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Intensification of forest management and improvement of wood harvesting in Northwest Russia

– Final report of the research project

Timo Karjalainen, Timo Leinonen, Yuri Gerasimov, Markku Husso and Sari Karvinen (eds.)

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Abstract

The project aimed to investigate the accessibility of forest resources in Northwest (NW) Russia, the impacts of both Scandinavian and current Russian forest management and wood harvesting on ecologically, socially and economically sustainable forestry, and to enhance the development of sustainable forest management and wood harvesting methods for NW Russia.

The research group found both positive trends, but also development needs in forest management in Northwest Russia. Since 1993, the area of lands without forest vegetation needing forest regeneration has decreased to a half. On the other hand, in 1999-2006 almost every fifth hectare of clear felling was left without active forest regeneration measures. Moreover, the extent of intermediate felling has been insufficient being only about fifth of the annual allowable area and 9% of the total timber harvesting volume.

Wood harvesting has been rather stable last 10 years in NW Russia, at the level of about 40 million m^3 per year. Less than half of the annual allowable cut is utilised and most of the round wood is produced by large and medium sized logging companies. Traditional full-tree and tree-length harvesting methods and systems are still dominating in most of the regions even though use of cut-to-length method is becoming more common. Several factors hamper development of wood harvesting, including for example weak production infrastructure, weak road network, lack of own turnover means in companies, low quality in harvester and forwarder operator trainging, and increasing variable costs.

Scenario analysis indicate that mature and over mature forests in NW Russia are able to secure wood supply at the current levels for the next 50 years, but that intensification of forest management would allow to substantially increase annual fellings. The discrepancy between forest resources and their accessibility has been regarded as one main problem of forest management. Good infrastructure is essential for harvesting operations and thus the economic accessibility of forest resources.

Keywords

silviculture, felling, forest code, wood procurement, logistics, conservation areas, forest resources, economic accessibility

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Contents

Authors 4

Foreword 7

Extended abstract 8

Intensification of forest management 8

Improvement of wood harvesting 9

Future development and economic accessibility of forest resources in Northwest Russia 11

1 Introduction 13

References 18

2 Intensification of forest management 20

2.1 Principles of forest management 20

2.2 Development of forest management in Russia 27

2.2.1 Overview to forest management development 27
2.2.2 Forest inventory and planning 31
2.2.3 Final cutting 33
2.2.4 Thinning 38
2.2.5 Forest regeneration 39
2.2.6 Especially protected natural areas (EPNA) 42
2.2.7 Tendencies of changes in forest management organization 44

2.3 Comparison of different forest management regimes in Lyaskelskoe lesnichestvo in the Republic of Karelia 46

2.3.1 Background 46
2.3.2 Method 47
2.3.3 Assumptions 48
2.3.4 Results 50
2.3.5 Net income analyse for 10 years period 55
2.3.6 Conclusions 56

2.4 Towards sustainable and intensive forest management – some important topics for further development of forest management in Northwest Russia 57

References 61

Appendix 2.1 64

Appendix 2.2 65

3 Improvement of wood harvesting in Northwest Russia 67

3.1 Development in wood procurement 67

3.1.1 Analysis of logging companies in the Republic of Karelia 71
3.1.2 Round wood balance and unreported flows 77

3.2 Development of harvesting methods and machinery 80

3.2.1 Wood harvesting methods and systems 80
3.2.2 Forest machinery producers 82

3.3. Development of wood transport logistics 85
3.3.1 Background and method 85
3.3.2 Application 87
3.4 Sustanability of wood harvesting and procurement 89
3.4.1 Economics of wood harvesting 89
3.4.2 Restrictions for wood harvesting and procurement in conservation areas 91
3.4.3 Environmental impacts of different wood harvesting methods and systems 97
3.5 Development program for improving wood procurement in Northwest Russia based on SWOT analysis 100
3.6 Conclusions 103
References 105

4. Future development and economic accessibility of forest resources in Northwest Russia 107
4.1 Introduction 107
4.2 Future development of forest resources in Northwest Russia 108
4.2.1 Aim and method 108
4.2.2 Data 108
4.2.3 Scenarios 109
4.2.4 Results 109
4.2.5 Discussion on scenario results 121
4.3 Analysing accessibility of forest resources 122
4.3.1 Method of analysis 122
4.3.2 Data 123
4.3.3 Input data and methods for analysing economic accessibility in Novgorod region 124
4.3.4 Results for technical accessibility analysis 125
4.3.5 Analysis of economic accessibility in Novgorod region 132
4.3.6 Case study on locating feasible routes from kvartals to the nearest road in the Novgorod region 132
4.3.7 Discussion 135
4.4 Conclusions and further research needs 135
References 136
Appendix 4.1 138

Appendix 1 Researchers 141
Appendix 2 Seminars 142
Appendix 3 Research training 147
Appendix 4 Publications 148

Foreword

Four year research project *Intensification of forest management and improvement of wood harvesting in Northwest Russia* was implemented in 2004–2007 with an aim to increase understanding about the development of forest management and wood harvesting in Northwest Russia. Information about the project, including also publications can be found in project web-site **http://www.metla.fi/hanke/3384/subproject-2.htm**.

Nearly 40 researchers from Finland and Russia participated in the project, from the Finnish Forest Research Institute, European Forest Institute, University of Joensuu, Karelian Research Centre (Forest Institute and Institute of Biology), All-Russian Research Institute for Silviculture and Mechanization of Forestry, Moscow State Forest University, Petrozavodsk State University, St. Petersburg State Forest Technical Academy, Rosgiproles, and Russian State Agricultural University.

The project was financed by the Russia in Flux research programme of the Academy of Finland (decision number 105379), and participating organisations. The project belonged to a larger research consortium Towards progressive forest sector in Northwest Russia, which has published the final report in Finnish **(http://www.metla.fi/julkaisut/workingpapers/2007/mwp062.pdf)** and Russian **(http://www.metla.fi/julkaisut/workingpapers/2008/mwp083.pdf)**.

We hope that this project has helped moving from notions to more concrete level of understanding about the development of forestry in Northwest Russia. We also hope that the results will serve information needs of different stakeholders and those interested in forestry in Russia.

We express our gratitude to the Academy of Finland and organisations that have financed the research, members of the steering group for their feedback during the project, researchers who participated in the project and for those who have contributed in different ways. We thank Leena Karvinen for finalising this report.

In Joensuu

Timo Karjalainen, Timo Leinonen, Yuri Gerasimov, Markku Husso, & Sari Karvinen (eds.)

Extended abstract

Intensification of forest management

In Northwest Russia, larger-scale concentrated clear cutting implemented for decades in the 20th century, with failures in forest regeneration and forest growing have weakened the structure and quality of forests. This development now threatens the sustained availability of wood for the forest industry and increases the pressure to over-cut remaining economically accessible mature and overmature forests, which also have ecological values. The aim of this sub-project was therefore to analyze the development of forest management systems from the beginning of the Soviet era up to nowadays to understand the past development and contribute to the development of sustainable forest management methods for Northwest Russia. The approach was, on one hand, descriptive and comparative by analyzing the past development based on official data and reports of the state forest authorities and the research literature on Russian forestry. On the other hand, the approach was practice-oriented by analyzing alternative forest management strategies for the Lyaskelskoe forest district (Karelia Republic) with the use of the Russian simulation model FORRUS-S.

In Northwest Russia, more than half of the total area of coniferous forests and about one third of the soft-broadleaved forests are composed of mature and overmature stands, while the proportion of maturing stands is only 7% and 10%, respectively. This kind of age-class structure describes large current harvesting potential together with a possibility to take care of nature protection and conservation of biological diversity. At the same time, this indicates a small timber yield of forests due to their high age and diminishing harvesting reserves during the coming decades due to the low proportion of maturing stands. Since 1993, the area of lands without forest vegetation needing forest regeneration has decreased to a half. On the other hand, in 1999–2006 almost every fifth hectare of clear felling was left without active forest regeneration measures. Moreover, the extent of intermediate felling has been insufficient being only about fifth of the annual allowable area and 9% of the total timber harvesting volume. In 2000s, the annual allowable cut in final felling has been utilized only by 40%, which describes well the current state of the forest sector in Northwest Russia. The proportion of specifically protected forest areas was 5% of the total forest area varying from 4% in the Republic of Karelia to 11% in the Pskov region. However, in production forests, ecological values of forests are not enough taken into account in forest management planning and in forest use.

Simulation modelling of different forest management alternatives for the Lyaskelskoe forest district (učastkovoe lesničestvo) showed that depending on a chosen time horizon, different forest management alternatives gave better results on dynamics of tree species' growing stock and annual net income. In the short term, the maximum net income was got on the forest management scenario of minimal expenses for planting and assistance to natural regeneration, and felling without undergrowth preservation. However, taking into account the long-term net income, this scenario took only the fifth place falling behind the best scenario for 14%. According to the profitability and stability, the most preferable was the scenario including lower annual allowable cut, age of final felling one age-class lower than regulated by norms, and implementation of thinning operations only in those stands, where the operations were profitable.

In the Lyaskelskoe forest district, due to current age-class structure, problems with the available cutting area can appear already in 65–70 years. Until this time, most of the coniferous stands will be cut and planted stands will achieve their rotation age only after 90–100 years. One of the main reasons for future decrease in fellings of coniferous stock is a significant decline of coniferous planting in the end of the last and the beginning of this century.

When developing the current forest management system, a forest user's objectives for forest exploitation should be more clearly taken into account in the stage of forest management planning. Moreover, a forest user should know the influence of proposed silvicultural and harvesting operations on future growth and yield, timber-harvesting volumes and assortment structure as well as their economic efficiency. Based on calculations, a forest user should be able to choose the appropriate development alternative best meeting the forest user's objectives for forest exploitation and the requirements of normative documents.

As a significant increase of forest road construction and exploitation of new forest areas will take for years and would be also costly, it is worthwhile to move to a more intensive model of forest management in the areas already having a satisfactory forest road network and other infrastructure. Implementation of intensive methods of forest regeneration, intermediate treatments and final felling can remarkably increase the removals of intended timber-assortments per hectare, improve the profitability of forest-growing and timber harvesting, and decrease the total area needed for commercial cuttings, meaning savings for example in timber-transport costs, but also the conservation of forest territories undisturbed by human development. Although the advantages of intensification become apparent only after decades, strategically intensive forms of sustainable forest management have no alternatives in Northwest Russia.

Improvement of wood harvesting

Present wood harvesting and procurement practices in Northwest Russia have been studied from the point of view of their efficiency, productivity and safety risks taking into account prevailing conditions. Results and conclusions have been summarized as follows:

- After the dropping of wood harvesting in the 1990s from 82 million m^3, the period 2000-2006 is characterized by relative stability in logging, about 40 million m^3 per year.
- The quality of forests has been declining during 50 years: output of sawlogs has decreased by 8%, half of stands have the relative density of 0.6-0.4 and 12% of stands have less than 0.3. Logging companies are working selectively, preferring to cut coniferous stands.
- Most of the surveyed logging companies use long-term lease (25 or 49 years) as a method for receiving logging permissions. Logging companies had approximately 40 million ha forests in lease and 47 million m^3 of annual allowable cut in 2006, which is approximately 50% of the total annual allowable cut in Northwest Russia. In the Leningrad region and the Republic of Karelia, approximately 80% of forests are in lease.
- There are great differences between the Nordic countries and Russia in wood harvesting methods and systems. In the Nordic countries, the cut-to-length method is dominating. In Northwest Russia, full-tree, tree-length, and cut-to-length wood harvesting methods are applied, but traditional full-tree and tree-length harvesting methods and systems are still dominating. Wood harvesting systems are usually partly mechanized.
- The unit cost in wood harvesting is high and sometimes exceeds harvesting costs in Finland. The productivity of labor in the companies using traditional Russian machinery is extremely low.
- Extraction of short-wood from the harvesting processes is becoming a more common practice in Northwest Russia. It is already common in the Republic of Karelia and Leningrad region, but expected to become more common also in the other parts of Russia.
- One of the challenges in wood procurement is forest road construction. The road network

density is poor in comparison with Finland and varies from 1.2 km/1000 ha in Komi to 11.6 km/1000 ha in Pskov.
- Another challenge is the low utilization of thinnings. In Northwest Russia, only 4.5 million m^3, or 12% of the total actual cut, is obtained from thinning operations currently. This is due to poor road network, lack of appropriate technology and lack of intensive forest management traditions and norms.
- Accident risk is high, equaling 20 accidents (0.5 fatal accidents) per 1000 employees.
- There is also lack of skilled harvester and forwarder operators.

Preconditions for implementing modern technology chains and harvesting methods adequate to the new conditions in forest management and logistics in the chain from felling to delivery of round wood have been defined. The analysis shows that

- There are several weak points in developing wood harvesting systems in Northwest Russia, including weak production infrastructure, lack of advanced road network, lack of own turnover means in companies, lack of advanced domestically made machinery, low quality of training especially for operators of harvesters and forwarders, and increasing variable costs.
- Application of cut-to-length method would allow increasing the productivity of wood harvesting and thus improving economics of the logging operations. At the same time, harvesting of forest resources by cut-to-length method causes less environmental impacts than traditional methods and improves the ecological state of forest sites both in the short and long term. The other reasons for the development of cut-to-length systems include introducing of leasing, high reliability, good ergonomic and ecologic performance of harvesters and forwarders, reducing annual allowable cut in industrial regions and the possibility to introduce thinning operations, attention of society to ecological impacts of wood harvesting, small size of logging areas, reducing frequent moving of machinery, better quality of industrial round wood, possibility for monitoring wood removals in logging area, increasing requirements for using public roads.
- Existing wood transport logistic methods and systems applied in Russia do not provide the basis for economic analysis. Approaches are suitable for companies which utilize traditional tree-length technology. However, introduction of the Nordic cut-to-length technology requires more attention to wood transport logistics.
- GIS-based decision support program has been developed to assist logging companies in decision making related to planning, utilization and optimization of vehicle fleet. Searching of optimal routes could be used also for other applications, i.e. for forest road planning, fuel supply, seedling transportation etc. Application of the program and comparison of alternative delivery plans show that the efficiency of short-wood transport can be increased by 40%. Application allows processing of delivery plans and thus provides possibilities for producing several alternatives taking into account possible changes both inside and outside the organization. Most importantly, the program allows optimization of transportation operations.

Requirements for economically and environmentally sustainable wood harvesting in changing forestry has been investigated and the results show that

- The most of round wood is produced by large and medium sized companies which have remained and have been privatized since the planned economy. The importance of small enterprises is growing in Northwest Russia. A significant growth of small enterprises has been observed in the Leningrad region.
- The economic, as well as technological, social, and environmental states of the logging companies vary greatly. Logging companies are becoming a part of vertically integrated structures of pulp and paper mills or sawmills that can develop logging. The Nordic cut-to-length method is rapidly being fully established. However, the tree-length method continues to play an important role as long as the old central processing yard equipment is in a good condition. The traditional wood harvesting method is also supported by effective western machinery. The

results of SWOT analysis predict shortage of forest resources for wood supply development in Karelia in the near future. Implementation of sustainable forest management based on commercial thinning operations and the Nordic cut-to-length method would improve the situation. Implementation of the cut-to-length method based on the modernization of machines or western engineering is an opportunity. Carefully made modernization and introduction of new methods could also improve the status of forest work among the young educated people. This would help to attract more motivated and skilled employees to companies.
- The investigation shows the same average wood harvesting cost at road-side for all applied wood harvesting methods - approximately 7-7.5€ per m^3. However, in the case of the cut-to-length method, the company has industrial round-wood, but in the case of the tree-length and full-tree methods logs need further processing at a central processing yard and additional production cost of 6-8€ per m^3 incur.
- The risk of unreported round wood or wood from conservation areas in the wood flow has to be taken into account when tracing the origin of wood for forest industries, as a part of the chain of custody.
- Estimated amount of unreported round wood in the wood flow is 23%. The most critical regions are Leningrad, Novgorod and Pskov.

In the Republic of Karelia and the Arkhangelsk and Vologda regions, the shares of official conservation areas of the forest fund vary from 6 to 8%. The Republic of Karelia has strict restrictions for wood harvesting. In the Republic of Karelia, all types of fellings are forbidden on a half of protected areas, and in the Vologda and Arkhangelsk regions in 40 and 27% of the protected areas. Wood procurement organizations operating in Northwest Russia are paying more attention to nature conservation than in the past. This increases the need for reliable information on existing limitations to forest use including restrictions for wood harvesting, road construction and other operations. Therefore the collected data for the current state of areas having wood harvesting restrictions, their locations and possible limitations to wood harvesting will be very useful for planning wood procurement activities in Northwest Russia.

Future development and economic accessibility of forest resources in Northwest Russia

Objective: was firstly, to study the future development of forest recourses in Northwest Russia and secondly to analyse accessibility of forest resources. The methodologies applied were the European Forest Information Scenario (EFISCEN) model and a geographical information system (GIS) network analysis. European forest and growing stock maps by the European Forest Institute and harvesting cost data were applied to estimate available forest resources and their physical and economic accessibility.

The EFISCEN model is a timber assessment model which predicts the development of forest resources in terms of standing stock, net annual increment and age class distribution. However, the model does not predict the demand of wood nor evaluate economically feasible felling levels. Future development of forest resources in the Northwest Russia included scenarios of forest resources until 2058. Three scenarios of forest management were applied: 1) *Baseline*- scenario, in which annual fellings were 85 million m^3; 2*) Increased felling*- scenario, in which supply of wood increased 10% on five year intervals to 2058 and 3) *Increased felling and thinning*- scenario which follows a Nordic type of forest management after transition of fifteen years with a 30% share of thinnings in annual fellings.

Although scenario analyses include numerous uncertainties, the results of the *Baseline*- scenario clearly indicate that in physical terms mature and over mature forests in Northwest Russia are able to secure wood supply for the next 50 years as well as a steadily increasing growing stock in all regions. The results of the two other scenarios indicate that in Northwest Russia there are enough forest resources to increase annual fellings over to level of 200 million m^3.

In the *Baseline*-scenario, the net annual increment decreased from 135 million m^3 in 2008 to 127 million m^3 in 2058 due to an increasing share of mature and over mature forests. In the *Increased felling*- scenario, the net annual increment was only three million cubic meters higher than in the *Baseline*- scenario since fellings increased gradually to 207 million m^3 in 2058 and a time span of 50 years is not long enough to generate a large proportion of middle age forests with high net annual increment. However, by increasing thinnings (*Increased felling and thinning*- scenario), the net annual increment will reach 155 million m^3 in 2058, according to the scenario results. When over mature forests form a substantial proportion of forest resources, like they do in many regions of Northwest Russia, fellings exceeded the net annual increment in our scenarios in some regions and thus did not fulfil one of the indicators of sustainable forestry. However, the only way to reach more productive forests is the regeneration of large areas of over mature forests. Long term forecasts for felling scenarios are highly uncertain because the future price movements of roundwood, market opportunities for wood products and harvesting costs in forestry are shrouded in uncertainty in Russia – and globally – for next 50 years.

The discrepancy between forest resources and their accessibility has been regarded as one main problem of forest management in Northwest Russia. Within Northwest Russia there are substantial differences between the different regions in the density of road and railroad networks and other infrastructure which is essential for harvesting operations and thus the economic accessibility of forest resources.

Due to a low yield of boreal forests of Northwest Russia, long distance transportation infrastructure (roads and railroads) has a significant impact on the economic accessibility of forest resources. In Leningrad and Pskov regions practically all forests (99%), in terms of both total forest area and total growing stock, have a road transportation distance of less than 100 kilometers to the nearest railway station while the corresponding figure in the Republic of Karelia is 82%, in Komi Republic 35 % and in Arkhangelsk region 38% of forest area and 36% of growing stock. However, it should be noted that floating as a timber transportation method was excluded from the GIS analyses and thus the gap in infrastructure between the well and less developed regions of Northwest Russia is not as substantial as the figures indicate. Secondly, all harvesting restrictions of commercial forestry (e.g. conservation areas) were excluded and thus the results indicate more potential related to existing infrastructure. A more detailed economic accessibility analysis of the Novgorod region highlighted the importance of a railroad network for forest management: a railroad network as a cost-efficient long-distance transportation system enables higher revenues for forestry and secures more options for timber allocation.

By taking into account the whole logistical chain, which includes transportation from forest to processing facilities and finally to markets of final products, Northwest Russia can be regarded as a prominent area for a more intensive forest management compared to Russian Far East or Siberia. In the long run, a better developed infrastructure together with a more intensive forest management will drive harvesting costs down, or at least compensates the future cost inflation to some extent.

Poor availability of data was one the main obstacles, but applied methodologies were found to be solid and worth of further development with more detailed data at the regional level.

1 Introduction

Russia is one of the major forest powers in the world. Almost all the forests of the Russian Federation belong to the boreal coniferous forest zone. As of January 1, 2006, the total area of lands managed for forestry purposes (the national forest fund) and forests that are not included in the forest fund was estimated in the Russian Federation at 1.2 billion ha with the growing stock of 82.3 billion m^3 (Table 1.1). The Ministry of Natural Resources of the Russian Federation controls 97% of the forest fund area and 93% of the total growing stock (Ministerstvo prirodnyh… 2007). The proportion of lands covered with forest vegetation amounts to 65% of Russia's terrain.

After the planning system's transformation, main tendencies in Russia's forests and forestry have been the following:

- forest area, growing stock and the percentage of forest lands have increased
- forest area under the valid forest management plan, volume of actual harvest and the ratio of harvest size to increment have strongly decreased
- structure of ownership has not changed (Table 1.1).

Table 1.1 General information about the forests of the Russian Federation (Lesnoj… 1990, Ministerstvo prirodnyh … 2007).

Parameters	01.01.2006	1988
Forest fund, 1000 ha	1 174 223	1 182 555
Forest lands, 1000 ha	879 380	884 094
Forest area (lands with forest vegetation)*:		
1000 ha	775 274	771 109
percentage of land area	45.4	45.2
Growing stock (mill. m^3)**	82 346	81 645
Final fellings:		
mill. m^3 overbark	127.6	302.7

Notes: *Forest area available for timber production (thousand ha): 2001 – 331 708.5 (43% of lands with forest vegetation); 1988 – 388 452.5 (50%), ** Growing stock on forest area available for timber production (mill. m^3): 2002 – 40 468.4 (49% of total growing stock), 1988 – 47 595.1 (58%) (National report… 2003, Korotkov 2004).

The Northwestern Federal District is rich of forest resources, as 16% of the growing stock of the Russian forests, available for exploitation, is concentrated in this region (Fig. 1.1). It is also the most important forest industry district producing 33% of merchantable wood, 28% of sawn wood, and 63% of paper in Russia (Federal'naja služba… 2007). This is a lot compared with the Siberian and Far Eastern Federal Districts, having more than half of the growing stock, where the corresponding proportions were 40%, 36% and 1%.

The forests of Northwest Russia make more than half of all forests of Europe (Lesnoj fond… 2003). The forest area of the Arkhangelsk region is equal of that of Finland. More than 70% of the lands with forest vegetation are concentrated in the Komi Republic and the Arkhangelsk region. The northern regions, namely the Republic of Komi, Arkhangelsk region, Murmansk region, Republic of Karelia, and Vologda region, are located mainly in the northern and middle-taiga (boreal) zone, which is characterized by rigorous climate and a growing period of 117–140 days (Fig. 1.2). The northwestern regions, including Leningrad, Pskov, and Novgorod regions, are located in the southern taiga zone and the zone of mixed forests with moderate climate and a growing season of up to 160 days. The annual precipitation varies from 300 mm in the northern taiga to 600 mm in the southern zone (Kaliničenko et al. 1991). The Vologda region and the Komi Republic have the highest percentage of forest lands in the European part of Russia (Appendix 1).

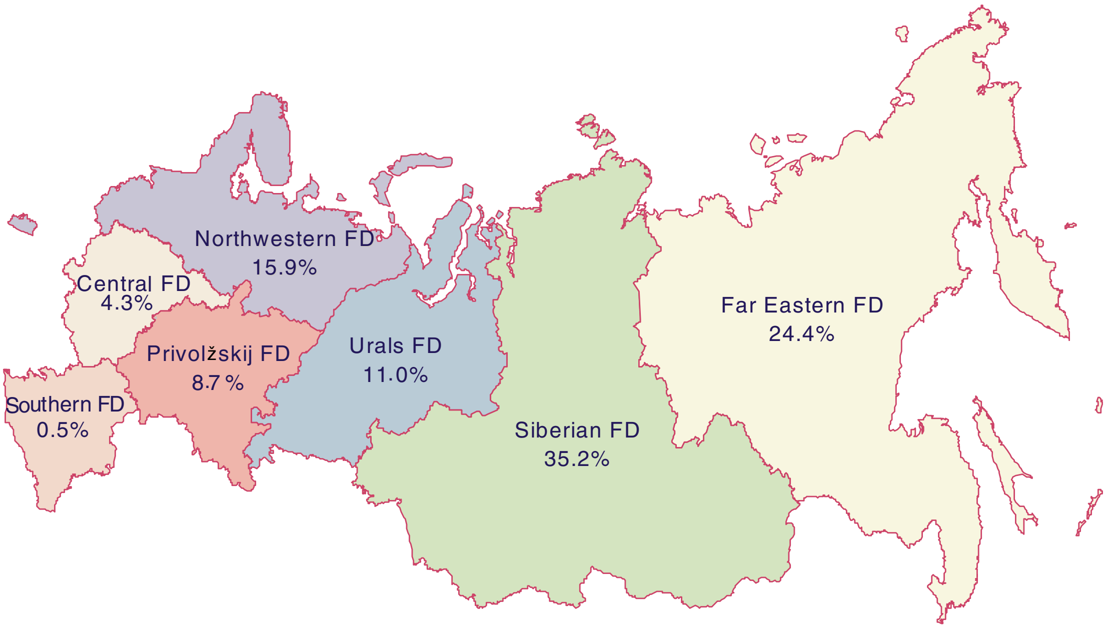

Fig. 1.1 Distribution of growing stock (%) available for exploitation in the Federal Districts (FD) of the Russian Federation in forests belonging to the Ministry of Natural Resources (Federal'noe agentstvo… 2007).

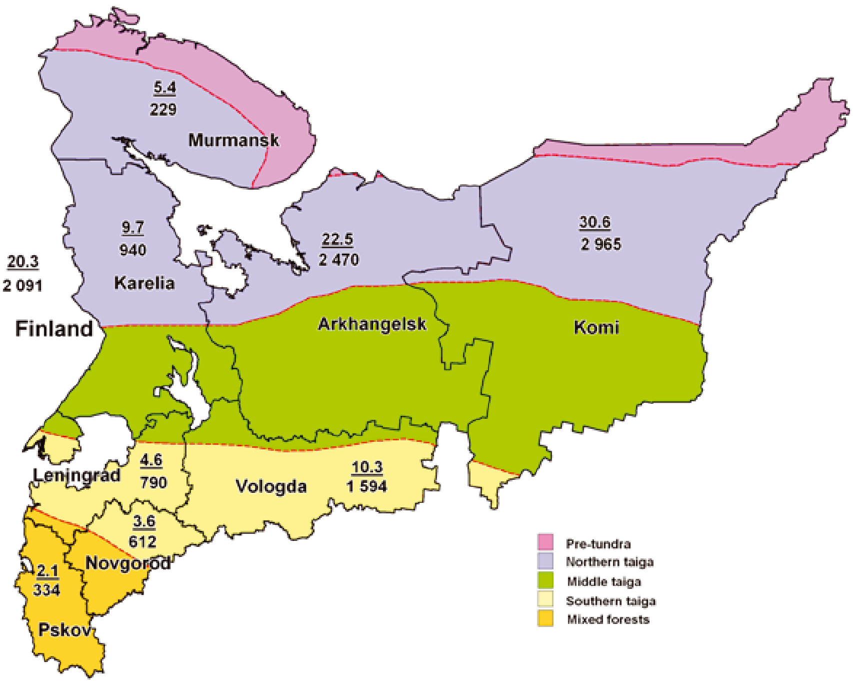

Fig. 1.2 Zones and sub-zones of forest vegetation and forest resources (numerator – forest land area, million ha, denominator – growing stock, million m^3) in the Northwestern Federal District and for comparison in Finland (Lesnoj fond… 2003, Finnish Forest Research… 2005).

In the district, the total area of lands with forest vegetation comprises 87.9 million ha with the growing stock of 10.0 billion m^3 and the volume of annual allowable cut 102.4 million m^3. The most important tree species are Norway spruce (*Picea abies* (L.) Karst.), Scots pine (*Pinus sylvestris* L.), birch (*Betula pendula* Roth. and *B. pubescens* Ehrh.) (Fig. 1.3). Stands with domination of coniferous species prevail in all the regions with the exception of the Novgorod region (Fig. 1.4). In the Komi republic, about 60% of the coniferous-dominated forests and about 70% of the soft broadleaved forests are possible to exploit. In the Arkhangelsk region, the corresponding shares are about 70% and 80%. The biggest forest-protection categories in the I management group forests[1], excluded from exploitation, are pre-tundra forests, restricted forest stripes protecting spawning grounds and forests of national parks and nature reserves.

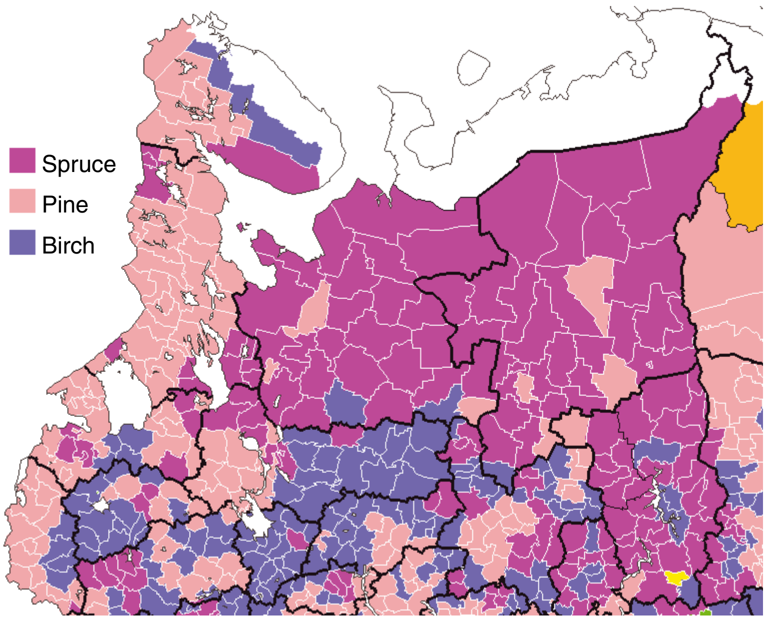

Fig. 1.3 Dominant tree species in Northwest Russia (Ministerstvo prirodnyh …2005, with modifications).

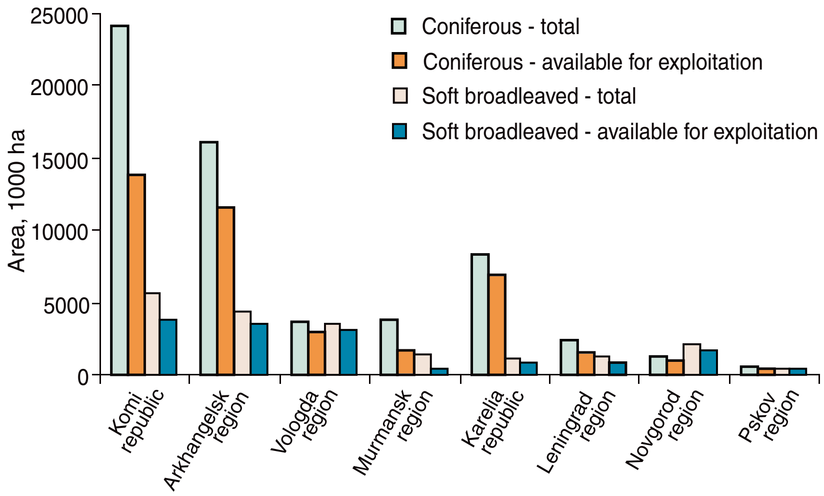

Fig. 1.4 Area of coniferous and soft broadleaved (birch, aspen, alder) forests in the regions of Northwest Russia (Federal'noe agentstvo… 2007)

[1] Include forests whose principal purpose is to perform water protection, protective, sanitation and health-improving functions, as well as forests of specially protected natural areas (Forest Code 1997).

More than half of the total area of coniferous forests is composed of mature and overmature stands (Fig. 1.5). Mature and overmature coniferous stands prevail in the Komi republic, Arkhangelsk and Murmansk regions because of the difficult economic accessibility of forest resources and the significant area of low-productivity forests. About 35% of the total area of soft broadleaved forests are composed of mature and overmature stands (Fig. 1.5). We can see a significant share of mature and overmature stands in all the regions of Northwest Russia. This is also connected with low economic accessibility of forest resources.

Great political, economic, organizational and social changes in the recent history of the Russian Federation had a huge impact on the Russian forestry and forest industry sectors. Just before the reforms, wood removals peaked with 357 million m^3 in 1987 (OAO NIPIEIlesprom 2003). In the shifting sands of the collapse of the Soviet Union, in 1990–1994 the volumes of realized fellings and produced merchantable wood[2] drastically decreased by 60% (Fig. 1.6). After 1998, timber harvesting companies could increase their cutting volumes, and especially their wood export, due to the devaluation of the ruble, favorable prices on the world market and more stable functioning of forest industry companies. In 2006, in Northwest Russia the production volume of merchantable wood was still less than half of the level in 1990 indicating that the forest industry has not recovered 15 years after the collapse of the planned economy system.

During the last few years, in Northwest Russia the volume of realized fellings has been 42–44 million m^3 (Fig. 1.7). A large majority of the timber removal, on average, 84%, was cut in final fellings, while the proportion of intermediate and other fellings was 7% and 9%, respectively. Other felling includes felling along routes, forest path and roads, felling for different kinds of needs, and sanitary felling. The tradition to concentrate fellings to mature and overmature forests, mainly by clear felling, and to neglect intermediate fellings in young and middle-aged stands has continued in Russia for decades (Strakhov et al. 1996, Melehov 2002, Red'ko and Red'ko 2002).

Forest management, wood harvesting, logistics, and delivery of wood to consumers are experiencing big changes due to ecological, economic, and social pressures from both inside and outside Russia. Traditional Russian systems are used side by side with imported modern technology. Economic sustainability can be questioned due to weak traditions and expertise of planning and control of systems by an economic basis. A big challenge for Russian forestry is to fulfill the requirements of western quality standards for ecological and social issues as well as for the quality of final products.

[2] Round or split wood, excluding firewood, pitchy wood, and technological woodchips.

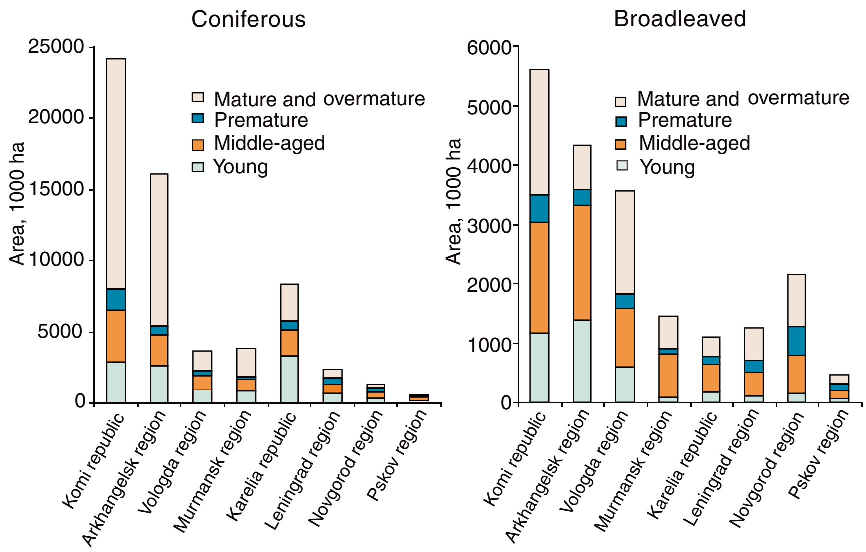

Fig. 1.5 Forest area of coniferous and soft broadleaved stands by age classes in the regions of Northwest Russia (Federal’noe agentstvo… 2007).

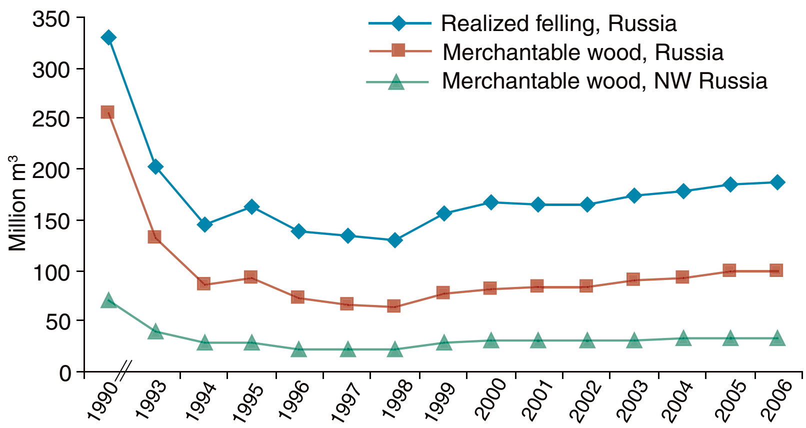

Fig. 1.6 Realized felling in Russia and the production of merchantable wood in Russia and Northwest Russia in 1990, 1993–2006 (Gosudarstvennyj komitet... 2001, Pisarenko et al. 2001, Federal’noe agentstvo… 2006, Federal’naja služba… 2006, 2007).

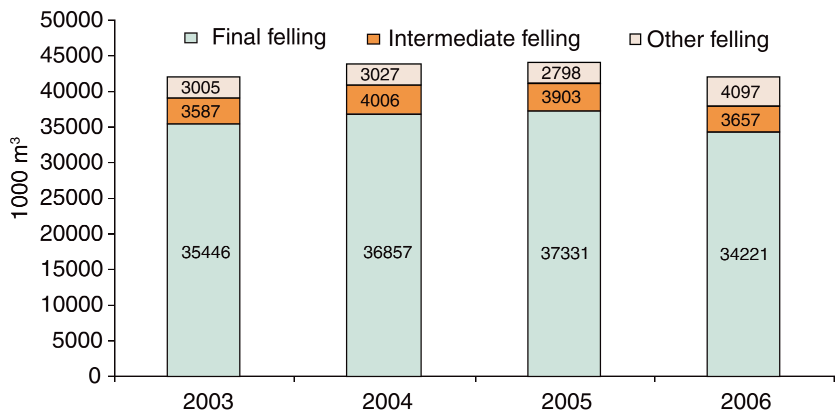

Fig. 1.7 Realized fellings in forests managed by the Ministry of Natural Resources in Northwest Russia in 2003–2006 (Federal’noe agentstvo… 2006, 2007)

This report represents the main results and outcomes of the project "Intensification of forest management and improvement of wood harvesting in Northwest Russia" (2004–2007) being a part of the extensive and internationally oriented research programme "Russia in Flux" launched by the Academy of Finland (www.aka.fi/russia). The objectives of the project were to investigate the impacts of both Scandinavian and current Russian forest management and wood harvesting methods on ecologically, socially and economically sustainable forestry and to enhance the development of sustainable forest management and wood harvesting methods for Northwest Russia in three work packages:

- Ecological and economic analysis of forest management modes and silvicultural norms and practices in Northwest Russia
- Evaluation of alternatives for wood harvesting and logistics
- Analysis on the accessibility of forest resources in Northwest Russia.

Altogether 38 researchers participated in the project from the following Finnish and Russian researcher organizations: Finnish Forest Research Institute, European Forest Institute, University of Joensuu, All-Russian Research Institute for Silviculture and Mechanization of Forestry (Pushkino, Russia), Moscow State Forest University, OAO Rosgiproles Institute (Moscow), Moscow Agricultural Academy, Petrozavodsk State University, Forest Engineering Faculty, Forest Institute and Institute of Biology of the Karelian Research Centre of the Russian Academy of Sciences (Petrozavodsk, Karelia republic), St. Petersburg State Forest Academy.

The project was a part (subproject II) of a larger consortium project "Towards Progressive Forest Sector in Northwest Russia" focusing on forest policy (subproject I), forest management, wood harvesting and use of forest resources (subproject II), exports of roundwood and sawnwood from Russia (subproject III) and forest industry investments (subproject IV). More information of the consortium project can be obtained from http://www.metla.fi/hanke/3384/index-en.htm . The final report of this larger consortium project in Finnish can be downloaded from http://www.metla.fi/julkaisut/workingpapers/2007/mwp062.htm .

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2 Intensification of forest management

2.1 Principles of forest management

The major principles of forest management are defined in the new Forest Code of the Russian Federation (Lesnoj kodeks… 2007) and in the number of other legal documents. Presently, these principles are designed for:

1 Sustainable forest management, conservation of biological diversity in forests, and enhancement of their potential;
2 Maintenance of habitat-forming, water-conservation, protection, sanitation, recreation and other beneficial functions of forests, to ensure that each person could exercise the right for a healthy environment;
3 Use of forests with due regard to their global environmental significance, as well as taking into account the length of their cultivation and other natural properties;
4 Multiple-purpose, sound, continuous, non-depleting use of forests to satisfy society's needs for forests and forest resources;
5 Renewal of forests, improvement of their quality and yield;
6 Ensured protection of forests;
7 Participation of citizens and civil society associations in decision-making which may affect forests when they are used, protected and renewed, with procedures for and forms of participation to be compliant with the legislation of the Russian Federation;
8 Forest use by methods, which are not detrimental to the environment and human health;
9 Division of forests according to their purpose and establishment of categories of protection forests depending on beneficial functions they perform;
10 Inadmissibility of forest use by public authorities and local self-governance bodies;
11 Payment for forest use.

Rules of forest management are defined by the legislative documents "Rules of forest logging", "Rules of intermediate felling" and other. Before the new Forest Code, the description of a traditional system on forest management was based on the following legislative documents approved by the orders of the State Forest Service of Russia: "Basic regulation of final felling in the forests of the Russian Federation" (1993); "Basic regulation of intermediate felling in the forests of the Russian Federation" (1993); "Basic regulation of forest regeneration and afforestation in the forest fund of the Russian Federation" (1993), regional rules on final felling; regional instructions for intermediate felling; regional instructions for forest regeneration and afforestation and others.

The traditional system includes the following types of forest management activities:

1 Final felling;
2 Intermediate felling;
3 Forest regeneration (artificial regeneration, assisted natural regeneration);
4 Fire prevention;
5 Bio-technical measures (among others, felling for feeding game animals);
6 Land improvement for recreation purposes;
7 Secondary forest use.

The objectives for preparation of the Forest Code were to divide the functions of management, control and utilization of forests from each other, to increase the utilization level of forests and to raise forest incomes, to delegate certain powers of the Federation in the area of forest relations to regional authorities, to increase the level of domestic wood processing and to prevent illegal loggings. According to the Code, forest lessees are responsible for forest regeneration and certain fire safety and sanitary safety measures within forest parcels leased out for wood harvesting based on a forest development plan. In other forests, forest administration is responsible for forestry operations which are implemented by an external body on the basis of an action.

Felling maturity and yield regulation

In Russia, wood logging as the main type of forest exploitation is carried out according to three felling types: final, intermediate and other felling. Ages of final felling are separately set for protection forests and production forests. Age of final felling (age of maturity) is determined according to its environmental, economic, and social function, stand productivity, and biology of tree species (Filipčuk 2003). Ages of felling for the main forest forming species are defined by forest regions (*lesnoj rajon*) in forestry plans (*lesnoj plan*) of the subjects of the Russian Federation. Forest regions are defined by natural and climatic conditions and forest vegetation zones, having rather similar conditions for use, conservation, protection and regeneration of forests (Forest Code 15 §). The basic valid optimum ages for final felling are presented in the Table 2.1.

Based on the Forest Code 2007, new rules of felling *(Pravila zagotovki drevesiny 2007*), forest tending (*Pravila uhoda za lesami 2007*) and forest regeneration (*Pravila lesovosstanovlenija 2007*) were approved in the summer of 2007. They define general requirements for these operations in all the forest regions of the Russian Federation. Besides, the authorized federal executive authority establishes individual rules for each forest region. In February 2008, these rules were still under preparation.

Currently, wood harvesting is the main type of forest use. In final felling, over-aged and ripe trees are cut. Logging is also carried out during thinning, selective sanitation, reconstruction and other fellings connected with removing low-value trees as well as cutting of trees and bushes-type vegetation that looses safety, water protective and other functions.

Wood harvesting is regulated in terms of annual allowable cut, whose calculation method state authorities of the Russian Federation determinate and which is indicated in a forestry management regulation (*lesohozjajstvennyj reklament*) for the territory of every forest district (*lesničestvo*) and forest park (*lesopark*). It is prohibited to exceed the annual allowable cut.

Table 2.1 Ages of final felling (age of maturity) in the middle-taiga region of Northwest Russia (Federal'noe agentstvo… 2008a).

Dominant tree species	Stand quality index (Bonitet)	Age of final felling (age of maturity)	
		production forests	protection forests
Middle-taiga region in the European part of Russian Federation*			
Pine, larch, spruce, fir	III and higher	81–100	101–120
	IV and lower	101-120	121-140
Birch, common alder	All	61–70	71–80
Grey alder, aspen	All	41–50	51–60

* Parts of Arkhangelsk, Vologda and Leningrad oblasts, Komi and Karelia republics

Final felling

Traditionally, the notion "forest use" implies wood harvesting. In final felling, timber is harvested in mature and overmature stands. In Northwest Russia, in practice most final-felling (over 80%) takes the form of clear felling (*splošnaja rubka*). Selective (*vyboročnaja rubka*) and continuous felling (*postepennaja rubka*) is more widely used in the Murmansk and Leningrad regions.

A grounded and reasonable volume of final fellings, which is statistically calculated, is referred to as the Annual Allowable Cut (AAC)[3]. In the past few years, AAC of Russian forests totaled up to 500 million m^3 (2005 – 570.7 million m^3), including 300 million m^3 for the coniferous category. The ratio of AAC and actualised cut illustrates the "state-of-the-art" in all branches of the forestry sector. In spite of the fact that in 2005, in Russia only 23% of AAC was actually logged.

In Northwest Russia, AAC decreased from 95.3 million m^3 in 1988 to 92.2 million m^3 in 2006 (for the coniferous category, from 67.5 to 52.0 million m^3) (Fig. 2.1). It is noteworthy that at the beginning of the 1990s, growing demands for environmental protection and exhaustion of economically accessible forest-resources had resulted in a decrease of AAC, especially for coniferous.

Along with the decrease of production, Russia is still going through structural reorganization. However, the forest sector has started to move its production facilities to the regions with higher consumption levels and closer location to foreign markets. Thus, based on the economic reasons, the Northwestern part of Russia has been prioritized for forest use and development. The most favorable economic conditions are created in the Karelia republic and in the Leningrad region, where in the 2000s, of the AAC 50–70% was used (Fig. 2.2).

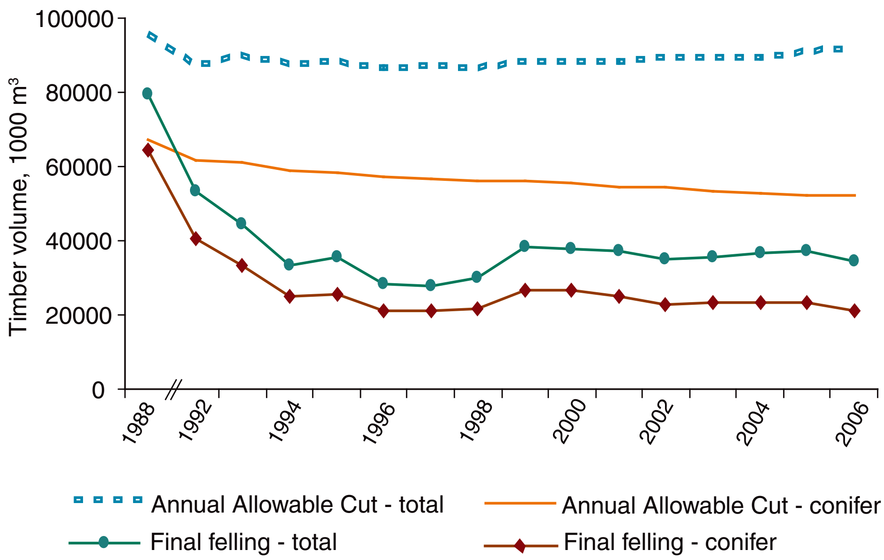

Fig. 2.1 Dynamics of the Annual Allowable Cut and the volume of final felling in Northwest Russia in 1988, 1992–2006 (Federal'noe agentstvo… 2006; http://www.roslesinforg.ru).

[3] AAC is computed for each *lesničestvo* and forest park separately for production and protection forests by tree species groups (coniferous, hard broadleaved, soft broadleaved) dividing the total volume of allowable annual removal of timber for each tree species group by dominant tree species (Ministerstvo prirodnyh… 2007a).

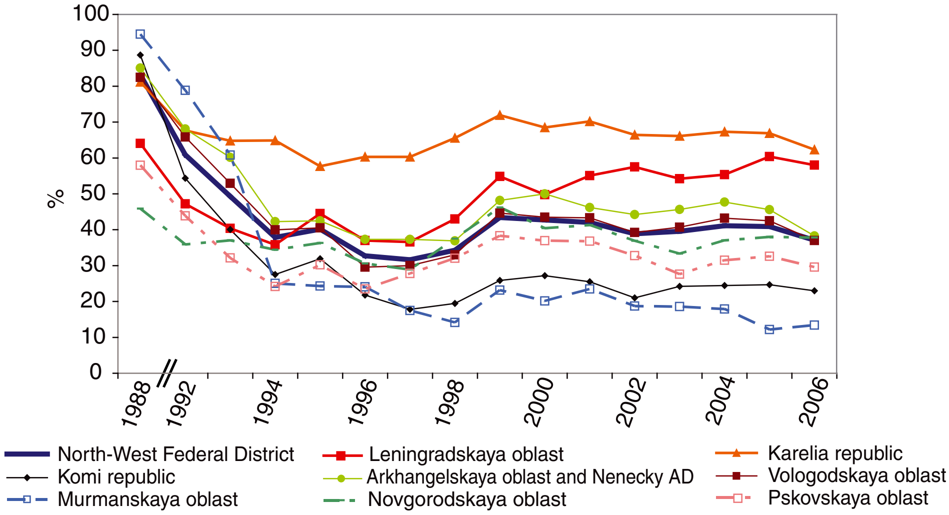

Fig. 2.2 Utilization of the Annual Allowable Cut in Northwest Russia in 1988, 1992–2006 (Federal'noe agentstvo… 2006; http://www.roslesinforg.ru).

Intermediate felling

Intermediate fellings (*rubki promežutočnogo pol'zovanija*) include thinning, selective sanitary felling (*vyboročnaja sanitarnaja rubka*), renewal (*rubka obnovlenija*) and reconstruction felling (*rubka pereformirovanija*) and other types of felling in low-value stands, as well as removal of shrubs and trees, which are losing their ability in nature protection.

These different types of felling are conducted to ensure high productivity of forests, to improve the quality of trees and the sanitary condition of forests.

The purpose of sanitary felling is to improve the condition of a stand by removing infected, damaged, dead and perished trees.

Thinning represents a system of selective types of felling in a growing forest stand. Thinning ensures favorable growing conditions for retention trees. Common principles of thinning are very similar to those in Finland. However, in thinning rules there are differences with regard to Finland mainly related to defining the intensity of thinning (relative density vs. basal area), low allowed intensity in tending of sapling stands in one go, requirements to mark removed trees more than 8 cm of diameter before cutting and to establish experimental plots in sapling and older stands to define the volume of removed trees (*Pravila uhoda za lesami 2007*). These kinds of requirements easily increase harvesting costs and can decrease amounts of these essential operations.

Depending on the age of a stand and the economic purposes of forest growing, thinning is subdivided as follows:

- Thinning of sapling stands (*osvetlenie*) – early cleaning (stand ages up to ten years), for improving species composition and the growth of the retention trees.
- Thinning of thickets (*pročistka*) – late cleaning is conducted in a young stand at the age of 11–20 years to improve growth conditions and regulate the density of the main tree species.
- Thinning in middle-aged stands (*proreživanie*) – thinning is conducted in middle-aged stands (21–60 years) to improve the stem and crown form of the trees.
- Thinning in maturing stands (*prohodnaja rubka*) – Late thinning is carried out in a maturing stand to provide faster increment of stem diameter by the final felling.

In Northwest Russia, the actual volume of intermediate felling in comparison with needed volume is insignificant (Fig. 2.3). In sapling stands, the actual volumes have annually been less than half of the planned volume (Lesnoj fond... 2003, Federal'noe agentstvo… 2006).

