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Dialogue on Sustainable Development of the Russian Forest Sector- Volume I

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Foreword

IIASA, the Russian Academy of Sciences, and the Russian Federal Forest Service, in agreement with the Russian Ministry of the Environment and Natural Resources signed agreements in 1992 and 1994 to carry out a large-scale study on the Siberian forest sector (The Siberian Forest Study). The goals were to assess Siberia's forest resources, forest industries, and infrastructure; to examine the forests' economic, social and biospheric functions, with these functions in mind, to identify possible pathways into policy options for Russian and international agencies.

In the fall of 1996, the Siberian Forest Study was transformed to the Sustainable Boreal Forest Resources Project. This project has the following overall objectives;

- to generate a quantitative output to a sustainable development concept for the boreal forest zone and specifically for Russia drawing on the work carried out earlier at IIASA, and

- to use the quantitative information generated in an efficient policy mode.

The first steps, in order to move into the policy mode for the Russian forest sector, were taken at the "Dialogue on Sustainable Development of the Russian Forest Sector" in Moscow in November 1996.

High-level Russian governmental representatives were invited to present their views on the emerging policy issues in the Russian forest sector.

The background information to and the results of this "Dialogue" have been documented in two volumes. This report is Volume I and deals with the background presentations at the "Dialogue", the statements made by Russian governmental participants, and the agreed-upon steps to follow with respect to policy work to be carried out by the IIASA Study. Volume II deals with the background information for the "Dialogue" in the form of short summaries on the results achieved so far by the different activities of the IIASA Study.

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Dialogue on Sustainable Development of the Russian Forest Sector - Volume I

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1. Introduction

The first effort of the IIASA Study to move into the policy mode was the arrangement of the "Dialogue on Sustainable Development of the Russian Forest Sector" which took place in Moscow from November 12-14, 1996. The "Dialogue" was organized by IIASA, the Russian Academy of Sciences, and the Federal Service of Forest Management of Russia. The ultimate goals of this Dialogue were to initiate intensive cooperation on future policy work and to stimulate increased governmental priority with respect to the Russian forest sector. To achieve these goals, the IIASA Study invited high-level Russian governmental representatives to present their views on the emerging policy issues in the Russian forest sector. An accurate presentation, based on comprehensive data and thorough analyses, is an important component in setting the stage for future policy work. To this end, the international research team of the IIASA Study presented quantitative scientific results achieved at this stage at the Dialogue. These results serve as critical input to the policy development process.

The overall outline of the "Dialogue" was the following: Problems in Sustainable Development of the Russian Forest Sector (statements and presentations by Russian governmental representatives), Presentation on 9 Aggregated Themes from Achievements by the IIASA Study (Summary Sheets on most of the subactivities carried out by the IIASA Study were distributed to the participants in advance), the Policy Mode, and Conclusions. The detailed agenda of the Dialogue is presented in Appendix I.

In this documentation of the Dialogue (Volume I) statements made by Russian governmental representatives, the theme papers, and the conclusions are presented. The summary sheets on activities and results achieved so far by the IIASA Study are presented in a separate volume (Volume II) from the Dialogue.

2. Problems in Sustainable Development of the Russian Forest Sector

In this section statements made by Russian governmental representatives during the "Dialogue" are summarized. The overall conclusions from these statements are the following:

- There is awareness and a clear identification by the Russian government of the serious problems and urgency policy issues in the Russian forest sector,
- The forest sector is identified to be crucial for the transition of the Russian society into sustainable socioeconomic development,
- The Russian government appears to be striving to further develop the forest sector and increase its status,
- There is a strong commitment to follow a sustainable development concept,
- There is a strong commitment to fulfill international agreements made with respect to the forest sector, but
- To achieve the above there is also a strong need to clearly identify a coordinated program for forest sector development, a coordinated policy-setting in the sector, and that international cooperation is required in this process.

The Vice-Premier of the Russian Government, Alexandr Zaverjukha stated that "the Dialogue is evidence of the renewed priority the Russian government is giving to the nation's forest sector and the development of policies that will enhance its sustainable development and its contribution to the economy, as well as its role in fulfilling international agreements to preserve the environment."

The Chairman of the State Committee of Environmental Protection, V.I. Danilov-Danilyan pointed out that "the Russian forest sector currently does not follow the basic principles of sustainable development and is missing an adequate legal framework but the Russian government is now focussed on the work of achieving sustainable development. But to reverse the present trends of unfavorable conditions in the forest sector, international partners, and international cooperation and contribution are required."

The Deputy Head of the Federal Service of Forest Management of Russia, A.I. Pisarenko stressed the reiterated importance of the Russian forest sector and recognized the necessity of joint efforts among different governmental agencies and departments in order to reach sustainable development of the forest sector. He also pointed out that "the work carried out so far and the planned work on long-term policies by the IIASA Study are important for the Russian government."

The Deputy Head of the State Committee of the Forestry Industry of Russia, V.A. Chuiko underlined that "the forest sector is more affected by dismal economic conditions than other sectors but the Russian forest sector can play a major role in moving the Russian economy out of its depressed situation."

The First Deputy Minister of Natural Resources of Russia, N.I. Micheev made it clear that "Russia for a long time will be very dependent on its natural resources from an economic point of view and that the time has come for big important decisions concerning a sustainable utilization of the natural resources."

The Deputy Head of the Department of Natural Resources and Environmental Protection of the Russian Federation, V.A. Parfenov stated that "the transition to sustainable development in Russia has been stated officially by the President's decree of 1996 and something has to be done now."

"All Russian scientists are called on and international contributions are welcomed to realize the necessary changes in order to improve the role of the Russian forest sector with respect to the global and Russian environments and Russian economic growth." Mr. Parfenov also identified that "in this process the IIASA Study with its many Russian collaborators can make a contribution and the first step would be to try to resolve the present dismal eco-environmental situation in the Russian forest sector and the second step would be development of new long-term policies."

The Deputy Minister of the Ministry of Economics of Russia, V.S. Evsjukov reconfirmed that "the Russian government is putting a high priority on the forest sector and that the sector is important for the transition of the Russian economy." Mr. Evsjukov also stressed the "burning and emerging issue of the establishment of coordinated policies within the Russian forest sector."

The statements and conclusions above were the basis for discussions on the future directions of the IIASA Study during the "Dialogue."

3. Presentation of Nine Aggregated Themes from Achievements by the IIASA Study.

The theme reports are produced by the core-team and the Russian network of the IIASA Study.

3.1. Russian Forests in an International Perspective

Sten Nilsson, International Institute for Applied Systems Analysis, Laxenburg, Austria

Background

Before discussing the Russian forests in an international perspective, we will briefly describe the study on the Russian/Siberian forest sector which is carried out as a joint venture between IIASA, the Russian Academy of Sciences, Federal Services on Russian Forest Management, and other Russian governmental agencies.

The study has an overall objective to assess Siberia's and Russia's forest resources, forest industries, and infrastructure; to examine the forests' economic, social and biospheric functions; with these functions in mind, to identify possible pathways for their sustainable development; and to translate these pathways into policy options for Russian and international agencies.

Everyone has a stake in an intelligent, sustainable development of the Russian forest resources. The ongoing changes in Russia bring unprecedented opportunities and risks. In spite of Russia's timber and mineral wealth, it suffers from a weak economy and severe social problems. Careless exploitation of the Russian forests could hold back Russia's economic renewal, permanently scar the local environment, and destabilize global functions. On the other hand, healthy forests and forest industries could help revitalize Russia's economy and society, open a new source of timber for global markets and improve the ecological well-being of the entire world.

The study was originally organized in 3 phases: Generation of databases and a GIS-system (Phase I), Assessment studies (Phase II), and the Policy Mode (Phase III). The structure is illustrated in Table 1. Phase I is finalized and we are currently about 60% on our way to finalizing Phase II. The assessment studies in this phase are organized within a policy framework around nine areas that we call cornerstones.

These cornerstone areas are:

- ◊ Refinement of databases and GIS-system
- ◊ Biodiversity and Landscapes
- ◊ Greenhouse Gas Balances
- ◊ Environmental Status
- ◊ Non-Wood Products and Functions
- ◊ Forest Resources and Forest Utilization
- ◊ Transportation Infrastructure
- ◊ Forest Industry and Markets and
- ◊ Socioeconomics.

Table 1.

	Components/ Activities	Forestry	Ecology and Global Change	Markets	Industry and Infrastructure	Socio-Economics	Time line
PHASE I	**Block 0** Feasibility of existing data and set-up of study	Integrated feasibility study of existing data on all components and set-up of study					1992
	Block I Collection analysis of existing data and generation of databases	•Forest Resources •Forest management •Management technology •Economic conditions	•Description of ecological status •Global change status	•Description of international markets •Description of domestic markets	•Description of existing industrial structue (capacities and technological status) •Description of existing infrastructure	•Description of socioeconomic conditions •Description of soico-economic indicators	– 1995
PHASE II	**Block II** Assessment studies	*Forest resources assessment* •Allowable cut •Sustainable forest structure •Multiple uses •Protection •Forest management	*Ecological assessment* •Sustainble ecological development options •Global change effects	*Market assessment* •Identification of market possibilities •Possible market strategies	*Assessment of industry and infrastructure* •Technological development options •Industrial development options •Infrastructural options	*Socioeconomic assessment* •Socioeconomic development options	1996 – 1997
PHASE III	**Block III** Integrated studies	Integrated analyses of all components based on results from Block II					1997
	Block IV Policy Implications	•Allowable cut •Forest management	•Strategies for regional and global sustainable development	•Market strategies •Marketing activities	•Industrial strategies •Infrastructural strategies	•Socioeconomic development strategies	– 1998

To use the quantitative information generated in Phase II efficiently, the information must be presented in an integrated and consistent form and be directly integrated into the policy process both in Russia and internationally. This will take place in Phase III of the study, which has the following tasks:

- to conduct consistent integrated analyses;
- to formulate implementable policies for Russia's forest sector; and
- to formulate policies together with policymakers.

From a study perspective, our objectives with the "Dialogue on Sustainable Development of the Russian Forest Sector" were:

- to present the work and results achieved so far by the study to Russian policymakers,
- to map the current policy scene in the Russian forest sector, and
- to set the platform for Phase III – the Policy Mode.

As previously stated, we have not yet finalized Phase II, but we will present our current results in nine aggregated theme presentations. These aggregated theme presentations are based on some 35 different substudies. From these substudies we have produced what we call "summary sheets" presenting the most important results and the policy recommendations. Each of these summary sheets have been distributed before the Dialogue allowing an easy overview of the results.

Before we turn to the first theme presentation, we would like to point out that all of this work could not have been achieved without the strong commitment and participation of the Study's huge Russian network. A network which is described in Appendix II.

Future Global Balances of Industrial Wood

Industrial Wood Availability

The Annual Allowable Cut (AAC) has been used by governments to control harvesting and is based on an estimated sustainable harvest level. AACs are being increasingly restricted by social and environmental constraints.

Recently a number of studies have been released that have attempted to estimate the future industrial wood supply based on conventional approaches. We have tried to harmonize, as consistently as possible, from these sources, where it has been possible to regionalize the information (Table 2).

Table 2. Estimated Availability of Industrial Roundwood (million m^3 under bark). The 1993 Figures Are Estimated Production Figures.

	1993		2010		2020	
	Coniferous	Non-coniferous	Coniferous	Non-coniferous	Coniferous	Non-coniferous
Canada	165.3	7.9	127-158	38-50	135-162	42-55
USA	285.8	116.7	245-289	117-140	265-317	125-155
Latin America	63.6	67.4	85-100	89-118	105-110	105-120
Africa	10.2	49.4	12-16	54-59	14-16	57-65
Oceania	23.6	13.3	33-41	17-18	53-58	19-21
China	63.3	35.5	50-60	30-35	53-60	32-40
Japan	18.8	6.8	20-55	8-9	22-55	9-10
Other Asia	12.0	133.2	14-16	65-124	16-19	65-129
Russia	86.2	31.7	130-194	30-70	175-235	30-80
Eastern Europe[1)]	48.0	32.7	59-64	47-52	61-66	49-53
Western Europe	78.1	35.8	86-108	39-56	91-113	41-58
Nordic region	85.0	9.6	89-108	11-14	89-116	12-15
World Total	939.9	540.0	950-1209	545-745	1079-1327	586-801

1) Includes the European countries of the former USSR.

There are large differences in the estimates of total roundwood supply in the USA, Latin America, Other Asia, Russia, and Japan, and in coniferous in Canada. Why is this so? There are two main reasons. First, we do not have sufficient inventory information especially on economically accessible wood. Second, there are great uncertainties as to how the changing values of the society will affect the utilization of the forests. In other words, how will social and environmental initiatives constrain future forest resources?

In the following we briefly discuss the reasons for these large variations in the regions listed above. Reliability of the existing forest inventories in the southern states of the USA are doubtful. Constraints that environmental initiatives will cause in the future is uncertain. The most recent impact of non-timber demands has reduced sales of the US Forest Service by 40 million m^3 since 1989.

The large variances identified in the availability of coniferous species in Canada are mainly due to uncertainties about future environmental regulations. In Latin America and Other Asian regions uncertainties are connected to the unreliability of inventory information on available forest resources, concerns regarding the speed at which supply will decrease from the natural forests, and the issues of implementation and performance of industrial forest plantations. There is great concern about how much of the forests will be accessible in Russia in the future. Japan has untouched forest reserves and has carried out a 10 million hectare plantation program. In spite of this, coniferous output has decreased by nearly 8 million m^3 and non-coniferous output by nearly 10 million m^3.

In addition to the regional estimates presented in Table 2, there are recent aggregated global estimates on future wood supply possibilities. These are presented in Table 3.

Table 3. Global estimates on possible wood supply. In million m^3 under bark.

.	1993			2010			2020		
	Conif.	Non-Conif.	Total	Conif.	Non-Conif.	Total	Conif.	Non-Conif.	Total
From Table 2	93 4	540	1474	950-1209	545-745	1495-1954	1079-1327	586-801	1665-2128
Wood Resources International (1996)				1142	1101	2243			
EFI & NIS K (1996)									1981-2278

Industrial Roundwood Demand

Presently most analyses on the future demand of industrial roundwood use econometric models that take into account population growth, economic growth, end-use patterns, technological change and other factors.

In Table 4 we have attempted to harmonize available estimates on future industrial roundwood demand at the global level as much as possible.

Table 4. Forecasts of Demand on Industrial Roundwood (million m^3).

	1993			2010			2020		
	Conif.	Non-conif.	Total	Conif.	Non-conif.	Total	Conif.	Non-conif.	Total
FAO 1995d	939	54 0	1479						
FAO 1995b				168 2	992	2674			
FAO 1995d				142 3	855	2278			
Pöyry 1994						2050			
Pöyry 1995[1)]						2000			
Apsey & Reed 1995				1210	730	1940	1400	850	2250
Simons 1994				1362	783	2145	1538	1013	2551
World Resources Intl. 1996				1332	943	2275			
EFI & NISK 1996						1840-2090			1870-2330

1) Revised projection due to new paper consumption forecasts presented by Jerkeman (1995).

These estimates indicate a total demand of some 2150 million m^3 (1330 million m^3 coniferous and 820 million m^3 of non-coniferous) in the year 2010. The corresponding figures for the year 2020 are 2400, 1470, and 930 million m^3 respectively.

The Balancing Act - The Global Balance

The global balance for industrial roundwood is presented in Table 5. Based on these estimates we can conclude that by the year 2010 there may be a shortage of as much as 250 million m^3, of which 175 million m^3 are in coniferous and 75 million m^3 in non-coniferous. By the year 2020 the total shortage could reach as much as 465 million m^3 of which 230 million m^3 are in coniferous and 235 million m^3 in non-coniferous.

Table 5. Global Industrial Wood Balance. In million m^3.

	2010			2020		
	Conif.	Non-Conif.	Total	Conif.	Non-Conif.	Total
Simons, 1994	+60	-39	+21	-82	-209	-291
Apsey & Reed, 1995	-257	-177	-434	-315	-251	-566
McNutt, 1995			-75 - -12 5			
IIASA, 1996	0 - -47 3	+15 - -310	+15 - -783	-73 - -459	-49 - -427	-122 - -886
Wood Resources Intl.,1996	-190	+158	-32			
EFI & NISK, 1996						+400 - -350

Even if these calculations identifying shortages are accurate, these shortages will never actually appear. In a shortage situation, a number of balancing measures will occur to achieve an equilibrium: decreases in demand due to increased prices, introduction of new and more fiber-efficient technology, substitution of products, and increased supply. But the balance will be very tight.

The outlook presented is a major challenge and opportunity for the Russian forest sector to intensify development.

Sensitivity Analyses - Wild Cards

There are a number of wild cards in the global wood balance, in addition to those previously mentioned.

Dramatically Increased Recycling

The scenarios presented above on global industrial wood balance take into account the foreseeable trends in recycling. But could a dramatic increase in recycling improve the balances of industrial roundwood?

Given market and price developments with less available waste paper on the market, increased collection costs and increased prices, it does not seem feasible that shortages in the global balances would be compensated by an unforeseen dramatic increase in recycling.

Plantations in the Southern Hemisphere

Many scientists and consultants advocate that plantations in the Southern Hemisphere would solve all future shortages in wood supply. But after studying the development of established plantations it can be concluded that with a few exceptions, forest plantations are generally yielding lower than expected and the potential of forest plantations has not been realized. It would be too time consuming to discuss the reasons for this development, however, it is feasible to assume that the importance of industrial forest plantations will continue to grow, but the increased reliance on plantation forests will not change the trend in the global industrial wood balance presented above.

Substitution of Non-Wood Fibers for Wood Fibers

The amount of non-woods suitable for the pulp and paper industry is enormous (some 2.5 billion tons per year). The technology is available and is continually being improved. But non-woods are mainly seasonal and have a variety of fiber and mills, which require specific fiber preparation. Thus, non-wood fibers have a bright future, but penetration will take time and will mainly occur in the developing world. Hence, non-woods will probably not change the trend identified within the time-frame for the global balances presented.

Land-Use Change and Deforestation

Deforestation will continue in the tropics. Estimates indicate a decline of commercial resources in the tropics from 7.9 billion m^3 to 2.55 billion m^3 between 1990 and 2020.

General land-use changes are estimated to decrease tropical forests by 650 million hectares and the temperate forests by 50 million hectares during the same time period.

Non-Wood Demands

"New" demands on non-wood functions have already significantly affected the wood supply and is expected to continue in the future.

- Carbon Sequestration
  Prospects for improving the carbon balance through plantations, improved silviculture and replacement of fossil fuels by wood are optimistic. But so far, very little has been done in practical management in this respect. As soon as large-scale carbon management is implemented, there will be impacts on future supply. But the question is if this carbon management will materialize.

- Biodiversity
  The tremendous losses of biodiversity which are mainly caused by land conversion or land-use studies indicate that some 40% of the total forests and other wooded lands in Latin America should be prioritized for biodiversity conservation. Studies in the Nordic countries indicate that current rates for certification will decrease long term wood supply by 15-20%. It is clear that if we are to solve the biodiversity issue in a effective manner huge areas and volumes will be affected.

- Non-Wood Productions and Functions
  The term "functions" refers to water protection, grazing, hunting, recreation etc. Studies by the ECE indicate that during a 10-year period in Europe, a high demand for wood production decreased by 13%, but areas with a high demand for other functions increased by 2-11% depending on the function.

  We can expect a similar development in countries with a fast-growing economy and a rapidly growing middle class. Such a development will affect large forest areas.

- Local and National Environmental Functions
  During the last 45 years an area the size of China and India (1.2 billion hectares) has suffered moderate to extensive soil degradation, and is expected to continue.

- Ecotourism or Nature Tourism
  Ecotourism, both international and domestic, is projected to grow, but a quantitative estimate of its impact on future utilization of global forest resources is currently an impossible task.

Taking all of the above factors into account, we have no doubt that the global industrial wood balance presented will become even tighter. This will of course make the Russian challenge even bigger.

Russian Forest Resources

In the public and world scientific community, the viewpoint is often expressed that Russian forests are disappearing. It is claimed that the deforestation rate in Russia is 2-3 million hectares annually. However, explicit conclusions on the state and development of forested areas and growing stock of Russian forests can only be based on numerical analyses of changes in inventory data over an extended period of time.

We have studied the Forest State Account from 1961-1993 and made adjustments for the accuracy of different inventory methods and for changed inventory instructions and redistribution of forests between different agencies over time.

From 1961-1993, the Forested Areas of Russian forests increased by 68 million ha, mainly in forests under state forest management. For this same time period, the total growing stock of all forests increased by 3.2 billion m^3, although growing stock of forests under state forest management decreased by 1.1 billion m^3. A significant decrease in growing stock was observed in coniferous stands (some 5 billion m^3) under state forest management. A significant decrease of growing stock of mature and overmature coniferous species of all forests took place between 1983 and 1993 (7.7 billion m^3), with the major decline occurring in Siberia. However, this decline can not be explained by the harvest, factors other than harvest have been driving the decline of growing stock in Siberia. All of the above is based on the inventory without adjustments for systematic errors, but if we were to make that adjustment we would get a development which is illustrated in Table 6.

Table 6. Reconstructed development of total growing stock in all Russian forests from 1961 to 1993.

Indicators	196 1	1966	1973	1978	1983	1988	1993
Percentage of FF area inventoried by FIP in European Russia	3 6	41	44	56	75	88	94
Percentage of FF area inventoried by FIP in Asian Russia	9	22	30	38	52	59	60
Reconstructed GS in European Russia x $10^9 m^3$	16.4	16.5	17.3	18.3	19.9	21.4	22.2
Reconstructed GS in Asian Russia x $10^9 m^3$	58.6	59.2	60.2	62.1	64.6	64.2	62.6
Reconstructed GS Total Russia x $10^9 m^3$	75.0	75.7[1)]	77.5	80.4	84.5	85.6	84.8
Deviation in percentage between reconstructed and official FSA data for total GS in Russia	-3.3	-1.7	-1.5	-0.4	+3.2	+4.9	+5.1

1) The long-term leased forests were not inventoried with respect to growing stock in 1966, (about 2.2% of the total growing stock).

In this case, we get an increase of the growing stock for all Russian forests of 9.9 billion m^3 during the studied period, but we still have a severe decline in Siberia from 1983-1993 (2 billion m^3).

The analyses carried out make it difficult to justify the premise that Russian forests are disappearing from a global and quantitative perspective. But the analyses also make it completely clear that there are very serious regional problems and that the quality of the Russian forests has been seriously impoverished between 1961 and 1993.

The Russian government must take immediate steps in order to restore the regional sustainability and quality of the Russian forests in all respects.

The Challenges for the Russian Forest Sector

Based on the above it can be concluded that the Russian forest sector can play a vital role, both with respect to sustainable global, economic and environmental development and to a sustainable domestic socioeconomic development. The challenge is tremendous but to meet this challenge the following must be done:

- Identify what contribution the Russian forest sector could make towards global and domestic environmental and socioeconomic sustainable development and in doing so, increase the status of the forest sector.

- Fulfill the international commitments made for sustainable forest management.

- Formulate and establish consistent policies and establish a supporting institutional framework for the forest sector based on current environmental and socioeconomic problems in the sector.

The IIASA Study can make a major contribution in the above process.

Basic Studies

The results presented above are based on the following work:

Nilsson, S. 1996. "Do We Have Enough Forests?" Occasional Paper #5, IUFRO, Vienna, Austria.

Shvidenko, A. and Nilsson, S. 1997. Are the Russian Forests Disappearing? *Unasylva* No. 188, Vol. 48, pp. 57-64.

Solberg, B., Brooks, D., Pajuoja, H., Peck, T.J. and Wardle, P.A. 1996. Long-Term Trends and Prospects in World Supply and Demand for Wood and Implications for Sustainable Forest Management. European Forest Institute and Norwegian Forest Research Institute, Joensuu Finland and ÅS, Norway.

Wood Resources International. 1996. The Global Wood Fiber Situation 1995-2010. An Overview Perspective. Wood Resources International Ltd., Reston, Virginia, USA.

3.2. The Study Database and Geographical Information System of the IIASA Study

Kai Blauberg, International Institute for Applied Systems Analysis, Laxenburg, Austria and Alexander Isaev, International Forestry Institute, Moscow, Russia

Introduction

The main objectives of the IIASA Study are to assess forest resources, forest industry and transportation infrastructure, to examine the forest's economic, social, and biospheric functions, to identify possible pathways for the sustainable development of the Siberian forest sector, and to formulate policy options for Russian and international agencies (IIASA, 1996). The formulated main objectives lead to a need for the development of a information depository in each of the interest areas of the Study. Due to the basic nature of the phenomena to be investigated - the locational aspect, and their relationships in space, in time, as well as between the various phenomena - the information system to be developed should enable the management and analysis of geographically referenced information.

In the initial stage of the study - the database and GIS development - the project was faced with a situation, where the various databases describing the interests of the study were both geographically and institutionally scattered. In some instances it became evident, that some specific information at that point in time, had not been compiled into databases. Therefore database development activities were started to meet the needs of the planned scientific research of the Study.

During the period from late 1993 to the present, the Study has generated as a collaborative effort with numerous Russian scientific institutes and administrative organizations an integrated geographic database, which serves as an information resource for a multitude of scientific activities. The driving force has been to collect the dispersed information under one umbrella. Furthermore, to utilize state-of-art information processing technologies, i.e. relational database management system (RDBMS), geographic information system (GIS), and remote sensing technologies, when developing better knowledge in the area of forest, economic and ecological sciences.

In its current extent the IIASA Study database on the Siberian and Russian forest sector consists of 370 data tables, containing roughly 5900 different parameters or approximately 1.6 million lines of data. The physical size of the relational database totals close to 400 Megabytes and the size of the various GIS layers total up to 610 Megabytes.

Database and GIS Development Procedure

The development procedure of the thematical and GIS databases followed the steps of database definition and database implementation. The **database definition** aims to develop the logical and physical definitions of the database. For this task the project implemented Entity-Relationship-Modeling (Chen, 1981), with the help of the System Architect (Popkin Software & Systems Inc.) and CASE-tool (Computer-Aided Software Development).

An Entity-Relationship (ER) model contains the top-level objects of interest, their descriptive attributes, and their relation to each other. The completed development of an ER-model produces a data dictionary, which is an organized listing of the descriptive data elements contained in the database system. The data dictionary gives an exact definition for each data element, as well as composition information, relevant values, and units of measurements (Yourdon, 1989). The IIASA Study data dictionary (Blauberg, 1996) serves as an interface into the database enabling the search for needed information by the scientist.

The **database implementation** incorporates the tasks of data input, digital map compilation, or data transformation from existing data systems. The implementation process was completed with a substantial involvement by the Russian network of the Study. The **data validation**, which is also very closely linked to the steps of database implementation, was done to insure the consistency and quality of the information, and the analogity with the established logical and physical database definitions.

The Database

Core database entities

The top-level data model of the Study database contains entity types, which fall into categories of economic, socioeconomic, ecologic, and forestry areas of interest, and are based on administrative or industrial activities. In the database's current state, the following top-level entity types have been identified (see Figure 1): administrative region, ecoregion, atmospheric pollutant, landscape, forestry enterprise, forest industry enterprise, and nature conservation unit. The geographical coverage of these entity types are either for Siberia or the whole Russian Federation.

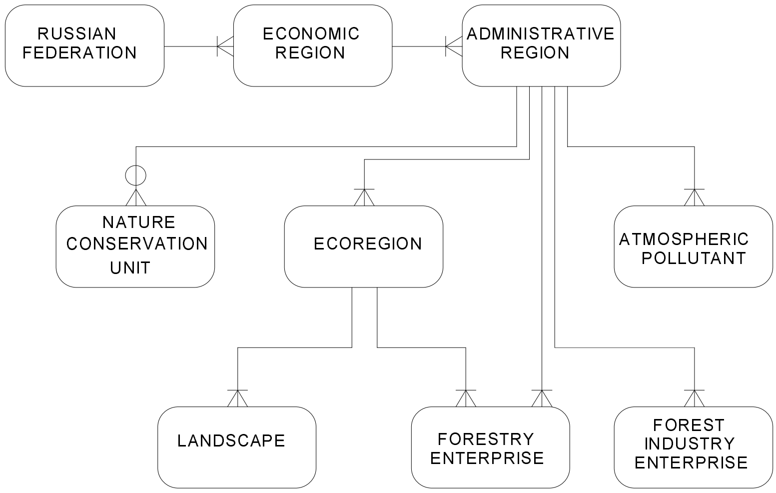

Figure 1 Top-level Entity-Relationship diagram of the Study database.

Administrative region is an entity type representing all the subjects of the Russian Federation as defined in the constitution of the Russian Federation.

Ecoregion is a territorial unit for the analyses of large-scale ecological questions such as biodiversity, greenhouse gas balances and landscapes. The Russian land area was subsequently divided using criteria based on the extent of the territorial unit; climatic, pedospheric, and vegetational homogeneity; macrorelief and state of permafrost; state of anthropogenic disturbances; and administrative regionalization (Shvidenko, 1996).

Atmospheric pollutant is a logical unit that emits polluting substances into the atmosphere. The pollution can originate from industrial production, from agricultural activities, or from power production facilities. The main sources of atmospheric pollutants are either administrative regions, large cities, or big industrial enterprises.

Forestry enterprise (leskhoz) is an independent management unit of the Federal Service of the Forest Management of the Russian Federation, which manages the state Forest Fund area and is primarily responsible for fiber production, silvicultural activities, and management of the state forest resources.

Forest industry enterprise (lespromkhoz) is a private or state-owned industrial company responsible for the harvesting and/or processing of fiber products into marketable goods, i.e. lumber, pulp, paper, or furniture.

Landscape, in the context of the Study, is a subdivision of an ecoregion. Regionalization of the landscapes is based on the requirement of a pure, natural homogeneity (Rojkov *et al.*, 1996).

Nature conservation units include nature reserves, national parks, and state hunting enterprises. These areas are mainly designated for nature protection and protection of the lifestyle of the indigenous people. Industrial utilization and forest management activities are prohibited or very severely limited in these areas.

Theme Descriptions

Each of the core database entities are described with a varying set of themes, which describe the various phenomena related to the interest areas of the study. Table 1., gives an overview on how various core entities are represented with different themes in the five interest areas of the Study.

Table 1. Matrix representation of the description of the core entity types with the theme areas of the Study database.

THEME AREA / CORE ENTITY	FORESTRY	FOREST INDUSTRY AND INFRA-STRUCTURE	ECOLOGY AND GLOBAL CHANGE	SOCIO-ECONOMY	MARKETS
Administrative region	X	X	X	X	X
Ecoregion	X	X	X	X	
Atmospheric emission source			X		
Forestry enterprise	X		X		
Forest industry enterprise		X			
Landscape			X		
Nature conservation unit	X		X		

Forestry Description

The **forestry description** originates from the 'All-Russian Scientific Research & Information Centre of Forest Resources of the Federal Forest Service', which is primarily responsibile for compiling the information at the federal level in Russia. The forestry description of the database characterizes the forestry conditions for the following core entity types: administrative region, ecologic region and forestry enterprise.

The forestry description is divided into the **State Forest Account (SFA), Annual Allowable Cut (AAC)** and **tapping descriptions**. The SFA documents the forest resources and the planned and the implemented management activities for each forestry enterprise, as well as for the other geographical objects. The AAC description identifies the level of AAC for different quality classes as well as for tree species in these classes. The tapping description identifies the level of tapping activities and tapping possibilities for the specific geographical object. The forestry description contains in total 232 parameters.

Socioeconomic description

The **socioeconomic description** was originally compiled by the 'The State Committee on Statistics of the Russian Federation' (GOSKOMSTAT), and characterizes the socioeconomic conditions at the level of the administrative region entity type. The content of the description is divided into 20 different sections, characterizing the following items: general identification, population, labor and salaries, industry, agriculture, capital construction, communication and transport, state trade and catering, utilities and services, health care and sport, education and culture, finance, public consumption, industrial production, interregional trade, labor resources, supply of materials, environmental protection, foreign trade, and price indices. The socioeconomic description contains approximately 3500 different parameters, and covers the period 1987 - 1993.

Atmospheric pollution description

The **atmospheric pollution description** has also been originally compiled by GOSKOMSTAT, and describes the atmospheric pollution output for the atmospheric pollutants, and further to a maximum of 53 industry branches inside a given atmospheric pollutant. The pollution description is divided into the sections: total emissions, inorganic emissions, organic emissions, solid and liquid emissions, dust emissions, flue gasses, filter residue, and recycled portion of the filter residue. The total number of characterizing parameters are 140.

Ecoregion description

The **ecoregion description** has been compiled by the research activity of the Study, involving numerous Russian scientific institutes in the development of the description. The content of the ecoregion description is divided into five different categories: anthroposphere, atmosphere, hydrospere, pedospere, and biosphere. The **antropospheric component** describes the general identification and the human activity of a specific ecoregion. The **atmospheric component** identifies various climatic parameters, the **hydrospheric component** characterizes the conditions of the various water ecosystems, and the **pedospheric component** identifies characterstics of the soil and parent material conditions of the ecoregion. The **biospheric component** describes the status of agricultural, forest, and peat lands of the ecoregions. The ecoregion description has a total of 382 **parameters for each ecoregion.**

Landscape description

The **landscape description** is a further development of the ecoregion description, which also has been compiled by the collaborative network of the Study (Rojkov *et al.*, 1996). The landscape description includes the following sections: classification, parent material, soil type, relief, and vegetation. The whole characterization includes 44 parameters.

Forest industry enterprise description

The **forest industry enterprise description** has been compiled by the 'Institute of Economics and Industrial Engineering' in Novosibirsk. The description includes information for all Siberian forest industry enterprises for the years 1989, 1992, and partly for 1993. Each of the enterprises is characterized by information, which can be divided into the sections: general identification, harvesting, production facilities, industrial production and costs. The total number or characterizing parameters is 36 for each forest industry enterprise.

CASE – studies

The Study has completed two regional database development projects, where the geographical focus is more detailed than in the high-level core entity types of the database. The **Ust-Illimnsk forestry enterprise** includes stand level information for two forest management units (lesnitshesva). The **Magadan sample plot** database contains the sample plot measurements for a limited geographical area in Magadan Oblast.

Geographical data components

The geographical data component of the Siberian Study database contains the digital layers for the core database entities, the other section consists of digital material whose function is to supplement the core entities with various themes. The accuracy of the digital material, in the majority of the cases, is to the scale of 1:1 Million. The GIS layers, which are present in the Study Database, for the core entities are:

- Subjects of Russian Federation
- Atmospheric pollutant
- Ecoregions
- Landscapes
- Forestry enterprises
- Forest industry enterprises.

The supplementary layers of the GIS are:

- Soil carbon map
- Endangered animal and plant species, and medicinal plant species
- Bazilevich map
- Humus content map
- Digital Chart of the World.

Additional Data

In addition to the databases and geographical components described above and available at IIASA, the following is available at the International Forestry Institute in Moscow, although not organized according to the IIASA concept;

- forestry inventory database for each forest enterprise and ecological-climatic region from 1988 and 1993

- phytomass database containing 2,100 sample sites distributed over the complete Forest Fund of Russia

- forest soil database for 840 sample plots covering the total Forest Fund of Russia and with 65 parameters collected for each sample plot

- forest fire database for 235,100 fires in the fire protected area of Forest Fund in Russia during the period 1980-1995 with each fire described over 50 parameters

- database on forest cover disturbancies (natural and anthropogenic factors)

- meteorological database containing monthly and yearly averages for 15 meteorological parameters from 3,000 meteorological stations distributed over the total Forest Fund of Russia

- database on stand dynamics for each ecoregion of Siberia

- database on forest reproduction for each ecoregion of Siberia

- database on natural forest succession for Siberia, and

- database on carbon pools by different forest ecosystems for all of Russia.

Discussion

The major accomplishment of the databases and GIS development, with the assemby of the IIASA Study database, has been the elimination of the geographical and institutional barriers, which effectively hindered the scientific research. In the current form the database and the application environment provide a unique resource for scientific work concerning the forests, forest industry, ecology and socioeconomics in Siberia and Russia.

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3.3. Biospheric Role of the Russian Forests

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Introduction

The impact of the forest cover on the biosphere mainly consists of its interactions with the main biogeochemical cycles, such as carbon or nitrogen, as well as hydrological cycles. The state, structure and productivity of forest ecosystems are the crucial components for such interactions. Both the productivity and maintenance of the biogeochemical cycles are criteria for sustainable development of natural landscapes, as well as for sustainable forest management.

Model

The basic equation for the interaction between forests and the carbon cycle is

$$dC/dt = I(t) - O(t), \quad (1)$$

where dC/dt is the dynamics of the summarized C flux generated by forest ecosystems, I(t) and O(t) are respectively the input and output of C in forest ecosystems (all indicators in equations (1) and (2) are expressed in Tg C/years). The practical application of (1) depends upon the approach and time step used as well as on the structure of C pools and fluxes. We use (1) in the form of a yearly time basis (2)

$$dC/dt \approx (NPP - WM - GPM + \Delta D + \Delta SOM)_t, \quad (2)$$

where NPP is the net primary productivity of the vegetation of a forest ecosystem; WM is the mortality of the woody parts of forest ecosystems; GPM is the mortality of green parts (litterfall, green forest floor, etc.); ΔD is the change of C in dead vegetational organics (detritus); and ΔSOM is the change of C in soil organic matter. It is evident that NPP-WM-GPM = PHt+1 - PHt = ΔPH (t+1, t), where PHt+1 and PHt are the total vegetational phytomass at the end respectively at the beginning of a year t. ΔPH is a part of the net ecosystem productivity (NEP) generated by vegetation. If evaluation is done on a yearly basis and under the absence of severe soil disturbances, the major part of the total NEP (more than 95%) is generated by the increment of wood. This short description reveals the crucial role which reliable estimates of phytomass, increment and impact of disturbances play in any evaluation of the interactions between forest ecosystems and the carbon cycle.

Any large-scale evaluation of the carbon budget requires the employment of relevant territorial units. We used ecological regions which have been defined within the framework of the IIASA Study based on following principles:

1. Input of each ecoregion into basic ecological cycles should be of the same magnitude. This requires a rough equality of basic indicators of productivity of terrestrial biota (e.g., for forests: growing stock, phytomass, increment, etc.).

2. Ecoregions should be homogeneous by climatic and soil conditions. Mountain areas and plains as well as permafrost and non-permafrost areas should be separated. Consequently, ecoregions should be homogeneous with respect to forest growth potential, basic features of forest cover, and regimes of natural disturbances. It means that such indicators for stands of a definite species, such as site index and relative stocking should not vary much within an ecoregion.

3. Character and level of anthropogenic and natural disturbances (e.g., disturbance regimes) should be similar.

4. Ecoregion's boundary should not cross the administrative boundaries of the objects of the Russian Federation (*oblasts, krajs, autonomic generations*).

