the demand of fuelwood increases with increase in population in rural & urban areas.

(b) Availability of firewood has significant effect on per capita fuelwood consumption.

(4) Singh, O.; Negi, M., 1995 have worked out Interrelationship between Biomass and Volume. Inorder of obviate the difficulty of felling standard of green trees on the new site where biomass estimation is required, regression equations are needed. Such regression equations have been worked out and the relationship between the bole biomass (OB & UB) and volume (OB & UB) have been developed for Eucalyptus hybrid, Eucalyptus grandis and Pinus patula. Various models were tried but the simple linear trend is established in which the coefficient of correlation comes out to be highly significant which is 0.98 or 0.79 in almost all case.

$Y = a + bx$, X = is the volume,
a = regression constant, b = regression coefficient

(5) A study on the optimum size of sample for forest inventory was done by P.N. Ray.

The equation

$$n = t^2CV^2/(AE\%)^2$$

where, CV = coefficient of variation, n is number of sampling units, AE is allowable Error, t = students-t with corresponding degrees of freedom.

Thus the present paper discusses and highlights issues connected with human resource development and the role of economic growth models in forest management for sustainable production of multiple benefits, which had been a matter of debate at various national and international fora.

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INTERACTIVE, DYNAMIC AND MULTATTRIBUTE TECHNIQUE FOR MODELLING IN FOREST PLANNING

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SUMMARY

To determine the optimal sequence of decisions for managing a forest for multiple uses, we developed a decision support model using a multiobjective dynamic procedure in combination with an interactive programming and multiattribute utility approach. The process in a forest is defined in terms of stages, states and decisions, and presented in the form of a network. The standard algorithm for finding the optimal path in such a network amounts to solving equations, based on Bellman's principle of optimality. This algorithm was adopted because of the multiobjective nature of the problem. A preference and utility procedure was used to analyze and rank the decisions according to the returns, measured by attributes. Further, the data used to express the returns are not all well-defined attributes, thus the decision-maker has to become involved in the optimization procedure. This involvement is called interactive programming.

Key words: forest management, operations research, decision support system, interactive and multiattribute decision making, multiobjective dynamic programming

INTRODUCTION

Forest management involves a set of resource inputs, like land and labor, to produce a set of goods and services such as timber, forage, water, wildlife habitat, an aesthetically pleasing environment for recreational use, protection of soil and gen resources, etc. The objectives of forest management are, therefore, multiple. They are usually non-commensurable, non-marketable, and have to be achieved simultaneously while also considering economic and environmental restrictions. The forest manager has to determine a sequence of forest management strategies that provides for sustained timber production and does not diminish non-timber forest resources, recognizing that the forest is a dynamic resource with an extremely long production period. In order to manage forests for all of these goals and to direct development of the existing forest state towards an ideal one, managers have turned to model-oriented forest management, in the hope that an optimal sequence of forest decisions could be obtained as an outcome of a multicriterion decision making process.

Researchers from different disciplines have directed considerable effort towards the development of models and methods which accurately represent and solve problems facing forest managers. Therefore, mathematical models are not new in forestry. Investment and econometric models, and growth models were applied to forest management problems in the early 1960s. Their development and application have been growing rapidly since then in accordance with the sustained and continuously changing social demands from the forest. The expanded use of models in forest management coincides with the rapid development of systems analysis, operations research and computer science. Additionally, the large quantity of data now available to quantify the forest requires computer-based operation-research tools. Most of the models are developed to compute the effects of selected decisions. Models can be classified by their deterministic or stochastic properties, then optimization of one or more objectives, and the algorithm used for solving the problem. In the earliest models linear programming was used (Johnson et al., 1977, Kent et al., 1985). The discrete-time and discrete-state version of dynamic programming as a method for solving sequential decision problems was applied to the optimal forest management by Amidon et al. (1968), Brodie et al. (1979), Valsta et al. (1985), Zadnik (1990), Haight (1991). Hool (1966) stated the need for stochastic methods in the forest management and introduced Markov decision processes to the forestry. The idea of multiple-use forest management was first expressed by goal programming (Field, 1973, Mendoza, 1986). Goal programming uses weights that reflect the relative importance of each objective. Assigning the proper weights to the goals is one of the most vexing problems in goal programming. Therefore, it had been subjected to criticism, and appears to be getting into disfavor. Some authors have suggested using preemptive goal programming to circumvent the problem of assigning weights (Nayak et al., 1989, Zadnik, 1993a). Other multiobjective models and methods applied to forestry include those presented in papers written by Bare et al. (1988), Liu et al. (1991), Gong (1992), Howard et al. (1993), Zadnik (1993b).

Despite the increasing emphasis on the multipurpose role of forests and the well demonstrated utility of multiple criteria decision making techniques, foresters have shown limited interest in the application of these methods. This may be because it is difficult to derive a measure for non-timber products which is comparable to revenue from timber production. Therefore, some problems in forest management are still unsolved or, at least, are not sufficiently elaborated in the optimization models. Our contribution to this issue is a decision support model which utilizes multiple objective dynamic programming, based on Bellman's principle of optimality, combined with interactive programming, and a management tool for analyzing and ranking forest decisions.