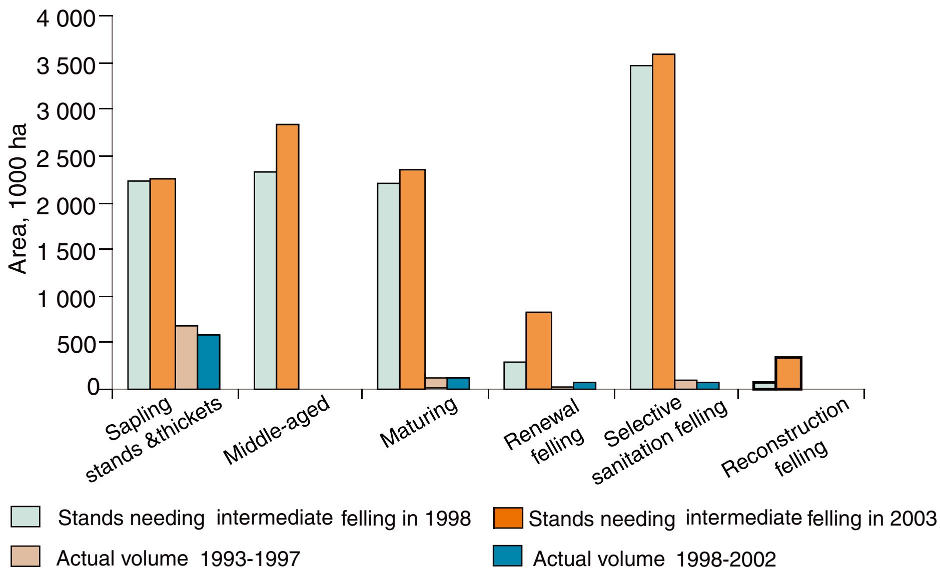

Fig. 2.3 Target and actual volume of intermediate felling by types in Northwest Russia (Lesnoj fond… 1999, 2003).

Reasons for small amounts of intermediate fellings have been, among others, concentration to more productive final fellings, wood-harvesting technology inappropriate for thinnings, undeveloped forest-road network and lack of demand for pulpwood in many regions. In Northwest Russia, in 2006 the volume of intermediate fellings made up only 3.7 million m^3. It was 11% of timber harvested at the final fellings. In fact, higher volumes could be harvested under the conditions of developed pulpwood markets. The volume of intermediate felling can make up at least half of final fellings volume without breaking the rules of sustainable forest management.

In Finland, during the rotation timely fellings and the utilisation of the natural drain can increase the total volume of harvested commercial timber by 20–30%, mainly logs, and the profitability of forest management by one third or even more compared to unmanaged stands (Hynynen and Ahtikoski 2005).

Forest regeneration

The main goal of forest regeneration is to timely restore economically-valuable stands on the felling sites, burnt areas and dying-off sites, as well as to decrease the land area of the forest fund not covered with forest vegetation.

In Russia, the overwhelming majority of forests are of natural origin, and only 3% of the lands covered with forest vegetation are artificially planted. Forest regeneration is closely linked to harvesting. The reduction of harvesting volumes has decreased clear-felled areas being the main type of forest regeneration sites. In Russia, the annual forest-regeneration area has exceeded the clear-felling area since 1989 (see Chapter 2.2.5). According to the state account of the forest fund (Lesnoj fond… 1995, 1999, 2003), in Northwest Russia the area of lands without forest vegetation has decreased significantly. On the other hand, in 1999–2006 almost every fifth hectare of clear-felling was left without active forest regeneration measures (Fig. 2.4). This development threatens the sustainability of forest management and worsens the quality of forming stands. According to Pisarenko et al. (1992), in 1966–1989 the ratio between regeneration areas and clear-felling areas averaged 0.84 in Northern and Northwestern regions of Russia. Therefore, the level of forest regeneration has not changed in last 40 years. For that reason, securing on-time and qualified forest regeneration should be highly recognized in forest policy, forest legislation and forest management in practice (Leinonen et al. 2008).

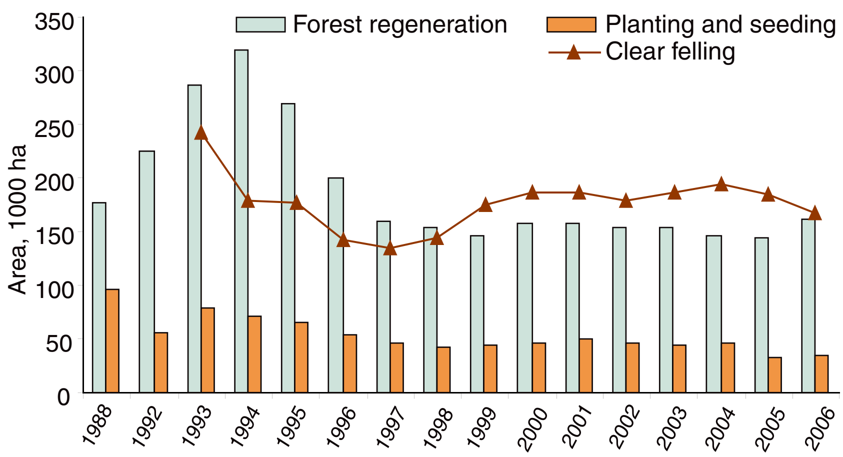

Fig. 2.4 Dynamic of forest regeneration and clear felling in Northwest Russia in 1988, 1992–2006 (Federal'noe agentstvo… 2006, Ministerstvo prirodnyh… 2007b).

Main differences between forest management in Russia and Finland

In Russia and Finland, common principles of forest management are rather similar. However, forest ownership, intensity of forest management and public support on forestry differ remarkably (Table 2.2).

Table 2.2 Comparison of forest management between Russia and Finland.

Russia	Finland
Forest land ownership, %:	
Federal 100	Private 60, state 26, companies 9, others 5*
Intensity of forest use: Annual timber removal, m^3 ha^{-1} in 2006	
Russia 0.2, Northwest Russia 0.5	2.8
Main felling methods; Proportions of methods from the total area treated with fellings in 2006:	
Final felling/intermediate felling/other	
Northwest Russia: 49/39/11	28/71/1
Infrastructure; Density of forest road network, m/ha	
Russia 1.3, Northwest Russia 2.0	12.3
Public support on funding for forest improvement works and forest road construction	
State subsidies are not enough. According to the new Forest Code (2007), regional authorities and lessees are responsible for forest improvement work and forest road construction	Tax deductions and state subsidies for private forest owners (incl., among others, tending of sapling and pole stands; tending of peatland forests, incl. restoration drainage; health fertilization; forest road construction)
Principles of forest management planning	
In production forests, the ultimate target is timber-production based on the principles of sustainability, while actions for conservation of biological diversity in forests are not enough	In commercial forests, more emphasis is laid on ecological sustainability, incl. conservation of biological diversity and important forest habitats, and on landscape factors and demands of multiple-use of forests
Designated functions of forest area – primary function in 2005, %**: 1. Production, 2. Protection, 3. Conservation, 4. Social services, 5. Multiple purpose	
Russia: 1-76.9, 2-8.7, 3-2.0, 4-1.5, 5-10.8	1-91.2, 2-0, 3-7.2, 4-0.2, 5-1.5

* Finnish Forest Research… 2007, ** FAO 2006

2.2 Development of forest management in Russia

At the beginning of an analysis of peculiarities and tendencies of forest-management development in Russia, it is essential to mention two factors, which have had a great influence. Firstly, forestry theory and forest planning appeared only in the first half of the XIX century, based on German roots, and only later Russian regulations were developed. Secondly, due to the vast forest resources and low-density population of Russia, the certain point of view still prevails, saying that it is possible to get enough timber without investments in silviculture.

During the last 15 years, Finnish-Russian co-operation in forestry and environmental protection between different stakeholders has been active. Finnish and other western partners including ministries, research and educational institutions, NGOs, forest industry companies need further researched based information about the development of forest management practices for the better planning and implementation of their actions related to Russia. Knowing the history helps to understand better the present and plan the future.

Chapters 2.2.1–2.2.5 are mainly based on the publication Knize, A. & Romanjuk, B. 2005. O dvuh toček zrenija na rossijskij les i lesnoe hozjajstvo [About two points of view on the Russian forest and forestry]. WWF Rossii, Moskva. 16 p. (In Russian). This publication summarizes the development of Russian forestry that may not be that familiar to non-Russian readers.

2.2.1 Overview to forest management development

On April 5 1918, Sovnarkom (People's Commissars Council - Soviet government) proclaimed the state property on forests. Forest management governing bodies began to form (Annex 2). After the October revolution 1917 and extraordinary fellings during the Civil War, the woodiness of European Russian dropped down from 35% in 1914 to 23% in 1926 (Strahov et al. 2001). Illegal logging reached the industrial scale. The main purpose of forestry of that period was to protect forests against illegal fellings.

During the 1920s–1930s, the aim of management of nationalized forests was felling of maximal amounts of wood using the cheapest methods, in order to maximize the quantity of cut wood. Forest inventory and planning (FIP) was cancelled and its projects were replaced with forest-exploitation plans. Therefore, instead of forest growing, only forest harvesting was practiced, and the dominating point of view was that nature would restore the cut forests by itself, with only minimal amount of silvicultural activities. In 1926, the forestry budget expenditures in the Russian Soviet Federative Socialistic Republic (RSFSR) were 5 kopecks per ha: 3 kopecks were used on leskhozes (forest management unit - FMU) maintain, 1 kopeck - on central and regional administration and only 1 kopeck - on silvicultural activities directly (Koldanov 1992).

The Soviet government understood that the assurance of wood export is important for the recognition of the Soviet state. Furthermore, this was a way to get the currency, which was very needful for the state. The restoration of timber export began in 1920, partially by means of granting northern forests into concessions. In 1921, the wood export was 750 000 m^3, in 1922 it reached 1 753 000 m^3, and in 1924 - 3 584 000 m^3. In terms of the sold timber cost, in 1921, Russia exported wood 7% of the pre-war one. In 1925, timber delivery of the whole country hardly exceeded 100 million m^3, and in 1927, it reached 136 million m^3. In 1932, forest harvesting was doubled, reaching 263 million m^3, and to 1937, it was planned to cut 550 million m^3 annually (Bobrov 2001). Later ecological distortion made the government divide the forests into two types – exploitable and protection forests.

The final changeover of the Russian economy from market-based “new economic policy” to the socialist command and distributive system, which was completed in the 1930s, led to the cardinal reconstruction of the forest management system. That new structure of forest management in Russia, formed in 1930, remained valid until 1993. Its main elements were:

1 Complex forest enterprises (leskhozes, lespromkhozes and so on), which carried out both forest management and final fellings with timber processing,
2 Absence of market relations; forest resources were distributed by orders,
3 Absolute centralization of forest-lands disposing functions in the ministries and government agencies of the Union of the Soviet Socialist Republics (USSR) (and Russia),
4 Priority of the timber industry over forest management (Girjaev 2004).

Therefore, while before 1930 the main source of money for forestry was the income from selling of standing wood on forest auctions, in later years, until recently, the main way of covering the forest-management expenses was government funding on leftovers.

Before forests, heavily break-up by hyper-intensive cuttings, could recover a bit and restore their ecological functions, the World War II started, and new extraordinary fellings started again. Huge overharvesting of the periodic yield was inevitable in that time. During 1942–1943, almost all-harvestable wood was cut in Povolzhsky, Uralsky, Volgo-Vyatsky and Central regions.

After the war, it was decided to increase wood harvesting in the forest-rich northeast of the European Russia. Soon harvesting volumes reached and overpassed the pre-war level. In 1945, 168 million m^3 was provided, in 1946–186, in 1947–202 and in 1948–250, which was 1.5% above the pre-war level (Bobrov 2001). Moreover, the structure of harvested wood changed significantly. Before and during the war, the major part of the wood was firewood. The share of merchantable wood, which reached 45–47% in the 1910s–1930s, decreased to 37% during the war (Tehničeskij proekt…, 1980). After the war, there was a massive rebuilding of ruined houses and the whole national economy was in the rebound. All that required a large amount of merchantable wood. Its proportion of the total volume of harvested wood began to increase, reaching 62% by 1950, and 71% by 1961. In 1950, 33% was covered by sawing and sleeper blocks, 25% by merchandise used in round form, and only 3% by pulpwood, peeler block, and match block. In 1960, these figures reached 46%, 20%, and 5%, respectively (Tehničeskij proekt…, 1980). Thus, while before and during the war merchantable wood formed less than a half of all harvested volume and the majority was firewood, after the war the most of harvested wood became merchantable wood. It should be noted that in Russia, the major part of the sawlogs are until now harvested from coniferous species (Federal’noe agentstvo… 2006).

The reduction of the need for firewood and the jump of the value of coniferous industrial wood clearly showed that the use of the existed harvesting methods (concentrated fellings), without any compensating silvicultural measures, leads to the significant replacement of coniferous species by hardwood and to the loss of forest resources’ functions (Fig. 2.5). This led to the development of felling rules, instructions for forest inventory and planning (FIP), and regulations on preserving coniferous and hard-leaved understory trees. In addition, more attention began to be paid to artificial regeneration.

Fig. 2.5 In large clear-felling areas, hardwood species have replaced coniferous. Muezeskij district, Karelia republic. *Photo: Pavel Čikulaev*

However, the size of cutover lands, which was far from silvicultural norms and other reasons, prevented the complete stop of the replacement process: during 1961–1966, the coniferous area declined by 4.4% (Koldanov 1992). That process was influenced not only by specific cutting methods, but also by the fact that the forest planting plan was fulfilled only pro forma. The formal completion of the forest-regeneration plan, not the real forest management, was the top priority; as a result, quantitative indicators were reached with prejudice to the quality of forest lands. The appraisal of leskhozes had almost no connection with the final aim of silvicultural activities – the increment of stands' productivity.

Forest administration suffered from a hard pressure of forest industry, and consequently, new felling rules were approved in the 1960s. Based on forest accounting in 1975–1979, it was found out that in the European part of Russia forest resources had significantly exhausted (Gusev et al. 2004). Moving the main timber harvesting into Siberian forests was not possible due to the insufficient working capacity of the Trans-Siberian main railway line.

In 1979, the next felling rules approved by the State Silvicultural Committee of the USSR were constituted (Belaenko et al. 1998). This was the first time when such rules were differentiated for regions of the USSR. However, we have to state that according to these rules, the sizes of cutting sites in harvesting units were far from those, which could assure regeneration of coniferous species.

In the USSR, harvest volumes began to decrease after 1988. In 1988–1990, they declined by 24%; this tendency continued in the subsequent years. In Russia, the volumes of wood harvesting and production of the main wood products reduced in 2–3 times compared with the pre-reformation period (Belaenko et al. 1998). The decrease of the haulage volumes was determined by the fact that since 1972, disposal of old logging facilities was higher than commissioning the new ones; renovation of the machinery and instrumentation stopped almost completely. Since 1991, the management of the Russian forests, as of the whole forest complex, came into the period of the most radical transformations.

On the 6 March 1993, the Supreme Soviet of the Russian Federation adopted a resolution "About the order of implementation of the Basis of forest legislation of the Russian Federation". Section 8 of the Basis confirmed the separation of forest management functions from final felling. Therefore, silvicultural units were exempted from the duty of industrial-scale wood harvest and the wood-processing department was exempted from the leskhozes. As a result, the main way left for leskhozes to earn their own money was wood harvesting during intermediate felling. In the situation of insufficient government funding, leskhozes began aggressively thin middle-aged and maturing stands and carry out renewal thinning which provided the high outcome of merchantable wood. While in 1975–1992, the proportion of intermediate fellings in the total volume of harvested wood was 7–9%, in 1994–1996, it reached 14–16% (Belaenko et al. 1998). In practice, those intermediate fellings were selective fellings where the most valuable trees were harvested, and this led to degrading stand quality.

The same document (sec. 28) allowed selling standing wood during forest auctions. Thus, the presence of the standing wood cost, which was rejected since the 1930s, was recognized de facto. On the other hand, neither owner's rights nor his amenability for the forest state and silvicultural level were defined.

The Basis of forest legislation was developed before the adoption of the Russian Constitution, which caused several contradictions between the Basis and the Main Law of Russia. That is why on the 4 February 1997, the Basis was repealed and replaced by the Forest Code of the Russian Federation. The new legislation act redistributed the powers between the federal government, the subjects (oblasts, republics), and the municipal administrations. The order of forest lands' leasing was changed, making forest tenders the main way of extending the lease. It was enacted into law that forest regeneration is funded from the budgets of the subjects of the Russian Federation. According to the Code, the central government of Russia should have defined the minimal rates for wood harvest and the regions the real values of these rates. However, the silvicultural funding system, described in the Code, worked only partially. A leskhoz had no economic interest in its activities, because any income from the mature forest sold went to the budget, then a certain sum was sent from the budget to the leskhoz, and this sum value was not affected by the quality of that unit's work.

After reforms in the beginning of the 1990s, forest industry units moved into the private sector of economy. They took forest lands on lease up to 49 years. Currently, there are regions, where forest lands are almost completely divided between leasers. Auctions where cutover lands are traded are also carried out now. The largest harvesting companies and leasers invested significantly into wood transportation, plant, and equipment. All this motivates the companies for long-term profitable business and investment into forest management.

To summarise, it is important to note that misunderstanding of the silvicultural role in the national economy causes the main problems. This is the very reason, why during the Soviet time, all reforms in silviculture affected only the highest levels of forest management of the whole country (see Annex 2). The central forest-management organ of the country many times changed its subordination, got and lost its sectoral independence more than 20 times, i.e. almost each 3–4 years. Chief executives of the branch were displaced 40 times, i.e. each 2 years on the average which could not support sustainable forest management (Vysšie organy… 1971). Currently understanding of this tradition has changed only little.

2.2.2 Forest inventory and planning

FIP functions began to restore little by little since 1922. In 1926, "Instruction for inventory, planning, inspection and economic investigation of national forests of RSFSR" was issued (Gusev et al. 2004). In 1923–1928, 61 million hectares of forests were inspected.

According to the All-Russian Central Executive Committee decree "About the situation and development perspectives in forestry" from 1929, forest management was completely organizationally united with the timber industry. FIP as an academic subject was excluded from the syllabus of forest colleges. The volume of forest use was settled not by the persistence of forest use, but only by the powers of logging units and by the accepted schedule of forest resource absorption. In the 1930s, the complex of FIP works was in fact replaced with forest-economical surveys and forest inventories.

Excessive cuttings in the most populated regions resulted in negative ecological consequences. Therefore, *Sovnarkom* (The Soviet National Committee) divided all Soviet forests into two types – merchantable and protection. In 1936, 20 km-wide water protection zone was detached along rivers, which made to develop the full projects of forest management. Thus, the normal FIP began to restore, which was concerned with the activity of the Main Administration of Forest Protection and Reforestation (*Glavlesookhrana*) created under *Sovnarkom*. The administration personnel developed "Instruction for field FIP works in 1938" and "Temporary rules for silvicultural actions according to FIP scheme in 1937–1938". The instruction specified the aims of forest management in water protection zones and defined the measures to be fulfilled for the regime of river improvement (Fig. 2.6). This document remained in force until 1946, when *Glavlesookhrana* approved a new one - "Instruction for inventory, planning, and revision of bank-protection forests" (Gusev et al. 2004). A task was set to increase the volume of intermediate felling and to rectify (put in order) forest sanitation and fire protection. Because of works fulfilled in 1937–1946, 49.5 million ha of forests was arranged.

Fig 2.6 In water protection zones along lakes and rives, forest use is restricted. Pečora river, Komi republic. *Photo: Vladimir Korotkov*

The state inventory of forest resources became regular only after the end of the World War II. The creation of the state inventory system demonstrated the need for uniform the valuation of any forest in the country. In the early 1950s, the Ministry of Forestry of the USSR developed and approved the new “Instruction for the USSR national forest inventory and planning”. Forest management projects began to replace forest exploitation plans. At the regional level, however, FIP, forest management and forest use was carried out according to the rules of state-planned economy, based on generalized numerical indicators, not concerned with factual cartographic materials. As a result, the planning and realization of state forest policy always suffered from the low response rate and sometimes were not adequate.

In 1964, the State Committee of Forest, Pulp and Paper, Woodworking Industry and Silviculture under the State Planning Committee of the USSR approved the second “Instruction for national forests inventory and planning”. It was developed taking into account forest groups and site types, in accordance with the principles of expanded reproduction and differentiated organization of forestry on vegetation zones and economic regions. This instruction was oriented to the interests of the forest industry even more than the previous one. While section 10 of the instruction said that FIP projects, after their approval, should be considered as obligatory tasks, this was not realized in practice. The gathering approach dominated: to harvest the naturally grown yield and move on.

All forests of Russia were recognized by the beginning of the 1970s. In 1986, Gosleskhoz (State Silvicultural Administration) of the USSR approved the first part of “Instruction for FIP in the united national forest resources of the USSR”. Organization issues and FIP tasks, stated in that instruction, were defined according to the requirements of “Basis of forest legislation of the USSR and united republics”, and constituted in 1977. In 1989, additions and changes to this instruction were approved. According to these documents, all forests, including collective farms, had to be arranged on a single technique. The second part of the instruction, which regulated the cameral work, was approved only in 1990. It was developed based on “Concept of the forestry development in the USSR till 2005”, approved by Goskomles (State Forest Committee) on May 6, 1989. For the revision period, the main task of FIP was to create long-term programs on the rational use and reproduction of forest resources at two levels of forest management – regional one and leskhoz one. Calculation methods for final and intermediate felling were not changed, although the principle of persistent use was approved as the basis, and the methodology for alternative calculations of felling in accordance with long-term forest land dynamics was suggested.

In 1994, Rosleskhoz (Federal Forestry Agency of the Russian Federation) approved the next instructions for FIP. The developers’ main aim was to provide the high reliability of FIP data, to specify and define quantity and quality characteristics of forest lands and forest resources as the basis for rent accounting of forest use, to implement the objective cadastral valuation of forests, and to organize rational and not-depleting forest use. The aim to get the high reliability of the data was not achieved due to the bad economic situation and the reduction of the forest-mensuration staff. The current materials of FIP contain a propagated systematic error in forest evaluation, caused by the domination of ocular evaluation methods.

Currently, FIP is considered as a middle-term (up to ten years long) program of sustainable forest management and use, which was historically developed on the local level (township, leskhoz, forest district – *lesničestvo*) in the general system of the federal-wide hierarchy of forest management including federal, regional and local levels. According to the revised forest legislation, FIP tasks include also the development of regional plans of forest use and resource reproduction (Lesnoj kodeks… 2007, Postanovlenie Pravitel'sva… 2007). The aim of these plans is to define the main strategic trends in forest use and forest management on a long-term basis, taking into account the whole complex of natural resources and economic development factors in every single constituent entity of the Russian Federation (region, republic etc).

Summarizing the review, we can state two serious problems in modern Russian FIP. Firstly, in spite of the increased scope of FIP, the related documentation is not updated in time. Secondly, until now, forest planning remains the weak point; contemporary Russian forest management plans do not correspond to business plans, which do not facilitate the investments; only some kinds of silvicultural activities are being planned, while their costs and effectiveness are not estimated at all. Forecasting dynamics of the forest-land areas and economic grounds of silvicultural activities do exist only within pilot projects.

2.2.3 Final cutting

In the 1920s, the Soviet government defined the aim of forestry as "to provide timber for working population, state needs, and wood industry". To achieve this, it was supposed to repeal silvicultural requirements for final cutting. In 1929, Sovnarkom decree allowed clearcut areas larger than 50 ha. Only in 1939, "Rules for cuttings in merchantable part of water-protection zone and for overmature forest cuttings in prohibited belt of water-protection zone" (Janickaja et al. 2003) were approved at last. According to these rules, the main harvesting method was clear-cutting. The width of the cutting area was defined as 50 m in dry lichen pine forests, 100 m in other coniferous forests, and 250 m in soft-leaved forests (Fig. 2.7). Cutting cycles were fixed at three years for pine and spruce and at one year for soft-leaved forests. All these rules were applied to bank-protection forests only, the others were still exploited without restraints.

In 1950, the first "Rules for final cuttings in the USSR forests" (Pravila rubok… 1950) appeared; before that, allotment instructions of 1940 were applied for merchantable forests. Those rules set the width of a cutting area for zones 2 and 3 of the II group forests (forests in densely populated or industrial areas) to be 100 m for coniferous species and the cutting cycles were set from three to five years, depending on a species and a stand type. The width of a cutting area could be increased with the permit of the forest-resource base. For the III group forests (the main source of raw material for forest industry), where logging operations were mechanized, the allowed width of a cutting site was 1 km for railroad logging and 500 m for trucking. The length of a cutting site was fixed at two kilometres, and cutting cycles were three years for pine and two years for spruce and soft-leaved species (including the cutting year). These rules did not limit timber harvesters too much.

Fig. 2.7 Clear cutting has traditionally been the main harvesting method in Northwest Russia. Muezeskij district, Karelia republic. *(Photo: Alexandr Seliverstov)*

In the I group forests (forests with water protection, protective, sanitation and health-improving functions), rare at that time, the situation was different. According to "Rules for forest restoration cuttings in the I group forests, prohibited and protection belts along rivers, highways and railroads" (Pravila lesovosstanovitel'nyh rubok… 1952), high cutting ages were set: for pine 161 years, for pine in lichen and sphagnum pine woods of IV - V capacity classes 141 years, for spruce 141 years, for birch and basswood 81 years, and for aspen and alder 61 years. For all species, the width of a cutting area was fixed at 50 m. Cutting cycles were the following: five years for pine, four years for spruce and three years for soft-leaved species. These rules secured forests from depleting cuttings.

Merchantable forests were still cut in an extermination way, and the situation only worsened with the appearance of the bucking program, which usually did not correspond to the assortment structure of merchantable volume. It was impossible to fulfil this program without overharvesting of coniferous species and undercut of hardwood ones. This led to the early depletion of resources. The main method of wood transportation was floating. Integrated timber harvesting enterprises (lespromkhoze*s*) rather widely used conditional clear-cutting, absent in the rules. In mixed hardwood-coniferous stands, the coniferous trees were cut, but the hardwood trees were left, because they drown during floating. The situation was so bad that in 1954, the special "Instruction for order of cutting-area exploitation with complex logging mechanization in accordance with the need to save saplings and undergrowth of coniferous as well as hard-leaved species" (Instrukcii o porjadke… 1954) was approved, and in 1959, undergrowth-preserving harvest techniques appeared. Thus, in the 1940s–1950s, a particular move to silviculture and preventing the coniferous-to-hardwood replacement teethed.

In late 1962, new cutting rules were approved (Pravila rubok… 1963) (see Table 2.3). These cutting rules met the objections of forest-industry chiefs and specialists, who attained the approval of Cabinet Council decree No. 418 from April 13th 1963, "About the measures for development of lumbering industry in richly-wooded regions of North-West, Ural, Siberia and Far East". According to this decree, in 1965 "Fundamentals of carrying out the final cuttings in the USSR forests" (Osnovnye položenija… 1965) were developed. It is interesting to retrace the influence of the changes in the branch management onto cutting rules and forest management instructions. Tables 2.3 and 2.4 allow comparing rules approved in 1962, when forestry was subordinated to the Main Department of Forestry and Forest Protection under the Cabinet Council of RSFSR, and new final cutting rules, approved in 1965 by the State Committee of Forest, Paper-pulp and Woodworking Industry and Silviculture under the State Planning Committee of the USSR.

Let us note other changes in the felling rules. The cutting pattern of the II group forests became significantly closer to the III group one. Cutting parameters for I and II groups became somewhat different, but the main changes concerned the II group forests, which were the resource bases of lespromkhozes. In these forests, the width of a cutting area was increased for pine (from 100 to 250 m), for spruce (from 200 to 250 m), for soft-leaved species (from 250 to 500 m). Moreover, the cutting cycle was reduced for pine (from 3–4 to 2 years) and for soft-leaved (from 1 year to annually); section 15 appeared, which allowed 500 meter-wide cutting areas for railroad logging and hard road haul covering all species, except cembra pine. Moreover, while the rules of 1962 allowed regional differences, in 1965 the rules were unified for the whole USSR again.

Table 2.3 Parameters of clear cuttings for the 3rd forest rate zone according to “Rules for final cutting in plain forests of the European part of RSFSR”, approved on November 12, 1962 (Pravila rubok… 1963).

Species	I forest group [1]		II forest group [2]			III forest group [3]				
			Width of cutting area, m			Width of cutting area, m		Area, ha		
	Width of cutting area, m	Cutting cycle, years	For lespromkhozes	Others	Cutting cycle, years	For lespromkhozes	Others	For lespromkhozes	Others	Cutting cycle, years
Pine	75	4	100	100	4	500	200	50	20	3
Spruce	100	3	200	100	3	500	200	50	20	3
Soft-leaved	200	1	250	250	1	1000	500	100	50	Annually

[1] Forests with water protection, protective, sanitation and health-improving functions
[2] Forests in densely-populated areas with both protective and limited exploitation values
[3] Forests in densely-forested areas intended for meeting the timber requirements of the national economy

Table 2.4 Parameters of clear cuttings for the 3rd forest zone according to “Fundamentals of carrying out final cuttings in the USSR forests”, approved on May 21, 1965 (Osnovnye položenija… 1965).

Species	I forest group [1]		II forest group [2]				III forest group [3]			
			For lespromkhozes		Others		Width of cutting area, m		Area, ha	
	Width of cutting area, m	Cutting cycle, years	Width of cutting area, m	Cutting cycle, years	Width of cutting area, m	Cutting cycle, years	For lespromkhozes	Others	For lespromkhozes	Cutting cycle, years
Conifers	100	2-5	250	2	100	1-4	500	200-250	50	3
Soft-leaved	100-250	2-5	500	Annually	250	1-4	1000	250-500	100	Annually

Comparison of the cutting rules of 1962 and 1965 shows the great pressure which forestry agencies suffered from the timber industry. Even being relatively independent in the branch management, they could not sometimes defend silvicultural priorities. Lespromkhozes had two plans: the general volume in cubic meters and the assortment structure plan. The latter did not usually correspond to the assortment structure of merchantable forest land, so the best part was cut first, which increased the mismatch, since the main harvest regions covered relatively small part of the USSR territory. The completion of the assortment plan led to the overharvesting of coniferous species and undercut of hardwood ones. E.g., in 1968 in the European part of RSFSR and Ural, coniferous overharvesting reached 8.5 million m^3 for the II forest group, and 22 million m^3 for the III forest group; hardwood underharvesting was 38 million m^3 (Koldanov 1992).

In 1978, "optimal" regional cutting ages for the whole territory of the USSR were approved. Before that, cutting ages were defined only in the rules of 1952 and only for the I forest group. As far as before 1978, defining cutting ages was the prerogative of FIP, they were changed by the orders of departments to which forestry was subordinated. However, the new rules, in fact, were not optimal: e.g., during the century passed after the works of A. F. Rudzky and M. M. Orlov, who used the 120-years cutting period for pine stands (Rudzki 1896, Orlov 1931), cutting ages for pine stands were lowered by 40 years. This, of course, increased the periodic yield, but worsened its assortment structure (sawlog to pulpwood) and lowered the price of mature pine stands. In 1979, the State Forestry Committee of the USSR approved new cutting rules (Pravila rubok… 1980). According to these rules, in the II group forests the length of a cutting area depended on the planning compartment size, but could not exceed 2 km (Table 2.5). For railroad logging and all-weather hard-road haul, the width of a cutting area was set to 500 m.

As distinct from "Fundamentals of carrying out final cuttings" of 1966, in the I forest group for the first time wider cutting areas and lower cutting cycle were allowed for lespromkhozes than for others. In addition, for the first time cutting rules were distinct for different regions, not uniform for the whole USSR. In spite of the depletion of merchantable forest lands, in lespromkhozes the sizes of cutting areas were far beyond the limits required to secure forest regeneration by conifers. All forestry authorities' efforts to cancel the overharvesting practice were overcome by timber harvesters' lobby. The last time the timber harvesters got the government allowance for the overharvesting of coniferous species by 17.6 million m^3 was in 1989 by-passing the State Forestry Committee (Strahov et al. 2001).

Since 1991, forest management, as management of the whole forest complex, entered the period of the radical reformation. Taking advantage of lowering the timber-industry pressure in forest policy, the State Forestry Committee of the USSR issued an order "About the adjustment of fundamentals of carrying out final cuttings and regeneration cuttings in the USSR forests", which made the width and length of cutting areas somewhat closer to the silvicultural norms. According to this order, in the I forest group the clear-cutting area should be 5–10 ha in size for conifers and 15 ha for soft-leaved species, with the maximal width of a cutting area equal to 100 m and 150 m, respectively. For the III forest group, the size of cutting area could not exceed 50 ha, with no more than 500 m width. In addition, the increment of the width and the area of cutovers in the resource forests, allowed before, were prohibited.

Table 2.5 Clear-cutting parameters for the 3rd forest zone according to "Cutting rules in plain forests of the European part of RSFSR", approved by the State Forestry Committee of the USSR on March 6, 1979 (Pravila rubok… 1980).

Species	I forest group				II forest group				III forest group			
	For lesprom-khozes		Others		For lespromkhozes		Others		Width of cutting area, m			
	Width of cutting area, m	Cutting cycle, years	Width of cutting area, m	Cutting cycle, years	Cutting area width, m	Cutting cycle, years	Width of cutting area, m	Cutting cycle, years	For lespromkhozes	Others	Area, ha, for lespromkhozes	Cutting cycle, years
Conifers	150	1-2	100	2-5	250	2	100	1-4	500	200-250	50	3
Soft-leaved	300	1-2	100-250	2-5	500	Annually	250	1-3	1000	250-500	100	Annually

The Federal Forestry Agency of Russia approved the new "Rules for final cutting in plain forests of the European part of the Russian Federation" on August 31, 1993 (Pravila rubok… 1993). Comparison of the clear-cutting parameters, set by the order of 1991 and the rules of 1993 shows that in the I and the III forest groups, cutting parameters remained intact, while in the II group forests, the size of cutting areas increased (Table 2.6).

Table 2.6 Parameters of the main managerial and engineering elements of clear-cutting set by the cutting rules of 1993 (Pravila rubok… 1993).

Parameters of the main managerial and engineering elements of cuttings	I forest group	II forest group	III forest group
Maximal size of cutting area by species, ha			
Conifers	10	20	50
Soft-leaved	15	25	50
Width of cutting area by species, m			
Conifers	100	200	500
Soft-leaved	150	250	500
Cutting cycle for cuttings with preliminary/ subsequent reproduction by species, years			
Pine	5/2	5/2	5/2
Spruce	4/3	4/3	4/3
Soft-leaved	2/-	2/-	2/-

Clear-cutting is still the main type of cutting in Northwest Russia. It covers 70% of all harvested volume in Russia, including 90% of all wood harvested in final cuttings (Knize and Romanjuk 2004). Clear-cutting, with the allowed area up to 50 ha (for the III group forests) and relatively short cutting cycles, transforms forest environment and negatively affect natural biodiversity in the maximal degree compared with other felling types. Clear cutting is far from always feasible even from the economic point of view: it often produces a large amount of small-diameter and low-quality wood. On the other hand, the effective use of selection (*vyboročnye rubki*) and gradual felling (*postepennye rubki*) often requires special wheeled vehicles.

During the last ten years, in Northwest Russia logging companies have increasingly more started to use the Nordic cut-to-length (CTL) method and purchased modern wood-harvesting machines especially in the Republic of Karelia and the Leningrad region. High-productive and high-tech harvesters and forwarders are suitable besides clear-cutting, also for thinning, enabling harvesting with small damages to ground and remaining trees (Anan'ev et al. 2005).

Recently, forest lease and forest auctions have been the main ways to get rights to utilise forest lands. The rates of this process slightly differ from region to region, which can be explained by market proximity, road net structure, and the placement of logging and wood-processing units.

In the Russian forestry, a significant problem is the insufficient density of forest roads. The average density of forest roads in Russia is 1.2 km per one thousand hectare, which is 1/10 of that in Finland. During the last ten years, road building for forestry purposes has significantly decreased (Fig. 2.8).

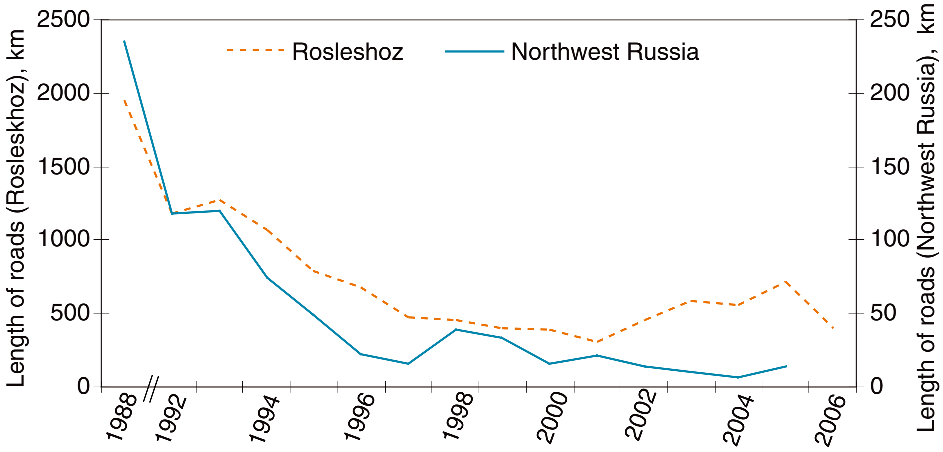

Fig. 2.8 Road-building for forestry purposes in the forests managed by the Ministry of Natural Resources in 1988, 1992–2006 (Federal'noe agentstvo… 2006).

2.2.4 Thinning

The lack of mature stands of valuable species at least 90 years old is the result of low quality of forest management during previous years. As described above, at the beginning of the XX century Russian forestry was reduced to forest exploitation planning and marking-cut coupes. The first rules for thinnings appeared only in "Instruction for field forest inventory and planning works in 1938" and "Temporary rules for silvicultural drafting in forest inventory and planning in 1937–1938." They appeared due to the development of instruction for forest management in water-protection zones and defined only the regime of river improvement activities. That instruction remained in force up to 1946, when Glavlesookhrana approved the new one - "Instruction for inventory, planning and revision of bank-protection forests", which set a task to increase the volume of thinnings and to rectify forest sanitation and fire protection (Gusev 2004).

During the 1940s–1950s, a particular move to silviculture and preventing coniferous-to-hardwood replacement teethed: different cutting rules were approved for different forest groups, felling rules for merchantable forests replaced marking-cut coupes instructions, the practice of development of forest inventory and planning projects instead of forest exploitation plans appeared. Thus, in 1950, 887 thousand hectares were thinned. Along with the increased amounts of silvicultural operations, their quality also improved: even some positive trends in forest land characteristics appeared. In spite of this modest success, during 1961–1966, when forest management projects were already in development, the area of conifers decreased by 4.4% (Koldanov 1992). That happened, because while the planting plan was officially carried out, forest management was not competent: first, the scopes of planting and thinnings in saplings were not coordinated. The latter were referred to the intermediate cut, while there is no realizable wood during cleaning and precommercial thinning (*osvetlenie i pročistka*) in the forest zone. As a result, these cuttings were carried out insufficiently in scope and intensity which led to the suppression of conifers by hardwood species (Fig. 2.9). That is why large-scale planting works have not produced awaited results. Due to the above-mentioned economic reasons and increasing forestry funding gap, since 1970 the scopes of thinnings and sanitary cuttings, essential to improvement of stands' quality and productivity, began to decrease.

Fig. 2.9 Planted sapling stand of pine suppressed by broadleaves needing for tending. Vyborskij district, Leningrad *region*. *(Photo: Vladimir Korotkov)*

In 1993, when leskhozes were exempted from the duty of industrial-scale wood harvest (see above), the main way left for them to earn their own money became wood harvesting during intermediate cuttings. In the situation of insufficient government funding, leskhozes began aggressively to carry out commercial thinnings and regeneration cuttings, which provided the high outcome of merchantable wood. While in 1975–1992, the proportion of thinning in the total volume of harvested wood in Russia was 7–9%, in 1994–1996 it reached 14–16% (Belaenko et al. 1998). The aim of thinnings became the commercial income at the time of cutting, rather than improvement of the stand quality to the moment of final cutting. In practice, this kind of selective cutting of the most valuable trees led to the degrading of the stand to the moment of final cutting.

In conclusion, we may note that during the last few years, in Russia the scope of improvement measures in saplings has stabilized, staying about 550–600 thousand ha annually, from which 200–230 thousand ha are processed in a mechanized way. The requirements for such measures, however, are up to 1.5–2 times greater. Accordingly, with sufficient funding, the potential for improvement of wood quality and value is far from being at the end, and the outcome of sawn wood could be significantly higher with the help of improvement measures.

2.2.5 Forest regeneration

Taking into account the above mentioned, it becomes obvious that during the first decades of the XX century, forest regeneration was miserable in Russia. Orlov (1931) mentioned that in the Northwestern region, on October 1, 1927 artificially regenerated forests covered only 14 304 ha, including 3 512 ha from the previous decade. Thus, the average annual area of artificial forests regeneration was 350 ha only. During 1927, in the whole Northwest Russia 1 192 ha of forests were planted on the total area of more than 8.5 million ha, where the cutting area reached 80 thousand ha (Bobrov 2001).

Only after the war, in the RSFSR the attention paid to artificially regenerated forests began to increase, and the area of sowing and planting increased from 64 thousand ha in 1946 to 233 thousand in 1950 (Koldanov 1992). For the first time, in accordance with the Plan of transformation of nature, planted forests were mostly established in the southern regions of the RSFSR, but soon the focus moved to the north, into the main logging regions. In 1950, in the USSR the area of forest regeneration reached 920 thousand ha, including 577 thousand ha of sowing and planting. However, merchantable forests were still cut in an extermination style, and unreasonable forest use led to species replacement. Only in 1959, undergrowth-preserving harvest techniques appeared.

During 1956–1960, in the USSR 12.7 million ha of forests were cut, while only 3.2 million ha (25%) were restored by sowing and planting. In the rest part of the cutting area, only natural regeneration and assisted natural regeneration took place (Fig. 2.10). During the 1960s, the volume of artificial regeneration jumped. In the 1960s–1970s, in Leningrad and Pskov regions forest-planting plans were so great that the unstocked land area was too small for them. During 1959–1965, forests were planted on the area of 6 472.6 thousand ha, which exceeded the cut area by 45%.

During the 1970s, the annual area of clear cuttings (mostly clearcuts in areas larger than 50 ha) reached 1.8–2.0 million ha, and, at least formally, forest regeneration covered all the cuts. Therefore, during 1971–1975, forests were regenerated in the area of 8.9 million ha, during 1975–1980 on 9 million ha, including 3.8 and 3.9 million ha by sowing and planting, respectively (Red'ko and Red'ko 2002). Assisted natural regeneration, mostly by preserving viable understory of pine trees during the cutting, covered 30–35% of the annual cutting area. Almost the same area of cuts was left for natural regeneration without human intervention.

During 1976–1980, lespromkhozes began widely use powerful felling-and-bunching machines for the traditional Russian tree-length method, which could not secure preservation of viable undergrowth. This, in spite of forest regeneration measures taken, greatly affected the species replacement. In addition, artificial forests were established, in the first instance, in the places, where natural regeneration was successful of itself (in pine woods, on sandy grounds), not in the places of species replacement. In sapling stands, the scopes of improvement cuttings were not coordinated with the scopes of artificial and natural regeneration. Moreover, those cuttings were insufficient in scope and intensity. In forest draining, the top priority was also to fulfil a plan – more properly, to over-fulfil by all costs. That is why about a third of drained areas were oligotrophic bog lands (*verhovye bolota*), which have almost no reaction on draining. This happened because of the lack of explicitly stated aims of forest management. Because of the factors mentioned above, large-scale artificial forest regeneration has not provided awaited results.

Fig. 2.10 Assisted natural regeneration by conservation of undergrowth is the mostly used regeneration method in Northwest Russia. *(Photo: Sergei Sin'kevič)*

For a long time, planned industrial cuttings were more than on 90% clear cuttings with the use of heavy machinery. This resulted in soil erosion and leaching, which made natural regeneration of forests almost impossible. Artificial regeneration was handicapped with the large amount of slash and low-quality wood left on cutting areas. Until the 1970s, cuttings scopes exceeded forest-regeneration ones. During that period, in the zone of intensive logging the principle of persistent and sustainable forest use was not followed.

During the 1980s, in the USSR the scopes of the whole complex of forest regeneration works reached their maximum. The annual area of planting and sowing comprised 0.8 million ha, and assisted natural regeneration covered up to 1.0 million ha. Since 1990, the rapid decrease of the scope of forest regeneration began due to the general decline of the Russian national economy and reduction of final cutting volumes. As a result, the ratio of forest regeneration and clear cuttings changed. During a long previous period, for the country in general, the clear-cutting area prevailed over the forest regeneration area. Since 1989, however, the annual regeneration area surpassed the area of clear cuttings (Fig. 2.11).

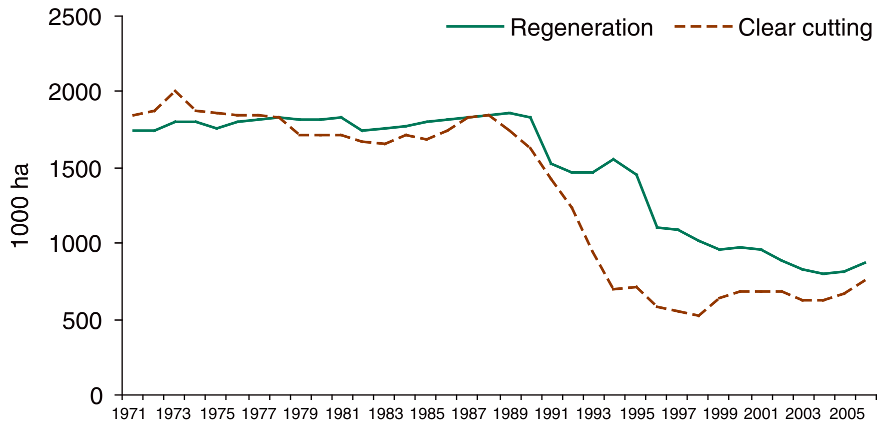

Fig. 2.11 Development of regeneration and clear-cutting area in Russia in 1971–2006 (Ministerstvo prirodnyh... 2002, Federal'noe agentstvo… 2006).

In recent years, clear cuttings cover about 600 thousand ha annually. The total area of annual forest regeneration on cuts and other unstocked lands comprises more than 800 thousand ha. Since 1989, the forest regeneration area did not decrease as rapidly as the cutting area. During this period, the area of artificial forest regeneration reduced by 25%. Planting remained the main method, but its area decreased by 28%. Sowing was more stable, staying about 7% of the whole forest regeneration area. During 1966–2000, the proportion of pine among all species decreased from 62% to 34%. Instead, the planting volume of spruce, which a moose damages less, increased. During those 35 years, in the European and Ural parts of the country, where artificially regenerated forests of oak are created mostly, their proportion reduced from 3.4% to 2.3%. As a result, the species composition of artificially regenerated forests, transferred to the category of forest-covered lands, has significantly changed in favour of spruce, to the detriment of pine and oak.

In the near-term outlook, the main tasks of forest regeneration are set in the subprogram "Forests" of the Federal target program "Ecology and natural resources of Russia (2002–2010)", approved by the Decree of the Government of the Russian Federation No 860, December 7th 2001. This subprogram defines targets for forest regeneration:

- Total forest regeneration area 6.4 million ha, including artificial regeneration 1.9 million ha, assisted natural regeneration 4.5 million ha
- Improvement cuttings in saplings 5.2 million ha
- Saplings' transfer to the category of economically valuable stands 9.3 million ha
- Supply of forest seeds 5 852 tons
- Setting up seed plots 1 355 ha
- Setting up permanent seed plantations 7 000 ha
- Production of planting stock 12 327 million items
- Organizing and building of forest tree nurseries 650 ha, including 188 ha of irrigated ones.

Planning of amounts and ways of forest regeneration is based on FIP projects in accordance with the changes occurred in the forest land. The Ministry of Natural Resources annually coordinates with regional authorities the scopes of works in terms of three parameters: forest regeneration in total, planting and sowing, and transfer of sapling stands to the category of economically valuable stands. However, in spite of the facts that the principle of persistent forest use is accepted, prices are set for standing wood and so on, we have to state that the whole state forest policy is still based on the concept of gathering rather than forest-growing. The next steps towards forest growing should be motivated by economic reasons, if we want to achieve sustainable results in improvement of quality and quantity of forest regeneration.

2.2.6 Especially protected natural areas (EPNA)

In Russia, the first reserved forests have appeared at the beginning of the XVIII century which was fixed by the decree of Peter I in 1703. The protection of the Russian forests in the XX century, after the period of severe harvesting during the Civil war and the 1930s, began in 1936 from the creation of the Main Administration of Forest Protection and Afforestation. Its main task was the protection of 20-kilometer belts along the rivers of Dnepr, Desna, Volga, Mologa, Sheksna, Oka, Moscow, Klyazma, Kama, Belaya, Vyatka, Unzha, Vetluga. The decree of the People's Commissars Council of the USSR "About the order of marking-cut coupes in the National forest land of the USSR and forest land to cut for 1943" divided all forests of the country into three groups, based on their economic value. Forests of the I group were intended for environment-protection functions, their exploitation was of minor value. To the II group were relegated the forests of sparsely-wooded and averagely-wooded regions of the country (except the I group forests), where the intensive forestry was practiced and, usually, the periodic yield was used. All other forests, located in richly-wooded regions, were relegated to the III group, and their level of use was determined by needs of the national economy. Further, in process of comprehension of environment forming and protective role of forests, the development of local infrastructure, building of new cities, settlements, railroads and highways, the proportion of the I group forests gradually increased and reached 22.5% according to the state inventory of forest lands for January 1, 2005 (for January 1, 1956 it was only 2.8%).

A network of especially protected natural areas (EPNA) plays an important role in conservation of typical and unique natural landscapes, biological diversity, and sites of natural and cultural heritage. These sites are officially excluded from the management regime and are under the specific nature protection management. According to the Federal law of the Russian Federation "On the Specially Protected Natural Areas" (1995), the following categories of specially protected sites are officially in use:

- State nature reserves (*gosudarstvennye prirodnye zapovedniki*), including biosphere reserves;
- National parks (*nacionalnye parki*);
- Nature parks (*prirodnye parki*);
- Wildlife preserves (*zakazniki*);
- Natural monuments (*pamjatniki prirody*);
- Dendrological parks (arboreta) and botanical gardens (*dendrologičeskie parki i botaničeskie sady*);
- Resorts and health-care sites (*kurorty i lečebno-ozdorovitelnye mestnosti*).

All these play a crucial role in formation of an ecological framework of a certain region. The proportion of specially protected forest areas is 5.2% of the total forest area, but the proportion of forests in strict nature reserves is insignificant (1.1%). The percentage value of forests in specially protected areas varies from 3.6% in the Republic of Karelia to 10.6% in the Pskov region (Janickaja et al. 2003). The Murmansk region, Komi Republic, Leningrad region, Pskov region, and the Republic of Karelia have a significant area of forests for conservancy and preservation of the environment.

The system of EPNA of Russia is rightfully considered one of the best in the world: EPNA cover up to 10% of the country's territory. However, borders of many such areas reflect the result of the compromise with various economic interests, not the nature protection idea. The EPNA system requires the further improvement, both by the way of expansion and management.

The net of the Russian federal and regional EPNA may be significantly complemented by the inclusion of essentially undisturbed by human development forest territories, called intact forest landscapes (IFL). IFL are defined as territories of more than 50 thousand ha in size, containing mature and overmature forest lands, without settlements and working elements of the economic infrastructure inside, formed by the natural ecosystems which have not been affected by intensive economic activities during the last 100 years (Yaroshenko et al. 2001). The minimal linear size of IFL should be 10 kilometres, the minimal distance between the borders of IFL contour 2 kilometres, hindering bordering effects. The most part of essentially undisturbed spruce and pine forests of the European part of Russia survived in the republics of Komi and Karelia, Murmansk, and Arkhangelsk regions. The majority of large undisturbed forestlands of Russia are unique and important for the maintenance of the ecological balance of ecosystems of the North, so they deserve the strictest protection (Fig 2.12).

Fig. 2.12 Intact forest landscapes of Pečoro-Ilyčskij biosphere nature reserve (zapovednik), Komi republic, with the area of 721,300 ha established in 1930. *Photo: Vladimir Korotkov*

During the compilation of the atlas of essentially undisturbed forest landscapes of Russia, it was found out that in a zone of closed forests (excluding the zones of tundra and forest-tundra, and sea water areas), the proportion of the federal level EPNA was only 2.4% (Yaroshenko et al. 2001). Herewith, only 5% of all IFL was protected (Janickaja et al. 2003). The detailed analysis (Karpačevskij 2001) of the layout in the areas of different categories of ENPT regimes and protection for the Arkhangelsk and Murmansk regions and the republics of Karelia and Komi showed that though the set of all EPNA occupied 11.6% of the overall area of these regions, final cuttings (industrial harvestings) were forbidden only on 4.7% of the overall area. The simultaneous interdiction of final cutting and intermediate cutting existed only on 3.1% of the territory. At that, only 12.6% of the remaining IFL in this region was protected.