The Russian territory has been regionalized by the IIASA Study into 141 ecoregions of which 63 are located in the Asian part .

Attention was given to forests dominated by 7 species (Pine, Spruce, Fir, Larch, Cedar, Birch, Aspen) which cover 87% of the total forested area in Russia and comprise 94% of the total growing stock.

Biomass Evaluation

Two forest biomass estimates for all Russian forests have been reported (Alexseyev and Birdsey, 1994; Alexseyev *et al.*, 1995; Isaev *et al.*, 1995). Both of these estimates are based on aggregated data from the State Forest Account (SFA) from 1988 using similar approaches. We were not able to use these results due to a number of reasons, the main ones being: 1) the initial territorial units used cover very large areas and are not homogeneous from a forest production point of view. It means that applications of the reported results for ecoregions could cause significant systematic errors; 2) coefficients of the basic biomass fractions were very aggregated due to the fact that they were calculated as averages for dominant species and age groups over vegetational zones and subzones; 3) there were no biomass models for carbon budget applications developed; 4) there are great differences between the results reported; the estimates of total biomass for forest ecosystems vary by more than 20% (35.1 Pg C [Isaev *et al.*] versus 28.0 [Alexseyev and Birdsey]).

Regression equations for the basic biomass fractions (stemwood over bark, bark, crownwood (over bark), foliage (leaves and needles), roots and understory (undergrowth, bushes, green forest floor)) were used as the basic functions in the form of a ratio:

$$R_{fr} = M_{fr} / GS = c_0 SI^{c_1} A^{(c_2 + c_3 RS + c_4 RS^2)}, \quad (3)$$

where M_{fr} is the mass of a definite fraction in *Tg*; *GS* is (green) growing stock in m^3; *A, SI, RS* are average age, site index respectively relative stocking of stands; and c_0, c_1, c_2, c_3, c_4 are regression coefficients. Furthermore, the mass of the biomass fractions are defined according to (4):

$$M_{fr} = R_{fr} \cdot GS^*, \quad (4)$$

where *GS** is the growing stock according to the forest inventory data.

The use of multidimensional equations allowed us to take into account the geographical diversity of forests for species covering large areas. The special database developed to generate regression equations was based on published results on biomass measurements, “semi-empirical” aggregations, archives and field measurements (a total of 2040 sample plots were used for the model development). Due to available experimental data and the extent of forest cover, some multidimensional models for individual species were regionalized based on a zonal principle. In order to calculate carbon content in biomass the following conversion factors were used: 0.50 for wood and 0.45 for green parts of forest ecosystems of the European Russia, and 0.50 for all forest phytomass in Siberia and the Far East.

Data from the State Forest Account of 1993 (growing stock by dominant species, age, site indexes and relative stocking (density)) were used in the calculations. Aggregated results by economic regions are presented in Table 1. More detailed data are given in Appendix 1.

Table 1. Biomass and carbon in vegetation of forest ecosystems of total forested areas of Russia in Tg.

Economic region[1]	Forests ecosystem biomass component, Tg, dry matter: stem-wood over bark	crown wood	roots	foliage	under-story	Total[2]	Phytomass density kg/m^2	Carbon content: Total, Tg	density Kg/C m^2
European part									
PRI	21.8	3.5	6.6	1.5	1.4	35.0	12.86	17.4	6.40
NOR	3660.6	721.3	1263.4	548.9	526.9	6721.1	8.87	3306.7	4.37
NW	700.2	86.2	213.1	47.2	49.8	1096.4	10.85	543.4	5.28
CEN	1355.7	166.8	431.1	93.0	99.0	2145.6	10.30	1063.2	5.10
VOV	816.9	105.9	256.2	61.6	64.1	1304.7	9.72	646.0	4.81
CEC	106.1	20.8	25.6	5.3	6.7	164.4	11.05	80.6	5.42
POV	284.6	39.1	74.2	14.2	18.4	430.3	9.00	213.6	4.47
NOC	361.2	107.2	86.4	14.3	16.5	585.6	15.68	291.3	7.80
URA	2245.9	308.8	705.0	194.9	181.1	3635.6	10.14	1799.0	5.02
Total	9553.0	1559.6	3061.6	980.9	963.9	16118.7	9.70	7961.2	4.79
Asian part									
WES	5062.6	898.2	1329.6	365.9	706.4	8374.6	9.30	4187.3	4.65
EAS	13044.3	1792.4	3969.0	768.2	1384.3	21241.5	9.32	10620.7	4.66
FEA	10441.0	1394.3	3576.6	509.7	1609.2	18637.7	6.67	9318.9	3.34
Total	28547.9	4084.8	8875.3	1643.8	3699.8	48253.8	8.08	24126.9	4.04
Russia									
Total	38100.9	5644.4	11936.9	2624.7	4663.7	64372.5	8.43	32088.1	4.20

[1] Abbreviations of the Russian economic regions in the table are: PRI-Pribaltisky, NOR-Northern, NW-North-Western, CEN-Central, VOV-Volgo-Vjatskiy, CEC-Central-Chernozjomny, POV-Povolshsky, NOC-North-Caucasus, URA-Ural in Russian Europe, and WES-West Siberia, EAS-East Siberia, FEA-Far East in Asian Russia.

[2] Total for the Asian part of Russia includes, in addition to the biomass of closed forests, the biomass of shrubs which are accounted for as forested areas in regions with severe climatic conditions in Russia, where closed forests can not grow: in WES-11.9 Tg of dry matter, in EAS-283.3 Tg, in FEA-1106.9 Tg; the shrubbery phytomass is mainly represented by biomass of ecosystems dominated by Dwarf pine *(Pinus pumila).*

As seen from Table 1, the total biomass of the Russian forests (total forested area) is estimated to 64372.5 Tg of dry matter or 32088.1 Tg C, of which European forests contain 24.8% and 75.2% of forest carbon is in Asian Russia. The distribution of the basic biomass fractions is: stemwood over bark comprises 59.2% of total biomass, roots 18.5%, crownwood 8.8%, understory including green forest floor 7.2%, and foliage 4.1%. Shrubberies (as a separate category of forested area where closed forests are unable to grow) contains 2.2% of the total biomass. The above-ground biomass constitutes 81.5% of the total. The structure of the biomass is similar in both parts of Russia, although in Asian forests there is more understory (7.7% versus 6.0%) and less foliage (3.4% versus 6.0%), but these figures are additionally impacted by differences in the general biomass structure (biomass of shrubberies in European forests is negligibly small). Average carbon density D for the whole country, European and Asian parts is estimated to 4.20 kg, 4.79 respectively 4.04 kg C/m^2. The ratio R = Total phytomass, Mg/Growing stock, m^3 is 0.398; 0.377 respectively 0.405 Mg C/m^3.

Due to the significant zonation of the forest productivity, the density *D* is dependent on forest vegetational zones. The average density for northern and sparse taiga ecoregions is about 2.0 kg C/m^2, forests of subzones of southern taiga and mixed coniferous-broadleaved forests have the highest values (5.7 respectively 5.9 kg C/m^2).

The total biomass of the Russian forest ecosystems reported by Isaev *et al.* (1995) was 35.07 Pg C (the SFA from 1988 indicated a forested area of 771.1 million ha, and a growing stock of 81644.5 million m^3). Alexseyev and Birdsey's (1994) estimate was 28.0 Pg C. It means that the Isaev *et al.* estimate is 9.3% higher and the Alexseyev and Birdsey estimate is 12.7% lower in comparison with our calculations. The growing stock decreased between 1988 and 1993 by about 1 billion m^3. Therefore, more accurate comparisons could be done based on derivative indicators, e.g., D and R. The average carbon density (D) indicated by Isaev *et al.* (1995) was 4.55 kg C/m^2 (+8.3% to our results) and ratio R = 0.430 Mg C/m^3 (+8.0%). The corresponding data from Alexseyev and Birdsey (1994, 1995) are respectively 3.63 kg C/m^2 (-13.6%) and 0.343 Mg C/m^3 (-13.3%). The final conclusion is that our estimates are very close to the average of the two results discussed above.

For the Canadian forests, Bonnor (1987) reported an aboveground trees phytomass density of 5.90 kg (of dry matter)/m^2; our average for Siberia is 5.98 kg/m^2 which is very close (for total Russia - 6.26 kg/m2). The density of above-ground woody phytomass for the North American boreal forests is estimated by Botkin and Simpson (1990) to be 4.18±1.01 kg/m^2 which can be compared with our estimates of 5.46 kg/m^2 for Siberia and 5.73 kg/m^2 for all Russian forests.

Analysis on the accuracy and sensitivity of the Russian phytomass estimates allows us to conclude that: 1) this evaluation has used the most detailed initial data which are available for large-scale phytomass evaluations; 2) multidimensional regression equations enables us to extract the maximum amount of information available from initial measurements; 3) the accuracy of the aggregated economic regional data is in the limit of ± 7-8% under a confidence probability of 0.8.

Biomass is an indicator in the Russian system of national criteria and indicators for sustainable development being discussed, thus it should be a permanently monitored parameter. Serious negative tendencies of the forest dynamics have been observed during the last decade for Siberia and the Far East. Table 2 contains, as an example, data on biomass fractions by the administrative units of Asian Russia. The forest phytomass density (*D*) varies much, from 1.24 kg C/m^2 in Magadan oblast to 6.98 kg C/m^2 in Primorsk kray.

Table 2. Biomass content of the forest vegetation of total forested areas in Siberia by administrative regions.

Region	Biomass component, Tg								Carbon density kg C/m^2
	Stem-wood over bark	of which bark	Branches	Foliage	Roots	Under-growth & bushes	Green forest floor	Total	
Altaj	549.8	76 .7	82.4	37.4	147.4	13.5	29.4	863.8	5.92
Kemerovo	302.7	39.6	51.1	24.6	72.4	5.1	13.2	469.4	4.54
Novosibirsk	291.5	42.7	64.1	19.0	82.4	8.4	19.5	485.4	4.32
Omsk	288.2	43.6	63.9	15.5	73.3	9.5	9.2	459.7	5.54
Tomsk	1277.2	172.3	241.2	76.9	329.0	51.3	82.2	2057.9	5.66
Tjumen	2353.2	349.1	395.6	192.5	625.1	92.8	372.2	4038.4	4.09
Chita	1313.2	240.1	175.3	68.5	472.1	38.1	136.6	2269.7	3.37
Tuva	540.1	91.4	68.4	32.5	180.6	15.2	55.6	894.2	5.48
Krasnoyarsk	5822.2	851.6	826.9	344.6	1689.5	180.8	510.3	9395.5	4.95
Irkutsk	4291.7	599.8	579.7	251.9	1266.2	98.3	200.2	6803.0	5.52
Buriatia	1077.1	178.0	142.1	70.6	360.6	28.7	120.5	1879.3	3.88
Primorsk	937.6	129.8	162.0	65.5	295.6	48.9	51.6	1564.0	6.58
Khabarovsk	2605.4	417.8	360.2	142.4	855.1	91.2	186.7	4497.8	4.56
Amursk	1047.5	194.8	147.2	46.3	381.0	37.6	96.0	1807.2	4.00
Kamchatka	508.5	66.0	115.7	20.4	160.3	96.8	49.2	1395.3	3.30
Magadan	225.9	43.9	28.9	9.6	88.3	9.8	55.6	581.7	1.24
Sakhalin	309.1	44.7	47.5	24.0	92.8	11.7	26.6	529.7	4.94
Jakutia	4807.0	869.4	532.9	201.6	1703.6	156.4	691.0	8261.9	2.84
Total	28547.9	4451.3	4084.8	1643.8	8875.3	994.2	2705.6	48253.8	4.05

Increment and Mortality

Two growth (increment) indicators, gross growth *dTV(A)* and net growth *dGS(A)*, defined respectively as $dTV(A) = f'(A)$ and $dGS(A) = g'(A)$; where *TV(A)* is *total volume (total production)* at age *A* (i.e., the total volume of all stem wood overbark produced by a stand up to age *A*); *GS(A)* is *growing stock* at age *A* (i.e., the total volume of stem wood over bark of all living trees in a stand at the age *A*), play a crucial role in estimating the potential and actual productivity of forests as well as for evaluating the interactions of forests with the global carbon budget. Evidently, *dTV(A)* and *dGS(A)* are respectively the (stem) woody part of net primary productivity (NPP) and respectively net ecosystem productivity (NEP) of forest ecosystems. If *dGS(A) and dTV(A)* are defined for fully-stocked stands (*normal stands* in the Russian classification), the expression $dM(A) = dTV(A) - dGS(A)$ gives *natural mortality* per year for age *A*. Natural mortality is a result of self-thinning, e.g., competition between trees, as well as mortality of overmature trees. If *GS(A)* describes the dynamics of the actual growing stock, $d_aGS(A)$ is the change of growing stock over time, and $dM_a(A)$ is the *actual mortality* whose structure can be significantly different including in different proportions *natural, pathological* and *mechanical* mortalities. For managed forests the actual mortality $dM_{am}(A)$ is caused mainly by wood removed by harvesting (a kind of mechanical mortality). The impact of other causes is relatively small. For unmanaged forests $dM_{au}(A)$ is basically generated by different disturbances, e.g., for boreal forests by forest fire, insects, diseases (pathological mortality), windfall (mechanical), etc.

In order to estimate *dTV(A), dGS(A)* and *dM(A)* we used a modeling system (MS) developed in the framework of the IIASA Study. The MS comprises a set of approximately 1200 unified models of stand dynamics by ecological regions for main forest forming species, forest types, site indexes, densities, and types of age stand structures. The major part of the MS is developed with empirical growth functions based on modal stands (i.e., actual stands for a definite region) and stands with a variable stocking (for a detailed description of the system see Shvidenko *et al.* 1995, and for modeling approaches see Shvidenko *et al.* 1996, 1996a). The calculations have been done based on data from the 1993 SFA and the percentages of net growth ($P_{GS}(A,SI,D) = 100dGS(A,SI,D) / GS(A,SI,D)$, where SI-site index, *D*-density (stocking)), and percentage of mortality ($P_M = 100dM/GS$) have been derived from the MS. Thus, the percentage of total volume is calculated as the ratio $100dTV/GS$ or $P_{TV} = P_{GS} + P_M$. Estimates of mortality, net and gross growth are presented for total forested areas and economic regions in Table 3. More detailed data are given in Appendix 2.

Table 3. Gross, net increment and mortality for total forested areas in Russia.

Economic region	Forested Areas thousand ha	Growing stock, million m^3	Net growth (million m^3/year)	Mortality (million m^3/year)	Gross growth (million m^3/year)
		European part			
PRI	271 .9	46.6	1.31	1.00	2.30
NOR	75742.4	7935.4	114.52	119.24	233.77
NW	10105.7	1583.9	29.22	26.48	55.70
CEN	20834.5	3109.6	77.46	61.08	138.55
VOV	13426.5	1862.7	48.28	40.00	88.28
CEC	1487.3	213.8	7.14	5.62	12.75
POV	4781.0	596.8	17.19	15.31	32.50
NOC	3735.8	662.3	13.06	11.68	24.74
URA	35838.6	5099.4	108.90	93.67	202.57
Total	166223.7	21110.9	417.08	374.08	791.16
		Asian part			
WES	90011 .5	10950.3	112.98	118.04	231.02
EAS	227836.0	27658.2	250.07	227.13	477.20
FEA	279429.6	20957.0	185.27	188.90	374.17
Total	597277.1	59565.5	548.32	534.08	1082.39
		Russia			
Shrubbery			0.9 1	5.30	6.21
Total	763500.8	80676.4	966.31	913.45	1879.76

Estimates on the increment can be used for many considerations and applications. We limit our discussion to a few general comments.

Russian forested areas generated a total of 1879.8 million m^3 of stemwood (gross growth dTV) in the beginning of the 1990s, of which net growth (dGS) comprises 52.2% (966.3 million m^3) and mortality (due to non-stand replacing disturbances) 47.8% (or 913.5 million m^3). It means that on average for the total forested areas dGS, dM and dTV are 1.27; 1.20 respectively 2.47 m^3/ha. The corresponding figures for the European-Ural zone are 2.50, 2.25 respectively 4.75 and 0.92, 0.90 and 1.82 m^3/ha for Asian Russia. It means that the average actual productivity of Asian forests in Russia is about 38% of the forest productivity in the European part. More severe climatic conditions beyond the Urals, different age structures of the forests, a more significant share of unevenaged forests in Siberia, and especially a much higher intensity of disturbances (fires, insects and diseases) in the forests of Asian Russia explain these large differences. The two latter factors are the main causes for the high level of mortality.

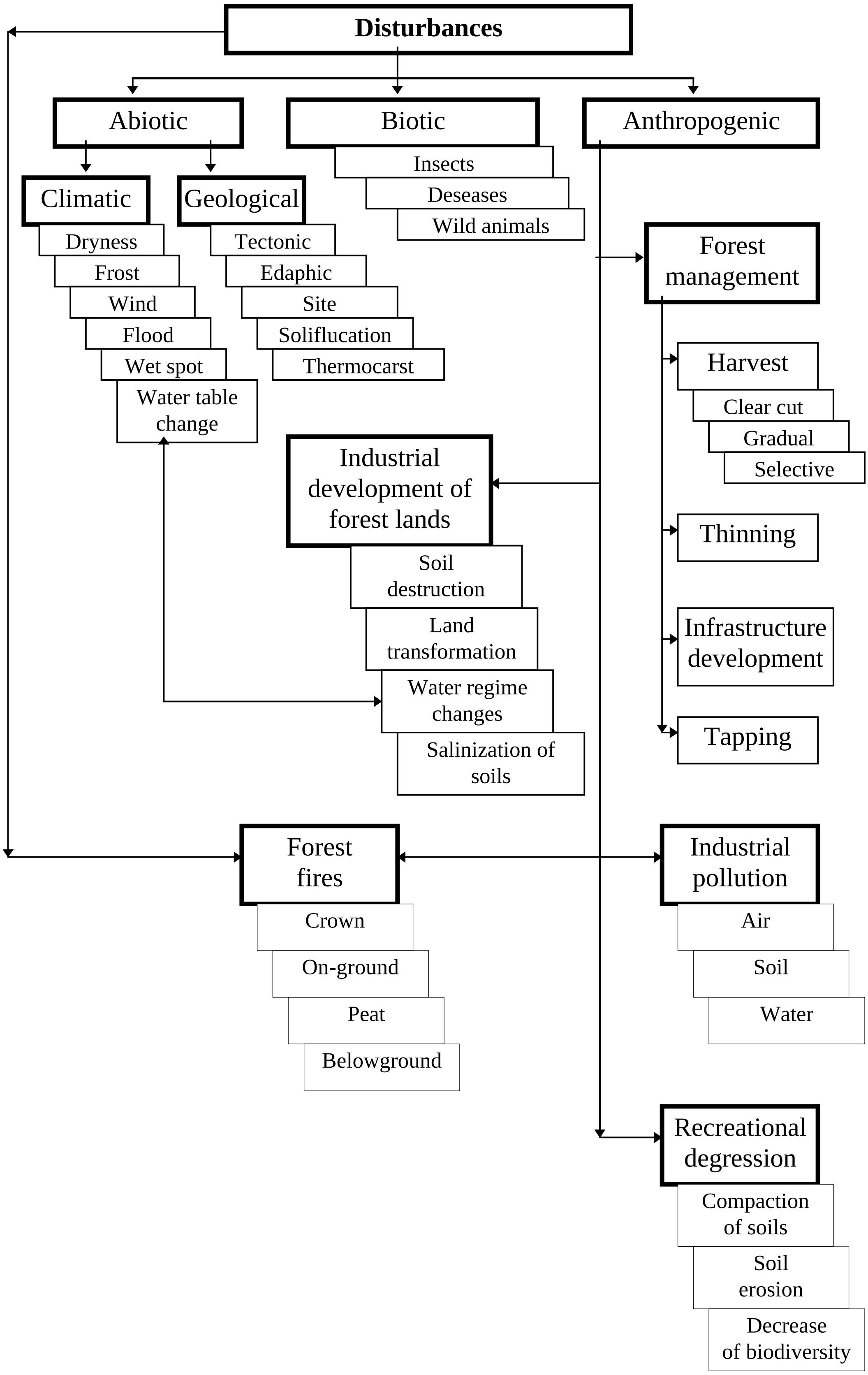
The total net growth of Russian forests is primarily generated by main forest forming species (965.4 million m^3 of total 966.3 million m^3 on forested areas). Forests dominated by coniferous species generate 69.2% of the net growth (dGS), hard deciduous 3.4%, and soft deciduous 27.4%. The contribution of young stands to the total dGS is 36.6%, by middleaged 38.2, by immature 10.4, and by mature and overmature forests about 15%. The reason for this high increment in mature forests is explained by the method in which we identify the age of maturity: for exploitable forests it is defined by the age of technical maturity (*tekhnicheskaja spelost'*), after which coniferous and hard deciduous species have a significant increment over several decades.

Disturbances

We consider a disturbance as any impact (internal or external) which changes the natural (evolutionary stipulated) state, structure, productivity and successional dynamics of the forests. A disturbance is a process which usually starts with a short intensive impact on an ecosystem. Disturbances can be classified in different ways; by genesis, end results, etc. Disturbances can be reversible and irreversible, stand replacing and non-stand replacing, natural and human-induced. The impact of disturbances on main biogeochemical cycles is usually considered in two stages: direct impact (e.g., direct fire emissions, harvests) and indirect (post disturbance) biogenic fluxes.

Among the numerous forest disturbances (Figure 1), 5 types play a crucial role and significantly impact successional dynamics, productivity, state and structure of forests: forest fire, insect and diseases infestation, harvests, land-use changes and, in some regions, industrial pollution. Quantitative analyses of the extent and intensity level of disturbances during the last decades reveal that the basic impacts of disturbances on the Russian Forest Fund are: 1) an increased share of pyrogenic, anthropogenic and biogenic successions as well as the transformation of forested areas to unforested areas, non-forest lands and secondary forests; 2) a decrease of the actual productivity and quality of the forests; 3) the formation of unevenaged forests; 4) the appearance of specific, sometimes irreversible features of the forest forming process; 5) significant (but not always) negative changes of biodiversity at ecosystem and landscape levels.

Figure 1. Classification of Disturbances.



Based on 1) statistical data on the distribution of disturbances; 2) expert estimates of the historically stipulated structure and change/ deterioration of forest cover by ecoregions; 3) data of forest inventory for 1961-1993; and 4) estimates of increment and mortality in Russian forests, it can be concluded that the actual productivity (growing stock, phytomass, increment) of the Russian forests comprises on average about 65% of the theoretically achievable level based on a sustainability concept. The non-stand replacing disturbances cause a high proportion of the current mortality and is estimated for large regions to be in the range of 45-50% of the total productivity. Losses of biodiversity are strongly dependent upon the type and characteristics of disturbances, geographical location, and landscape peculiarities.

Without any consideration for detail on the methods, models, specifics of initial data, etc., which were basically published (Shvidenko *et al.*, 1995a, 1996a), we enumerate the basic quantitative estimates on the impacts of disturbances on Russian forests and the corresponding impact on the global carbon budget. The carbon fluxes generated by disturbances are quantified below without any consideration for regeneration processes (as average annual values for the period 1988-1993).

Forest fires. The average annual area impacted by different types of forest fires is estimated to be 3.5 million ha of which 3 million ha are in Forest Fund and 0.5 million ha in tundra areas in the extreme north. Direct fire emission is estimated to 58.1 Tg C/year and the postfire biogenic flux caused by the decomposition of organics of incombustible residuals and post fire die-back is estimated to 91.6 Tg C/year. The total forest fire carbon uptake by the atmosphere is about 150 Tg C/year.

Pests, diseases, another biotic factors. The total annual areas affected by pests and diseases outbreaks are estimated to about 4 million ha. Comprehensive and detailed inventory of these disturbances does not exist in Russia. Very rough and approximate estimations, based on available statistics, publications, and fragmentary data from different surveys gives an average annual flux caused by insect and diseases of about 90 Tg C/year. If we take into account other biotic factors (e.g., damage caused by recreation, unregulated forest grazing, wild animals, etc.) the probable estimate is about 100 (from 90 to 115) Tg C/year.

Harvest. The results of modeling the impact of industrial forestry on the carbon budget indicates that of the 4.0 Pg C removed from Russian forests by industrial harvest during 1946-1995, only about 25% were stored in long-lived forest products by 1996. Of the total estimate of annual carbon flux caused by harvest (87 Tg C/year, annual average for the period 1991-1993, including local consumption), most carbon releases are due to manufacturing and decomposition of forest products (57%), decomposition of harvest residuals and wastes (27%), and use of wood for fuel (16%).

Abiotic impacts. Industrial pollution, land-use change and unfavorable climatic conditions are the most important among abiotic impacts. There are no complete surveys of the extent and intensity of these processes for the total Russian Forest Fund. Based on data for separate regions and expert estimates we received a rough estimate of carbon losses for different scenarios due to different abiotic factors to be between 40 and 65 Tg C annually.

Thus, disturbances in the beginning of 1990s caused a "pure" flux of about 390 Tg C annually. The accuracy of this result cannot be estimated by classical statistical methods. A "what...if" approach indicates a probable error of ±7%.

Estimates on Carbon Budget

The results presented above allow us to make some aggregated estimates on the interaction between Russian forests and the global carbon budget. In the following, we consider two approaches.

Estimates Based on Biomass and Forest Inventory Data Inventory data could be used in a "bookkeeping" approach, when results are evaluated as the difference between C storage in the C pools at the beginning and the end of a definite period. Table 4 contains dynamics of C content in forest ecosystems vegetation from 1961 to 1993. The calculations are done based on estimated values of the ratio R (MgC/m^3) for European and Asian parts of Russia discussed earlier.

Table 4. Dynamics of carbon storage in Russian forests in 1961-1993

Indicators	196 1	1966	1973	1978	1983	1988	1993
Dynamics based on data of official forest statistics							
Forested Area (FA), x10^6 ha	695.5	705.6	729.6	749.5	766.5	771.1	763.5
FA in European Russia	148.9	161.3	158.8	163.5	164.4	166.0	166.2
FA in Asian Russia	546.6	544.3	570.8	586.0	602.2	606.1	597.3
Growing stock (GS), x10^9 m^3	77.5	77.0	78.7	80.7	81.9	81.7	80.7
GS in European Russia	16.3	17.0	17.4	18.7	19.3	20.3	21.1
GS in Asian Russia	61.2	60.0	61.3	62.0	62.6	61.4	59.6
C in phytomass, Pg	30.933	30.711	31.388	32.162	32.631	32.522	32.088
C in European Russia	6.147	6.411	6.562	7.052	7.278	7.655	7.961
C in Asian Russia	24.786	24.300	24.826	25.110	25.353	24.867	24.127
Dynamics based on "reconstructed" growing stock							
Growing stock, x10^9 m^3	75.0	75.7	77.5	80.4	84.5	85.6	84.8
GS in European Russia	16.4	16.5	17.3	18.3	19.9	21.4	22.2
GS in Asian Russia	58.6	59.2	60.2	62.1	64.6	64.2	62.6
C in phytomass, Pg	29.920	32.201	30.908	32.054	33.670	34.074	33.728
C in European Russia	6.184	6.222	6.524	6.901	7.504	8.070	8.372
C in Asian Russia	23.736	23.979	24.384	25.153	26.166	26.004	25.356
Deviation (%%) between "reconstructed" and official C storage	-3.3	-2.2	-1.5	-0.0	+3.2	+4.8	+5.1

We have provided the calculation in 2 variants: 1) for official data of the State Forest Account (SNKh, 1962; Gosleshoz SSSR, 1968, 1976, 1982, 1986; Goscomles SSSR, 1990, 1991; FSFMR, 1995) and 2) for "reconstructed" dynamics. The latter is a result of expert estimations of the systematic errors of growing stock given by the Russian forest inventory

(Shvidenko *et al.*, 1996c). Evidently *R* is dependent on the state and structure of forests, and consequently our assumption is an approximate, but due to the rather stable dynamics of the aggregated characteristics of Russian forests probable uncertainties generated by this assumption can not significantly distort the conclusions.

If we use official data, we conclude that during 1961-1993 the total amount of carbon in the vegetation of forest ecosystems in Russia increased from 30.93 to 32.09 Pg C or by 1.16 Pg (+3.8%) and with a peak value in 1983 (32.63 Pg C). It reveals that during the last 32 years Russian forests provided on average a modest net sink of 36 Tg C/year accumulated in forest vegetation. During 1961-1983 the accumulation of C in forest biomass was more significant, about 77 Tg C/year. After 1983 the Russian forests became a source with an average annual C release to the atmosphere of about 54 Tg C/year. This change is caused by changed dynamics of the Russian Asian Forests. While the forests in European Russia are estimated as a sink for the entire period 1961-1993 and with an average uptake of 59 Tg C/year, the average estimates for the Asian forests for 1961-1993, 1961-1983 and 1983-1993 are -21; +26; respectively -123 Tg C/year.

The picture is more optimistic if we use the data for the “reconstructed” growing stock. In this case, the average estimates of the C sink for the periods 1961-1993, 1961-1983 for Russia are 119, 170 respectively 12 TgC/year (and - 69 Tg C/year for the period of 1988-1993); for European Russia 68, 60 and 87; and for Asian Russia 51, 110, and - 81 Tg C/year.

Of course, the conclusions are approximate, the SFA data have a significant uncertainty and some delay in reporting. But the results and the dynamic tendencies seem to be correct. It means that during the last 10 years, the processes of forest ecosystems vegetational destruction in Siberia prevail over the accumulation, and that defines the result for total Russia. As stated earlier the negative dynamics of Siberian forests could be explained by the high level and intensity of disturbances (Shvidenko and Nilsson, 1994).

Estimates of ΔD and ΔSOM from equation (2) are more uncertain. ΔD is strongly dependent on the structure of forests, and specifically on the previous history of disturbances. Aggregated data on the detritus storage have never been reported by the Russian forest inventory system. Nevertheless, there are many publications on research dealing with the biological productivity as well as results of surveys dealing with investigations of some forest formations or some types of disturbances. Thus, available information for the total Russian forests is only sufficient for very approximate expert estimates. There are even greater uncertainties in evaluating ΔSOM. Taking into account estimates of the extent and intensity of disturbances during the 1960-1990s, and basic peculiarities of forest regeneration (areas, land-use categories, etc.), we assume the ΔD could be estimated to some 7% of the C accumulation in biomass; with corresponding estimates for the ΔSOM (including litter) about 18%. Thus, the total estimates during the period 1961-1993 indicate that the Russian forested areas accumulated about 45 Tg C on average annually if we use data from the official forest statistics, and about 150 Tg C/year based on our reconstructed dynamics.

Estimates Based on Model Evaluation of Productivity Based on the results mentioned above and aggregated C fluxes calculated from data for increment and impact of disturbances, we could estimate a number of different scenarios with this approach that correspond rather well with the results based on the "reconstructed" dynamics, but with a 10-12% underestimate for all periods considered. The estimated accuracy of the latter approach is about 20% and for the considered time period is worse than for the approach based on forest inventory data.

The balance of production and consumption of wood during the period 1983-1993 revealed some important conclusions: 1) if we use official forest statistics, the "losses" of wood (which include uncertainties in the calculations and unaccounted die-back in Russian forests) are estimated to be close to 0 as an annual average for 1983-1993 in the European part and about 620 million m^3/annually in the Asian part; 2) when we use "reconstructed" growing stock these figures are 50 respectively 500 million m^3/year. The level of losses for the Asian part is much higher than expected; 3) the combined consideration of increment data and impacts of disturbances quantified above are in a good correspondence with the aggregated estimates of the sink C in forest vegetation of about 120 Tg C/year during 1961-1993.

Finally, we can conclude that the most probable estimates on the role of the Russian forests in carbon cycle are: during 1961-1993 Russian forests were on average a net C sink of 150 Tg C/year but after 1988 the Russian forests were neither a sink nor a source of carbon (if we use "reconstructed" dynamics), and became a net source (of 54 Tg C/year) if we use data of official statistics. These estimates do not include the impact of unforested areas and non-forested lands.

These latter results are significantly lower than all results published before. Isaev *et al.* (1995) reported a net sink of 184.4 Tg C/year sequestered by Russian forest ecosystems for the early 1990s. For this time period we have a C flux between +15 and -54 Tg C/year. Other publications (Kolchugina and Vinson, 1993; Krankina *et al.*, 1996) reported a sink of at least double that which is reported by Isaev *et al.* (1995).

Possibilities for Increased Carbon Sequestration through Improved Forest Management in Russian Forests

The Russian forest sector has significant possibilities to increase carbon sequestration during the next century through improved forest management. The current state and structure of the Russian Forest Fund is insufficient as well as forest management in many regions. The quantification of the effects of management intervention on C sequestration was based on the following approach:

(total C storage with management intervention) - (total C storage without management intervention) = added C storage.

To determine a realistic forest management scenario for Russia the concepts of “no-regrets” or “risk-adverse” strategies have been followed with the following additional assumptions:

1. The direct cost of sequestering 1 t C should not exceed US$3 (1992 dollar value).

2. Sufficient labor and technical equipment will be available.

3. Relevant methods of forest management (including forest fire protection) will be implemented in conjunction with the proposed system for forest management measures.

4. The period for realization of the identified options has been estimated to be 40 years, and the effects of the options are calculated for a 100-year period after the start of the scenario’s implementation.

5. Forest plantations that are necessary for local, regional, or sustainable reasons (watershed belts, rehabilitation of destroyed forest land, etc.) are included in large-scale reforestation programs (LSR programs), even if these lead to a sequestration cost that exceeds US$ 3 per ton of C.

6. All measures that are normally required for the protection of the forests must be continued in combination with the new management options studied.

7. All options must be simultaneously established in areas selected for the implementation of the scenario.

Three groups of measures were considered: 1) increased forest productivity by improved status and structure of the Forest Fund; 2) decreased C losses (by improved forest protection and utilization of wood); and 3) improved landscape management. Relevant models were developed to calculate changes of the C pools and fluxes. Final results are presented in Table 5. Generally it can be concluded that implementation of the scenario could provide an additional annual C sink in the range of 270 (which corresponds to approximately a 25% quartile) of the theoretical distribution of the results to 620 Tg C/year (a 75% quartile). Evidently the quantitative estimates are strongly dependent on the prerequisites and models used, future political, economical and social development in Russia as well as upon the reliability of our knowledge on future climate change.

Table 5. Possible increase of C sequestration by improved forest management in Russia

Measures	Tota l area, in million ha	Annual rate, million ha	Ad. C fixation Pg	Total C sink by version		Average C sink t/ha year	
				Low	High	Low	High
LSR in unforested areas	64	1.6	9.8	6.9	14.0	1.3	2.7
Reforestation after current disturbances	20	0.5	3.1	2.1	4.4	1.3	2.7
Reconstruction of low-stocked forests	60	1.5	6.7	4.0	12.1	0.8	2.4
Rehabilitation of “climax” stands	20	0.5	2.2	1.3	3.9	0.8	2.4
Replacement of soft deciduous stands	25	0.6	2.7	2.2	5.1	1.1	2.6
Implementation of appropriate thinning	75	6.0	-	-	3.0	-	5.0
Mitigation of impact of disturbances	600	600	7.1	5.5	10.4	-	-
Agroforestry	120	3.0	3.5	2.6	5.1	-	-
Improvement of forest industry	-	-	4.0	2.7	4.2	-	-
Total for scenario	-	-	39.1	27.3	62.2	-	-

Conclusion

The results presented above give much evidence of the global significance of the biospheric role of the Russian forests regarding their current and future impact on the global carbon budget. Uncertainties of the results depend on many factors and are rather great for some components of the investigations but they cannot change the direction and the magnitude of the results.

Appendix 1.

Table 1. Phytomass and carbon in vegetation of forest ecosystems of European Russia.

Species group and total	Phytomass component, Tg						Phyto-mass density, kg/m^2	Carbon content	
	foliag e	crown wood	stem wood	roots	under-story	total		total, Tg	density, kg/m^2
Pre-Baltic									
Coniferous	1.1	1.2	6.7	2.2	0.6	11.8	12.3	5.8	6.1
Hardleaves	0.2	1.4	6.1	1.4	0.2	9.3	17.8	4.6	8.8
Softleaves	0.4	0.9	8.8	3.1	0.7	13.8	11.7	6.9	5.8
Total	1.5	3.5	21.8	6.6	1.4	35.0	13.1	17.4	6.4
Northern									
Coniferous	512.6	659.4	3134.8	1068.2	398.1	5773.1	9.5	2841.0	4.7
Hardleaves	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Softleaves	36.2	61.8	525.8	195.2	128.9	948.0	6.2	465.7	3.1
Total	548.9	721.3	3660.6	1263.4	526.9	6721.1	8.8	3306.7	4.4
Northwest									
Coniferous	35.8	51.9	356.0	107.6	26.4	577.6	10.8	285.7	5.4
Hardleaves	0.0	0.2	1.0	0.2	0.0	1.4	14.5	0.7	7.2
Softleaves	11.4	34.1	343.2	105.3	23.4	517.4	10.3	256.9	5.1
Total	47.2	86.2	700.2	213.1	49.8	1096.4	10.6	543.4	5.4
Central									
Coniferous	65.3	89.5	611.8	182.5	43.9	992.8	11.1	491.0	5.5
Hardleaves	1.3	9.5	41.8	9.9	1.2	63.8	12.1	31.8	6.0
Softleaves	26.5	67.8	702.1	238.8	53.8	1089.0	10.1	540.4	5.0
Total	93.0	166.8	1355.7	431.1	99.0	2145.6	10.6	1063.2	5.1
Volgo-Vjatskij									
Coniferous	45.2	63.1	425.9	128.1	34.0	696.3	10.1	344.2	5.0
Hardleaves	0.9	7.1	29.4	6.7	0.9	45.0	11.6	22.4	5.8
Softleaves	15.4	35.9	361.6	121.4	29.1	563.4	9.4	279.5	4.6
Total	61.6	105.9	816.9	256.2	64.1	1304.7	9.8	646.0	4.8
Central-Chernozjemnij									
Coniferous	2.5	4.0	30.0	7.7	3.4	47.5	11.4	23.5	5.7
Hardleaves	2.1	15.4	58.8	11.6	2.3	90.2	12.4	44.8	6.2
Softleaves	0.7	1.4	17.3	6.3	0.9	26.6	8.2	13.2	4.1
Total	5.3	20.8	106.1	25.6	6.7	164.4	11.2	80.6	5.4
Povolshskij									
Coniferous	5.6	9.2	74.0	19.1	7.6	115.4	10.0	57.1	4.9
Hardleaves	3.0	25.3	86.8	15.1	4.4	134.6	8.9	66.9	4.4
Softleaves	5.5	4.7	123.9	39.9	6.5	180.4	8.6	89.6	4.3
Total	14.2	39.1	284.6	74.2	18.4	430.3	9.0	213.6	4.5
Northern Caucasus									
Coniferous	4.6	6.4	41.9	12.9	3.0	68.8	16.6	34.1	8.2
Hardleaves	8.2	98.7	288.1	62.1	11.3	468.6	17.2	233.2	8.6
Softleaves	1.5	2.1	31.2	11.4	2.2	48.2	9.1	24.0	4.5
Total	14.3	107.2	361.2	86.4	16.5	585.6	16.0	291.3	7.8
Ural									
Coniferous	151.1	203.8	1247.0	393.6	97.9	2093.3	10.9	1034.3	5.4
Hardleaves	2.1	19.8	68.6	12.5	3.0	106.0	11.0	52.8	5.5
Softleaves	41.7	85.2	930.4	298.8	80.2	1436.3	9.2	712.0	4.6
Total	194.9	308.8	2245.9	705.0	181.1	3635.6	10.2	1799.0	5.0
Total and average	980.9	1559.6	9553	3061.6	963.9	16118.7	9.70	7961.2	4.79

Table 2. Phytomass and carbon in vegetation of forest ecosystems of Asian Russia.