FOREST PROCESS PRESENTED AS A NETWORK

The process in the forest is characterized as a multistage decision process. Therefore, it is defined in terms of stages, states and decisions, and presented in the form of a network.

Due to the exceptionally long duration of forest production, the forest planning horizon equals the production period of the forest or is even longer. It is divided into equal time periods (stages), assigned by a finite and discrete variable t. Thus, the stage variable t defines the sequence in which the decisions are made in the process. Increments of, for example, one year in the process define time as a discrete stage variable. Each stage t has more states associated with it. The instantaneous situation of the process at each stage t is completely specified by state variables s_1, $s_2, \ldots$, as basal area, number of trees per acre, average stand height, volume, species, capacity of the forest area, quality of the existing tree species, development stage, growth function, etc. In defining state variables it is helpful to consider of what changes from stage to stage and what is affected by decisions. The values of state variables can differ in any stage t and are determined by the process. The state variables which define a possible state of the forest at stage t form a state vector $s(t,s_1,s_2,\ldots) \in S(t)$, where S(t) is the set of all possible forest state vectors at the stage t, if we suppose that there exists a finite number of such vectors at each stage t. Considerable attention must be paid to determination of the goal state of the forest $s^*(t^*,s_1^*,s_2^*,\ldots)$. It is defined in accordance with the idea that the forest development should be towards a healthy, well-groomed forest that delivers timber and non-timber forest products on a permanent basis.

The decision-maker can influence the process by invoking forest management decisions. The decisions are expressed by decision variables d_1, d_2, ... At each state, the state vectors $s(t,s_1,s_2,\ldots)$ build a finite discrete set of decisions $D(s(t,s_1,s_2,\ldots))$. The decision variables are sometimes called control variables as the effect of the decision d_i is to move the forest process from a stage and state to another state at the next stage. The relationship between the state variables at the next stage and the state and decision variables at the current state is described by the equation:

$$s'(t+1,s_1',s_2',\ldots) = f(s(t,s_1,s_2,\ldots),d_i(s(t,s_1,s_2,\ldots))) \quad (1)$$

The equation (1) says that the state variables at the next stage are a function f of the existing state and the decision variable undertaken at this state. The function f transforms the current state and the decision to the next state and is, therefore, called the transformation function. This function is described by Zadnik (1990) and by Bare et al. (1994) who limits the number of state variables to two.

The forest management process defined by stages, states, decisions and equation (1) is normally graphically presented in the form of a network. The stage values are placed on the x axis, the state vectors on the y axis, while the equation (1) tells how to move from the existing state vector to the next state vector, under the influence of the decision variable, until reaching the goal state vector (Fig. 1).

To indicate the optimal sequence of decisions, controlling the initial state vector over all stages to the goal state vector, the performance criterion is used. The objective function defines the performance criterion and is the function that is optimized. It reflects the managerial objectives and links the state and decision variables. Therefore, the objective function, associated with each state and decision, is a vector function defined by a number of attributes, such as profit, existing timber volumes, timber output, non-timber products, water yields, aesthetics, habitat condition, visitor days, biological diversity, employment, etc.

The standard algorithm for finding the optimal sequence of decisions in a designed network, i.e. to find the optimal path in a network, amounts to solving equations, based on the Bellman's principle of optimality (Bellman, 1957). But, because we are dealing with a multiobjective problem, while the ordinary Bellman's principle of optimality deals with only one objective, the algorithm was adopted to the multiobjective dynamic programming algorithm. Because the number of decisions at each state and stage in the network is great and requires an exhaustive search over the paths, we used a preference and utility procedure, first to analyze and then to rank the decisions according to the attributes. Further, because the data used to express the objective function, measured by attributes, are not all well-defined, the problem is ill-defined in the sense that the decision-maker has to become involved in the optimization procedure. This involvement is called interactive programming, Using it, the decision-maker determines the preferences for the path taken within the network.

PROCEDURE FOR ANALYZING AND RANKING THE DECISIONS

As the basis for determining the preference order of possible decisions at each state and stage we have chosen a preference analysis and utility theory (Keeney et al., 1976) and not an equivalent cost-benefit calculation.

We assume that there are n attributes $X_1, \ldots, X_n$, whose quantities are denoted by $x_1, \ldots, x_n$, associated with each decision at each state and stage. To quantify the preferences of the decision-maker we assign a utility u to each of the possible consequences $(x_1, \ldots, x_n)$. If the decision-maker prefers the consequence $(x_1, \ldots, x_n)$ to the consequence $(x_1', \ldots, x_n')$ then $u(x_1, \ldots, x_n) > u(x_1', \ldots, x_n')$, whereas, the equality holds, if the decision-maker is indifferent. Because of the nature of forest management problems we may infer a separable preference structure, in the form of additive functions:

$$u(x_1, \ldots, x_n) = \sum_{i=1}^{n} k_i u_i(x_i), \quad \text{where} \tag{2}$$

k_i are positive scaling constants which present the weights of attributes X_i.

There are two components for assessing the preference structure:
- assess the preference function over individual attributes,
- assess the tradeoffs among attributes.