In spite of the large area occupied by IFL in Northwest Russia, their wood resources are relatively low and hard-to-reach. Thus, the allocated IFL basically consist of the least productive forest lands of Russia, which were kept in minimally disturbed condition mostly due to their low-productive capacity.

2.2.7 Tendencies of changes in forest management organization

The new Forest Code of the Russian Federation came into force on January 1, 2007. At the first time in 300-years history of Russian forestry, it radically decentralized forest management. The first steps of pre-arranged cardinal decentralization has partially been made already in the Federal Law 199 passed in December 2005. The new Forest Code continues the concept of long-term lease as the main form of forest use, declared in the Code of 1997 (currently about 2/3 of wood is harvested under the such form), but is also aimed to fix the previous problems with regeneration and forest protection, making those who cut the forest responsible for its renewal.

According to the new Code, a very limited amount of general-level functions remains solely in the federal authority, such as

- Remote monitoring of forests (protection from fires, pests, tree diseases and illegal cuttings);
- State forest accounting and inventory (forest planning works will be carried out under the order and at the expense of forest users);
- Forest seed-growing, oriented to the valuable species with advanced hereditary characters;
- Sectoral science and education;
- Publishing guidance documents for forest management regulation (differentiated by new forest zones *(lesnye rajony*) with relatively similar conditions of forest use, protection and renewal).

All the instruments of state forest management, including the territorial administrations of Rosleskhoz, *leskhozes*, fire fighting stations, aviation bases and other support units, are delegated to the subjects of the Russian Federation. Exclusions to this will make federal state enterprises "*Roslesozaščita*" (protection), "*Centrlessem*" (seed growing) and "*Centrlesproekt*" (inventory and planning), which will become the base for the network of representative offices, carrying out the federal functions. The delegated powers will be financed by subventions from the federal budget in the amount of 2006 expenses, corrected by deflators. The regions may also use their own funds.

Before January, 1 2008, *leskhozes* should have been reorganised from federal organisations to regional administrative bodies with separated functions of administration and commercial operations. Main activities of the newly formed state-owned companies are forest protection and regeneration tasks, conducted on the contract basis. They also have some privileges, e.g. rights for short-term use on their parcels on the non-competition basis.

On the leased forest parcels, the lessee is responsible for fire-preventing and sanitary measures and for regeneration according to the adopted forest development plan. The state fulfils the public functions, like fire fighting, forest-protection, protection from law violations. For non-leased forests, state foresters organise the respective works on a competition basis for persons and organizations.

The Forest Code keeps (with minor exclusions) the federal property of forests, introducing private and municipal property only for some categories of forest lands. The federal centre keeps three major forms of control, carried out by respective bodies:

1 Regulation of forest relations (Ministry of Natural Resources),
2 Control and supervision over the performance of forest management and compliance with norms and rules (*Rosprirodnadzor* – Federal Service for Inspecting the Utilization of Natural Resources),
3 Monitoring forest condition, performance of delegated powers, maintaining the state forest ledger and cadastre, funding forest activities by subventions (*Rosleskhoz*).

The lessee gets the rights for:

1 Declarative forest use (forest declaration instead of felling license),
2 Subleasing, delegation of rights and powers to a third party, pledge of chattels real or including them in the authorized capital,
3 Prolonging a lease agreement on non-competition basis (if the previous agreement rules were not violated).

The lessee may also build required forest infrastructure and conduct all kinds of cuttings. The Forest Code allows the complex development of forest resources for all kinds of forest use on a leased parcel. Concluding lease contracts on non-competition basis is also allowed to fulfil the investment agreements in the aim to create and use wood-processing infrastructure (which includes sawing, woodworking, energy and transport facilities). However, the new Forest Code is not a directly applicable law; its realization requires a lot of subordinate legislation (including regional-specific) to be approved.

In conclusion, it can be said the conditions for economic forestry appeared at last. However, due to massive cuttings in the 1920s–1930s, in Northwest Russia large areas are now occupied by deciduous species, which became already overmature and rotten and almost cannot be utilized by the timber industry. Large amounts of mature stands are not available for exploitation due to economic inaccessibility. Due to exhausted raw material bases, pulp and paper mills try to organize special-purpose forestry for accelerated growing of stands for the reception of appropriated timber assortments (Karpačevskij 2001). In fact, that is just a try to declare that the main purpose is to grow pulpwood instead of sawlogs and to decrease a cutting cycle. The nearest future will show if such establishment can be economically acceptable. In Northwest Russia, the proportion of coniferous species in the periodic yield is significantly lower than in forest lands for which this periodic yield is calculated. The lack of economically accessible forests, especially ones including the most valuable timber assortment - coniferous sawlog, against the significant undercut of the periodic yield, can become the motivating factor for developing intensive and sustainable forest management, i.e. forest-growing.

2.3 Comparison of different forest management regimes in Lyaskelskoe lesnichestvo in the Republic of Karelia

Alternative forest management strategies have been analysed for the Lyaskelskoe forest district (*učastkovoe lesničestvo*) of the Pitkyarantsky forest management unit (*centralnoe lesničestvo*) in the Republic of Karelia with a simulation model FORRUS-S. Different cutting volumes, ages of final felling, preservation of undergrowth, different regeneration methods and types of thinning were compared.

2.3.1 Background

The aim of the comparison was to study, how different forest management regimes effect on development of growing stock, timber assortment structure, allowable harvesting volumes and economic profitability of timber growing during the rotation time. The effective forest code and forest management regulations in Russia were taken into consideration.

The Lyaskelskoe forest district is situated 150 kilometers to south-west from Petrozavodsk on the northern shore of the Lake Ladoga. The total area of the forest district is 7 412 hectares, and it is divided into 1 247 compartments. Pine and spruce with 48% and 35% shares are the most common tree species, while the proportion of birch is 17% (Fig. 2.13). Forest productivity is at the average level, the stands of site classes 3 and 4 occupy 63% of the area (Fig. 2.14). Most of the stands have a mixed species composition. Pure stands (the proportion of main species more than 80%) occupy 26% of the area, mixed stands with one dominant tree species (main species occupy 50–80%) 57%, and mixed stands with several tree species 17%.

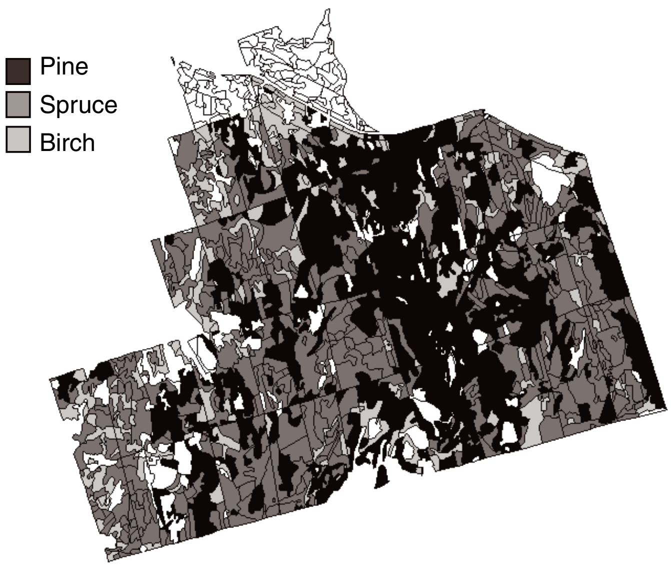

Fig. 2.13 Stand map of the Lyaskelskoe forest district

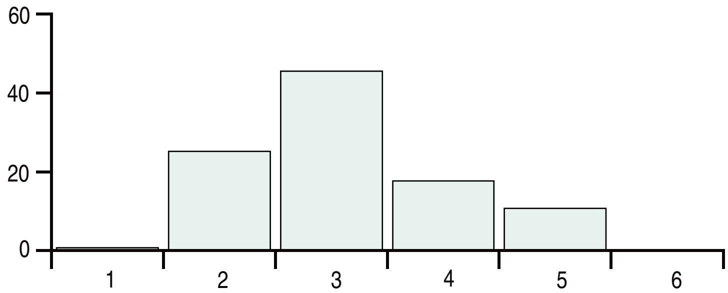

Fig. 2.14 Distribution of forest area by site classes (%). (class 1 – most productive, 6 – least productive)

2.3.2 Method

The used FORRUS-S model has been designed for simulating of forest stands and analysing dynamic processes in forest ecosystems (Chumachenko 1993, 1998, Chumachenko et al. 1997, 2000, 2003, Palenova et al. 2001). The model utilizes forest inventory data that is usually available for the whole territory of Russia. The FORRUS-S consists of two submodels 'Natural Development' and 'Exogenous Influence' which includes silvicultural activities, and a service block of GIS and a set of accessory programs (reference databases, analytical modules for recoding and visualization of output information etc).

The model of natural development of multi-species uneven-aged stand utilizes the principle of subdivision of the space into discrete three-dimensional elements. This approach makes it possible to consider the available photoactive radiation (PAR) in the zone of active growth in a tree crown, and also to take into account spatial heterogeneity of growth conditions, such as topography and soil characteristics. Since within the zone of mixed coniferous and broad-leaved forests in European Russia PAR is the main limiting factor, it is recalculated at each five year time step used for simulation. The model 'Natural Development' uses the technique of ecophysiological (explanatory) modeling and consists of four submodels: 'Light', 'Growth', 'Natural Thinning' and 'Natural Reproduction'. Correspondingly, the model performs simulation of basic processes in a forest: growth increment, endogenous thinning (mortality) and natural reproduction of a forest stand.

The modeling is based on repeated calculations of the current growth increment (by diameter and height) and thinning out in terms of three dimensional crown structure. The calculations are performed for each cohort (a group of individuals of same species and age) in a multi-species uneven-aged stand. Growth increment values are calculated based on the influence of the local light conditions on a tree crown with implications for properties like canopy density, species interactions and availability of basic resources (soil, water and nitrogen). Information on the availability of resources is based on the forest inventory data of the model object. The model uses dynamics of basic forest inventory parameters (height, diameter, age, growing stock etc.), and changes in species composition and age of the stand are forecasted.

Model 'Exogenous Influence' supplements the computer program FORRUS-S by possibilities of solving various applied tasks, e.g., modeling of different variants of intermediate cutting, cleaning cutting, silvicultural activities, forest fires etc. This model consists of submodels 'Final Felling', 'Intermediate Felling' and 'Silvicultural Activities' that process output data from the model 'Natural Development'. All programming algorithms of these submodels are based on the regulations for silvicultural activities officially recommended for the European part of the Russian Federation (Nastavlenie po… 1994, Osnovnye položenija… 1993, Osnovnye položenija… 1994). Model 'Exogenous Influence' can be enabled or disabled at any step of FORRUS-S operation.

The use of computer modeling method on the base of FORRUS-S allows calculating long-term dynamic of forest resources for different forest management. In order to find the most rational strategy of forest management, an experiment was formulated and performed. The period of prognosis was 150 years consisting of 30 time steps of 5 years.

2.3.3 Assumptions

During the elaboration of forest management, the following input variables were chosen as parameters of the model.

Table 2.7 Models' parameters.

№	Variable	Min value (code «-1»)	Max value (code «1»)
Var_1	Minimal allowable income from harvested stands, rubles/cubic meter	0	50
Var_2	Maximum allowable cutting volume, thousands of cubic meters/year	27	30
Var_3	Age of final felling	One age class lower than regulated by norms	Standard, regulated by norms
Var_4	Undergrowth preservation	No	Yes
Var_5	Proportion of planted stands*, %	30	80
Var_6	Assisted natural regeneration, %	30	75
Var_7	Type of thinning	Silvicultural	Commercial
Var_8	Level of timber price	Low prices	High prices

*for clearness of the experiment only planted pine stands were considered

The calculation concerns both forest management activities and economic outputs. The latter ones include:

Var_1. *Minimal allowable income from harvested stands.* Net income is determined as a difference between the market value of timber and logging costs occurred from forest to lower landing. Market value is assessed on the base of timber consumption and market price of certain timber assortments. The cost of wood harvesting consists of full logging costs, including also construction and maintenance of haulage roads, and normal income of a logger. Profitability of timber selling depends on many factors: demand for round wood, density of transport ways in the region, quality of haulage roads, organisation of logging, quality and size characteristics of forest resources. In current research all these characteristics, excluding the last one, are considered as organizationally managed. All managed factors, besides varying price, are taken on their present level (end of 2007).
The primary timber resource from the forest is a tree stem. For modeling of timber resources' dynamics on a certain area, profitability of producing one stem, i.e. "stem profitability" is used. Stems are differentiated by species, diameter class, height class, and quality. On the base of stem profitability, the total income of selected stock is calculated. The income can be both positive and negative.

Var_8. *Level of timber price.* Two levels are considered: Low prices – prices correspond to current demand for round wood production; High prices – prices correspond to perspective demand for round wood production.

Forest management activities include:

Var_2. *Maximum allowable cutting volume.* It is a major parameter of efficient forest use. Different ways of calculation can be used. One of the aims of this study was to search for a systematic solution for calculation of this parameter. Thus, felling volume of the experiment was considered as maximum allowable volume of annual cutting, varying on two levels: 1 – confirmed annual allowable cut (27 000 m³/year); 2 – volume is increased to 30 000 m³ per year, i.e. + 11%.

Var_3. Age of final felling. Two variants were considered: age of final felling, indicated by the norms for final felling (Osnovnye položenija… 1994). Alternative variant – decrease of the age of final felling by one age class, closer to the recommendations used in Finland.

Var_4. *Undergrowth preservation.* In case of modeling with preservation of undergrowth (in this case spruce), the number of undergrowth on a cutting area was counted. If the number of undergrowth was higher than the standard value regulated in norms, a felling with preservation of undergrowth was modeled. Otherwise, undergrowth was not preserved and measures of artificial regeneration (planting or seeding) or assisted natural regeneration were done after felling. The model assumptions were that transportation is possible all the year around and all silvicultural operations could be provided in all stands.

Var_5. *Proportion of planted stands*. Pine was planted and tending was provided 7 years after the planting. Only the area of final felling without preservation of undergrowth was included.

Var_6. *Assisted natural regeneration*. Assisted natural regeneration of coniferous species by partial soil scarification was modeled. Only the area after final felling without undergrowth preservation and without planting or seeding was considered.

Var_7. *Type of thinning*. Two systems of thinnings were modeled: according to silvicultural rules and commercial. In first the case, stands were thinned according to all requirements (Osnovnye položenija… 1993) and not considering profitability of operations. In the other case, stands were thinned only if it was profitable. It is notable that there were no limitations for thinning volume.

Two values for every variable were given (Table 2.7). The large amount of input variables emphasized the importance to plan calculations in a proper way. Experiment planning is a procedure of choosing an appropriate number of experiments and conditions essential for the task solution with a necessary precision. All the variables changed simultaneously according to certain rules. Experiment results were shown in the form of mathematical model with a certain statistical characteristics, for example, minimal dispersion of model parameters estimation. The most typical research method is one-factor experiment, when one factor is varying and others stay constant. Therefore, a significance of other factors cannot be estimated. It could lead to wrong recommendations.

If we do in this particular case full multi-factorial experiment, it would require 256 experiments ($N = 2^8$), which would be demanding to perform and analyse. The use of fractional 2**(k-p) factorial plans allows us to decrease the number of experiments significantly. In our case, there were 32 experiments which were divided into two blocks, differing by the price of timber – low and high level (var_8). Both blocks contain 7 parameters with fixation of values on min (code "-1") and max (code "1") levels (Table 2.8). For arranging and analysing of fractional factorial plans, we used software Statistic pocket Ver. 6.0. We provided 16 experiments for each block.

Table 2.8 Combination of treatments, i.e. how the study area was managed. (Values for parameters are shown in the table 2.7)

Parameter \ Experiment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Var_1. Minimal allowable income	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1	1	-1	1	-1
Var_2. Maximum allowable cutting volume	-1	-1	1	1	-1	-1	1	1	1	1	-1	-1	1	1	-1	-1
Var_3. Age of final felling	-1	-1	-1	-1	1	1	1	1	1	1	1	1	-1	-1	-1	-1
Var_4. Undergrowth preservation	1	-1	-1	1	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1
Var_5. Proportion of planted stands	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1
Var_6. Assisted natural regeneration	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1	1	1	-1	-1
Var_7. Type of thinning	-1	1	1	-1	1	-1	-1	1	1	-1	-1	1	-1	1	1	-1

Dispersion analysis was used to reveal statistically significant factors. For this purpose, the program STATISTICA 6.0 was used. The given level of significance was 95%.

2.3.4 Results

Spruce stock dynamics with low timber price level *(first block)***.** Analyses of spruce standing stock showed that for different time periods (35, 100 and 150 years), different controlling factors and models were important. Table 2.9 shows results of statistical treatment of output data after 35 years from starting the simulation for spruce stock (dependent variable). After 35 years the volume of the growing stock mostly depended on the felling volume (Var_2) and the preservation of spruce undergrowth during final felling (Var_4) – only these two parameters were statistically significant. During the next decades, spruce growing stock decreased due to past management.

Table 2.9 Results of statistical treatment (spruce growing stock,) after 35 years of modeling (on the seventh step)

	Effect	Std.Err.	t(8)	p	-95,%	+95,%
Mean/Interc.	**342095**	**3538**	**96,6874**	**0,0000**	**333936**	**350254**
(1)Var1	-9633	7076	-1,3613	0,2105	-25951	6685
(2)Var2	**-44460**	**7076**	**-6,2830**	**0,0002**	**-60778**	**-28142**
(3)Var3	-12427	7076	-1,7562	0,1171	-28746	3891
(4)Var4	**18697**	**7076**	**2,6422**	**0,0296**	**2379**	**35015**
(5)Var5	-13983	7076	-1,9760	0,0836	-30301	2335
(6)Var6	7857	7076	1,1103	0,2991	-8461	24175
(7)Var7	-13216	7076	-1,8677	0,0988	-29534	3102

Note: Mean/Interc. – The estimate of the intercept of the regression model.
Effect – Estimate effect of dependent variable's change when independent variable grows from -1 to 1.
t(8) – T – Criteria for 8 freedom degrees.
p – Input variable has statistical significance, if value $p < 0.05$.

The situation changed after 100 years simulation as more relevant became factors of undergrowth preservation (var_4) and type of thinning: silvicultural or commercial (var_7). Further situation was the same. Analysis of spruce growing stock on the last step of modeling showed that all the scenarios could be divided into three groups (Fig. 2.15). The first group included 8 scenarios with the gradually decreasing spruce stock (5–10 times lower in the end in comparison with the first step). The reason was that these scenarios include final felling without preservation of spruce undergrowth. Therefore, this resulted in an alternation of species into broadleaved or pine stands. We should remember that just pine planting was modeled. Two other groups (both have 4 scenarios) differ by a thinning system. In case of silvicultural thinning, the volume of spruce was noticeably higher than after commercial ones.

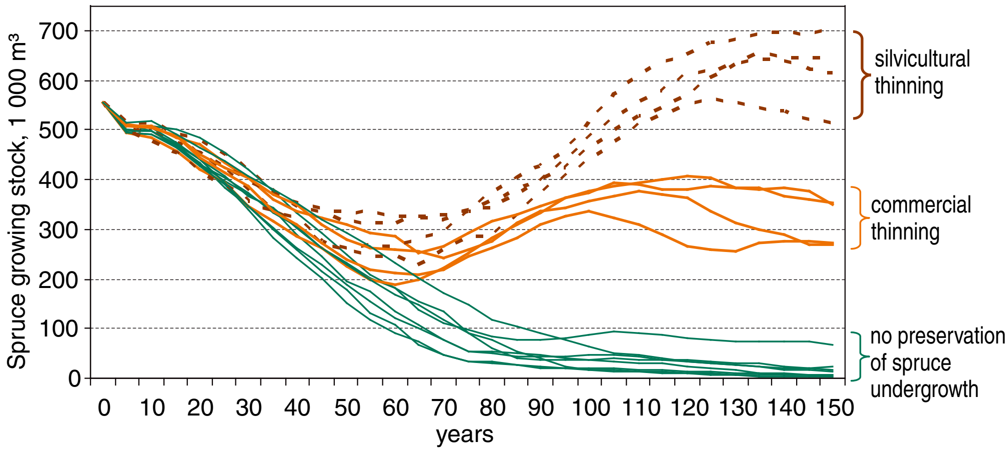

Fig. 2.15 Dynamics of spruce growing stock.

Pine stock dynamics *(low timber price)***.** Many factors influenced on pine's growing stock and depended on the period of simulation. After 35 years simulation, the stock mostly depended on felling volume, rotation age and the proportion of planted stands. The effect of the felling volume was negative «-»: the more we cut, the less was the pine stock. It is quite natural, as pine is the most profitable species on this territory. Two other factors have a positive effect «+»: increase of the factor value lead to increase of the variable's value, in our case – pine's stock.

After 100 years simulation, pine's stock was affected by age of final felling («+»), undergrowth preservation («-»), proportion of planted stands («+») and type of thinning («-»). The relevance of undergrowth preservation is explained by the increase of the area for planted pine stands after final felling without preservation of undergrowth. Thinning according to the silvicultural rules noticeably increased the proportion of pine in the stand. Such a situation lasted till the end of simulation.

Birch stock dynamics *(low timber price)***.** Birch's stock was dependent on the proportion of planted pine stands. It is quite logic as the more stands are planted, the less area is left for natural regeneration and, consequently, less area is occupied by birch stands.

Annual cut *(low timber price)***.** The principle of sustainable forest use is the basis for the strategy of forest management planning. It was formulated by professor Orlov 100 years ago. According to this principle, the volume of annual cut is set up at the level, which does not lead to decrease of cuttings in next years and meet the requirements of full use of forest resources during the rotation period. There are several different ways to estimate the allowable annual cut for final fellings. For simulation, the annual allowable cut of the forest district was 27 000 cubic meters per year.

Critics for different methods cannot be avoided, but we can examine these estimations by simulation modeling. We set up limitations for the cutting capacity. Modeling could show, if this limitation allowed achieving the principle of sustainable use in a long-term. However, the experiment demonstrated that the forest management scenario influenced on the actual cutting volume. In addition, the level of timber price had significant influence on the annual cut (Fig. 2.16).

The analysis of scenarios of the first block with the low level of timber price demonstrated that some scenarios did not fulfill the principle of long-term sustainability (6th and 12th scenarios). The logging volume started to decline after 75 years being at the lowest 4 300 cubic meters per year, which is only 20% of the annual allowable cut. On the other hand, scenario number 4 allowed to increase cutting until 30 000 cubic meters per year, following the principle of sustainability.

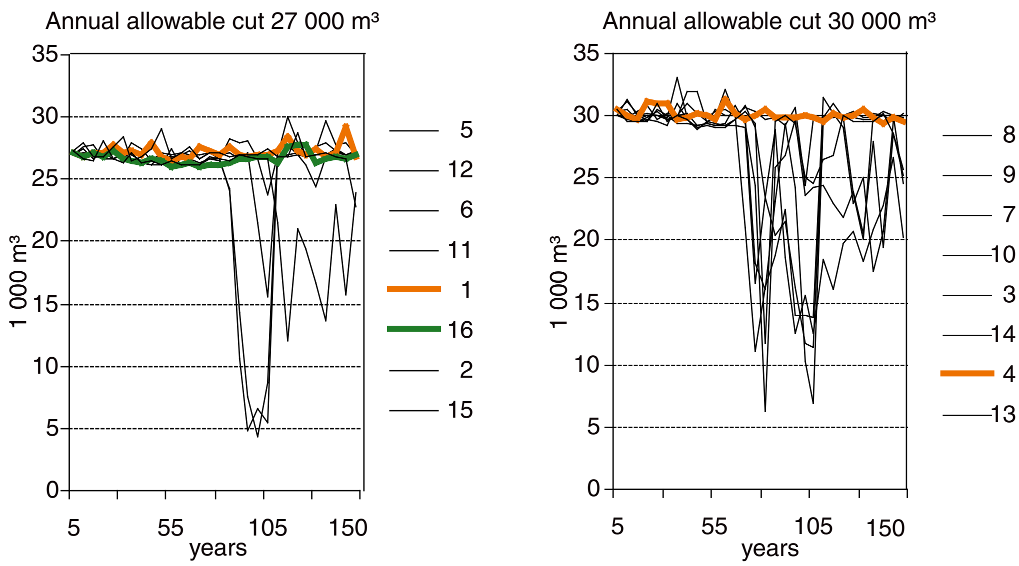

Fig. 2.16 Forest management scenarios and the principle of sustainable forestry for different levels of annual cut.

In the Lyaskelskoe forest district, problems with the available cutting area can appear already in 65–70 years. Until this time, most of the coniferous stands will be cut and artificial stands will achieve their rotation age only after 90–100 years. One of the main reasons for future decrease in fellings of coniferous stock is a significant decline of coniferous planting in the end of last and beginning of this century.

In the 4th scenario, the stability of cutting volume on a high level is probably explained by shortened rotation age, cutting with undergrowth preservation, low level of planting (30% of the felled area), and use of silvicultural type of thinning. As a result, mixed stands with domination of birch and spruce are formed. Therefore, after 70 years, birch stands are mature and spruce increases the economic result of final felling.

Involving high level of timber prices (block 2), already three scenarios (4, 13 and 14) achieved higher level of logging (30 000 m³/year). However, some scenarios did not fulfill the principle of long-term sustainability even in the lower level of logging (scenarios 6 and 12). These two scenarios had normal rotation age, final cutting without undergrowth preservation and planting on 80% of the felled area. Therefore, after 70–90 years we will have huge areas of pine stands, not reached the rotation age.

The first step was to analyse the summarized income from the harvested stands for the first block of experiment (low level of timber price) for the whole simulation period. The income was quite unstable in all the scenarios. The best scenario (8) was one and a half times better than the worst one (3). Three periods could be distinguished according to analysis of the net income dynamics: 35, 100 and 150 years from the beginning of modeling (Fig. 2.17). During the first period, the income increased in all the scenarios with maximum at 35 years. In some scenarios within the second period the incomes declined suddenly reaching the minimal level in about 100 years and in other scenarios, the income became drastically negative. During the third period (till 150 years), the net income stabilised in most of the scenarios.

In the second block, the net income scattered less (Fig. 2.18). The net income changed in the same way as in the first block: increased during 35 years, decreased till 100 years and stabilised till 150 years. In the second block, more flat scattering could be explained by the higher level of wood prices.

The next thing was to analyse the cumulative net income for chosen periods: first 35 years, up to 100 years, up to 150 years and last 25 years of modeling. Received sums were statistically analysed using the program pocket Statistica 6.0 for determination of statistically significant factors (Table 2.10).

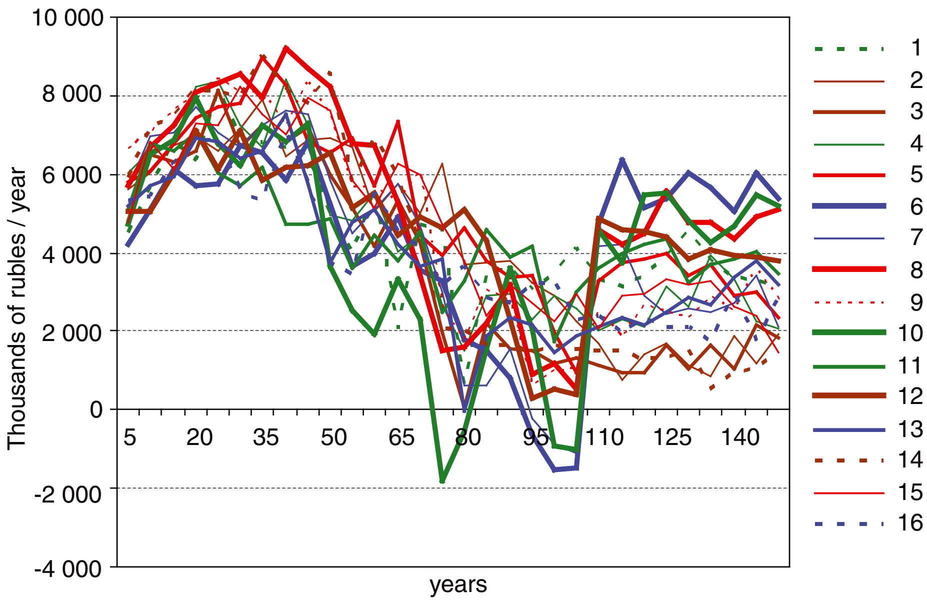

Fig. 2.17 Net income dynamics of the first block with minimal timber prices.

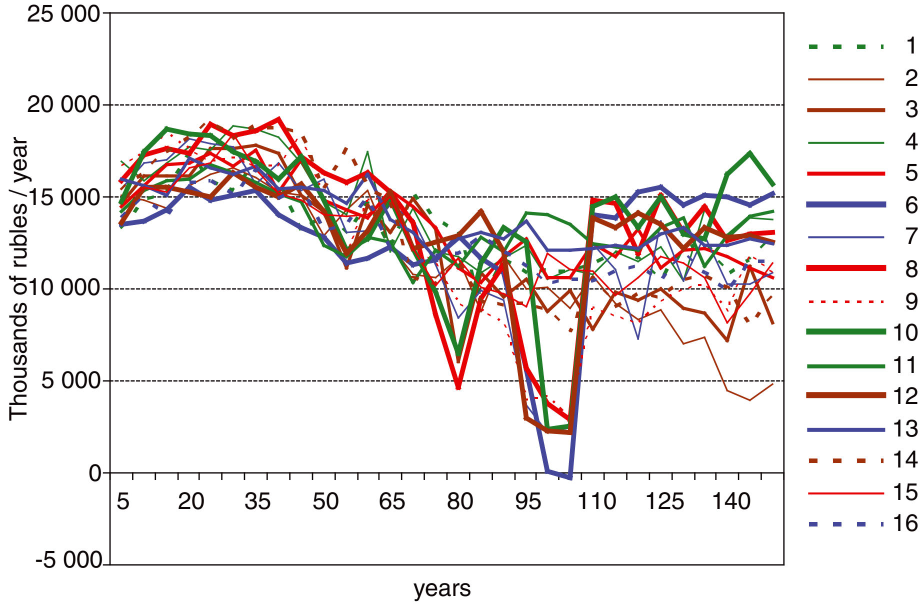

Fig. 2.18 Net income dynamics in the second block with high level of timber price.

Table 2.10 Statistically significant factors for cumulative net income for different time periods.

		Net income with low level of timber price (block 1)				Net income with high level of timber price (block 2)			
		first 35	up to 100	up to 150	last 25	first 35	up to 100	up to 150	last 25
		years							
Var_1	Minimal allowable income								
Var_2	Maximum allowable cutting volume	+				+	+		
Var_3	Age of final felling			+	+				+
Var_4	Undergrowth preservation	+		+		+	+	+	
Var_5	Proportion of planted stands	-	-		+	-			+
Var_6	Assisted natural regeneration								
Var_7	Type of thinning	+	+	+	-	+			-

In all the cases, two of seven factors were not significant, namely minimal allowable income and assistance to natural regeneration. Some factors, such as increased cutting volume, standard rotation age, and undergrowth preservation, increased the net income for certain periods.

On the contrary, the factors “Proportion of planted stands” and “Type of thinning” had both negative and positive influence for different periods. In the first periods, “Type of thinning” had a positive influence on the net income, if it was chosen as “Commercial”. It is logical, as refusal from silvicultural cuttings decreases losses and increases incomes. The same was for the factor “Proportion of planted stands”: the less planting, the higher net income we will get.

Compared to other time-periods, during the last 25 years, the influence of these factors differed a lot, when increased planting area and silvicultural thinning increased also the net income.

As described earlier, the model parameter “Age of final felling” had two values: first, a standard, recommended in Russia, and the other having one age-class lower, which is closer to recommendations used in Finland. In the first turn, the assortment structure of logged timber was analysed, as coniferous timber is the most profitable one. During the first time-period (up to 35 years), change in the age of final felling did not influence much on the assortment structure. Quite big stock of mature stands, accumulated by the present moment, allows cutting large-sized logs even in the conditions of decreased age of final felling. Analysis of the last 25 years of simulation indicates that shorter rotation age leads to a noticeable deterioration of the assortment structure. With the lower age of final felling, the most part of the logged timber would be medium-sized.

2.3.5 Net income analyse for 10 years period

According to the present practice in Russia, a forest management plan is valid 10–15 years. In this case, the decision is made based on limited information. Let us examine a scenario, which shows the maximum net income for the first 10 years of our simulation as an example (Table 2.11, Fig. 2.19).

In the first decade, from 16 scenarios of the first block (low level of timber price), 5 could be chosen as the most profitable: 9th, 14th, 7th, 4th, 8th (placed in the order of the net income decrease). The 9th was the most profitable, as it included minimal expenses for planting, assistance to natural regeneration, and felling without undergrowth preservation. However, taking into consideration the net income of the whole considered 150 years period, this scenario took only the fifth place falling behind the best one for 14%. Moreover, the net income significantly scattered from 0,6 to 8 millions rubles per year.

Table 2.11 Net incomes for the first 10 years period in different scenarios, 1 000 rubles/10 yrs.

Number of scenario	1	2	3	4	5	6	7	8
Total net income	50 979	58 366	56 430	62 937	59 461	46 452	63 233	62 142
Number of scenario	9	10	11	12	13	14	15	16
Total net income	68 441	56 343	59 393	50 502	54 364	65 598	57 890	53 928

In the second decade, these 5 scenarios formed two groups. The first included the 9th, 14th and 8th scenarios, in which the net income continued to grow. In the second group, 4th and 7th scenarios were slowly falling behind.

During the third decade, the net income kept growing in the 8th, 9th, 14th and 4th scenarios (placed according to net-income). Scenario 8 was the best, including such minimal parameters, as felling without undergrowth preservation and the minimal (30%) proportion of artificial stands. This scenario was the most profitable during the whole simulation period (150 years). However, the net income significantly fluctuated from 0,5 to 9 millions rubles per year (Fig. 2.17).

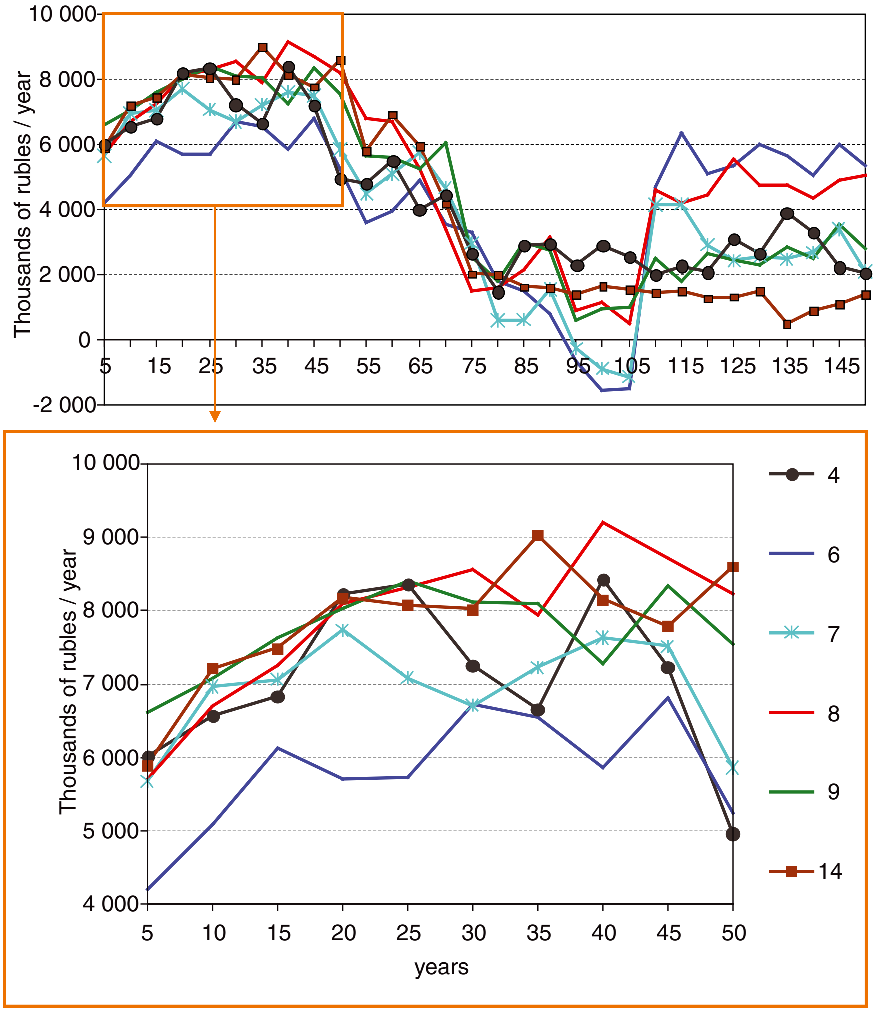

Fig. 2.19 Prognosis of net income dynamics for the first 50 years of stand exploitation.

Short-term optimization leads to the risk of losses in the future. When analysing the whole period of the 8th scenario, we can note the period of the rapid decrease in net income, lasting from the 75 to 105 years. After this, the net income value, with a little growth, became even.

It should be noted that in the long-term perspective the 14th scenario proved to be one of the least profitable, because the period of the reduction in net income starts at 35 years and continues till the end of the modeling period. Firstly, this is connected with the significant future decrease in logging volumes of large-sized coniferous timber. The short rotation age and the low planting activity led to such a difference between this and 6th (the most profitable for this period) scenario in last 25 years of simulation: 14th scenario showed six times lower volume of large-sized coniferous timber.

2.3.6 Conclusions

We consider the current work as a step towards creating an informative and analytic support system in decision-making in the forest sector. The major aim was to prepare comprehensive data for decision-makers. Our experience shows that choosing the optimal strategy of forest management depends not only on the geographical position, belonging to a certain forest vegetation zone, but also on the transportation networks, stand structure (tree species, age characteristics) and spatial heterogeneity of forest resources.

As in every optimization task, we should choose criteria for optimization and some limitations. Here the net income was considered as a criterion for optimization. For choosing the most optimal scenario, firstly, the time period should be determined. For example, by choosing a short period (10–20 years) we are risking the benefits in longer term and resulting not-profitable stands with low quality of wood (as we saw in the scenario 14). Choosing the most profitable scenario for the whole period (scenario 8), we got quite big fluctuations of net income.

According to profitability and stability, the most preferable was the scenario 15: cutting volume was on the maximal level, rotation age was short, and commercial thinnings were carried out. For the first periods, its profitability was just 15% lower than of the most profitable scenario 9 for this period. However, income analysis for the last 25 years showed that it makes up 50% less from the maximal income for the period of scenario 6 in which cutting volume was on the maximal level, rotation age was normal and silvicultural thinnings were carried out.

The current work gives just a partial answer to a question about optimization of forest management and arises even more questions than gives answers. Nevertheless, searching for the compromise between the aim to get maximum profit in a short-term and the interest of long-term sustainability is a very difficult task. As analytical tools can help to find the compromise, elaboration and implementation of the scientifically proved decision-making support systems in practice is a necessity. We realize that a competent person should make decisions. Our aim is to prepare for him/her comprehensive information, including separate conclusions of decisions, which are made today.

2.4 Towards sustainable and intensive forest management – some important topics for further development of forest management in Northwest Russia

Since the beginning of the 1990s, the Russian forest sector has been in a constant change. Although the new Forest Code came into force at the beginning of 2007, changes in forestry continue. According to the Forest Code, in the leased forest parcels responsibilities on silvicultural and forest-improvement works, including road construction, were transferred from the forest administration to forest lessees. At the federation level, the preparation and adaption of new normative documents for realization of the new Forest Code is more or less completed, but at the regional level the work is still going on. One of the main principles of the norms has been agreed sustainable forest management and conservation of biological diversity. At the same time, timber harvesting volumes are planned to increase remarkably. The new Forest Code and norms are not enough, as they provide preconditions. Critical issue is practice – implementation of norms, plans and recommendations.

Below are listed some topics and actions on forest planning, silviculture and timber harvesting, which the project experts see essential in the development of ecologically sustainable, but also effective and economically profitable forest management and timber harvesting in Northwest Russia.

Intensification of forest management in production forests

Current stage	During the Soviet era, a common practice in forest utilisation was to cut large forest sites by concentrated clear-fellings with insufficient investments in silviculture and infrastructure, and then to move to new virgin forest areas. This practice has continued in a large extent until nowadays.
Recommendation	To intensify forest management operations to obtain the intended volume and quantity of forest products (usually timber-assortments) by sustainable and economically effective methods from a smaller area.
Justification	Implementation of intensive methods of forest regeneration, tending of sapling stands, thinning, drainage, fertilization and final cutting in the area of developed forest-road network can remarkably increase the removals of intended timber-assortments per hectare, improve the profitability of forest-growing and timber harvesting, and decrease the total area needed for commercial cuttings, meaning savings in timber-transport costs, but also the conservation of forest territories undisturbed by human development. Although the advantages of intensification become apparent only after decades, strategically intensive forms of sustainable forest management have no alternatives in Northwest Russia.

Objective of timber-production

Current stage	It is not clearly defined, if the objective of forest-growing is to produce high-quality, large-diameter logs or pulpwood. Looking at the current Russian forest management practice, the cutting cycle is long and referring to the production of logs. On the other hand, a thinning system consists of a small number or no thinning, referring to the production of pulpwood.
Recommendation	Depending on a forest owner's or user's aims, the objective of timber-production should be clearly defined in the stage of forest management planning.
Justification	For planning and implementing target-oriented silvicultural and timber-harvesting operations, the objective of timber-production should be known to get the maximum volume of intended timber-assortments.

Update of forest management plans

Current stage	In 2003, in Russia 52% and in Northwest Russia 38% of forest management plans were older than 10 years (Potapov 2003).
Recommendation	The cycle of forest management plans should be shortened for 10 years maximum. Moreover, the forest inventory and planning system needs technical and methodical upgrading.
Justification	Outdated forest management plans do not allow providing the sufficient evaluation of validity of resources and to plan silvicultural and harvesting operations at the strategic, planning and operational levels. The simulation of stand dynamics and alternative management operations of a forest area and the choice of an alternative fulfilling best forest user's aims would allow solving the task of the management system selection, cutting age optimization and forest-use scale as a triune.

Economic evaluation of forest management practices

Current stage	Current forest management plans miss the procedure of evaluation of the economic efficiency of forest management measures
Recommendation	In developing a forest management planning system, forecasting the influence of different silvicultural operations (e.g. regeneration, tending of sapling stands, thinning, fertilisation, drainage) on growth and yield, timber-harvesting volumes and assortments and the economic profitability of forest-growing should be included.
Justification	A forest user should know the economic efficiency of proposed silvicultural and harvesting operations and be able to choose the appropriate development alternative based also on the economic factors. The net profit, as the difference between the income from wood selling in final and intermediate cuttings and the expenses (wood price, forest regeneration, cleaning in saplings, harvesting and transportation costs, other costs), in any of its three forms (integral, cumulative, current dynamics), is an absolute criterion for forest management effectiveness. Economic evaluation could also facilitate investments in silvicultural measures and improvement of forest-road network.

Level of forest regeneration in Northwest Russia

Current stage	In most of the regions, the annual clear-cutting area exceeds the forest regeneration area by 20–30%.
Recommendation	The obligations of forest regeneration should be more strictly controlled; the importance of qualified forest regeneration should be highly recognized in forest policy, forest legislation and in forest management in practice.
Justification	Neglecting on-time, qualified regeneration of the whole clearcut area prolongs a regeneration period, weakens the composition of stands and timber-assortment structure and threatens the availability of quality raw timber for timber-processing industry in the future.

Methods of forest regeneration

Current stage	Large proportion of natural regeneration without human intervention (19%) [1] in Northwest Russia.
Recommendation	The proportion of non-assisted natural regeneration should be minimised, the proportion of artificial regeneration should be increased in appropriate forest types especially in the southern and middle-taiga zones.
Justification	Non-assisted natural regeneration is the most inefficient method; artificial regeneration enable to reduce a regeneration period, growing of intended tree species (usually coniferous) and quicker receive intended timber-assortments.

[1] Recommended method by forest management planning for regeneration of clear cuts. Source: Federal'noe agentstvo… 2008b.

Low level of thinnings

Current stage	In Northwest Russia, thinnings cover 9% [1] of the total timber-harvesting volume, in Finland – 45% [2] in 2006.
Recommendation	To increase thinning volumes under intensive forms of forest management till 20% by 2015.
Justification	Thinnings can foreshorten a cutting cycle and increase the total volume of harvested sawlogs and income from timber-harvesting in the circumstances of market demand for pulpwood from thinnings, moderate short-haul and long-haul transport distances and developed forest-road network.

[1] Source: Federal'noe agentstvo… 2007. Incl. tending of sapling stands, thinning in middle-aged (*proreživanie*) and maturing stands (*prohodnaja rubka*), reneval and reformation felling (*rubki obnovlenija i pereformirovanija*) and selective-sanitary felling (*vyboročnye sanitarnye rubki*)

[2] Source: Finnish Forest… 2007. Rough estimation. Used harvesting outturns: First commercial thinning – 40 m^3 ha^{-1}, other commercial thinnings – 80 m^3 ha^{-1}

Forest road network

Current stage	Lack of developed forest-road network is one of the most crucial bottlenecks in developing economically sustainable forestry and timber-harvesting.
Recommendation	The State should subsidise and coordinate activities of all interested administrations and organisations in developing a forest-road network to support the development of the forest sector and the rational use of financial resources. Besides, instructions, training and education on forest-road construction should be revised soundly.
Justification	Investments to forest-road construction would essentially assist in implementing silvicultural and timber-harvesting operations and intensifying forest management in the range of road network and thus reduce the pressure to cut ecologically valuable forest areas elsewhere. Besides, forest roads would also support multiple-use of forests, including harvesting and collecting non-wood forest products, recreation, hunting, etc.

Conservation of biological diversity and valuable key habitats in production forests

Current stage	In typical forest management planning and forest use, ecological values of forests are enough not taken into account. However, in pilot areas (e.g. Pskov Model Forest project, Segezha Pulp and Paper Mill in the Republic of Karelia), new concepts and instructions have been developed for safeguarding biological diversity in practical forest management.
Recommendation	Delineation of ecologically valuable habitats in forest planning and their conservation in practical forestry should become a common practice in Russian forest management.
Justification	Despite the large territories of especially protected nature areas in Russia (10% of the land area), safeguarding biological diversity also in production forests is essential from the viewpoint of ecology, but also to fulfill the requirements of international forestry and environmental agreements, forest certification schemes and growing demands of environmentally-aware end-users of forest products.

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Appendix 2.1 Characteristics of the Forest fund lands in Northwest Russia (Lesnoj fond… 2003).

Regions	Area of Forest fund lands, thousand ha		Forest vegetation, % of the total	Percentage of forest land, %	Growing stock, mill. m^3
	Total	Lands with forest vegetation			
Arkhangelsk region	29 094	22 337	77	54	2 504
Nenecky AD	447	190	42	1	18
Vologda region	11 653	10 095	87	70	1 602
Murmansk region	10 048	5 359	53	37	231
Karelia republic	14 908	9 486	64	53	946
Komi republic	38 901	30 184	78	72	2 966
Leningrad region	5 898	4 667	79	56	825
Novgorod region	4 112	3 507	85	64	614
Pskov region	2 467	2 122	86	38	342
Total for the region	117 528	87 947	75	53	10 049

Appendix 2.2 Main changes in administration and in regulatory basis of forest industry and forest management in 1917–2006.

Year	Central forest industry governing bodies	Central forest management governing bodies	Basic regulatory acts
1917		Forest Department of People's Commissariat of Agriculture of RSFSR	
1918	Main Committee of Forest Policy and Woodworking Industry (Glavles)	Central Forest Administration (CLU) in the structure of People's Commissariat of Agriculture	Decree of State property on forests Temporary forest management statute Fundamental Forest Law
1919	Glavtop of Supreme Council of National Economy (VSNH)		
1922		Forestry Administration and Inter-agency Harvesting Committee (Harvesting Fund) attached to People's Commissariat of Agriculture	
1923		Forest Administration of People's Commissariat of Agriculture of RSFSR	Forest Code of RSFSR
1929	Glavlesprom (Main Administration of Forest Industry) of VSNH		Statute of Soviet Forestry Ordinance of Labor and Defense Council from Aug 29, 1929 "About the long-term development plan on forestry and forest industry in the USSR for 1929–1932"
1930	All-Union Forest Industry Association (Sojuzlesprom)	Forest Administration of the Supreme Council of National Economy (VSNH of RSFSR)	
1931		Main Administration of Forestry in the structure of People's Commissariat of Agriculture of the USSR (Glavleskhoz)	
1932	People's Commissariat of Forest I ndustry of the USSR		
1936		Main Administration of Forest Protection and Reforestation attached to People's Commissars Council of the USSR (Glavlesookhrana)	
1947	Ministry of Forest Industry of the USSR (1947–1992)	Ministry of Forestry of the RSFSR	

Appendix 2.2 Continue.

Year	Central forest industry governing bodies	Central forest management governing bodies	Basic regulatory acts
1953		Main Administration of Forestry and Field-protective Forestation in the structure of Ministry of Agriculture and Procurement of RSFSR	
1959		Main Administration of Forestry and Forest Protection attached to Council of Ministers of RSFSR (Glavleskhoz RSFSR))	Forestry and forest industry were united in the structure of Sovnarkhozes.
1965		Ministry of Forestry of RSFSR Union-Republic State Forestry Committee of Council of Ministers of the USSR (Gosleskhoz)	
1977			Basis of the forest legislation of the USSR and Soviet Republics
1978			Forest Code of RSFSR
1988		State Forest Committee of the USSR (Goskomles)	Complex forest enterprises in the structure of forest industry were organized (and got the power over Forest Fund)
1992	Forest industry was privatized	Ministry of Agriculture of the Russian Federation Forest Committee in the structure of Ministry of Nature	
1993		Federal Forestry Service of Russia (Rosleskhoz)	Basis of the forest legislation of the Russian Federation
1997			Forest Code of the Russian Federation
2000		Federal Forestry Agency of Ministry of Natural Resources of Russia	
2006			Forest Code of the Russian Federation

3 Improvement of wood harvesting in Northwest Russia

3.1 Development in wood procurement

Project publications “Development in wood harvesting and procurement in Northwest Russia” (Gerasimov et al. 2007) and “Northwest Russian forestry in a nutshell” (Karvinen et. al 2006) provides overall analyses of development in wood harvesting in Northwest Russia. Wood harvesting dropped in the 1990s from 82 to 40 million m^3 per year, and in 2000-2006 it was characterized by relative stability (Fig. 3.1). There are five dominating regions from wood harvesting point of view: Arkhangelsk and Vologda regions harvest about 10 million m^3; the Republic of Komi, the Republic of Karelia and Leningrad region about 7 million m^3.

The annual allowable cut has been used incompletely, approximately 45% in case of all species and 60% in case of coniferous. Utilization of annual allowable cut is highest in the Republic of Karelia, 75%. Moreover Karelia has the strongest forest sector in the regional economy. Therefore, Karelia has been examined closer in the study.

Most of the round wood is produced by large (more than 250 employees) and medium (100-250 employees) sized companies which remained and have been privatized since planned economy. For example in Karelia, 84% of the wood volume is harvested by large and medium sized companies. Twenty biggest companies logged 4.1 million m^3 or 66% of the total wood harvesting in 2005. Approximately 85% of the logging companies are private.

The importance of small (less than 100 employees) enterprises has been growing in Northwest Russia (Figures 3.2 and 3.3). Number of small enterprises has grown especially in Leningrad region. Easy access to forest resources through auctions was one of the reasons for the increasing number of small enterprises in 2002-2005. But this may change due to new policy in providing forest resources for use.

According to the 1997 Forest Code, forest resources were rented for short period up to 5 years or for a longer time from 5 to 49 years through open competition or regional authority’s decision. Moreover, logging permissions were obtained for short-term forest usage (1 year) by auction or by regional authority’s decision.

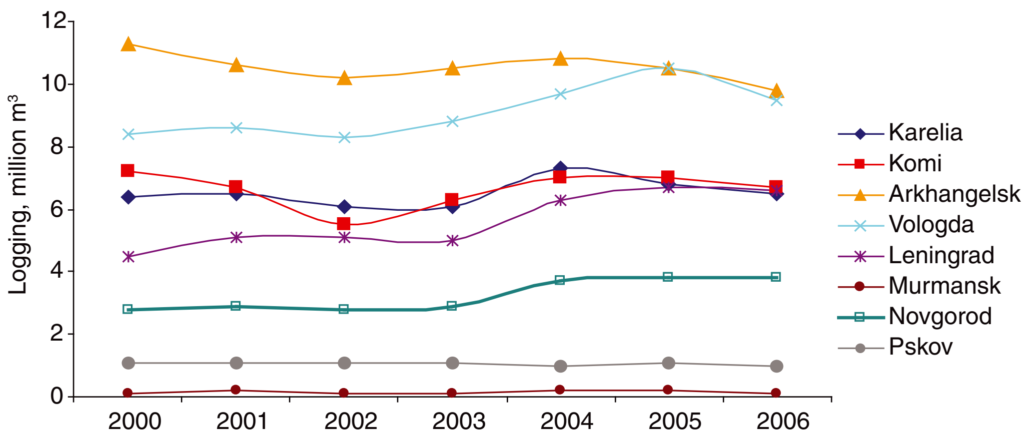


Fig. 3.1 Development of round wood removals in Northwest Russia in 2000-2006.