Species	Biomass component, Tg of dry organic matter								Carbon density, kg C/m2
	Stem wood over bark	of which bark	Branches	Foliage	Roots	Under growth & Bushes	Green forest floor	Total	
West Siberia									
Total	5062.6	724.0	898.2	365.9	1329.6	180.7	525.7	8374.6	4.65
Coniferous	3134.0	427.2	440.4	291.5	845.6	83.6	464.8	5259.8	4.34
Pine	1301.1	155.0	185.8	127.0	312.8	30.6	203.6	2160.9	3.42
Spruce	283.5	39.7	45.4	34.5	96.1	6.8	44.5	510.9	4.88
Fir	261.6	32.3	36.2	27.5	40.7	3.3	19.6	388.9	4.66
Larch	357.7	66.8	38.0	12.1	130.7	13.6	56.0	608.1	4.40
Cedar	930.0	133.5	134.9	90.4	265.3	29.2	141.0	1591.0	6.19
Hard decid.	0	0	0	0	0	0	0	0.1	1.32
Soft decid.	1928.6	296.7	457.8	74.4	484.0	97.1	60.9	3102.8	5.66
Birch	1444.6	247.8	378.8	57.9	318.8	73.2	45.0	2318.4	5.41
Aspen	478.0	47.8	77.5	16.2	163.7	23.7	15.7	774.7	6.56
Shrubs								11.9	0.43
East Siberia									
Total	13044.3	1961.0	1792.4	768.2	3969.0	361.2	1023.2	21241.5	4.66
Coniferous	11335.2	1685.1	1386.8	688.5	3465.8	287.0	958.5	18121.8	5.18
Pine	2503.4	247.1	348.3	197.7	696.2	38.7	183.3	3967.6	5.39
Spruce	732.8	89.5	112.7	75.8	222.8	15.0	72.9	1232.1	5.14
Fir	660.8	83.0	96.4	65.9	116.6	10.2	45.9	995.7	5.40
Larch	5428.3	979.6	558.7	165.5	1861.6	173.5	465.2	8652.8	4.80
Cedar	2009.9	285.9	270.7	183.5	568.7	49.7	191.2	3273.7	6.10
Hard decid.	0.2	0	0	0	0.1	0	0	0.3	3.32
Soft decid.	1708.9	275.8	405.5	79.7	503.1	74.2	64.7	2836.0	3.94
Birch	1303.7	232.7	336.2	64.4	359.4	55.6	51.8	2171.1	3.68
Aspen	400.5	42.3	68.1	15.0	142.5	18.4	12.7	657.1	5.10
Shrubs								283.3[a]	0.85
Far East									
Total	10601.2	1786.8	1431.1	516.4	3635.7	471.8	1166.0	18637.7	3.33
Coniferous	8994.3	1554.1	1033.9	440.0	3109.1	275.6	1060.7	14913.6	3.70
Pine	461.6	60.1	62.6	49.7	83.3	12.1	78.4	747.8	3.12
Spruce	1067.9	126.9	162.0	109.7	328.8	19.7	83.1	1771.1	6.648
Fir	134.4	17.1	19.1	15.1	23.4	2.0	10.4	204.3	4.78
Larch	7033.3	1308.6	751.6	238.5	2587.6	236.0	865.6	11712.6	3.44
Cedar	297.1	41.4	38.6	27.1	86.1	5.8	23.1	477.8	6.79
Hard decid.	779.6	93.1	185.1	30.4	262.8	157.0	64.4	1479.3	5.67
Oak	160.1	20.4	36.9	6.6	59.0	19.5	9.2	291.4	5.76
Soft decid.	654.9	116.8	172.0	38.4	199.6	19.7	30.6	1115.1	3.31
Birch	416.5	78.4	112.5	26.3	129.3	10.1	18.0	712.8	2.82
Aspen	59.6	6.5	10.1	2.9	22.1	2.0	2.8	99.4	3.89
Other species	12.2	2.4	3.3	0.9	5.1	0.1	1.2	22.8	1.22
Shrubs								1106.9[b]	1.19
Total									
Total	28547.9	4451.3	4084.8	1643.8	8875.3	994.2	2705.6	48253.8	4.04
Coniferous	23463.6	3666.5	2861.0	1420.0	7420.6	646.2	2483.9	38295.3	4.39
Pine	4266.1	462.2	596.7	374.4	1092.3	81.5	465.3	6876.3	4.32
Spruce	2084.2	256.0	320.1	220.1	647.7	41.5	200.5	3514.0	5.75
Fir	1056.9	132.4	151.7	108.4	180.6	15.4	75.9	1589.0	5.16
Larch	12819.2	2355.0	1348.3	416.1	4579.9	423.2	1386.8	20973.5	3.92
Cedar	3237.1	460.8	444.2	301.1	920.1	84.6	355.4	5342.4	6.22
Hard decid.	779.9	93.2	185.1	30.4	262.9	157.0	64.4	1479.7	5.67
Oak	160.1	20.4	36.9	6.6	59.0	19.5	9.2	291.4	5.76

Soft decid.	4292.3	689.3	1035.4	192.5	1186.7	191.0	156.2	7054.1	4.35
Birch	3164.9	559.0	827.6	148.6	807.5	138.9	114.8	5202.3	4.04
Aspen	938.0	96.6	155.7	34.1	328.2	44.0	31.1	1531.3	5.66
Other species	12.2	2.4	3.3	0.9	5.1	0.1	1.2	22.8	1.21
Shrubs								1402.1[c]	1.10

HLD and SLD are hard deciduous respectively soft deciduous species.
a) including 216.1 Tg of Dwarf pine; b) incl. 932.0 Tg; c) incl. 1148.1 Tg of Dwarf pine.

Appendix 2.

Table 1. Net growth in forested areas of Russia by main forest forming species and age groups expressed in million m3.

Group of species	Dominant species	Distribution by age groups: Young stands	Middle-aged	Immature	Mature and overmature	Total
		European Russia				
Coniferous		130.17	70.03	21.93	42.48	264.60
	Pine	57.86	32.19	9.47	8.35	107.86
	Spruce	69.18	36.43	12.12	33.67	151.40
	Larch	0.31	0.18	0.06	0.10	0.64
	Ceder	1.43	0.56	0.05	0.06	2.10
	Fir	1.39	0.68	0.23	0.30	2.60
Hard deciduous		9.42	10.31	1.80	1.88	23.41
Soft deciduous		31.41	61.34	15.74	20.58	129.07
	Birch	19.75	38.85	10.98	13.97	83.55
	Aspen	10.20	18.47	3.87	5.81	38.35
Total		171.00	141.68	39.46	64.94	417.08
		Asian Russia				
Coniferous		149.15	166.11	47.96	41.94	405.15
	Pine	28.57	41.49	11.37	10.76	92.18
	Spruce	17.67	20.56	8.17	8.98	55.38
	Larch	72.79	74.00	20.41	17.03	184.24
	Ceder	20.22	19.03	2.38	0.90	42.53
	Fir	9.91	11.02	5.62	4.27	30.83
Hard deciduous		5.08	2.68	0.45	0.96	9.16
Soft deciduous		28.37	56.79	12.39	36.46	134.01
	Birch	18.77	37.97	7.51	25.47	89.71
	Aspen	9.18	17.56	4.71	10.67	42.12
Total		182.60	225.57	60.79	79.35	548.32
		Total Russia				
Coniferous		279.32	236.14	69.88	84.41	669.76
	Pine	86.42	73.67	20.84	19.11	200.05
	Spruce	86.85	56.99	20.30	42.65	206.78
	Larch	73.10	74.18	20.47	17.13	184.88
	Ceder	21.66	19.59	2.43	0.95	44.63
	Fir	11.30	11.70	5.85	4.57	33.42
Hard deciduous		14.50	12.99	2.24	2.84	32.58
Soft deciduous		59.78	118.13	28.13	57.04	263.07
	Birch	38.52	76.81	18.49	39.44	173.25
	Aspen	19.38	36.02	8.59	16.48	80.47
Total		353.60	367.25	100.26	144.30	965.40

Table 2. Mortality in forest areas of Russia by main forest forming species and age groups expressed in million m3.

Groups of species	Dominant species	Distribution by age groups: Young stands	Middle aged	Immature	Mature and overmature	Total
		European Russia				
Coniferous		82.95	66.75	24.79	55.75	230.23
	Pine	47.18	31.12	10.95	9.79	99.04
	Spruce	34.34	34.15	13.46	45.41	127.37
	Larch	0.18	0.12	0.04	0.03	0.36
	Ceder	0.77	0.71	0.08	0.10	1.67
	Fir	0.48	0.63	0.26	0.42	1.80
Hard deciduous		2.57	11.13	2.60	3.47	19.77
Soft deciduous		19.91	66.46	16.77	20.95	124.08
	Birch	11.69	44.52	13.17	15.97	85.34
	Aspen	6.96	18.32	2.76	3.82	31.86
Total		105.42	144.34	44.16	80.16	374.08
		Asia Russia				
Coniferous		94.80	143.24	51.14	91.00	380.18
	Pine	20.98	42.35	14.27	11.70	89.30
	Spruce	8.24	21.63	9.86	14.23	53.97
	Larch	50.97	44.21	16.50	50.85	162.54
	Ceder	10.26	24.31	3.72	7.59	45.88
	Fir	4.35	10.74	6.77	6.63	28.50
Hard deciduous		1.33	2.66	0.79	4.36	9.14
Soft deciduous		17.86	68.10	13.20	45.59	144.75
	Birch	10.49	48.46	9.48	33.81	102.25
	Aspen	6.85	18.51	3.59	11.42	40.38
Total		113.99	214.00	65.13	140.95	534.08
		Total Russia				
Coniferous		177.75	209.99	75.93	146.75	610.41
	Pine	68.15	73.47	25.22	21.49	188.33
	Spruce	42.58	55.79	23.32	59.65	181.34
	Larch	51.15	44.33	16.54	50.88	162.90
	Ceder	11.03	25.02	3.81	7.69	47.55
	Fir	4.84	11.37	7.04	7.05	30.29
Hard deciduous		3.90	13.79	3.40	7.83	28.91
Soft deciduous		37.77	134.56	29.97	66.54	268.83
	Birch	22.17	92.98	22.65	49.78	187.59
	Aspen	13.81	36.84	6.35	15.23	72.24
Total		219.41	358.34	109.30	221.12	908.15

Table 3. Gross growth in forests of Russia by main forest forming species and age groups expressed in million m^3.

Groups of species	Dominant species	Distribution by age groups: Young stands	Middle-aged	Immature	Mature and overmature	Total
		European Russia				
Coniferous		213.12	136.77	46.72	98.22	494.83
	Pine	105.03	63.31	20.42	18.14	206.90
	Spruce	103.52	70.58	25.58	79.09	278.77
	Larch	0.49	0.30	0.09	0.12	1.01
	Ceder	2.21	1.27	0.13	0.16	3.76
	Fir	1.87	1.31	0.49	0.72	4.39
Hard deciduous		11.99	21.44	4.40	5.35	43.18
Soft deciduous		51.31	127.80	32.51	41.53	253.15
	Birch	31.43	83.37	24.15	29.94	168.89
	Aspen	17.16	36.79	6.64	9.62	70.21
Total		276.42	286.02	83.63	145.10	791.16
		Asian Russia				
Coniferous		243.95	309.35	99.09	132.94	785.34
	Pine	49.55	83.83	25.64	22.46	181.48
	Spruce	25.91	42.20	18.04	23.21	109.35
	Larch	123.75	118.21	36.91	67.89	346.77
	Ceder	30.48	43.34	6.11	8.48	88.41
	Fir	14.26	21.77	12.39	10.90	59.32
Hard deciduous		6.41	5.34	1.24	5.32	18.30
Soft deciduous		46.23	124.88	25.59	82.05	278.75
	Birch	29.26	86.42	16.99	59.28	191.95
	Aspen	16.03	36.07	8.31	22.09	82.50
Total		296.59	439.56	125.93	220.31	1082.39
		Total Russia				
Coniferous		457.07	446.12	145.81	231.16	1280.17
	Pine	154.58	147.14	46.06	40.60	388.38
	Spruce	129.43	112.78	43.62	102.29	388.12
	Larch	124.24	118.52	37.01	68.01	347.78
	Ceder	32.69	44.61	6.24	8.64	92.18
	Fir	16.13	23.07	12.89	11.62	63.72
Hard deciduous		18.40	26.78	5.64	10.67	61.49
Soft deciduous		97.54	252.68	58.10	123.58	531.90
	Birch	60.69	169.79	41.14	89.22	360.84
	Aspen	33.19	72.86	14.94	31.72	152.71
Total		573.01	725.58	209.55	365.41	1873.55

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3.4. Dynamics of the Siberian Forest Fund and Potential Wood Supply

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Introduction

To achieve sustainable development of the forest sector in Russia a relevant extent of conservation of the forest resources must take place, a suitable economic infrastructure must exist, and a high sustainable harvest level is required. This is especially important in Siberia and the Far East, where the forests constitute more than 80% of the total forests of Russia and have 75% of the total growing stock. Half of the territories in these regions is located in permafrost zones and mountainous areas, which are sensitive from an ecological point of view.

About 45% of all the forests in Siberia and the Far East are considered available for exploitation, although huge areas have never before been exploited for industrial purposes. The forest resources of the region play a role as global and regional ecological stabilizers and are a source of raw material for a substantial industrial capacity.

A sustainable high harvest level is possible if a balance is kept between withdrawals and the regeneration of forests. To achieve such a balance should be one of the goals of national sustainable forest policy and for regional sustainable strategies for forest management.

The policies and forest management strategies should be based on estimates on the long-term development of the Forest Fund in a quantitative form. Within the framework of the IIASA Study, a model for estimating the maximum sustainable harvest from an ecological and biological point of view (sustainable biological potential) has been developed. With the help of this model, it is possible to investigate different forest management strategies.

Methodology

In the following we will briefly present the general approach used for analyses of the Forest Fund dynamics and the maximum biologically sustainable harvest over time.

Regional specifics of the forest resources in Siberia and the Far East require that the analyses take spatial aspects into account and use relevant subregions. The subregional unit used in the analyses is the ecoregion, which is defined and used by the IIASA Study in other analytical aspects

(Shvidenko and Raile, 1996). The results for the basic units (ecoregions) can be aggregated later to be valid for administrative units (oblasts) and economic regions.

Thus, estimates on long-term dynamics of the forest resources are based on analyses of each individual ecoregion. The analytical tool used is a system of discrete mathematical models.

The dynamics of the Forest Fund is reflected by parameters, such as species and age structure distributions over time and is a result of the biological processes growth and natural mortality, and by a complex of controlled and uncontrolled external interventions (or disturbances). In the category of uncontrolled disturbances are; forest fires, pests, diseases, and other natural and anthropogenic factors. In the controlled category of disturbances are; forest harvests, intensity of forest protection, and regeneration. The natural dynamic processes of the forests are stochastic and described in a determined manner with the parameters of these processes characterized by mathematical expectations.

The state of the Forest Fund is characterized for each time period by the distribution of the forests over categories of forest protection (the Russian system of protection with 3 groups of forests), over forest species and age groups. Modeling of Forest Fund dynamics includes exploitable forests, and back-log covered or not covered by forests. Unexploitable forests, sparse forests and glades are not included in the dynamic part of modeling, but are regarded as a static part due to the lack of data and the long period of basic biological processes in these latter forests.

Exploitable forests consists of those in which final harvest in mature forests is allowed. Forests with no permission for final harvest belong to non-exploitable forests. Final harvest is subdivided into clear cut, selected harvest and gradual harvest. Clear cuts in the model are transferred to unforested areas after the harvest. In some cases the understory is left after the clear cut. In these cases the structure and age of the understory is used in the model.

Selection harvest refers to parts of the growing stock that are left unharvested. The extent of the harvest of the growing stock and the harvesting time in these forests is based on rates defined in Russian management handbooks.

Gradual harvesting refers to growing stock of a stand that is harvested and reduced in different time intervals step by step. After the last gradual harvesting, the total growing stock is harvested but with the understory left to grow into a new stand.

Each individual part of the Forest Fund is represented by so-called hoz-sections, which are homogenous from an ecological and economic point of view. Ecological homogeneity is achieved by forests with similar types of landscape, similar forest forming species, and similar groups of productivity into a hoz-section. Economic homogeneity is achieved by including forests of similar type and age for final harvest into a hoz-section. Silvicultural homogeneity is achieved by including forests with similar growth and developments into a hoz-section.

The state of the Forest Fund is estimated by the distribution of hoz-sections over age groups and average growing stock (m^3/ha). The initial state of the Forest Fund is determined based on data from the current State Forest Account (1993). The future state is determined (for each period) as a function of the State of the Forest Fund at the previous time period and by the external disturbances at present.

Two types of dynamics are defined in the model; natural and anthropogenic. Natural dynamics are determined by biological growth processes of forest stands, by the processes of destruction and mortality of stands caused by biotic and abiotic factors, by the forest's natural succession, and by the processes of forest regeneration on burned areas and other categories of unforested areas.

The process of forest stand growth (before maturity) is characterized by the changed age structure over time and the average growth. Thus, the dynamics of the growing stock are described as a function of the biological age of the stands. The process of natural succession of forest stands is described as changes in species and age structure as an effect of changed forest forming species. These changes are described in the form of matrixes with changes in forest forming species, age structure, by average growing stock, and by transition into a stationary state (unmanaged stands).

The process of forest destruction due to forest fires, insects and forest diseases is characterized by the transition of forested areas into unforested areas. These transitions are described by matrices over the mortality of forest stands due to the disturbances reflecting the scale and age structure of the destroyed stands. Hence, the model applies the aggregated impact of the above mentioned impacts and harvesting withdrawals. The simplicity of the model is driven by the imperfect knowledge of the impact of fires, insects, diseases and other natural influences. The information in the State Forest Account is also not optimal from an analytical point of view.

The processes of natural forest regeneration on burnt areas and other categories of unforested areas is characterized by the age at which regeneration closes to a forest (the time of transition to forested area), and by the species structure of the understory. These developments are described by matrices over the species structure of time for the regeneration to reach the stage of a closed forest.

The anthropogenic dynamics of the Forest Fund is modeled by adding intervention impacts to the natural dynamics. These interventions are the main harvest, sanitation harvest, reforestation measures, and measures for protection and conservation. As discussed above, the model deals with three types of main harvest (clear, selected, and gradual) and three types of intermediate cuts (increment felling for increased light, pre-commercial thinning, and commercial thinning). The results of these interventions in the model is a withdrawal of growing stock and forested areas and changes in the species and age structures.

Measures for forest regeneration include artificial regeneration and assisting regeneration in stands with natural reproduction. The result of these measures in the model is the establishment of forest cultures in unforested areas and new understories in assisted natural regenerating stands.

The extent of prevention against forest fires, sanitary monitoring, and protection against insects and diseases defines the level of forest protection in the model. The impact of the prevention is reflected by the scale of forest destruction and degeneration, and by the transition of forested areas to nonforested areas.

The regimes of forest utilization are characterized by the intensity and time intervals of the different harvests in the model. The forest utilization regimes are formed on the basis of regional plans and handbooks with respect to harvesting age and intensity.

The regimes of forest regeneration are characterized in the model by the scales of artificial and natural regeneration and species distribution. These scales are defined by taking into account the probability for natural regeneration in different growth zones and survival rates for the understory.

The regimes of forest protection are characterized by yearly scales of forest destruction related to the degree of protection. This regime is treated as an exogenous activity in the model.

The evaluation of the Forest Fund dynamics is formulated as the problem of finding the trajectory between the maximum allowable harvest and ecological constraints. There is also a restriction in the calculation system on non-decreasing harvest over time of valuable species. The ecological constraints secure the maintenance of the forest species diversity and species distributions over time. The calculations on the dynamics are carried out over a 200 year period, but the goal function optimizes the allowable harvest level during the first 20 years of the rotation period.

Different regimes for forest utilization (harvesting), silviculture, and protection are formulated as scenarios.

Among the results generated by the model solution the following can be mentioned:

- maximum allowable harvest level
- distribution of forest species over areas, growing stock and age classes
- extent of artificial and natural regeneration over different types of forest lands
- distribution of forested areas with different types of disturbances
- distribution of exploited areas and type of harvest
- distribution of species, assortments and qualities of the harvested volume.

For the analyses of the forest dynamics in each ecoregion of Siberia eight scenarios were employed. These scenarios include:

- different protection regimes
- different intensities in forest utilization and intensities and types of forest regeneration
- with and without restrictions on the species structure at the end of the protection period (200 years).

Overall Results

The analyses are finalized although we have not yet compiled all the detailed results at this stage. Therefore, we are only able to present general results and conclusions from the analyses.

- The driving forces determining the natural dynamics of the Forest Fund of Siberia and Far East are the natural succession and the scale of disturbances by fires, insects and diseases.

- Fluctuations of the natural disturbances cause oscillations in the dynamics of the Forest Fund. These oscillations mean that the forests go through a transition, leaving an equilibrium state and later return to another equilibrium. The time period required to reach this second equilibrium depends on the scales of fluctuations and the power of the types of disturbances. The length of the transition period varies between 10-100 years.

- However, under the current scales of natural disturbances there are no irreversible changes of species and age structure of the forests.

- The introduction of a constraint to the species composition at the end of the planning horizon (200 years) leads to a substantial decrease of the allowable harvest in certain ecoregions and to a complete exclusion of clear cuts in other ecoregions.

- Under the conditions of the current extent of forest protection, that the dominating part of the regeneration is carried out as natural regeneration (as of today), and no restrictions on species structure at the end of the planning horizon result in lower allowable cuts than the current AAC set by the Russian authorities.

- The allowable harvest level in the individual ecoregions of Siberia is strongly dependent on the initial state of the Forest Fund and the intensity of forest protection. With an increase in forest destruction, due to inappropriate protection, from 0 to 1% of the forested areas annually may decrease the long-term sustainable allowable harvest level by 50%.

The quantitative results of the analyses will be published in the near future by IIASA.

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3.5. Evaluation of Current Forest Forming Processes in Siberia

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Introduction

The possibility of achieving sustainable development in the boreal forests is determined mainly by the character and extent of human impacts, and in particular, by economic activities. A major part of Siberian forests is not being effectively managed. About 50% of the Siberian Forest Fund is not under forest fire protection or any other protective measures. Areas of forest plantations, thinned forests, etc., are negligibly small. Thus, the basic forest forming processes in Siberia are natural by nature, but they are simultaneously under strong and specific anthropogenic impacts, e.g. human-induced forest fires, overharvesting, air pollution, etc. Any estimates dealing with the sustainable development of forests should be estimates on changes of evolutionary stipulated successional dynamics over a complete successional cycle of forest ecosystems, i.e. over hundreds of years. Reliable and quantitative knowledge of successional dynamics is crucial for many scientific applications, such as evaluation of biodiversity at ecosystem and landscape levels, or development of regional forest dynamics models. Finally, successional regularities are an important basis for rational forest management. This short review explicitly reveals the crucial role of successional dynamics for the current and future state of the Siberian forests.

Objectives

The perception of successional dynamics in Siberia is only possible through the consecutive application of a landscape approach. The structure and peculiarities of the landscapes define to a large extent the state and productivity of forests, regimes of disturbances, etc. This is why this presentation aims mainly at two interconnected tasks: 1) to describe basic landscape regularities in Siberia, and 2) to develop a quantitative description of successions of Siberian forest lands. Some practical implications of the results generated are presented as illustrations.

Methods and Results

Landscape Classification

There are several scientific landscape schools in Russia and a large variety of terms and definitions used in the field (e.g., Solntsev, 1948; Polynov, 1956; Armand, 1975; Milkov, 1977; Prokaev, 1983). In order to minimize terminological disagreement and uncertainties, the following definition for a landscape is used: "... a natural complex which is homogenous in zonal and azonal aspects, with uniform climate, general relief type, homogeneous foundation, and homogeneous morphological structure" (Voronina and

Isachenko, 1983). Due to the absence of a commonly accepted landscape classification in Russia we aim to develop an uniform quantitative information database which can serve as a comprehensive basis for any landscape classification. Such an approach allows us to use different statistical methods and measures to estimate, in a quantitative way, specifics of the landscape structure, similarities of corresponding taxonomic groups, etc. For instance, landscape diversity can be defined as a typological variety of polygons (contours) within the limits of a definite hierarchical level of the classification used. Measures of the diversity could be different; in this case we used Shennon's measure for this goal.

Initially two somewhat different approaches on the partition of Siberia into homogeneous components have been employed: we used *ecoregions* of which specifics and basic designations were discussed by previous speakers, and *large landscape regions.* Each of the latter were described by 69 numerical indicators, but after multiple statistical analyses of their correspondence to the tasks formulated, they appeared to have heterogeneous natural conditions, different forest formations and succession regularities. Cluster analyses showed that the initial subdivision proposed for the landscapes (large landscape regions) was too rough to estimate their biodiversity and forest developments. Therefore, in the next stage a comprehensive hierarchical classification scheme was developed. As a basis for this scheme, the landscape map in the scale 1:2.5 M (Gudilin, 1987) has been used. The following taxonomic level for the new classification was employed:

- DIVISION of landscapes is based on the tectonic structure of the area,

- GROUPS of landscapes (19) are divided according to macroclimatic and soil-vegetation peculiarities and take into account the latitudinal and vertical zoning and the degree continentality of the climate,

- CLASSES (4) characterize the geomorphology of landscapes (occurrence in mountains and on plains) with interplatformed mountains, intermoutainous, and piedmont plains being recognized,

- TYPES of landscapes (15 on plains and 19 in mountains) are determined by water and temperature properties and soil-vegetation peculiarities,

- SUBTYPES of landscapes (10) are divisions of the type determined by dominating soil subtypes and groups of forest formations, and vertical zoning is taken into account in mountains,

- GENERA (50) of landscapes are determined by morphosculpture and morphostructure of deposits,

- VARIANTS are divided by the occurrence of a landscape in one of the geomorphological zones having peculiar regional features. The following variants of landscapes are recognized in Siberia: Central Siberian, West Siberian, Taimyr-Severnaya Zemlya, Altai-Sayans, Pribaikalski-Transbaikalian, Northeastern, Daur-Far Eastern, and Sakhalin-Kamchatka, and

- SPECIES is the total of individual landscapes being similar in origin and structure.

The most detailed level of the landscape classification, which contains about 4,000 initial typological unites (species) and is represented by about 10,000 polygons (contours) for whole Russia is illustrated in Figure 1. Aggregated variants of landscapes are shown in Figure 2.

Classification of Successions

The information available on the forest development depends on the degree of detail of the landscape. For example, small-scale maps only allow retrieving general information. Every landscape is also characterized by a certain forest formation. Thus, the forest formation might be expressed as successional changes of different phases (stages) during the development of a forest.

A commonly accepted classification of forest formation is still absent due to the huge amount of existing succession classifications. In turn, their abundance results from a diversity of elementary successions recognized, different methodological approaches, and disagreement in the use of terms.

The original succession classification used (Table 1) was proposed by a team of authors; D.Efremov, A.Isaev, V.Rozhkov, V.Sedykh, V.Sokolov, and A.Shvidenko. It is still under development but one variant is presented in this paper. It accounts for all major factors required for characterization of successional stages: origin, geography, successions of plant communities, and changes in a stand in the course of time.

Figure 1. Landscape Species of the Former Soviet Union. (There are about 4,000 initial typological units indicated in the computer version of the map which represent more than 10,000 polygons.)

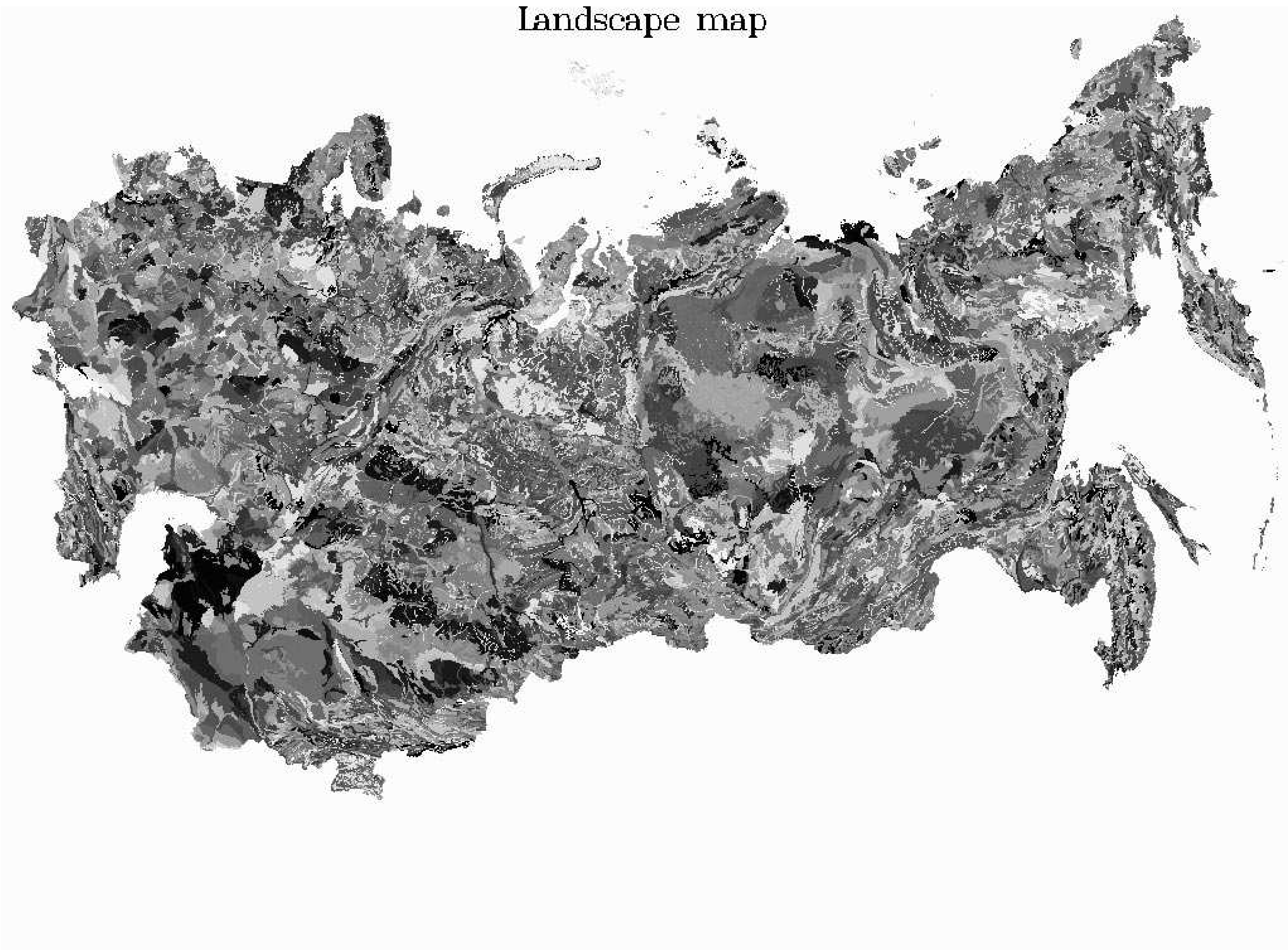


Figure 2.


Landscape variants
I Karelo-Kolsky
II East-European
III Middle-Siberian
IV Kazakhstansky
V Middle-Asian
VI West-Siberian
VII Novozemelsko-Uralsky
VIII Taimyro-Severozemelsky
IX Tyan-Shan-Dzhungarsky
X Altae-Sayansky
XI Pribaikalo-Zabaikalsky
XII North-Eastern
XIII Daursko-Far-Eastern
XIV Carpatsky
XV Crimean-Caucasian
XVI Kopet-Dagsky
XVII Pamirsky
XVIII Sakhalino-Kamchatsky

Table 1. Classification of Succession Types

Succession types	Variants of development *	Possible phases (stages) of development**
1. Climatic geomorphogenic (singenetic changes of forest communities)		
1.1. Alluvial 1.2. Denudation 1.3. Volcanogenic 1.4. Cryogenic 1.5. Hydrogenic	I	1. Pioneer 2. Recovery 3. Thicket 4. Polewood 5. Maturity 6. Breakup
	2	1. Pioneer 2. Recovery 3. Thicket 4. Perch forest 5. Maturity 6.Climax
	3	1. Pioneer 2. Recovery 3. Sparse stand 4. Low stocked stand 5. Moderately stocked stand 6. High stocked stands 7. Climax
2. Biogenic		
2.1. Zoogenic 2.2. Pathogenic	1	1. Breakup 2. Recovery 3. Canopy closure 4. Second layer formation 5. Principal canopy formation 6. Climax
3. Cenogenic (age-related changes)		
3.1. Cyclic age-related without species change (gap dynamics) 3.2. Cyclic age-related with temporal species change 3.3. Age-related point-dispersed	1	1. Gap breakup (gap dynamics) 2. Appearance of late successional species 3. Canopy closure 4. Second layer formation 5. Principal canopy formation 6. Climax
	2	1. Gap breakup (gap dynamics) 2. Appearance of early successional species 3. Canopy closure of early successional species 4. Early successional species form a second layer; appearance of late successional species 5. Late successional species form a layer 6. Breakup of early successional stand, late successional species start to form the principal canopy

Succession types	Variants of development *	Possible phases (stages) of development** 7. Climax of late successional species
	4. Pyrogenic (afterfire)	
4.1. Restoration without species change 4.2. Restoration with species change 4.3. Regressive	1	1. Pioneer 2. Recovery without species change 3. Thicket 4. Polewood 5. Maturity 6. Gap dynamics
	2	1. Pioneer 2. Recovery without species change 3. Thicket 4. Perch forest 5. Maturity 6. Climax
	3***	1. Pioneer 2. Recovery with species change 3. Thicket, appearance of late successional species 4. Polewood, late successional species form a layer 5. Maturity and breakup of early successional stand, late successional species penetrate into the principal canopy 6. Climax
	4	1. Pioneer without reforestation 2. Bogs
	5	1. Pioneer without reforestation 2. Erosional—destruction
	6	1. Pioneer without reforestation 2. Sod development
	7	1. Pioneer without reforestation 2. Overgrowing by shrubs
	5. Anthropogenic	
5.1. After logging 5.2. Emission (toxicogenic) 5.3. Edaphotoxigenic 5.4. Technoedaphogenic 5.5. Technohydrogenic 5.6. Agrogenic 5.7. Recreational	1	1. Complete stand breakup 2. Recovery without species change 3. Canopy closure 4. Thicket 5. Polewood 6. Maturity 7. Climax
	2	1. Complete stand breakup 2. Recovery with species change 3. Thicket, appearance of late successional species 4. Polewood, late successional species form a layer 5. Maturity and breakup of early successional stand, late successional species start to form the principal canopy 6.Climax
	3	1. Partial (incomplete) stand breakup
		2. Recovery without species change

Succession types	Variants of development *	Possible phases (stages) of development**
		3. Closure of layers 4. Formation of second (age-related) layer 5. Breakup of a first generation, the second generation starts to form the principal canopy 6. Climax
	4	1. Complete stand breakup 2. Bogs
	5	1. Complete stand breakup 2. Soil cover destruction
	6	1. Complete stand breakup 2. Sodding
	7	1. Complete stand breakup 2. Overgrowth by shrubs
	8	1. Partial stand breakup 2. Breakup 3. Grass glades
	9	1. Partial stand breakup 2. Sparse stand

Notes: * Possible trend in tree stand development;
** changes in tree stand composition and structure;
*** provisional synonyms to indicate maturity stages of successions in this trend of the development: 1. Pioneer; 2. Young stand; 3. Polewood; 4. Immature stand; 5. Mature stand; 6. Overmature stand.

Description of Successions in the Landscape Database

In order to input successions into the landscape database, a special form was used (Table 2).

In our database, the successions are characterized by several attributes. The basic unit for their description is Ecological Modification of Natural Forest Formation, which is set with the help of dominating species and comprise the native late successional forest and by the type of hydrological regime; automorphic, mesomorphic respectively hydromorphic regimes.

The amount of species includes the total number of species that could occur at all phases of a given succession type (or subtype) in a particular landscape.

Four succession types (pyrogenic, biogenic, anthropogenic, zoogenic) are described at any occurrence within the landscape. Also, the successions resulting from management interventions (for example, harvesting) are described for the case when they are absent for the moment but could appear during the next 20-30 years.

Other succession types are described if they occupy more than 10% of the landscape area. In addition, unique, ecologically and economically important successions should be described no matter what area they occupy. In the last case, the decision is made by the investigator.

Table 2. Form for succession description

Map sheet____________________Ecoregion code___________________________Landscape number________________________

Ecoregion name ____

Ecological modification of forest formation (EMFF)		Number of species	Succession type		Phase	Stage	Continuity, years		Type of vertical structure	Type of age structure	Tree layer composition		Mean site class	Stocking m^3		Percent of species
Name	Percent in landscape		Name	Percent in EMFF			from	to			I	II		from	to	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Phases and stages are time intervals of succession. The phase is determined by development of a new quality within a cenosis (normally, a "new" quality is interpreted according to the requirements of the *Forest Inventory and Planning Instruction* for establishing the borders between primary inventory units). The phase reflects the inclusion (removal) of every new component of scientific or economic importance into (from) the cenosis. The description starts from the reforestation phase. The stage represents the period of time of the phase. They are given only for those phases for which this makes sense (if the succession can be identified by *State Forest Account* data).

For each phase (stage), the estimated number of species is given as an integer percentage of the total number of species possible within a particular succession type. The descriptions of successions contain variants of predictions for development of a forest community.