The assessment of preference functions for individual attributes obtains possible ranges for the measures x_i of each attribute X_i, scaling the measures by assigning a preference value of zero to the worst level and one to the best level, through interactive questioning of the decision-maker. Assessing the tradeoffs between the attributes requires preference ordering among the attributes, for example:

$$k_2 > k_3 > \ldots > k_j.$$

The attribute weights k_i are normalized using the fact that they should sum to one:

$$k_1 + \ldots + k_n = 1$$

Attributes are measured in different dimensions and scales. The attributes can be cardinal - like costs, time - or ordinal - like biological diversity and scenic view. Attributes with ordinal scales have to be converted to interval scales, as for example: a=5, b=4, c=3, d=2, e=1 (Zadnik, 1995). Further, the procedure consists of estimating utility functions (preferences) u for each of the attributes and analyzing value tradeoffs within each attribute and between the attributes. In the case that the decision-maker is risk neutral, the linear utility function for single attribute is given with:

$$u(x) = (x - x_{worst})/(x_{best} - x_{worst}), \text{ where } u(x=x_{worst}) = 0 \text{ and } u(x= x_{best}) = 1. \quad (3)$$

Using formula (3) and then (2), we are able to evaluate each possible decision chosen at each state and stage, and to rank the decisions regarding the value $u(x_1,...,x_n)$. To keep the network from becoming exhaustive, we suggest taking into the optimization problem at each state and stage only some initial decisions (for example starting with two) from the ranking list obtained by the utility procedure described.

MULTIOBJECTIVE DYNAMIC PROGRAMMING AND INTERACTIVE PROCEDURE

Let us assume that we dispose of a network in which the forest states are the nodes and the connection between the states, presented by equation (1), its arcs. Let the arc simple assign as (i,j), where j > i and presents the nodes connected with the node i. Each arc (i,j) is associated with a vector u(i,j) of n attributes: $u(i,j)=u(x_1(i,j),...,x_n(i,j))$. Because clear attributes which constitute the objective function of the problem do not always exist, the decision-maker must take an active role in locating the optimal path in the network. Such an involvement calls for an interactive programming approach which must be incorporated into the multiobjective optimization procedure (MOP). It is an iterative procedure based on Bellman's principle of optimality (Bellman, 1957). The optimal paths from node i to the sink (goal forest state, end node) is found recursively solving Bellman's equations:

$$f(i) = opt(u(i,j) + f(j):j<i); \; i>1, \; f(1)=0, \text{ where } f \text{ and } u \text{ are vectors.} \quad (4)$$

The recursive Bellman's equations used to find the optimal path with multiattributes are solved by interaction with the decision-maker who selects an optimal path from a set of available paths (Mitten, 1974). It is assumed that the preferences are represented by a linear function over the attributes. In each iteration of the MOP an uncertainty interval is given so that it is certain that the true values are in the interval (e,f), if the decision-maker has not changed his preference order. The algorithm starts out by assuming that the coefficients b_m of the linear function are positive: $b \in R^n$, $b>0$ and $\sum b_i=1$. Given two vectors u and u' in R^n, u' is preferred to u if bu'>bu for all possible b. The algorithm is simple when there are only two attributes (n=2), because the coefficients are $b_1=b$ and $b_2=1-b$, and the uncertainty interval of b is initially (0,1) (Henig, 1994). The problem is reduced to verifying that bu'>bu or bu'<bu. Otherwise, according to the decision-makers

preference, either e or f is replaced by b^*, where $b^*(u'-u)=0$. The procedure finds the optimal path simultaneously after an appropriate labeling of the nodes, according to the input data (c_{ij},t_{ij}) for each arc (i,j), $j<i=2,\ldots,m$, where m is the number of all nodes in the network, c_{ij} the value of the first and t_{ij} the value of the second attribute for the arc (i,j). Assigning (c_i,t_i) as the value of the optimal path of the node i, and n(i) the first node from i on that path, $i=1,2,\ldots,m$, the procedure can be explained using the following seven points:

1. $(c_1,t_1)=(0,0)$, $i=2$, $e=0$, $f=1$, $k=r=1$.
2. If $i=m+1$ terminate. Otherwise, $k=r=j_{min}$.
   For meaningful nodes $j<i$: $C(j)=c_{ij}+c_j$, $T(j)=t_{ij}+t_j$.
3. $w_1=eC(k)+(1-e)T(k)$, $v_1=fC(k)+(1-f)T(k)$.
4. $r=r+1$. If r is not equal to meaningful j, $r=r+1$. Otherwise, if $r=i$ then $(c_i,t_i)=(C(k),T(k))$, $n(i)=k$, $i=i+1$, goto 2.
   Otherwise, $w_2=eC(r)+(1-e)T(r)$, $v_2=fC(r)+(1-f)T(r)$.
5. If $w_1\le w_2$ and $v_1\le v_2$ then goto 4.
   If $w_1\ge w_2$ and $v_1\ge v_2$ then $k=r$, $n(i)=k$, goto 3.
6. Let b solve $bC(k)+(1-b)T(k)=bC(r)+(1-b)T(r)$.
7. Interaction with the decision-maker:
   If $(C(k),T(k))$ is preferred to $(C(r),T(r))$, i.e.
   $b_1C(k)+b_2T(k)>b_1C(r)+b_2T(r)$ then,
   if $w_1<w_2$ and $v_1>v_2$ then $e=b$,
   if $w_1>w_2$ and $v_1<v_2$ then $f=b$.
   If $(C(r),T(r))$ is preferred to $(C(k),T(k))$, i.e.
   $b_1C(k)+b_2T(k)<b_1C(r)+b_2T(r)$ then $k=r$,
   if $w_1>w_2$ and $v_1<v_2$ then $f=b$,
   if $w_1<w_2$ and $v_1>v_2$ then $e=b$.
   Goto 3.