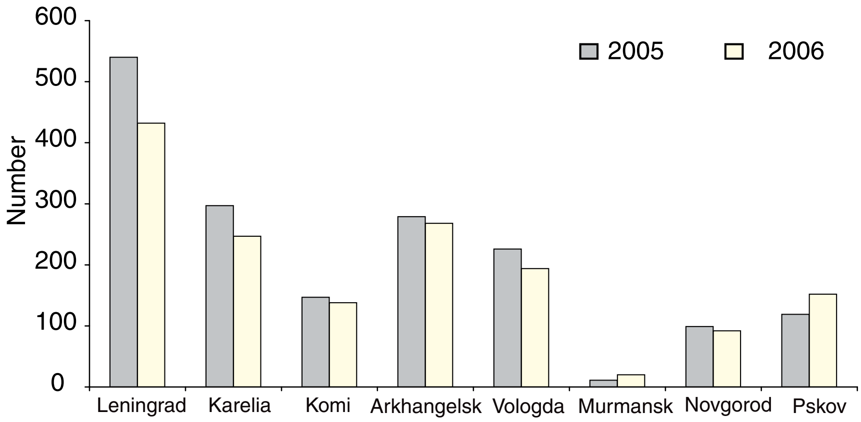


Fig. 3.2 Number of small sized enterprises in Northwest Russia.

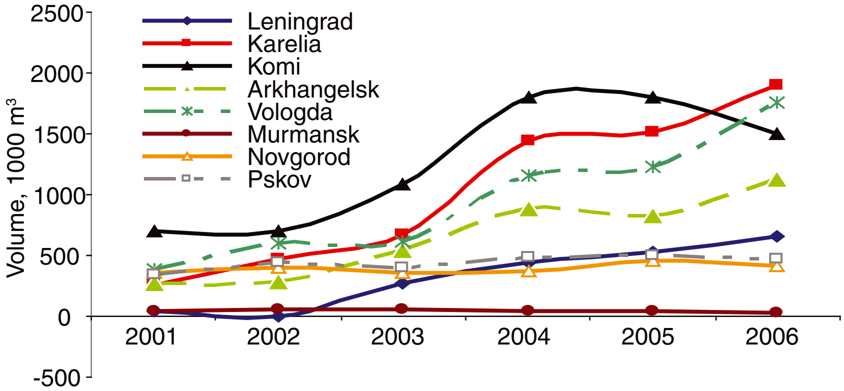


Fig. 3.3 Development of wood harvesting by small sized enterprises in Northwest Russia in 2001-2005.

Most of the surveyed logging companies in Karelia have now contracts for long-term forest lease (25 or 49 years). Short-term forest use dominated before 1998. During 1999-2003 the longer period for 5 years became more common and 24-49 years in the 2003 edition of Forest Code (Figure 3.4). According to the current 2006 Forest Code forest areas can be leased up to 49 years by auctions only.

Logging companies had nearly 40 million ha forests in lease and 47 million m^3 of annual allowable cut in 2006, which was approximately 50% of the total annual allowable cut in Northwest Russia. In the Leningrad region and Karelia approximately 80% of forests have been leased (Figure 3.5). The actual cut in the leased forests was 34 million m^3, or 39% of the allowable cut in Northwest Russia in 2006. However, the use of annual allowable cut of leased forests in Karelia, Leningrad and Vologda was as high as 60%.

Harvested wood is delivered according to advance concluded contracts to domestic pulp and paper mills, sawmills etc or exported. Round wood export has been increasing over the years from Northwest Russia (Figure 3.6), and according to the Russian official statistics, it was 18.8 million m^3 in 2005. Round wood export has supported high wood prices in the domestic market and has benefited logging companies.

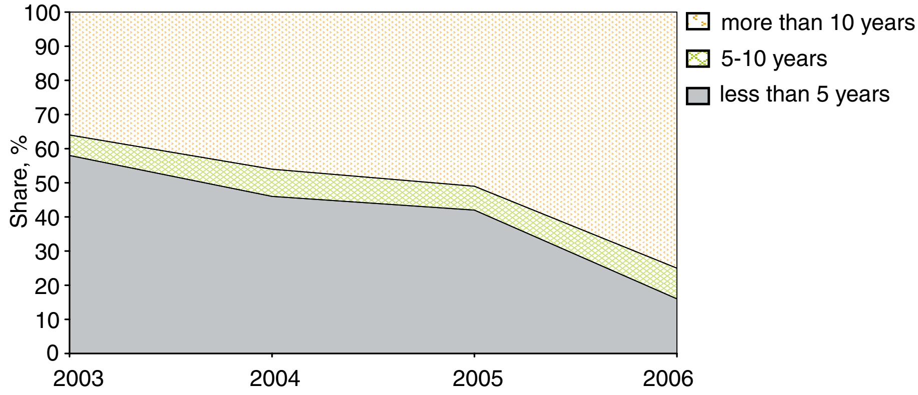


Fig. 3.4 Development of lease term in Russia.

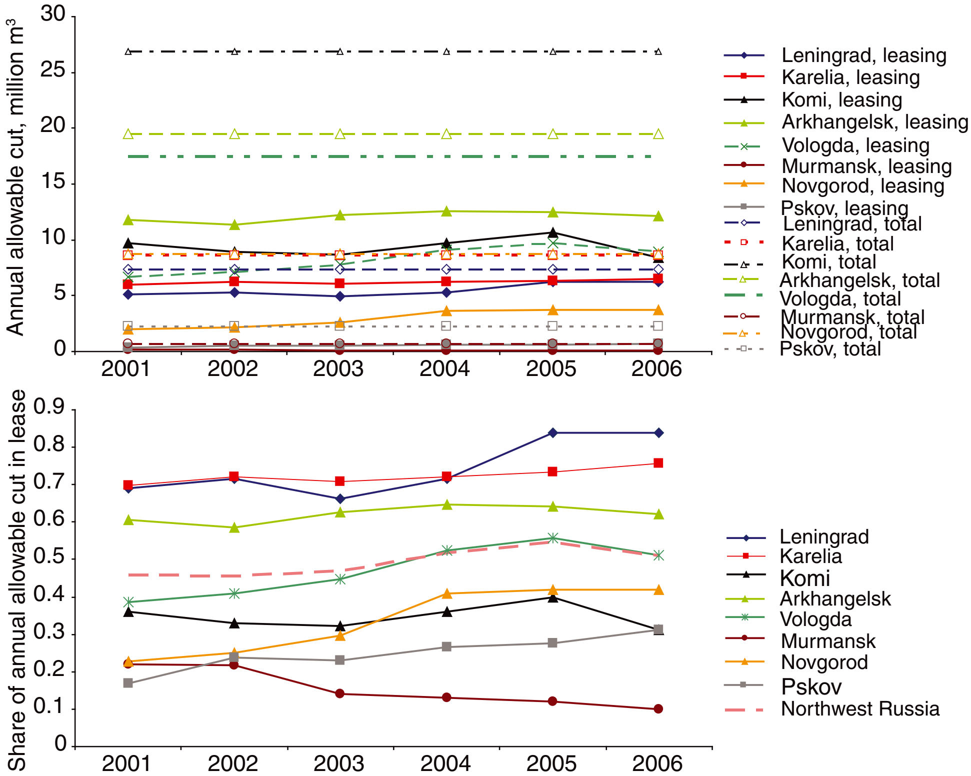


Fig. 3.5 Development of forest lease in Northwest Russia in 2001-2006.

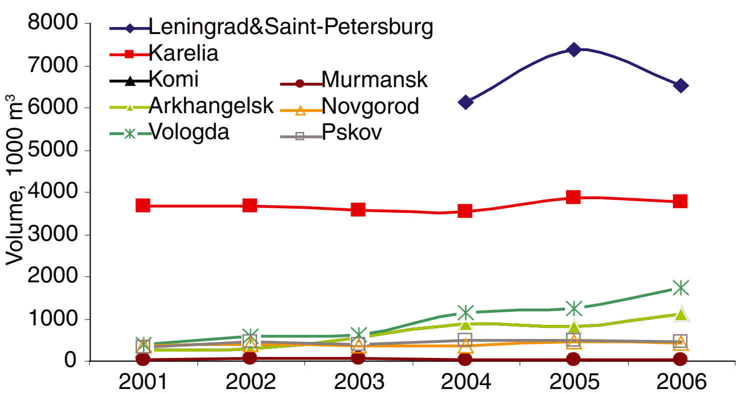


Fig. 3.6 Development of round wood export in Northwest Russia.

Introduction of increasing custom duties for round wood in July 2007 has double meaning. On the one hand, the development of wood processing in Russia is supported by the Russian government and society. But on the other hand, logging companies are suffering from price dumping by domestic pulp and paper mills and lack of birch and aspen processing industry. Wood harvesting and thus round wood export has employed numerous people (Table 3.1). If domestic demand would not compensate round wood export, harvesting volumes would drop and less labour would be needed. Especially Karelia, Leningrad and Vologda regions may experience unemployment.

One of the challenges in wood procurement is forest road construction. The road network density in Northwest Russia is poor varying from 1.2 km/1000 ha in Komi to 11.6 km/1000 ha in Pskov (Figure 3.7) compared to average 12.3 km/1000 ha in Finland. The reasons for this are high costs of road construction and limited financial possibilities of forest leasers to build roads. Moreover, half of the forests have low bearing capacity. At least in near future these forest areas will continue to be harvested during winter season by temporary winter roads. Lack of infrastructure prevents efficient introduction of cut-to-length technology and intensive forest management.

Another challenge is low utilization of thinnings. Approximately 4.5 million m^3 or 12% of the total actual cut in Northwest Russia has been obtained from thinning operations in 2005 (Figure 3.8). Reasons for this are poor road network, lack of appropriate technology and lack of intensive forest management traditions and norms.

Table 3.1 Number of employees involved in logging operations and round wood export in 2005.

Region	Actual cut (without thinnings) in 2005, mill. m^3	Industrial round wood in 2005, mill. m^3	Average number of logging employees in 2005	Labor needs for 1 mill. m^3 of industrial round wood	Industrial round wood export in 2005, mill. m^3	Number of logging employees involved in export
Republic of Karelia	5.9	5.8	12694	2189	3.885	8503
Republic of Komi	6.5	5.1	12723	2495	0.007	17
Arkhangelsk region	10.6	9.6	21308	2220	0.06	133
Vologda region	10.3	6.3	16275	2583	2.52	6510
Kaliningrad region	0.2	0.3	402	1340	0.233	312
Leningrad region	5.5	3.9	19870	5095	1.202	6124
Murmansk region	0.1	0.1	230	2300	0.054	124
Novgorod region	3.4	1.8	1937	1076	1.89	2034
Pskov region	1.1	0.6	1526	2543	0.821	2088
Northwest Russia totally	43.6	33.5	86965	2596	10.672	27707
To Finland				2596	18	46727

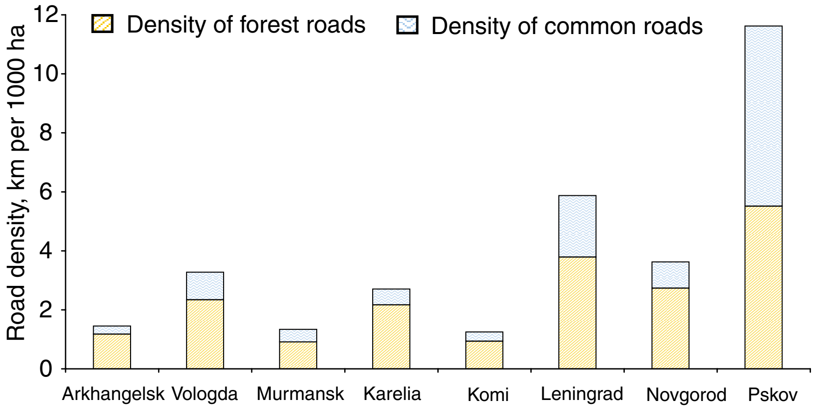


Fig. 3.7 Density of road network, km/1000 ha.

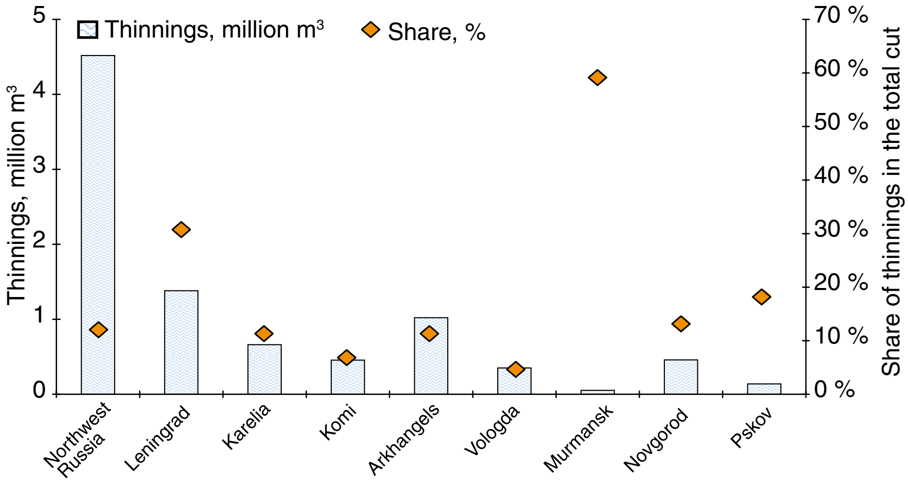


Fig. 3.8 Thinnings in 2005.

3.1.1 Analysis of logging companies in the Republic of Karelia

Logging companies in the Republic of Karelia have been analyzed in the project publication "An analysis of logging companies in the Republic of Karelia" (Gerasimov et al. 2005). Wood harvesting is concentrated into large and medium sized logging companies (Figure 3.9). The 10 largest logging companies with an annual cut of more than 200 000 m^3 (Zapkarelles, Pudozhsky LPH, Muezersky LPH, Shujales, Ladenso, Olonetsles, Piaozersky LPH, Volomsky KLPH, Medvezhegorsky LPH, and Ledmozerskoe LZH) are logging 60% of the annual volume in Karelia.

After the collapse of the USSR, all 30 large and medium sized state logging companies were privatized. Four companies were transferred into close companies, 19 as public companies, and 7 as companies with limited liability. These companies still play a key role in Karelia; as their share is 85% of the total logging. Companies have own visions how to develop wood harvesting, and since the 1990s they have developed significantly in order to adopt to the new business environment. Economic, social and ecological pressures have forced logging companies to adopt latest technology, machinery, and management.

Data were collected on the current state of the logging companies for analysing how new bussiness environment, economic, social and ecological pressures have forced logging companies to up-date their technology, machinery and management. Students from the Petrozavodsk State University interviewed logging companies in Karelia in 2004. Based on the geographical location of the individual companies, their data were integrated into East (Pudozhsky district), West (Suoyarvsky district), Northwest (Myezersky district), and Northeast (Kondopozhsky district) cluster (Figure 3.10). There were two to three companies in each cluster.

Most of the surveyed logging companies used long-term lease (25 or 49 years) as a method for receiving logging permissions and had approximately 3.4 million ha forests in lease, which was approximately 30% of the total lease area in Karelia (Figure 3.11). The share of the third-group forests was 90-95% of the leased forests in the Northwest, East and West clusters, the rest of the forests belonged to the first-group (Figure 3.12). Only the Northeast cluster had all types of forests.

The distribution of stands by age was quite similar for all clusters (Figure 3.13). Although young and advanced seedling stands dominated (40-50%),.the share of mature and over mature stands was quite high (20-35%) but small for young thinning stands (8-10%) and advanced thinning stands (3-10%). The best situation was in the Northeast cluster which had even age class distribution. Situation was worse in the Northwest cluster, which had only 3% advanced thinning stands. Pine stands dominated in the Northwest, West and Northeast clusters (up to 73%), while spruce was the main species in the East cluster (47%) (Figure 3.14). The share of birch was high in the East and Northeast clusters (up to 20%). The share of aspen was very low, except in the East cluster (3%).

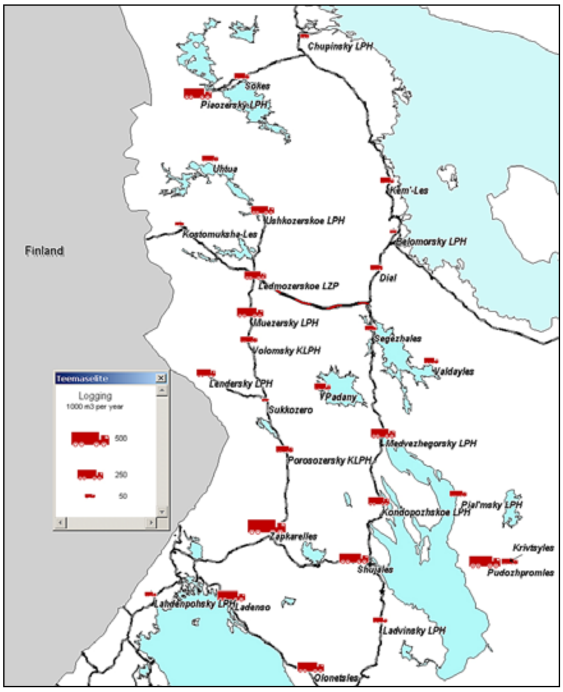


Fig. 3.9 Key logging companies in Karelia.

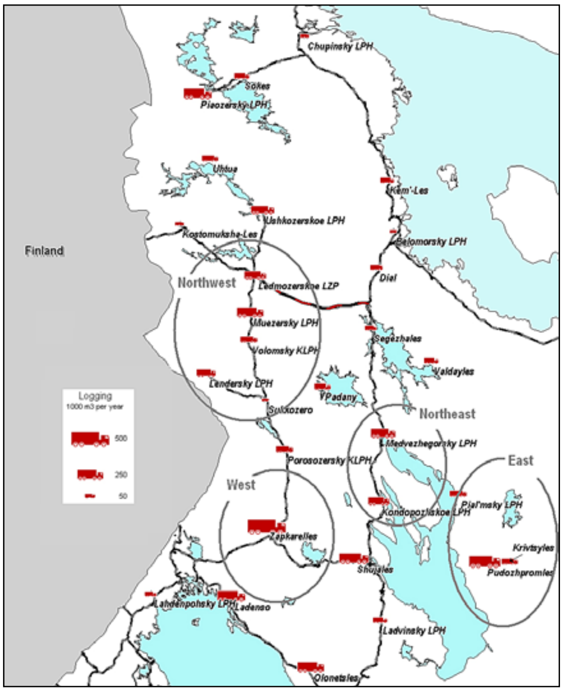


Fig. 3.10 The survey areas of logging companies in Karelia.

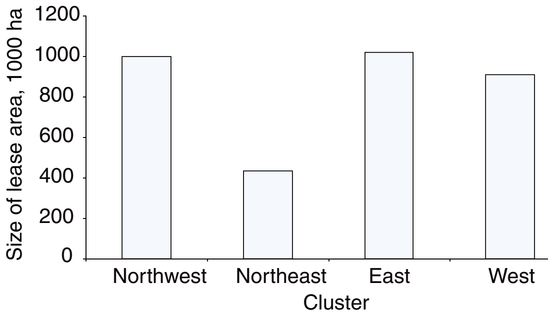


Fig. 3.11 Size of leased forest areas in 2003.

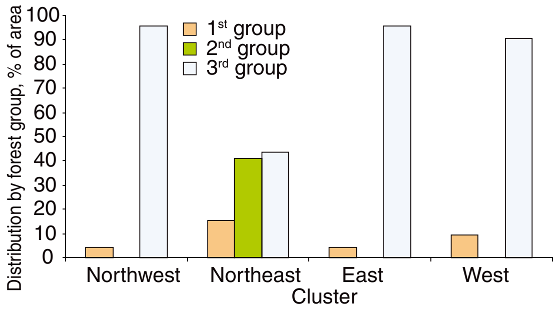


Fig. 3.12 Distribution of leased forests by groups according to area in 2003.

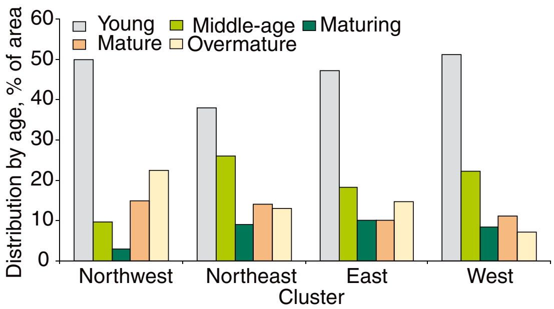


Fig. 3.13 Age class distribution of leased stands in 2003.

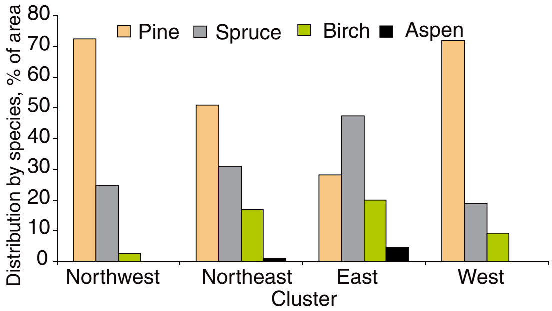


Fig. 3.14 Species distribution of leased stands in 2003.

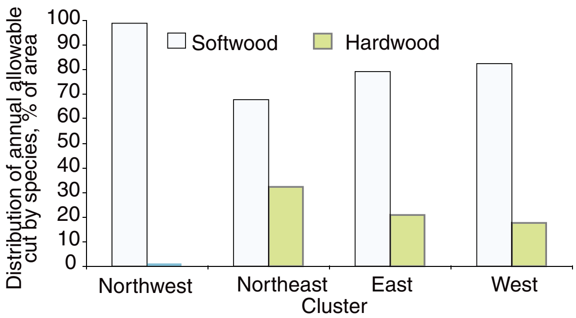


Fig. 3.15 Species distribution of the allowable annual cut in 2003.

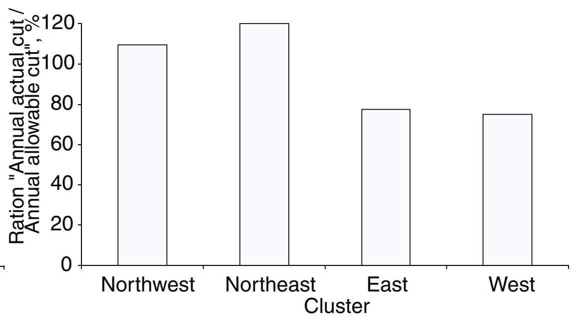


Fig. 3.16 Utilisation of the allowable annual cut in 2003.

The allowable annual cut is separately determined by the Federal Forest Agency for each group of species (coniferous, soft-deciduous and hard-deciduous), within the limits of the forest groups, arising from the principles of sustainable use of the forests. It is determined for final fellings. Coniferous species dominate the allowable annual cut in all clusters (Figure 3.15). The utilization of the allowable annual cut in the East and the West clusters was quite high, approximately 80% (23% is an average in Russia) (Figure 3.16). The Northwest and the Northeast clusters did not have enough leased forests, and used therefore additional cutting areas for a short-term forest use (utilization of annual allowable cut exceeded 100%).

The composition of assortments from the actual cut varied in the clusters (Figure 3.17):

- coniferous saw logs 30-45%
- coniferous pulpwood 25-35%
- decideous pulpwood 5-25%
- deciduous saw logs less than 1%; this may be due to poor quality of aspen sawlogs and that there is no industry for this
- firewood 10-17%

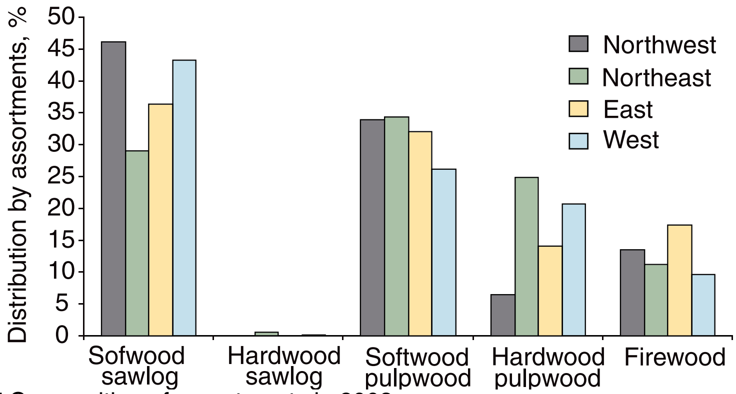


Fig. 3.17 Composition of assortments in 2003.

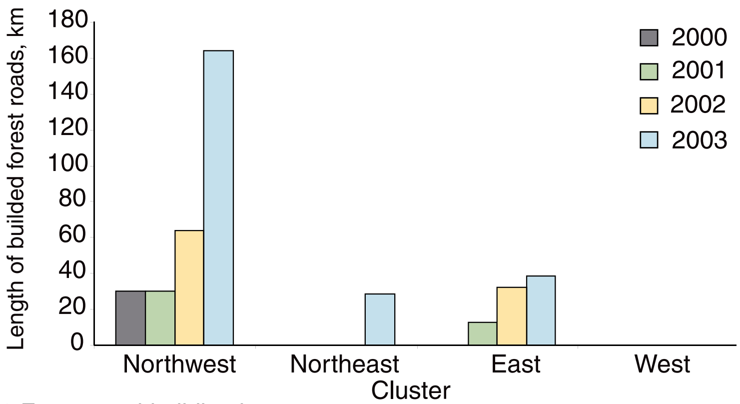


Fig. 3.18 Forest road-building in 2000-2003.

All clusters had low output of coniferous saw logs, especially the Northeast cluster, only 27% due to high demand of coniferous pulpwood from nearby Kondopoga and Segezha pulp and paper mills. The East cluster had 17% firewood output, which is high compared to 8-13% average in Northwest Russia.

The current situation in road-building is limiting economic accessibility of forest resources in Karelia (Figure 3.18). Logging companies in the Northwest cluster have made investments in the road construction during the last years only because of implementation of cut-to-length method.

Natural and artificial (sowing and planting) regeneration methods are used in forest regeneration according to the norm "Basic instructions for forest regeneration in the Russian Federation". Natural regeneration was the most common method in the East cluster, while artificial regeneration was the main method in the Northwest and Northeast clusters (Figure 3.19). Sowing was dominating in artificial regeneration, except in the Northwest cluster (Figure 3.20).

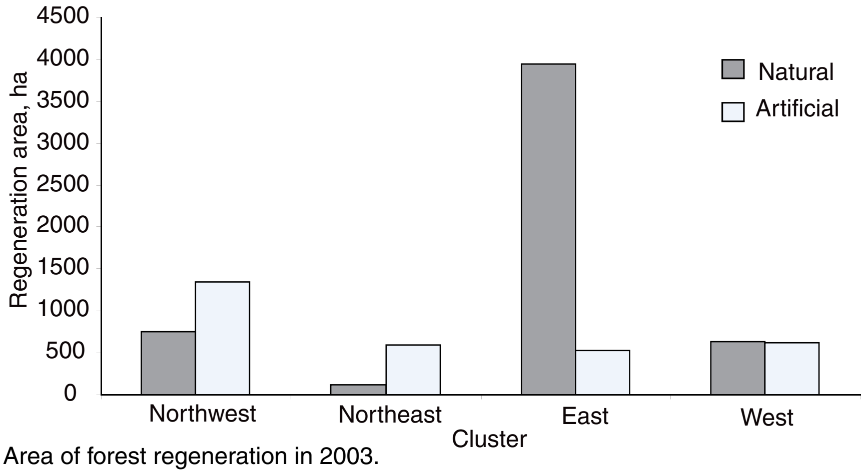


Fig. 3.19 Area of forest regeneration in 2003.

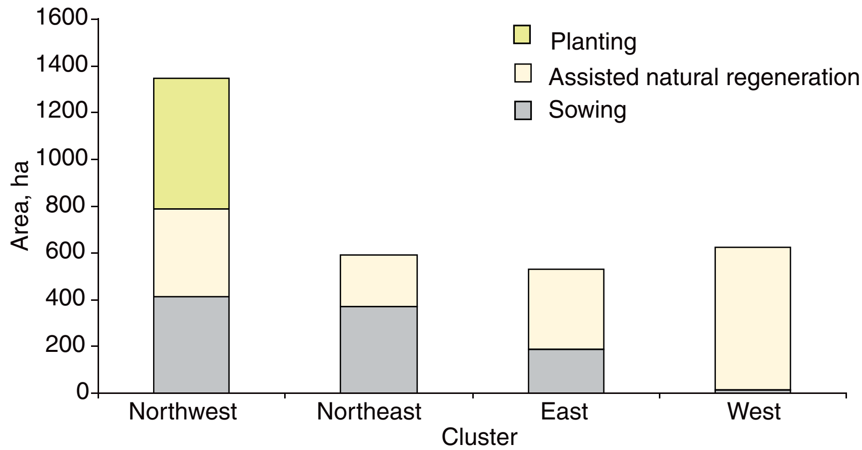


Fig. 3.20 Forest regeneration by artificial methods in 2003.

The average transportation distance from a cutting area to a lower landing (traditional technology) or to a customer (or to a railway/water terminal for further long distance transport) varied from 33 to 45 km (Figure 3.21). The East cluster had the shortest average transportation distance due to close location of forest resources, situation was vice versa in the Northwest cluster.

The productivity of labor varied because the logging companies used different wood harvesting technologies and machinery. The West cluster had the lowest productivity of 550 m^3/man, because they used traditional tree-length technology and Russian machinery (Figures 3.22 and 3.23). Productivity was calculated as the ratio of the company's logging (m^3 u. b.) to the average number of logging workers (in the forest, in the lower landing, in wood transportation) in 2003. On the other hand, the Northeast cluster, where logging companies used the Nordic cut-to-length method or western machinery for the traditional method, productivity was twofold, 1350 m^3/man. The rest of the clusters, which used mixed cutting methods and machinery, had intermediate productivity.

The surveyed companies varied in size from 150 to 2500 persons with an average of 790 employees. Logging companies had problems in recruiting logging workers, and have used workers from Ukraine, Moldova etc. However, the share of local workers was more than 90%.

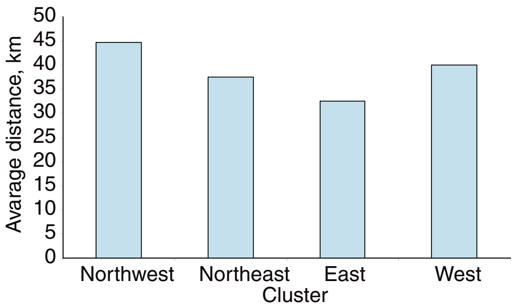


Fig. 3.21 Average distance for transportation of wood in 2003.

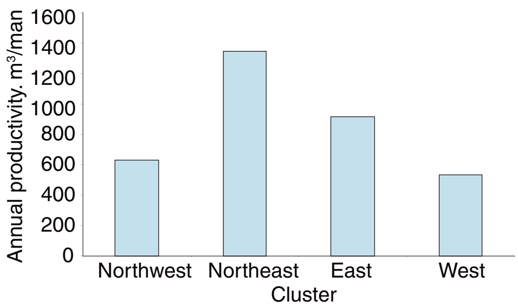


Fig. 3.22 Annual productivity of logging workers, m^3 u. b. of cut in 2003.

Managers had university degrees, foremen university or college degrees, and workers special or a general secondary education. The current change in the cutting method places new demands on the employees and their education. Companies implementing cut-to-length method spent 300-770 RUR per employee for training in 2003, while companies using the traditional tree-length method only 17-180 RUR per employee.

Logging companies in the Republic of Karelia during the USSR era had developed instructions which controlled procedures and monitored work safety, and companies continue to follow them based on current legislation. According to work safety statistics from 2001-2003 in the Northwest cluster, the most common reasons for accidents (Figures 3.24 and 3.25) were carelessness, neglect of work safety instructions and technological processes. The total number of accidents was 43 (no fatal accidents, i.e. nobody died) in 2001, 43 (1 fatal accident) in 2002, and 42 (2 fatal accidents) in 2003. The accident rate is higher than the average for logging in Russia, which equals 20 accidents (0.5 fatal accidents) per 1000 employees.

The goal of the current work safety system is to prevent accidents and sickness by improving working conditions at the workplace, protective equipment, work discipline etc. The logging companies' support for work safety actions varied from 550 RUR/employee to 2 750 RUR/employee, with average 940 RUR per employee in 2003.

All companies have been deeply involved in local community activities and in the development of the districts. Taxes allocated to the local budget contribute to local welfare. Moreover, the forest lease contracts include also obligations to community, such as

- forest and municipal road construction and maintenance
- fuel wood supply for local community
- support for local schools
- support for local hospitals
- support for pensioners
- support for social development programs initiated by the local administrations
- scholarships for local university students

Contribution of the logging companies to local community support varies widely and was 0.03-0.8% of the annual turnover in the investigated companies.

The latest forest inventory with the necessary ecological expert assessment was conducted in 1994 in West and North East clusters, in 1998-1999 in North West cluster, and in 2003 in East cluster. These corresponded to current forest legislations. Environmental expenses varied from 0 to 0.045% of the annual turnover. Logging companies did not highlight any specific relationships with state leskhozes and non-governmental organizations.

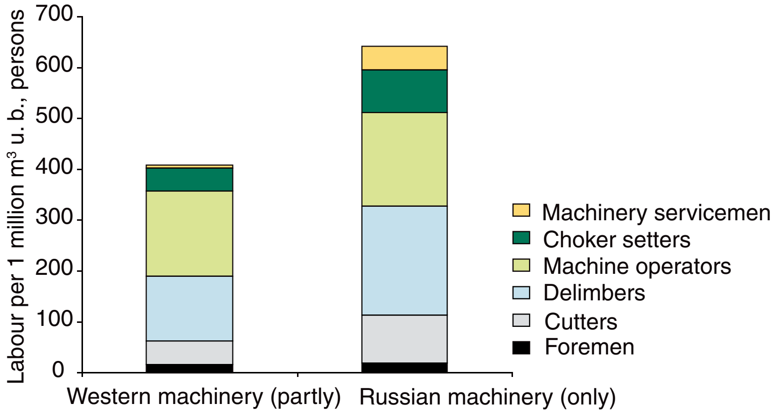


Fig. 3.23 Labour needs for 1 mill m^3 u. b. of the annual cut by the tree-length method, using both Russian and western machinery, and only Russian machinery in 2003.

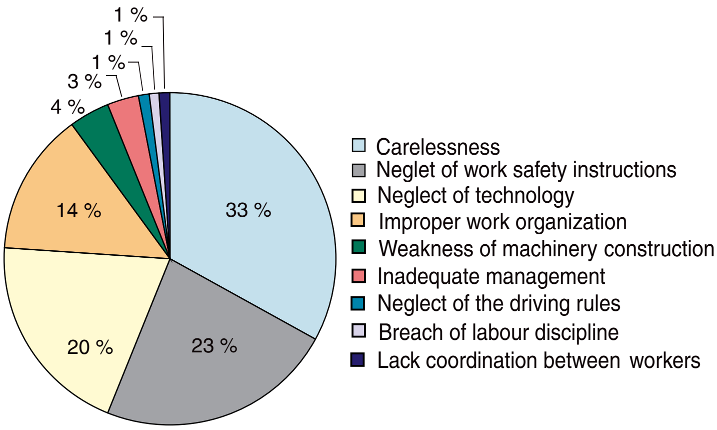


Fig. 3.24 Reasons for accidents, 2001-2003.

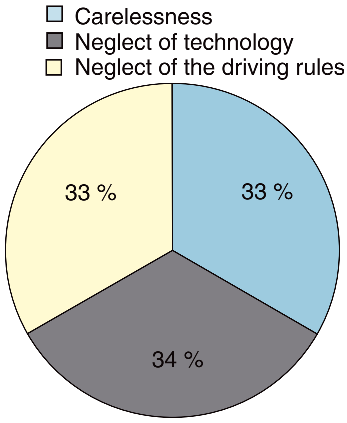


Fig. 3.25 Reasons for fatal accidents, 2001-2003.

3.1.2 Round wood balance and unreported flows

Industrial round wood flows into, within and out of Northwest regions of Russia have been analyzed in project publication "Development of Wood Procurement in Northwest Russia: Round Wood Balance and Unreported Flows" (Gerasimov&Karjalainen 2006). The study examined sawlog, pulpwood and fuelwood used for industrial purposes, obtained from logging, and chips obtained from the wood-processing industry. Trends in wood harvesting, industrial round wood export and forest industries development that have an influence on unreported wood in Russia have been analyzed. The developed method, which uses wood balance diagrams, provides an interpretation of data from different Russian sources in order to offer better transparency regarding wood flows from forests to mills. It also helps to explain the seeming imbalance between round wood supply and demand and it helps to assess the possible share of unreported industrial round wood production in Northwest Russia.

In 2002, industrial round wood demand in the whole Northwest Russia was approximately 40.3 million m^3 u. b. Nearly all (96%) of the wood supply was from harvesting operations in Northwest Russia. Only 4% was imported from the nearest Kostroma and Kirov regions. Approximately 64% of the wood was used in local industry, 35% was export abroad, and only 1% was export to the Moscow region. Northwest Russia, as a whole, can be therefore described as a round wood supply region for local forest industries but having also significant export abroad.The Northwest Russian regions can be characterized as:

- There is heterogeneity in the regions in relation to industrial round wood production, consumption and trade.
- The most important industrial round wood producing regions are Arkhangelsk and Vologda, which produce more than Karelia, Komi, Novgorod, Murmansk and Pskov combined.
- The main domestic industrial round wood consumers (wood industry) are located in Arkhangelsk. The industrial round wood consumption of Arkhangelsk is more than Karelia, Vologda, Leningrad, Novgorod, Pskov, and Murmansk combined.
- The export oriented regions are Leningrad, Karelia, Vologda, Novgorod, and Pskov. There are very little export of round wood from Arkhangelsk and Komi.
- Vologda and Komi provide industrial round wood to domestic markets.
- Arkhangelsk, Karelia and Leningrad are recipients of domestic industrial round wood.
- Unreported flows in industrial round wood exist, especially in the Leningrad region (including the city of Saint-Petersburg) and border regions.

An examination of the wood flow model presented in form of equations and the available statistics explain quite well the existing wood balance in Northwest Russia. As a whole the consumption of industrial round wood corresponds to round wood production. However, wide deviation can be observed on a regional level, especially in the Leningrad region. This region (with Saint-Petersburg) had a negative industrial round wood balance of 2.8 million m^3 u. b. in 2002. At the same time, Vologda, Novgorod, Komi and Karelia combined had a positive balance of 2.9 million m^3 u. b. This means that there are unreported industrial round wood flows from Northwest Russia into Saint-Petersburg resulting in export to Europe. These phenomena can be explained by the independence of the Northwest Russian round wood market, on the whole, from other Russian regions. For the overall Northwest Russia, wood balance mainly resulted from quite reliable statistical data based on annual reports of the Ministry for Natural Resources, Customs and forest industries. For the individual regions, wood balance also resulted from less reliable statistical data (for example, domestic export) based on reports from individual logging companies.

Unreported industrial round wood flows may be explained by unsound business practices. It is necessary to emphasize that unreported volume usually has nothing to do with illegal cutting, according to Russian forest legislation. Logging companies have cutting licenses and pay stumpage. But some logging companies, especially small and medium sized, try to avoid taxes and show understated volumes of round wood products through cash payment, collude in submitting bids or tenders to obtain cutting permits cheaply, use illegal labour or illegally paid labour, transport timber without authorization and so on. Taking into account the official data for industrial round wood production by the State Committee of Statistics, 30 million m^3 vs. 39 million m^3 u. b. according to our calculation for 2002, the unreported volume can be estimated at 9 million m^3 or 23% of the total volume of industrial round wood production for 2002.

In particular, an important part of the unreported round wood enters the market in the western regions; in Leningrad, Novgorod, and Pskov (Figure 3.26). Analysis show that more than 9 million m^3 u. b. of industrial round wood is involved in the "grey" market in Northwest Russia. Share of Leningrad and its neighboring Vologda and Novgorod regions of unreported industrial round wood is approximately 5.5 million m^3 or 60% alone. There are export oriented regions that do not have developed high value-added forest industries. Due to lack of local demand for industrial round wood, many small sized companies are involved in wood export trade or small sized sawmilling using lower declared values and volumes than have exported, cash payment, and other unsound practices in the payment system to avoid taxes, all leading to unreported wood flows.

In addition, some other factors can influence the assumed share of unreported industrial round wood. Logging companies registered in one region may have cutting areas in another region. In reality, the harvesting and industrial round wood productions are recorded in different regions. Wood exporters registered in one region may declare the exported wood volume to a custom office located in another region and vice versa, they may originally declare the exported wood volume from another region.

The risk of unreported round wood in the wood flow has to be taken into account when tracing the origin of wood for forest industries, as a part of the chain of custody.

Northwest Russian regions can be characterized as (Figures 3.27-3.28):

- High domestic utilization, low level of export (abroad and to other regions), small share of unreported flows
    - *Arkhangelsk, Komi.*
- Average domestic utilization, average level of export, small share of unreported flows
    - *Karelia, Vologda.*
- Average domestic utilization, average level of export, large share of unreported flows
    - *Leningrad, Novgorod, Pskov.*
- Low domestic utilization, high level of export, large share of unreported flows
    - *Murmansk.*

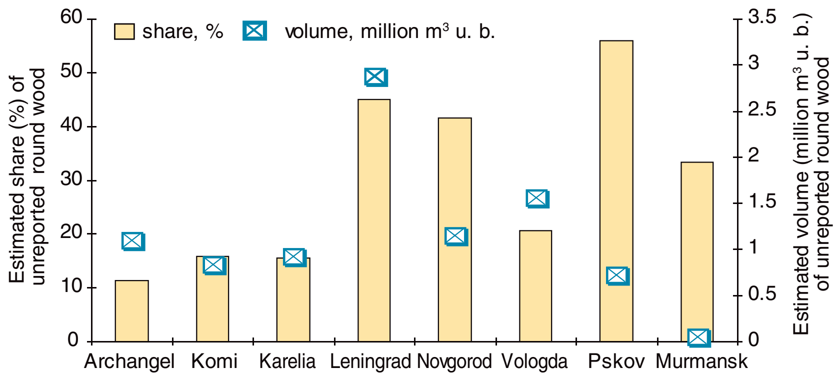


Fig. 3.26 Estimated share of unreported production of industrial round wood in Northwest regions of Russia in 2002.

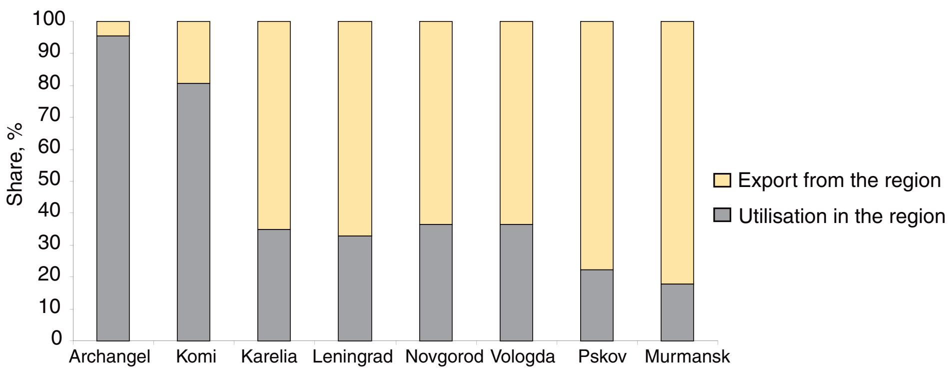


Fig. 3.27 Distribution of industrial round wood use in Northwest Russia.

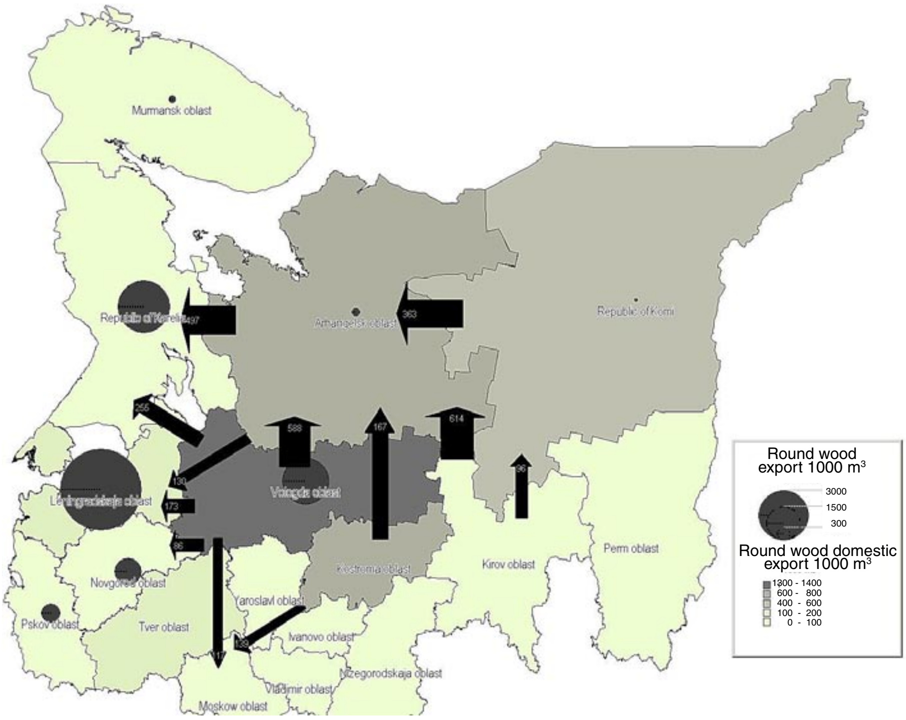


Fig. 3.28 Industrial round wood export (including domestic) in 2002.

3.2 Development of harvesting methods and machinery

3.2.1 Wood harvesting methods and systems

Wood harvesting methods and systems in Northwest Russia have been examined in several project publications (e.g. Siounev et al. 2006, Pecherin&Chikulaev 2005, Gerasimov 2004). Nordic and Russian methods and practices in wood harvesting differ substantially. Full-tree, tree-length, and cut-to-length harvesting methods are applied in Northwest Russia. The wood harvesting systems can be classified as fully mechanized and partially mechanized. In fully mechanized system all logging operations are implemented by forest machines (harvester + forwarder, feller-buncher + skidder + delimber, etc), while in partly mechanized some operations are implemented by chain-saw or axe.
Partially mechanized full-tree and tree-length methods have been used by logging companies in Northwest Russia since early 1950s. Typical wood harvesting system include manual felling and delimbing with chainsaw (Figure 3.29), and skidding of trees or logs using Russian caterpillar cable skidders. In small scale, also fully mechanized system with feller-bunchers and grapple skidders are used.

Cut-to-length (CTL) method is used in several logging companies especially in the Republic of Karelia and Leningrad region (Figure 3.30). In Karelia for example, Karellesprom, Ladenso, Shuyales, Medvezhegorsky LPH, Segezhsky CBK, Kostomukshales, Piaozersky KLPH, Olonetsles, Pyalmsky LH and Ladvinsky LPH use CTL technology.



Fig. 3.29 Felling with chain-saw. Delimbing with chain-saw. Skidding with skidder TDT-55.


Feller-buncher Timberjack 850. Skidder ML-136.

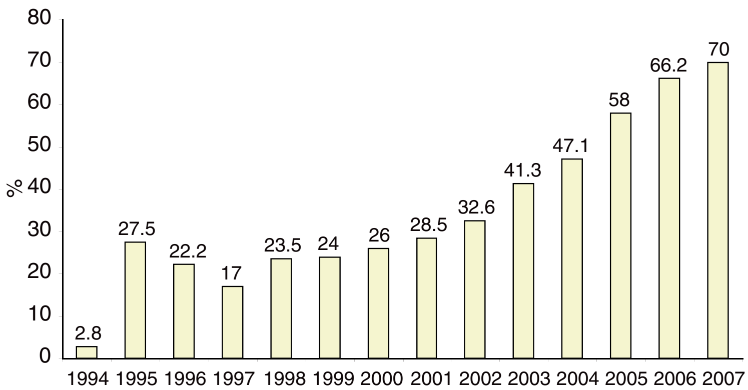


Fig. 3.30 Share of cut-to-length method of the fellings in Karelia in 1994-2006.

CTL systems have developed in Northwest Russia due to introduction of leasing, high reliability, good ergonomic and ecologic performance of harvesters and forwarders, reduction of annual allowable cut in industrial regions and possibility to introduce thinning operations, increasing attention to ecological impacts of wood harvesting, requirements for sustainable forest management, need of frequent moving of machinery due to small logging areas, better quality of industrial round wood, possibility for monitoring wood removals in logging area, and increasing safety requirements in public roads.

Use of fully mechanized CTL technology has been increasing since 2000 due to increasing number of harvesters and forwarders. Most of the machines have been produced in Finland. Number of shifts in use for harvesters and forwarders is constantly growing and they are used usually in 2 or 3 shifts. John Deere Forestry (Timberjack) has the biggest market share in CTL systems in Northwest Russia. Three biggest producers have over 90% of the market in Karelia (Figure 3.31).

The most common machines in the medium size class are for example John Deere Forestry harvester 1270 and forwarders 1010/1410, Ponsse harvesters Ergo and Beaver, and forwarders Buffalo, and Komatsu Forest harvesters Valmet 911/901 and forwarder Valmet 860. Smaller harvesters (for example Sampo Rosenlew 1046X, Logman 801) are used quite seldom. Heavy harvesters are usually based on excavators (for example as Volvo EC210BF, Kobelco SK 135 SRL, or Hitachi Zaxis 230). Some companies in Northwest Russia, like Ukhtuales, Porosozero, Volomsky KLPH, Leskarel and Muezersky LPH are using full-tree or tree-length methods without central processing yards (lower landing). Delimbing and cross-cutting operations are made then at roadside storages with harvester as a processor (Figure 3.32).

There are several reasons making development of wood harvesting systems in Northwest Russia difficult. These include among others weak production infrastructure, lack of advanced road network, lack of own turnover means, lack of advanced domestically made machinery, low quality of training especially harvester and forwarder operators, and increasing variable costs.

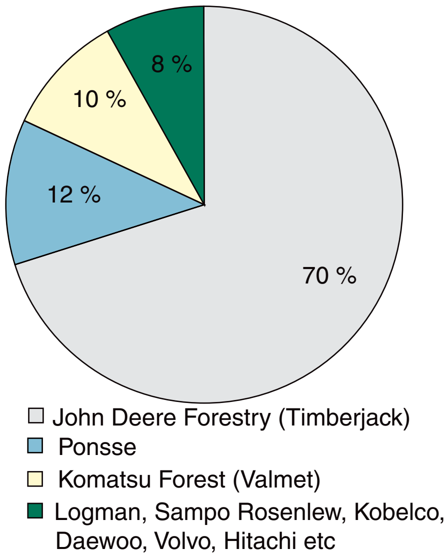


Fig. 3.31 Percentage of forest machine trademarks in CTL systems in Karelia in 2006.

Fig. 3.32 Harvester (processor) Hitachi Zaxis 230.

3.2.2 Forest machinery producers

Forest machinery development has been examined in several project publications (e.g. Siounev & Gerasimov 2005, Siounev & Selivestrov 2005). The first Russian forest skidder KT-12 was designed and tested in 1946 by Saint-Petersburg (Leningrad) Forest Engineering Academy and produced by Kirovsky plant (Leningrad) in 1947-1951. Two thousand skidders were produced in 1951. Since 1952 the production and the development were moved to Minsky tractor plant. The plant designed new models of skidders, including TDT-40 for Northwest Russian and TDT-54 for Siberian conditions, and produced 5500-6000 machines annually. Since 1956 the Onego tractor plant (Petrozavodsk) was in charge for design and production of forest machines for Northwest Russia based on TDT-40 skidder. In 1965 special design department of Onego tractor plant developed skidder TDT-55 which was in mass production from 1968 till 2002. Altogether 12 500 forest skidders were used in 1950-1951. In 1990, 10 600 forest skidders, 1000 skidders with crane, 800 feller-bunchers and feller-skidders, 1580 delimbers and 2000 chap loaders were produced.

Since 1960 forest machinery design has been based widely on using hydraulic cranes in Russia. In 1960 the first crane was tested in skidder TDT-40 by Saint-Petersburg (Leningrad) Forest Engineering Academy designers, but only since 1973 Onego tractor plant started to produce new skidder with crane TB-1. Feller-buncher-skidder LP-17 based on TB-1 was designed by Central Research Institute of Mechanization and Electrification (Moscow) in 1977 and produced by Syktyvkar mechanical plant. The forest crane was produced by Lesmach plant (Velikie Luki). The most advanced excavator-based feller-buncher LP-19 was designed and has been produced by Joshkar-Ola forest construction plant since 1974.