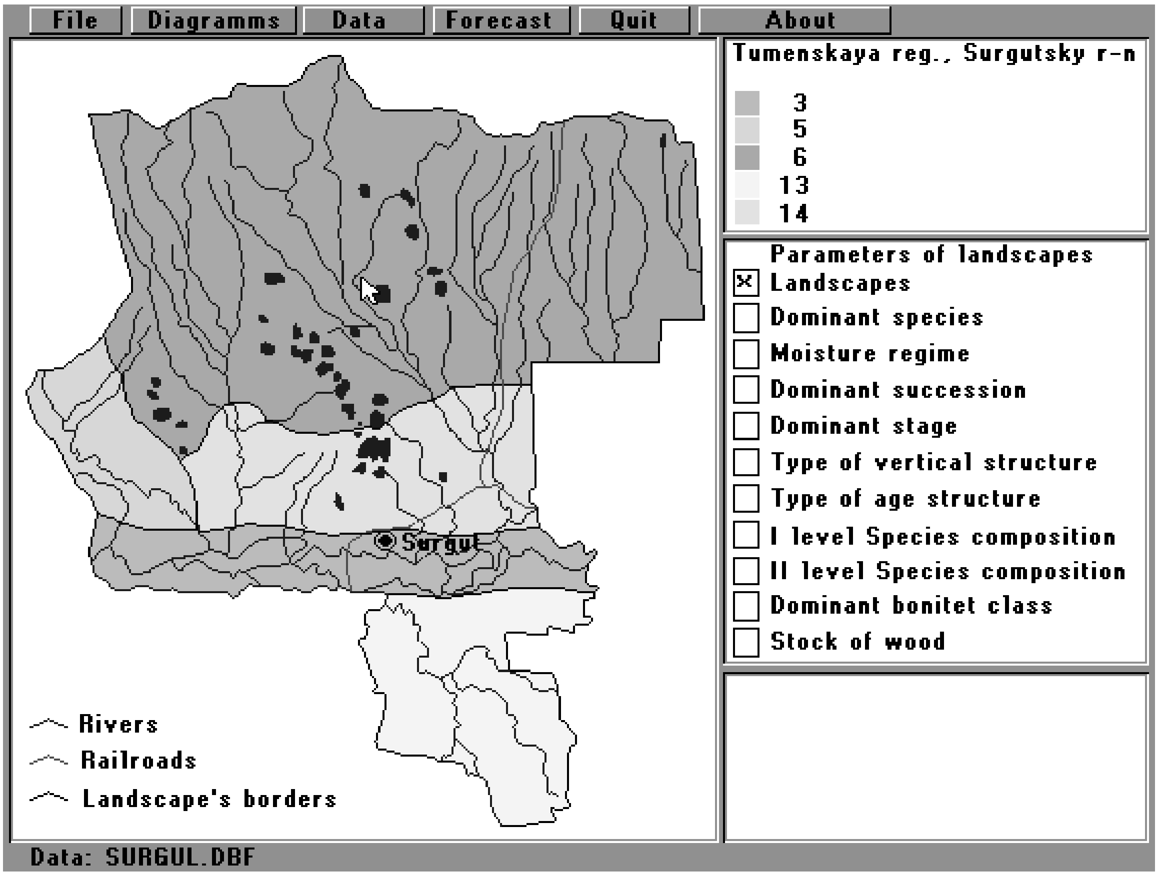
Preparatory Work for Inclusion of Successional Dynamics by Landscapes

Several years ago a special mapping expert system was developed to predict forest cover dynamics in the Yuganskiy National Reserve. The dynamics of the forest cover was predicted by using a map of the actual state of stands, site class index at the level of contours, and information on patterns of forest development expressed in a rule-of-thumb system.

Later a similar system was used to predict the dynamics of sparse larch stands in northern Yakutia. This system also accounted for the contour location on the map.

The work aimed at combining earlier developed landscape-based descriptions of successions and State Forest Account (SFA) data in order to predict the successional dynamics, for which information on the actual state of stands is required. This information can be retrieved from the SFA data if the data can be distributed quantitatively within landscapes and successions. A study of the actual state of stands and probable forest cover dynamics based on the database of landscape classifications and State Forest Account data was carried out as an example for the *Surgutskiiy Forest Enterprise* in Tyumen' Oblast (Figure 3).

Figure 3. Landscape division of the *Surgutskiiy Forest Enterprise* in Tyumen' Oblast (part of the expert system *Suktsessii* (“Successions”). Landscape numbers are shown in the upper right corner.



By overlapping the landscape map on the map of forest enterprises in a GIS system we achieve the overlapping of landscape contours and borders of forest enterprises. In doing so, one can determine the area of each landscape within the limits of a particular forest enterprise. Furthermore, only those records of the database on landscape classifications are used that contain information about ecoregions and units of landscapes within the forest enterprise studied.

When predicting the development of a current stand i.e., succession, it is also necessary to know the actual state of forest cover. The actual state describes the fractions of the successional phases (stages) by a certain year for all landscapes occurring within the borders of the forest enterprise. Information on the structure of the forests and the area distribution over dominating forest forming species and age groups is received from the State Forest Account. These data are sufficient for predicting successional dynamics after stand-replacing disturbances (complete mortality of a stand as a result of fire, clearcut, etc.). In this case, the forest development starts from a zero-state, therefore succession fractions and the continuity of phases (stages) within the limits of each landscape correspond to expert estimates on the landscape classifications.

To obtain fractions of individual successional stages, State Forest Account data were recalculated by a special algorithm developed. This algorithm is based on several prerequisites:

1. The combination of the Ecological Modification of Natural Forest Formation Units and their fractions in every landscape are kept constant for each initial unit of a landscape (genera in the case of the *Surgutskiiy Forest Enterprise*,

2. The same is applicable for successions and their phases (stages) within each unit of Ecological Modification of Natural Forest Formation,

3. There are similar patterns of development for identical succession types belonging to different landscapes located within the borders of a particular forest enterprise having a similar distribution of the area by tree species and phases (stages), and

4. The distribution by age groups of a particular tree species is practically constant for all successions in late successions.

These hypotheses are based on the fact that different landscapes occurring within a forest enterprise are characterized by a similar complex of anthropogenic and natural disturbances. But, even initially homogenous stands can develop according to different patterns.

Let us assume that the areas of succession calculated with the help of expert estimates and the areas with different tree species according to the State Forest Account *represent true values*. Then, due to the nature of the State Forest Account and the data from the database on landscape structures the incompleteness consists of:

1. The averaging of the composition of a stand by the State Forest Account,
2. The averaging of the composition of tree stand according to the landscape classification,
3. The uncertainty with regards to the actual stand distribution by primary inventory units of the State Forest Account database, and
4. The uncertainty with respect to the proportions of individual successional phases carried out as expert estimates.

Drawbacks and uncertainties of the algorithm are due to the non-universal character of the assumptions underlying the algorithm. In addition, in a case when two different but intensive successions are present, e.g., pyrogenic succession and successions after logging, there is no possibility to show specific deviations (from the mean value) of the distributions by age groups for stands by the State Forest Account without expert knowledge of the actual state of each succession type. This is especially likely to occur when the composition and properties of these succession types are similar.

For example, emission (toxicogenic) successions have emerged as a result of the beginning of intensive oil and gas exploitation in the region. The oldest stands developed after such influence are now 30 to 50 years old. For the stands with pyrogenic successions, the situation is different, the development is associated with years of extensive forest fires (and high fire frequency), which have always been present.

Similar problems arise when tree species are distributed among different successions. There is a lack of knowledge on the actual state of each kind of succession and, therefore, it is impossible to show the deviation of age structures from the mean identified in the State Forest Account.

In addition, in the State Forest Account data, the information on areas covered by individual tree species is not given for the tree distribution by the primary inventory units (as in the database for landscape classification for successional stages) but by the principal forest forming (dominating) species. This obviously decreases the accuracy of the distribution of individual species areas over successions.

In spite of the drawbacks and uncertainties, successional dynamics in the final form are described by the unified classification scheme, which was applied to the special database. The database contains the formal description of successions by each phase (stage) within the limits of the initial units of classification (landscape species).

The results achieved allow us to develop a principally new informatic database on Russian forests which could be extremely useful in many practical and scientific applications. The idea is: based on the landscape map and data of the State Forest Account by forest enterprises (a total of roughly 1900 for whole Russia and about 500 for Siberia and the Far East) to recalculate the data of the forest inventory by forest enterprises to be valid for natural units (landscape species). Such data could represent very useful information for forest management and specifically for predictions of future state and dynamics of forests; i.e., succession dynamic descriptions in the context of global change.

Evidently, such recalculations require the development of a special expert system of decision rules, which has to be generated on a regional level. As an example, we examined the possibility to generate such a system for the Surgutskiy Forest Enterprise in Tjumen' Oblast. The final result of the work is the expert system *Suktsessii* ("Successions").

Applications and Examples

Calibration of the State Forest Account data with respect to the total Forest Fund, area distribution by principal forest forming species and by their age groups over individual succession has been carried out and is illustrated by the following examples.

Cenogenic Successions

Let us assume that the cenogenic age-related point-dispersed successions, beginning with number 33** (3303), preserve their age structure constant in the course of development. That means that under natural conditions the age class distribution is described by a zero phase at any time (Table 3).

Table 3. Cenogenic successions in the *Surgutskiy Forest Enterprise*

Landscape	EMFF	Succession	Principal	Area by map		Stand composition*
no.		code	tree species	%	thou ha	phase 0
5	1	3303	Pine	1.1 1	14570	10 Pine
6	1	3303	Pine	33.5 0	439706	10 Pine
14	1	3303	Pine	1.9 2	25201	10 Pine
14	10	3303	Birch	0.4 9	6431	7 Birch, 2 Spruce, 1 Cedar

* Proportions of each tree species are shown as a mean integer for each 10% of the growing stock of I layer according to *the Forest Inventory and Planning Instruction:* Sp is spruce; F is fir; Po is poplar; Pn is pine; C is cedar; W is willow (tree); Br is birch; As is aspen.

Uncertainties: according to the database for landscape classification, all forests should be composed of overmature stands only. However, according to the State Forest Account data, the actual areas occupied by overmature stands are very small. Therefore, the distribution of age classes should be used on average State Forest Account data for a particular species. In addition, all data on tree distribution in a stand in the State Forest Account are generalized to be valid for principal (dominating) species, and by that have less accuracy with respect to the composition of trees in a stand.

Distribution algorithm: since the succession is composed of only the zero phase, the area with tree cover is attributed to the principal tree species of the zero phase according to the database on landscape classifications and the age structure of tree species coincides with the average according to the State Forest Account.

Climaticgeomorphogenic successions

Let us refer to the case where all State Forest Account data on forests of the 1st group all correspond to alluvial successions, i.e., it means a starting point with figure 11** (Table 4). Then our hypothesis is that the age structure of forests of the 1st group by the State Forest Account correspond with the successions. Based on the State Forest Account, we calculate the current area occupied by individual successional stages.

Table 4. Climatic morphogenic successions in the *Surgutskiy Forest Enterprise*

Landscape	EMFF	Succession	Principal	Area by map		Stand composition*	
no.		code	tree species	%	thou ha	phase 0	phase 2
6	4	1104	Spruce	8.38	109994	6Sp2F2Pn	6Pn3Br1W
6	4	1104	Spruce	0.49	6432	6Sp2F2Pn	6Pn3Br1W
14	5	1104	Cedar	8.38	109994	4Sp1F3C2Pn	6Pn3Br1W
14	6	1104	Cedar	0.43	5644	4Sp1F3C2Pn	6Pn3Br1W
3	4	1105	Willow	1.65	21658	10W	10W
3	3	1106	Poplar	0.55	7219	8Po2W	7W3Po

* see *Notes* in Table 3.

Here uncertainties relate to the absence of willow and poplar in the State Forest Account data, while they should be present according to the database on landscape classifications. In addition, the total area of forests of the 1st group is substantially less than the total area of alluvial successions.

Unforested area of forests of the 1st group is distributed among all alluvial successions to an extent proportional to the areas estimated by the GIS-application. Since willow and poplar are absent in the State Forest Account, data for aspen, willow (shrub), and basswood should be used by employing 1105 and 1106 successions.

State Forest Account data for pine, birch, cedar, spruce, and fir are distributed among successions according to code 1104, beginning with species more abundant during successions (i.e., pine and birch) and climaxing with spruce and fir. The abundance of a specific tree species is estimated by the most common (1 to 4) phases of each successions. If the area of a specific tree species according to the database on landscape successions is greater than that available by the State Forest Account, the extent is adjusted by the area of this species in the State Forest Account which is present during the most common stages proportionally to its distribution during these stages.

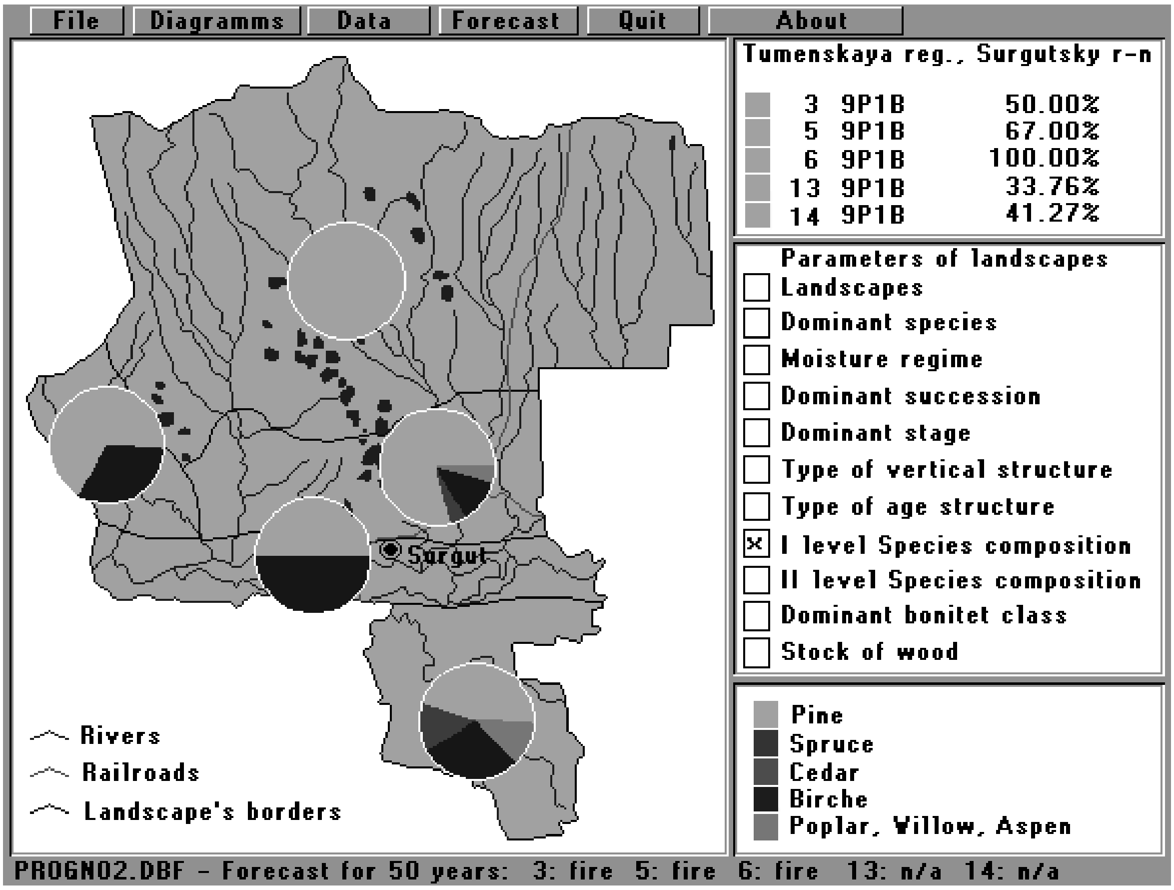
Since the total area of forests of the 1st group is less than the area of these successions, the areas of forests of the 2nd group are to be used in proportion to the tree distributions of successions already obtained.

Pyrogenic and Emission (Toxicogenic)Successions

The area of unforested lands of the Forest Fund (burns, glades, etc.) is distributed in proportion to the area of *all* pyrogenic and emission (toxicogenic) successions.

Forest fires are the main reason for the successional dynamics in this region. Fires occur so often that stands very rarely become overmature. Forest fire successions start according to Figure 4. Some successions dominated by pine develop without species change (4110). Other successions (42**) change their composition in the course of development (4212). They are represented by successions dominated by birch replaced by spruce after 120 years and those dominated by pine are replaced by cedar after 250 years (Table 5).

Figure 4. Prediction on the stand composition of the first forest layer during the first 50 years following a forest fire by using the expert system *Suktsessii* ("Successions").



The area of individual species is distributed among all successions, where a species dominates the composition at the most common (1 to 4th) successional phases, in proportion to the succession area. The areas used for cenogenic point-dispersed successions (3303) and forests of the 2nd group used for alluvial successions are subtracted from the total area covered by a tree species. Thus, areas covered by pine are distributed among all pyrogenic successions without species change, successions with species change where pine is present at the first stages (4212), and with areas after pollution (5112).

Table 5. Pyrogenic and emission (toxicogenic) successions in the *Surgutskiy Forest Enterprise*

Landscape	EMFF	Succession	Principal	Area by map		Stand composition*	
no.		code	tree species	%	thou ha	phase 0	phase 2
14	2	4110	Pine	1.9 2	25214	10Pn	9Pn1Br
3	2	4212	Birch-Spruce	0.27	3507	8SP2F	10Br
14	9	4212	Aspen-Cedar	0.43	5609	7C3Sp	10As
5	4	4212	Birch-Cedar	0.7 9	10263	6C3Sp1F	8Br2As
14	7	4212	Pine-Cedar	0.4 3	5476	6C2Sp2Pn	7Pn2Br1C
14	3	4411	Pine	0.9 6	12633	10Pn	9Pn1Br
6	3	5212	Pine	10.0 5	132256	10Pn	8Pn2Br

* see *Notes* in Table 3.

For successions dominated by birch (aspen) in early stages or during the whole succession (pyrogenic, 4110), the age group distribution is regarded as being constant. The proportions are calculated by the same pattern used for pine stands. However, when adding up the successions, the total area of the succession should not be greater than that in the database on landscape classifications.

Spruce, cedar and the rest of birch and aspen is distributed among successions, where they present the last successional stages in order to fit the values calculated by the map.

Vegetation of 3rd, 5th, and 6th landscapes was completely burned, while 13th and 14th landscapes developed without any disturbance. The pie diagrams show the tree stand composition at current stage of landscape development according to the database on landscape classification. In the right upper corner the principal forest forming species can be identified as well as their distribution.

Conclusions

The main conclusion of our work is that the landscape approach is appropriate to describe the state and dynamics of the forest cover at most levels of territorial aggregation. The database proposed for the landscape classification combined with the landscape digitized map is the foundation which allows us to link different approaches into a unified system for description of potential and actual productivity of terrestrial biota, dynamics of forests under different climate and forest management regimes, and of the ecosystem and landscape diversities.

The experience from the development of the GIS and expert system Suktsessii ("Successions") for Surgutskiy Forest Enterprise in Tyumen Oblast confirmed the possibilities of employing State Forest Account data for specification of the successional dynamics of the forest cover, and illustrated many fields of possible future applications. It has been shown that landscape uniformities generate similar regimes of disturbances and general tendencies of forest dynamics over large areas. Nevertheless, significant uncertainties and imperfections of the existing State Forest Account data were recognized. In order to overcome these shortcomings, regional decision rules applied to the smallest units of the landscape classification (genera or species dependent on the geographical zones) should be developed.

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3.6. Criteria and Indicators for Sustainable Forest Management in the Russian Federation

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Introduction

Following the Decree of the President of the Russian Federation, April 1, 1996 (No. 440) on sustainable development, "The Conception of Transition to Sustainable Development in the Russian Federation" was adopted by the Russian government (May 8, 1996, No. 559). Based on this decree the government also established a taskforce to develop a national program for sustainable development. In compliance with this, the Federal Forest Service of Russia has worked out new principles for national forest policy setting and one of these principles is "Criteria and Indicators for Sustainable Forest Management in the Russian Federation."

The main purpose of this latter principle is to try to secure conditions for implementation of the international committments Russia has made with respect to forestry. These committments are the ratification of the UN Conventions on Biodiversity and Climate Change, as well as the fulfillment of the agreements made at the UN Conference on Sustainable Environment and Development in 1992 concerning sustainable forest management (Forest Principles and Agenda 21). In these latter agreements tasks of the different governments were identified with respect to securing sustainable development of all aspects of forests in order to meet the needs of current and future generations.

The new Russian principles of criteria and indicators for sustainable forest management are based on the results from discussions on sustainable management criteria and indicators developed for the European forests (the so-called Helsinki process) and for temperate and boreal forests based on the results from the so-called Montreal process. The list of criteria and indicators from these two processes were investigated with respect to their adapatation for Russian conditions.

In this latter process, not only natural and socioeconomic peculiarities of Russia were taken into account, but also the specific features of the existing forest managment in Russia. The current version of the newly developed critieria and indicators for sustainable forest management have been developed after reviews and suggestions for improvement by different forest management bodies, forest inventory and planning units, and research institutions in Russia.

The criteria for sustainable forest management and corresponding indicators presented in this document are planned to serve as a component of the new forest policies for the Russian Federation and in individual administrative units within the Federation.

The indicators have been selected by taking into account the existing available forest inventory information in Russia. Each criterion should be able to describe the conditions in the total Federation as well as in specific natural or economic regions. Among the indicators selected are also indicators which currently are not collected by the Russian inventory system, but are regarded as being of great significance.

The scope of this document does not cover criteria and indicators at the level of individual forest management units. The implementation of sustainable management criteria at this level has to be regulated in successional work in connection with required certification rules based on international recommendations.

The criteria and indicators considered in this document are tentative and subject to further improvement. Better data and information will be collected and used for further improvement of the critieria and indicators.

Qualitative and quantitative assessment of the selected indicators needs to be carried out in the next stage. The assessment with respect to total Russia, has to be carried out by the Federal Forest Service of Russia. With respect to regional and local forests the assessment has to be carried out by regional forest management bodies. The data sources for the assessments are the State Forest Account, data from most recent forest inventory and planning operations, data from the forest enterprises, and data from State environmental bodies, and different research institutes.

Terms and Definitions

Sustainable Forest Management

The objective of sustainable management of the Russian forests is to achieve a long-term stable ecological and economic relationship between people and the forest ecosystems. Sustainable forest management also implies conservation of the forests, as a part of Russian landscapes, inperpetuity.

The management of the Russian forests should be realized based on the best available scientific knowledge and on comprehensive assessments of the possible impacts on the forest ecosystem. The sustainable management requirements should be reflected in the forest policy, in legislative and normative acts, and in forest management handbooks.

Sustainable forest managment should be based on both ecological and socioeconomic criteria. These criteria should provide a sound basis for forest practices in order to observe the long-term development of conservation and sustainability of forests. This monitoring should guide the Russian authorities in assessing the progress or failure in sustainable forest management. Sustainable management of the Russian forests implies a balanced utilization of the forest resources, maintenance of all forest functions and characteristics, both commercial and non-commercial.

The current principles for forest management in Russia are expressed in the Russian constitution and in "The Principles of Forest Legislation in the Russian Federation." The sustained-yield management principles has dominated in Russia since the begining of the 18th century (by the forestry reforms initiated by Peter the Great). The wording of this principle, which more or less remained unchanged for a period of three centuries, was later added to "The Principles of Forest Legislation in the Russian Federation," and in other documents regulating the operations by the Federal Forest Service of Russia. The phrasing of this principle in these documents is "Securement of sustained and uninterrupted utilization, reproduction, protection and conservation of Russian forests."

Criterion
A criterion represents a strategical direction of a practical operation aiming at implementation of accepted principles. The criterion on sustainable forest management should be assessed by a set of indicators.

Indicator
An indicator is a quantitative and descriptive characteristic related to a criterion or criteria on sustainable forest management. A set of indicators makes it possible to assess trends of changes in the forest management with respect to a specific criterion. Consistent tracing of indicators over time makes it possible to discover the trends of changes in forest management.

Regions and natural-economic areas of Russia
Each region is part of the Russian territory in accordance with its administrative division at the level of the Russian Federation.

Each natural-economic area is a part of the Russian territory, which comprises several regions featured by similar natural and economic conditions. The boundaries of those areas coincide with administrative boundaries of the constituents of the Russian Federation.

The Russian Federation is divided into the following natural-economic areas: Baltic, North, North-West, Central, Volgo-Vyatsky, Central-Chernozyom, Povol-zhysky, North-Caucasian and Ural areas in the European Ural part of Russia, and West Siberia, East Siberia and Far East in the Asian part of Russia.

Biodiversity
Biodiversity (biological diversity) of Russian forests comprises quantitative and qualitative characteristics related to the variability of living organisms, as well as to forest-related ecological complexes inhabited by those organisms.

Conservation of biological diversity implies conservation and maintenance of the historically established organization of living organisms at genetical, specific and ecosystem levels within the Russian forests.

The ultimate objective of the conservation of biological diversity is the survival of species, maintenance of ecosystems, and the genetic variability within species. Viable breeding populations of species and natural genetic variation do not exist independently, but as a part of interdependent physical and biological systems or processes, communities, or ecosystems.

Ecological processes and viable populations of species that are characteristic of forest ecosystems are usually dependent on a continguous ecosystem or ecosystems of specific minimum sizes.

Genetic diversity within a species population depends on the maintenance of subpopulations and the existence of forest ecosystems, that cover a large part of their natural range.

Criteria and Indicators

CRITERION 1. MAINTENANCE AND CONSERVATION OF THE PRODUCTIVE CAPACITY OF THE FORESTS

Strategic objectives to be achieved:

- To create a national system for long-term assessments of the forest conditions based on forestry practices and to carry out a forestry accounting (forest inventory and planning operations, forest monitoring, and forest cadastre) with the purpose of ensuring conservation and maintenance of the productive capacity of the forests.

- To implement (at the Federal and at the level of regions of the Russian Federation) a measure of the forests' capability to meet people's demand for timber products, based on the data available on forest area being suitable for commercial harvesting and to compare with the total stocked forest area in Russia, or within a region of the Russian Federation.

- To monitor the removal of timber and non-timber forest products, and to compare with the allowable harvest levels ensuring a sustained harvest.

Key Elements of Criterion 1:

- The dynamics of the stocked forest area impacted by forest management defines the direction of changes to occur in Russia on the whole, or in a certain region of the Russian Federation.

- A balance between the average net increment and the total felled volume within a region/natural economic area/country over the past 5-10 years indicates conservation and maintenance of the natural capacity of forests to restore the extent of timber resources. This index is of particular importance when evaluating sustainable forest management.

Indicators

- Extent of area of commercial forests within region/natural economic area/country relative to total forest area (5 year average).

- Calculated Sustainable Allowable harvesting volume relative to the actual felled volume in commercial forests within region/natural economic area/country (5 year average).

- Changes in proportions of stocked forest area within forest land of region/natural economic area/country (5 year average).

- Average net increment compared to total felled volume within region/natural economic area/country over the past 5 or 10 years.

- Extent of annual removals of non-wood forest products (i.e., wild medicinal herbs, fruits, mushrooms, honey, technical raw materials and game) and compared with calculated sustainable harves levels within a region/natural economic area/country.

- Proportion of national forest land covered by forest inventory and planning activities and management plans (5 year average).

CRITERION 2. MAINTENANCE OF THE VITALITY OF THE FORESTS

Strategic objectives to be achieved:

- To monitor anthropogenic and natural impacts on forests and collect data concerning trends and extent of those impacts on the forest vitality in Russia.

- To assess the impact of forest management on the vitality of forests, as well as on the maintenance conditions required for the existence of forest-dependent plant and animal species.

- To determine forestry strategies with respect to mitigating adverse impacts of air pollutants on the vitality of the forests.

Key Elements of Criterion 2:

- Assess changes in the depositions of pollutants within the forest land.
- Forecast adverse impacts of pollutants on forests.
- Evaluate trends in changes of the vitality of the forests contaminated by pollutants (including radionuclides).
- Evaluate the capabilities of the forests with respect to sustained resources, ecological and social functions.

- Plan measures aimed at elimination of adverse impacts of pollutants on forests.

Indicators
The total area of forests damaged or perished annually under the influence of adverse agents:

a) fires;
b) insects and diseases;
c) industrial emissions;
d) other agents.

The extent of forest area exposed to radioactive contamination.

The total (and per unit of forest area) amount of depositions of pollutants (5 year average).

The extent of forest area featured by serious defoliation, assessed according to UN/ECE methods.

CRITERION 3. MAINTENANCE AND CONSERVATION OF THE PROTECTIVE FUNCTIONS OF FORESTS

Strategic objectives to be achieved:

- Conservation of forest soils, prevention of soil erosion, protection and control of the integrity of soil cover and of soil fertility.

- Maintenance and enhancement of the role of gorged forests at sites featured by rugged or mountainous relief, at slopes of ravines, gorged forested strips, forests on sandy soils, as well as of agricultural and adjacent forest lands, including the forests situated along railways and highways.

- Conservation of water bodies in forested areas, prevention of their degradation, and maintenance of water quality and water quantity.

Key Elements of Criterion 3:

- Manage gorged forests with the objective to maintain their ecological and social functions.

- Manage forests for water protection with the objective to maintain their ecological and biospheric functions.

- Protect water bodies with respect to felling operations and deforestation of watershed areas.

- Ensure a sustained water balance within a year, maintain good water quality, a balance of water-soluble mineral and organic disturbances, and protect water habitats of forests flora and fauna.

Indicators

- The share of forest area managed for soil protection (forested steep slopes, national shelter belts, strips of coniferous forests, gully forests, protective forest strips along railways and highways of national, republic or regional importance).

- The share of forest area managed for water protection (forest belts adjacent to rivers, lakes, storage reservoirs and other water bodies, forests protecting spawning grounds for fish, forests for sanitary protection of water supply sources).

- The share of forest area managed for other protective purposes (pre-tundra and subalpine forests).

- The share of forest area managed primarily for sanitary and health-improving purposes.

CRITERION 4. CONSERVATION AND MAINTENANCE OF BIOLOGICAL DIVERSITY OF FORESTS AND THE FORESTS' CONTRIBUTION TO THE GLOBAL CARBON CYCLE

Strategic objectivves to be achieved:

- To conserve habitats (completely or partly) for survival of animal and plant species.

- To maintain forest composition and structure (forest land structure and landscapes) that would ensure conservation of viable breeding populations in species.

- To provide optimal conditions for pollination and dissemination of seeds, movement of animals between separate forest sites and their breeding.

- To make long-term forecasts on the total biomass accumulation and methane fluxes with the purpose of estimating the role of the Russian forests in the global processes of regulating the atmospheric carbon and methane contents.

Key Elements of Criterion 4:

- Assess the area occupied with coniferous, hard- and soft deciduous species, as an index at the ecosystem level that reflects the natural diversity of forests at a zonal level.

- Assess the forests' stability within region/natural economic area/country by trends in changes of the species composition of the forests.

- Maintain and enhance the biodiversity by regulating the age and species compositions of the forests.

- Establish protected forest territories with various natural conditions, such as climax forests, virgin forests, as well as specially-protected forest areas being of scientific or historical value, with the purpose of maintaining the ecosystem diversity.

- Conserve biological species with small populations or significantly reduced ranges, which run the risk of complete extinction or losing important genetic traits, with the purpose of maintaining species and genetic diversity of forest ecosystems.

- Maintain the global forest functions with respect to the greenhouse gas balances.

- Monitor the efforts made in Russian forestry to implement the UN Conventions on climate change, and conservation of biodiversity. In addition, to preserve the variability of all living organisms, as well as the carbon sequestration by forest biomass.

Indicators
The extent of area covered by coniferous, hard- and soft deciduous species, relative to the total stocked forest area (5 year average).

The extent of forest area occupied by main tree species and their age class distributions (5 year average).

The extent of area of specially protected forest territories (5 year average):
a) nature reserves;
b) national and natural parks;
c) reserved forest areas of scientific or historical value (natural monuments).

The number of forest-related animal and plant species that are considered to be threatened (according to “The Red Data Book of the Russian Federation”; 5 year average).

The extent of forest area intended for conservation or maintenance of forest genetic diversity (5 year average).

The total amount of phytomass and carbon accumulated by forest ecosystems in regions/natural economic areas (5 year average).

CRITERION 5. MAINTENANCE OF THE SOCIOECONOMIC FUNCTIONS OF THE FORESTS

Strategic objectives to be achieved:

- To secure development of economic and financial mechanisms for sustainable forest management.

- To combine the use values of forest utilization and non-use values of conservation of the forest resources in a sustainable manner.

- To ensure effective forest management with the objective to preserve and maintain sustainable and undisturbed forest utilization (multiple-use).

- To secure a relevant spatial-temporal distribution of the utilization of the forest resources.

Key Elements of Criterion 5:

- Ensure economic efficiency and ecological safety in Russian forestry.

- Obtain necessary financial resources for ensuring a sustainable and undisturbed use of multiple forest functions.

- Increase the profitability of forestry by an increased competitive position for all kinds of forest products in domestic and foreign markets.

- Add the costs of sustainable forest management to the value of any forest product derived from forest resources.

- Balance the interests with respect to the current state of the forest resources, the current demands on the forest resources, and the supposed needs of future generations.

- Ensure governmental policies (at the level of the Constitution, Forest Legislation and regional legal actions) for sustainable forest management, including the regulation of all issues relating to the utilization, restoration, protection and conservation of forests.

- Conserve and maintain the conditions for traditional ways of life of local groups of indigenous peoples residing in the territories of the Russian forests.

- Conserve the traditions and ancient cultures of indigenous peoples.

Indicators

- The share of the forest sector in the gross national product (based on environmentally oriented accounting).

- The value and volume of wood and non-wood products.

- The value of investments in the traditional forest sector as well as investments for non-wood and environmental production and functions.

- Employment in the forest sector with special emphasis on employment in rural areas and in regions inhabited by indigenous people.

- The level of expenditure on research and development, and education in forestry.

CRITERION 6. FOREST POLICIES FOR FOREST CONSERVATION AND SUSTAINABLE MANAGEMENT.

Strategic objectives to be achieved:

- To improve forest policy-setting and forest legislation in the Russian Federation to ensure sustainable forest management.

- To improve, clarify and use the legal mechanisms to promote the utilization of forest resources, forest functions and specific features of social, ecological, historical, and cultural importance for the population and the country.

- To clarify and assess economic mechanisms for sustainable reproduction of non-market forest values.

- To provide guarantees for long-term forest utilization from a socioeconomic point of view.

- To ensure the participation of all groups of the population in the decision-making process with respect to forest management.

- To integrate the efforts of different forest-related departments, organizations, enterprises and scientific communities with the purpose of generating a broad public understanding of the forest sector issues.

- To acknowledge Russia's obligations related to various problems of sustainable forest management.

- To stimulate an active national dialogue on all key issues of sustainable forest management (e.g., Federal and regional interests, property structure, responsibilities, finances, etc.).

Key Elements of Criterion 6:

- Improve forest policy and forest legislation, and extend the legal framework to make use of economic regulating measures aiming at sustainable forest management.

- Improve the regulatory basis and structure of the forest management.

- Activate public opinion with respect to the necessity for conservation and protection measures of forests and to involve all population groups in the forest managment processes.

- Activate social motivations (at the level of social and professional groups, and families) concerning the necessity of sustainable forest management.

- Establish partnerships between forest management bodies and independent non-governmental organizations engaged in environmental protection and forest conservation.

- Establish taxation policies promoting a balanced development of the forest sector and sustainable forest management.

Indicators

- The legal mechanisms (laws, regulations, norms, guidelines) promoting conservation and sustainable management of forests.

- The organizational mechanisms, including development and review of forest policy, as well as making relevant forest-related information available to the public.

- The coordination mechanisms related to activities of different forest-related organizations, enterprises and scientific communities.

- The international mechanisms of cooperation on various problems of sustainable forest management.

- The economic and financial mechanisms for sustainable forest management, including investment and taxation policies aimed at ensuring a multiple long-term use of the forest resources.

Conclusion

The global significance of the forests becomes more evident as forest cover declines. The forests have demonstrated the need for spatial-temporal stability of global functions. The spatial-temporal stability is not only an issue of current public awareness, but also for issues which will influence mankind's future.

The core of modern economical and ecological rational is formed by the idea of a steady development of society in harmony with the natural process of the biosphere and with protection of the environment. The main contradictions in development, transformation and protection of the forest resources are as a rule in the socioeconomic sphere.

The non-exhausting, multi-purpose use of forest resources and their restoration are the main goals of forest management in all countries of the world. Today, the mechanisms for multi-resource forest management in comparison with single-purpose forestry is not yet completely developed, and this will demand essential efforts from forest science and forest policy-setting. Until now, non-wood resources have, to a large extent, been used without consideration for their sustainability.

There is a need to develop management measures for efficient, long-term use of the entire complex of forest resources, and to improve the complete knowledge about the distribution of non-wood forest resources.

The balance between interests of the contemporary generation and possible needs of future generations with respect to the forest resources may be provided by State obligations on sustainable forest management, in particular the obligatory State control of forest management, reforestation, forest conservation and protection, stipulated by the Consitution and the Forest Legislation.

The utilization of timber can no longer be analyzed separately from the non-wood and non-market resources of the forests. The need to secure the sustainable development of all these products and functions for the people was brought up by the UNCED (1992).

The only possibility to fulfill the international commitments to preserve the forests, maintain biodiversity and regulate the climate (according to the “Forest Principles”and “Agenda of the 21st Century”) is if national forest policies take forest conservation and sustainable management into account.

These new policies must be implemented at the local, regional, national and global levels. Russia possesses one-fifth of the world’s forest resources. Therefore, the assurance of sustainable management, utilization, protection and reproduction of Russia’s forest resources is not only a national problem, but a global one as well. A great contribution to the realization of a new forest policy in Russia can be made by the implementation of Criteria and Indicators at the national, regional and local levels as relevant Sustainable Forest Management Tools.

3.7. Russian and Siberian Forest Industry - Past, Present, and Future: The Way Ahead

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INTRODUCTION

The forest sector of the former Soviet Union, now Russia, has long fascinated timber interests from around the world. Although it is regionally an important producer and trader of wood products, it is Russia's stock of forest resource that has captured the imagination, ever more so now in light of drastically reduced harvest potentials taking place in many parts of the world. Furthermore, collapsing industrial activity inside Russia and the other republics of the former Soviet Union has revealed an apparent surplus between what the forest resources can seemingly sustain and what the current harvest supporting both domestic consumption and current export levels would suggest, presenting opportunities for export led growth in the future.