A NUMERICAL EXAMPLE WITH TWO ATTRIBUTES

To illustrate the procedure for analyzing and ranking the decisions let us suppose that at the existing forest state $s(t=0,s_1,s_2,\ldots)$ there are five possible decisions $d_1,\ldots d_5$. The impact of each decision on the existing forest state is analyzed by two attributes X_1 (profit, measured in thousand USD/ha) and X_2 (biological diversity, measured in ordinal scale). The value of attributes in dependence of the decision, the utility function u(x) for single attribute, defined by (3), and normalized attribute weights are given in Table 1.

Table 1: Decision impacts on multiple criteria for the forest with the state $s(t=0,s_1,s_2,\ldots)$, utility function for single attribute and normalized attribute weights

Attribute	Decision d_1	d_2	d_3	d_4	d_5	x_{worst}	x_{best}	u(x)	nor.at. w. k_i
X_1	1	5	2	1	0	0	5	x/5	0.73
X_2	a	e	c	b	c	1	5	(x-1)/4	0.27

Using the equation (2) for evaluating the decisions, we rank the decisions according to the Table 2: $d_2 > d_3 > d_1 > d_4 > d_5$.

Table 2: Evaluation of decisions

Decision				
d_1	d_2	d_3	d_4	d_5
0.416	0.73	0.427	0.3485	0.135

To demonstrate the multiobjective dynamic and interactive procedure we deal only with three stages and six states (nodes), m=6 (Fig. 1). In the existing state (node 1) we took into account the first two decisions (d_2 and d_3) from the ranking list (Table 2). The new state at the next stage (node 2, node 3, etc.) is calculated using formula (1). Each state transition (arc) is associated with two values (attributes). For example, the arc (1,2) is associated with $(c_{12},t_{12})=(5,1)$, according to the decision d_2 and Table 1.

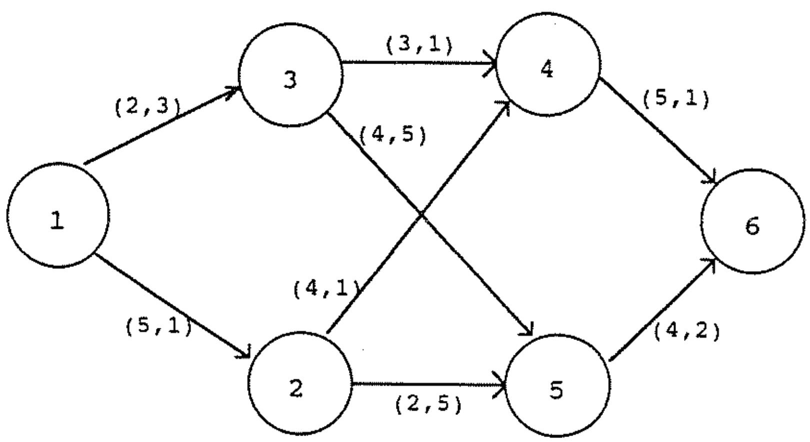

Fig. 1: Network of the numerical example

In the example presented in Fig. 1 we got with b=0.5 $(c_2,t_2)=(5,1)$, n(2)=1, $(c_3,t_3)=(2,3)$, n(3)=1. $(c_4,t_4)=(9,2)$ because (9,2) was in the interaction with the decision-maker preferred to (5,4) (point 7 in the interactive programming procedure), and n(4)=2, (e,f)=(0.33,1). Further, we got $(c_5,t_5)=(6,8)$ after the interaction with the decision-maker because (6,8) was preferred to (7,6), n(5)=3 and (e,f)=(0.49,1). Because the decision-maker preferred (10,10) to (14,3) we got $(c_6,t_6)=(10,10)$ and n(6)=5. The optimal path follows the nodes: 1 - 3 - 5 - 6. We carried out the numerical example also using b=0.3 and b=0.8. For b=0.3 there was no difference according to the optimal path. But assuming 0.8 for b, we obtained the path: 1 - 2 - 4 - 6 as optimal, where $(c_6,t_6)=(14,3)$.

CONCLUSIONS

An interactive, multiattribute dynamic programming technique for analyzing management problems in forestry was presented. It searches for the optimal decision trajectory, starting with the current forest state, and shows how it should be managed over time to optimize the stated objectives. The algorithm was explained in detail for two attributes and it results in a modified standard efficient shortest path algorithm. A detailed, i.e. more complicated, investigation is required to relate the network to more than two attributes. The use of the model produces more "optimal" solutions as there are numerous optimal paths that depend on assumptions about the internal and external parameters produced by the decision-maker. That is why the decision-maker has to be quite familiar with the problem, i.e. well educated and experienced.