The most important producer of wood harvesting machines for Northwest Russia is Onego tractor plant. Between 1970 and 1988 the Onego tractor plant produced 10-12000 skidders per year, which was half of the total production in the USSR. Production of the plant dropped several times during “perestroyka” period (Figure 3.33).

High level of inflation in 1991-1994, antimonopoly state regulation for prices and tax on inflationary profit declined own turnover means of the plant. In 1994 plant went bankrupt. The plant was not able to provide the installment for selling. The second market was established by trade houses which played significant role that time as intermediate between the plant and logging companies.

The crisis in skidder production immediately influenced on production of other forest machines in other companies. These enterprises produced for example delimbers and chap loaders based on these skidders (Figure 3.34). This fact had great influence on competitiveness of Russian forest construction industry. Since 2002 the Onego tractor plant produced cable model TLT-100A and crane model TB-1MA-15.

The TLT-100A has been the main skidder for traditional Russian harvesting technology. The tractor TB-1MA-15 was produced only case by case. In general the quality and design of tractors has been poor. Ergonomics of skidders correspond to Russian standards, but is much worse than the requirements in the Nordic countries. Thus production of tractors continues to decrease. In 2002, the plant tried to overcome the difficulties and it changed marketing policy, liquidated the second market of tractors, and created a dealer network. In 2002, the Onego tractor plant established department of external economic activities, and as a result 22 skidders were exported, 8 in Latin America. In 2003, 100 machines were exported. The production was 288 tractors in 2004, and 360 (+20%) in 2005. In 2005, the plant produced mainly model TLT-100, but at the same time the new model TLT-300 with better ergonomic characteristics was designed (Figure 3.35).

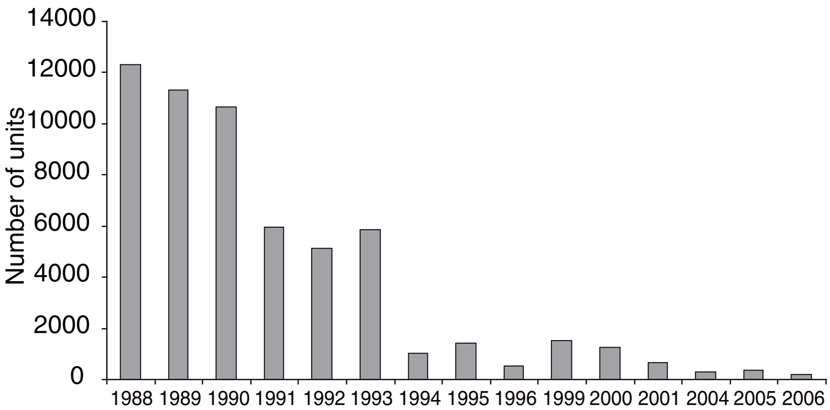


Fig. 3.33. Production of skidders in the Onego tractor plant.

Fig. 3.34 Cable model of caterpillar skidder TLT-100A (left) and crane model of caterpillar skidder TB-1MA-15 (right).

Fig. 3.35 Skidder TLT-300 (“Онежец-300”).

In addition to continue production of caterpillar skidders, the plant is also trying to produce harvesters using Dutch components by Silvatec Sleipner. In 2007 the plant tried to start production of harvesters which will have 25% lower price than imported harvesters. The plant planned to produce harvesters and forwarders based on own wheel tractor TLK 4. Harvester was equipped by Swedish crane Cranab CRH12 and head SP 551 LF by Maskiner AB. Plant also tried to organize assembly of German forwarders HSM 904F – OTZ using imported components. However, only few harvesters and one forwarder were produced. Harvesters have been working in Belozersky logging company in Vologda region.

At the present time construction of wood harvesting machinery in Northwest Russia continues only in the Onego tractor plant with two models of traditional caterpillar skidders. There is also one small producer of harvesters and forwarders in Northwest Russia. This company is “Harvy Forest” and it assembles approximately 10 Finnish Pinox machines per year in Medvezhegorsk, in the Republic of Karelia.

3.3 Development of wood transport logistics

3.3.1 Background and method

A logistic system based on GIS-solutions for increasing the efficiency of introducing cut-to-length technology in Northwest Russia, decreasing of wood transport costs, improving the utilization of short-wood truck fleet has been presented in the project publication "GIS-based decision-support program for planning and analyzing short-wood transport in Russia" (Gerasimov, Sokolov & Karjalainen, 2008). Depending of the used harvesting methods wood is transported either directly to the end user from the road side storage or via intermediate storages or central processing yard. It is quite easy to manage logistic issues when using traditional tree-length method as all tree-length wood from cutting areas is transported to one central processing yard. Application of the cut-to-length method requires more attention on wood transport logistics as different timber assortments or short-wood from cutting areas should be delivered directly to several customers, to pulp mills, sawmills, wood-based boards mills, wood terminals, and railway stations. The short-wood logistics is complicated and can not be realized by current tree-length approaches effectively. Logistical approaches for cut-to-length method are not yet well developed in Russia. Software and tools developed in countries having long experience of cut-to-length method and short-wood logistics, namely Finland and Sweden, are not necessarily applicable to Russian conditions. This is due to the specific organizational structure of Russian logging companies which include a transport department with own vehicle fleet, garages and repair workshops. Russia also has specific requirements for axle load of trucks, own standard of round-wood, category of roads, poor state and maintenance of roads, seasonality of road availability etc. Moreover solutions are usually company specific, thus tailored programming tools need to be developed for improving planning and optimization of wood transport on operational level.

Objective was to develop GIS-based decision support program for planning and analyzing short-wood transport on logging company level in Russia. The program should give the logging company comprehensive information about the benefits and limitations of different short-wood transport options. The logging company should get sufficient information to make sound decisions in short and long term. Development of the program should be also supported by the latest research results in this project.

Economic feasibility of logging operations that provide short-wood is a critical element for the development of forestry and wood harvesting in Russia. Developed decision support program also acts as a set of guidelines for logging companies since it takes economic aspects into consideration, warns lack of timber trucks and gives recommendations for organizational management of logistics (i.e. delivery planning, locations of garages and temporary wood terminals) when required.

Problem in the short-wood transport is to define delivery plan, which allows maximizing wood removals and rationalizing the use of short-wood truck fleet in a logging company. Delivery plan means an output schedule for truck fleet for a given time period, including for example places and time for loading and unloading, type of transported assortments.

Decision support program has been constructed in MapInfo environment using Map Basics for coding and Microsoft Excel for reporting. In MapInfo environment is possible to build a program with user interfaces and custom dialog boxes with MS Excel. An overview of the program structure and most important components is presented in Figure 3.36.

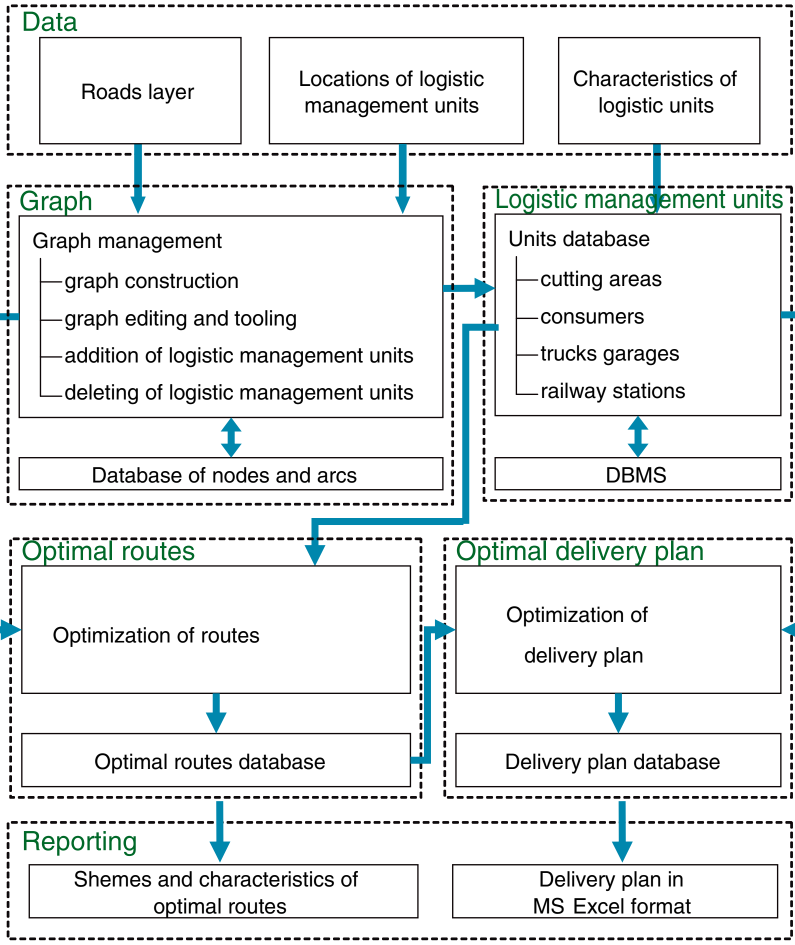


Fig. 3.36 An overview of the program structure.

Data module includes information about roads and their quality, locations of logistic management units (i.e. cutting areas, customers, truck garages, and railway stations) and their characteristics. User can easily manage data with a user friendly interface. The second part of the program is Graph module, where user can regenerate layer of roads including logistic management units. Several sub-modules have been created for the graph management (construction, editing, deleting, and adding). The module of Optimal routes helps the user to search with heuristic optimization method better short-wood transportation route. The module of Optimal delivery plan helps the user to optimize with dynamic programming daily tasks for each timber truck. The Reporting module contains reports of optimal routes and delivery for short-wood transport for the logging company.

Data required for planning and analyzing short-wood transport include road maps in MapInfo format, location of logistic management units (cutting areas, customers, railway stations, garages) and their characteristics. Before searching optimal routes, the initial layer of roads has to be transferred into the graph. The first step is the creation of the layer of nodes. Nodes are numbered and saved in the database. The next step is the creation of the layer of arcs – every road is transferred into several independent segments. The starting and the ending points of segments coincide with dotty objects of the layer of nodes. Type of the road, number of starting and final dots, arc length and computed time of moving are entered into database for each arc. User has to add the average speeds of all types of roads for calculation of moving time.

The search of optimal routes helps to find the route with the lowest transport costs. Relative or absolute wood transport costs per 1 m^3 by different types of roads and trans-shipment costs at the terminals have to be given. Important elements for the optimization are estimation of moving time and costs between the logistic management units. Moving time depends of the distance and the average speed of moving along the road which condition can be different. Usually several paths can be used for moving. Original heuristic method based on the Dijkstra algorithm was applied for optimal route searching. All routes and their characteristics are saved in the database and downloaded from there when queries are repeated. This helps to significantly save time during calculation of new alternatives for the delivery plan for the same graph.

The synthesis of the delivery plan can not be solved by classical approaches. This problem may be classified as "open" and "without end". The process of the delivery plan calculation for every truck stops and the procedure for return to the garage starts because shift ends, or lack of short-wood in cutting areas, or obligations of the wood trade contracts already realized. The original algorithm based on dynamic programming was developed for these tasks.

The criterion for optimization is wood transport per shift for every truck. Total time of the truck moving is minimized during limited shift without non-technological stops. Found optimal decision directly corresponds to maximum wood transport per shift, i.e. number of runs. During conditional optimization on every step of the dynamic programming for every current cutting area in turn sets customers with minimum total moving time. Moving time is calculated from the beginning of shift till arriving to current cutting area.

3.3.2 Application

Efficiency of the developed program was tested in real logging process. Comparison of three delivery plans was done for a logging company operating in the Republic of Karelia (Figure 3.37). The company provided forest inventory and infrastructure information and thus map layers were created for roads (5 types of quality), forest stands, and cutting areas. The "basic" delivery plan (Plan 1) was done in a traditional way without program support. Two delivery plans (Plan 2 and Plan 3) were done with the program. The difference between the second and the third delivery plan is that in the third plan (Plan 3) the drivers of the trucks are changed on the route without retuning to the garage in every shift.

Delivery plans were compared using performance indexes total work time (hours), total run (kilometers), total number of runs, total volume of wood transport (m^3), total cargo run (kilometers), required number of trucks, fleet utilization rate per shift, loaded distance, and operation work (m^3/km).

Fleet utilization rate per shift is calculated as, $k = \dfrac{t_p}{t_s \cdot n}$

where t_p – total work time per day, hours;
t_s – total length of shift, hours;
n – number of working trucks, units.

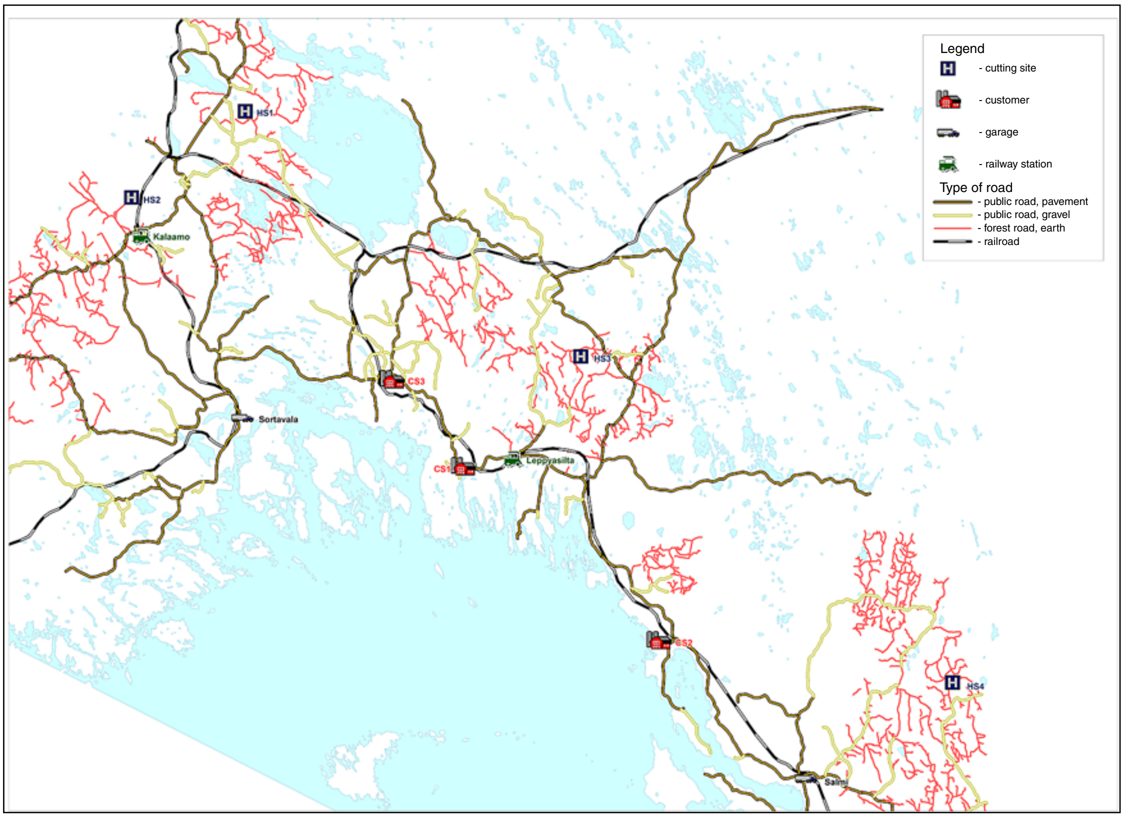


Fig. 3.37 Location of logistic management units in the application.

The fleet utilization rate per shift has somewhat different meaning than standard fleet utilization rate. This rate shows truck utilization within a shift, i.e. how effectively trucks are utilized in the delivery plan. If the truck was standing idle during a day, it was excluded from the calculation. The most efficient delivery plan means the least working trucks for the same daily short-wood transport or, vice versa, the biggest short-wood transport for the same number of working trucks.

Loaded distance means the ratio between the total cargo run and the total run. Operation work shows how much short-wood is delivered per 1 km of the total truck's run.

Comparison of the results between delivery plans when applying the basic method (Plan 1) and the program (Plans 2 and 3) are presented in Table 3.2. The change in the indexes (in percents compared to the basic method 1) is shown in parentheses.

Table 3.2 Comparison between the basic delivery Plan 1 and delivery Plans 2 and 3 done with the decision support program.

Plan	Total working time, h	Total run, km	Number of runs	Total volume, m^3	Total cargo run, km	Required number of trucks	Fleet utilization rate	Index of loaded distance	Operation work, m^3/km
1	307	7382	53	2740	2212	5	0,754	0,300	0,371
2	255	7382	58	2996	2697	5	0,728	0,365	0,406
	(-17%)	(0%)	(+9%)	(+9%)	(+22%)	(0%)	(-4%)	(+22%)	(+9%)
3	239	5743	58	3000	2872	4	0,895	0,499	0,526
	(-22%)	(-22%)	(+9%)	(+10%)	(+30%)	(-20%)	(+19%)	(+66%)	(+42%)

Optimization of the schedule using the program with Plan 2 shows that the total delivered wood volume increases from 2740 m^3 to 2997 m^3 (+9%). The total run is the same, but the total working time decreases by 17%. The required fleet is the same, 5 short-wood trucks. The fleet utilization rate decreases slightly (-4%), loaded distance increases by 22%, and the total volume of transported round wood per km increases by 9%.

Optimization of the schedule using the program with Plan 3 shows that the total delivered wood volume increases from 2740 m^3 to 3000 m^3 (+10%). The total run decreases from 7382 km to 5743 km (-22%), and the total working time from 307 h to 234 h (-22%). It reduces the required fleet from 5 to 4 trucks. The fleet utilization rate increases by 19%, loaded distance by 30%, and the total volume of transported round wood per km by 42%.

Extraction of short-wood from the harvesting processes is becoming a common practice in Russia. Logging companies are faced with a large number of options for short-wood transport, but they have limited knowledge of the potential in logistics. The developed GIS-based decision support program is a unique tool assisting the logging companies to make comprehensive decisions on organizational options for short-wood transport most beneficial for them. Application of the program allows to increase efficiency when introducing cut-to-length technology in Northwest Russia, to decrease wood transport costs, and to improve utilization of short-wood truck fleet. Testing of the program and comparison of alternative delivery plans show that the efficiency of short-wood transport can be increased by 40%. Program could be used also for other applications, like for road planning, fuel supply or logistics in silviculture, and it also provides an excellent opportunity to convey knowledge gained in research to the companies by practical and understandable means.

3.4 Sustanability of wood harvesting and procurement

3.4.1 Economics of wood harvesting

Actual wood harvesting costs are examined in several project publications (Siounev & Konovalov 2006, Siounev & Konovalov 2007a, Siounev & Konovalov 2007b), and are based on field data partly collected in the TACIS project "Comparison of Harvesting Methods - Impacts on Wood Quality and Overall Performance of Wood Harvesting Companies". Altogether 15 logging enterprises were investigated in the Republic of Karelia in 2006-2007, and their description is presented in Table 3.3.

Annual logging volume and harvesting costs were obtained from logging companies and are shown in Figures 3.38 and 3.39. The annual actual cut of the investigated companies was 2 186 500 m^3 which was one third of the total wood harvesting of Karelia. Altogether 865 800 m^3 was logged by cut-to-length method (39% of the actual cut), 935 400 m^3 (43%) by tree-length method and 385 300 m3 by full-tree method (18%).

The biggest dispersion in harvesting costs by 2 times was observed in companies which use cut-to-length method. The harvesting costs of cut-to-length system "lumberjack + forwarder" varied from 140 RUR/m^3 (company 7) to 340 RUR/m^3 (company 2). The harvesting costs of cut-to-length system "harvester + forwarder" varied from 200 RUR/m^3 (company 2) to 370 RUR/m^3 (company 6). Logging companies 1, 14 and 15 applied full-tree system and had similar harvesting costs - 250 RUR/m^3. The harvesting costs of tree-length system "lumberjack + forwarder" slightly varied from 220 RUR/m^3 (company 13) to 300 RUR/m^3 (company 12).

The study shows similar average wood harvesting costs at road-site for all wood harvesting methods (Figure 3.40), approximately 7-7.5€/m^3. But it should be noted that in case of cut-to-length method the company has industrial round-wood, while in case of tree-length and full-tree methods logs need further processing at central processing yard and additional production cost of 6-8€/m^3.

Table 3.3. Description of investigated logging companies.

Number	Species distribution	Harvesting technology	
1	pine 40%, spruce 50%, birch 10%	CTL TL FT	(harvester + forwarder) (lumberjack +TDT-55) (feller-buncher + skidder)
2	pine 30%, birch 70%	CTL CTL	(harvester + forwarder) (lumberjack + forwarder)
3	pine 50%, spruce 30%, birch 20%	CTL	(harvester + forwarder) (lumberjack + forwarder)
4	pine 60%, spruce 20%, birch 10%, aspen 10%	CTL	(harvester+forwarder)
5	pine 40%, spruce 20%, birch 20%, aspen 20%	CTL TL	(harvester + forwarder) (lumberjack + TDT-55)
6	pine 20%, birch 80%	CTL	(harvester + forwarder)
7	pine 30%, spruce 20%, birch 50%	CTL	(lumberjack + forwarder)
8	pine 10%, spruce 30%, birch 40%, aspen 20%	CTL	(lumberjack + forwarder)
9	pine 20%, spruce 20%, birch 40%, aspen 20%	CTL	(lumberjack + forwarder)
10	pine 20%, spruce 30%, birch 30%, aspen 20%	TL	(lumberjack + TDT-55)
11	pine 10%, spruce 40%, birch 30%, aspen 20%	TL	(lumberjack+TDT-55)
12	pine 30%, spruce 10%, birch 60%	TL	(lumberjack + TDT-55)
13	pine 10%, spruce 30%, birch 40%, birch 10%	TL	(lumberjack + TDT-55)
14	pine 60%, spruce 30%, birch 10%	TL FT	(lumberjack + TDT-55) (feller-buncher + skidder)
15	spruce 50%, birch 30, aspen 20%	FT	(lumberjack+TDT-55)

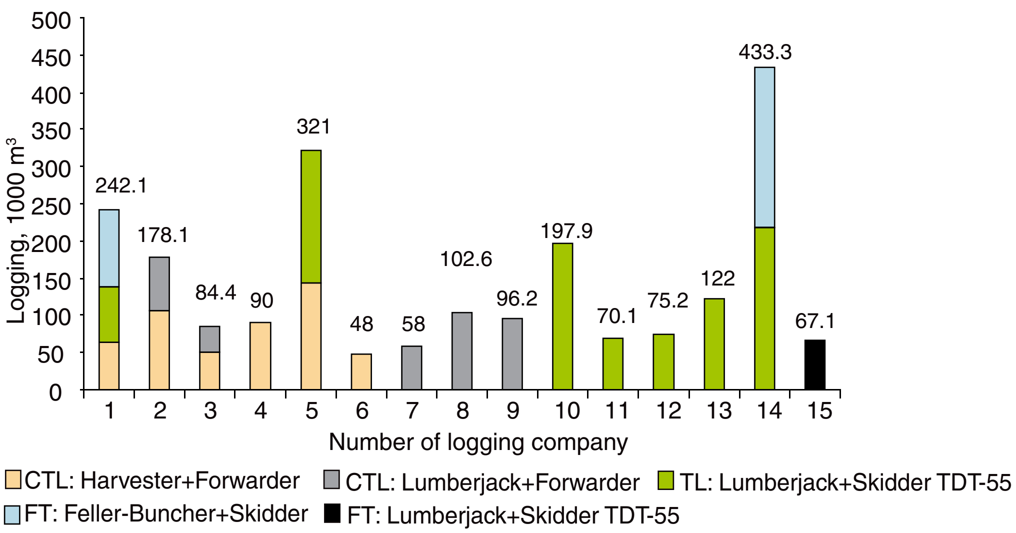


Fig. 3.38 Annual logging volumes by wood harvesting technology.

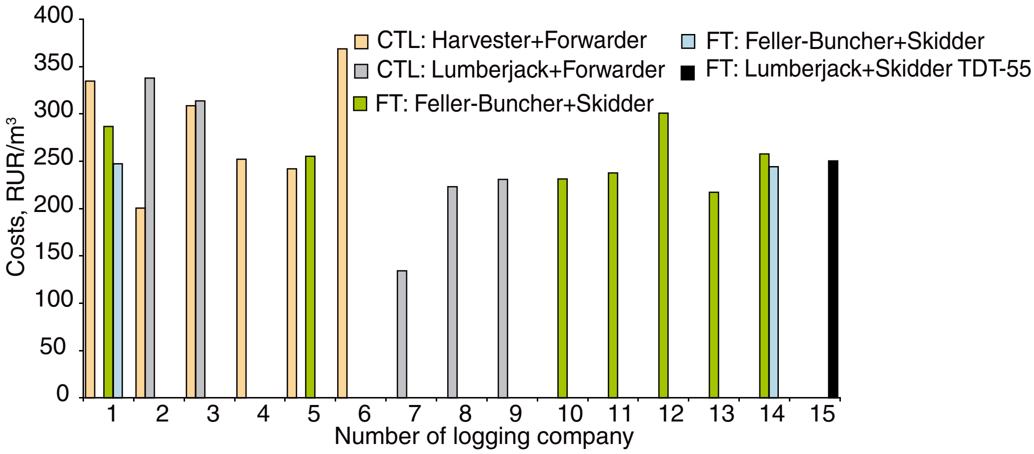


Fig. 3.39 Wood harvesting costs in logging companies by wood harvesting technology.

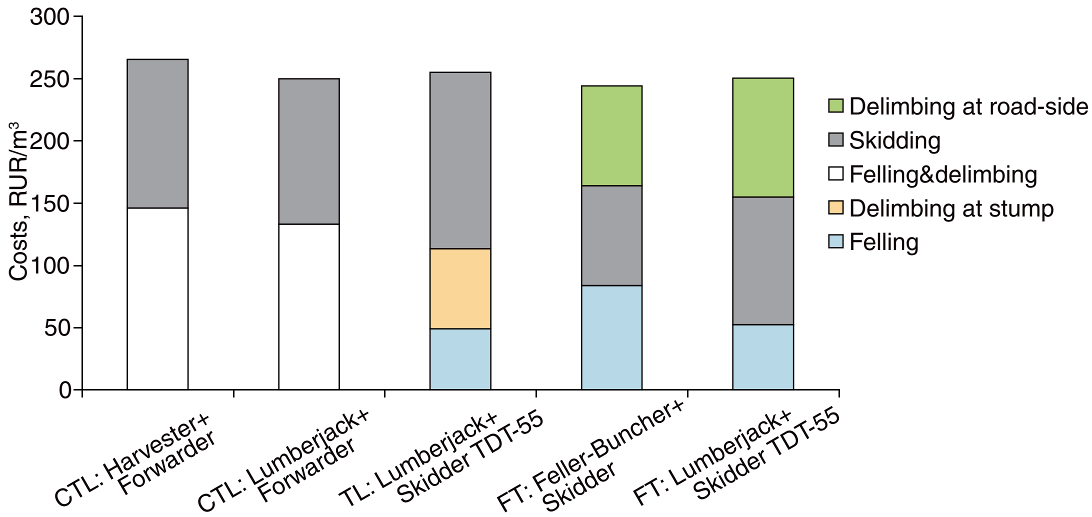


Fig. 3.40 Avarage wood harvesting costs of logging operations by wood harvesting technology.

3.4.2 Restrictions for wood harvesting and procurement in conservation areas

Officially existing and planned conservation areas and old-growth forests which have unofficial protection status in the Republic of Karelia, Arkandelsk and Vologda regions have been examined in several reports (Gerasimov et al. 2006, Gerasimov et al. 2008a, Gerasimov et al. 2008b). Stakeholders have utilized results widely, and for example the Government of the Republic of Karelia uses the results for the annual environmental reporting (Gosudarstvennyj doklad o sostojanii okruzhajuschej prirodnoj sredy Respubliki Karelija v 2007 g.).

In the beginning of 2006 Karelia had 215 official conservation areas with the total area of 933000 ha which is 6.3% of the total forest fund of Karelia. All types of fellings were forbidden in 58 official conservation areas (448000 ha or 3% of the forest fund of Karelia). Final fellings (or clearcut) were forbidden in 23 official conservation areas (151000 ha or 1% of the forest fund of Karelia). The rest of the conservation areas (345000 ha or 2.3% of the forest fund of Karelia) did not have restrictions for wood harvesting, but clearcut is forbidden by the current Forest Code. Three officially planned conservation areas (106000 ha or 0.7% of the forest fund of Karelia) have been also clearly recognized.

NGOs suggested 40 detached areas of old-growth forests to be protected (approximately 980000 ha or 6.6% of the forest fund of Karelia) in 2005. Major areas of old-growth forests are located in Kemsky, Muezersky, Kostomukshsky, Pudozhsky, Pialmsky, Piaozersky, Sosnovetsky, Chupinsky and Yushkozersky leskhozes. Since 2000, when the previous version of old-growth forest map was published, locations of old-growth forests have changed substantially. Environmentally responsible forest industry companies have not yet officially acknowledged new version of the map. For the sake of transparency it is important to inform forest industry representatives about new initiatives of NGOs and to monitor the process in the future.

Locations of the conservation areas and old-growth forests are shown in the whole Karelia, at the level of forest district (leskhoz) and forest block (kvartal) in Figures 3.41–3.44. Considered areas are overlaid with wood harvesting restrictions.

The results of the study have been reviewed by the "Rosprirodnadzor" Federal service which is responsible of the inspection of nature management in the Republic of Karelia, by forest industry companies "Segezha pulp and paper mill" and "Stora Enso", by non-governmental organizations Biodiversity Conservation Center and Greenpeace Russia. They have considered this kind of fresh study and report very important for stakeholders dealing with wood procurement, forest certification and forest legislation.

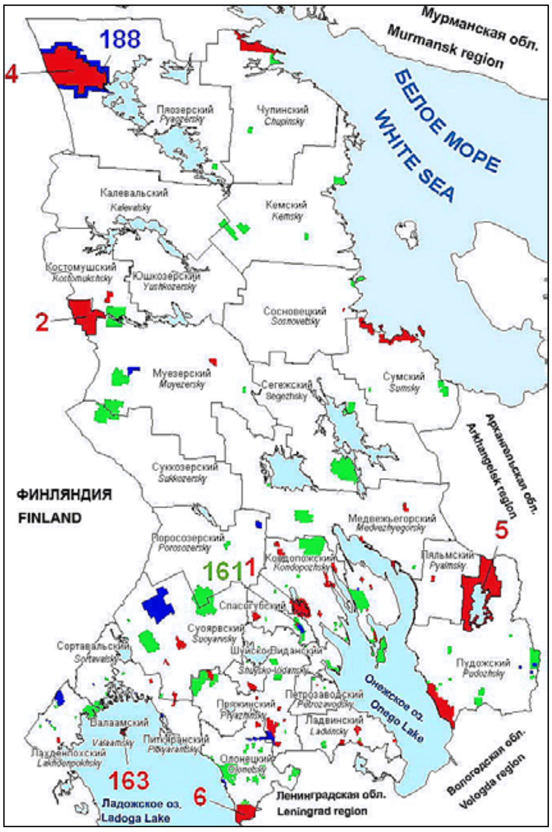


Fig. 3.41 Location of the existing conservation areas in the Republic of Karelia according to wood harvesting restrictions: red – all types of fellings are forbidden, blue – final fellings are forbidden, green – no restrictions for felling , but clearcut is forbidden by the valid Forest Code.

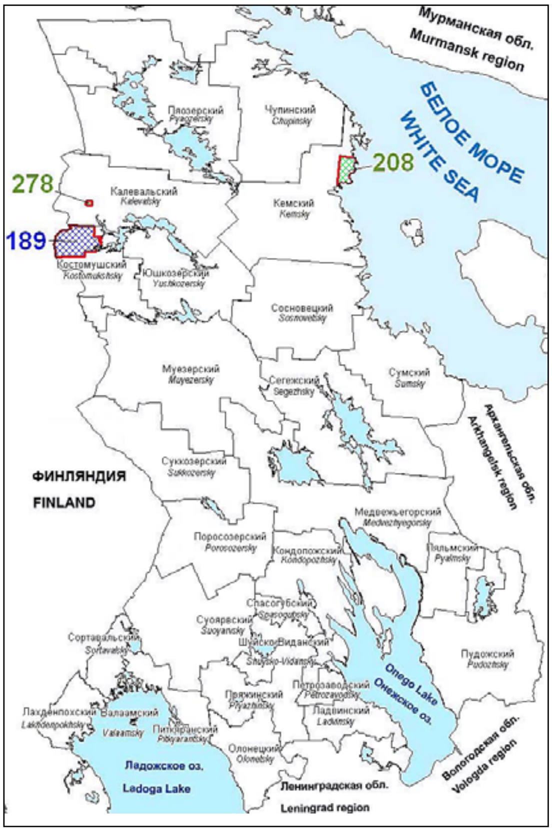
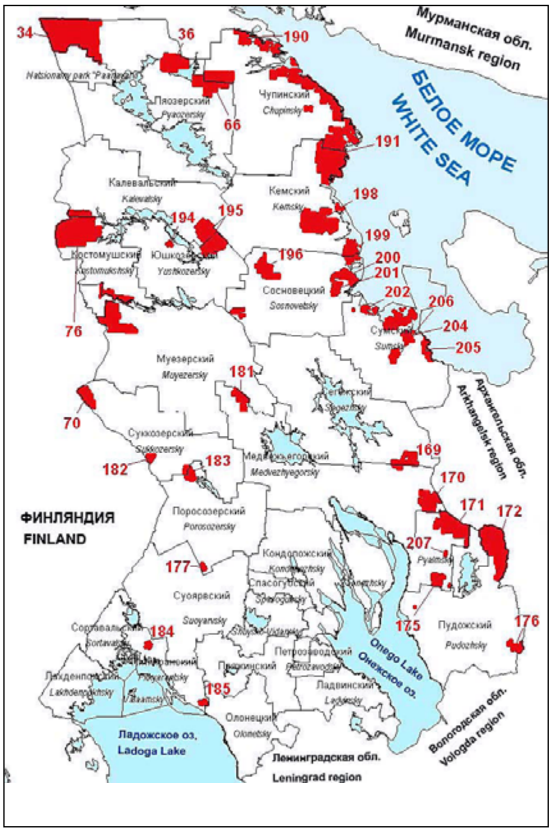


Fig. 3.42 Location of planned conservation areas in the Republic of Karelia according to wood harvesting restrictions: blue – final fellings are forbidden, green – no restrictions for felling.



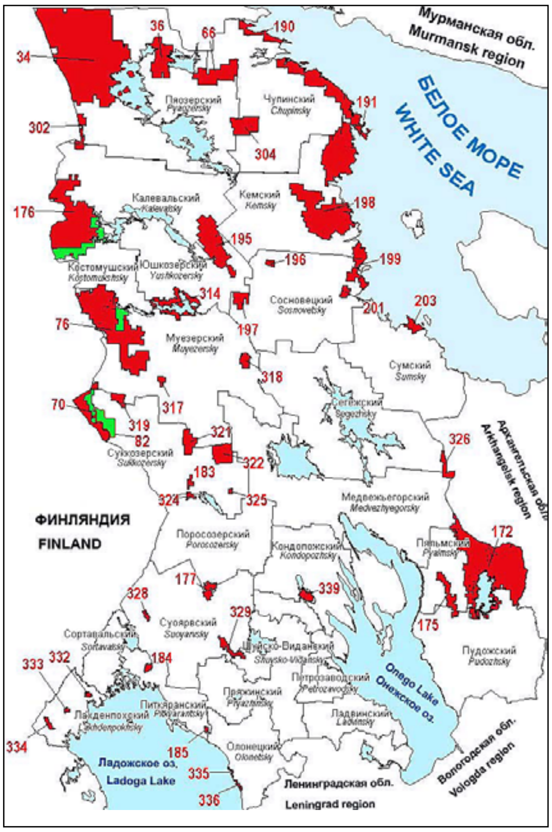


Fig. 3.43 Location of old-growth forests in the Republic of Karelia suggested by NGOs in 2000.

Fig. 3.44 Location of old-growth forests in the Republic of Karelia suggested by NGOs in 2005. Green colour – no restrictions for felling based on agreements.

In the beginning April 2008, Arkhangelsk region had 106 official conservation areas with a total area of 6.5 million ha. However, several reserves, such as the large reserve "Frants-Iosif Land" located in Baretsevo sea islands, were out of forest fund of Arkhangelsk region. The total area of the forest-related conservation areas was 2.2 million ha (7.6% of the total forest fund of Arkhangelsk region). All types of fellings are prohibited in 11 official conservation areas (0.6 million ha or 2.1% of the forest fund of Arkhangelsk region). Final fellings (or clearcut) were prohibited in 51 official conservation areas (1.6 million ha or 5.4% of the forest fund of Arkhangelsk region). The rest of the conservation areas (28600 ha or 0.1% of the forest fund of Arkhangelsk region) did not have restrictions for wood harvesting, but clearcut is forbidden by the valid Forest Code. Two officially planned conservation areas (5.3 million ha) have been clearly recognized; however only the "Onezhskoye Pomorye" national park (180400 ha or 0.6% of the forest fund of Arkhangelsk region) is located within forest fund of the region and has restrictions for wood harvesting. NGOs have suggested 11 separate areas of intact forest landscapes, covering approximately 9.5 million ha or 32.4% of the forest fund of the Arkhangelsk region to be protected. The major areas of intact forest landscapes are located in Leshukonsky, Mezensky, Severodvinsky, Onezhsky, Karpogorsky, Krasnoborsky, Pinezhsky, Priozerny, Sursky, Vyisky and Bereznikovsky leskhozes. Locations of conservation areas and old-growth forests are shown in the whole Arkhangelsk region, at the levels of forest district (leskhoz) and forest block (kvartal) in the maps in Figures 3.45-3.47. Protected areas are overlaid with wood harvesting restrictions.

In the beginning April 2008, Vologda region had 182 official conservation areas with a total forest fund area of 779000 ha (5.3% of Vologda region area). There were 719000 ha or 6.2% of the forest fund of Vologda region. All types of fellings were prohibited in 91 official conservation areas (411000 ha or 2.8% of the region). There were 344000 ha or 3,0% of the forest fund of Vologda region. Final fellings (or clearcut) were prohibited in 90 official conservation areas (377000 ha or 3.7% of the region. There are 375000 ha or 3.2% of the forest fund of Vologda region. Only one conservation area (97 ha) did not have restrictions for wood harvesting. Officially planned conservation areas have not been clearly recognized. NGOs have suggested one separate old-growth forest area to be protected (approximately 100000 ha or 0.8% of the forest fund of Vologda region). The major areas of old-growth forests are located in Babaevsky, Kadujsky, Cherepovetsky and Ustuzhensky leskhozes. Locations of conservation areas and old-growth forests are shown in Figure 3.48 for the whole Vologda region, at the levels of forest district (leskhoz) and forest block (kvartal). Protected areas are overlaid with wood harvesting restrictions in the map.

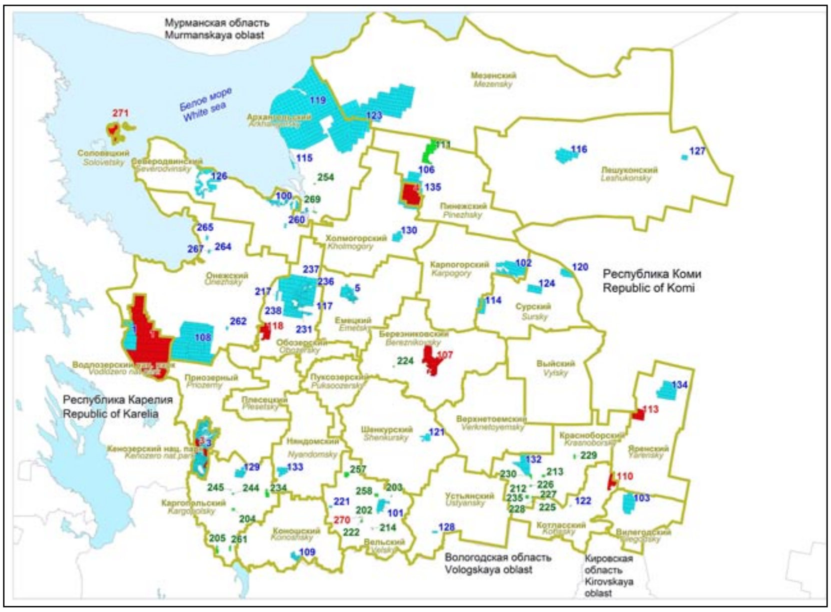


Fig. 3.45 Location of existing conservation areas according to wood harvesting restrictions in Arkhangelsk region: red – all types of fellings were forbidden, blue – final fellings were forbidden.

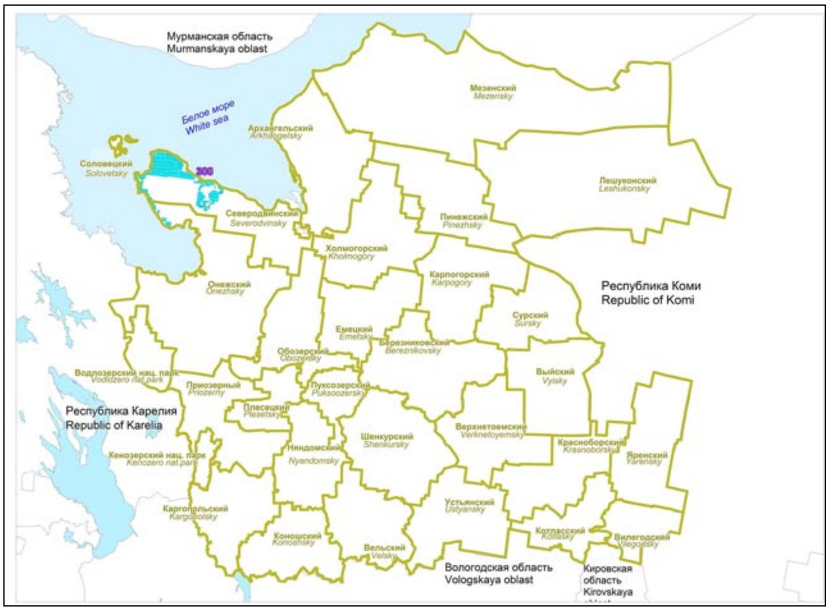


Fig. 3.46 Location of planned conservation area according to wood harvesting restrictions in Arkhangelsk region: blue – final fellings were forbidden.

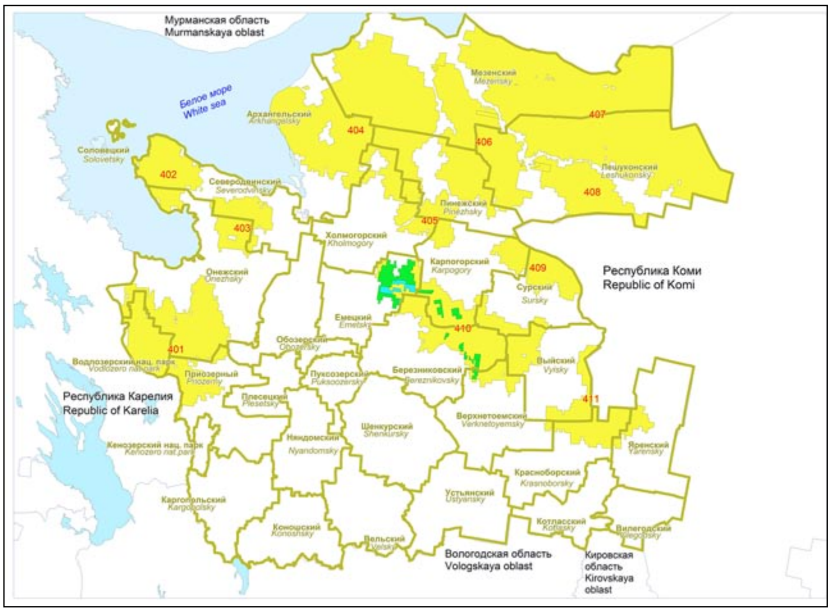


Fig. 3.47 Location of intact forest landscapes (yellow colour) suggested by NGOs in Arkhangelsk region taking into account wood harvesting restrictions based on agreements with forest leasers: blue – final fellings are forbidden, green – no restrictions for felling.

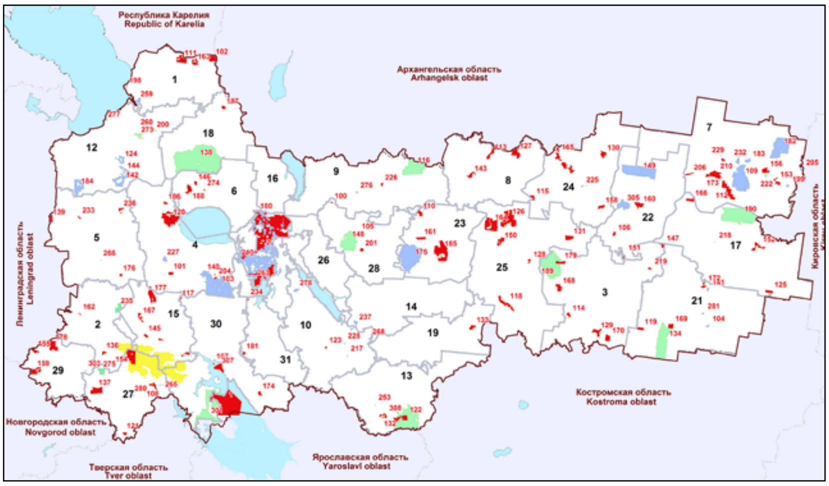


Fig. 3.48 Location of existing conservation areas according to wood harvesting restrictions in Vologda region: red – all types of fellings were forbidden, blue – final fellings were forbidden, green – no restrictions for felling. Location of old-growth forests suggested by NGOs in yellow.

Official conservation areas are 6.2-7.6% of the forest fund in the studied regions (Figure 3.49). The Republic of Karelia and Vologda region had the strongest policy for harvesting restrictions. All types of fellings were forbidden on half of the protected areas (3% of forest fund area). In Arkhangelsk region all types of fellings were forbidden in 27% (of 2.1% of forest fund area) of the protected areas.

The average size of protected areas varies significantly (Figure 3.50). The largest conservation areas were located in Arkhangelsk region (20000 ha), and the smallest in Vologda region (4000 ha). The old-growth forests (Figures 3.51 and 3.52) cover as much as 1/3 of the forest fund area of Arkhangelsk region. There were 11 detached areas, and average size of detached area is huge, 0.9 million ha. Vologda region had only one such area (95500 ha). Karelia had 40 old-growth forest areas with average size of 7000 ha.

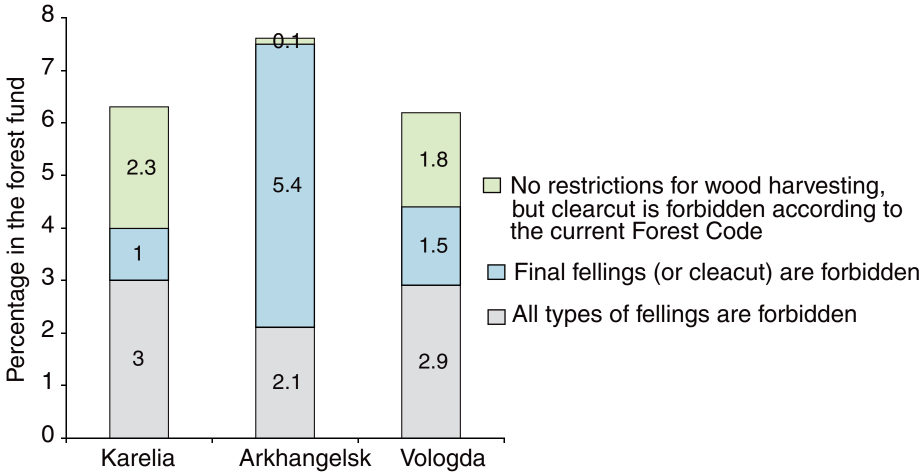


Fig. 3.49 The shares of official conservation areas according to restrictions for wood harvesting.

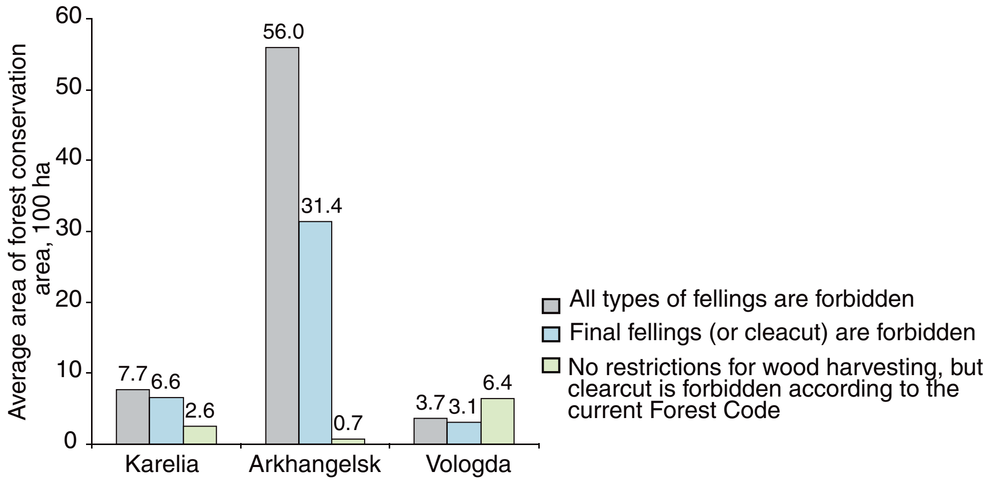


Fig. 3.50 Average size of official protected areas according to restrictions for wood harvesting.

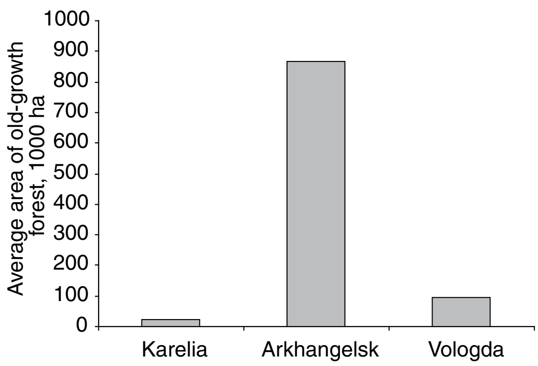


Fig. 3.51 Average size of old-growth forests.

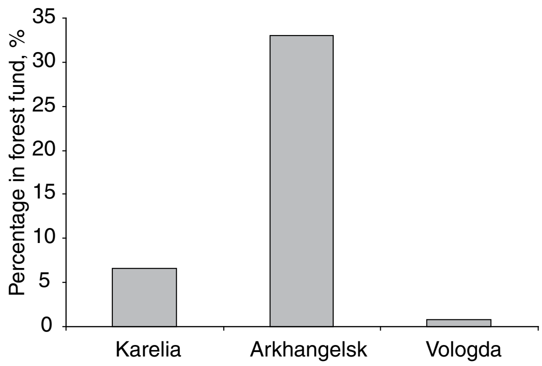


Fig. 3.52 The share of old-growth forests of the forest fund area.

Wood procurement organizations operating in Northwest Russia are nowadays paying more attention to nature conservation than in the past. It increases the need for reliable information on existing limitations for forest use including restrictions for wood harvesting, i.e. final felling, thinning, road construction and other operations. Therefore the collected data for the current state of areas having wood harvesting restrictions and their locations and possible limitations for wood harvesting will be very useful for planning wood procurement activities in Northwest Russia.

3.4.3 Environmental impacts of different wood harvesting methods and systems

The study was done based on field data partly collected also in the TACIS project "Comparison of Harvesting Methods - Impacts on Wood Quality and Overall Performance of Wood Harvesting Companies". Before estimation of environmental impact, wood harvesting methods and systems have been classified by:

- short distance transportation: trees or logs are skidded, assortments are forwarded
- tree felling: directly on ground, with vertical move to strip-road
- chassis: wheel, caterpillar
- transmission: mechanical, hydro volumetric, hydro mechanic

The environmental impacts are caused to:

- soil: track formation, compaction, change of porosity
- remaining trees: bark damage, tree tops and branches breaking off, stem slope, major roots cutting
- pollution of the environment: exhaust, oil.

The study was done in 13 clear cutting sites in summer time and in 7 clear cutting sites in winter time in the Republic of Karelia. Influence of thinning operations by tree-length and cut-to-length methods is shown in Table 3.4, decrease of soil porosity on the strip-road after logging in Figures 3.53-3.54, average depth of the track in Figure 3.55, soil mineralization in Figure 3.56, and undamaged state of undergrowth in Figure 3.57. Results show that cut-to-length systems (chain-saw+forwarder or harvester+forwarder) are better in thinning operations, because of less damages to upper layer of sandy soils. Traditional harvesting systems, especially based on western feller-bunchers, are better for undergrowth and strip-roads in loamy soils.

Table 3.4. Influence of thinning operations by TL and CTL methods (loamy soils, the composition of species is 40% spruce, 30% birch, 30% aspen).