General trade among, and economic activity within the Republics including that linked to the forest sector have fallen steeply following the demise of the USSR and the centrally planned economy. A rebounding economy in each of the Republics including Russia, brought on by the subsiding of chaos which appeared following the collapse of the centrally planned economy and the political union of the USSR, can be expected to create a potential market for exporters located in Russia and elsewhere, as well as increasing demand inside Russia. Furthermore, domestic manufacturers and purveyors of forest products in the non-Russian republics will also have opportunities to capitalize on the latent economic rebirth. This paper examines the harvest potential of the forest resources of Russia and provides an assessment of future harvest levels and export potential. It reveals in a more structured way the balance between supply and demand of forest products within Russia. The extent to which *inter* Republic trade contributed to historical and present consumption patterns provides an indication of the potential market awaiting the rebound in economic activity once the turbulence caused by dissolution of the Soviet Union fades away. A look into the future demand through five scenarios of economic growth provides a framework when examining forest sector activity taking place into the twenty-first century. Following the discussion of past, present and future structure of the forest sector, observations and implications for policy are presented.

FOREST RESOURCE AND FIBER SUPPLY

The Russian coniferous resource, accounting for more than 70 % of the stocked forest land and nearly 80 % of the volume, contains 552 million hectares of stocked forest land and 64 billion cubic meters of growing stock (**Figures 1a** and **1b**). The deciduous resource amounts to 157 million hectares of stocked forest land and 16 billion cubic meters, or approximately one-fifth of both the total Russian stocked area and concomitant growing stock. The balance of 62 million hectares (8 %) and 1.4 billion cubic meters (2 %) consists of species that do not contribute a significant share of the aggregated inventory. The deciduous resource in the western parts of Russia (European Russia and West Siberia) accounts for some 35 percent of the stocked forest land and growing stock while in the Eastern parts of Russia (East Siberia and the Far East) it accounts for only some 10 percent. Virtually all of the stocked forest land supporting growing stock of the lesser important species is located in Eastern Russia.

The forests of Russia can be credited with annual net growth of nearly one billion cubic meters. However much of this potential is not realizable by the forest industry due to uses of the forest that conflict with timber extraction or accessibility affected by the absence of a transportation network or technological limitations. It is these limitations, discussed below, that decrease the overall annual potential of the Russian forest resource to some 600 million cubic meters that are believed available to the forest sector in the longer term.

Almost 10 % of the forest growth potential is supported by extremely low site forest unlikely to ever have utility for the forest sector (**Figure 2**). Another one-quarter is not realizable during the next two decades, even with the infrastructure developmental priorities of the late 1980s under the former regime, and may in fact never be realizable in the longer-term due to environmental factors. Some 15 % are not currently available due to restrictions on harvest to accommodate protection values. Almost one-fifth (200 million cubic meters), although potentially available in the medium to longer term, depend on either additions of technology or infrastructural development not supportable solely by the forest sector to be realizable. Of the nearly one billion cubic meters of net growth, some 40 % (400 million cubic meters) remains that can be considered realistically accessible in the short to medium term.

The coniferous resource supports only 57 % of the short to medium term fiber potential, or some 235 million cubic meters (**Figure 3**). The deciduous forest resource supports the remaining 43 % of the fiber flow (180 million cubic meters). The coniferous resource is more heavily represented in the medium to long-term resource potentially accessible to the forest sector, where it accounts for almost two-thirds of the 200 million cubic meters falling in this category (130 million cubic meters). The deciduous forest supports the remaining one-third, or 70 million cubic meters.

Western Russia accounts for two-thirds of the short term - medium term fiber supply, slightly more than one-half of which is supported by deciduous forests. Only one-third of the medium to long-term fiber is located in Russia West, nearly 60 percent of which are supported by deciduous forest. Eastern Russia, accounting for one-third of the short to medium term fiber, is dominated by coniferous forests which support three-quarters of the total. Two-thirds of the medium to long-term fiber supply is located in Russia East, four-fifths of which are supported by coniferous forests.

Not all of the fiber potential identified above has commercial utility. A portion of the harvested fiber is lost between the place of harvest and the place of first processing. Additionally, the harvest that is actually delivered and available consists of a non-commercial component. Accounting for both of these losses reduces the potentially realizable fiber from the forest resource over the medium to long term from 600 million cubic meters to some 370 million cubic meters, two-thirds of which are believed to be available to the forest sector in the short to medium term (**Figure 4**). Two-thirds are supported by coniferous forests with the balance by deciduous forest. Russia West accounts for almost 60 percent of the total while Russia East accounts for the remaining. A small amount of the commercial supply is supported by the medium to long term forest in Russia West while nearly one-half of the commercial supply is supported by such forests in Russia East.

FIBER UTILIZATION AND ECONOMIC ACCESSIBILITY

Since 1989, the degree to which the fiber potentially accessible to the forest sector has been utilized has been falling (**Figure 5**). From nearly complete utilization of the short to medium term fiber supply in 1989, represented by a harvest of 439 million cubic meters, only 251 million cubic meters were actually harvested in 1993, representing a utilization of only 60 % of the Russian resource believed available in the short to medium terms. During 1994 harvest levels continued to plummet as economic activity fell, declining between one-quarter and one-third on levels existing in 1993.

While indicating “economic” harvest levels of the day, these values do not necessarily provide an indication of what the economic harvest levels might be when the chaos following the collapse of the USSR subsides and links among the producers and sellers are re-established. Harvest levels evident in 1993 and 1994, although reflecting the economic realities of that time period, are not necessarily representative of the levels possible when the domestic price and cost matrix achieves some stability with the international level and choices among suppliers and demanders becomes more widespread.

While an estimate of economic accessibility is rife with uncertainty given the fluctuating exchange rate and inflationary tendencies characteristic of the environment in Russia at the present time, modified to incorporate firewood and harvest loss, economic harvest levels in the short to medium fiber resource could amount to 230 million cubic meters while that in the resource available in the medium to long term could add some 95 million cubic meters under the Base Case identified as #1 on **Figure 5**. These values represent more than 55 percent of the harvest potential in the short to medium term resource and slightly less than one half in the medium to long term resource.

Incorporating a higher price for roundwood available in the Pacific Rim market (#2), the economic harvest levels could amount to 310 million cubic meters in the short to medium term fiber and 145 million cubic meters in the medium to long-term fiber. These harvest levels represent three-quarters of the short to medium term maximum fiber possibly available and slightly more than 70 percent of the medium to long-term maximum fiber potential.

FOREST SECTOR ACTIVITY - PAST AND PRESENT

Russia dominated the activity in the forest sector of the former USSR to varying degrees with the largest share of her production taking place in Russia West (**Figures 6a** and **6b**). More than two-thirds of the harvest took place in Russia West in 1989. While accounting for 70 percent of the lumber output and three-quarters of the pulp output, almost 90 percent of the panel and paper/paperboard production took place in Russia West. Russia East accounted for one-third of the Russian total lumber production but less than 15 percent of the paper and paperboard and panel output. Significantly more of the pulp production was located in Russia East, accounting for one-quarter of the Russian total. By 1993, harvest and lumber output in Russia West had declined by nearly 50 percent while that in Russia East had fallen more steeply, by nearly three-fifths in the case of lumber and slightly over 50 percent in the case of harvest (**Figures 7a** and **7b**). While pulp production had fallen by one-half in each of the Russian regions, paper and paperboard production fell less steeply in Russia West where the decline amounted to only 45 percent on 1989 levels. In Russia East, the decline amounted to almost two-thirds. The output of panel products fell the least with the decline in Russia West amounting to slightly more than one-quarter and 45 percent in Russia East. The fall in production continued into 1994 as lumber output fell by 24 percent in Russia West and 28 percent in Russia East. Panel output fell by 30 percent, pulp output by one-quarter and paper and paperboard by 23 percent and 38 percent respectively. Harvest continued to decline as well, falling by nearly one-third. By 1994, rising transportation costs had shifted production proportionately westwards with Russia West accounting for slightly higher share of the overall production with European Russia having a significantly higher share.

A significant share of the production of the Russian forest sector has depended on export markets, amounting to 14 percent of commercial roundwood output, 21 percent of lumber output, 18 percent of panel output, 13 percent of pulp output, and 21 percent of paper and paperboard output as late as 1990. Taking into consideration exported manufactured forest products, one-quarter of commercial roundwood production in Russia depended on export markets for their activity prior to the demise of the former Soviet Union (**Figure 8**). Of the 2 million forest industry and forestry workers in 1990, one-quarter owed their livelihood to markets external to Russia. By

1993, export markets had collapsed in the Near Abroad and the Baltics, thus depriving Russian producers of more than one-half of their traditional external markets. Further compounding the drops brought on by a collapsing domestic and Near Abroad market was the sharp fall of markets in hitherto COMECON countries of East Europe. Despite the decline in the traditional markets, net exports still consumed nearly one-quarter of the fiber supply on sharply lower volume (10 percent of commercial roundwood, 16 percent of lumber, 17 percent of panels, 21 percent of pulp, and 21 percent of paper and paperboard). By 1994, while Near Abroad markets continued their decline, Far Abroad markets began to firm despite a further deterioration in the domestic market. Indeed, net exports in 1994 accounted for more than one-third of the fiber supply in the forest sector and a similar volume as that in 1993. Some 30 percent of workers in the forest industry and forestry sectors depended on markets external to Russia.

Between 1989 and 1993, consumption of forest products fell sharply. Consumption of lumber and paper and paperboard fell the steepest with consumption levels amounting to only one-half of those evident in 1989 (**Figure 9**). Panel consumption continued to hold up as late as 1993 with consumption levels only one-quarter below those existing in 1989. By 1994, consumption levels had declined even further, varying from 29 percent in the case of paper and paperboard, 45 percent in the case of panels, and 38 percent in the case of lumber of 1989 levels.

Although employment in the forest sector has fallen, it has not fallen as steeply as physical output (**Figure 10**). As a result, productivity per employee has plummeted from levels evident as recent as 1990 to less than one-half by 1994. Despite the declining productivity per manday, unemployment in the forest sector has risen with estimated unemployment amounting to at least 14 percent, and almost 30 percent if focusing solely on the harvesting sector (**Figure 11**). If productivity were restored to 1990 levels with the output in 1994, unemployment in the forest sector would amount to at least 60 percent. Unemployment levels are lower in European Russia where levels are 7 percent in the forest sector, 23 percent in harvesting sector, and 50 percent in the forest sector if productivity evident in 1990 were achieved in 1994. Corresponding figures in West Siberia are 24 percent, 37 percent, and 71 percent; East Siberia - 22 percent, 32 percent and 66 percent; and in the Far East - 42 percent, 39 percent and 78 percent.

Prices and costs have changed dramatically since the late 1980s with the rising transportation costs having a greater affect on activity in the periphery areas (**Figure 12**). By 1995, transportation costs on the railway had increased nearly twice as fast as had the price for roundwood. Similar increases have taken place in pulp and paper/paperboard while the increase in the case of lumber is somewhat less. Furthermore, price increases in industry in general have exceeded those of the forest sector. Indeed, it is the more rapidly rising costs of transportation which have led to the sharply lower production levels in the Asian part of the country.

Not only have prices in the forest sector lagged behind general prices levels, but wages in the forest sector have also not kept pace. Indeed, relative to wages earned in 1990, the forest sector has become a less attractive sector to work. Compared to the average wage in industry in 1990, forest sector wages were close to par. By 1994 forest sector wages were only some 80 percents of the industry average.

THE FUTURE

Although economic activity and consumption and trade of forest products have fallen steeply since 1989, the outlook for the future is based on a different set of paradigms connecting producer with consumer and republic with republic. While linked to the past through the existing human, financial, and physical capital stock left over from the previous regime, and the cumulative experience of the peoples of the former Soviet Union, future activity and prospects in the forest sector and opportunities for trade among the former republics let alone trade with the Far Abroad are expected to take place under a more market oriented system in which prices play an allocative role for resources rather than a role monitoring the designs of a central plan.

The important factors: While prices and costs will play a role, future activity in the forest sector will be based on three major overriding factors.

First, the extent to which domestic demand rebounds following the introduction of links among the different participants of the economies will provide the basis on which future consumption levels can be placed. While it is uncertain the magnitude of the change in demand brought on by re-establishing the framework within which economic activity takes place, some indication of the boundaries within which future demand might fall can be developed by assuming a low, middle, modified high, high and very high path of economic growth for a 10 period time horizon with each period having five years. The first five year period corresponds to 1994-1998. The most likely scenario is the modified high growth.

Second, fiber availability to support domestic manufacture and consumption, and possible export of forest products is crucial in order to provide the raw material on which deeper processing and investment depends.

Third, capital must be attracted to the forest sector to replenish existing capital stock and add to the manufacturing capacity to meet rebounding domestic demand and seize export opportunities. Furthermore, capital must also be attracted to improve infrastructural development and to facilitate the transfer of forest products from regions rich in resources to those resource poor. Without capital, rising demand can only be met through import, often at prices significantly higher than those possible if the products were manufactured in Russia.

Demand: Following on general decline in economic activity in the first five year period, demand is presented according to a very high, high, modified high, medium, and low growth scenario. Shown in **Table 1**, future demand of forest products is very dependent on the likely trends in economic activity.

A very high growth scenario assumes that a successful transition has been completed and that Russia can sustain economic growth of 7.5 percent per year beginning in the second period. Consumption levels in 1989 are only re-attained in period 3 with levels attained earlier in Russia West than in Russia East. A high growth scenario assumes a growth rate of a more modest 5 percent, with return to pre-beak-up consumption levels correspondingly postponed. The modified high growth scenario assumes a 5 percent growth for the first five periods followed by a more modest increase of 2.5 percent for the last five periods with the pre-break-up consumption levels correspondingly postponed.

A low growth scenario is depicted through a rate of 1.25 percent with not one of the regions re-attaining pre-break-up consumption levels. A middle scenario assumes a growth rate of 2.5 percent. Levels of consumption in 1989 are only attained at the earliest in period 6 in Russia West. Preexisting consumption levels are not encountered within the 10 period time horizon employed in the analysis for the Russia East.

Assuming no changes in manufacturing capacity and fiber availability, the need to import forest products and the surplus available for export changes under the different expectations of growth. Evident from **Table 2**, both regions in Russia are net exporters in the first period while Russia West quickly becomes dependent on imported fiber beginning in the second period with the very high growth scenario, the period at which import takes place just being postponed for the other growth assumptions. Russia East, endowed with surplus harvesting capacity, available fiber and a low domestic demand, continues to be a net exporter until the third period for the very high and fourth period for the high growth scenarios at which times Russia East becomes a net importer as well as rising demand intersects with an inflexible boundary of capital constraints. Under low growth assumption, Russia East is a net exporter in period 10 even in the absence of additions to the manufacturing and harvesting capacities.

In total, European republics other than Russia are net exporters of fiber in the first period for all growth scenarios and it is only for the very high growth scenario that the European region needs to import beginning in the second period. However, by the fourth period except for the low growth scenario, all regions must import to meet rising demand. The Kazakhstan and the Central Asian republics of the FSU (Former Soviet Union) must continue to import forest products, and with distance separating them from the more fortunate European regions, must rely on imports from Russia to meet their rising needs.

While capital invested in manufacturing capacities can play an important role in meeting future demands, and in expanding the manufacturing capacity to meet domestic requirements and create export opportunities, it is the availability of the fiber supply which provides the limitations affecting the ability of the region to meet future demand and capitalize on the emerging export opportunities. Without the additions to the fiber base, additions of capital dedicated for manufacturing capacity can play a limited role in meeting future domestic demand and creating the surplus to seize export opportunities. Adopting a low growth scenario does not change the long-term outlook for supply and demand, only postpones it, though does create opportunities to capitalize on export opportunities as the differences between installed capacity and current demand take a longer time to narrow. Furthermore, in cases where roundwood exports exist, capital can be consumed by constructing manufacturing facilities to produce more deeply manufactured products from the currently exported roundwood.

Fiber availability: The fiber base can be expanded in four ways. First, with rising relative prices for forest products, the economic accessibility of the currently accessible resource can be expanded as hitherto uneconomic resource becomes profitable to harvest (Adams, D., personal communication, 1996). Second, additions of technology to utilize lower quality wood or wood of inferior species can expand the commercial fiber independent of the effect rising prices have in bringing forth additional supplies. Furthermore, advances in technology can decrease the quantity of raw material required per unit of output independent of the quality of wood fiber being employed. Third, there exists a forest resource which is presently located far from existing transportation infrastructure for which the forest sector cannot alone support its development. Bringing this resource into currently accessibility adds to the stock available for competing users. Fourth, the use of secondary fiber such as by-product wood chips and the recycling of waste paper can provide a vehicle through which fiber is then available for use within the domestic economy, for import substitution with appropriate additions of capital, or for export.

Table 3 shows the impact increasing domestic fiber supply has on the need to import or level of export, demonstrating the degree to which future demand can be met by fiber resident in the former USSR. There is sufficient raw material resources potentially available to meet the consumption levels evident with the high growth scenario up until the middle of the fourth period and the modified high growth scenario in the tenth period, though being unable to generate sufficient fiber to meet emerging demand between the fifth and ninth periods due to the lack of capital. By the tenth period due to development of the fiber reserves tied up in the potential resource, Russia once again is able to generate sufficient forest products to satisfy both internal domestic demand and possibly meet demands in the other regions belonging to the former USSR, though in doing so, there is a large demand on transportation services from east to west. Should growth continue at the very high scenario, fiber frontiers of the former USSR will be encountered much sooner and Russia will be unable to meet even its own domestic requirements.

It is the development of this potential, becoming available between period 5 and 8 which provides the base needed to meet the rising demands in the more populated regions, particularly Russia West and the European republics, although the urgency is dependent on the likely growth and concomitant demand. Central Asian Republics and Kazakhstan Republics of the FSU, faced with a small resource base relative to demand, must rely on imported products in large measure to meet projected demand levels, which by the fifth period account for between three fifths and nearly one hundred percent of total consumption in the modified high growth scenario. The share rapidly increases in the second 25 year period as additions in demand must be met by imports rather than utilization of new fiber sources. In the absence of fiber reserves materializing through increasing real prices for wood fiber, better forest management, improved utilization of the forest resource and higher utilization of post consumer paper and paperboard, the development of the resource tied up in the potential fiber flow looms significant in meeting future demand, and underscores the degree to which the transportational infrastructure must be relied upon to carry forest products from the timber surplus regions to those in a deficit position.

Capital: The capital requirements of the forest sector are enormous, not only to replenish the existing capital structure, but to add capacity to take advantage of export opportunities and meet future demand opportunities created by an expanding domestic economy. Shown in **Table 4**, even meeting the demands brought on by a modified high growth scenario, involving an increase in GDP of 5 percent per annum for the first 25 years followed by a more gradual increase of 2.5 percent requires enormous quantities of capital amounting to more than 30 billion U.S. dollars in the first five year period alone, most of which being required within Russia, primarily Russia West. By the fifth period between 13 and more than 60 billion dollars are needed rising to an astounding 103 billion dollars per five year period in the aggressive investment strategy. Rising fiber availability in Russia East attracts an increasing share of the capital so that by period 10, almost sixty percent of the funds required by Russia are being located there versus only one-third in period one. Even within the European republics, capital requirements are not small, rising from between 2 and 3 billion dollars in the first five year period to between 2 and 5 billion dollars in period 5. By the tenth period, capital requirements amount to more than 7 billion dollars within the five year interval of each period.

However, timing of capital investments do have an impact, creating imbalances which result in the need to import selective products until sufficient capital has been invested to utilize the rising fiber supply brought on by utilizing the different sources. Shown in **Table 5**, the level of exportable wood based material and the size of imports is directly linked to the investment strategy chosen. While an aggressive strategy linked to a maximum of a 50 percent increase in capacity of the previous period depends on the availability of fiber on which to act generates sufficient fiber resources to meet demand in Russia and in the other regions in each of the ten periods, a 25 percent strategy provides only enough fiber to meet Russia's domestic needs. While sufficient exportable material is available during the first half of the time horizon, insufficient capital to develop the additional fiber sources becoming available translates into an apparent gap in the non-Russian regions. In the low investment case, Russia East remains a marginal player exporting a small share of its overall production with demand in the non-Russian regions left unmet by Russia.

In regions such as the Central Asian region which lack a domestic resource on which to act, the different strategies to attract capital do not have a very large impact on the size of imports required while in European non-Russian Republics, which have in the initial periods, some surplus fiber potential, the different investment strategies can yield different results in the interim periods, though by the end of the time horizon, the needs to supplement domestic production to meet local demand are similar. This phenomenon is clearly evident when examining Russia West. The two highest strategies deliver similar results by the tenth period though the more aggressive strategy produces larger export volume and reduces the overall fiber requirements in the intervening periods. In Russia East, where large fiber reserves connected with the potential resource are located and which become available beginning in the fifth period, the capital can be fully employed developing this resource such that by the tenth period, exports are almost 50 percent higher in the case of the aggressive policy when compared to the next best alternative.

OBSERVATIONS AND POLICY IMPLICATIONS

Clearly markets do exist for Russian producers not only in Russia but in the non-Russian regions, with markets in the Central Asian region being more important at present than those in the European Republics which collectively are expected to be net exporters into the first decade of the twenty-first century. Rising domestic prices brought on by the convergence of demand and supply could well reward those willing to invest now in Russia. However, these opportunities will depend on a number of issues affecting the background environment of economic activity.

Rapid growth characterized by the very high and high growth scenarios is not an unlikely event particularly if the different republics are successful with political and economic restructuring of their societies though in the most likely scenario of modified high growth annual increases in economic activity are expected to decline in the second twenty-five year period. Meeting the demands placed on the forest resource by economies expanding at such rates though requires commitments on the part of governments to improve the efficiency of the capital system to handle and to attract the capital necessary to support forest sector development. While sufficient fiber reserves do exist to meet the demand characterized by the modified high growth assumption, it depends on a financial infrastructure which can support the massive transfers of capital and the domestic and international communities perceiving the political stability necessary for adopting a long-term horizon over which to benefit from such investments. Consequently, the perception of risk and the security of capital, must be addressed by the government if the private sector is to be called upon to participate in a major way in the reorganization of the Russian nation. Decreasing the international community's perception of risk will lower the premium demanded by domestic and international investors alike. Not only will the overall rates of return needed decline, but investors will not be looking for a quick repatriation of the invested capital to minimize a "windfall" loss within the labyrinths of Russian society. Higher growth characterized by the very high growth scenario would simply increase the urgency underlying the need to address the capabilities of the financial infrastructure while a lower growth scenario would simply postpone it and not eliminate it.

Long-term balance of supply and demand within Russia and within the regions belonging to the former USSR rests with the potential fiber supply principally located in Russia East in the absence of changing preferences for forest products consumption. The ability of the non-Russian regions to balance supply with projected demand in future periods is linked to developments in Russia, over which they have little if any control. Most of the surplus fiber reserves are located in Russia East, situated far from both Russia West, a deficit region beginning in period three through six depending on the success of the investment strategy in the modified high growth scenario, and far from the non-Russian European regions. Bringing from potential to current accessibility this resource depends on a strategy at the central level of government to not only promote extensive development of the frontier in Siberia but also the integration of east with west despite the distances and costs of transportation involved. Additionally, developing this potential may involve environmental costs which are at present not clearly understood. Furthermore, Russia East, located closer to the Pacific Rim than to markets in Russia West, or the other regions except for Central Asia and Kazakhstan, may see its future more closely linked to events taking place in the burgeoning Asian market. Meeting emerging demands in the European regions from resources situated in Russia East may require an active policy on the part of the Russian government to grant preferential tariffs for the transport of goods from the resource rich areas to the resource poor in the western reaches of the former USSR. However, placing future reliance on import of products which are directly linked to policy decisions at a governmental level exposes both final consumers and a manufacturing sector reliant on imported raw materials to the vagaries of a political system facing the need to ration its present financial resources and future commitments.

While demands in the non-Russian European regions can be met in principal by the domestic forest sector and that in Russia West well into the fourth period, alternatives will exist for Russia. Self-sufficient for the first two periods, the non-Russian European regions will not be attractive markets for producers in Russia who will be searching for markets elsewhere, developing producer-buyer relations which would need to be balanced against emerging market opportunities taking place into the second decade in the non-Russian European regions. There is no guarantee that the regions will indeed be able to compete for the available supply with other consumers located in Europe, the demand of forest products for which also being expected to increase over at least the next two decades with no near surplus supply outside of that in Russia appearing on the horizon. The urgency with which the non-Russian forest sectors look at developing future fiber supplies should be increasing.

Marginal increases in the productivity of the forest resources in the European region of Russia has been assumed to amount to only 10 percent of the maximum available in the first period. Higher increases in productivity of the Russian forests may in fact be possible with additions of capital and labor though the incremental increases should be examined more closely. Increasing the capability of the forest resources in Russia West and for that matter those of the non-Russian European regions can have two effects. It will create a reserve of raw material which can be utilized to support higher domestic consumption within the regions and possibly create the opportunities to service export markets which are likely to appear within the next quarter of century. Additionally, it can reduce the need to develop and bring to market in the west products supported by the potential fiber supply of Russia East thereby decreasing the risk to the environment and losses connected with transportation subsidies.

Accomplishing investments in the forest resource or even in infrastructural development though will be difficult under present circumstances. The European non-Russian Republics, and Russia West regions are expected to be net exporters for the next decade while financial resources from the public purse may be severely rationed. With a current surplus of fiber and budgetary woes, it will be difficult to prioritize available funding to support more intensive forest management in the absence of other supporting factors. Other supporting factors include work creating opportunities for presently the under employed or the non-employed of the forest sectors, or increasing the carbon sequestering potential of the forest resource through an active afforestation program designed to mitigate some of the impacts of global warming from increased industrial activity.

A successful transformation of the economy linked to a robust export market and an attractive environment for capital investment could well provide sufficient ingredients to not only meet rebounding domestic demand but also meet growing demand in the market regions beyond the boundaries of the former USSR for the next quarter of century. Furthermore, although the non-Russian republics face a shortage of forest resources relative to market demand, needing in the long-term to import from either Russia or elsewhere, additions of capital to the forest resource, improving manufacturing and harvesting technology, and increasing recycling of the paper and paperboard resource can substantially ease the burden placed on imports or the domestic resource, and reduce reliance on Russia as a potential source. Additionally, examining uses of forest products inside the domestic economies and finding alternate products more readily available may in the long-run provide another method by which reliance on imported forest products can be reduced.

By focusing now on these areas, as increasing demands are placed on the forest resource by both a resurgent domestic demand and a vibrant export market, Russia can benefit from increasing welfare through higher consumption levels and a higher standard of living due to export lead growth.

This paper is based on various studies carried out under the framework of the IIASA Study focusing on the forest industry and market cornerstone. These studies include:

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	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Table 1: Fiber demand in 1989 and average annual fiber demand for ten periods for five GDP growth assumptions (millions c.m. r.e.)**												
2													
3		1989	1994-98	1999-2003	2004-08	2009-13	2014-18	2019-23	2024-28	2029-33	2034-38	2039-43	
4													
5	RUSSIA WEST												
6	very high	162.0	80.1	111.9	201.3	324.8	447.9	558.3	697.5	865.2	1099.6	1428.0	
7	high	162.0	80.1	94.2	141.7	195.4	271.2	342.1	395.6	466.3	567.3	678.7	
8	modified high	162.0	80.1	94.2	141.7	195.4	271.2	328.1	354.9	381.0	411.0	446.8	
9	medium	162.0	80.1	80.1	99.2	116.5	137.2	161.8	191.3	226.5	264.2	294.4	
10	low	162.0	80.1	74.2	82.8	89.7	97.3	105.7	114.7	124.6	135.5	147.3	
11													
12	RUSSIA EAST												
13	very high	61.1	16.8	21.4	36.3	52.0	69.8	89.3	107.6	129.6	160.4	203.7	
14	high	61.1	16.8	18.5	26.6	35.9	48.8	61.5	73.9	86.4	99.7	114.4	
15	modified high	61.1	16.8	18.5	26.6	35.9	48.8	58.7	64.1	70.3	77.6	83.9	
16	medium	61.1	16.8	16.2	19.5	22.7	26.4	30.7	35.9	41.9	48.5	54.2	
17	low	61.1	16.8	15.2	16.7	18.0	19.4	21.0	22.6	24.4	26.4	28.5	
18													
19	RUSSIA												
20	very high	223.1	96.9	133.3	237.6	376.8	517.7	647.6	805.0	994.9	1260.0	1631.7	
21	high	223.1	96.9	112.8	168.4	231.3	320.0	403.6	469.5	552.7	667.0	793.2	
22	modified high	223.1	96.9	112.8	168.4	231.3	320.0	386.8	419.0	451.3	488.6	530.6	
23	medium	223.1	96.9	96.3	118.7	139.2	163.6	192.6	227.1	268.5	312.7	348.6	
24	low	223.1	96.9	89.4	99.5	107.8	116.8	126.6	137.3	149.0	161.8	175.8	
25													
26	Abbreviations and explanc	million - '000,000; c.m. - cubic meter; r.e. - roundwood equivalents											
27													
28	Notes: Very high growth scenario assumes increase in GDP of 7.5 percent beginning in the second period. High growth scenario assumes 5 percent, the medium growth assumes 2.5 perc												
29	growth assumes 1.25 percent. In the first period, increase (decrease) in GDP on 1993 levels has been assumed to be -2 percent in the Russian regions												
30													
31	Source: Backman (1996)												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Table 2: REGIONS - Trade in 1989 and annual net trade of forest products by period for different growth scenarios and only with replacement of existing capital (million c.m. r.e.)**												
2													
3		1989	1994-98	1999-2003	2004-08	2009-13	2014-18	2019-23	2024-28	2029-33	2034-38	2039-43	
4													
5	RUSSIA WEST												
6	very high	-52.8	-18.0	12.8	98.9	217.2	337.6	447.1	585.0	751.4	983.7	1309.2	
7	high	-52.8	-18.0	-4.4	41.4	92.8	165.3	232.1	285.2	355.3	455.3	565.9	
8	modified high	-52.8	-18.0	-4.4	41.4	92.8	165.3	218.7	244.8	270.7	300.4	335.9	
9	medium	-52.8	-18.0	-18.1	0.3	16.9	36.7	60.2	88.4	122.0	157.7	185.5	
10	low	-52.8	-18.0	-23.8	-15.6	-8.9	-1.6	6.3	15.0	24.5	34.8	46.2	
11													
12	RUSSIA EAST												
13	very high	-37.4	-26.2	-21.8	-7.3	7.8	25.0	44.3	62.4	84.3	114.8	157.7	
14	high	-37.4	-26.2	-24.5	-16.7	-7.7	4.7	16.8	29.0	41.5	54.7	69.2	
15	modified high	-37.4	-26.2	-24.5	-16.7	-7.7	4.7	14.2	19.3	25.5	32.7	38.9	
16	medium	-37.4	-26.2	-26.8	-23.6	-20.5	-16.9	-12.7	-7.8	-1.9	4.4	9.8	
17	low	-37.4	-26.2	-27.7	-26.3	-25.0	-23.7	-22.2	-20.6	-18.9	-17.0	-14.9	
18													
19	RUSSIA												
20	very high	-90.2	-44.3	-9.0	91.7	224.9	362.5	491.4	647.4	835.7	1098.6	1466.9	
21	high	-90.2	-44.3	-29.0	24.7	85.1	170.0	248.9	314.3	396.8	510.0	635.1	
22	modified high	-90.2	-44.3	-29.0	24.7	85.1	170.0	233.0	264.1	296.2	333.1	374.9	
23	medium	-90.2	-44.3	-44.9	-23.3	-3.6	19.7	47.5	80.6	120.1	162.0	195.3	
24	low	-90.2	-44.3	-51.6	-41.9	-33.9	-25.3	-15.8	-5.6	5.6	17.9	31.2	
25													
26	EUROPEAN NON-RUSSIAN REPUBLICS												
27	very high	34.2	-2.0	4.4	28.9	52.6	82.2	128.0	201.4	294.7	409.2	569.4	
28	high	34.2	-2.0	-0.9	11.0	22.2	34.2	48.5	67.6	93.4	128.6	175.4	
29	modified high	34.2	-2.0	-0.9	11.0	22.2	34.2	44.1	52.3	61.8	72.9	85.6	
30	medium	34.2	-2.0	-4.9	-0.3	3.4	7.9	12.5	17.1	22.6	28.5	34.6	
31	low	34.2	-2.0	-6.4	-4.3	-2.8	-1.2	0.5	2.4	4.5	6.6	8.5	
32													
33	CENTRAL ASIAN + KAZAKHSTAN												
34	very high	12.9	2.5	3.3	7.2	13.3	23.1	39.0	61.1	91.9	133.2	188.1	
35	high	12.9	2.5	2.6	4.7	7.3	11.3	16.5	23.6	33.9	45.9	60.4	
36	modified high	12.9	2.5	2.6	4.7	7.3	11.3	15.0	18.0	21.5	25.8	31.0	
37	medium	12.9	2.5	2.0	2.9	3.7	4.8	6.1	7.5	9.1	11.0	13.3	
38	low	12.9	2.5	1.8	2.2	2.5	2.9	3.4	3.8	4.4	4.9	5.6	
39													
40	Abbreviations and explar	million - '000,000; c.m. - cubic meter; r.e. - roundwood equivalents											
41													
42	Notes: Very high growth scenario assumes increase in GDP of 7.5 percent beginning in the second period. High growth scenario assumes 5 percent, the medium growth assumes 2.5 per												
43	growth assumes 1.25 percent. In the first period, increase (decrease) in GDP on 1993 levels has been assumed to be -2 percent in the Russian regions and -4 percent in all other region s												
44													
45	Source: Backman (1996)												

	A	B	C	D	E	F	G	H	I	J	K	L
1	**Table 3: REGIONS - Net annual trade of fiber for 1989 and for ten period for high and mod. high growth scenarios with all sources of fiber (millions c.m. r.e.)**											
2												
3		1989	1994-98	1999-2003	2004-08	2009-13	2014-18	2019-23	2024-28	2029-33	2034-38	2039-43
4												
5	RUSSIA WEST											
6	high gr. - base	-52.79	-18.03	-4.43	41.40	92.78	165.27	232.08	285.23	355.28	455.35	565.86
7	high gr. - all sources	-52.79	-18.03	-23.48	-1.11	21.26	57.85	82.29	79.89	105.32	174.03	267.04
8	mod. high gr. - all sourc	-52.79	-18.03	-23.48	-1.11	21.26	57.85	71.66	49.45	32.79	33.70	54.80
9	mod. high gr. - excl. pc	-52.79	-18.03	-23.48	-1.11	21.26	57.85	71.66	58.24	73.40	90.75	111.85
10												
11	RUSSIA EAST											
12	high gr. - base	-37.37	-26.23	-24.54	-16.68	-7.68	4.72	16.82	29.03	41.47	54.67	69.25
13	high gr. - all sources	-37.37	-26.23	-32.76	-34.79	-37.71	-39.74	-44.66	-53.71	-66.35	-82.43	-102.76
14	mod. high gr. - all sourc	-37.37	-26.23	-32.76	-34.79	-37.71	-39.74	-47.01	-61.88	-79.76	-101.25	-129.26
15	mod. high gr. - excl. pc	-37.37	-26.23	-32.76	-34.79	-37.71	-39.74	-47.01	-61.88	-68.07	-63.60	-60.43
16												
17	RUSSIA											
18	high gr. - base	-90.16	-44.25	-28.97	24.72	85.09	170.00	248.90	314.26	396.76	510.02	635.11
19	high gr. - all sources	-90.16	-44.25	-56.24	-35.90	-16.45	18.11	37.63	26.17	38.97	91.61	164.28
20	mod. high gr. - all sourc	-90.16	-44.25	-56.24	-35.90	-16.45	18.11	24.65	-12.43	-46.97	-67.55	-74.46
21	mod. high gr. - excl. pc	-90.16	-44.25	-56.24	-35.90	-16.45	18.11	24.65	-3.64	5.33	27.15	51.43
22												
23	EUROPEAN NON-RUSSIAN REPUBLICS											
24	high gr. - base	34.23	-1.98	-0.94	11.00	22.16	34.22	48.45	67.61	93.42	128.57	175.40
25	high gr. - all sources	34.23	-1.98	-2.63	6.10	13.82	21.83	31.47	48.58	72.18	104.81	148.54
26	mod. high gr. - all sourc	34.23	-1.98	-2.63	6.10	13.82	21.83	27.12	33.26	40.74	49.32	59.17
27	mod. high gr. - excl. pc	34.23	-1.98	-2.63	6.10	13.82	21.83	27.19	33.38	40.91	49.52	59.39
28												
29	CENTRAL ASIAN + KAZAKHSTAN											
30	high gr. - base	12.93	2.53	2.59	4.67	7.35	11.26	16.55	23.63	33.85	45.94	60.40
31	high gr. - all sources	12.93	2.53	2.55	4.40	6.78	10.39	15.22	21.80	31.63	43.27	57.43
32	mod. high gr. - all sourc	12.93	2.53	2.55	4.40	6.78	10.39	13.66	16.13	19.31	23.16	28.05
33	mod. high gr. - excl. pc	12.93	2.53	2.55	4.40	6.78	10.39	13.66	16.38	19.74	23.80	28.69
34												
35	Abbreviations and explar	million - '000,000; c.m. - cubic meter; r.e. - roundwood equivalents; gr. - growth; excl. - excluding; pot. - potential forest resource										
36												
37	Source: Backman (1996)											