The technique presented above has not been implemented yet, because the large state and decision space, as well as ill-defined objective functions, measured by attributes, are an imposing computational problem. This study indicates the feasibility of using the technique described to optimize forest management decisions. Recent advances in computer technology and continues interest in forest management optimization applied to practical forest planning make continues use and development of computerized models likely. The practical experience gained will continue to provide new ideas which will improve long term forest planning.

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NEW TRENDS IN FOREST MANAGEMENT PLANNING OF SMALL-SCALE FELLING SYSTEM

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1.0. INTRODUCTION

The principle of sustainability in the forest management is a forestry and political principle of natural resources utilization with a simultaneous preservation and improvement of their reproduction ability. The goal of forest management as a practical activity as well as a scientific discipline is, from a very beginning, to secure forest sustainability and yields from it. In spite of the fact that the contents and the method of forest management planning have been changed and developed in the particular periods of the social development, the principle of a sustainability has been preserved even at the parallel implementation of an ecologization, polyfunctional forest management and a formation of nature-simiral forest (PRIESOL-POLÁK 1991, KORPEĽ-SANIGA 1994, KURTH 1994).

The social and economical changes of the society and deteriorating condition of the forest health being damaged by pollution, influence mostly the forest management in our domestic conditions. Forest management units for planning have been changed, investigation of the management conditions and investigation of forest state as a base for general planning (long-term) and detailed (short-term) planning, are being made more exact. The obligatory character of managing according to the forest management plans for every forest owners and users, has been strengthened (PRIESOL-HLADÍK 1993, ŽÍHLAVNÍK 1992).

The goal of the work is to point out the new approaches of forest management planning in the present conditions of the forest management in Slovakia.

2.0. UNITS OF FOREST MANAGEMENT FOR INVESTIGATION OF MANAGING CONDITIONS AND FOREST STATE

The task in the spatial arrangment of the forest is to outline the management and technical units as the frames for management planning and a forest state assessment. They are the following units:

Forest estate the part of forests according to their use: it is the largest unit, for which the forest management plan constructed. In the recent past, when the right of use of the all forests was subordinated to the State Forests, the forest management unit was correspondent with the organizational unit of the State Forests (approximately 5 - 7 000 ha). The present management units have the area of 50 - 6 000 ha.

Forest region, subregion or the part of the forest region, subregion, which are demarcated by the nature conditions: basic territorial unit for the general planning (VLADOVIČ 1995).

Forest regions are the territorial units formed as the permanent natural units of the regional level on the base of biogeographic regionalization, for which the synthesis of criteria of geomorphological, macroclimatical and pedogeological classification are decisive. They are the regional system territorial ecological units, generally and naturally homogenous, which have character of specific combination of an occurrence of forest typology and pedology basic units, specific by generally similar inclination towards the ecological stability, specific in production respect and to the large extent by the forest functions as well.

Forest subregions and the parts of forest regions are the lower territorial units of a regional to a local systematic level.

Forest subregions (from the point of view of more detailed judgement within the framework of forest regions) have character mainly of significant pedogeographical differentiations supported also by climatical differentiations which are possible to localize by geomorphological unit or by any lower existing unit of the geomorphological classification.

The parts of the forest regions (subregions) are formed considering the detailed level of forest regions determination (resp. subregions) with preference of the macroclimatical point of view in this determination. These units are possible to localize only partially by existing unit of the geomorphological classification. The lines of these units are defined mainly topographically.

The solution of the territorial localization of the forest regions, subregions and their parts (components), based on a preference of geomorphological territorial classification of Slovakia, has been justified by the time sustainability and good ability to be indentified in the field. Based on these criteria, 47 forest regions (Fig. 1) have been formed in the territory of Slovakia, which are independent on ownership and users' relations to forest and on the organizational and geopolitical division of the territory.

Management class: is the basic unit for elaboration of management models within the framework of forest region. Determination of the management class is based on the forest type as an unit with the same site conditions, and on the stand type as an unit with the same management forest state. These analytical units should be generalized to the wider units, for which it is already possible to establish the management methods. In this way there is formed, on one side, the management group of forest types and on the other hand, the management group of stand types. For the operational purposes in determination of the concrete management measures, both groups are necessary to combine in to the associated unit-operation management class. The scheme of the management class construction is in the Fig. 2.

Subcompartment is the lowest permanent unit of the spatial forest demarcation, which has unified or, at least, similar production conditions; it is independent in a management and technical way, with suitable form and size, it serves for investigation of forest state, for planning, record keeping and supervision of management measures and for orientation in forest. The partial plots or stand groups are outlined in it according to the need. It serves for the detailed investigation of forest state and planning of management measures.

The formation of permanent units of forest demarcation is an essential issue for the forest management. This is so because these units form the basis for the whole construction of the forest management; they are the foundation of the spatial forest arrangement, they are operational units for forest silviculture, forest protection, felling and timber transportation, and in addition, they form preconditions for a solution of production and economical problems, for monitoring and record of forest development, i.e. supervision of production in a wider sense.

3.0. FOREST MANAGEMENT PLANNING

Forest management planning is a complex of knowledge, decisions and measures on the methods of the future forest management on the base of the public and user' interests and found out natural, social, technical and economical conditions of the object arranged, and the present state of forests up to the lowest units of forest demarcation.