Index	Unit	Harvesting method	
		Lumberjack + skidder TDT-55	Harvester + Forwarder
Share of strip roads and storages in the whole cutting area			
Road-side storage area	ha	0.11	0. 036
Width of strip-roads	m	4.5	3.8
Width of cutting strip	m	26	19.5
Share of strip-roads in cutting area	%	17	19
Influence on remaining growing trees			
Damage to remaining trees	%	2.6	1.5
Influence on small trees			
Undamaged small trees	%	81	85
Influence on soil			
Decreasing porosity	%	5	6
Share of mineralization	%	6	7
Depth of trail	m	0.07	0.14

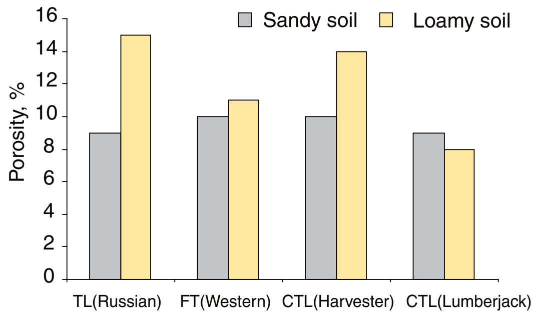


Fig. 3.53 Decrease of soil porosity on the main strip-road after logging.

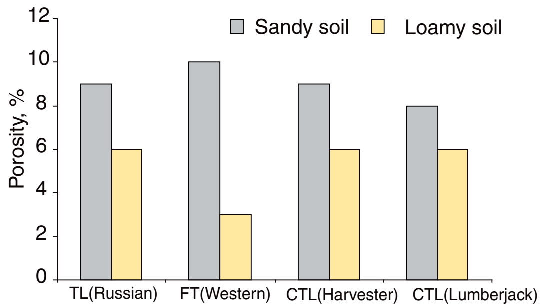


Fig. 3.54 Decrease of soil porosity on the logging trail.

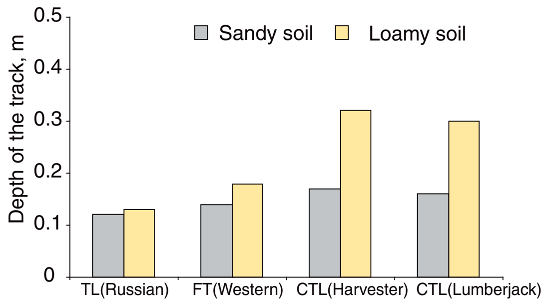


Fig. 3.55 Average depth of the track.

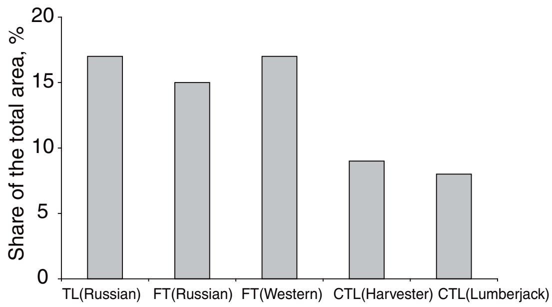


Fig. 3.56 Soil mineralization.

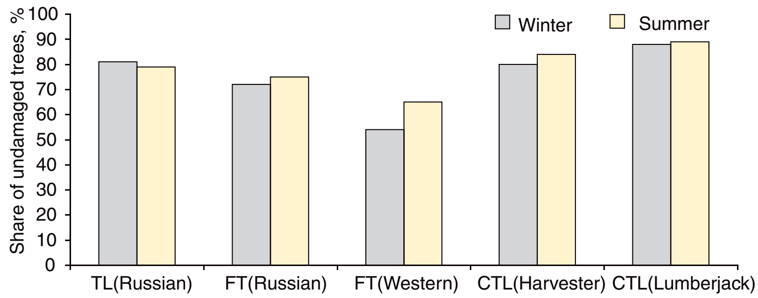


Fig. 3.57 Undamaged state of small trees.

Empirical investigations show that:

1. Skidding of trees and logs cause greater damages than forwarding to soil, small trees and remaining stand in the area of strip-roads. The major damages in trees after thinning when using skidding were on strip-road turnings. Small trees, less than a machine road clearance, are completely damaged on strip-road areas. Soil is damaged by both chassis and bunch of trees or logs. Sometimes the central track is carved on strip-road. Forwarding does no cause such damages.
2. The interaction between chassis and soil takes place during movement on a strip-road. However this interaction should also be taken into account when working loads from crane or other technological equipment are transmitted via chassis to soil and compaction is caused. Thus working areas of delimbers and processors on excavator chassis (Figure 3.58, Muezersky and Pudozhsky forest districts of Karelia) had significant soil damages. It is well-known that the machine movement nearby growing trees and even static pressure on soil more than 89 kPa

hampers fine root activity and thus decreasing growth by 15% during 3-4 years after the force. Wood harvesting machines carve deep tracks especially on wet soils. Water stands too long in the track, resulting amelioration of stands. Russian caterpillar machines and foreign harvesters and forwarders (especially equipped by caterpillar chains) have similar ground pressure. The influence of caterpillar feller-bunchers or harvesters on excavator chassis is weaker than harvesters and forwarders at the same number of passages.

Besides of compaction, soil is damaged by machine skid that lead to cut of the upper layer and intensive track formation (Figure 3.59). Such damages are typical when using Russian machines with mechanic transmission. Modern foreign forest machines have hydro volumetric or hydro mechanic transmission, which decreases the influence on soil.

Fig. 3.58 Delimber LP-30 (left) and processor Hitachi on excavator chassis (right).

Fig. 3.59 Results of several passages of forwarder (left) and caterpillar skidder (right).

Number of machine passages influences significantly on root system damages. The relationship between damages and number of passageways has S-shape increasing sharply between 3 and 9 passages.

3. Felling of trees directly on ground with chainsaws and harvesters causes bigger damages to remaining trees and small trees than felling method where trees are moved in vertical position to strip-road. In this last mentioned method feller-bunchers are used. Five percents of the total felling machines in Northwest Russia are feller-bunchers.
4. Inadequate skills of operators, difficult location of felled tree, too narrow strip-road, curved trajectory or slope are reasons for damages of machinery on environment. New machinery and proper training of operators can decrease damages to 2-3%.

3.5 Development program for improving wood procurement in Northwest Russia based on SWOT analysis

Gerasimov & Karjalainen (2008) have analyzed strengths, weaknesses, opportunities, and threats (SWOT) of wood procurement in Russia from a Finnish forest industry perspective. Paper considers potential technological, economic, social and environmental impacts on wood procurement development. Northwest Russia, including regions of Karelia, Komi, Arkhangelsk, Vologda, Leningrad, Novgorod and Pskov, plays key role in the Russian forest sector and has been well developed in comparison with the rest of Russia. In 2006 the region produced 37% of the total industrial round wood of Russia, 63% of the pulp, paper and cardboard, 38% of the plywood, and 27% of the sawn timber. For comparison Northwest Russia has only 10% of the forest land and 12% of the growing stock of the whole Russia. Nevertheless, the region not only supplies the domestic forest industry, but also the export market of industrial round-wood. In fact, Northwest Russia has been the most important industrial round-wood supplier to Europe, particularly the Nordic counties. Finland has been traditionally one of the key importers of Russian industrial round-wood. Round-wood export to Finland has been increasing steadily during the past 10-15 years and was approximately 17 million m^3 over bark in 2005. This was 31% of the round-wood export and equaled 24% of the consumption of industrial round-wood in Finland.

Well-known global Finnish corporations, such as Stora Enso, UPM-Kymmene and Metsaliitto, are not only the biggest importers of round-wood from Northwest Russia into Finland (Figure 3.60), they are also growing investors into Russian mechanical wood processing. Currently, 5 sawmills are owned by Stora Enso (Nebolchi, Impilahti), Metsaliitto (Podporozhye) and UPM-Kymmene (Chudovo-RWS, Pestovo), which collectively use approximately 1.8 million m^3 saw logs annually. Also Swedish owned Swedwood-Kostamuksha and Swedwood-Tikhvin and Austrian owned Mayer-Melnhof-Holz Efimovsky have invested into sawmilling in Northwest Russia.

Recent development in Russia suggests, however, that export of industrial round-wood is not going to increase any more, on the contrary to decrease. This is due to increasing export duties for round-wood. Aim of the Russian authorities is to decrease export of industrial round-wood and increase wood processing in Russia. Russia has also renewed forest legislation aiming at clarification of responsibilities and rights between state (forest owner) and private business (forest user), and also between the federation and regions.

Stagnation trends in Russian wood harvesting, the recovering forest industry of Russia (Figure 3.61), and increasing round-wood export (Figure 3.62) demonstrate importance for wood flow security. Taking also into account low utilization of allowable annual cut (currently 40%), low utilization of thinnings (15% of the harvested volume), and illegal wood harvesting activities (estimated to 20-25%), wood procurement operations could and should be further developed.

Wood procurement development in Russia, particularly in a foreign company, is characterized by a chain of ideas, plans, decisions and operations subject to constant uncertainty and lack of clear and reliable information. In such planning environment, analysis of strengths, weaknesses, opportunities and threats (SWOT) could be used to identify critical issues for wood procurement management in any situation and to organize them in a way that enables one to use sound strategic approach for decision making.

Strengths, weaknesses, opportunities, and threats of wood procurement have been analyzed in Northwest Russia from foreign, in particular Finnish companies' points of view. Based on the results of the analysis, some suggestions are proposed and outcomes are presented which may be utilized in decision-making. Qualitative and quantitative data from multiple sources, including the State Statistical Committee of Russia, the Ministry of Natural Resources of Russia, forest industry companies, NGOs, mass-media and own experience have been analyzed. Data has been categorized against key themes.

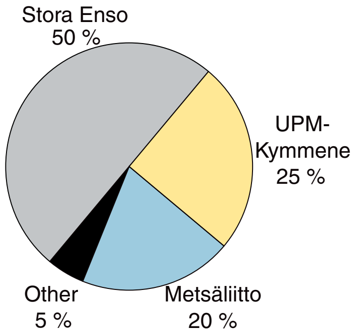


Fig. 3.60 The major importers of Russian round-wood in Finland, altogether 17 million m^3 in 2006.

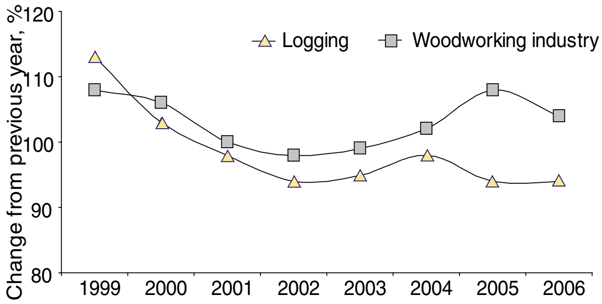


Fig. 3.61 Development trends in logging and woodworking industry based on production output.

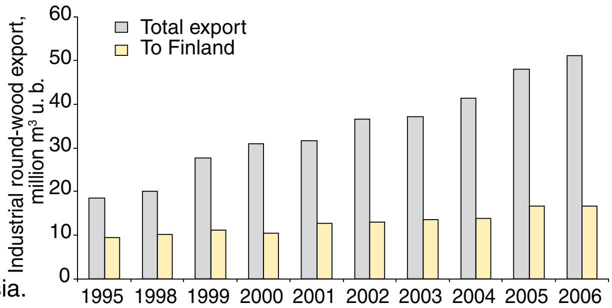


Fig. 3.62 Industrial round-wood export from Russia.

The SWOT analysis of the development of wood procurement in NW Russia covers following areas:

1 *general institutional factors*: forestry policy and legislation, educational conditions and programs, health and safety, export operations, operational organization, infrastructure
2 *wood harvesting factors*: allowable and actual forest resources, technology and machinery, productivity and utilization, compliance with legislation and norms, logistics
3 *industrial factors*: demand and supply of round wood, international investments, sustainable management including economic, environmental and social issues.

Strengths, weaknesses, opportunities, and threats of the wood procurement conditions in Northwest Russia from the foreign companies' point of view are presented in Table 3.5.

The preceding framework is provided as a starting point to assist in developing wood procurement in Northwest Russia from viewpoint of a Finnish wood procurement organization operating in Russia. Weaknesses and threats should be minimized or avoided, while strengths and opportunities should be matched to develop wood procurement. Because of the complexity of the task, problems have been classified in order to build a development program. Key issues for the development program include wood supply planning, wood sources, wood markets, logistics, harvesting, environmental responsibility, human resources and social responsibility for further discussion. Some weaknesses are not presented, however, the whole list of weaknesses should be processed in order to convert them into strengths, also threats should be converted into opportunities.

Table 3.5. Mapping of internal feasibility and external environment of wood procurement conditions in Northwest Russia from a foreign or Finnish organization point of view.

Strengths	Weaknesses
• Historical background in wood purchasing • Financial capability • All assortments buyer – also birch and aspen pulpwood which not common in Russia • Reputation as a reliable partner • Russian speaking management • Experience in domestic wood terminal operations • Experience in domestic logistics operations • Experience in domestic harvesting operations • Good knowledge about domestic wood market in border regions • Investments into mechanical woodworking and harvesting in Russia	• Weak synergy of wood supply planning with the allowable cut, logistics and logging operations, infrastructure conditions and market issue • Poor knowledge about distant wood resources • Economically and environmentally sound wood resources limited • Poor knowledge about wood market in distant regions • Seasonal fluctuation in wood delivery • Small share of controlled wood resources • Weak wood terminal network • Poor partnership system • Competition between and within other Finnish companies • Wood exchange not common • Size of assortment - hard to change, problem in the cross-cutting optimization • Dependence of wood trade companies • Stiff wood price system • Extensive forest management based on traditional logging technology dominated • High wood procurement cost • Incomplete system for tracing origin of wood • Forest certification (FSC, PEFC) are not common • Probability of illegal wood in the procurement chain • Low productivity of labor. High risk of accidents • Lack of qualified human resources in the countryside • Lack of skilled harvester/forwarder operators • Social obligations including unemployment
Opportunities	**Threats**
• Potential wood resources existing • Few species, coniferous dominant • Low utilisation level of allowable cut • Low stumpage price and labour cost • Possibility to acquire Russian logging companies • New forest legislation aiming to long term leasing agreements • GSM/GPS development • Transfer of technology from Scandinavia • Improvement of logistic operations in Russia • Developing forest industry • Growing Russian economy and consumption of wood products	• Poor infrastructure, roads network and high costs of developing it • Lack of all year forest roads • Strong competition, constantly growing wood prices • Integration process in wood business inside of Russia: competition on regional and national levels • Russian regional authorities influence on distribution of forest leases – lobby for the local companies • Necessity to Invest into local wood processing • Corruption • Unsound business practices (cash payment, bribery, terminals along the border) • Price speculation. Local and regional protectionism • Shortage of wagons and vessels • Customs and export regulations/duties • Illegal and unreported logging. Poor reputation as a business. • Lack of security of investments.

3.6 Conclusions

After dropping of wood harvesting in the 1990s, the beginning of this decade has been characterized by relative stability in wood harvesting. Biggest volumes are harvested in Arkhangelsk and Vologda regions (10 million m^3), the Republic of Komi, the Republic of Karelia and Leningrad region (5-7 million m^3). The annual allowable cut is used incompletely, approximately 45% in case of all species and 60% in case of coniferous species is used. Utilization of annual allowable cut in the Republic of Karelia is the highest in Russia (75%).

The quality of forest resources has been declining during the past 50 years, output of sawlogs has decreased 8%, half of the stands have 0.6-0.4 relative density and 12% of stands have less than 0.3. Logging companies are harvesting selectively as they prefer to cut coniferous stands.

Most of round wood is produced by large and medium sized companies which have remained and have been privatized after planned economy. The importance of small enterprises has been growing in Northwest Russia. Especially in Leningrad region number of small enterprises has grown significantly.

Status of technological, economic, social, and environmental issues in the logging companies vary greatly. Logging companies are becoming part of vertically integrated structures of pulp and paper mills or sawmills that have capacity to develop logging. Most of the surveyed logging companies use long-term lease (25 or 49 years) as a method for receiving logging permissions. According to the current Forest Code (2006), leasing of the forest areas is up to 49 years by auctions only. The Nordic cut-to-length method has been rapidly established. However, the tree-length method continues to play an important role as long as the old lower landing equipment is in good condition. Moreover, the traditional wood harvesting method is also supported by effective western machinery. The unit cost in wood harvesting is high and sometimes exceeds harvesting costs in Finland. The productivity of labor in the companies using traditional Russian machinery is extremely low. Analysis shows shortage of forest resources for wood supply in Karelia in the near future. This means that implementation of sustainable forest management based on commercial thinning operations and the Nordic cut-to-length method is needed. The implementation of the cut-to-length method based on the modernization of machines or western engineering is an opportunity. Carefully made modernization and introduction of new methods could improve the status of forest work among young educated people. This would help to attract more motivated and skilled employees to companies.

Harvested wood is delivered according to advance contracts to domestic pulp and paper mills, sawmills etc or exported. According to Russian official statistics, 18.8 million m^3 of round wood was exported in 2006 from Northwest Russia. This is supporting high wood prices on domestic market in Northwest Russia and benefiting logging companies. Increasing export duties for round wood has double meaning. On the one hand, developing of wood processing in Russia is supported by the Russian government and society. On the other hand, logging companies are concerned about price dumping by domestic pulp and paper mills and lack of processing industry for birch and aspen.

One of the main challenges in wood procurement is forest road construction. Roads density in Northwest Russia is poor in comparison to Finland and varies from 1.2 km/1000ha in Komi to 11.6 km/1000ha in Pskov. This is due to high costs of road construction and limited financial possibilities of forest leasers. Moreover, half of the forests have low bearing capacity which increases cost of construction substantially. In the near future these forest areas will continue to be harvested during winter seasons only by temporary winter roads. Lack of infrastructure prevents efficient introduction of cut-to-length technology, and intensive forest management. Another challenge is low utilization of thinnings. Approximately 4.5 million m^3 or 12% of the total actual cut in Northwest Russia was from thinning operations in 2005. This is due to poor road network, lack of appropriate technology and intensive forest management traditions and norms.

Nordic and Russia wood harvesting technology differs greatly. Full-tree, tree-length, and cut-to-length method are applied in Northwest Russia;. Wood harvesting systems are classified as fully mechanized and partly mechanized. Fully mechanized system means that all logging operations are implemented with forest machines (harvester + forwarder, feller-buncher + skidder + delimber, etc). In partly mechanized systems some operations are implemented with chainsaw or axe.

Cut-to-length method has been introduced by many logging companies especially in the Republic of Karelia and Leningrad region. The most common machines are medium sized forwarders and harvesters. Small sized harvesters are not common. Heavy harvesters are usually based on excavators. CTL systems in Northwest Russia are supported by introducing of leasing, high reliability, good ergonomic and ecological performance of harvesters and forwarders, reduction of annual allowable cut in industrial regions and possibility to introduce thinning operations, increasing attention to ecological impacts of wood harvesting, sustainability requirements for forest management, need for frequent moving of machinery in small logging areas, better quality of industrial round wood, possibility for monitoring wood removals in logging area, and increasing safety requirements on public roads.

Wood harvesting construction industry in Northwest Russia continues in the Onego tractor plant. They produce two models of traditional caterpillar skidders, currently 200-300 machines per year. Overall quality and design of skidders are poor. Ergonomics of the skidders correspond to Russian standards, but is much below the Nordic requirements.

Extraction of short-wood from the harvesting processes is becoming more common practice in Northwest Russia particularly in Karelia and Leningrad region. Short-wood transport is expected to increase also in other parts of Russia. Application of cut-to-length method would allow to increase productivity of wood harvesting and thus improve economics of the logging operations. At the same time, harvesting of forest resources by cut-to-length method causes less environmental impacts than traditional methods and improves the ecological state of forest sites both in short and long term.

Review of existing logistic methods and approaches applied in Russia show that logging companies are using different approaches. These approaches do not provide good basis for economic analysis. Moreover decision making is strongly based on the experience of logistic manager without supporting software. Approaches are suitable for companies which utilize traditional tree-length technology and one central processing yard. Introduction of the Nordic cut-to-length technology requires more attention to wood transport logistics as round wood from cutting areas has to be delivered directly to several customers, terminals, and railway stations. GIS-based decision support program has been developed to assist logging companies in decision making related to planning, utilization and optimization of vehicle fleet. Searching of optimal routes could be used also for other applications, i.e. forest road planning, fuel supply, seedling transportation etc. Application of the program and comparison of alternative delivery plans show that the efficiency of short-wood transport can be increased by 40%. Application of the program allows computer based processing of delivery plans and thus provides possibilities for easy production of several alternatives which take into account possible changes both inside and outside the organization. And most importantly, the program allows to optimize transportation operations.

Economical case-study of logging companies shows similar average wood harvesting costs at road-side for all used wood harvesting methods and systems, approximately 7 €/m^3. But, when cut-to-length method is applied the company has industrial round-wood. When using tree-length and full-tree methods logs need further processing at central processing yard and additional production cost of 6-8 €/m^3.

Environmental impacts case-study in logging companies shows that cut-to-length systems are better in thinning operations, cause less damage to upper layer of sandy soils. However the traditional harvesting systems, especially based on western feller-bunchers, cause less damages to undergrowth and strip-roads in loamy soils.

The risk of unreported round wood in the wood flow (estimated to be 23%) has to be taken into account when tracing the origin of wood for forest industries, as a part of the chain of custody. Northwest Russian regions can be classified for possible unreported industrial wood flows as:

- High domestic utilization, low level of export (abroad and to other regions), small share of unreported flows: Arkhangelsk, Komi.
- Average domestic utilization, average level of export, small share of unreported flows: Karelia, Vologda.
- Average domestic utilization, average level of export, large share of unreported flows: Leningrad, Novgorod, Pskov.
- Low domestic utilization, high level of export, large share of unreported flows: Murmansk.

Wood procurement organizations operating in Northwest Russia are at present paying more attention to nature conservation than in the past. It increases the need of reliable information on existing limitations for forest use and restrictions for forest operations, including final felling, thinning, road construction and other operations. Therefore the collected data for the current state of areas having wood harvesting restrictions and their locations and possible limitations for wood harvesting are useful for planning wood procurement activities in Northwest Russia.

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4 Future development and economic accessibility of forest resources in Northwest Russia

4.1 Introduction

The forest resources of the European part of Russia are vast (appr. half of the European forests), and form a major part of the total timber trade in Europe. The Russian Federation's forest resources amount to appr. 883 million hectares of forest land and the Northwest Russia's forest land to almost 90 mill. ha (Karvinen et al. 2006). This equals about 26% of the whole European forest area. The forests in the Northwest Russia are in the boreal zone, and the most common tree species are spruce, pine, and birch. Other species include aspen and larch. The forests are categorised into three groups and each group has its own set of management tasks that can be executed (Pisarenko et al. 2001).

Nearly half of the forests in European part of Russian Federation (145 mill.ha) are located in the Northwestern part, i.e. nearly 78 million hectares (UN-ECE FAO 2000, Pisarenko et al. 2001). Currently annual allowable cut (AAC) is approximately 16% less than it used to be before the collapse of Soviet Union in 1990. In European part of Russia, the AAC is approximately 224 million m3, but actual harvesting is only about 35% of the AAC. However, it is more than in the Siberian part, where it is less than 15% of the AAC. While harvesting levels are much lower than they were before 1990, they have been recovering slowly since 1998 (Gosudarstvennyj doklad o…2004). A majority of the procured wood is exported, mainly as roundwood and sawn logs, but also as chips, plywood and pulp.

At least theoretically it would be possible to intensify harvesting in Northwest Russia, but due to existing protected areas, available infrastructure (logging, transportation, forest industries), much less of the resources are technically, ecologically and economically accessible as discussed in ealier chapters of this report and later in our maps. Poor road conditions, frost damages to the roads, lack of forest roads and large amounts of wetlands have concentrated the forest harvesting to areas which are close to railways, main roads and watercourses, i.e. in easily accessible areas. Having cut the mature forests from the roadsides, the less valuable and young forests dominate in accessible areas and the mature and over mature forests in remote areas are not harvested. With modern technology, harvesting is possible in thick, remote forests as well, if no consideration is given to the costs involved. If/when the costs are considered, it becomes economically infeasible to harvest in these areas.

The large discrepancy between forest resources and economically accessible forests is among the largest problems in forest management of Russian federation (Niskanen et al. 2002). As the industry needs wood supply, increasing pressure has been put on harvesting those ecologically valuable forests, which are accessible. If the economically accessible areas with mature forests were known more precisely, and those with no significant ecological value were identified, it would make the decision regarding wood harvesting substantially easier.

Development of the forest sector in Northwest Russia requires analysis of the theoretical and technical accessibility of forest resources and restrictions therein due to ecological and economic reasons. This basic information is a necessary input also in the other studies regarding forest sector development in northwest Russia.

Analysis of forest resources and their future development has been based on applications of the EFISCEN scenario modelling approach. Main output covers tree species and age class composition, growing stock, increment of forest resources up until 2058. Chapter 4.3 includes results from GIS analyses on the economic and physical accessibility of forest resources, with special emphasis on the Novgorod region. Chapter 4.4 concludes with discussion on the main results and identification of future research needs.

4.2 Future development of forest resources in Northwest Russia

4.2.1 Aim and method

The objective of this project was to get insight of possible long-term development of forest resources and wood supply in Northwest Russia. There are a lot of uncertainties in the long term development of forest resources, e.g. demand of wood, climate change, natural disturbances and other needs of society for forests, and therefore, the selected scenarios in this study presents only a small sample of possible future development.

In this study European Forest Information Scenario (EFISCEN) model has been used to simulate development of forests in Northwest Russia. The model structure has been described in more detail in Pussinen et al. (2001). The same method has previously been used for forest resource projections in Russia for Leningrad (Päivinen et al, 1999), Arkhangelsk (Trubin et al. 2000) and Vologda region (Lyubimov et al. 2003).

EFISCEN is a timber assessment model, which means that the user specifies a certain harvest level and the model checks if it is possible to harvest that amount and simulates the development of the forest under that harvest level. The forest area is first divided into forest types. For each country different forest types can be distinguished by region, owner class, site class and tree species depending on the level of detail of the input data. The development of forest resources is depicted as an area distribution over age and volume classes over time.

Forest management is controlled at two levels in the model. First, a basic management for each forest type, like thinning and final felling regimes, is incorporated. These regimes constrain forest management, e.g. rotation length, and they are based on current management. Second, the required total volume of the harvest is specified for each region for conifers, deciduous tree species for each time period.

4.2.2 Data

EFISCEN requires data by different forest which are distinguished by region, owner class, site class and tree species. For each forest type the following data should be available for each age class:

- area (ha)
- average standing volume over bark (m^3 ha^{-1})
- net current annual increment over bark (m^3 ha^{-1})

For this study we used data from Pisarenko et al. (2001) since no more recent data on sufficient detailed level on forest area/forest type/age class by regions were available. The same data has been used to make forest resource projections for the European Forest Sector Outlook Studies of the UN-ECE (Schelhaas et al. 2006).

The total forest land area of Northwest Russia in this study was 89.6 million ha, which is very close to more recent published 89.0 million ha by Karvinen et al. (2006). The difference of these two data sources is 5 years and both include all forest land. The total volume estimate is also very close, 9.94 billion m^3 in our study and 10.1 billion m^3 in Karvinen et al. (2006).

The data used made it possible to distinguish three forest management groups: protection forests, multipurpose forests and forests for commercial use. Three tree species groups were distinguished:

1 Coniferous species: Pine, spruce, larch, Seberian cembra pine, fir
2 Soft broadleaved species: Birch, aspen, lime
3 Hard broadleaved species: Oak, beech, maple

4.2.3 Scenarios

In the EFISCEN model it is possible to make future scenarios by changing forest area (afforestation, deforestation), changing amount of felling, changing ratio between final felling and thinning, changing management regimes, changing growth due to e.g. climate change, changing tree species after final felling and all combinations of previous. In order to simplify results tree scenarios which are suitable to the framework of the whole research project ‘Towards Progressive Forest Sector in Northwest Russia’. The scenarios are carried out systematically, i.e. they are not designed to fulfil any interests of groups or all current regulations, e.g. amount of allowable cut. The scenarios are the following:

Baseline- scenario, demand is increasing only in the beginning of simulations and forest management, i.e. rotation length, is as now. The basic demand is based on Pisarenko et al. (2001). However, during two first simulation steps (until 2003) demand increases 10 % per simulation step as in all scenarios in order to produce comparable current state of forests between all scenarios. We assumed, based on Pisarenko et al. (2001, Figure 5.1) that the share of bark and logging residues is 51 % of removals under bark, i.e. removals were multiplied by 1.51 in order to get fellings.

Increased fellings- scenario, demand of wood, i.e. fellings, is increasing every five years simulation period 10 % from previous five years simulation period. Ten percentage increase per five years was selected to represent fast but realistic increase, since infrastructure, demand of wood and human resources limit more rapid increase of fellings.

Increased felling and thinning- scenario, (later called ‘more thinning scenario) fellings are increasing as previous scenario but share of thinnings is increased gradually (in three simulation steps of five years) to 30%. This relation of thinnings and final felling is close to current management practises present in Finland.

4.2.4 Results

In results section increment is always expressed as Net Annual Increment (NAI), which is a difference between gross annual increment and natural losses. Fellings are the part of growing stock, which is lost due to logging and silvicultural activities. Note that removals over bark are fellings minus logging residues and transport losses. The results will be next presented by different regions.

Arkhangelsk region

The forest area in Arkhangelsk region was 22.5 million hectare and more than 80 % was coniferous dominated. Nenetskiy autonomic district is not included in the study. Fellings between 2003 and 2008 were 75% of the net annual increment (Fig. 4.1). In increasing felling scenario fellings exceeded net annual increment after 20 years but there was enough mature forest to provide enough timber .

Net annual increment was27 % higher in 2058 when more forests are thinned, i.e. part of natural mortality was thinned. Under other two scenarios there were no difference in the net annual increment, since old and very young forests grow slow and under more final fellings scenario old forests are transferred to young forests in 50 years. Later on net annual increment would be higher under increasing fellings scenario when regenerated forests reach middle age classes.

The average volume in Arkhangelsk was 112 m^3/ha in 2008 and under baseline scenario it increased to 130 m^3/ha (Fig. 4.2). Under other two scenarios the average volume started slightly decrease after the year 2033.

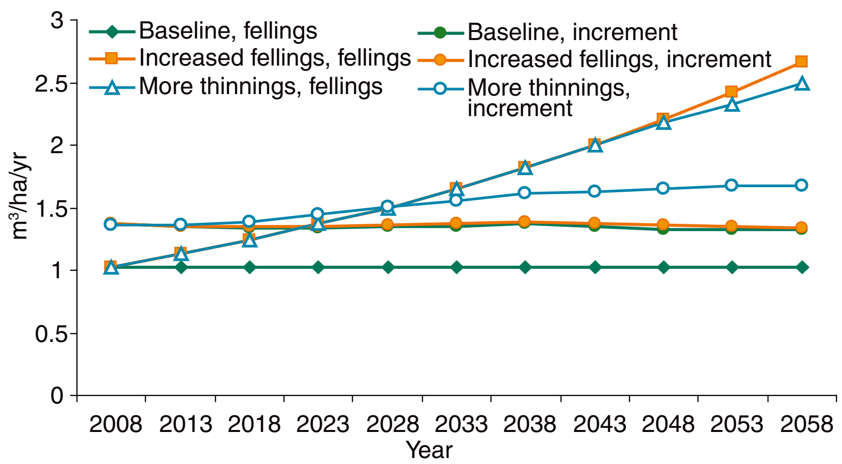

Fig. 4.1 The average net annual increment and fellings in Arkhangelsk region from 2008 to 2058 under three different scenarios.

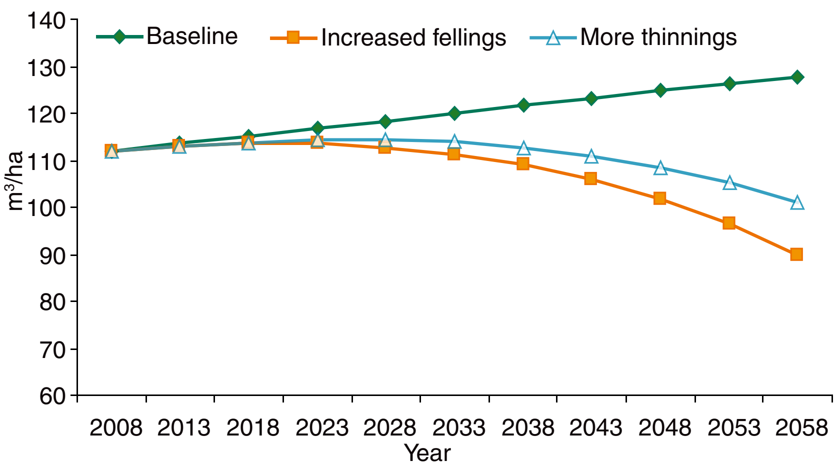

Fig. 4.2 The average standing volume in Arkhangelsk region from 2008 to 2058 under three different scenarios.

In 2008 there was more than 7 million hectare forests, about one third of the forest area, older than 140 years (Fig. 4.3). Under business as usual scenario age class distribution stayed very close to current distribution. Increasing fellings scenario decreased the amount of old forests to three million hectare in 2058.

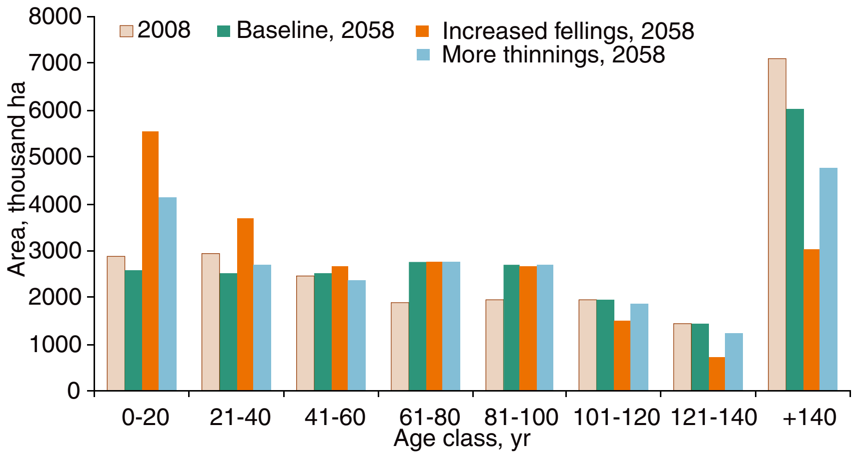

Fig. 4.3 Age class distribution in 2008 and in 2058 under tree different scenarios in Arkhangelsk region.

Vologda region

The forest area in Vologda region was 8.0 million hectare and 55% was dominated by conifers. In the beginning fellings and net annual increment were close to each other (Fig. 4.4). This indicates that forests are rather intensively utilised in Vologda region. This can be seen also in Figure 4.6 since age class distribution is quite even distributed. Under more felling scenario there is not enough mature forest to fulfil demand in the end of simulation period. The use of thinnings increased net annual increment by 24% as compared to baseline scenario.

The mean volume was 140 m^3/ha in 2008 (Fig. 4.5). The baseline scenario produced rather stable mean volume while other two scenarios resulted declining average growing stock. In this case it seems to be proper to select felling level of baseline scenario and increase thinnings if there is more demand for wood. However, the felling level of baseline scenario was already 14.5 million m^3/yr which results about 10 million m^3/yr removals over bark when we take into account logging residues and losses during transportation.

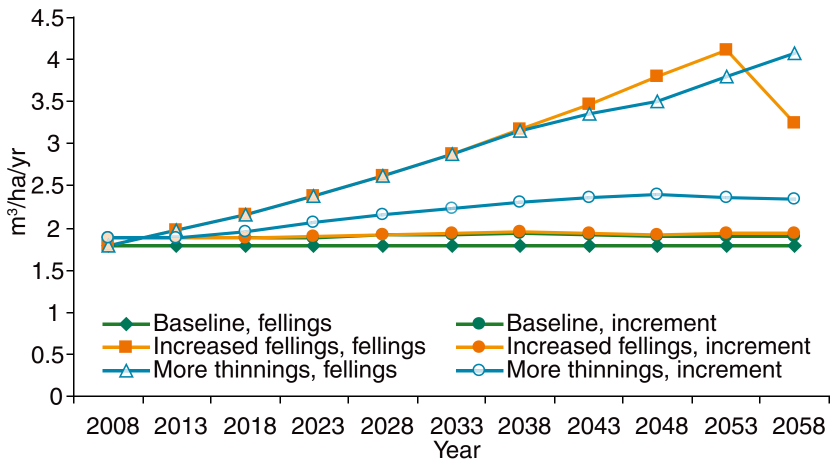

Fig. 4.4 The average net annual increment and fellings from 2008 to 2058 under three different scenarios in Vologda region.

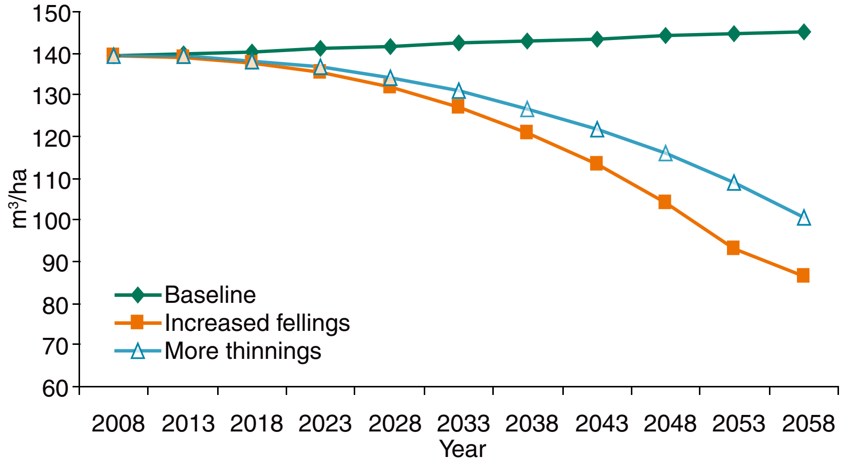

Fig. 4.5 The average standing volume from 2008 to 2058 under three different scenarios in Vologda region.

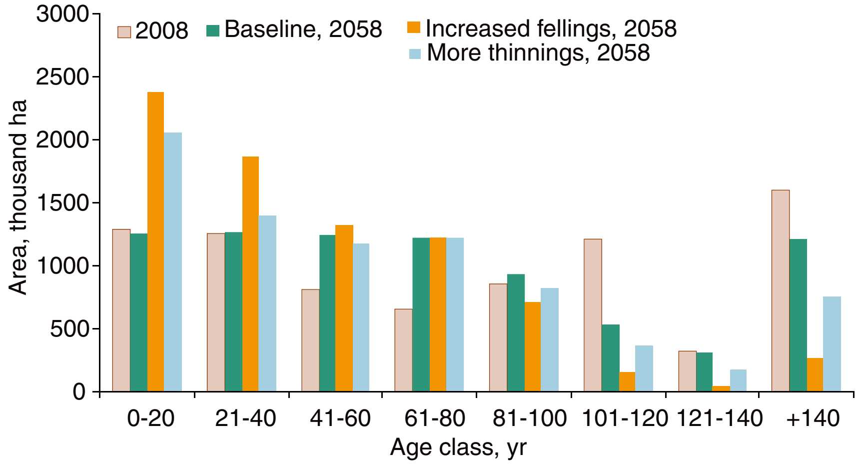

Fig. 4.6 Age class distribution in 2008 and in 2058 under tree different scenarios in Vologda region

Murmansk region

The forest area of Murmask region was 5.6 million hectare and 74% is dominated by conifers. Net annual increment is lowest in North-West Russia, only 0.8 m^3/ha/yr, and fellings only 0.2 m^3/ha/yr (Fig. 4.7). Under cold climate forestry is not the most important function of forests in Murmansk region.

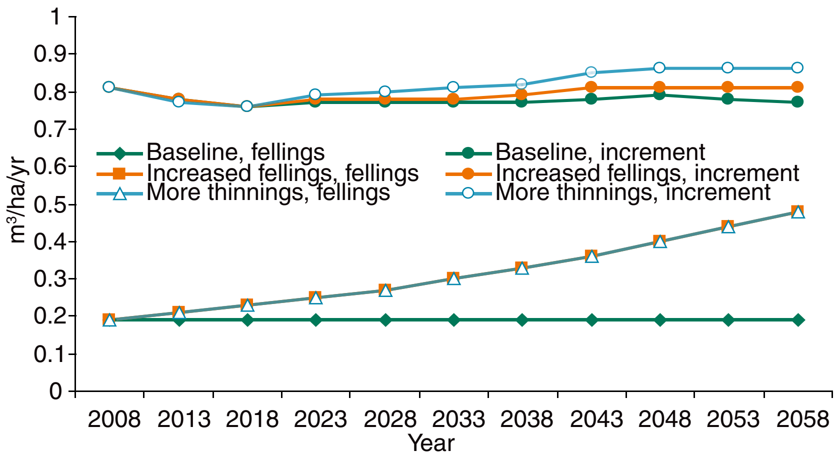

Fig. 4.7 The average net annual increment and fellings from 2008 to 2058 under three different scenarios in Murmansk region.

The mean volume was about 48 m^3/ha in 2008 and under all scenarios the average growing stock was increasing (Fig. 4.8). In 2008 about one third of forest area was older than 140 years and due to low utilization rate the forests got older under all scenarios (Fig. 4.9).

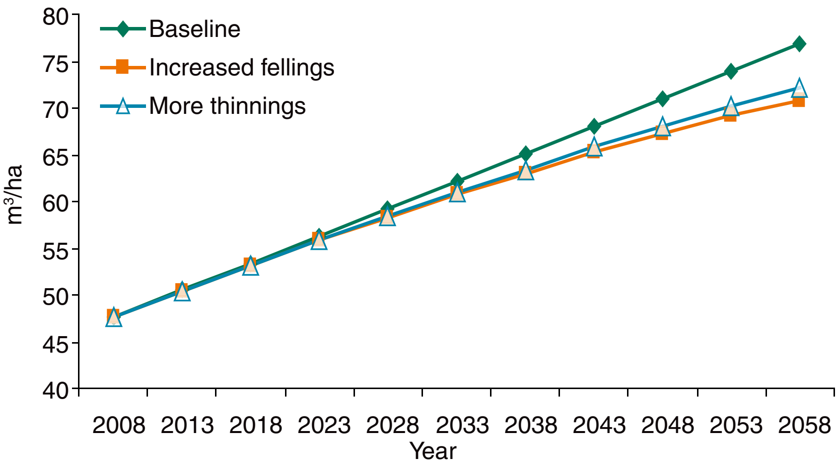

Fig. 4.8 The average standing volume from 2008 to 2058 under three different scenarios in Murmansk region.

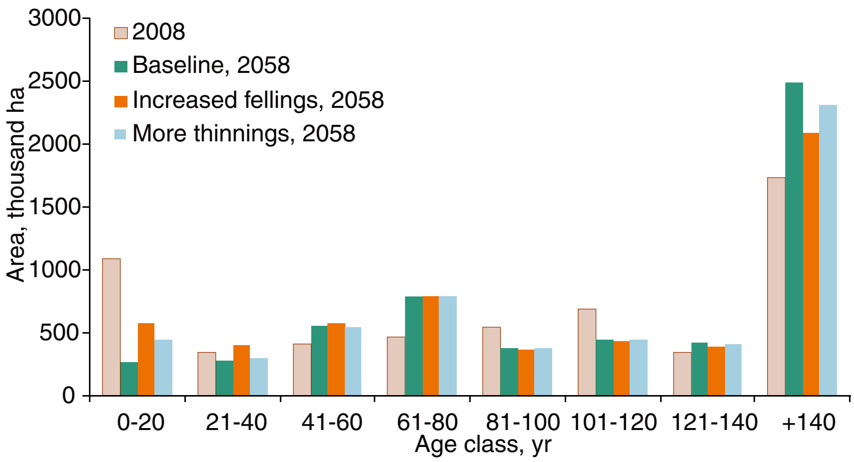

Fig. 4.9 Age class distribution in 2008 and in 2058 under tree different scenarios in Murmansk region

Republic of Karelia

The forest area of Karelian rep. region was 10.4 million hectare and nearly 90% was dominated by conifers. In our scenario 74% of the net annual increment was utilised in 2008 (Fig. 4.10). Under increased fellings scenario there was not enough old forests to be cut during the last simulation period. Under baseline and increased fellings scenarios increment was rather stable until 2058. Under increased thinnings scenario increment increased by 17% compared to baseline scenario.

The mean volume was 99 m^3/ha in 2008 and under baseline scenario it increased to 122 m^3/ha in 2058 (Fig. 4.11). Under other two scenarios the average volume decreased during last 20 years. In 2008 there was a lot of forest over 140 years age, but not much forests between the age of 100 and 140 years (Fig. 4.12). There was also quite a lot of younger age classes, which indicates that forest utilisation has increased gradually in Karelia as compared to more stable situation in some other regions.

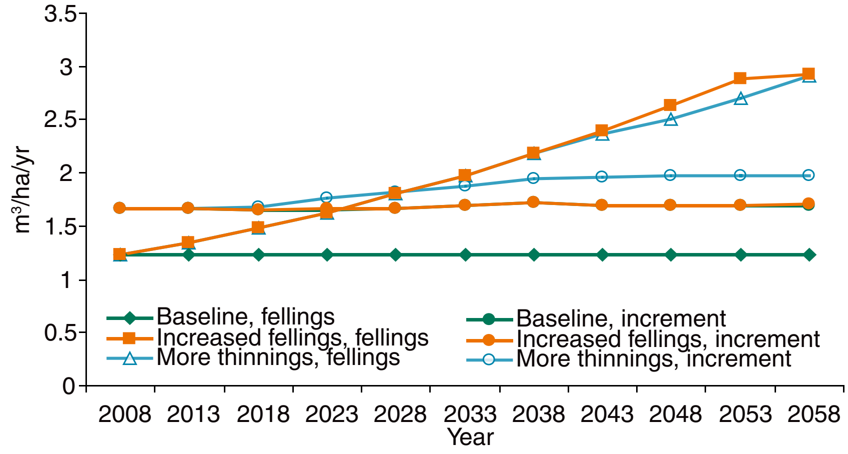

Fig. 4.10 The average net annual increment and fellings from 2008 to 2058 under three different scenarios in Karelia region.

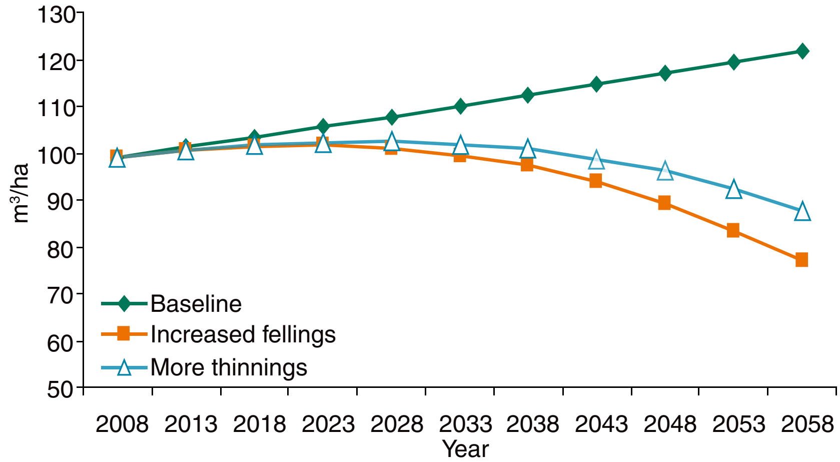

Fig. 4.11 The average standing volume from 2008 to 2058 under three different scenarios in Karelia region.

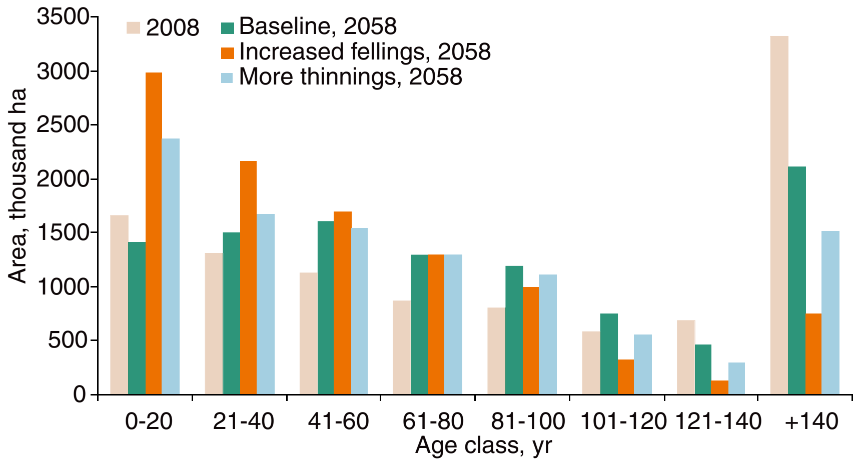

Fig. 4.12 Age class distribution in 2008 and in 2058 under tree different scenarios in Karelia region.

Republic of Komi

The forest area in Komi rep. region was 32.3 million hectare, the largest in North-West Russia, and 82% of the area was dominated by conifers. According to simulation, in 2008 fellings were 56% of increment. The net annual increment decreased slightly under baseline and increased fellings scenario, but increased under more thinnings scenario from 1.2 m^3/ha/yr to 1.44 m^3/ha/yr in 2058. This was 25 % more than increment of baseline scenario (Fig. 4.13).

The mean volume was 109 m^3/ha in 2008 and under baseline scenario it increased to 135 m^3/ha in 2058 (Fig. 4.14). Forests were able to provide wood for the increasing fellings scenario and the mean volume did not decrease under the average volume in 2008. The age class distribution show that there are a lot of old forests in 2008 and even increased fellings did not decrease amount of old forest significantly in 2058, i.e. the forest resources of Komi are rather vast and utilisation of forests can be increased a lot during the next 50 years (Fig. 4.15).

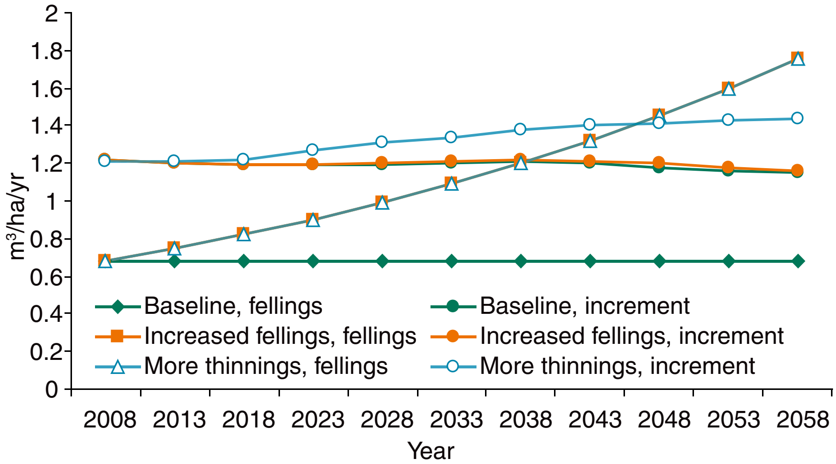

Fig. 4.13 The average net annual increment and fellings from 2008 to 2058 under three different scenarios in Komi region.

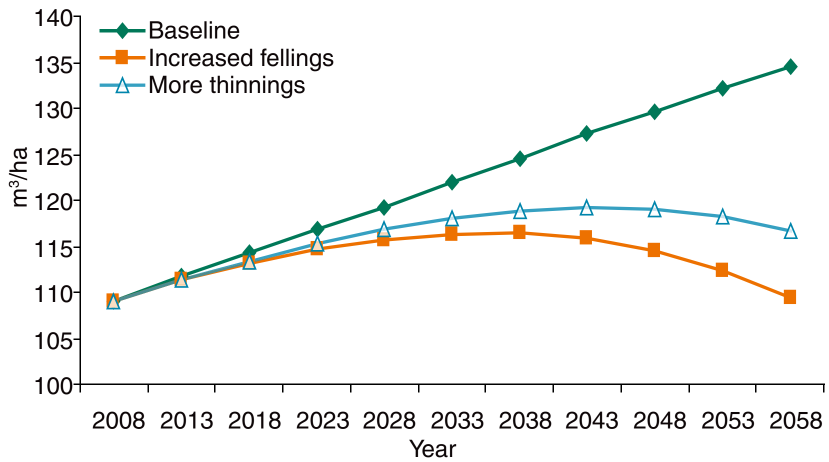

Fig. 4.14 The average standing volume from 2008 to 2058 under three different scenarios in Komi region.