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Table 4: REGIONS - Capital requirements in each five year period for mod. high growth scenario, all fiber sources, and different investment strategies (millions US $)**												
2													
3		1989	1994-98	1999-2003	2004-08	2009-13	2014-18	2019-23	2024-28	2029-33	2034-38	2039-43	
4													
5	RUSSIA WEST												
6	Mod. high - base	N/A	8,862	8,862	8,862	8,862	8,862	8,862	8,862	8,862	8,862	8,862	
7	investment - 10	N/A	11,059	11,969	12,713	13,671	14,690	15,820	17,009	18,457	19,922	21,504	
8	investment - 25	N/A	14,338	17,274	20,839	24,798	29,744	35,682	40,347	44,055	45,850	50,943	
9	investment - 50	N/A	18,872	25,555	30,609	32,734	35,677	38,757	39,804	43,822	42,577	44,441	
10													
11	RUSSIA EAST												
12	Mod. high - base	N/A	4,634	4,634	4,634	4,634	4,634	4,634	4,634	4,634	4,634	4,634	
13	investment - 10	N/A	5,750	6,220	6,729	7,280	7,818	8,439	9,111	9,404	10,030	11,043	
14	investment - 25	N/A	7,423	8,946	10,783	12,999	15,671	18,895	22,785	27,477	33,140	39,974	
15	investment - 50	N/A	10,212	14,417	19,809	21,951	27,941	35,194	40,544	49,838	50,313	58,757	
16													
17	RUSSIA												
18	Mod. high - base	N/A	13,496	13,496	13,496	13,496	13,496	13,496	13,496	13,496	13,496	13,496	
19	investment - 10	N/A	16,809	18,190	19,442	20,951	22,508	24,259	26,121	27,861	29,952	32,547	
20	investment - 25	N/A	21,761	26,220	31,622	37,797	45,415	54,577	63,131	71,533	78,990	90,917	
21	investment - 50	N/A	29,085	39,972	50,418	54,685	63,617	73,951	80,349	93,661	92,890	103,198	
22													
23	EUROPEAN NON-RUSSIAN REPUBLICS												
24	Mod. high - base	N/A	2,229	2,288	2,288	2,288	2,288	2,288	2,288	2,288	2,288	2,288	
25	investment - 10	N/A	2,479	2,663	2,779	3,009	3,246	3,533	3,709	3,836	4,054	4,286	
26	investment - 25	N/A	2,732	3,134	3,501	4,165	4,784	5,029	5,392	5,959	6,628	7,440	
27	investment - 50	N/A	3,103	3,746	4,052	4,960	5,355	5,784	5,810	6,239	6,749	7,346	
28													
29	CENTRAL ASIAN + KAZAKHSTAN												
30	Mod. high - base	N/A	283	283	283	283	283	283	283	283	283	283	
31	investment - 10	N/A	289	296	302	335	350	367	385	404	425	448	
32	investment - 25	N/A	296	316	334	412	474	542	624	717	774	877	
33	investment - 50	N/A	308	342	381	487	550	640	659	736	768	843	
34													
35	Abbreviations and explar	N/A - not available; million - '000,000; investment - 10 - sufficient capital available to support up to a 10 percent increase in average capacity of the previous											
36	It does not mean that the total capital available is utilized. It means that at most the pool of capital represented by a 10 percent increase in capacity can be used.												
37													
38	Source: Backman (1996)												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Table 5: REGIONS - Distribution of annual net exports for modified high growth scenario and all sources of fiber for different investment strategies (million c.m. r.e.)**												
2													
3		1989	1994-98	1999-2003	2004-08	2009-13	2014-18	2019-23	2024-28	2029-33	2034-38	2039-43	
4													
5	RUSSIA WEST												
6	Mod. high - base	-53	-18	-5	39	87	162	218	245	271	300	336	
7	investment - 10	-53	-18	-13	24	63	123	169	183	196	211	232	
8	investment - 25	-53	-18	-23	-1	21	58	72	49	33	34	55	
9	investment - 50	-53	-18	-42	-37	-16	22	29	33	33	34	55	
10													
11	RUSSIA EAST												
12	Mod. high - base	-37	-26	-25	-17	-8	4	14	19	25	33	39	
13	investment - 10	-37	-26	-28	-24	-19	-11	-6	-6	-5	-3	-3	
14	investment - 25	-37	-26	-33	-35	-38	-40	-47	-62	-80	-101	-129	
15	investment - 50	-37	-26	-41	-56	-72	-72	-101	-127	-155	-185	-181	
16													
17	RUSSIA												
18	Mod. high - base	-90	-44	-30	22	78	165	232	264	296	333	375	
19	investment - 10	-90	-44	-40	0	44	112	163	177	191	208	228	
20	investment - 25	-90	-44	-56	-36	-16	18	25	-12	-47	-68	-74	
21	investment - 50	-90	-44	-83	-93	-87	-49	-72	-95	-122	-151	-127	
22													
23	EUROPEAN												
24	Mod. high - base	34	-2	-1	11	22	34	44	52	62	73	85	
25	investment - 10	34	-2	-2	8	17	27	35	41	49	58	69	
26	investment - 25	34	-2	-3	6	14	22	27	33	41	49	59	
27	investment - 50	34	-2	-3	6	13	21	25	31	39	48	58	
28													
29	CENTRAL ASIAN												
30	Mod. high - base	13	3	3	5	7	11	15	18	22	26	31	
31	investment - 10	13	3	3	5	7	11	15	17	21	25	30	
32	investment - 25	13	3	3	4	7	10	14	16	19	23	28	
33	investment - 50	13	3	3	4	7	10	13	16	19	23	28	
34													
35	Abbreviations and explar	N/A - not available; million - '000,000; c.m. - cubic meter; r.e. - roundwood equivalents; investment - 10 - sufficient capital available to support up to a 10 perce											
36	increase in average capacity of the previous period. It does not mean that the total capital available is utilized. It means that at most the pool of capital represented by a 10 percent i												
37	can be used.												
38													
39	Source: Backman (1996)												

Figure 1a: Russian stocked forest land

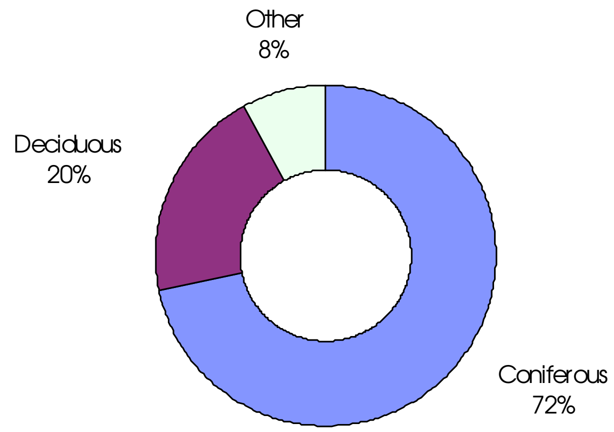


Figure 1b: Russian growing stock

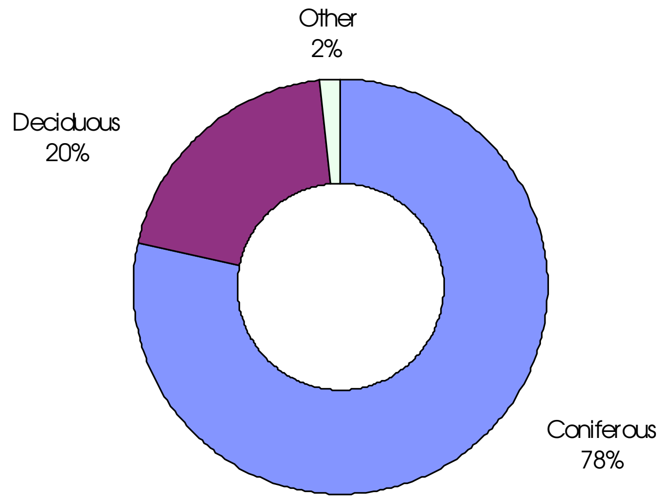


Figure 2: Estimated annual growth of Russia forests

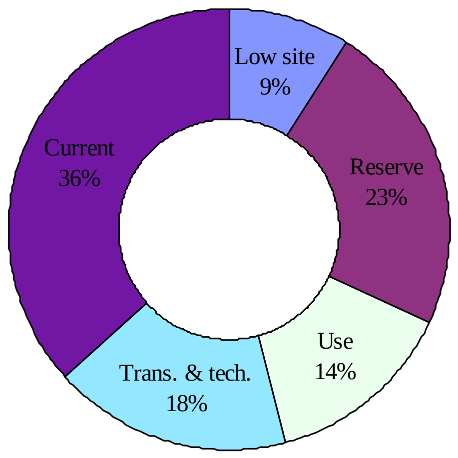


Figure 3: Estimated maximum annual fiber supply in Russia

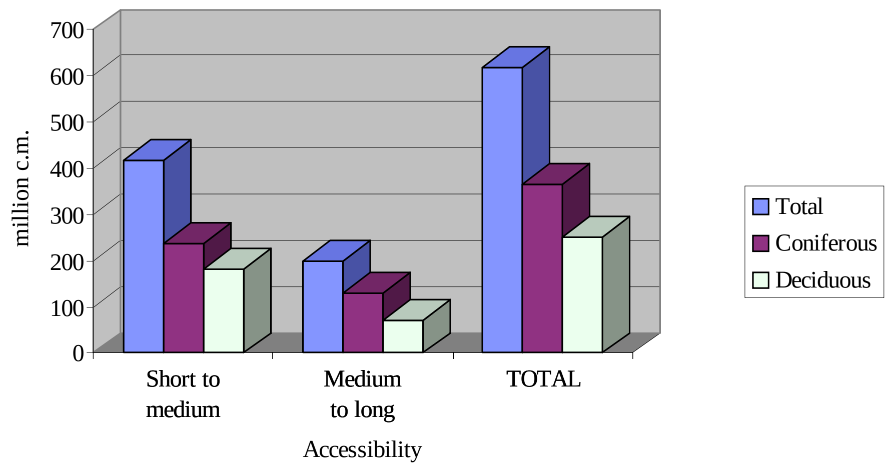


Figure 4: Maximum annual fiber available from Russian forests

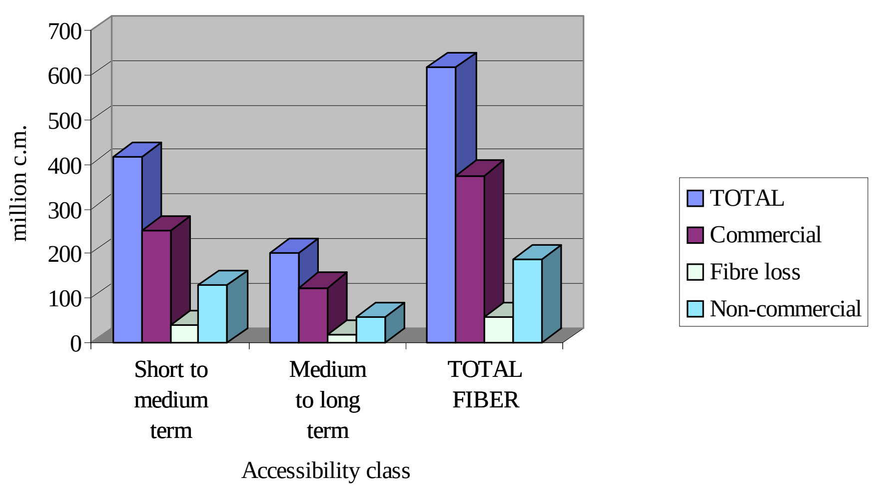


Figure 5: Russian estimated annual fiber supply and estimated economic harvest

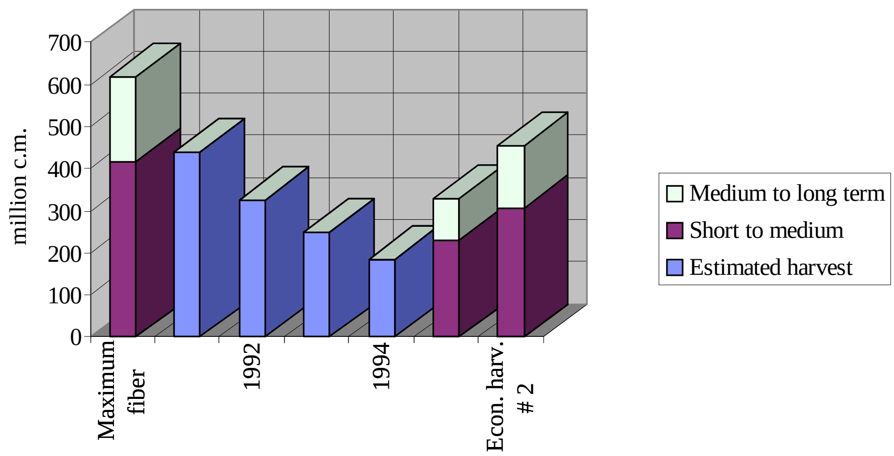


Figure 6a: Production of roundwood, lumber and panels in 1989 in Russia

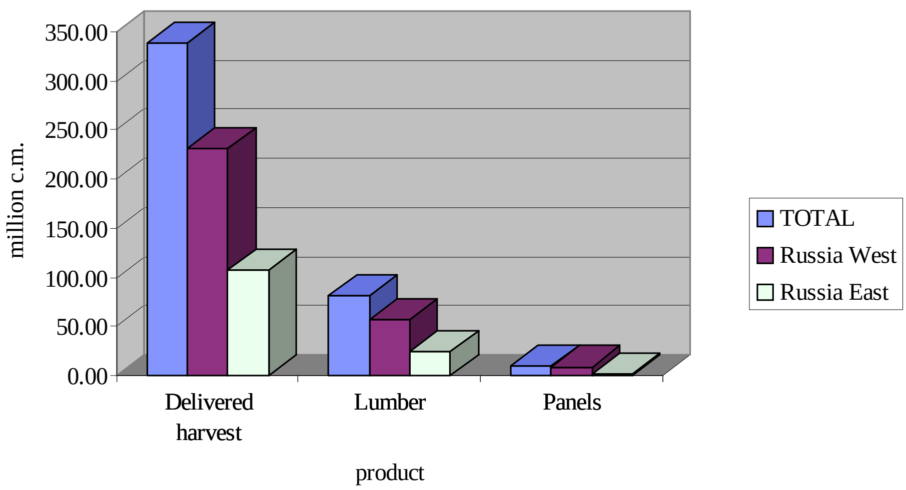


Figure 6.b: Production of pulp and paper/paperboard in Russia in 1989

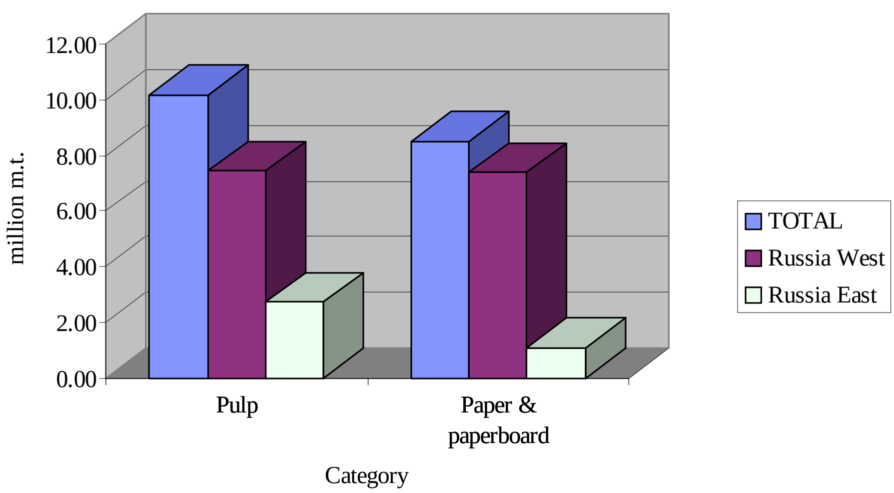


Figure 7.a: Decline in production in Russia West

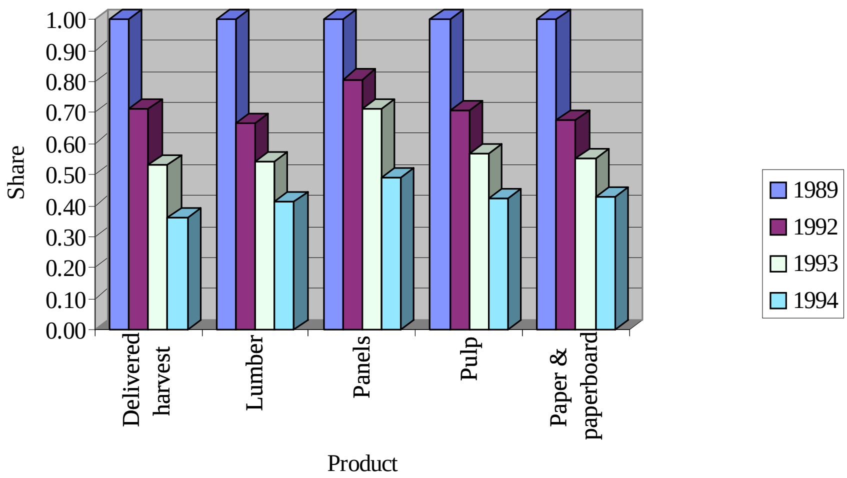


Figure 7.b: Decline in production in Russia East

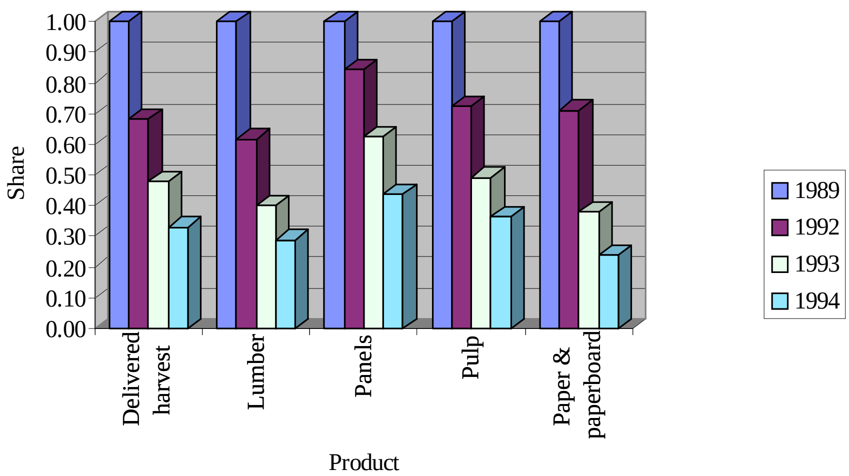


Figure 8: Commercial fiber supply and net export

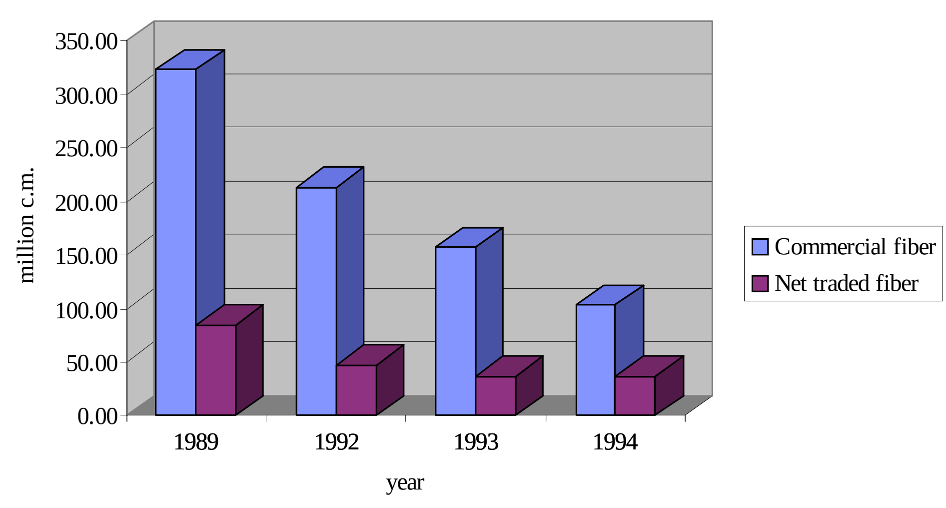


Figure 9: Declining consumption of major forest products in Russia (1989=1.00)

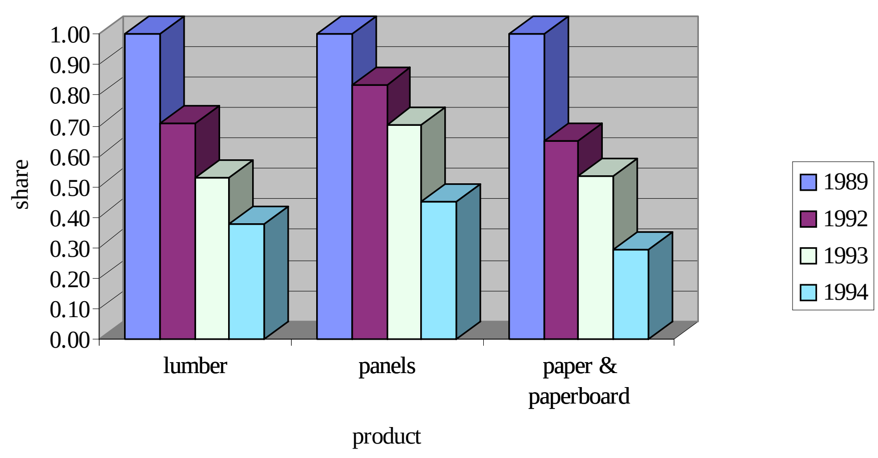


Figure 10: Forest sector activity and employment (1990=1.00)

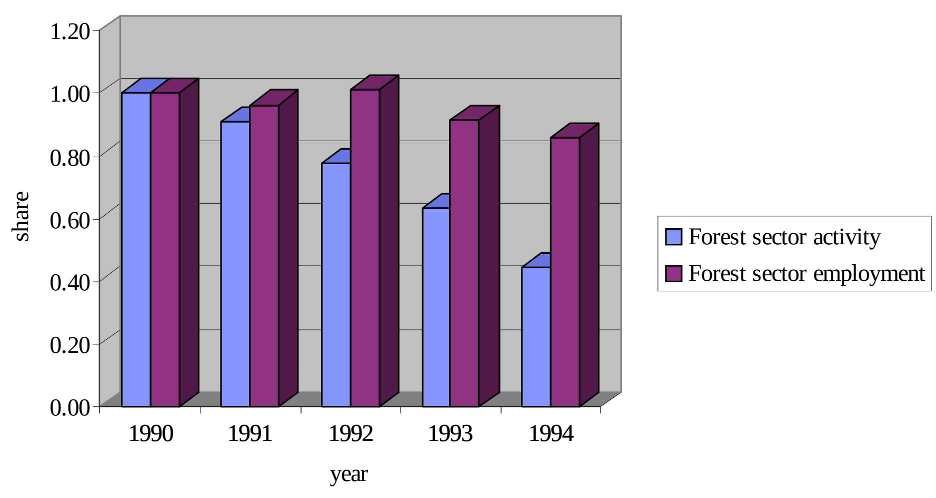


Figure 11: Estimated unemployment in the forest sector in 1994

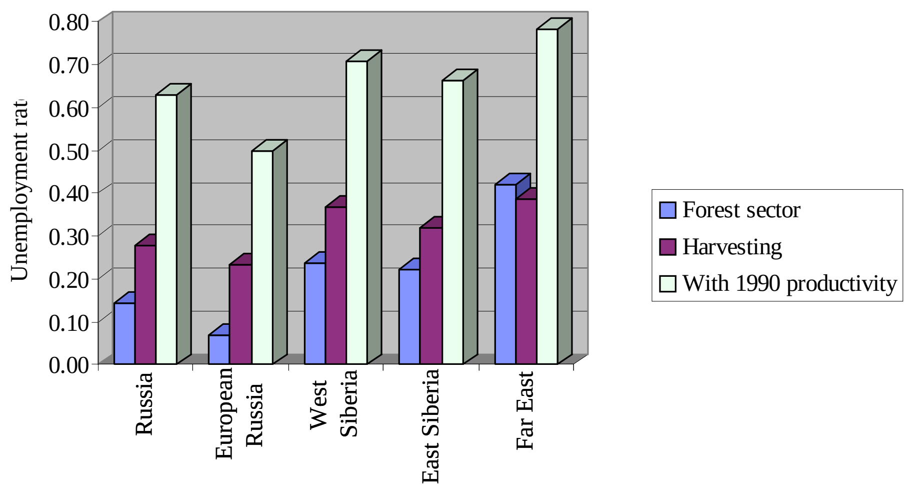
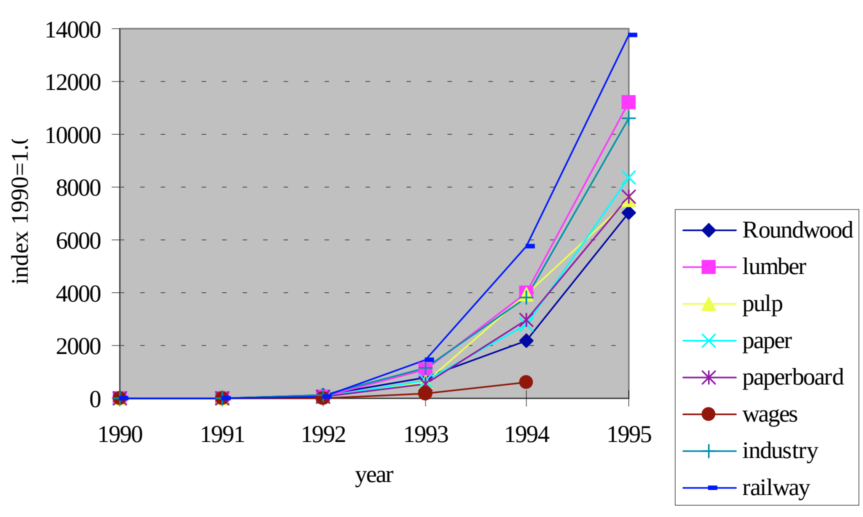


Figure 12: Relative changes in prices



3.8. Socioeconomic Development and the Russian Forest Sector

Jan Granåsen, Umeå University, Sweden; Sten Nilsson, International Institute for Applied Systems Analysis, Laxenburg, Austria; and Andreas Wörgötter, Institute for Advanced Studies, Vienna, Austria

Background

Industrial production has fallen rapidly by 50% during the ongoing transition in Russia. During the same period, prices have increased by a factor of over 30,000%. This has resulted in substantial stratification across the regions and industries and also a significant social strain for the society. In this paper our objective is to illustrate some of the socioeconomic developments which have occurred during the transition.

Relocation of the Russian Industry 1987-1993

A data set that breaks down the total industrial production in Russia into 12 industrial groups for each of the 79 regions of the Russian Federation (based on the socioeconomic database of the IIASA Study) has been studied. As a result, it has been possible to document the complete regional-industrial structure of the Russian economy from 1987-1993.

In the analyses three major hypothesis have been tested:

- that the former location of industrial production was inefficient, that production did not take place in those regions where returns would be highest, and that industry was overly localized, meaning more concentrated in particular regions of the former USSR than is optimal;
- that the transition itself changes the “optimal location” of the industry in the former centrally planned economies;
- that as industries concentrate in a single region it may become a source of increasing returns to scale due to a) the local labor pool acquires industry specific skills b) industry specific services may be provided in these regions c) the concentrated localization provides informational advantages.

Changes in the Regional Composition of Output

From the analyses three groups of industries can be identified: fast relocating (fast changes in regional composition of output), medium relocating, and slow relocating industries.

Power, Non Ferrous Metallurgy, Machinery, Chemicals and Fluor industries have had a rapid relocation process. Machinery, Chemicals and Power production were high priority sectors in the centrally planned system. The slow relocating industries are Food, Light industries, Forestry, Fuel, and Ferrous Metallurgy showing that resource dependent industries have undergone less relocation.

Diversification or Concentration

The conclusion from the analyses is that industries which are highly dependent on the availability of natural resources are heavily localized in Russia, while industries that either produce reliquitos inputs, such as the electric power industry, machinery and construction materials, or are more consumer oriented, such as food and fluor, are more evenly distributed across the regions. One startling feature is a general trend to concentrate rather than diversify. This trend seems to have gained momentum after 1990. Large producers seem to have lost less in the industrial production than small producers. Thus, the large producers have significantly increased their share of total production.

Changes in Regional Composition of Output and Concentration Characteristics

It can be concluded that rapidly relocating industries tend towards a more concentrated production. Changes in relative capital productivity have been significantly more rapid than changes in relative labor productivity. This is probably a result of legal restrictions on reducing the work force in firms.

Productivity changes across regions seem to be much more important in Russia than are changes in location of production. It is within region restructuring rather than relocation that major steps have been taken in order to increase the efficiency of the Russian industry. The efficiency gains are a result of changes in capital productivity rather than in increased labor productivity. It can also be concluded that high labor productivity regions are also high capital productivity regions.

Conclusions

From the analyses of total industrial production of the Russian industry during the transition period 1987-1993 the following can be concluded:

- Changes in the geographical composition of industrial output lack a clear sectoral pattern. But resource dependent industries have been slowly relocating;

- Changes in the geographical composition of output are typically associated with an increase in geographical concentration. Large producers have thus increased their share of the total output;

- Relative productivity has changed more rapidly across regions than the regional composition of output;

- Large producers have managed to increase their productivity more than small ones.

Relocation of the Forest Industry

The share of Forestry, Wood Processing and the Pulp and Paper industry in the country's industrial output, with the exception of 1991, has been declining since 1987. Its 1987 share was 5.62% (7th position) and in 1993 it was 4.76% (9th position) of the total industrial output.

The rating of the 10 leading contributors to the branch was rather stable, probably due to its resource dependency, which is illustrated in Table 1a-1b. The top ten Forestry, Wood Processing and Pulp and Paper industries produced 44% of the branch production in 1987 and 52% in 1993.

Table 1a. Top ten regions regarding Output of Forestry, Wood Processing and Paper Pulp Industry in 1987.

Position	Region Name	Share of total output in Rubles
1	Irkutsk Reg.	8.36
2	Arkhangelsk Reg.	6.77
3	Krasnyarsk Territory	5.15
4	Perm Reg.	4.52
5	Sverdlovsk Reg.	4.03
6	Komi Republic	3.87
7	Republic of Karelia	3.61
8	Leningrad Reg.	2.95
9	Moscow Reg.	2.93
10	Nizhny Novgorod Reg.	2.76

Table 1b. Top ten regions regarding the Output of Forestry, Wood Processing and Paper Pulp Industry in 1993.

Position	Region Name	Share of total output in Rubles
1	Irkutsk Reg.	9.24
2	Arkhangelsk Reg.	7.54
3	Republic of Karelia	4.90
4	Krasnoyarsk Territory	4.33
5	Perm Reg.	4.24
6	Komi Republic	4.19
7	Moscow	3.85
8	Moscow Reg.	3.58
9	Sverdlovsk Reg.	3.18
10	Leningrad Reg.	2.87

Changes in the regional composition of the output from the forest industry can be identified during the transition period. This is illustrated in Table 2.

Table 2. Share of physical production within the Russian forest industry. In percentage.

	Total	European Russia	West Siberia	East Siberia	Far East
Delivered Harvest					
1989	100	58	10	22	10
1992	100	59	10	22	9
1993	100	61	9	21	9
1994	100	62	8	21	9
Lumber					
1989	100	59	11	23	8
1992	100	61	11	23	6
1993	100	65	11	20	5
1994	100	67	10	19	4
Paper and Paper board					
1989	100	86	1	7	6
1992	100	85	1	8	5
1993	100	90	1	7	3
1994	100	92	1	7	1

From Table 2 it can be seen that European Russia has gained production shares during the transition period at Siberia's expense. The changes can be an effect of the market forces, namely that the biggest markets are in European Russia and that the increased transportation costs in Siberia have increased the production costs and decreased the competitive position of the industry in Siberia. A somewhat surprising development is the strong decline of production in the Far East, which is closely located to the high-paying Pacific Rim markets.

Social Restructuring of Russian Enterprises

The firm was a central institution in the USSR society providing employment, producing goods and services, and also offering a large variety of social assets to be used by employees and often by the local population. The transition to a market economy has fundamentally changed the role of firms in this latter respect. The transition has forced firms to be much more economically efficient, forcing them to substantially downsize social functions.

The following analyses are based on data collected in Russia at the end of 1995. In total 97 firms of industrial enterprises were visited and the social assets of each enterprise between 1989-1995 were investigated.

The changes of a number of social establishments during the period 1989-1995 are presented in Tables 3a-3b.

Table 3a. Total number of social establishments: European part of Russia (43 enterprises).

Establishments	1989	1990	1991	1992	1993	1994	1995	Percent change 1989-1995
1.Kindergarten/crèches	58	58	57	48	39	32	28	-52
2.Dormitories	40	39	39	36	37	37	36	-10
3.Apartment blocks	530	533	522	528	491	440	443	-16
4.Medical & recreation establishments	62	64	60	60	55	57	56	-10
5.Vacation & Holiday Establishments	17	17	15	14	12	11	11	-35
6.Sports establishments	15	15	11	10	9	9	9	-40
7.Catering establishments	89	89	88	106	85	85	86	-3
8.Cultural & educational establishments	21	21	20	17	15	14	14	-33
9.Subsidiary agricultural farms	12	12	14	12	11	12	14	+17
10.Other social establishments	21	21	20	20	20	18	20	-5

Table 3b. Total number of social establishments: Siberian part of Russia (44 enterprises).

Establishments	1989	1990	1991	1992	1993	1994	1995	Percent change 1989-1995
1.Kindergarten/crèches	191	191	185	164	127	80	56	-71
2.Dormitories	93	93	93	93	90	85	84	-10
3.Apartment blocks	1115	1126	1134	1137	1106	951	912	-18
4.Medical & recreation establishments	100	99	99	106	86	82	78	-22
5.Vacation & Holiday Establishments	41	41	40	41	40	39	40	-2
6.Sports establishments	30	30	30	30	31	27	27	-10
7.Catering establishments	151	150	146	142	120	106	99	-34
8.Cultural & educational establishments	39	39	39	38	38	38	34	-13
9.Subsidiary agricultural farms	21	22	22	19	15	12	11	-48
10.Other social establishments	12	12	15	16	18	19	21	+75

It can be seen that there are substantial reductions in a number of social establishments during the transition period. There also seems to be regional differences in the changes and to some extent more changes in Siberia. It can be concluded that the firms are trying to shed all types of traditional social establishments, but on the other hand some firms have already started to provide new social services (see other social establishments in Tables 3a-3b). The most dramatic decline of social establishments has taken place in the very large firms.

The reasons given for restructuring of the social assets are deteriorating financial conditions of the firms, reduced state subsidies, and high interest rates on bank credits.

The changing situation with respect to social establishments still continues and it is difficult to estimate how this transition will evolve.

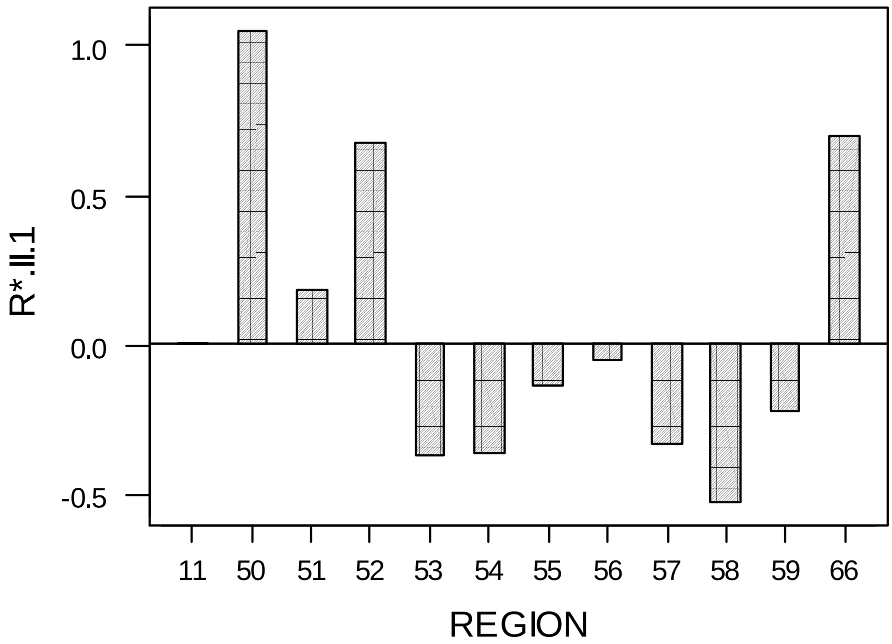
Employment

By 1994, employment in the industry in Russia had decreased by 20% from the employment level in 1990 (a 4.6 million decrease). The direct employment in the forest sector decreased from 2.0 to 1.8 million during the same period (or a decrease by 25%).

During this period, the decline was constituted by 70% in forestry, 20% in woodworking industry, and 10% in the pulp and paper industry.

Based on the detailed socioeconomic database of the IIASA Study, the relative registered unemployment (total unemployment) at a regional level can be studied for the period 1987-1993. From Figure 1, it can be seen that for 1993 there are rather large differences in the registered unemployment. It indicates that the more rural the area, the less registered unemployment. This could be because people in these regions are less inclined to register for unemployment.

Figure 1. Registered unemployment per 1,000 inhabitants for 1993.



REGION

11 Russian Federation	54 Pre-Volgian
66 North	55 North-Caucasus
50 North-West	56 Ural
51 Central	57 West Siberia
52 Volgo-Vyatka	58 East Siberia
53 Central Chernozem	59 Far East

While the number of employees which depend indirectly on activities in the forest sector for their livelihood is uncertain, it is likely that up to 6 million employees (12 million including dependents), almost 10 percent of the work force and total population of Russia, are indirectly supported by activities in the forest sector.

Although employment in the forest sector has fallen, it has not fallen as steeply as the physical output.

Demographic Development

Based on detailed data for the period 1987-1993 (the socioeconomic database of the IIASA Study) some key parameters with respect to the demographic development have been studied.

Birth Rates
Birth rates are not a real measurement of fertility, but are an important factor in judging the development of the population. The figures for birth rates (entire Russian Federation) have decreased yearly from 1987-1993. There was almost a 50% decrease during this period, which is dramatic with respect to the short time span (Figure 2). This pattern is the same over the entire Federation, but the levels and speed to which it occurs differ for different oblasts.

Death Rates
Death rates for the entire Federation have increased every year from 1987-1993. This increase has not been as fast as the decline in birth rates, but reached nearly 40%, which is dramatic considering the time frame (Figure 3). This pattern is the same over the entire Federation, with a strong increase in death rates.

Natural Growth Rates
Natural growth rate is the difference between birth and death rates. The two negative trends identified earlier strengthen each other in this measure. At the federal level, there was a positive natural growth in 1987, which declined to a level of zero in 1991 and to a negative level after that year (Figure 4).

Life Expectancy
Normally life expectancy moves very slowly from year to year. In this case, however, there has been a very dramatic decline in the life expectancy during a very short period of time (Figure 5).

Total Population Change
The development of the population at the federal level and for economic regions during the studied period is presented in Figure 6. Most remarkable is the trend break around 1991 from an increasing to a decreasing population. In spite of a net migration of some 600,000 people into the federation, the total population decreased substantially during the last two years of the studied period. Only one economic region (Kaliningrad) had growth in the population throughout the studied period. This can be explained by a net migration.

In the presentation above we have only presented the results at an aggregated level. In the basic analyses the results are also available at the oblast level.

Figure 2.