There are two types of the management planning as follows:

- General planning (long-term)
- Detailed planning (short-term).

For the recognition of management conditions there is, at present, executed the entire investigation of forest state for the general planning, monitoring of the forest state and forest resource development. It is realized for the territorial parts of forest regions, subregions or their parts through the mediation of an forest ecological survery and the special investigations. The results will be applied at the detailed investigation and planning in the particular stands.

The detailed investigation of forest state contents the data on the category, forest functions, forest form, management class, rotation of management class, area, age, stand density, exposure, slope, method of stock determination in stand, and data on tree species composition, mean height, diameter, site class, stock, damage. The numerical data can be completed with the word description.

Forest ecological survey integrates the activities of ecologically orientated special surveys (typological investigation, forest protection investigation and game management investigation, survey of protection and formation of landscaping, amelioration investigation, special surveys of transport conditions and economic investigation). In addition to the results of ecological survey, the permanent information from monitoring of the forest ecosystems obtained from permanent monitoring plots in the network of 4 x 4 km, are used in the works of the forest management.

Forest ecological survey in the framework of the particular territory includes:

- assessment of the natural conditions (geomorphological, orographic, climatical, geological, hydrological, typological and pedological conditions, state and assessment of forest the ecosystems and their basic components),
- categorization of forest functions, functional forest types,
- forest management typification,
- ecological stability,
- stands health condition,
- breakdown of injurious agents,
- zones of endanger,
- forest tree species genepool and phenotypic classification,
- forest transportation network,
- game management,
- regional general planning - management models,
- amelioration,
- outputs of the ecological survey,
- map of an ecological stability (state of the forest ecosystems),
- map of the proposal of the ecological measures.

3.1. General planning of forest management

The general planning solves the methods of the forest management so that the goals and mission of forests can be reached. It is based on the application of the principles of complex forest assessment as the forest ecosystem; on an application of the territorial principle, relations to an ecological stability and principles of ecologization in planning. The general planning is elaborated regardless the kind of ownership and type of using.

The basic unit for the general planning is a forest region, subregion (or their parts).

For the basic territorial framework - forest region, subregion or their parts, the general planning is differentiated according to the functions of forest, natural and stand conditions, forest state and its potential cudangerement.

The particular forest function is determined by biological, biotechnical and special functional requirements. It is expressed by category of commercial forests, protection forests, special purpose forests. The nature conditions are expressed by the management group of forest types or associated management group of forest types, in dependence on the level of possibility and purposefulness of the management principles differentiation.

The growth conditions are expressed by the management form, management group, stand type and by an equivalent expression of a form of combination of existing tree species composition.

The state of forest with regard to the site inclination to the ecological stability and changes of its potential damage, is expressed by a level of an ecological stability.

General planning of forest management is elaborated on the basis of the results of the forest ecology investigation and further special surveys and findings.

General planning of forest management contains:

- quantification of basic input data
- trends and prognosis of the development of basic characteristics
- models of management
- specifics and deviations from the management models.

Quantification of basic input data is formed by surveys on ecosystems conditon, ecological assessments, as well as management conditions (surveys on typological units, degrees of ecological stability of forest ecosystems, forest categories according to functions, zones of endangerement and degrees of endagerement, degrees of damage to forest stands and forest tree species, harmful agents, operation groups, silvicultural systems and forms, incidental fellings, afforestation losses).

Trends and prognoses of the development of basic characteristics observe changes of ecological characteristics of given territory in time period, with their subsequent prediction as follows:

- forest tree species damage according to the kind of harmfull agent, range and intensity
- changes of tree species growth intensity
- chemical load of assimmilatory organs of forest tree species
- chemical load of soils
- total damage and endangerement of forest ecosystems.

Models of management are optimized basic decisions, objects and principles of decisions, objects and principes of management classified in the structure of management class and associated management forest type groups within the framework of relevant forest category according to functions, forest form, endangerement zone, immission type and degree of ecological stability (PLÍVA 1991).

Models of management contain:

a) basic decisions: forest category according to functions, management form of forest, silvicultural system and its forms, rotation cycle, regeneration period, period of security, recovery period;

b) management goals: goal tree species composition, future production, spatial arrangement, potential degree of ecological stability;

c) principles of management: principles of tending, regeneration, stand establishment, accessiblent, stabilization, functional demands (Fig. 3).

Specifics and deviations from the models of management are territorially conditioned, naturally well-founded, reasonable changes of the basic models of management which can not be in contradiction with the objects of ecological forest management.

Characteristics, which are with their contents and arrangement determining factors for construction and identification of models, are named the identifiers of management models. The identifiers are also used for combining general outline of forest management and detailed planning.

The results of general outline are incorporated into the principles for the elaboration of forest management plan and they are obligatory.

3.2. Detailed planning

Detailed planning is the determination of management measures for separate stands during the period of forest management plan validity. It follows from the principles of general planning, forest condition being found, possibilities and needs of forest stands, principles of spatial arrangement with the aim to reach the long-term objectives of management. Within the framework of detailed planning there are determined regeneration felling, tending felling, afforestation, protection, stand accessiblent and cutting of lines and further needed management measures respectively according to local conditions, as well as according to the results of special projects elaborated individually.