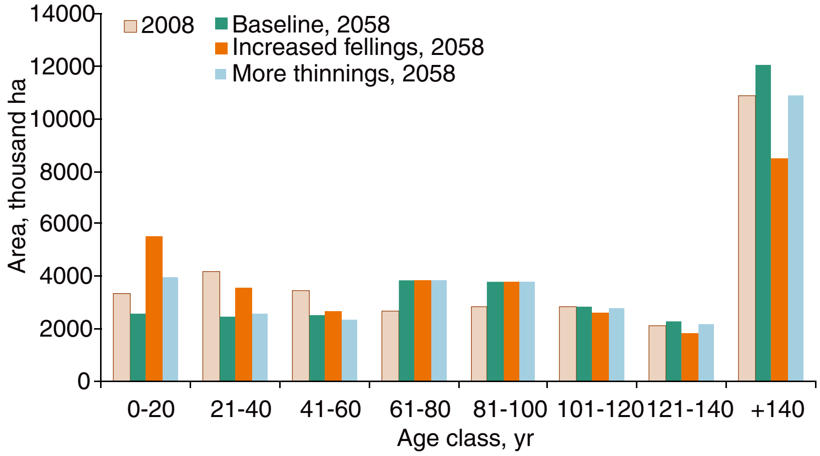

Fig. 4.15 Age class distribution in 2008 and in 2058 under tree different scenarios in Komi region.

Leningrad region

The forest area of Leningrad region was 5.4 million hectare and 66% was dominated by conifers. About half of the net annual increment was felled in 2008 (Fig. 4.16). The net annual increment decreased quite strongly under baseline scenario, to 76% of the value in 2008. Instead, under more thinning scenario, the increment was rather stable.

The mean volume was 197 m^3/ha in 2008 and it increased under all scenarios (Fig. 4.17). Under baseline scenario it reached 258 m^3/ha in 2008. The age class distribution differed from many other regions (Fig. 4.18) since there were a lot of middle aged forests in 2008. Under baseline scenario the amount of old forests doubled and only increasing felling scenario resulted less old forests in 2008 than in 2058.

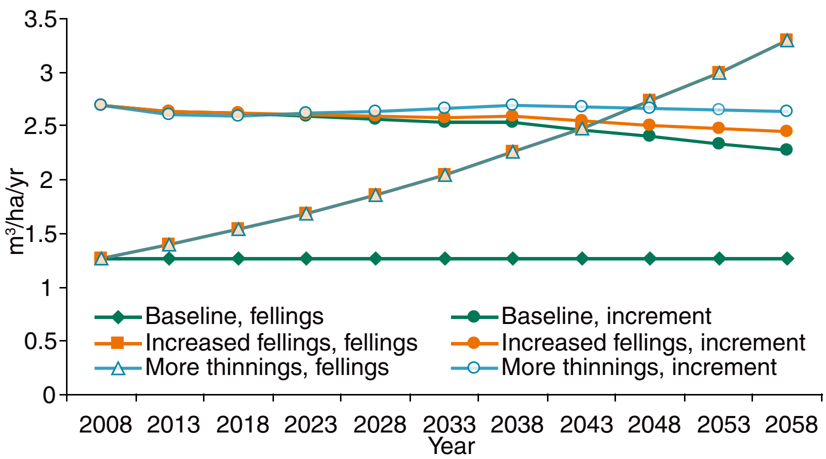

Fig. 4.16 The average net annual increment and fellings from 2008 to 2058 under three different scenarios in Leningrad region.

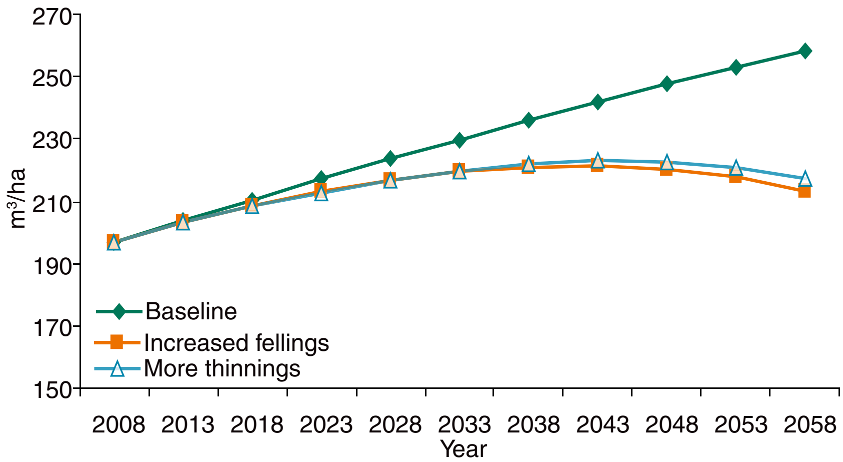

Fig. 4.17 The average standing volume from 2008 to 2058 under three different scenarios in Leningrad region.

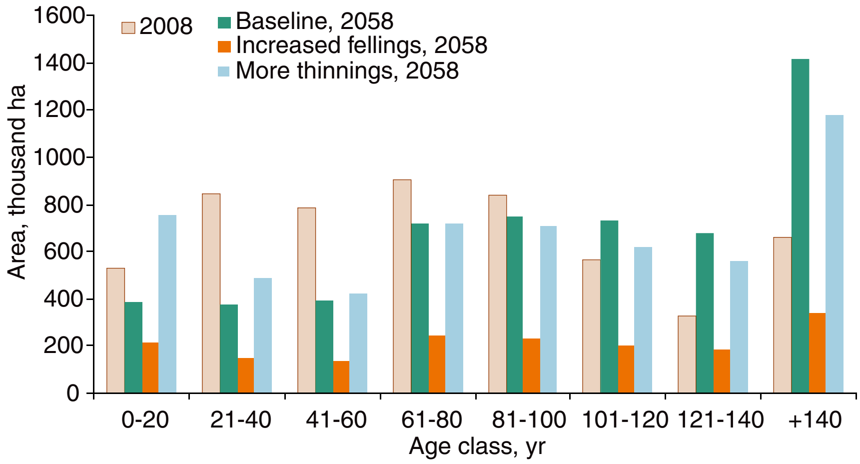

Fig. 4.18 Age class distribution in 2008 and in 2058 under tree different scenarios in Leningrad region.

Novgorod region

The forest area of Novgorod region was 3.4 million hectare and 43 % of the area was dominated by conifers. In 2008 the level of fellings were only 39% of increment (Fig. 4.19). Under baseline scenario ageing forests resulted declining net annual increment and only more thinnings scenario resulted stable increment.

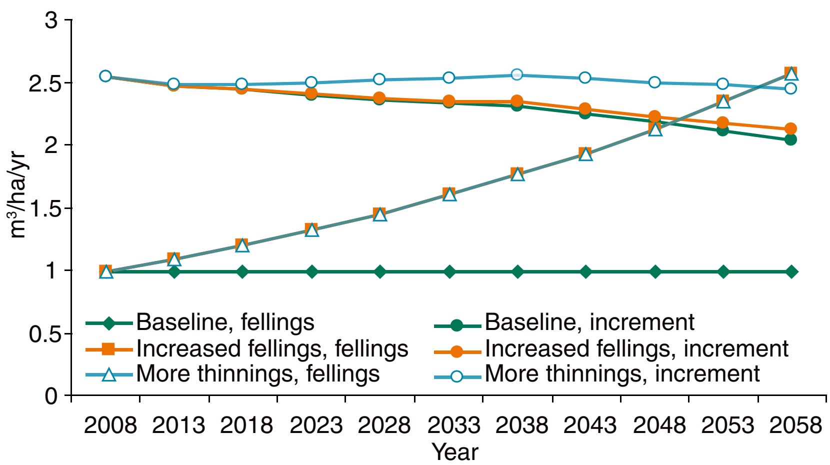

Fig. 4.19 The average net annual increment and fellings from 2008 to 2058 under three different scenarios in Novgorod region.

The mean volume in Novgorod was 195 m^3/ha in 2008 and under all scenarios it increased during simulations (Fig. 4.20). Also in Novgorod region there was a lot of middle aged forests and their low utilisation level results more old forests in the end of simulation period (Fig. 4.21).

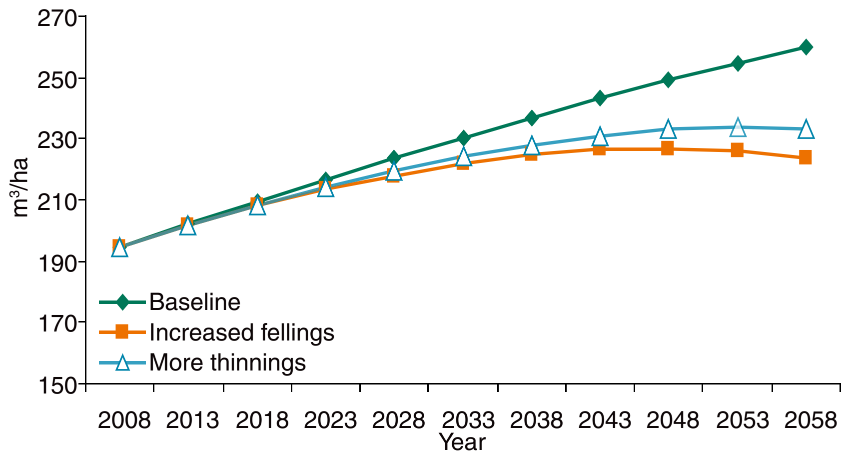

Fig. 4.20 The average standing volume from 2008 to 2058 under three different scenarios in Novgorod region.

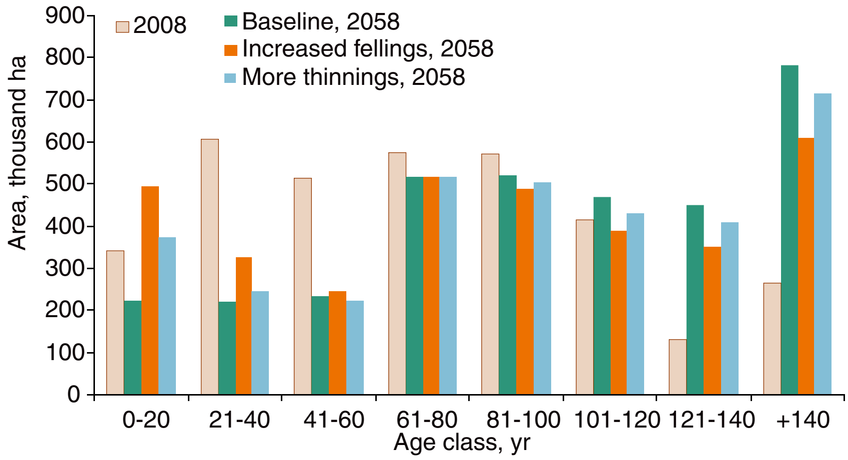

Fig. 4.21 Age class distribution in 2008 and in 2058 under tree different scenarios in Novgorod region.

Pskov region

The forest area of Pskov region was 1.9 million hectare and 56% of the area was dominated by conifers. In 2008 fellings were only 38% of increment (Fig. 4.22) which was about 2.5 m^3/ha/yr. Under baseline scenario increment decrease close to 2 m^3/ha/yr. Under more thinnings scenario increment is 16% higher than under baseline scenario in 2058.

The mean volume was 159 m^3/ha in 2008 and under all scenarios the average growing stock was increasing (Fig. 4.23). The age class distribution is rather even in the beginning which indicate rather intensive management in the past (Fig. 4.24). Therefore, the low current utilization rate is rather surprising. Under all scenarios forests got older and area in oldest age class in 2058 doubled compared to 2008.

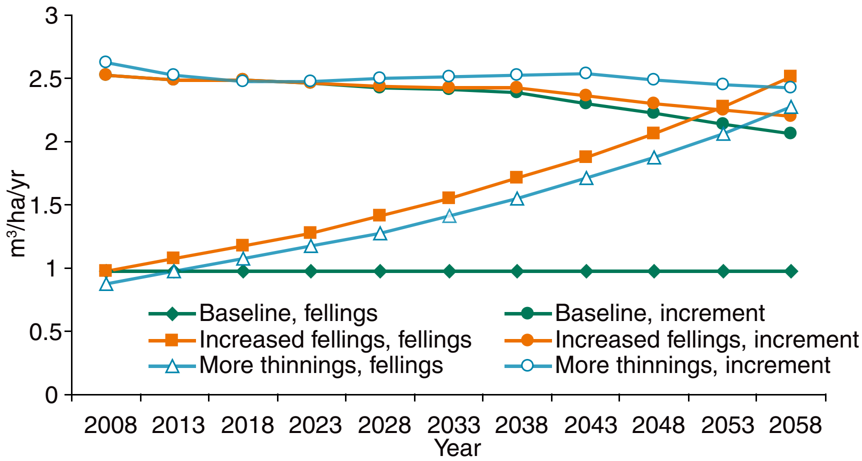

Fig. 4.22 The average net annual increment and fellings in Pskov region from 2008 to 2058 under three different scenarios.

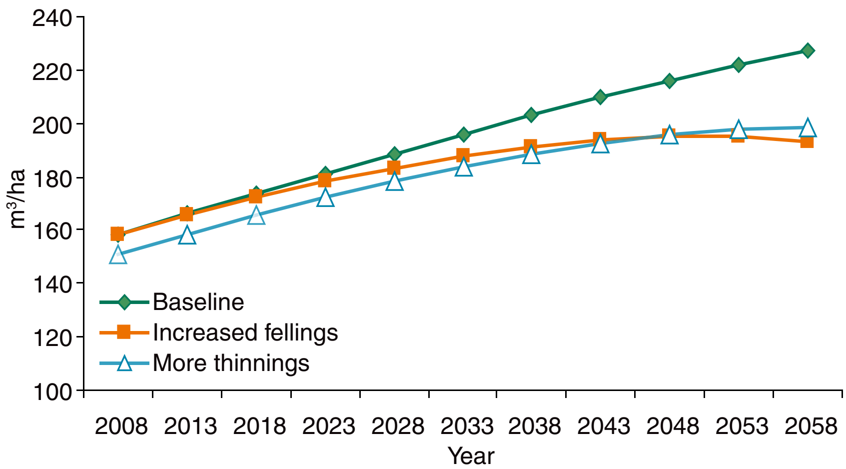

Fig. 4.23 The average standing volume from 2008 to 2058 under three different scenarios in Pskov region.

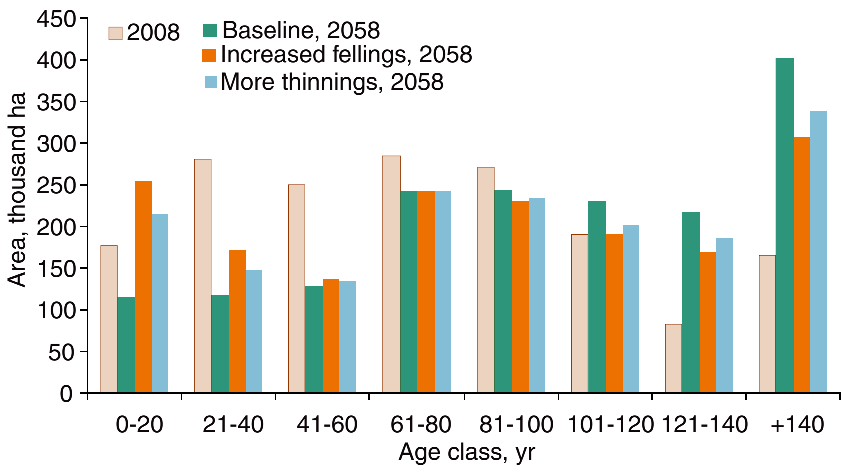

Fig. 4.24 Age class distribution in 2008 and in 2058 under three different scenarios in Pskov region.

Northwest Russia

The average growing stock in 2008 was 117 m^3/ha in Northwest Russia (Table 4.1 and Figure 4.25). Under baseline scenario it increased to 143 m^3/ha in 2058. Increasing final fellings to more than 200 million m^3 per year resulted slightly smaller growing stock in 2058 than in 2008. (Fig. 4.26) When share of thinnings was 30 % of increasing fellings the average growing stock was at the same level in 2058 as in 2008.

Table 4.1 Average standing volume of growing stock, fellings and net annual increment in 2008 and in 2058 under three scenarios in Northwest Russia.

	Average growing stock, m^3/ha	Fellings, million m^3/yr	Net annual increment, million m^3/yr
2008	117.1	85.3	134.9
Baseline, 2058	142.8	85.3	126.9
Increased fellings, 2058	108.6	206.9	129.8
More thinnings, 2058	117.3	209.6	155.3

Under baseline the net annual increment decreased from 135 million m^3 per year in 2008 to 127 million m^3 per year in 2058 since forests get older under low utilisation level. Increasing fellings scenario results only slightly higher increment since fellings increase gradually and in 50 years this scenario can not produce middle aged forests with high increment. Therefore, the two scenario lines in Figure 4.25 practically overlap. Under thinnings scenario the net annual increment increases to 155 million m^3 per year in 2058 due to lower mortality.

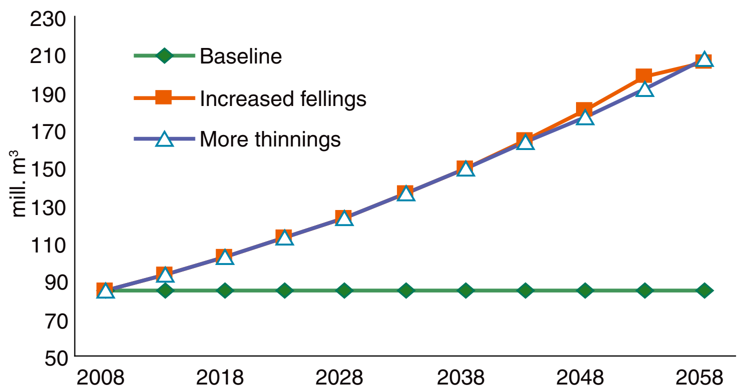

Fig. 4.25 The annual fellings in Northwest Russia from 2008 to 2058 under three different scenarios.

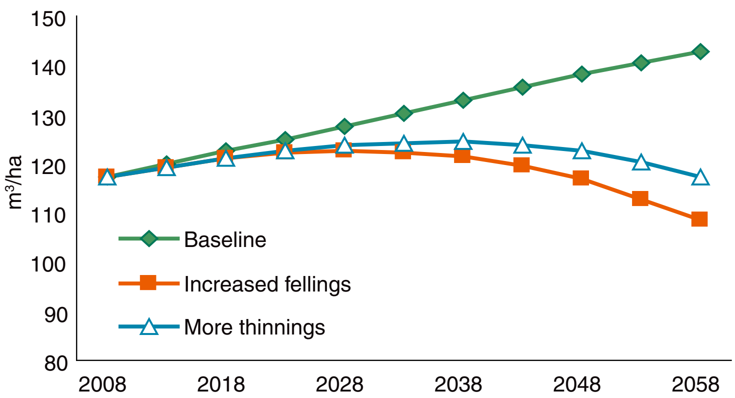

Fig. 4.26 The average standing volume from 2008 to 2058 under three different scenarios in Northwest Russia.

4.2.5 Discussion on scenario results

The results show that there are a lot of possibilities to increase forest utilization in Northwest Russia. In most of regions there was enough forests to increase fellings three fold compared to fellings in Pisarenko et al. (2001). This also enables to use forests for other uses, e.g. nature conservation and recreation. This results agree well with previous studies and e.g. data in Karvinen et al. (2006) where the volume of mature and over mature forests is 5 475 million m^3 and yearly removals 42 million m^3, i.e. the existing stock in mature and over mature forests can fulfil close to 100 years removals when we take into account difference between removals and fellings. Another question is that are these resources accessible at reasonable prise.

Usually one indicator of sustainable forestry is increasing forest resources. In our scenarios fellings exceeded net annual increment many times, which means that the average growing stock is decreasing. However, in a situation where old forests form a major part of forest resources, the only way to reach more productive forests is to regenerate large areas and gradually reach more even age class distribution and, therefore, use of scenarios can be seen also sustainable.

The only forest resource data available in Russia is collection of compartment wise inventory. This data is objectively estimated and usually it is systematic underestimation of growing stock. However, Kinnunen et al. (2003) found out 13% underestimation in Novgorod region, and if similar magnitude of underestimation exists in some other regions, the volumes are greatly underestimated. Another problem is the date of inventory data. In our study we used Pisarenko et al. (2001) data, where the date of inventory data is the year 1998. This was used since more recent detailed enough data are not available. Furthermore, the inventory data is collection of compartment data which is on average about 5 years old. Therefore, the starting point of our simulations was 1993. The changes in forest resources are very slow and for that reason the age of forest inventory data is not crucial for our analyses.

Our modelling approach needs felling level data as input and it should be based on real felling level in the region, but the historic regional felling level is very difficult to determine. Firstly, many sources do not determine if the number presented is fellings, i.e. growing stock cut including felling residues, or removals, i.e. fellings minus logging residues and transportation losses. Furthermore, removals can be under bark or over bark as in Finland. Secondly, statistics are not reliable because of e.g. unreported and illegal loggings. For example, even though different years are covered, there are quite large differences between Pisarenko et al. (2001) and Karvinen et al. (2006) regarding the volumes at the regional level (Table 4.2), although the volume at Northwest level is relatively close despite of different base year. In this study we decided to use the same source, i.e. Pisarenko et al. (2001), for fellings as for forest inventory data since it was sufficiently detailed to enable analysis. However, some other more recent data sources suggest that there have been significant changes in the regional allocation of fellings in Northwest Russia (Table 4.2). The amount of fellings in 2003 seem to be higher in the south and lower in the north than in 1993. This has not been taken into account in this study since this trend can reflect also short-term situation, and the reliability of the data is unknown.

Increment, in addition to fellings, is a key variable for long-term development of forest resources. We have used again Pisanko et al. (2001) data calibrated to Russian forests (Appendix 11) combined with more detailed data from some regions. This data are not very reliable but there is no better data available. However, future increment is even more uncertain due to e.g. changes in management regimes, fertilization, draining, nitrogen deposition, natural disturbances (e.g. fire and storms) and climate change. For example, in Finland growth of forests was estimated to increase 44% between 2050 and 2099 due to a climate change (Kellomäki et al. 2005).

Table 4.2 Comparison of removals between Pisarenko et al. (2001), removals from the year 1993, and Karvinen et al. (2006), removals from the year 2003.

Region	Removals, Pisarenko et al. 2001, million m^3/yr	Removals, Karvinen et al. 2006, million m^3/yr	Difference between Pisarenko and Karvinen, %
Arkhangelsk	12.7	10.1	25
Vologda	7.8	6.6	19
Murmansk	0.6	0.1	473
Karelia	7.0	7.1	-2
Komi	12.0	6.8	77
Leningrad	3.8	6.3	-40
Novgorod	1.9	3.5	-47
Pskov	0.9	1.0	-10
Sum	46.6	41.5	12

The demand in Northwest Russia is concentrated in large sized timber and, therefore, the price of small diameter timber is low. The EFISCEN model does not include estimates about timber assortments and effects of management practices on timber assortments has to be estimated using other data sources. In this study the more thinnings scenario results, in addition to higher increment, more large sized timber, but this can not be analyzed with applied modeling approach.

More detailed analysis of development of forest resources in the future requires also more detailed data as it has been done for some regions (Päivinen et al., 1999, Trubin et al., 2000 and Lyubimov et al., 2003). In this study the data were robust despite of its shortcomings and then only robust scenarios are reasonable. However, the main conclusion of this study remains, i.e. there are a lot of mature and over mature forests in Northwest Russia and these forests alone can provide wood supply for increasing demand for next 50 years. Locally this is not always true and with more detailed data, both forest resource, increment and felling data, more options of management could be studied at smaller scale.

4.3 Analysing accessibility of forest resources

4.3.1 Method of analysis

The development of infrastructure in Northwest Russia differs considerably between regions. Harvesting costs depend on the accessibility of forest resources through existing infrastructural networks. Utilizing available spatial information on road and railway networks in Northwest Russia it is possible to estimate harvesting costs by analyzing the transportation distances from potential cutting sites to lower landing using geographical information system software. Combining information on transport costs with transportation distances along roads to the closest railway station was used as a method to study the economic accessibility of wood resources in Northwest Russian regions.

After topological correction of the input data, GIS network analysis was carried out in ESRI ArcGIS Network Analyst. From any point in the road network the shortest path to the closest train station was found and the road length was accumulated. For Novgorod region the analysis also included sawmill locations as destinations. The distance from any potential harvesting point to the nearest road was then determined using a method similar to Michie et al. (2006). The shortest path from any off-road location to the closest road was found while rivers and lakes, which make direct access to the road infeasible, were functioning as barriers. If a road could be accessed directly the shortest path was equal to the perpendicular distance to the road. In case of water barriers the method aimed at making the off-road transport as short as possible when compassing waterways. Both the forest-to-road and road-to-railway distances were then summed up to total transportation distance.

Available cost information on transportation to lower landing with a given average distance of 65 kilometers (see Table 4.3) was used to derive average transportation costs per kilometer. Using calculations of OAO of NIPIELesprom (2007), the shares of fully automated and manual harvest in harvesting operations in Arkhangelsk, Karelia, Komi and Vologda were given with 50% each, whereas harvesting operations in Leningrad, Murmansk, Novgorod and Pskov were assumed to be 80% manual, 10% semi-automated and 10% fully automated. According to these assumptions different average transportation and fixed harvesting costs were applied depending on the region (see Table 4.4). The final cost for every location was calculated as the sum of the fixed harvesting cost and the cost of transport (transportation cost per kilometer multiplied by the total transportation distance to the nearest railway station or sawmill).

4.3.2 Data

Spatial input data

To cover other Northwest Russian regions road network data of the dataset ‘Land resources of Russia’ were utilized which was available from the International Institute for Applied Systems Analysis (IIASA / RAS, 2002). The dataset provides spatial information on Russian roads covering a total length of 916.000 kilometers. Information on railway stations and main water network was taken from map data provided with ESRI ArcGIS software 9.2. ESRI railway data are derived from AND’s Global Road Data and are annually updated (Automotive and Navigation Data, 2005).

The European forest map (Päivinen et al. 2001; Schuck et al. 2002) and the growing stock map of Europe (Päivinen et al., in prep.) were applied to estimate available timber resources within the study region. The maps are based on forest proportion per land area derived from Earth observation data and regional forest area and growing stock statistics from National forest inventories. They show the area and volume of coniferous and broadleaved forest in a resolution of one square kilometer for the pan-European area.

Cost data

Detailed information on harvesting and transportation costs was available for Kirov and Kostroma region and provided by OAO NIPIELesprom (2007). Facing the lack of available reliable cost data for the Northwest Russian district the existing cost information was used in the accessibility analysis. The cost data include direct and indirect harvesting costs and distinguish between harvesting techniques of different automation levels. The information covers the harvesting process from cutting until transportation to lower landing as can be found from Table 4.3 and 4.4.

Table 4.3 Illustration of harvesting costs per m^3 (under bark) in roubles (OAO NIPIELesprom 2007).

	Harvesting technique		
	Manual harvest	Semi-automated harvest	Automated harvest
Stumpage price	54.80	54.80	54.80
Harvest	138.80	126.70	232.54
Transportation to lower landing (in average 65km)	148.41	148.41	157.82
Lower landing costs	73.14	73.14	15.29
Subtotal	360.35	348.24	405.65
Labour	56.33	50.27	50.27
Machinery	93.75	93.40	93.40
Subtotal	150.08	143.67	143.67
Overheads for administration etc.	36.42	36.42	36.42
Total price at lower landing	**601.65**	**583.13**	**640.53**

Table 4.4 Applied transportation and fixed harvesting costs per m^3 (under bark) by regions in ruble.

Region	Average transportation costs to lower landing per m^3 per km	Fixed harvesting costs per m^3 (total harvesting costs excluding transportation)
Arkhangelsk, Karelia, Komi, Vologda	2.36	467.98
Leningrad, Murmansk, Novgorod, Pskov	2.30	454.34

The resulting distance maps were classified into 6 distance classes for Novgorod and 10 distance classes for the remaining regions. Likewise, the resulting cost maps were classified into 6 cost classes for Novgorod and 10 cost classes for the other regions. The classified maps were combined with the growing stock and forest area maps of Europe to calculate forest resources available for each distance and cost class. Protected forest areas where cuttings are either prohibited or only partly allowed were excluded during the calculation for Novgorod region. The volume data derived from the growing stock map refers to cubic meters over bark and was converted to volume under bark applying conversion factor of 0.89 based on annual removal data over and under bark for the Russian Federation. The conversion factor was obtained from TBFRA 2000 database (UNECE/FAO 2000).

4.3.3 Input data and methods for analysing economic accessibility in Novgorod region

Comprehensive map data on roads, rivers, lakes and protected forest areas have been available for Novgorod region (Lopatin 2005). Road data include information on three different road categories ‘gravel road’, ‘asphalt road’ and ‘highway’. Data on protected forest areas cover the categories ‘cutting not allowed’, ‘cutting not allowed or limited’, ‘cutting partly allowed’, ‘thinning allowed’ (see Figure 4.27). They were used to exclude regions where wood harvest is prohibited or only party allowed from the estimation of available timber resources.

For Novgorod region the accessibility to nearest sawmills was also studied.The more detailed analysis on Novgorod is justified, since it is seen as a progressive area for foreign investments and in the past decade has seen a few new mills being built by foreign companies. These include UPM Kymmene's Pestovo sawmill (inaugurated in 2004), Chudovo mills (100% shareholder since 2005) and Stora Enso's Nebolchi sawmill (inaugurated in 2004) (UPM-Kymmene 2006, Stora Enso 2006). Map data covering the Novgorod region includes the general layers of kvartal, leshoz (24 in the Novgorod region), parks, wildlife reserve boundaries, relief, roads, railroads, urban areas, leshoz centers, forest areas, non-forest area, marshes, lakes and rivers. The road network of the Novgorod region is rather comprehensive and increases the industrial attractiveness of the region. The road network crosses the region leading to major cities such as St. Petersburg, and from there onwards to Finland and the Baltic Sea as well as through Moscow to other areas of eastern Europe. Waterways make it possible to carry cargo in vessels and boats from Lake Illmen, to the Baltic and White seas and then onwards to other regions in Europe and countries outside of Europe, such as Turkey.

For Novgorod region locations of six sawmills were digitized, including UPM Chudovo plywood and veneer mill, UPM Pestovo sawmill, Stora Enso Nebolchi sawmill, Parfino plywood factory, Madok GmbH Malaya Vishera sawmill and Pfleiderer Podberezie wood-based boards mill.

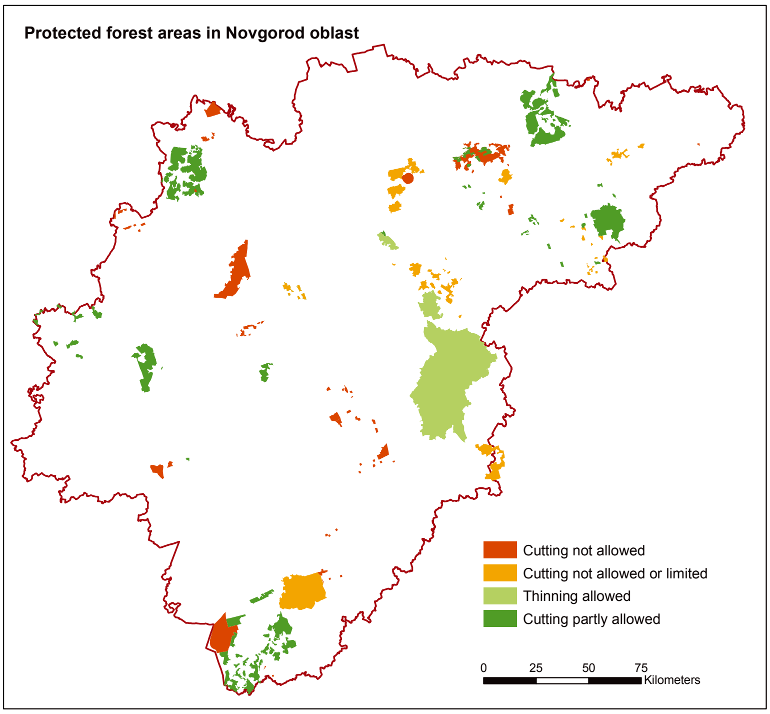

Fig. 4.27 Protected forest area categories in Novgorod region.

4.3.4 Results for technical accessibility analysis

Results of distance and cost calculations are presented below in the form of tables and maps. First, the tables 4.5 to 4.6 list available forest area and timber volume for different distance and cost levels for Northwest Russia by broadleaved and coniferous wood. The similar distance tables by all different regions are given in Appendix 1. The distance maps are given by each region showing calculated timber costs and transportation distances in 6 classes for easier readability.

Table 4.5 Forest resources in different distance levels from the nearest railway station for Northwest Russia (excluding Nenets region).

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0 - 10	3022.7	1373.3	327.4	175.0
10 - 25	6265.9	2826.7	634.4	338.3
25 - 50	8817.2	3615.3	822.2	400.2
50-100	12831.0	4067.5	1170.6	421.8
100-200	15955.8	4400.3	1507.6	422.7
200-300	9155.4	2034.7	876.2	205.8
300-400	3175.4	607.1	280.3	50.9
400-500	2687.5	499.0	232.0	42.3
500-600	1289.4	280.7	107.3	28.5
> 600	621.7	208.0	51.4	23.3

Based on these results, the infrastructural networks are of highest density in the Karelia, Leningrad, Novgorod and Pskov regions, having transportation distances to nearest railway station within 100 kilometers for most parts of these regions. Connected harvesting costs do not exceed 700 rubles per cubic meter. In Arkhangelsk, Komi, Murmansk and Vologda regions transportation distances are higher than 200 kilometers for large parts of the regions due to lack of railway connections. That results an estimate for harvesting costs over 940 rubles for a total of ca. 1.9 billion cubic meters of wood.

Table 4.6 Forest resources in different cost levels for harvest and transportation to the nearest railway station for Northwest Russia (excluding Nenets region).

Transportation and harvesting costs (rouble)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
< 500	5477.2	2764.9	600.9	355.9
500- 550	8160.4	3454.9	780.6	392.0
550- 600	6578.0	2428.0	597.1	257.1
600- 700	10466.8	3184.3	949.6	324.7
700- 800	7661.4	2216.0	718.6	213.9
800- 900	6389.1	1670.8	607.6	157.8
900-1000	5092.1	1301.7	483.2	129.2
1000-1500	10248.0	2052.4	952.2	194.2
1500-2000	3337.0	702.6	285.6	68.6
> 2000	412.0	136.9	34.1	15.3

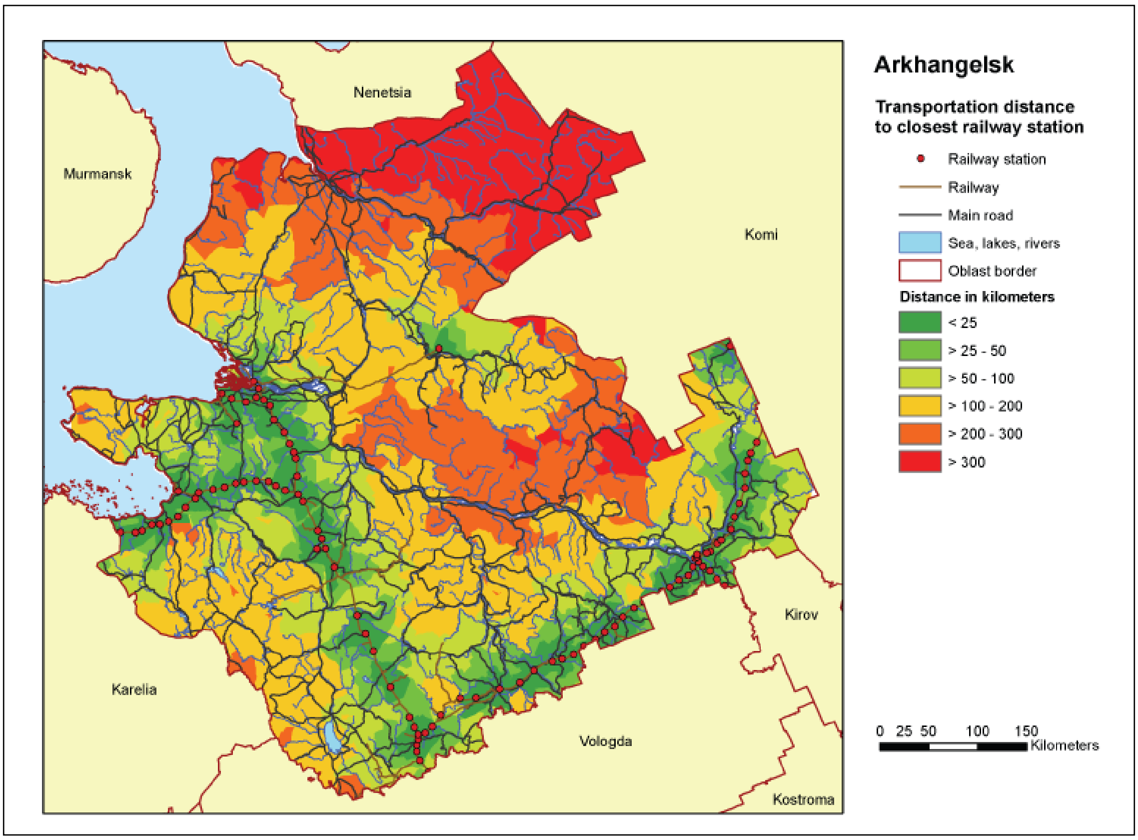

Fig. 4.28 Transportation distance to the nearest railway station for Arkhangelsk region.

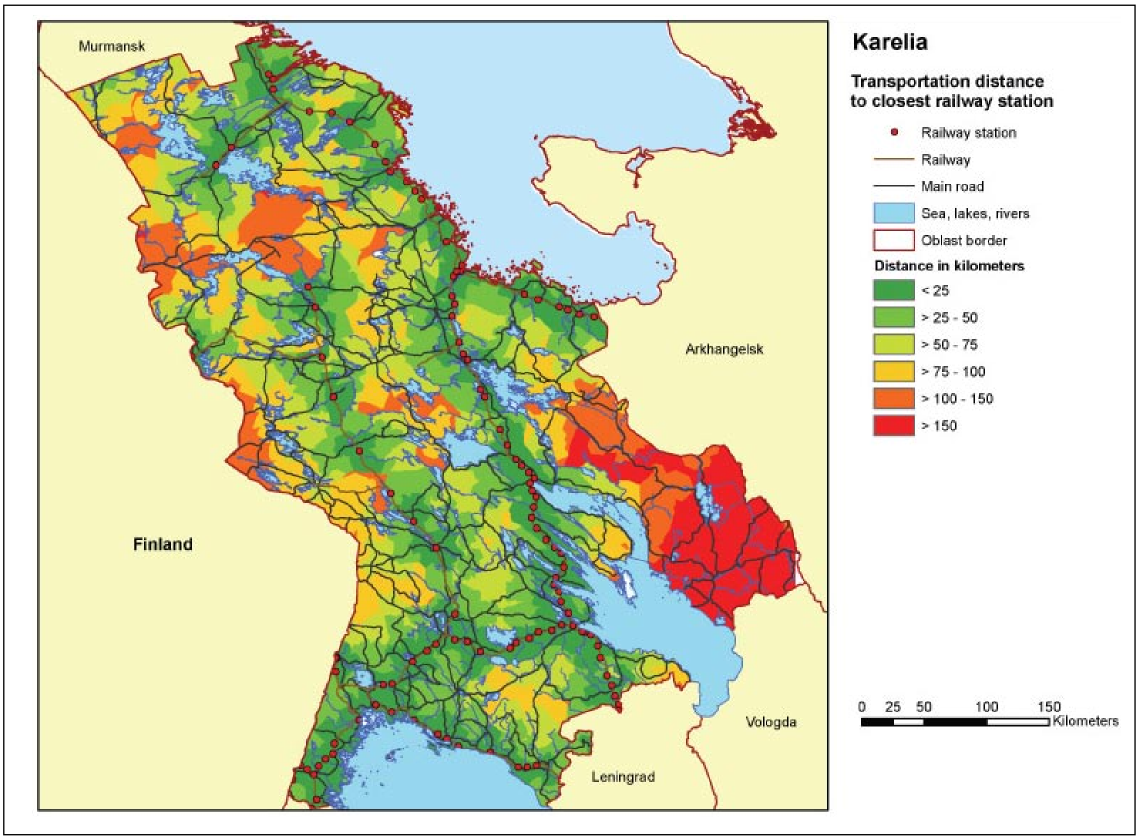

Fig. 4.29 Transportation distance to the nearest railway station for Republic of Karelia.

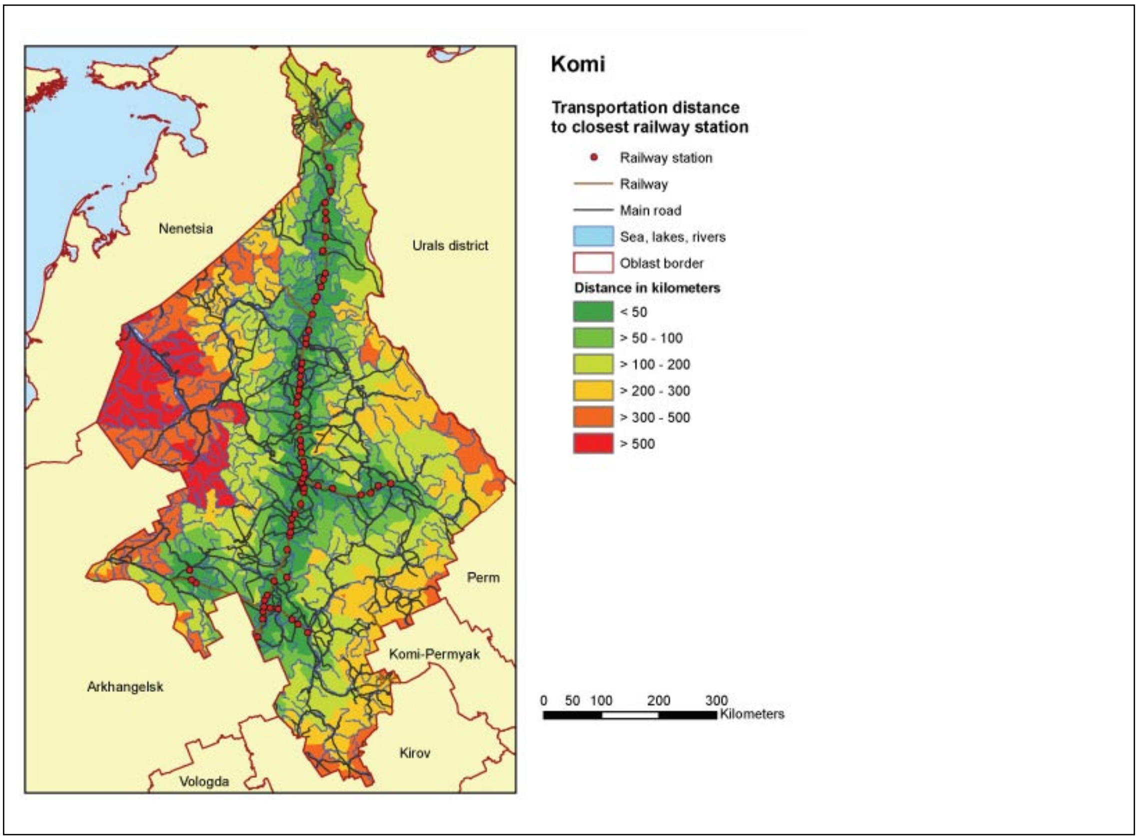

Fig. 4.30 Transportation distance to the nearest railway station for Republic of Komi.

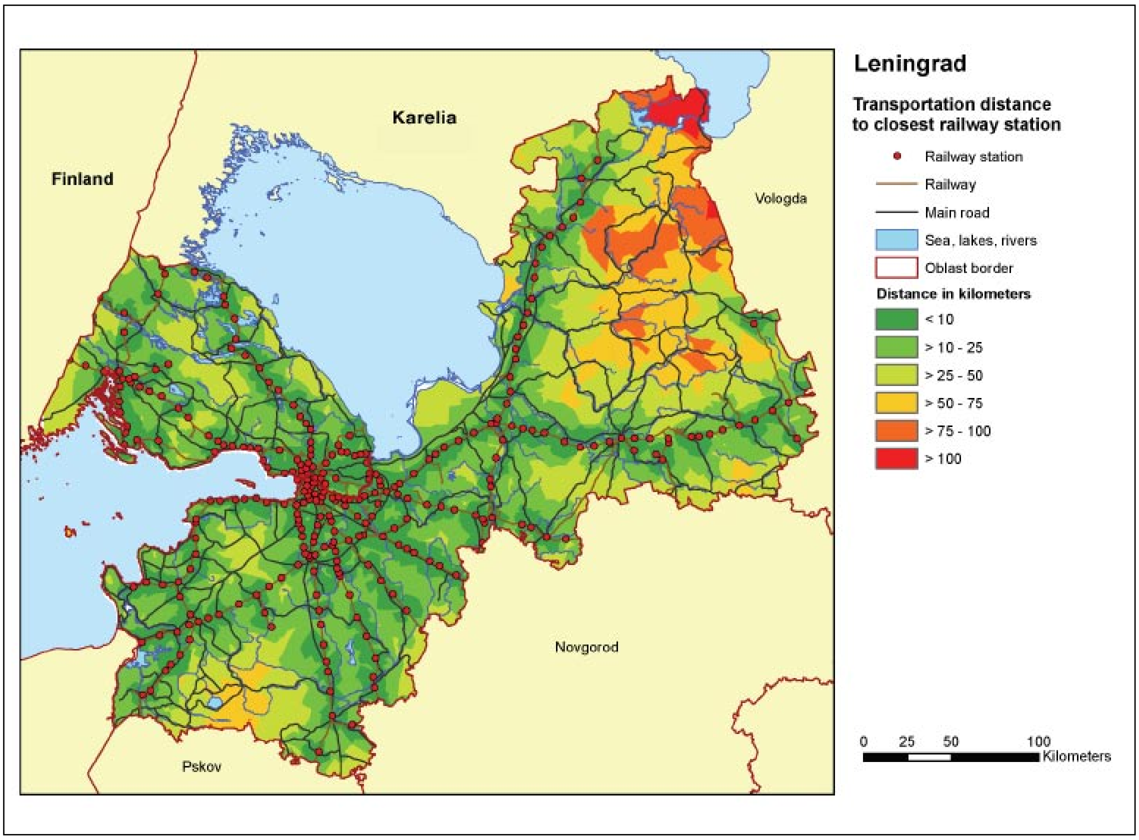

Fig. 4.31 Transportation distance to the nearest railway station for Leningrad region.

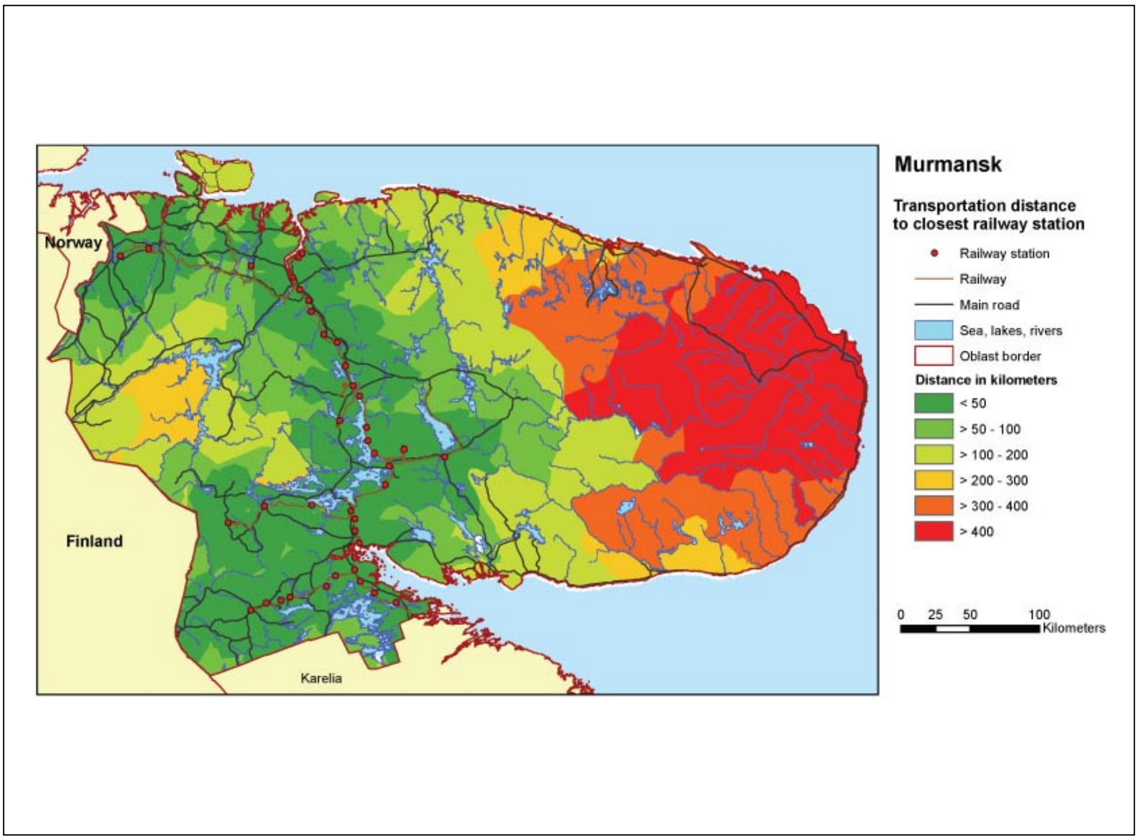

Fig. 4.32 Transportation distance to the nearest railway station for Murmansk region.

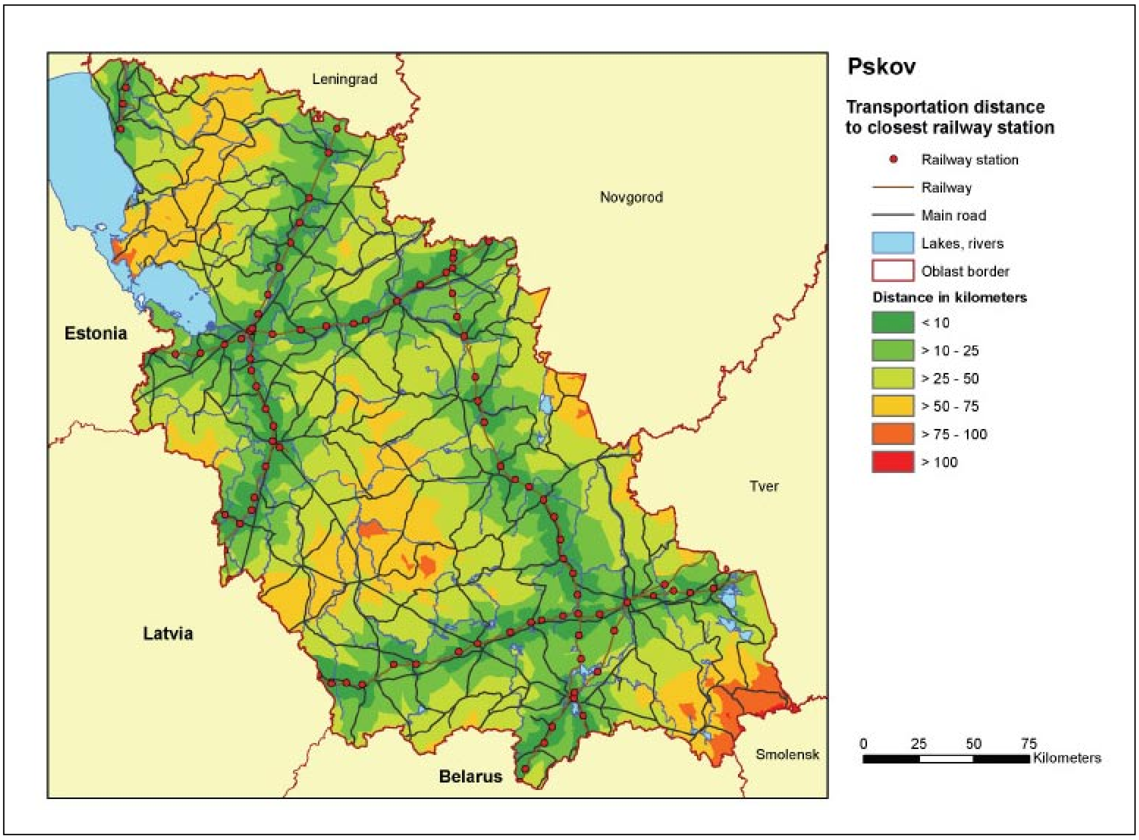

Fig. 4.33 Transportation distance to the nearest railway station for Pskov region.