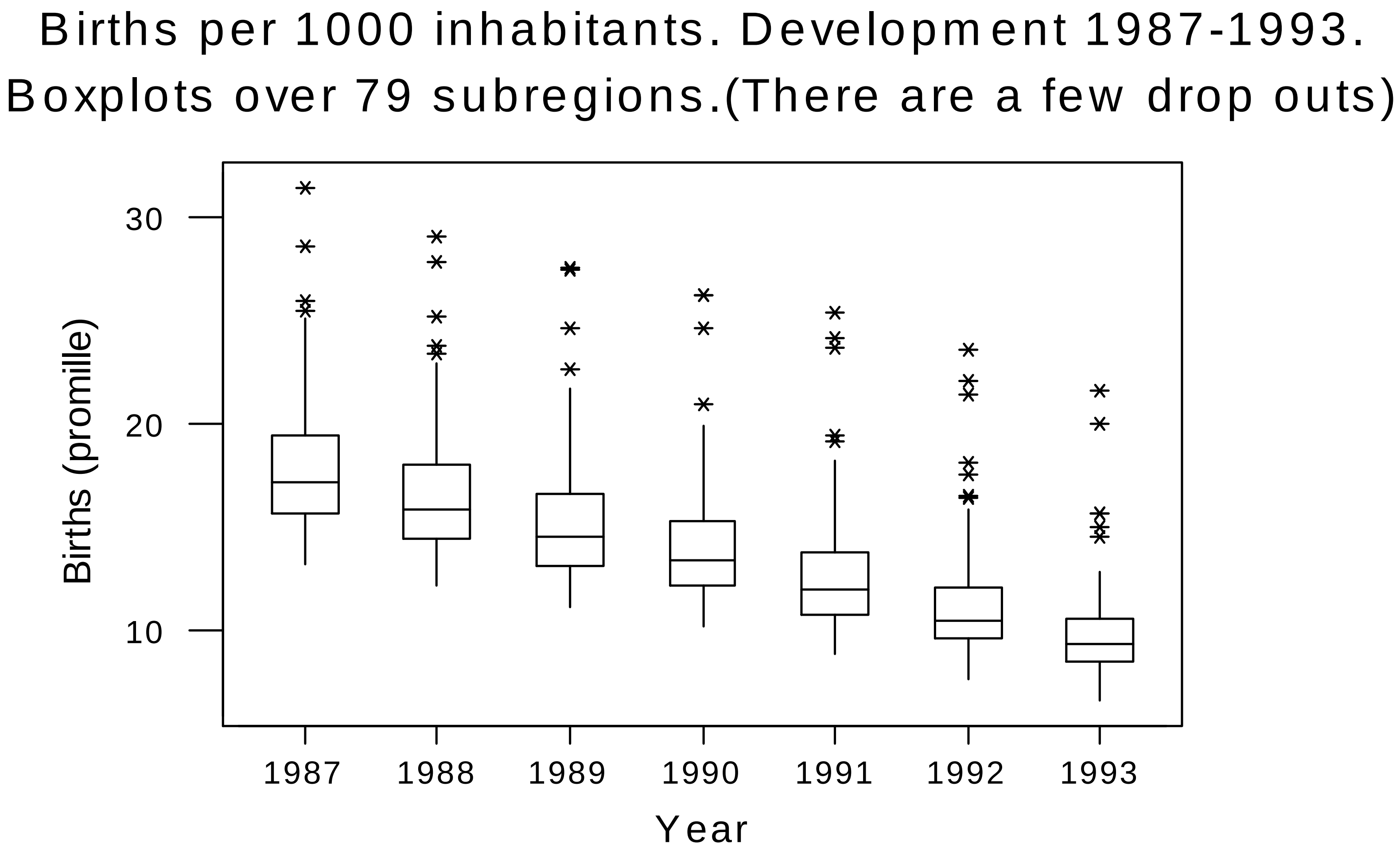

Births per 1000 inhabitants. Development 1987-1993.
Boxplots over 79 subregions.(There are a few drop outs)
Births (promille)
30
20
10
1987
1988
1989
1990
1991
1992
1993
Year

Figure 3.

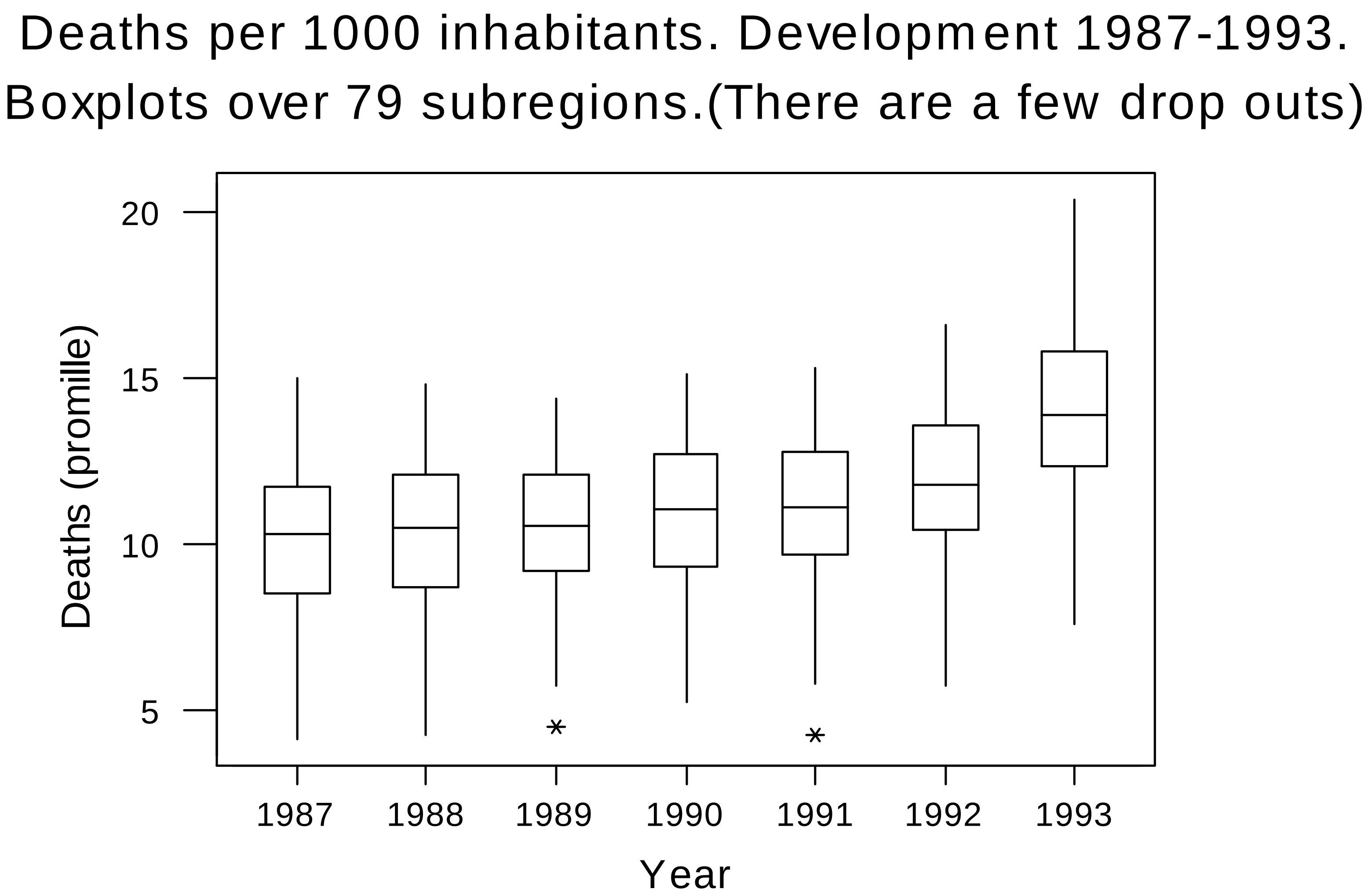

Deaths per 1000 inhabitants. Development 1987-1993.
Boxplots over 79 subregions.(There are a few drop outs)
Deaths (promille)
20
15
10
5
1987
1988
1989
1990
1991
1992
1993
Year

Figure 4.

Natural growth per 1000 inhabitants. Development 1987-1993.
Boxplots over 79 subregions.(There are a few drop outs)

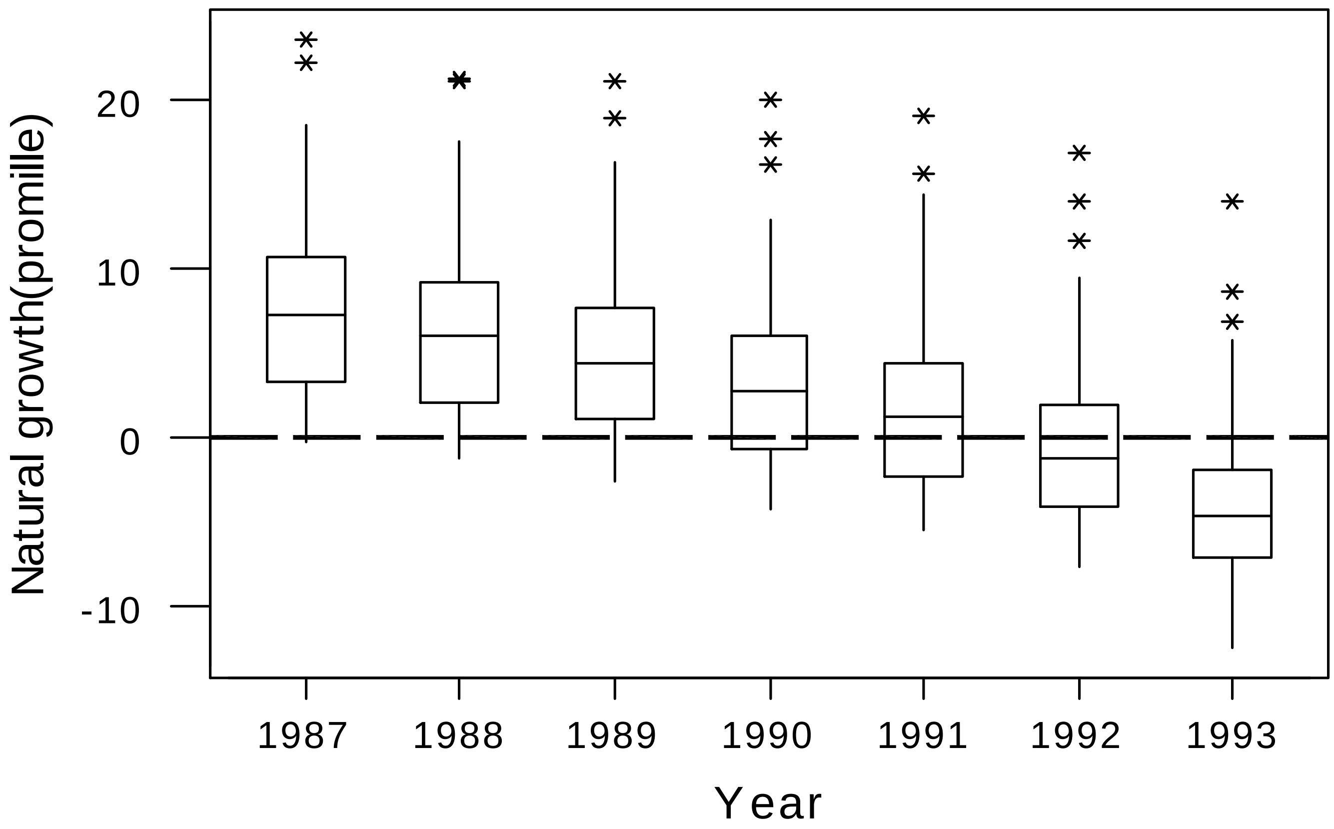
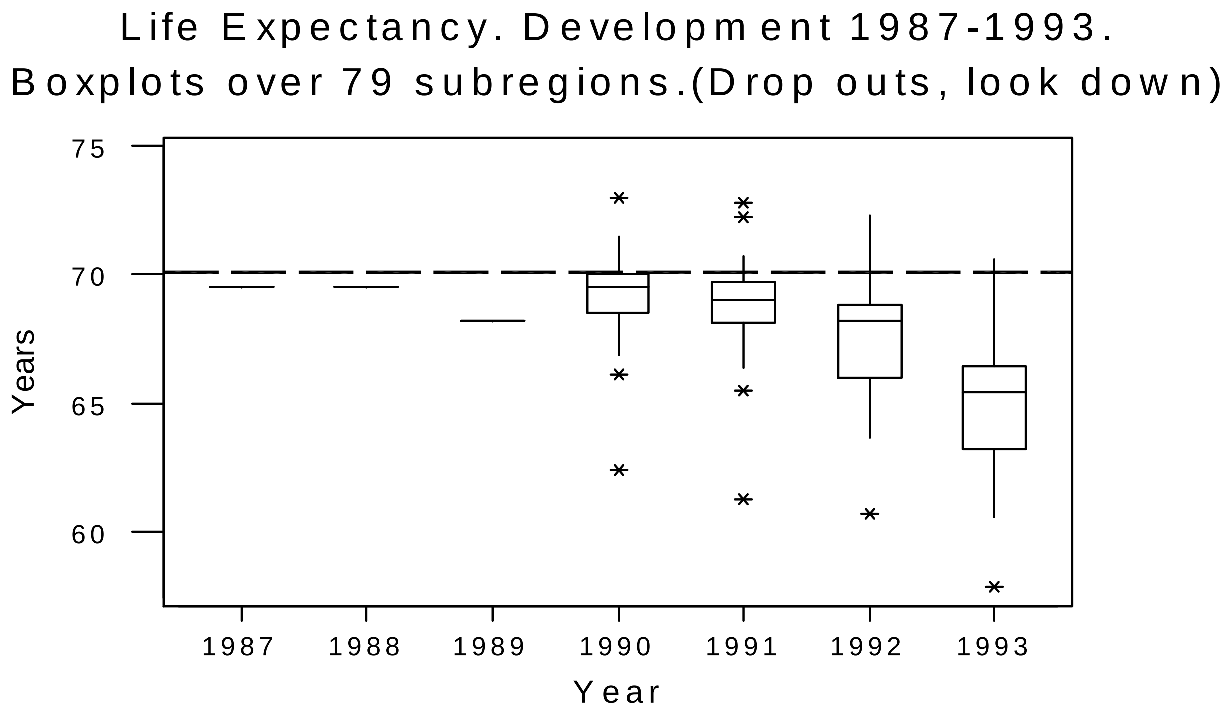


Figure 5.

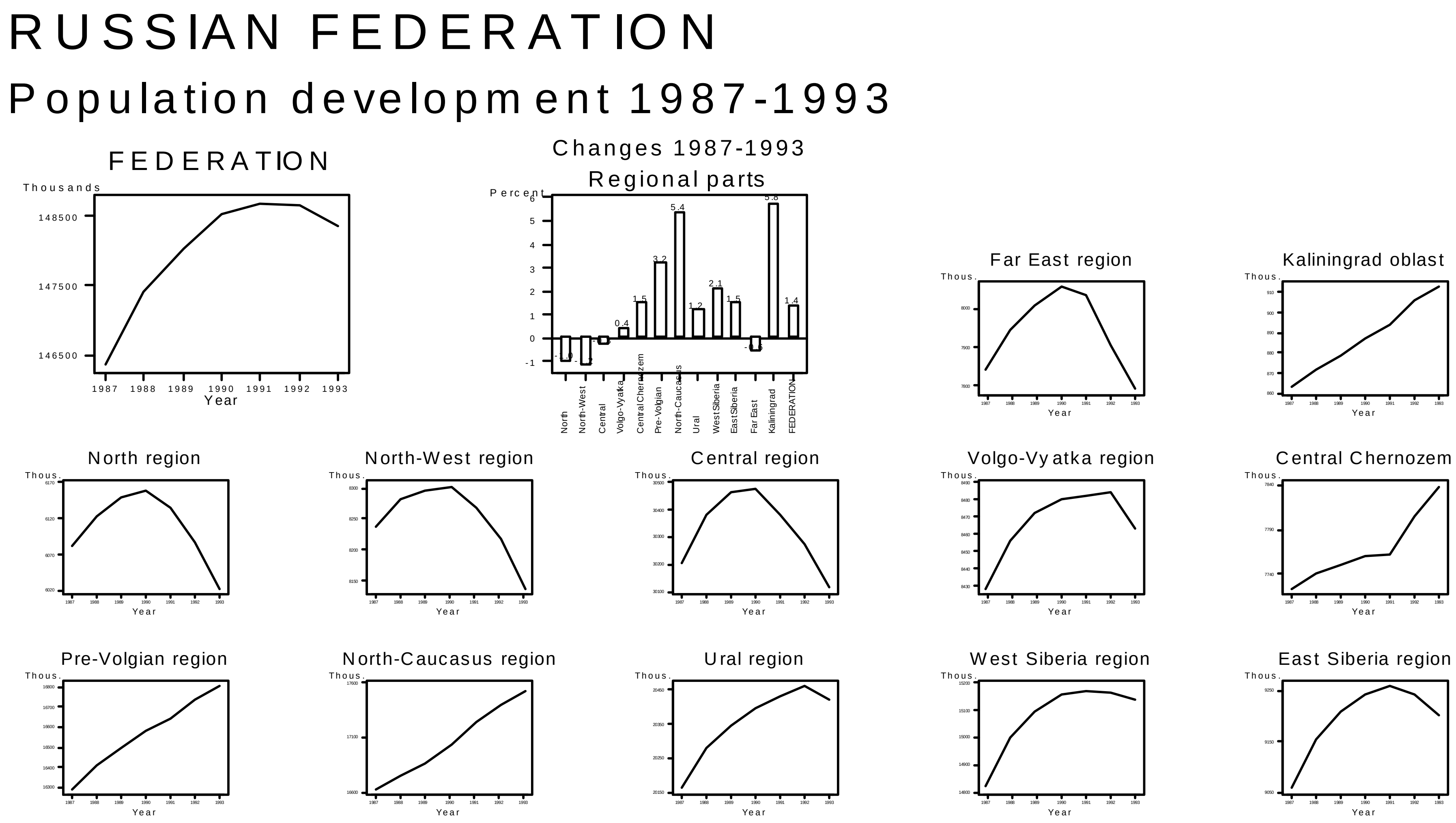


Comments to the diagram

Reference line at the observed level for the entire Federation in 1987

	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Number of sub regions in boxplots	1	1	1	70	77	79	79
Krasnoyarsk kray(alone 1987-89)	69.5	69.5	68.2	67.9	67.7	65.8	62.65
Median level sub regions 1990-1993				69.5	69.0	68.2	65.44
FEDERATION (not in diagram)	70.1	69.9	69.6	69.4	69.2	67.9	65.14

Figure 6. Development of total population. Entire Federation and Regions (notice vertical scales).



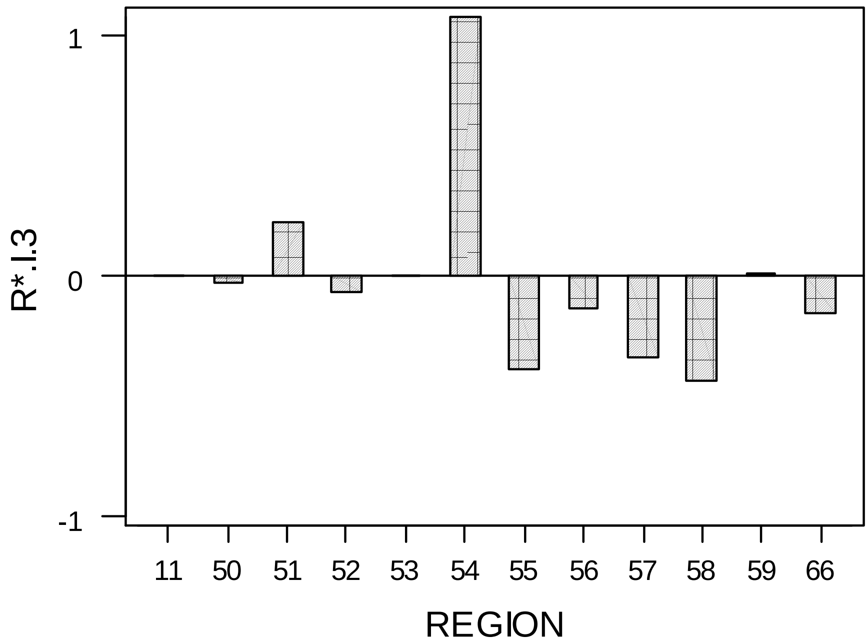
Welfare Indicators

In order to achieve a sustainable society, welfare must reach a critical minimum level. This level is also crucial in achieving any sustainable regional development. Welfare needs to be evenly distributed in a country, as it plays a dominating role in avoiding social unrest and is necessary for achieving competitiveness in a country or in regions of a country.

We have used the detailed socioeconomic database of the IIASA Study to analyze regional welfare indicators for the period 1987-1993. Here, we can only present some of the indicators studied. So far, we have not been able to generate one single welfare index based on the different indicators (due to statistical problems) and hence can present only individual welfare indicators for the year 1993. These individual indicators are shown as ratios between regions and the average for the Russian Federation.

In Figure 7, the relative production of consumer goods is presented. It can be seen that there are rather large regional differences with less production in the vast and less populated regions. Production of consumer goods also seems to be concentrated to the European part of Russia.

Figure 7. Production of Consumer Goods per 1,000 inhabitants. Ratio between regions and the Russian Federation.

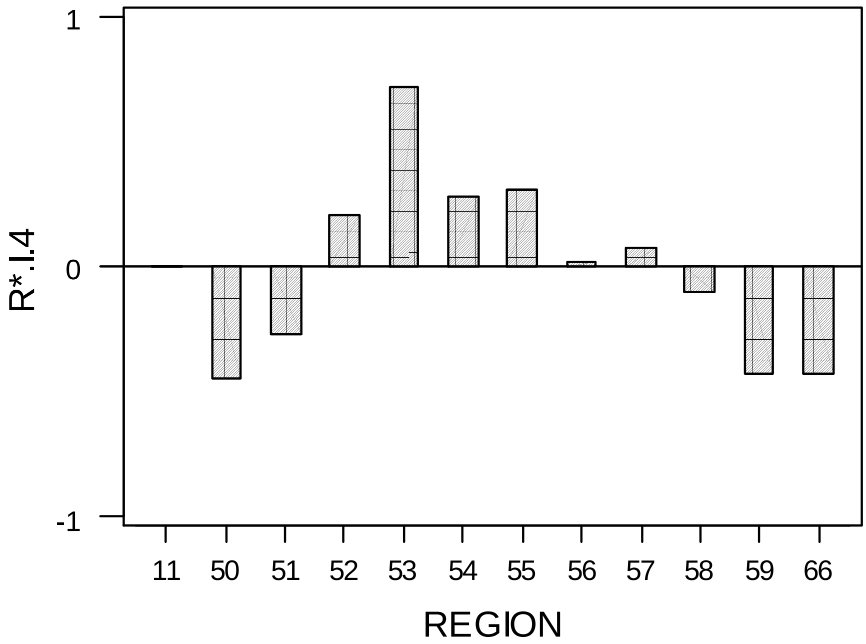


REGION

11 Russian Federation	54 Pre-Volgian
66 North	55 North-Caucasus
50 North-West	56 Ural
51 Central	57 West Siberia
52 Volgo-Vyatka	58 East Siberia
53 Central Chernozem	59 Far East

In Figure 8 the relative gross agricultural production is illustrated. As expected, production is concentrated in the agricultural regions of Russia, with much less production in the regions of Siberia and European North. To have an adequate food supply for all regions with a production pattern requires an efficient distribution system, which is presently lacking.

Figure 8. Gross production in Agriculture per 1,000 inhabitants. Ratio between regions and the Russian Federation.

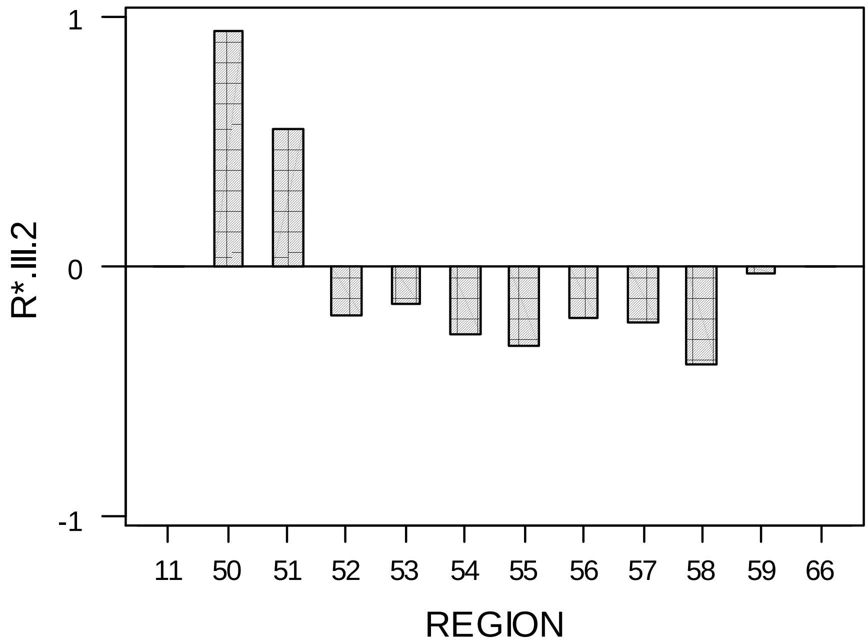


REGION

11 Russian Federation	54 Pre-Volgian
66 North	55 North-Caucasus
50 North-West	56 Ural
51 Central	57 West Siberia
52 Volgo-Vyatka	58 East Siberia
53 Central Chernozem	59 Far East

A communication infrastructure is vital to improve the development of the socioeconomic structure. The telecommunications system plays an important role in this social communication infrastructure. From Figure 9 we can see that there are large differences in the accessibility to phones between the regions, the greatest accessibility being concentrated in the European regions.

Figure 9. Number of telephones per 1,000 inhabitants. Ratio between the regions and the Russian Federation.

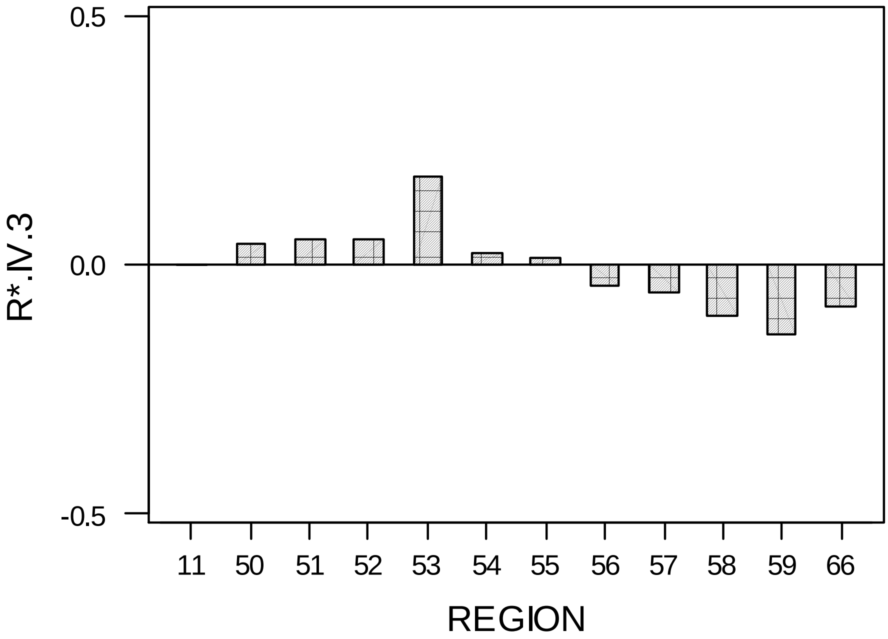


REGION

11 Russian Federation	54 Pre-Volgian
66 North	55 North-Caucasus
50 North-West	56 Ural
51 Central	57 West Siberia
52 Volgo-Vyatka	58 East Siberia
53 Central Chernozem	59 Far East

An important welfare indicator is housing space. There are regional differences in housing space, with more space in the European part and less availability in the vast regions. This can be seen from Figure 10.

Figure 10. Housing space in m^2 per inhabitant. Ratio between regions and the Russian Federation.

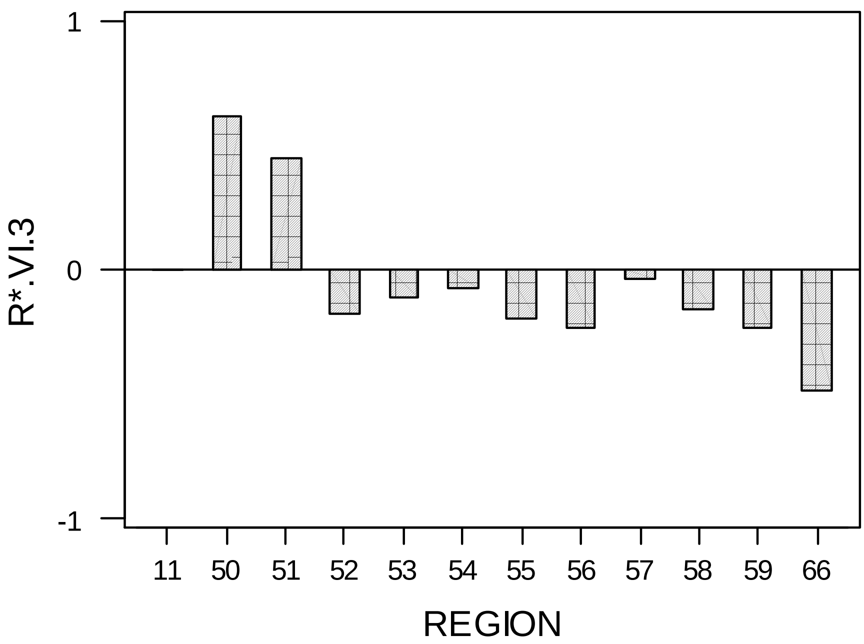


REGION

11 Russian Federation	54 Pre-Volgian
66 North	55 North-Caucasus
50 North-West	56 Ural
51 Central	57 West Siberia
52 Volgo-Vyatka	58 East Siberia
53 Central Chernozem	59 Far East

Education is vital in reaching a critical level of welfare in the long-term. The educational level in the regions can be measured by the output of specialists from higher educational establishments (Figure 11). It can be seen that the highest output of specialists is concentrated in the European part (Moscow and St. Petersburg), with vast rural areas lagging behind.

Figure 11. Output of specialists from higher educational establishments per 1,000 inhabitants. Ratio between the regions and the Russian Federation.

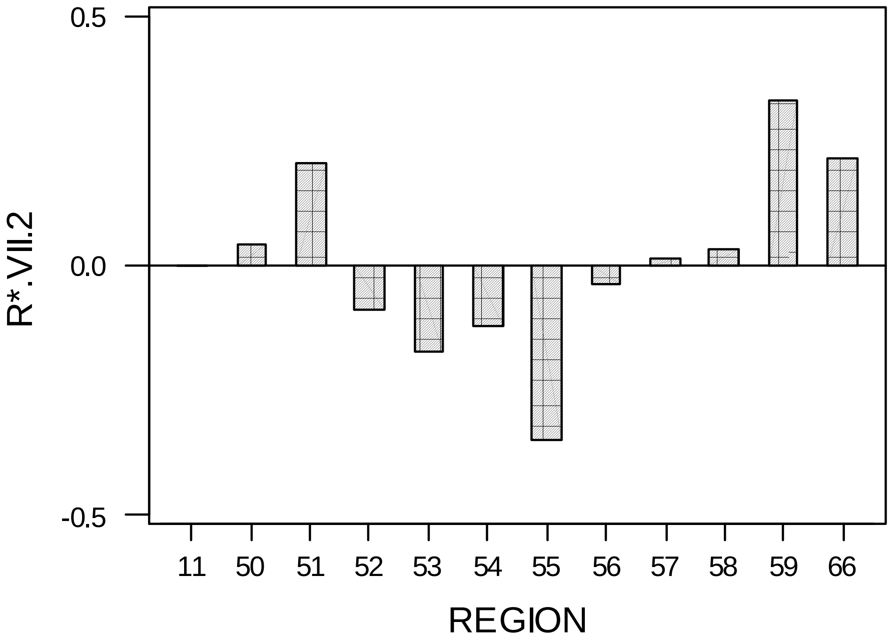


REGION

11 Russian Federation	54 Pre-Volgian
66 North	55 North-Caucasus
50 North-West	56 Ural
51 Central	57 West Siberia
52 Volgo-Vyatka	58 East Siberia
53 Central Chernozem	59 Far East

Expenditures made for the consumption of goods and services also vary from region to region, with a tendency for higher spending in the richer natural resource regions than in the more agriculturally oriented ones (Figure 12).

Figure 12. Expenditures on goods and services per 1,000 inhabitants. Ratio between regions and the Russian Federation.



REGION

11 Russian Federation	54 Pre-Volgian
66 North	55 North-Caucasus
50 North-West	56 Ural
51 Central	57 West Siberia
52 Volgo-Vyatka	58 East Siberia
53 Central Chernozem	59 Far East

As seen from the above figures, some examples of welfare indicators have been studied. We can conclude that there are large differences in welfare indicators for different regions. Differences which are higher than expected in a former centrally-planned economy.

The system developed to analyze the welfare indicators can be used in the future as a tool to check the efficiency of new policies in improving regional welfare.

Policy Issues

Based on the different analyses conducted, a number of urgent policy issues have been identified.

Industrial Relocation

- Local Economies play an important role in regional industrial development.

- In the light of our findings, policies which preserve local or regional human and material capital base, while allowing for maximum flexibility with respect to necessary restructuring, are justifiable.

- Policy measures that could yield particularly high rewards are investments in development of the infrastructure and policies designated to develop vertical and horizontal links within the regional economy.

- Infrastructure development could improve the competitiveness of more resource-based industries across regions.

Restructuring of Social Functions within Russian Firms

- The restructuring of social assets in Russian enterprises has gone through a dramatic change during the last few years. Companies are shedding these assets to a large extent, many of which are crucial for a functional society and from a competitive point of view. Hence, there is a strong need to develop concrete plans on the future responsibilities for these assets which are being shed by the firms. If this dilemma is not solved social unrest in the regions is likely to occur.

Employment

- The rate of unemployment in the forest sector has increased dramatically, especially in the forestry component. There are high social costs and a risk for social unrest linked to this development. Within the framework of this study, a strong need for improved forest management has also been identified.

- Therefore, a program for increased and improved forest management, including the retraining of unemployed workers, must be established.

- In regions closely situated to export markets, incentives and training programs for entrepreneurs who are willing to invest in infrastructure, re-equipping of enterprises, and operations for the export market need to be established.

Demographic Development

- The demographics have undergone a dramatic negative development during the transition, which will cause severe negative societal consequences if they continue.

- Therefore, there is a need to start immediately investigating the causes for these negative developments.

- After the driving forces for the decline have been identified, efficient countermeasures must be taken.

- Based on the demographic developments presented, projections should be carried out on the future population development at a regional level with respect to total population, distribution of age class and sex.

- Knowledge about future demographic conditions is crucial for every future measure to stimulate a sustainable regional development.

Welfare Indicators

- From the large number of welfare indicators studied, it can be concluded that there are substantial differences in welfare indicators for different regions.

- It is important to realize that the causes for these differences in welfare indicators have to be explained by further analyses.

- Regional authorities must put serious effort into establishing policies which will improve welfare in regions lagging in this respect. An acceptable level of welfare is one of the prerequisites for the sustainable development of societies and regions.

Conclusion

From a socioeconomic point of view, it is important for the Russian government to set priority on rapid forest sector improvement and development in order to achieve a sustainable society.

Basic Studies

This paper is based on various studies carried out within the framework of the IIASA Study, namely:

Backman, C. 1996. Employment in the Forest Sector. Unpublished Manuscript. IIASA, Laxenburg, Austria.

Granåsen, J., Nilsson, S. and Zackrisson, U. 1997. Russian Forest Sector — Human Resources. Interim Report IR-97-008. IIASA, Laxenburg, Austria.

Huber, P., Nagaev, S., and Wörgötter, A. 1996. The Relocation of Russian Industry 1987-1993. Working Paper WP-96-162. IIASA, Laxenburg, Austria.

Lundquist, B., Nilsson, S. and Zackrisson, U. 1997. Russian Forest Sector - Welfare Indicators. Forthcoming Interim Report, IIASA, Laxenburg, Austria.

Wörgötter, A., Tratch, I. and Rein, M. 1996. Social Asset Restructuring in Russian Enterprises: Results of a Survey in Selected Russian Regions. In: The Changing Social Benefits in Russian Enterprises, OECD Documents, Centre for Co-Operation with the Economies in Transitions, Paris, France.

3.9. Land-Use and the Forest Sector

Vladimir Stolbovoi, International Institute for Applied Systems Analysis, Laxenburg, Austria

Background

Natural dynamic processes of material transfers and energy flows have taken place at global, regional and local scales, resulting in both gradual and catastrophic transformations of the atmosphere, lithosphere, hydrosphere and biosphere. However, changes of the land cover driven by anthropogenic forces are currently the most important and most rapid of all such changes (IGBP Report, No. 35 - HDP Rep. No 7). As the levels of knowledge and technology develop, human beings acquire an ever-increasing capability to transform the surface of the Earth.

The implications of global change for sustaining human society and its well-being have created a sense of urgency in understanding the consequences of land cover changes. This has resulted in the establishment of international research efforts, such as the International Geosphere-Biosphere Program (IGBP). In recent years much progress has been made in interfacing and synthesizing traditional natural science disciplines.

Human activities have been identified as one of the major elements affecting the dynamics of the Earth's system. It has only recently been acknowledged that too little attention was given to these activities and that an improved understanding of the human driving forces of global change is needed to make meaningful scenarios for the future state of the Earth system.

The International Human Dimensions Program (IHDP) has been launched to investigate demographic, economic, technological, social and political perspectives of global change.

Interactions between biophysical parameters and socioeconomic conditions result in land use. Land use refers to the purposes for which humans exploit the land and can be characterized by activities like agriculture, forestry, mineral extraction and recreation. According to modern understanding, the Earth operates as a system of interrelated subsystems or elements, where changes in one sub-system may have some positive or negative reactions in others. Thus, the idea of sustainability can only be achieved based on results by multisectoral analysis based on interrelations among different, very often competitive, land uses as opposed to individual treatment of each sector.

Tasks

- To demonstrate the complexity of land use patterns in Russia and their possible changes in the future.
- To overview the status of soil degradation in Russia as an indicator of non-sustainability of land use and the consequences for the forest sector.

Approach

Multidisciplinary and multisectoral approaches of the land-use analysis are based on the assumption that the Earth incorporates a wide range of closely interrelated systems varying from natural to artificial and from managed to unmanaged. According to FAO (1976) land is: "An area of the Earth's solid surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above or below this area, including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity."