Regeneration felling is planned in volume units according to tree species together and on the felling area. Felling and regeneration progression, direction of progression, location of regeneration felling and felling urgency as well are determined for regeneration felling.

Tending felling is planned on the thinning area real and multiplied, in volume units according to tree species together, and at the same time it is possible to determine time of tending measure.

Cleanings are planned on the area real and multiplied as well.

Afforestation is planned to be classified into afforestation of present clear-felled areas, improvement of young forest stands, afforestation of clear-felled areas from planned felling. Afforestation is stated on the area according to tree species, on the area of expected natural regeneration according to tree species and together according to the classification of afforestation.

Based on comparison of the present contents of detailed planning with the contents elaborated according to previous legislative standards, as well as the contents given in schoolbooks and publications published till now, it can be stated that they are unchanging relatively. The basic unit of spatial division of the forest always remains the object, but also the contents of planned management measures are constant regeneration and tending felling, cleaning afforestation, further silvicultural activity).

Only sphere of input information, which are at the elaboration of this plan available for working plans officer, is considered to be more extensive (models of management, detailed information of ecological research and monitoring of forest health condition).

4.0. CONCLUSION

In accordance with valid legal regulations, all forest users are obliged to plan management in such a way to increase fertility of forest lands and production of wood substance at the present security of public-beneficial forest functions. For that reason, forest management plans contain:

a) obligatory data, which are for the units of spatial division of the forest as follows: silvicultural system and its form, upper limit of the volume of tending planned cut in the stands over 50 years, lower limit of the volume of tending planned cut in the stands to 50 years, the area of cleaning and tending felling, regeneration composition of principal tree species;

b) directive indices and data, which are especially as follows: silvicultural system of forest, allocation and progression of fellings, method of changes and forest stands amelioration;

c) orientation indices, which are for example the following: characteristics of natural, economical and technical conditions of management in forests.

At the determination of obligatory data in commercial forests it is necessary to take into account also distribution of timber supply, increment conditions and felling continuousness, in protection and special-purpose forests it is necessary to take into account forms of silvicultural systems being determined in relation to predominant forest functions. The organs of state administration of forestry performs the control of the fulfilment of regulations of forest management plans and their observance.

The formation of forest regions and models, which contain basic decisions, objects and principles of management incorporated into the structure of operation groups and associated management forest type groups, represents a significant contribution to materialization of forest management planning.

The quality and rationalization of works is increased by still improving computerized information system (HERICH-TAJBOŠ 1991, ŽÍHLAVNÍK, Š.-HERICH 1994).

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Fig. 1. **Forest regions of Slovakia**

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J. Vladovič and col.