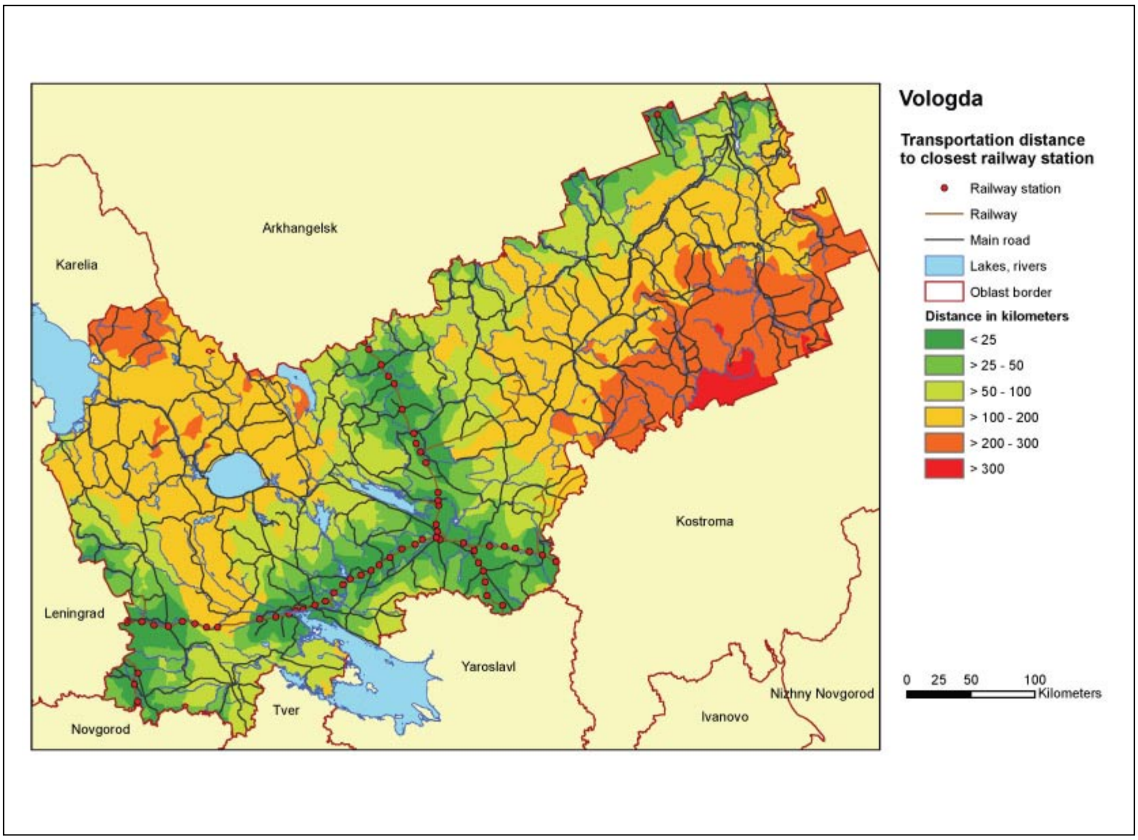

Fig. 4.34 Transportation distance to the nearest railway station for Vologda region.

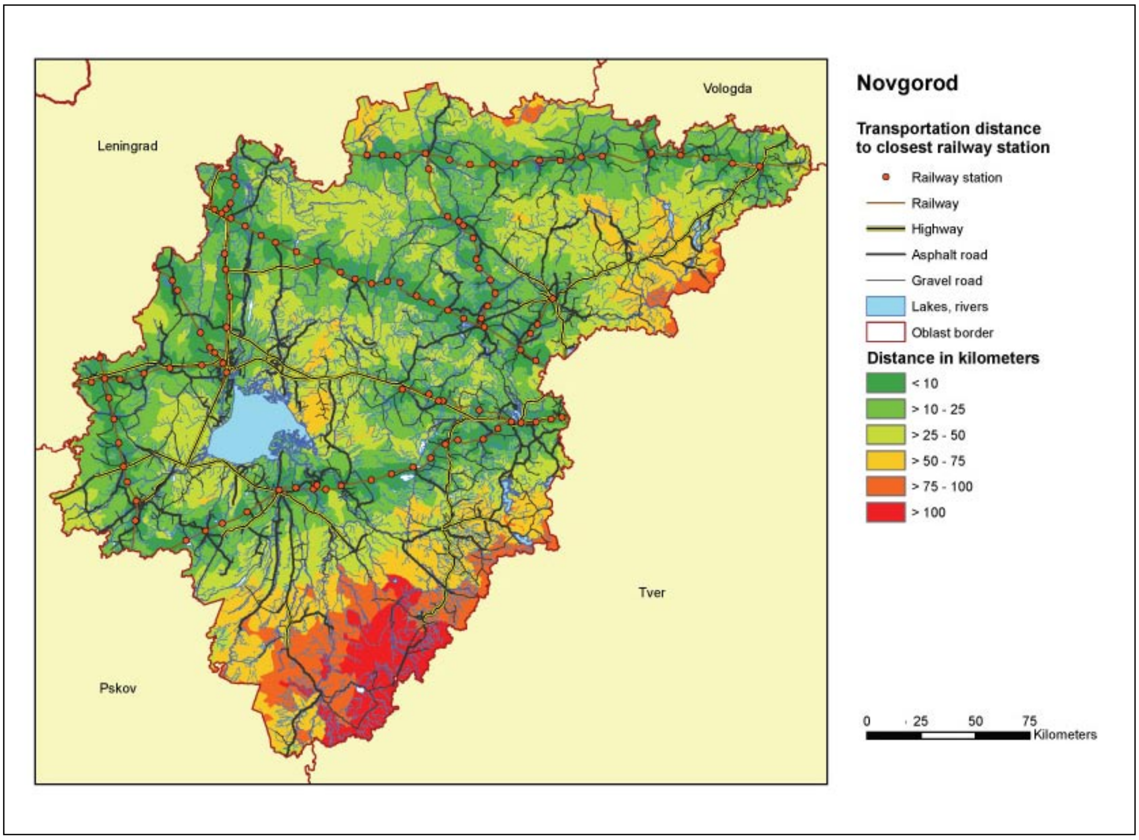

Fig. 4.35 Transportation distance to the nearest railway station for Novgorod region.

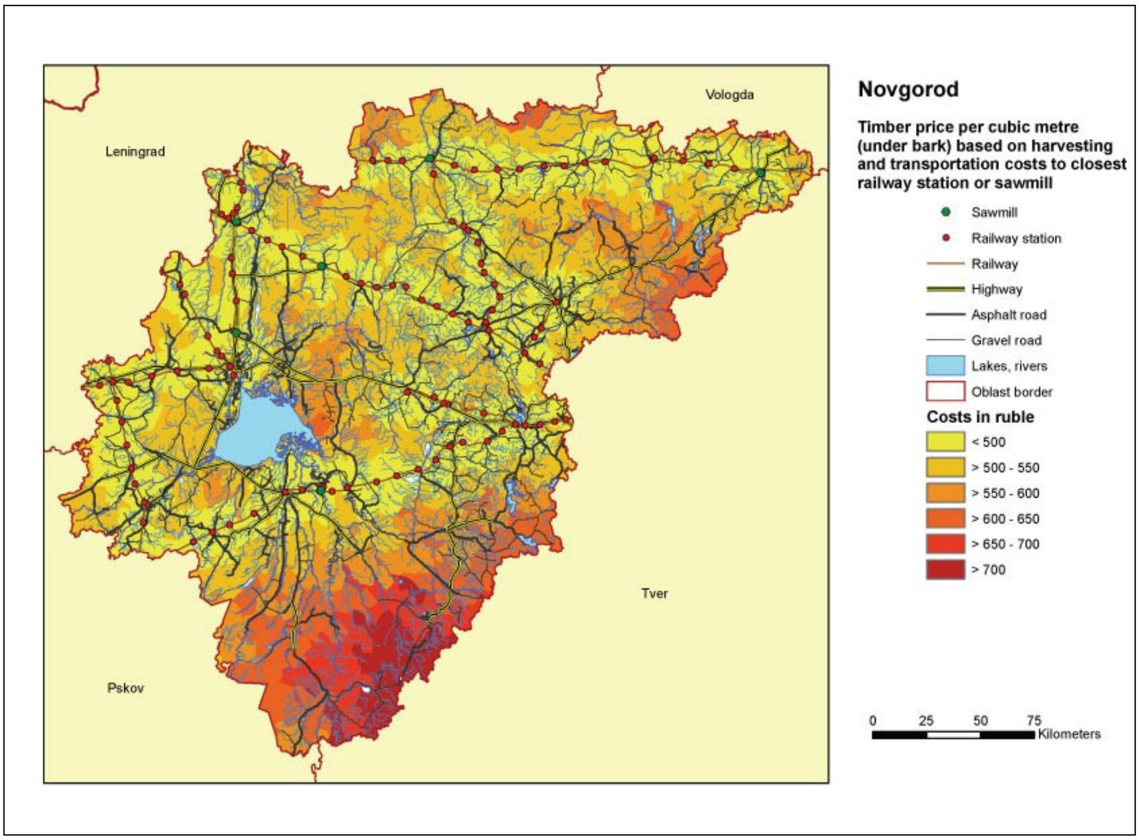

Fig. 4.36 Timber costs per cubic meter (under bark) based on harvesting and transportation costs to nearest railway station or sawmill for Novgorod region.

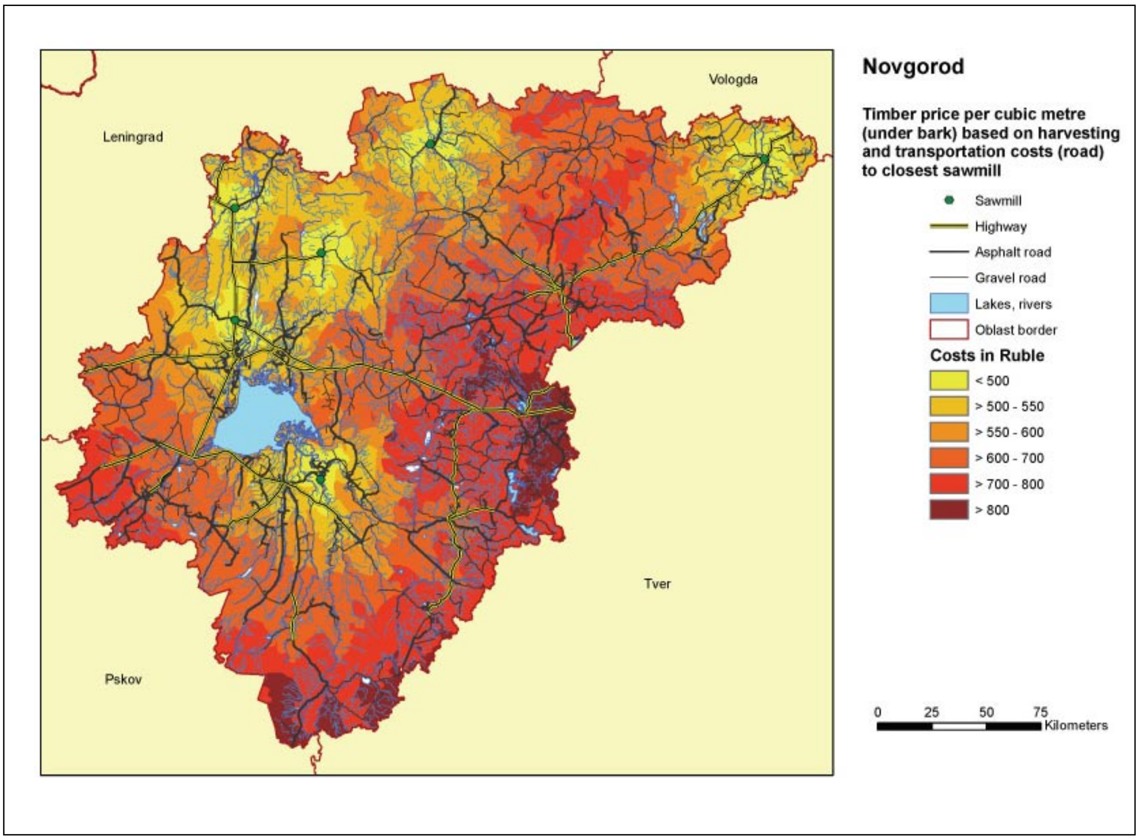

Fig. 4.37 Timber costs per cubic meter (under bark) based on harvesting and transportation costs to nearest sawmill for Novgorod region.

4.3.5 Analysis of economic accessibility in Novgorod region

Two different cost maps are presented for Novgorod region. The first depicts timber costs associated with transportation to the nearest railway station or sawmill while the other one shows the costs connected with transport to the closest sawmill neglecting railway stations.

The associated level of forest resources for the two calculations are given in Tables 4.7 and 4.8 showing some that the more comprehensive approach including both forest industry facilities and railway station points produces particularly at lower cost levels several times higher estimates for accessible broadleaved or coniferous wood.

Table 4.7 Forest resources in different cost levels for harvest and transportation to the nearest railway station or sawmill for Novgorod region.

Transportation and harvesting costs (RUB/m^3)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
<500	513.9	699.9	77.3	101.1
500-550	457.4	569.9	68.6	81.8
550-600	168.1	219.1	25.2	31.2
600-650	97.3	122.7	14.4	17.3
650-700	41.4	56.1	6.2	7.8
>700	40.8	46.5	5.9	6.1

Table 4.8 Forest resources in different cost levels for harvest and transportation to the nearest sawmill for Novgorod region.

Transportation and harvesting costs (ruble)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
<500	83.0	105.0	12.5	15.1
500-550	234.4	329.5	35.3	47.5
550-600	227.2	312.7	34.3	45.4
600-700	389.3	529.3	58.6	76.2
700-800	324.4	388.8	48.1	54.7
>800	60.6	48.9	8.8	6.4

4.3.6 Case study on locating feasible routes from kvartals to the nearest road in the Novgorod region

Previously, maps of the Novgorod region have been used to investigate the accessibility of forest resources in that region (Michie et al. 2004) and the shortest distance from a kvartal center to the nearest road was used as a benchmark for accessing forest accessibility in Novgorod region. However, the current amount of forest roads is only a third of the recommended amount (Michie et al. 2004), and there is hope for improvement due to new forest legislation. As one of the biggest challenges in dealing with accessibility of forests in Novgorod region is the large number of rivers, lakes and bogs, in this case study (Michie et al. 2006), it was found essential to develop a method for finding feasible routes to as many kvartals as possible and then to use the length of these feasible routes as a general measure of accessibility of forest land in Northwest Russia.

The shortest distance from a kvartal center (centroid) to the nearest road (or perpendicular distance) has been used as a benchmark for assessing forest accessibility. Very often when a line is drawn from the centroid of a kvartal to the nearest road it crosses rivers, lakes or deep bogs making the route infeasible. As a result some kvartals have no feasible direct access to the road. Those kvartals for which direct access to the road is feasible (a perpendicular line from the centroid of the kvartal to the nearest road crosses no obstacles) become access points for other kvartals.

Initiating distance to road calculations starting from the kvartal rather than the road (as is done when buffers are used) allows scale changes (grouping of management units) to reduce the number of necessary calculations (as forest workers might also try to use one forest road to access several remote forest management units). This is especially important when dealing with the large numbers of management units that typically occur in Russia. Using perpendicular distance to road segments allows distance to each road segment to be evaluated with just 3 distance checks (two end points plus the intersection of a perpendicular line from the management unit centroid to the line segment). For more detailed description of this approach, see Michie et al. (2006).

As a main result, a comparison between the shortest (max. two bends) distance and the feasible distance for the 17 926 management units for which feasible access was determined showing that the feasible distance is 1.5 times as large as the shortest distance. A test of the method for determining feasible routes to kvartals in the Novgorod Region of Russia consisted of 20 201 kvartals with total enclosed area of 2.8 million ha (including areas of non forest). A line connecting the centroid of each kvartal to the closest road segment was drawn and then tested to see if it crossed any rivers, lakes or deep bogs. A feasible direct route from 8174 kvartals 1.1 mill ha to the road was found. As an illustration, Figure 4.38 shows 302 kvartals along with feasible direct routes to the nearest road.

In order to determine feasible routes for the remaining 12 027 kvartals an attempt to find feasible routes from these remaining kvartals to 21 889 road access points (the centroids of 8174 kvartals that do have feasible direct access to the road plus another 13 715 regularly spaced points that also have feasible direct access to the road). Using this method 8104 kvartals 1.1 mill ha were found to have feasible one-bend road access. Altogether 291 kvartals were found with feasible *one-bend road access* and 1648 kvartals (226 768 ha) were found to have *two-bend feasible access*. That leaves 2275 kvartals (341 694 ha) with no feasible access. While no attempt was made to discover kvartals accessible with routes having three bends, it is clear that many kvartals with no feasible access along routes allowing no, one or two bends would have access to kvartals having two-bend access. So if the process were extended to allow routes with three bends many, if not all, of the remaining kvartals would be found to be accessible.

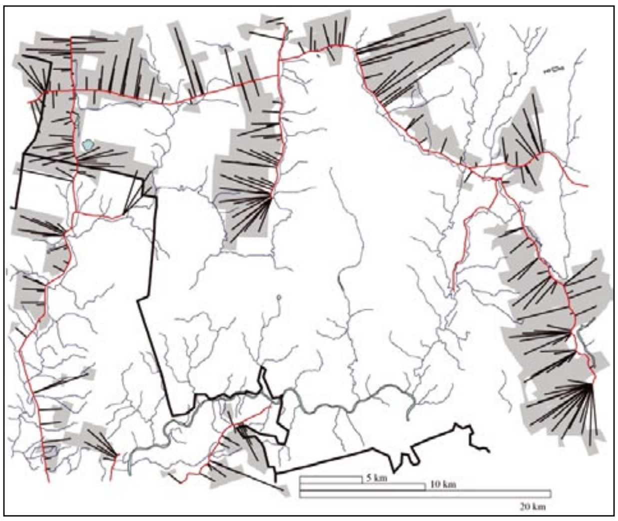

Fig. 4.38 Kvartals in Novgorod region which have direct feasible access to the nearest road (302 kvartals)

Tables 4.9 and 4.10 show that feasible distances are substantially longer than shortest possible routes and that the longer the distance to the road is the more likely that feasible distances are greater than shortest distances. In the first three classes the feasible distance for more than half of the kvartals (measured in both numbers of kvartals and hectares) remains in the same distance class as the shortest distance. In the next five classes the feasible distance to the kvartals can be found in less than half of cases in the same distance class as shortest distance class implying that the farther kvartals are from the nearest road the more likely that obstacles are encountered along the way to the road making feasible distances longer than the shortest distance to the road.)

Table 4.9 Feasible distance vs shortest distance matrix for 20 201 kvartals (numbers of kvartals) in Novgorod region.

Shortest distance (km)	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 9	9 to 11	11 to 31	No feasible access found	total
1 to 2	2898	204	79	38	23	27	26	16	34	64	3409
2 to 3		2348	365	171	117	78	104	44	95	156	3478
3 to 4			1710	428	199	117	164	105	153	233	3109
4 to 5				1224	327	178	243	143	225	223	2563
5 to 6					790	273	285	170	269	199	1986
6 to 7						499	342	174	267	203	1485
7 to 9							634	334	536	317	1821
9 to 11								259	520	264	1043
11 to 25									691	616	1307
total	2898	2552	2154	1861	1456	1172	1798	1245	2970	2275	20201

Table 4.10 Feasible distance vs shortest distance matrix for 20 201 kvartals (thousands of hectares) in Novgorod region.

Shortest distance (km)	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 9	9 to 11	11 to 31	No feasible access found	total
1 to 2	378	26	12	6	4	4	3	2	4	9	448
2 to 3		308	50	22	18	10	14	5	14	24	465
3 to 4			224	57	25	16	21	15	22	30	410
4 to 5				168	43	26	32	20	30	27	346
5 to 6					112	37	39	24	33	31	276
6 to 7						67	46	25	37	44	219
7 to 9							91	45	74	49	259
9 to 11								35	75	40	150
11 to 25									100	87	187
total	378	334	286	253	202	160	246	171	389	341	2760

In conclusion, the shortest distance and feasible distance from kvartals to the nearest road gave two measures of the accessibility of forest land in the Novgorod Region of Russia. The shortest distance to the road is entirely dependent on road infrastructure, while feasible distance is a measure of accessibility, which also includes an attempt to avoid obstacles such as rivers, lakes and deep bogs. In order to reduce the shortest distance to the road network it would be necessary to build more roads. Reduction of the feasible distance to the road (downward toward the shortest distance) could be achieved by building very short roads in combination with bridges. However, the cost of building roads would have to be compared with the cost of building bridges in order to determine the cheapest way to reduce transport costs along forest roads.

4.3.7 Discussion

It is important to note that there was a shortage of detailed data on Northwest Russian infrastructure, which lowers the accuracy of the results and need to be considered when interpreting the maps. The study should be regarded as an example for how economic accessibility of timber resources in Northwest Russia can be analyzed. With the given input data the presented results can provide only rough estimates of real transportation and harvesting costs.

The calculated distances to closest road might in reality be either longer than the assumed shortest connection or shorter if bridges allow crossing of a river which functioned as barrier in the GIS analysis. Due to incomplete road data also several railway stations could not be connected to the road network and hence were excluded as a destination in the shortest distance calculations. This causes problems for the final distance maps visible e.g. in the maps of Vologda where calculated distances and costs tend to be high in the vicinity of railway stations which are not connected to any road in the dataset. It should be emphasized that the methodology would give more accurate estimates if detailed data on forest roads and railway networks as well as region dependent cost information was available.

4.4 Conclusions and further research needs

Analysing the impact of intensification of forest management in the Northwest Russia with EFISCEN scenarios, the net annual increment decreased under “business as usual” baseline scenario from 135 million m^3 per year in 2008 to 127 million m^3 per year in 2058, since forests get older under low utilisation level. Under Increasing fellings- scenario results only slightly higher increment since fellings increase gradually and in 50 years this scenario can not produce middle aged forests with high increment. Under Increasing fellings and thinnings scenario, which resembles most the Finnish management practises, the net annual increment increased to 155 million m^3 per year in 2058 due to lower mortality.

The results show that there are a lot of possibilities to increase forest utilization in Northwest Russia. In most of regions there was enough forests to increase fellings three fold compared to fellings in Pisarenko et al. (2001). This also enables possibilities to use forests for other uses, e.g. nature conservation and recreation. These results agree well with previous studies and e.g. data in Karvinen et al. (2006) where the volume of mature and over mature forests is 5 475 million m^3 and yearly removals 42 million m^3, i.e. the existing stock in mature and over mature forests can fulfil close to 100 years removals when we take into account difference between removals and fellings. Another question is whether these resources are accessible at reasonable price.

In Northwest Russia, the infrastructural networks are of highest density in the Karelia, Leningrad, Novgorod and Pskov regions, having transportation distances to nearest railway station within 100 kilometers for most parts of these regions. Connected harvesting costs do not exceed 700 rubles per cubic meter. In Arkhangelsk, Komi, Murmansk and Vologda regions transportation distances are higher than 200 kilometers for large parts of the regions due to lack of railway connections. That results an estimate for harvesting costs over 940 rubles per cubic meter for a total of ca. 1,9 billion m^3 of wood.

In analysing accessibility of forest resources, it is important to note that there was lack of sufficiently detailed regional level data on Northwest Russian harvesting infrastructure, which lowers the accuracy of the results and need to be considered when interpreting the maps. All in all, the results in this study should be regarded as an example for how economic accessibility of timber resources in Northwest Russia can be analyzed. With the given input data the presented results can provide only rough estimates of real transportation and harvesting costs and feasible harvesting areas. For example, in a case study on the number of accessible kvartals in Novgorod region, the shortest distance and feasible distance from kvartals to the nearest road gave two alternative and differing measures of the accessibility of forest land.

In the future, improving access to forest areas that are located far from the nearest road will decrease transportation costs for logs harvested from forests in Northwest Russia. Additionally, there will be less chance that remote areas are avoided due the high cost of access, which will help to maintain the sustainability of forestry and increase the availability of larger diameter trees which are often found far from the nearest road. Changes in the future demand for e.g. bioenergy or other changes in demand may mean that areas that have been harvested once for large tress may again become attractive for the harvesting other types of trees making easy access doubly as important.

In conclusion, the mature and over-mature forests in Nortwest Russia can provide wood supply for increasing demand for next 50 years, although locally this is not always true. With more detailed data, both forest resource, increment and felling data, more options of management could be studied at smaller scale. However, markets of roundwood may prove to be the limiting factor for utilization of forest resources since it is impossible to harvest if there is not enough capacity in Russia to further process roundwood and roundwood exports are restricted by increasing export tariffs.

The lack of reliable cost data for the Northwest Russian district and the uncertainty on the existing cost information was limiting the economic accessibility analysis. In the future studies, the methodologies applied and developed in this study should therefore be developed further and applied with the more reliable cost data.

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Appendix 4.1

Table 1 Forest resources in different distance levels from the nearest railway station for Arkhangelsk region.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0- 10	502.0	129.0	51.2	7.4
10- 25	1168.1	345.8	118.4	19.7
25- 50	1635.2	611.8	166.5	39.5
50-100	3017.0	818.0	319.8	49.9
100-200	5722.3	1124.3	631.2	59.7
200-300	3503.5	371.8	394.5	21.8
300-400	1264.0	97.0	134.0	5.6
400-500	899.6	60.6	93.4	3.2
500-600	146.8	14.5	14.8	0.9

Table 2 Forest resources in different distance levels from the nearest railway station for Republic of Karelia region.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0- 10	577.9	70.6	45.2	7.1
10- 25	1236.1	150.1	96.9	15.1
25- 50	1957.5	244.5	153.7	24.5
50-100	2750.2	324.2	215.0	32.2
100-200	1069.0	156.5	84.1	15.7
200-300	280.8	44.6	22.1	4.4

Table 3 Forest resources in different distance levels from the nearest railway station for Republic of Komi oblast.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0-10	451.9	116.5	37.4	13.0
10-25	1236.4	344.0	102.4	38.5
25-50	2278.2	567.1	188.7	63.5
50-100	4180.4	897.1	346.5	100.4
100-200	6178.9	1131.0	512.0	126.7
200-300	4299.4	984.3	357.4	110.1
300-400	1476.7	332.6	123.6	37.0
400-500	1584.3	331.8	131.7	36.9
500-600	1100.5	242.8	91.3	27.1
> 600	624.4	209.3	51.6	23.4

Table 4 Forest resources in different distance levels from the nearest railway station for Leningrad oblast.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0- 10	818.8	437.8	122.6	67.1
10- 25	1076.6	593.7	160.9	90.7
25- 50	727.7	415.9	108.1	63.3
50-100	444.5	255.2	66.5	39.3
100-200	34.2	20.0	5.0	3.1

Table 5 Forest resources in different distance levels from the nearest railway station for Murmansk oblast.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0- 10	150.7	40.4	5.5	0.9
10- 25	415.0	143.7	15.1	3.2
25- 50	730.1	254.5	26.6	5.6
50-100	763.4	256.5	28.0	5.7
100-200	760.3	253.8	27.7	5.6
200-300	231.9	83.3	8.4	1.8
300-400	345.5	133.9	12.6	2.9
400-500	218.8	109.5	8.0	2.4
500-600	48.4	23.6	1.8	0.5

Table 6 Forest resources in different distance levels from the nearest railway station for Pskov oblast.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0- 10	136.3	122.7	13.3	17.2
10- 25	328.1	290.4	32.5	40.6
25- 50	474.7	396.2	48.0	55.3
50-100	261.1	176.3	26.2	24.5
100-200	2.6	1.8	0.3	0.2

Table 7 Forest resources in different distance levels from the nearest railway station for Vologda oblast.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (million m^3 under bark)
0- 10	170.5	157.8	19.2	19.3
10- 25	390.9	389.4	44.9	48.2
25- 50	622.5	637.4	71.2	78.2
50-100	1220.0	1058.2	137.8	129.9
100-200	2135.0	1656.1	240.1	203.8
200-300	856.9	556.0	95.7	68.3
300-400	93.3	45.8	10.6	5.6

Table 8 Forest resources in different distance levels from the nearest railway station or sawmill for Novgorod oblast.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest m^3 under bark)
0- 10	227.4	302.6	34.2	43.7
10- 25	425.0	573.4	63.9	82.8
25- 50	398.2	490.9	59.7	70.4
50- 75	150.2	203.2	22.4	28.8
75-100	66.4	83.1	9.8	11.5
100-150	51.7	61.1	7.5	8.1

Table 9 Forest resources in different distance levels from the nearest sawmill for Novgorod oblast.

Distance (km)	Coniferous forest area (1000 ha)	Broadleaved forest area (1000 ha)	Growing stock coniferous forest (million m^3 under bark)	Growing stock broadleaved forest (m^3 under bark)
0- 10	26.0	28.3	3.9	4.1
10- 25	99.7	138.6	15.0	19.9
25- 50	289.5	405.8	43.6	58.7
50- 75	227.2	304.6	34.3	44.0
75-100	228.7	314.3	34.5	45.3
100-150	386.1	472.6	57.4	66.7
>150	61.6	49.9	8.9	6.6

Appendix 1 Researchers

Finnish Forest Research Institute
Gerasimov Yuri, Goltsev Vadim, Ilavsky Jan, Karjalainen Timo, Karvinen Pauliina, Karvinen Sari, Leinonen Timo, Röser Dominik, Rummukainen Arto, Sikanen Lauri, Tyukina Olga, Välkky Elina

European Forest Institute
Husso Markku, Michie Bruce, Ottitsch Andreas, Pussinen Ari, Saramäki Kaija, Toppinen Anne, Tröltzsch Katja

University of Joensuu
Kolström Taneli, Lopatin Eugene

Karelian Research Centre, Forest Institute and Institute of Biology
Ananyev Vladimir, Grabovik Svetlana

All-Russian Research Institute for Silviculture and Mechanization of Forestry
Filipchuk Andrey, Korotkov Vladimir, Palenova Maria, Nesterenko Yuri

Moscow State Forest University
Chumachenko Sergey, Kuhkarkina Ekaterina, Yakovleva, Anna

Petrozavodsk State University, Forest Engineering Faculty
Chikulayev Pavel, Dyakonov Victor, Komkov Victor, Pecherin Vladimir, Siounev Vladimir, Sokolov Anton

St. Petersburg State Forest Technical Academy
Garbuzova Taicia, Kuznetsov Evgeny, Lioubimov Alexandre

Rosgiproles (Moscow)
Pochinkov Sergey

Russian State Agricultural University (Moscow)
Khlustov Vitaly

Appendix 2 Seminars

22.3.2005. Academy of Finland, Vilhovuorenkatu 6, Helsinki

How to develop economically effective, ecologically and socially responsible forest business in Northwest Russia

Organisers:
- *Finnish Forest Research Institute*
- *All Russian Institute of Continuous Education in Forestry*
- *University of Joensuu*
- *Academy of Finland*

Opening of the seminar
T. Karjalainen, professor, Metla

Opening address
A. Reunala, Head of the Forestry Department, Ministry of Agriculture and Forestry

Forest administration and management under the new Forest Code
J. Gagarin, Head of Forest Usage Division, Federal Forestry Agency
Given by A. Petrov, Professor of All Russian Institute of Continuous Education in Forestry

Institutional changes of forest administration in the Leningrad region
V. Chikalyuk, Head of Federal Forest Agency in Leningrad Region and St. Petersburg

Stumpage prices and forestry financing under new legislation
A. Petrov, Professor of All Russian Institute of Continuous Education in Forestry

Social responsibility of forest sector in the Northwest Russia
L. Shustov, Vice minister, Ministry of Economical Development, Republic of Karelia

Ecological responsibility of forest sector in the Northwest Russia
E. Kulikova, Director of Forestry Programme, WWF Russia

Northwest Russia as business environment for Russian forest industries
D. Chuiko, Director for Development of Logging and Woodworking, Ilim Pulp

Northwest Russia as business environment for Finnish forest industries
A. Juvonen, Director, UPM

Closing remark
H. Kivelä, Councellor, Embassy of Finland in Moscow

19.5.2005. All-Russian Institute for Continuous Education in Forestry, Pushkino, Russia

Prospects of the Russian forest sector

Organisers:

- *Finnish Forest Research Institute*
- *All-Russian Institute for Continuous Education in Forestry*
- *University of Joensuu*

Current state and prospects of the Forest sector reform in Russia
Y. Gagarin, Director, Federal Forest Agency

Trends and prospects of the Russian industry and forest product markets
N. Burdin, Professor and Director, OAO "NIPIEIlesprom"

1.3.2006. Finnish Forest Research Institute, Joensuu

Finnish Forest Research Institute 25 years in Joensuu, First event of the seminar series: Development of forest sector in Russian and impacts to Finnish forest sector

Welcome
J. Parviainen, Director, Finnish Forest Research Institute

Towards progressive forest sector in Northwest Russia – presentation of the research consortium
T. Karjalainen, Professor, Finnish Forest Research Institute

Russian forest policy – challenges for economical use of forests
T. Torniainen, Researcher, University of Joensuu

Wood harvesting is developing in the Republic of Karelia
V. Siounev, Professor, Petrozavodsk State University

Business strategies of woorworking firms – case study in Leningrad region
A.Toppinen, Senior researcher, Finnish Forest Research Institute

Investments in forestry in Russia and changes in business environment
P. Ollonqvist, Professor, Finnish Forest Research Institute

Development of Russian forest sector
H. Kivelä, Councellor, Embassy of Finland in Moscow

30.11.2006. Petrozavodsk State University, Petrozavodsk, Russia

Towards progressive forest sector in Northwest Russia

Organisers:

– *Petrozavodsk State University*
– *Finnish Forest Research Institute*
– *The Ministry of Agriculture and Forestry of Finland*
– *Barents Forest Sector Task Force*

Opening of the seminar
A. Voronin, Rector, Petrozavodsk State University

Development of the forest sector in the Northern Europe - focus in Northwest Russia
T. Karjalainen, Professor, Finnish Forest Research Institute

Current state of the forest sector in the Republic of Karelia
S. Moshkov, Manager, Karellesprom

A new forest management regime in Russia - a view from abroad
T. Torniainen, Researcher, University of Joensuu

Intensification of forest management and improvement of wood harvesting in NW Russia
T. Karjalainen, Professor, Finnish Forest Research Institute

Game theoretic approach to Russian-Finnish roundwood trade
A. Mutanen, Researcher, Finnish Forest Research Institute

Forest industry investments and economic effects of wood flows on local and regional communities in Northwest Russia and Finland
P. Ollonqvist, Professor, Finnish Forest Research Institute

Theory into practice - presentation of projects in higher forest education in the Russian-Swedish forest sector cooperation programme
P. Hazell, Project manager, Skogsstyrelsen

Challenges of the new forest code - a company view
V. Golubev, Head of the forest resource department, Segezha pulp and paper mill

Launching of Neighbourhood programme projects on Wood quality and comparison of harvesting methods
V. Syunev, Professor, Petrozavodsk State University

5.6.2007. Finnish Embassy in Moscow, Russia

Intensification of Forest Management and Improvement of Wood Harvesting in Northwest Russia

Organisers:
- *Finnish Forest Research Institute*
- *All-Russian Research Institute for Silviculture and Mechanization of Forestry (Pushkino, Russia)*

Russia in the light of the new forest code
A. Filipchuchk, Deputy Director, All-Russian Research Institute for Silviculture and Mechanization of Forestry

Forest planning
S. Pochinkov, Head of Department Rosgiproles

Finnish embassy in Moscow
H. Kivelä, Councellor, Embassy of Finland in Moscow

Russian forest policy
H. Kivelä, Councellor, Embassy of Finland in Moscow

28.11.2007. Academy of Finland, Vilhovuorenkatu 6, Helsinki

Towards progressive forest sector in Northwest Russia – final seminar of the project

Organisers:
- *Finnish Forest Research Institute*
- *University of Joensuu*
- *Academy of Finland*

Opening
T. Karjalainen, Coordinator

Forest policy and forest programmes
T. Torniainen, Researcher, University of Joensuu

Forest management and wood harvesting in change in Russia
T. Karjalainen, Professor, Finnish Forest Research Institute

Export of roundwood and sawnwood from Russia and theri impacts on market competition
A. Toppinen, Docent, Finnish Forest Research Institute / European Forest Institute

Income and employment effects of forestry in Eastern Finland and Republic of Karelia
P. Ollonqvist, Professor, Finnish Forest Research Institute

Comments and discussion

Status of forest sector in Russia
K. Kyyrönen, Councellor, Embassy of Finland in Moscow

25.6.2008. St. Petersburg Forest Technical Academy, Institutsky per. 5, St. Petersburg, Russia

Towards Progressive Forest Sector in Northwest Russia

Organisers:

- *Finnish Forest Research Institute*
- *University of Joensuu*
- *St. Petersburg Forest Technical Academy*
- *Forest Department of the Northwest Russia Federal District*
- *Petrozavodsk State University*

Opening
T. Karjalainen, Professor, Finnish Forest Research Institute

Implementation of the new forest code and investments in forestry
V. Petrov, Deputy Director, Forest Department of the Northwest Russia Federal District

Forest industry in change
K. Kyyrönen, Councellor, Ministry for Foreign Affairs of Finland

Finnish analysis of the forest sector reform in Russia
T. Torniainen, Researcher, University of Joensuu

Experiences from the Baltic and Eastern European countries for the forest sector reform in Russia
E. Välkky, Researcher, Finnish Forest Research Institute

Income and employment impacts from roundwood use, forest industry and related value chain investments in Northwest Russia and Finland
I. Pirhonen, Researcher, Finnish Forest Research Institute

Wood export from Russia and effects on market competition
A. Mutanen, Researcher, Finnish Forest Research Institute

Quality differences between Finnish and North-West-Russian spruce and birch timber
H. Heräjärvi, Researcher, Finnish Forest Research Institute

Intensification of forest management
T. Leinonen, Researcher, Finnish Forest Research Institute

Challenges in wood harvesting
V. Siounev, Professor, Petrozavodsk State University and Y. Gerasimov, Researcher, Finnish Forest Research Institute

Appendix 3 Research training

Master thesis

Lopatin, E. 2004. Case study of long-term forest growth of Siberian spruce and Scots pine during last 200 years: Komi Republic, North West of Russia. Final thesis of MSc in European forestry. University of Joensuu, Faculty of Forestry. 51 p.

Goltsev, V. 2005. Analysis of experimental thinning management options in the Taiga Model Forest area. Final thesis of MSc in European forestry. University of Joensuu, Faculty of Forestry. 67 p.

Karvinen, P. 2005. Mechanising logging operations in Automous Socialistic Soviet Republic of Karelia in 1972–1990. Final thesis of MSc in forestry. University of Joensuu, Faculty of Forestry. 48 p.

Chikulaev, P. 2005. Analiz i perspektivy razvitija mashinizatcii sortimentnoj zagotovki v Respublike Karelija [Analysis of cut-to-length harvesting method mechanisation and its development scenarios in Karelia]. Petrozavodsk State University. Forest Engineering Faculty. Diploma thesis. 110 p. (In Russian)

Pecherin, V. 2005. Analiz i perspektivy razvitija mashinizatcii sortimentnoj zagotovki v Respublike Karelija [Nordic cut-to-length method in Karelia: analysis and prespective]. Petrozavodsk State University. Forest Engineering Faculty. Diploma thesis. 130 p. (In Russian)

Elina Välkky. 2008. Venäläinen metsäntutkimus vuosina 1992-2002 - asiantuntija-arviot ja kirjallisuuskatsaus metsänuudistamisen tutkimukseen. [Russian forest research in 1992-2002 - Expert evaluations and literature review of forest regeneration research]. Master's thesis. University of Joensuu, Faculty of Forest Sciences, Forest Planning and Economics. 69 p. (In Finnish)

Doctoral dissertations (related, not completed in this project)

Olga Tyukina. Comparison of economics of different wood harvesting chains in Russian Karelia

Timo Leinonen. Ecological and economic analysis of forest management modes and silvicultural norms and practices in Northwest Russia

Dominic Röser. Optimal wood harvesting systems in selected European countries and countries in economic transition

Taicia Garbuzova. Optimization of utilization of forest resources and protection of forest ecosystems in sub-taiga of Novgorod region

Appendix 4 Publications

Year 2008

Gerasimov, Y., Sokolov, A. & Karjalainen, T. 2008. GIS-based decision-support program for planning and analyzing short-wood transport in Russia. Croatian Journal of Forest Engineering 29(2): 163-176.

Gerasimov, Y. & Karjalainen, T. 2008. Development program for improving wood procurement in Northwest Russia based on SWOT analysis. Baltic Forestry 14(1): 87–92.

Gerasimov, Y., Markovsky, A. & Ilina, O. 2008. Analiz ogranicheniyj lesopoljzovaniya na osobo okhranyaemihkh prirodnihkh territoriyakh i v malonarushennihkh lesakh Vologodskoyj oblasti [The analysis of wood harvesting restrictions in conservation areas and old-growth forests of the Vologda oblast]. Working Papers of the Finnish Forest Research Institute 87. 103 p. (In Russian)

Gerasimov, Y., Markovsky, A, Ilina, O. & Dobrynin, D. 2008. Analiz ogranicheniyj lesopoljzovaniya na osobo okhranyaemihkh prirodnihkh territoriyakh i malonarushennihkh lesnyh territorijah Arkhangeljskoyj oblasti [The analysis of wood harvesting restrictions in conservation areas and intact forest landscapes of the Arkhangelsk oblast]. Working Papers of the Finnish Forest Research Institute 86. 116 p. (In Russian)

Gerasimov, Y. & Sokolov, A. 2008. Informacionnaya sistema dlja resheniya zadachi logistiki lesomaterialov [Information system for solving problem in wood logistics]. In: Pamfilov, E.A. (pod. red.). Aktual'nye problemy lesnogo kompleksa. Sbornik nauchnyh trudov po itogam mezhdunarodnoj nauchno-tehnicheskoj konferentsii. Vypusk 21. BGITA, Bransk. pp. 180-183. (in Russian)

Leinonen, T., Sungurov, R., Kolström, T., Sokolov, A., Žigunov & A., Dorošin, A. 2008. Forest regeneration in Northern and Northwestern Russia in 1993–2004 — Methods, results and development needs. Forest Ecology and Management 255/3-4: 383–395.

Siounev, V. Sokolov, A. & Gerasimov, Y. 2008. Logistika lesozagotovok: programma poiska optimal'nogo lesotransportnogo plana [Logistics in wood harvesting: program on searching for an optimal wood transportation plan]. In: Federal'noe agentstvo lesnogo hozjajstva. Lesnaja Rossija No 5-6: 54-61. (in Russian)

Välkky, E. 2008. Venäläinen metsäntutkimus vuosina 1992-2002 - asiantuntija-arviot ja kirjallisuuskatsaus metsänuudistamisen tutkimukseen. [Russian forest research in 1992-2002 - Expert evaluations and literature review of forest regeneration research]. Master's thesis. University of Joensuu, Faculty of Forest Sciences, Forest Planning and Economics. 69 p. (In Finnish)

Year 2007

Gerasimov, Y., Markovsky, A, Ilina, O. & Dobrynin, D. 2007a. Analiz ogranicheniyj lesopoljzovaniya na osobo okhranyaemihkh prirodnihkh territoriyakh i v malonarushennihkh lesakh Arkhangeljskoyj oblasti [The analysis of wood harvesting restrictions in conservation areas and old-growth forests of the Arkhangelsk oblast]. Working Papers of the Finnish Forest Research Institute 56. 118 p. (In Russian)

Gerasimov, Y., Markovsky, A., Markovskaya, N. & Dobrynin, D. 2007b. Analiz ogranicheniyj lesopoljzovaniya na osobo okhranyaemihkh prirodnihkh territoriyakh i v malonarushennihkh lesakh Arkhangeljskoyj oblasti [The analysis of wood harvesting restrictions in conservation areas and old-growth forests of the Arkhangelsk oblast]. Part 1. PROLes 3: 10–47. (In Russian)

Gerasimov, Y., Siounev V., Selivestrov, A. & Katarov, V. 2007. Analiz razvitiya lesozagotovok na Severo-Zapade Rossii [Development in wood harvesting and procurement in Northwest Russia]. Les I Bisnes 3(33): 58–63. (In Russian)

Karjalainen, T., Leinonen, T., Gerasimov, Y. & Toppinen, A. 2007. Metsien käsittelyn tehostaminen ja puunkorjuun kehittäminen Luoteis-Venäjällä [Intensification of forest management and improvement of wood harvesting in Northwest Russia]. In: Karjalainen, T., Ollonqvist, P., Saastamoinen, O. & Viitanen, J. (eds.). Kohti edistyvää metsäsektoria Luoteis-Venäjällä - Tutkimushankkeen loppuraportti [Towards progressive forest sector in Northwest Russia – final report]. Working Papers of the Finnish Forest Research Institute 62: 27–52. (In Finnish)

Karjalainen, T. & Toppinen, A. 2007a. Russia rising export duties of roundwood. EFI-News 2/2007: 12–13.

Karjalainen, T. & Toppinen, A. 2007b. Protektionistinen metsäpolitiikka vaikeuttaa investoimista Venäjälle (vieraskynä). Helsingin Sanomat 19.1. [Protectionistic forest policy complicating investments to Russia]. (In Finnish)

Siounev, V. & Konovalov, A. 2007a. Osobennosti ucheta zatrat pri razlichnihkh tekhnologiyakh zagotovki lesa na predpriyatiyakh Respubliki Kareliya [Main features of expenditures and cost calculation for different harvesting technologies for Karelia Republic's condition. Part 1.]. Lesnoy Expert 1(38): 60–62. (In Russian)

Siounev, V. & Konovalov, A. 2007b. Osobennosti ucheta zatrat pri razlichnihkh tekhnologiyakh zagotovki lesa na predpriyatiyakh Respubliki Kareliya [Main features of expenditures and cost calculation for different harvesting technologies for Karelia Republic's condition. Part 2]. Lesnoy Expert 2 (39):12–14. (In Russian)

Siounev, V. & Selivestrov, A. 2007. Sovremennihe finskie kharvesterih i kharvesternihe golovki v Rossii [Modern Finnish harvesters and harvester heads in Russia]. In Russian. http://www.idanmetsatieto.info/rus/cfmldocs/document.cfm?doc=show&doc_id=1082

Tyukina, O. 2007. Development of alternative cost accounting methods of wood harvesting in Russia. Integrative science for integrative management. IUFRO Division VI symposium 14–20.08.2007, Saariselkä, Finland. Abstracts. pp. 26.

Year 2006

Ananyev, V.A., Leinonen, T. & Grabovik, S.I. 2006. Rezul'taty issledovanija sovremennyh tehnologij nesplošnyh rubok v lesah Karelii [Results on investigating modern harvesting technology for thinning in forests of the Republic of Karelia, Russia]. In: Severnaja Evropa v XXI veke: priroda, kul'tura, ekonomika. Materialy Mezhdunarodnoj konferentsii, posvjashsennoj 60-letiju KarNTS RAN (24-27 oktjabrja 2006 g., g. Petrozavodsk). Karel'skij Nauchnij Tsentr RAN, Petrozavodsk. pp. 37–39. (In Russian)

Gerasimov, Y. & Karjalainen, T. 2006. Development of wood procurement in Northwest Russia: round wood balance and unreported flows. European Journal of Forest Research 125: 189–199.

Gerasimov, Y., Markovsky, A., Markovskaya, N. & Lapshin, P. 2006a. Analiz ogranicheniyj lesopoljzovaniya na osobo okhranyaemihkh prirodnihkh territoriyakh i v malonarushennihkh lesakh Respubliki Karelia [The analysis of wood harvesting restrictions in conservation areas and old-growth forests of the Republic of Karelia]. Working Papers of the Finnish Forest Research Institute 22. 148 p. (In Russian)

Gerasimov, Y., Markovsky, A., Markovskaya, N. & Lapshin, P. 2006b. Analiz osobo okhranyaemihkh prirodnihkh territoriyj i v malonarushennihkh lesov Respubliki Kareliya na urovne leskhozov [The analysis of conservation areas and old-growth forests on the leskhoz level]. PROLes 5–6: 56–60. (In Russian)

Gerasimov, Y., Syunev, V. & Sokolov, A. 2006a. Optimizacionnihyj raschet parametrov gidravlicheskikh mekhanizmov privoda manipulyatora lesnoyj mashinih [An optimized synthesis of the hydraulic crane mechanisms for a forestry machine]. Stroitelnye I dorozhnye machiny 12 (2006): 26–31. (In Russian)

Gerasimov, Y., Sunev, V. & Sokolov, A. 2006b. Optimizacionnihyj sintez skeletnoyj skhemih manipulyatora lesnoyj mashinih [An optimized synthesis of the skeleton diagram for a forestry manipulator]. Stroitelnye I dorozhnye machiny 4 (2006): 29–31. (In Russian)

Karjalainen, T. & Torniainen, T. 2006. Venäjällä metsät säilyvät tulevaisuudessakin valtion omistuksessa. [Forest resources remain in the state ownership also in future in Russia]. Tilastokeskus. Tieto ja Trendit 5/2006: 48–51. (In Finnish)

Karvinen, S., Välkky, E., Torniainen, T. & Gerasimov, Y. 2006. Northwest Russian forestry in a nutshell. Working Papers of the Finnish Forest Research Institute 30. 98 p.

Michie, B., Saramäki, K. & Pussinen, A. 2006. Locating feasible routes from kvartals to the nearest road in the Novgorod region of Russia. In: Proceedings of the Biannual Meeting of the Scandinavian society of Forest Economics, Uppsala, Sweden, May 8–11, 2006. p. 207–214.

Siounev, V. & Selivestrov, A. 2006. Razvitie sortimentnoyj tekhnologii lesozagotovok i ispoljzovanie kharvesterov v Respublike Kareliya [Development of cut-to-length method of logging and using of harvesters in the Republic of Karelia]. Les I Bisnes 7(27): 58–61. (In Russian)

Siounev, V., Selivestrov, A. & Konovalov, A. 2006. Sebestoimostj mashinizirovannoyj sortimentnoyj tekhnologii v usloviyakh Respubliki Kareliya [Development of cut-to-length method in the Republic of Karelia]. Les I Bisnes 9: 54–59. (In Russian)

Toppinen, A., Mutanen, A. Viitanen, J. & Karjalainen, T. 2006a. Venäjän metsäsektori muutoksessa. [Russian forest sector in transition]. Paperi ja Puu – Paper and Timber 88 (7): 384–386. (In Finnish)

Toppinen, A., Mutanen, A., Viitanen. J. & Karjalainen, T. 2006b. Venäjän metsäsektorin kehityksen vaikutukset Suomeen [Impacts of the development in the Russian forest sector to Finland]. In: Hetemäki, L. ym. (toim.). Suomen metsiin perustuva hyvinvointi 2015. Katsaus Suomen metsäalan kehitykseen ja tulevaisuuden vaihtoehtoihin [Welfare based on Finnish forests 2015. Glance to development and future alternatives in Finnish forestry]. Working Papers of the Finnish Forest Research Institute 26: 143–149. (In Finnish)

Year 2005

Anan'ev, V.A., Leinonen, T. & Grabovik, S.I. 2005. Resultaty obsledovanija srednevozrastnyh elovyh drevostoev posle rubok uhoda [Results of the research in spruce stands after thinning operations]. In: Syonev, V., Pitukhin, A., Kostyukevitch, V., Gerasimov, Y., Leinonen, T., Karvinen, S. & Levicheva, L. (eds.). Trudy lesoinženernogo fakul'teta PetrGU. Vypusk 6 (special'nyj). Research Reports of the Forest Engineering Faculty of the Petrozavodsk State University 6: 5–7. (In Russian)

Chikulaev, P. 2005. Analiz i perspektivy razvitija mashinizatcii sortimentnoj zagotovki v Respublike Karelija [Analysis of cut-to-length harvesting method mechanisation and its development scenarios in Karelia]. Petrozavodsk State University. Forest Engineering Faculty. Diploma thesis. 110 p. (In Russian)

Gerasimov, Y., Siounev, V., Chikulaev, P., Pechorin, V., Dyakonov, V., Komkov, V., Sikanen, L. & Karjalainen, T. 2005. An analysis of logging companies in the Republic of Karelia. Working Papers of the Finnish Forest Research Institute 16. 39 p.

Goltsev, V. 2005. Analysis of experimental thinning management options in the Taiga Model Forest area. Final thesis of MSc in European forestry. University of Joensuu, Faculty of Forestry. 67 p.

Karjalainen, T., Mutanen, A., Torniainen, T. and Viitanen, J. 2005a. Venäjän metsäsektorin muutokset ja haasteet [Changes and Challenges in the Russian Forest Sector]. Metsäsektorin suhdannekatsaus 2005–2006 [Finnish Forest Sector Economic Outlook 2005–2006]. Metsäntutkimuslaitos, Vantaa. pp. 58–61. (In Finnish)

Karjalainen, T., Mutanen, A., Torniainen, T. and Viitanen, J. 2005b. Changes and Challenges in the Russian Forest Sector. Finnish Forest Sector Economic Outlook 2005–2006. Finnish Forest Research Institute. Vantaa. p. 50–53.

Karvinen, P. 2005. Mechanising logging operations in Automous Socialistic Soviet Republic of Karelia in 1972–1990. Final thesis of MSc in forestry. University of Joensuu, Faculty of Forestry. 48 p.

Pecherin, V. 2005. Analiz i perspektivy razvitija mashinizatcii sortimentnoj zagotovki v Respublike Karelija [Nordic cut-to-length method in Karelia: analysis and prespective]. Petrozavodsk State University. Forest Engineering Faculty. Diploma thesis. 130 p. (In Russian)

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