Results

The role of forests in landscape formation is closely interrelated with other land-uses. Their significance and specific functional role differs in a variety of land-use patterns. According to the State land account (National Land report, 1996) the Land Fund (LF) of Russia amounts to 1709.8 million ha (Table 1). The structure of the LF of Russia shows that Forested Areas occupy 784.7 million ha, corresponding to approximately 46% of the total area of the country. More than 620.5 million ha (79 %) of this area is under management by forest authorities. About 164.2 million ha (21%) of the forests are managed by other organizations, of which 134.4 million ha of forests are managed by agricultural enterprises. However, it should be pointed out that the classification of forest land given in the Land Fund data (National Land report, 1996) is different from the classification used in the State Forest Account and presented in Section 3.1. In the latter group, the forests play a very important role regulating the circulation of nutrients between forests and agricultural ecosystems, and the hydrological balance of a specific territory. About 13 million ha of forests are set aside for land protection whose objective is to improve the site characteristics and mitigate degradation processes. About 8.8 million ha of the total forests are located in urban and industrial areas. These forests are very valuable and play extremely significant ecological and recreational roles.

The total land area managed by forest enterprises is 838.6 million ha (Table 1) but only 74 % of this area is covered by forests. These numbers show that on average 26% of the forests are occurring in combination with other land use or land cover patterns, which are under management by different authorities. In fact, intersectoral overlapping of various land use or land cover patterns can easily be recognized by discrepancies in the accounts of the Forest Fund, Forested Area, etc., made by different organizations responsible for land (ROSKOMZEM) and forests (ROSKOMLES) in Russia.

Analyses of the historical expansion of agriculture in various natural zones (Table 2) shows that 15% of the forest zones in Russia are occupied by different combinations of forests and tilled areas. More than half of this territory is represented by land-use combinations in which tilled areas vary from 50 to 80 %. In the forest-steppe zone, 90% of the land is represented by a combination of natural and cultivated lands. The proportion of tilled areas in these territories is on average 85%. The steppe zone demonstrates very intensive agricultural intervention (more that 92% of the territory is represented by a combination of natural and cultivated lands) and tilled areas that exceed 85%.

The specific features of land-use combinations are driven by a variety of natural conditions e.g., climate, relief, soils, etc. and a wide range of socioeconomic conditions (population density, infrastructure, economic activities, etc.). These conditions vary widely, both spatially and temporally and, the mosaics of their combinations change from one area to another and in a temporal perspective.

It has been proposed to use the dynamics of different changes of ecosystems in the forest biomes (Isakov, et. al., 1986) as indicators for the assessment of current status and future changes in land-use (Table 3).

Intensive exploitation of the taiga took place during 1930-1980 from Europe to the Far East. Broad-leaved and coniferous broad-leaved forests (Table 3) were originally represented by seminatural self-maintaining ecosystems and were widely distributed in the beginning of XIX century. During the XX century the human impact increased considerably and the anthropogenic ecosystems expanded substantially. It is expected that in the next century this development will continue causing the absolute dominance of anthropogenic ecosystems. Due to this perspective, to maintain the ecological balances different regulations have to be implemented.

Thus, based on the changes, which have taken place during the last 200 years it can be estimated that the share of indigenous ecosystems in the taiga (broad-leaved and coniferous broad-leaved forests) will, according to some scenarios, dramatically decrease in the beginning of the next century and practically disappear by the end of the century. Anthropogenic ecosystems which are a result of human intervention will dominate. This result calls for strengthening of multisectoral cooperation of all users of land, policy and decision-makers to prevent such an alarming scenario from being fulfilled.

Soil degradation is caused by humans in the utilization and manipulation of natural and environmental resources. Maintenance of the productive potential of land resources, and control of the land degradation, are fundamental elements of a sustainable land use (Pieri, *et al.* 1995). However, as was shown above, the reality demonstrates intricate mosaics of different land-uses. The role of forests in landscape formation is closely interrelated with other land-uses. It means that sustainable development in general can only be achieved in harmony with all land-uses. The task of spatial organization of a territory based on interrelations between all land uses is a very important issue. For each territory or landscape a substantial area of forests must be set aside from an ecological perspective (climate-, water-, soil protection, etc.). These forests will provide autoregulation and self-reproduction in a territory or a landscape. The amount of these areas required within a region may serve as a criterion for land protection.

As a negative example of the effect of the reduction of forest areas, the decline in the forest-steppe zone of the European part of Russia can be used, which resulted in degenerated river floodplains. This forest decline led to erosion and decreased ground water tables, which in turn caused serious problems in the restoration of the vegetation on areas covered with forests not long ago.

Soil degradation includes water and wind erosion, secondary salinization, desertification, underfloods, compaction, disturbances of organic horizons caused by industrial wood harvests, disturbances caused by fires, thermokarst, and surface corrosion, caused by overgrazing and industrial activities.

The total extent of soil degradation in Russia is 242.6 million ha or 14.5% of the soil cover (Stolbovoi and Fischer, 1996).

Soil compaction is the most widespread type of soil degradation (48.2 million ha). It should be emphasized that the increased soil density due to compaction may cause irreversible changes, and it is possible that the soil will lose the ability of self-discompaction.

Soil water and wind erosion (deflation) is the second largest type (25.2 million) of soil degradation caused by improper tillage.

Permafrost embraces the north European territory and north of the West Siberian territory and nearly the entire territory east of the Yenisei river. The total area, covered by permafrost, is estimated to be more than 1100 million ha (about 65% of the entire land area).

Overgrazing of tundra causes processes of surface corrosion (60.2 million ha) in permafrost soil (soilfluction, landslides, etc.).

Thermokarst (31.3 million ha) is the type of soil degradation which develops mainly on deer's pastures. It is basically caused by industrial activities such as mining, and infrastructural development.

Disturbances of the soil organic horizon in forests caused by fires are estimated (average for a 10-year period) to constitute 15.4 million ha or about 2% of the total forested area.

Protection measures, as a result of erosion, have been implemented over the total area of Russia. Water erosion is combated by land management practices such as contour-tillage, contour-strip-cropping, minimum-tillage, and land-use design. To prevent wind erosion, joint plantation and land management practices are applied. Plantation management includes application of fertilizers, crop rotations, increased plant density, stubble-mulching and agroforestry.

Russia still has 1472.5 million ha (85.5 %) of soils which are naturally and artificially stable: under natural vegetation (1264.3 million ha); natural bare land (30.1 million ha) developed in deserts, high mountain zones; and human influenced soils (177.5 million ha).

Conclusions and Policy Recommendations

1. The reality demonstrates intricate mosaics of different land-uses. Its complexity depends on various combinations of natural and socioeconomic factors and their interrelations. The role of forests in landscape formation is closely interrelated with other land-uses. Their significance and specific functional role differs in a variety of land-use contributions geographically, and will change over time, accordingly.

2. Human pressures on the land have overstepped critical loads and caused different forms of soil degradation. Recent trends towards further soil deterioration and loss of basic soil functions will continue if counter measures are not provided. Protection of soils and prevention of these negative processes are crucial elements of a sustainable multisectoral development.

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FAO. 1976.: A framework for land evaluation. Soils Bulletin. No. 32. FAO. Rome and ILRI, Wageningen, The Netherlands. Publ. No 22. 79 p.

Stolbovoi V., G. Fischer, 1996.: A New Digital Georeferenced Database of Soil Degradation in Russia. Abstracts from the 9th Conference of the International Soil Conservation Organisation (ISCO), Bonn, Germany, p. 235.

Table 1. The structure of the Land Fund of Russia, Million ha (based on National Land report., 1996)

Land categories	Land Use							
	Land of agricultural enterprises	Land of forest enterprises	Urban land	Industrial land	Land of water fund	Protection areas	Reserves	Total
Total agricultural	186.6	3.8	24.4	1.2	0.0	0.4	5.4	221.8
Cultivated	122.9	0.2	5.9	0.2	-	-	1.5	130.7
Forest and shrubs	134.4	620.5	5.0	3.8	0.1	13.0	7.9	784.7
Swamps	15.8	77.1	1.6	0.4	0.7	1.6	11.0	108.2
Water bodies	19.6	12.9	0.9	0.8	18.2	1.4	18.0	71.8
Deer pastures	253.3	60.1	0.0	0.1	-	1.7	12.8	328.0
Infrastructural land	3.6	1.7	5.0	3.0	0.0	0.1	0.0	13.4
Others	54.4	62.5	1.7	8.3	0.4	9.1	45.5	181.9
Total	667.7	838.6	38.6	17.6	19.4	27.3	100.6	1709.8

Table 2. The share of land with cultivated lands in natural zones of Russia

Natural zone	Extent (Million ha)				The share within the natural zone, %
	with less than 20%	with 20-50%	with 50-80%	with more than 80%	
Tundra	no	no	no	no	no
Forest-tundra	no	no	no	no	no
Forest	20.0	1.7	48.2	19.1	15.7
Forest-steppe	2.7	11.2	23.9	23.4	89.9
Steppe	8.9	1.7	17.4	52.8	92.2
Semidesert	0.7	0.2	0.5	2.1	22.6
Desert	no	no	no	no	no

Table 3. The Dynamics of the occurrence of different categories of ecosystems (after Isakov, *et al*.,1986).

The Taiga Biome					
Century, years	XIX	XX		XXI	
	1800-1850	1900-1930	1980	Beginning	End
Categories of ecosystems					
Indigenous	xxxx	xxxx	xxx	xx	x
Neorelict	-	xx	xx	xxx	xxx
Anthropogenic subclimax	-	x	xx	xxxx	xxx
Seminatural self-maintening	x	xx	xxx	xxxx	xx
Anthropogenic ecosystems	x	x	xx	xxx	xxxx

Broad-leaf and coniferous broad-leaf forests					
Century, years	XIX	XX		XXI	
	1800-1850	1900-1930	1980	Beginning	End
Categories of ecosystems					
Indigenous	xxx	xxx	xx	x	-
Neorelict	x	xx	xx	xx	xx
Anthropogenic subclimax	x	xx	xxx	xxxx	xx
Seminatural self-maintaining	xxxx	xxxx	xx	x	-
Anthropogenic ecosystems	xxx	xxx	xxxx	xxxx	xxxx

The occurrence: - does not occur; x - rarely; xx - not significant; xxx - significant; xxxx - dominant.

4. The Policy Mode

Based on the policy problem identified by the participating Russian governmental representatives (Section 2), the theme papers presented in Section 3, and the summary sheets from each of the ongoing subactivities of the IIASA Study (see Volume II from the Dialogue), a dialogue was carried out in order to tackle the identified policy problems. As an additional platform for this discussion, two additional papers were presented on so-called Policy Exercises respectively Institutional Aspects, which are presented in the following.

4.1. Policy Exercises and Their Potential Application in Studies of Russian Forest Policy.

Peter Duinker, Lakehead University, Thunder Bay, Canada

Introduction

Policy formulation is about the future, which is highly uncertain and full of surprises. Strong approaches to understanding the future usually include some form of scenario building and evaluation. For forest policy, such a process might well include: posing plausible (and interesting) courses for the future of the forests, evaluating their implications, posing strategies for dealing with undesirable elements of the posed futures, and evaluating the consequences of those strategies.

For national-scale forests, no-one knows for sure the range of feasible strategic policy alternatives for coping with possible long-term consequences of major driving forces such as climatic change, industrial pollution, economic exploitation of forest resources, and society's expectations for forest conservation. To address these knowledge deficiencies, and to strengthen understanding of methods for policy exploration, IIASA's former Forest Study researchers in the late 1980s designed and implemented a series of "policy-exercise" workshops. The workshops were attended by policy-makers and analysts from governments, industries, and international organizations related to the forest sector in Europe and elsewhere. The main objective of the exercises was to derive lessons for policy strategy with respect to the European forest-decline problem.

Policy Exercises

Papers by Brewer (1986), Clark (1986) and Sonntag (1986) documented the intellectual foundations for policy exercises, and Toth (1986) proposed an operational framework. Briefly, the objectives of a policy exercise are:

a) to foster communication and mutual learning through effective face-to-face communications;

b) to synthesize policy-relevant and useful information through integration of disparate sets of formal and informal knowledge; and

c) to discover the implications of alternative, plausible futures through structured exploration of scenarios.

Within the methodological work of the former IIASA Biosphere Project, development of the policy-exercise approach was a major activity, and involved elaboration and testing of operational protocols (e.g., Toth, 1986; 1988a; 1988b).

A policy exercise consists of preparation, interaction, and evaluation phases. One or more workshops, in early conceptions of the policy exercise, comprise the interaction phase in which policy-makers and analysts discuss future histories concerning the forests and their use and management. A future history is a record, looking back to the present from a specified future time, of (a) trends of indicators and phenomena relevant to the problem at hand, (b) policy initiatives taken in response to expected trends, and (c) expectations of policy consequences vs. realized policy consequences.

One way of viewing the policy-exercise workshop is as a scenario processor. In this view, a goal of the policy exercise is to generate policy lessons through (a) working policy realism into "policy-less" scenarios, and (b) comparing several "policy-rich" scenarios in the search for meaningful policy options. Thus, the policy exercise begins with the generation or collection of raw materials for scenario construction, and the writing of scenarios that are essentially void of policy adaptation. These scenarios are prepared by analysts in advance of policy-exercise workshops, although they may be checked by the policy participants to ensure consistency and acceptance as plausible and interesting materials to work with at the workshop. The workshop then is charged with rebuilding the scenarios into stories that contain real-world kinds of policy adaptation to new circumstances, including quite unpredictable (surprising) events and twists of fate. A set of scenarios thus processed, if sufficiently different from one another and sufficiently rich in details of cause-effect relationships among policies and resource behaviour, can be fruitfully compared to reveal sensible policy strategies for the real-world problem being addressed.

Method Developments and Trial Applications in the Former IIASA Forest Study

We organized and held 5 policy-exercise workshops in the Forest Study (see Duinker *et al.* (1993) for details). The evolution of our testing started with a large group of scientists playing policy-participant roles, then reverted to small groups of experienced policy people, continued with another try with a large group of scientists, and ended with a large group of experienced policy people. Each exercise involved the use of one or more scenarios for the future development of European forests. In brief, policy participants would propose policy decisions for each time period of the scenario, and analysts in turn would "update" the world in response to the policy decisions and to other driving forces.

Some key lessons emerging from our five test applications of the policy exercise are:

a) Adequate preparation with technical materials is crucial. Workshop participants need to have technical materials well before they meet.

b) Persons participating as policy-makers need to have real policy-development and implementation experience to be able to make strong contributions.

c) People have a hard time removing themselves from present circumstances, which makes policy exploration for periods several decades into the future rather difficult.

d) If computer-based models are to be used to examine policy consequences during a workshop, it must be possible to generate new outputs rapidly.

e) Policy people and analysts generally have their own ideas on what the most likely future will be. When scenarios are rather different from their personal expectations, they tend to disbelieve the offered scenarios.

f) Scenario data usually have to be quite detailed (i.e., quantitative and not just general trend indications) before policy participants will take them seriously.

g) When discussing and analyzing scenarios, it is highly constructive to have participants arranged into several kinds of small groups, including geographic, theme and sectoral groupings.

h) It is crucial to engage some policy participants before the workshops (e.g., in scoping meetings) to set reasonable bounds on the materials to be discussed.

i) Interactions between analytical and policy participants must be frequent throughout an exercise.

Having also conducted a forest-policy workshop in Poland in 1989, our IIASA Forest Study team has experience with alternative designs for the policy exercise. In the Polish workshop, we set several possible futures for the Polish forest sector before the participants, and simply asked them to evaluate the likelihood and merits/demerits of each. Scenario gaming, which was our approach in the test exercises described above, is but one only way to discover what kinds of policies would make sense for the long-term sustainable development of forests.

Design of Policy Exercises for Russia's Forest Sector

Some form of policy workshop is proposed as the core approach to policy analysis for IIASA's studies of sustainable development of the Russian forest sector. Russian collaborators must be intimately involved in the design and implementation of such workshops. The following preliminary ideas are offered to guide design of policy workshops focused on sustainable development of Russia's forests:

a) A wide variety of people involved in forest use and management should be invited to participate, including forest-policy administrators, forest managers, wood-products industry people, forest recreationists, hunting and fishing enthusiasts, environmentalists, parks advocates, researchers, educators, community-development experts, public-policy experts, journalists, and others.

b) The design for discussion-oriented interaction among participants needs to draw people out of their ordinary modes of thinking into creative, future-oriented thinking, and yet give them sufficient intellectual comfort to remain productive and engaged on the objectives of the exercise.

c) One approach could be to prepare several scenarios for the development of the Russian forest sector in the period 2000-2050, and have workshop participants (a) discuss their respective plausibility and desirability, and (b) generate policy requirements to ensure or prohibit particular scenario outcomes.

d) Another approach would be to choose 8-10 key driving forces (e.g., global markets for forest products, global climate change, demands for forest recreation, demands for biodiversity conservation), describe their nature and links to forests, give alternative futures for the forces, and discuss how the forests and forest sector might respond to these forces, and what policies would be needed to make the responses more favourable.

e) Interviews of participants by policy analysts would serve as an excellent vehicle for preparing participants and analysts for the intense engagements at workshops.

f) Regional workshops could be held across the country in advance of a central workshop or set of workshops in Moscow where a country-wide policy analysis would be undertaken.

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4.2. Prerequisites for the Evolution of Markets. An Institutional Analysis of the Russian Forest Sector

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Background

Contemporary research indicates that the wood supply from the USA, Canada, and the tropical areas will decline. Russian forests are underexploited and have the potential to fill this gap. This is, however, primarily depending on whether adequate *institutional arrangements* will be developed in order to smoothen the entrance and the entrenchment in this new market. In this context it is important to emphasize that institutional arrangements are not to be understood as formal organizations and formally written laws and regulations. Institutions are "the rules of the game," i.e., those formal or informal rules that are *de facto* used by a set of actors. Such a well functioning institutional arrangement is a basic prerequisite for the development of Russian forestry. Logically, a poorly governed Russian forestry sector will be a severe obstacle for the transition to a market economy.

It is important to realize that forests are not resources *per se*. Only within a framework of institutional arrangements can a forest resource be regarded as an asset in an economic sense. Socioeconomic development requires new institutions to facilitate the processes. The forestry sector can be expected to play a significant role in such a development. Trade, transport, management, marketing, etc., and, in the end, the *sustainable utilization* of the entire Russian forest resource, are dependent on the establishment of an adequate institutional framework. When referring to institutional arrangements relevant for forestry, we mean, among other things, the existence of market information systems, rules, and technology. We also refer to the clarity and simplicity of rules of trade, financing, contracting, etc. Finally, we refer to a whole cluster of variables related to property rights, ownership, usufruct rights, monitoring and sanctioning of infringements, etc.

Task

The reconstruction of the economies in east European countries and the former Soviet Union (FSU) has thrown new light on economic theory and its usefulness has been questioned. In fact, it seems that we lack good theories of how such a reconstruction can (or should preferably) be achieved. There is, however, no reason to believe that the Russian forestry sector would be well served by copying all Western solutions and institutional concepts that were developed for centuries under quite different circumstances. What can be done then? Given the fact that we in some sense lack coherent theories, what might be attained is a better understanding of what is possible to achieve. This calls for empirical research and, in particular, an in-depth study of the institutional framework embedding the Russian forest sector. This activity would focus on two basic questions:

1) What is the exact configuration of the present institutional framework related to Russian forest sector and its historical roots? How do central characteristics and features of this framework correspond with the possibility of a sustainable exploitation of Russian forests?

2) Compared to the forest sectors in other countries (e.g., in Sweden, Finland, Canada, etc.), to what extent are crucial characteristics in Russia different or lacking?

Approach

In studying the institutional arrangements related to Russian forest sector a methodology that focuses on the sets of rules that govern the activities at the local level will be utilized. Thus, the focus of interest is not on how actors *supposedly* act (or should behave) according to some *formal* regulation, but on how they *actually* behave. The *Institutional Analysis and Development* (IAD) framework is the most distinguished and tested framework for institutional analysis. (The IAD framework has been elaborated and used by a number of prominent scientists during the last decade.) It is based on a limited version of rational choice theory and it is sufficiently broad to be compatible with a wide range of theories, such as, collective action theory, transaction cost theory, game theory and constitutional choice theory.

The Russian forest sector consists of many sub-sectors and branches. Given the bottom-up methodology of the IAD framework it is hardly possible to analyze the entire sector. Therefore, an *action arena* that performs a central function will be investigated. Forest industrial enterprises, such as sawmills, and pulp and paper mills, which are occupying a central position in the institutional framework under which the forest sector is governed, fulfill this criterion. Thus, the activities they perform will also reflect the broader set of institutional arrangements which govern raw materials producers, processing industries, and others. Presumably, these institutions will guide ongoing and future activities related to the conversion of the former Soviet system to a prosperous market economy.

Expected Results

The aim of this activity would be to provide new and seminal results that will promote analysis along four different lines:

1. This activity should collect current data from a specific, but important, sector of the Russian economic forest sector. The analysis of this data will broaden our knowledge regarding the very formation of market economies.

2. By identifying and analyzing obstacles and possibilities for the development of a more world market oriented, but sustainable, Russian forest sector, this activity can serve as a basis for policy making, not only within forestry but possibly also in other segments of the economy. A better understanding of the institutional framework related to the forest sector, its structure, function, and potentiality for commercialization—will reduce costs of information and facilitate actions taken by enterprises and thus contribute to the reconstruction of the economy.

3. Finally, this activity will broaden our understanding of the Russian privatization process, its components and different appearances. It will be demonstrated that privatization is not only a matter of changing ownership. It is also a question of reestablishing an institutional framework that accommodates these new, "privatized" units. The activity will throw new light on the role of institutions in these efforts.

5. Conclusions Concerning Future Activities in the Policy Mode

Sten Nilsson, International Institute for Applied Systems Analysis, Laxenburg, Austria

In Section 2 it was illustrated that Russian governmental officials identified a strong need for coordinated policy-setting in the forest sector, which requires international cooperation. In the Dialogue it was also identified that the forest sector has a low political profile in Russia, which the Russian government needs to substantially increase its priority on. The Russian forest sector had already started to lose political priority in the former USSR. Since the early 1970s, no major investment programs have been carried out in the Russian forest sector (Nilsson, *et al.*, 1994; Simons, 1992).

During the Dialogue it was concluded that all work intended to deal with long-term policies for the Russian forest sector is only feasible based on a thorough assessment of the current policy-setting and institutional conditions in Russia. Among these Russian specifics are:

- the contradictions between policy decisions and practices in the forest sector at federal versus regional levels, and
- the fact that federal laws are only partially implemented in regional and local policies.

It was strongly stated that even if the IIASA Study were to start working on the Policy Mode at this stage, the ongoing work on the study's quantitative analyses must continue in parallel, as the results from these analyses are crucial towards relevant, long-term policy-setting.

The following overall approach for future policy work by the IIASA Study was found to be sound and acceptable by the participants at the Dialogue:

1. In the short-term (months)
   Sector response to the Presidential Sustainable Development Decree

2. In the medium-term (within one year)
   Priority setting of Sustainable Development Issues: Immediate needs

3. In the long-term (within 3-4 years)
   Long-term Sustainable Development of the Sector

4. In parallel to the above:
   Institutional Analyses.

Thus, the overall approach for future long-term policy work with respect to the Russian forest sector is constituted by four components. Some of which may need to be finalized outside the framework of the IIASA Study.

The sector response document, based on the Sustainable Development Decree by the Russian President from April 1996 (component 1), has three major objectives: 1) to demonstrate to the Russian government that the forest sector does have a possibility to reach sustainable development; (2) to constitute a sound basis for inter-ministerial discussions on the long-term development of the forest sector; and 3) to set the platform on how the second stage of the policy mode should be undertaken.

In the second component, new ideas about forest sector development should be brought in, which would set new priorities and reverse some of the non-sustainable trends in the forest sector. Most of the results of the quantitative analyses of the IIASA Study should be brought into this second component, together with regional aspects and concerns. This component should also act as a platform for the third component, which will concentrate on nationwide and long-term policy exercises for sustainable development of the Russian forest sector. In component II there should be a strong interaction between scientists and policy-makers and inner-ministerial interactions. In the second component there is also a strong need to extend some of the quantitative analyses of the IIASA Study to cover all of Russia.

Rough frameworks for the second and third components are presented in Appendixes I and II respectively.

It was recommended that the fourth component, the institutional analyses, should start immediately in the form of regional case studies and be carried out in parallel with the direct policy-oriented components of the work and described above.

The Dialogue also recommended the establishment of a group to guide the execution of the required components of the policy work. This group should include participants from the State Committee of Environmental Protection, Federal Service of Forest Management of Russia, Department of Natural Resources and Environmental Protection of the Government of the Russian Federation, the State Committee of the Forest Industry of Russia, Ministry of Finance, Ministry of Economics, Russian Academy of Sciences, and IIASA.

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APPENDIX I:

Examples of Policy Issues to Consider in the Second Stage of the Policy Mode

Economic Issues

- wood supply
- markets
- industry
- infrastructure
- technology
- energy
- investments
- governmental debts

Environmental Issues

- ecological functions
- carbon balance
- climate change
- biodiversity
- pollution
- land-use

Social Issues

- income and living standards
- employment
- social attitudes
- labor skills

Institutional Issues

- governance
- laws and regulations
- institutional organization and responsibilities
- forest inventory system

APPENDIX II:
Ideas on Policy Exercises on the Russian Forest Sector Policy

Effective forest policy:

- goals and objectives
- means of implementation

Key features of strong policy development:

- integrated quantitative analyses, linking specific policy strategies with specific policy outcomes
- dialogues involving main policy actors to discuss and choose a promising direction and associated strategy

Risks in policy development without incisive analyses:

- physical impossibilities to achieve intended results
- undesirable side-effects

Risks in policy development without appropriate dialogues:

- non-ownership by implementation people
- technical non-implementability

What kind of analyses?

- development of a range of internally consistent scenarios outlining possible future paths for the forest sector

Critical features of scenario-oriented analysis:

- multiple different scenarios
- comprehensive scenarios
- policy-relevant scenarios
- detailed, quantitative scenarios

What kind of dialogues?

- engage all key parties in informal, structured workshops:
  - ◊ key parties
  - ◊ informal
  - ◊ structured
  - ◊ workshop

- requirements for success:
  - ◊ strong input materials (scenarios)
  - ◊ series of meetings
  - ◊ several locations across the country
  - ◊ professional facilitation

Conclusions:

- Choosing and embarking on a promising transition path toward sustainable development of the forest sector requires:
  1. a deep understanding among all participants
  2. a profound commitment at all levels
  3. resources sufficient to the task

- Policy exercise based on scenario analyses at structured workshops can help create understanding and commitment

- These are suggestions; like sustainable development itself, policy development for a sustainable Russian forest sector needs a made-in-Russia approach.

6. Press Releases from the Dialogue

In connection to the Dialogue, two press-releases were issued. These releases are presented in the following.

Decision Time for Russian Forest Sector Policy

IIASA study reveals economic and environmental effects at stake

Moscow, Russia/Laxenburg, Austria – 2 December 1996 – Long-term and effective forest management practices and forest sector policies are needed. If nothing is done, the forestry industry can collapse. These interim findings are part of a continuing study conducted by the Forest Resources Project at the **International Institute for Applied Systems Analysis** (IIASA) in Laxenburg, Austria, with the collaboration of many Russian institutes belonging to the Russian Academy of Sciences, the Russian Federal Forest Service and others.

Russia possesses an impressive percentage of the world's forests. This resource's environmental and commercial importance extends beyond the borders of Russia to the global climate and economy. But during the transition to a market economy, conflicting policies and inadequate controls have led to abuse and exploitation of resources. Forests are no exception. "Fundamental issues of survival face the Russian forest sector. Securing sustainable development of Russian forests and the forest industry while simultaneously nurturing improved socioeconomic conditions calls for adopting necessary policies without delay," states Professor Sten Nilsson, Project Leader.

Based on its own unique comprehensive data collected from Russian contributions and integrated assessment analyses, the IIASA Project has completed an unparalleled account of the status of the Russian forest sector. Selected results show that:

- current, overly complex *forest legislation* is still based on centrally planned principles – it does not cover all functions of forest resources, there is a lack of mechanisms for implementation, and it is riddled by contradictions due to non-forest sector regulations;
- *mature growing stock of forests* under state management is declining substantially;
- between 1990 and 1994, Russian *forest sector output* fell by 55 percent, domestic consumption of forest products declined by 60 percent, commercial harvest dropped 68 percent with greater declines in Asian Russia than in European Russia and production of non-wood products fell;

- traditional *export markets* have all but disappeared in the Baltic states, the former COMECON partners, and the states of the former Soviet Union;
- dramatic increases in *transportation costs* have disadvantaged enterprises located in the center and east of the country;
- in 1994, *wages* in harvesting and woodworking industry were only 75 percent of the 1990 level;
- almost 10 percent of the Russian *workforce* could be directly and indirectly supported by activities in the forest sector, but unemployment has been steadily rising, especially in Asian Russia, implying high social costs in the future and potential migration problems;
- threats to *forest biodiversity* are high, mainly due to lack of protected areas and future careless timber exploitation, and many species are on the verge of becoming endangered, including those that serve medicinal (40 percent of medications used in Russia are of plant origin), nutritional, and commercial purposes;
- *forest management* affects emission of various gases from the soil that influence the greenhouse effect – Russian soils generate 3-10 percent of the global net annual methane exchange between the ground and the atmosphere; and,
- industrial centers cause *air pollution* that seriously damages at least 3.5 million hectares of forest (major pollutants are sulfur, nitrogen and heavy metals in areas such as Irkutsk region, Norilsk area, Ural and Altai Mountains, regions near Kazakstan, southern Far East, Sakhalin, etc.).

In summary, inefficient forest management, insufficient forest protection, substantial losses due to human activities, and huge losses of wood during harvests and processing due to inferior practices and technology are major problems that are intensified under present Russian economic conditions.

Nonetheless, the potential for the Russian forest sector is huge. Realizing this potential requires revised forest sector policies reflecting emerging environmental and economic values of today and tomorrow. This is where IIASA's Forest Resource Project continues to contribute. "Based on its previous work, the Project is poised to formulate implementable policies for the Russian forest sector," adds Nilsson.

In order to ensure that this collaborative international IIASA activity proceeds effectively, a meeting with high-level participants from the Russian government, the Russian Academy of Sciences, and other Russian institutions is scheduled for November 12-13 in Moscow.

Together, this group is developing a formal working plan for the policy portion of the IIASA study. Different stakeholders in the Russian forest sector from various Russian regions will participate in the process to set the stage for policies that enable, promote, and ensure the implementation of sustainable management practices for Russian forest resources. If successful, the socioeconomic situation can improve hand-in-hand with that of the environment. Integrated management can secure domestic growing stock and wood harvests as well as manufactured wood products for the international market, money for infrastructure and other investments, and forests rich in non-wood products with high recreational and environmental value.

Priority for Developing Russian Forest Sector Policy

Russian policy makers stress cooperation with Forest Resource Study at IIASA

Laxenburg, Austria/Moscow, Russia - 2 December 1996 - Collaboration between Russian government and international experts will produce new forest sector policies to revitalize the depressed Russian forest industry, improve environmental conditions, and raise the status of the forest sector within Russia. In a major step toward producing effective forest sector policy, high-level Russian government representatives met, in Moscow, with the international Forest Resources Project team from the **International Institute for Applied Systems Analysis** (IIASA) and with its collaborators from many institutes of the **Russian Academy of Sciences**, the **Russian Federal Service of Forest Management** and others. The new policies will lay the foundation for improving socioeconomic and environmental conditions in Russia and enhancing the positive contribution of the Russian forest sector to the global climate and market.

"This joint effort is evidence of renewed Russian government priority regarding the nation's forest sector and its importance in enhancing sustainable environmental and economic development. The transformation of the forest sector also plays a major role in Russia's fulfillment of international environmental commitments," Alexandr Zaverjukha, Vice-Premier of the Russian Government, in a statement prepared for the meeting. Zaverjukha added, "I am convinced that this joint activity will be instrumental in constructing policies to secure the sustainable development of the Russian forest sector and to promote further international cooperation in this field."

By implementing such policies, Russian decision makers can appease international critics and help the Russian people. Internal and international pressures have increased the urgency for the Russian government to take action regarding the country's troubled forest sector which has faced diminishing commercial and industrial output, withering recreational and esthetic values due to pollution and conflicting regulations, and difficulties meeting international environmental standards.

Consequently, Vitali Parfenov, Deputy Head of the Department of Natural Resources and Environmental Protection of the Russian Government, and other government representatives explicitly recognized the timeliness of this meeting and the need for international cooperation on these issues. Due to IIASA's strong tradition of productive and internationally collaborative contributions on Russian-related forest issues, Parfenov called on "the Forest Resources Project (at IIASA) with its many Russian collaborators to contribute to Russian forest sector policy development;" thereby, acting as a catalyst in its transition to sustainable development.

Deputy Minister Evsjukov from the Ministry of Economics also emphasized, "the high priority the Russian government was giving the forest sector in recognition of its importance in the transition of the Russian economy." Evsjukov added, "There is a fundamental need for establishing coordinated policies in the forest sector."

With the approval of Russian government representatives, Sten Nilsson, Leader of the Forest Resources Project, and Alexandr Isaev, the Project's chief Russian collaborator, plan a three-stage approach to developing policies for sustainable development of the Russian forest sector:

1. *An immediate policy document emphasizing the need to enhance the status of the forest sector in response to the Russian Presidential Decree on Sustainable Development*: In the next two months, the Forest Resources Project and Russian collaborators will provide Russian decision makers with principles necessary for the sustainable development of the forest sector. These principles will indicate the overall economic and environmental potential of the forest sector and will provide the basis for interministerial discussion.
2. *Setting and augmenting priorities of sustainable development issues and identifying priorities to reverse unsustainable trends in the forest sector*: This component will utilize IIASA's unique collection of data and analysis combined with the Russian collaborators' expertise on the (regional) characteristics of the Russian conditions to provide input for stage three and to provide alternatives to Russian policy makers regarding the development of Russian forests and forest industry in the medium-term.

3. *Constructing long-term policies for the complete transformation of the Russian forest sector to sustainable development*: This long-term activity will be based on nation-wide policy exercises organized with the support of the Russian government by the IIASA/Russian network and will include participants from government, industry and science. The new policies for sustainable development of the forest sector will be delivered directly to Russian policy makers. The policies will be flexible and adaptable to changing socioeconomic and environmental conditions and advances, particularly with respect to the forest industry.

Each phase will form the basis for the subsequent phase. IIASA/Russian cooperation is essential for formulating effective and implementable policies by this process. Russian government officials welcome the impartiality and objectivity of IIASA's international, interdisciplinary input.

Appendix 1

Dialogue on Sustainable Development of the Russian Forest Sector

November 12-14, 1996

Moscow, Leninsky prospect, 32a (2nd floor, Presidential Hall)

Tuesday, November 12, 1996

9:30–9:45	Introductory Address	Acad. V.A.Koptyug, Vice-President of the Russian Academy of Sciences
9:45-10:00	Key-note address	A.Kh.Zaverjukha, Vice-Premier of the Russian Government
10:00-13:35	**Problems in Sustainable Development of the Russian forest sector**	**Chairman A.S.Isaev**
	• V.I.Danilov-Danilyan	Chairman of the State Comm. of Environmental Protection
	• A.I.Pisarenko	Deputy Head of Federal Service of Forest Management of Russia
	• V.A.Chuiko	Deputy Head of the State Comm. of the Forest Industry of Russia
11:00-11:20	**BREAK**	
11:20-11:40	• N.N.Mikheev	Minister of Natural Resources of Russia
11:40-12:00	• Y.M.Selenin	Deputy Head of the Comm. of Natural Resources of State Duma
12:00-12:20	• A.M.Novikov	Head of Department, State Comm. of Russian Federation on Science and Technology
12:20-12:40	• V.A.Parfenov	Department of Natural Resources and Environmental Protection of the Government of the Russian Federation

12:40-13:15	Discussion	
13:15-14:15	**LUNCH**	
14:15-18:00	V. Presentation on 9 Aggregated Themes from Achievements in Phase II of the Siberian Forest Study	Co-chairmen Acad.A.S.Isaev, Acad.S.Nilsson
14:15-14:45	Russian Forests in an International Perspective. Overview and Findings by the Siberian Forest Study.	Acad.S.Nilsson, IIASA
14:45-15:15	Databases and GIS of the Siberian Forest Study	Acad.A.S.Isaev, Russian Academy of Sciences
15:15-15:45	Biospheric Role of the Russian Forests	Prof.A.Z.Shvidenko, IIASA
15:45-16:15	Dynamics of the Siberian Forest Fund and Potential Wood Suply	Dr. G.N.Korovin, International Forest Institute, Moscow
16:15-16:30	**BREAK**	
16:30-17:00	Basic Features of Current Forest Forming Process in Siberia	Acad.V.A.Roshkov, Russian Academy of Agricultural Sciences
17:00-18:00	Press Conference	Acad. A.S.Isaev, Acad. S.Nilsson, Acad. A.I.Pisarenko, and participants of the workshop
18:00-20:00	**Reception**	
	Wednesday, November 13, 1996	
09:30-10:00	V.S.Evsjukov	Deputy Minister, Ministry of Economics
10:00-12:50	**Continued Presentation on Aggregated Themes**	**Co-chairmen Dr.M.Apsey, Acad. A.I.Pisarenko**
10:00-10:30	Russian and Siberian Forest Industry, Current state and Perspectives	Dr.Yu.Blam, Siberian Division of the Russian Academy of Sciences
10:30-11:00	Criteria and Indicators for Sustainable Development of the Russian Forest Sector	Dr.V.V.Strakhov, Federal Service of Forest Management of Russia

11:00-11:30	The Russian Forest Sector and Socioeconomic Development	Mr. M.Obersteiner, Institute for Advanced Studies, Austria and Dr. Jan Granåsen, Umeå University, Sweden
11:30-11:50	Land-Use and the Forest Sector	Dr.V.S.Stolbovoj, IIASA
11:50-12:50	Discussions on results presented during Day 1 and 2 and priority setting on policy issues and a research agenda for the Russian forest sector	
12:50-14:00	**LUNCH**	
	The Policy Mode	
14:00-14:30	Presentation of the Policy-Exercise Concept	Acad.S.Nilsson, IIASA, Acad.A.S.Isaev, Russian Academy of Sciences, Dr. Peter Duinker, Lakehead University, Canada
14:30-15:20	Comments	Russian Federal Ministries and Governmental Agencies
15:20-16:00	Institutional Aspects	Dr. Lars Carlsson, Luleå University of Technology, Sweden
16:00-16:20	**BREAK**	
16:20-18:00	General discussion on the design of the policy mode of the study	
	Thursday, November 14	
09:00-11:30	Drafting Working Plan for the Upcoming Policy Part of the Study	IIASA and Russian Network of the Study
11:30-13:00	Round table Discussion with participation by mass-media	Acad.S.Nilsson and Acad.A.S.Isaev
13:00-14:30	**LUNCH**	

Appendix 2

Study Network Contributors to the Dialogue Presentations
Listed in Alphabetical order.

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