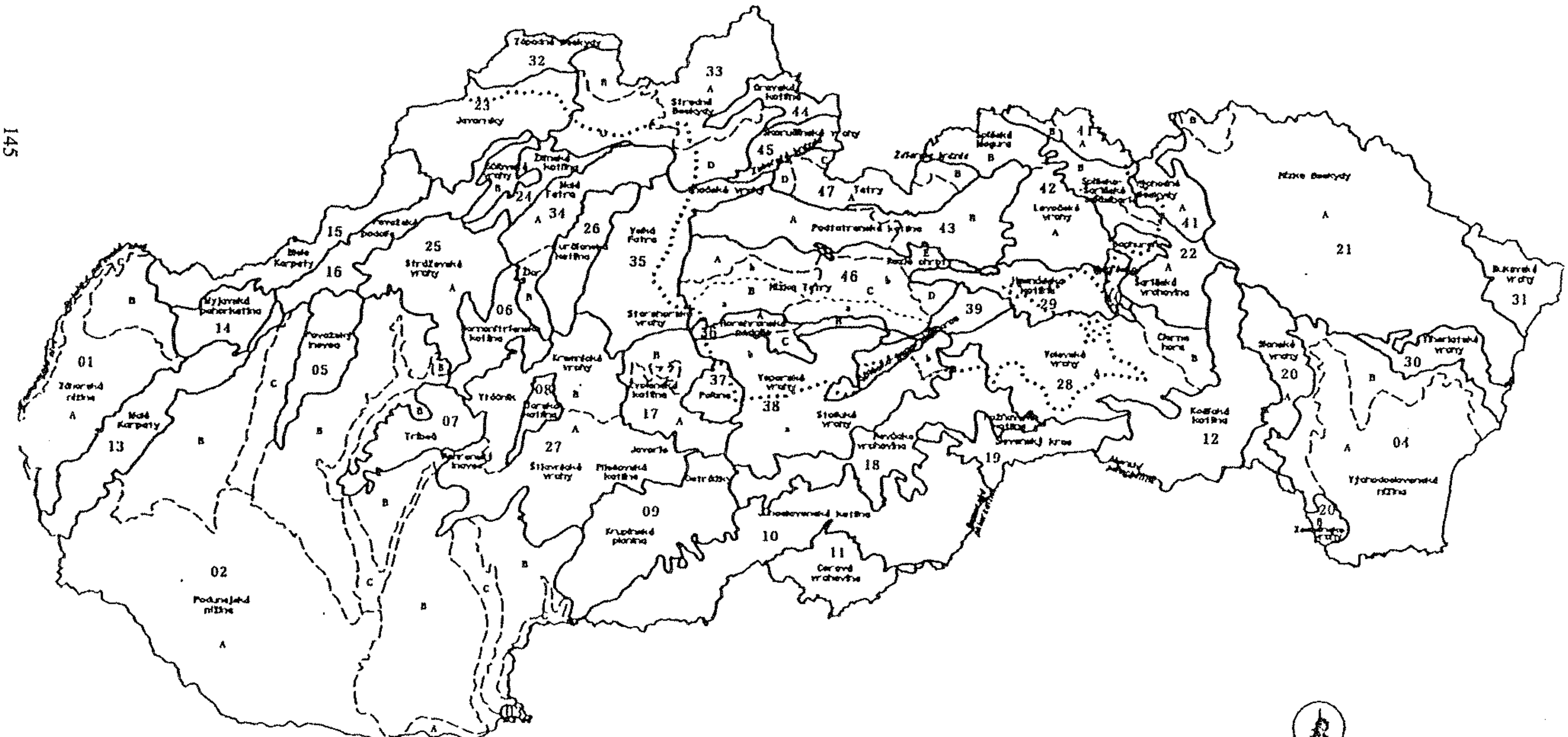

Fig. 2. Scheme of the management class construction

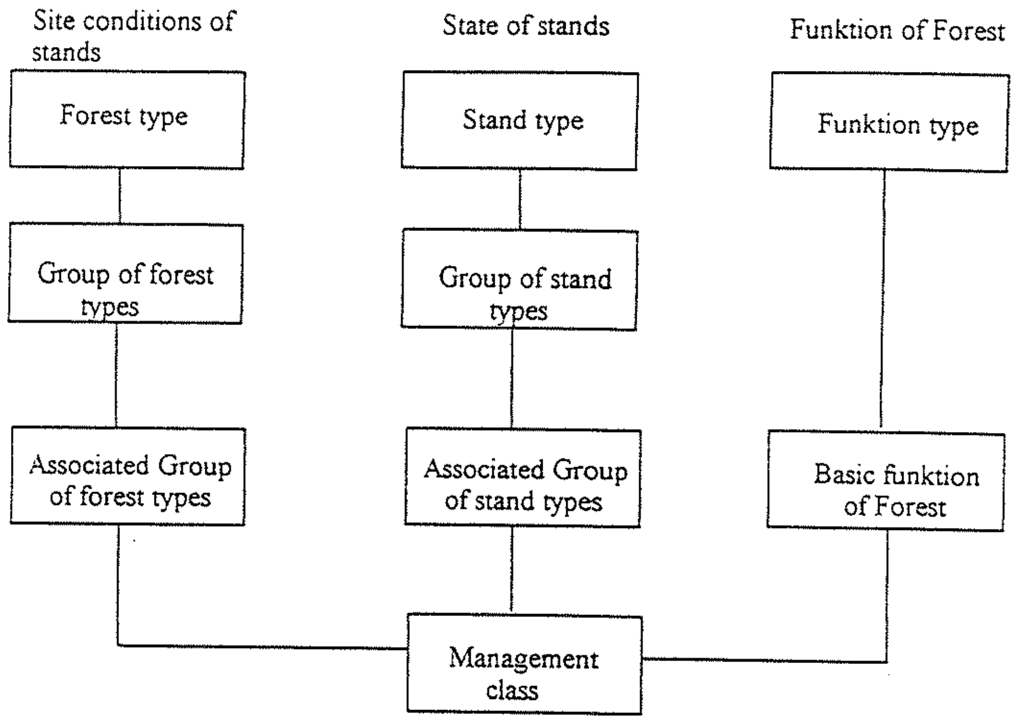

Fig. 3. Management model of forest region 43A - Undertatra basin

Year 1994	Region 43A	TSES	R 120	EZ D	IT A00	F CF	L	FF H	MKL 65	FTG 611	STG 11	ES 1.2
Basic decisions		F	R 120	ch. R R-10	Sa 1 FI Sa 2 Sa 3	R1 120 R2 R3	Regener. per. 40 Security per. 7 Recover. per. 10			M. system and form	1 SSHE 2 SCUT 3	
Goal		Ecolog. stability 1,2		Production m^3 1958-2555			Sp. arangement 4 H					
Tree species composition (Tree species from - to) SP 50-50, LA 25-25, FI 10-10, MA 10-10, PI 5-5, SO, AS Regeneration goal (Tree species from to) SP 30-60, LA 30-30, FI 15-20, MA 10-10, PI 5-5, AS												
Specifics and deviation				C	A00	P	B	H	O2	719	11	1.2

F: CF, F: H

GZ	IT	MKL	FTG	STG	ES	R/ch	RP	MSF	SP	RP	GES	TO	Tree species composition
D	A00	65	611	11.	1,2	120	40	SSHE SCUT	7	10	1,2	1958 2555	SP 50, LA 25, FI 10, PI 5, SO, AS ,MA 10
D	A00	65	611	22	1,2	120	40	SSHE	6	10	1		SP 50, LA 25, FI 10, MA 10, PI 5, SO, AS
C	A00	65	719	11	1.2	120	40	SSHE	6	10	1		SP 50, LA 25, FI 10, MA 10, PI 5, SO, AS