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Dialogue on Sustainable Development of the Russian Forest Sector – Volume II

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Contents

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 II and deals with the background information for the "Dialogue" in the form of short summaries on the results achieved so far by the IIASA Study.

Dialogue on Sustainable Development of the Russian Forest Sector – Volume II

Sten Nilsson, Editor

1. Introduction

The Russian Academy of Sciences, the Federal Service of Forest Management of Russia, and IIASA hosted a "Dialogue on Sustainable Development of the Russian Forest Sector" in Moscow in November, 1996. The ultimate goals of the "Dialogue" were to initiate intensive, cooperative policy work for the future between the Russian Academy of Sciences, various Russian ministries and agencies, and IIASA and to stimulate increased governmental priority with respect to the Russian forest sector. To achieve these goals, IIASA's study on the Russian forest sector 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. Towards this end, the international team of the IIASA Study presented the scientific results achieved so far by the study.

The outline of the agenda of the Dialogue was the following: statements by Russian governmental representatives, aggregated theme presentations on achieved results by the IIASA Study, presentations of a future policy concept and required institutional analyses of the Russian forest sector.

In addition, short "Summary Sheets" describing each of the subactivities carried out so far by the IIASA Study were distributed to the participants before the Dialogue. Each of the summary sheets have the following outline where applicable: Title, Background, Task, Approach, Results, Most Important Findings, and Policy Recommendations.

In Volume I the theme papers and conclusions are presented, and in Volume II the summary sheets are presented.

These summary sheets were originally produced by members of the IIASA Study core-team and by members of the Study's Russian network.

2. List of Summary Sheets for Individual Subactivities of the IIASA Study

1. Databases and GIS of the Siberian Forest Study
    - Databases and GIS
2. Development of the Russian Forests
    - The Development of the Russian Forests
3. Greenhouse Gases
    - Current Increment and Mortality of Russian Forests
    - Phytomass of the Russian Forests
    - Disturbances in Russian Forests
    - Soil and Litter Carbon
    - Carbon Cycle and Forest Management
    - Russian Forests and the Global Carbon Cycle
    - Assessment of Methane Fluxes from the Russian Soils
4. Forest Resources and Utilization
    - A system for Evaluation of Growth and Productivity of the Russian Forests
    - Modeling the Forest Fund's Natural and Anthropogenic Dynamics
    - Estimation of the Maximum Sustainable Allowable Harvest
    - Economic Wood Supply
5. Biodiversity
    - Biodiversity of Siberian Forests: Concepts, Preliminary Analyses, and Proposed Research Directions
    - Landscapes and Bioproductivity
    - Endangered Species
    - The Influence of Forest Exploitation on Species Biodiversity in the Russian Far East
6. Non-Wood Products and Functions
    - Non-Wood Products from the Russian Forests
    - Some Aspects of Hydrology of Siberian Forests
7. Environmental Status
    - Anthropogenic Stress Factors to Forests in Siberia
8. Transportation Infrastructure in Siberia
    - Transportation Infrastructure
9. Industry and Markets
    - Trade and Marketing
    - Industrial Structure

10.Socio-Economics
- Relocation of Russian Industry
- Restructuring of Social Assets in Russian Enterprises
- Employment in the Forest Sector
- Welfare Indicators
- Demographic Development

11. Institutional Aspects
- Russian Forest Legislation

3. Presentation of the Individual Summary Sheets

In the following the individual summary sheets are presented.

TITLE: Databases and GIS

BACKGROUND: The IIASA Forest Study has from the very beginning set to its prime objectives to **develop a comprehensive geographical database for facilitating the research activities**. In the early stages of the study, the project was faced with the situation, that most of the relevant information describing the interest areas of the study were distributed both geographically and in various administrative as well as scientific organizations. A prerequisite for enabling the planned research activities in the different interest areas regarding the Siberian forests, was an integrated information system. Due to the locational aspect of the various phenomena, and their relationships both in time and space, the information system had to incorporate the capability of managing geographically referenced information.

TASKS: The process of establishing the IIASA Siberian Study Information System (IISIS) included a **database development** and an **application development** life cycle. The database development followed the path of database design, implementation, and validation. The application development succeeded through the phases of system definition, system design and implementation. As an overseeing objective of the 'Databases and GIS' cornerstone was to **develop a geographical database** containing the data needed for the scientific research of the Siberian Forest Study, as well as to **implement an application environment** to facilitate the management of the databases and the access of the geographical database for the scientific end-user.

APPROACH: The **database design** step targets to define the logical and physical structure of the database system, which is based on the information needs of the project. The design of the database system was executed using the Entity-Relationship (ER) methodology by Chen, with the help of the System Architect (Popkin Software & Systems Inc.) CASE-tool (Computer-Aided Software Engineering).

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

The **system definition** included the investigation of the technical computing environment, which was employable for the project, and the end-user requirements of the application environment. The technical requirements, extent of the database and foreseeable end-user profile, and the existing hardware and software environment, led to the decision of a client-server implementation of the application environment. Due to the project timing constraints, as well as the basic nature of a scientific research project, a decision was made to implement the application environment using standard software packages.

The **implementation of the application environment** relied on the computing infrastructure supported by the International Institute for Applied Systems Analysis (IIASA). The application environment was divided into server applications, which are running on UNIX servers, and end-user applications, which are running on the personal computers of each scientist. The server application are used mainly for the setup and management of the information system, and the processing of special needs. For the activity of relational database management Oracle DBMS (version 7.0.16) was used, and for the need to manage the geographical information system Arc/Info (version 7.0.1) was used. The end-user applications facilitate a 'point-and-click' access to the database, and a simple map browsing and drawing capability. This was archived using Microsoft Office package and the Arc/View (version 2.1) program.

RESULTS: The database design task concluded with the **logical and physical database descriptions**. This collection of data definitions and background information about the IIASA Study database can also be referred to as a **meta-database**. This description of the database acts as the starting point for the scientific end-user of the existing data resources. In the current state the data description of the IIASA Russian Forest Study database contains the definitions for 370 data tables or 5908 parameters.

The implementation of the **IIASA Study database** consisted of a relational database development task, and GIS map compilation tasks. In its current form the Study information system contains the following **thematic data components**: the Forest State Account, the GOSCOMSTAT socioeconomic description, the GOSCOMSTAT atmospheric pollutant description, the ecoregion description, the landscape description, the forest industry enterprise description, as well as a number of different case-study descriptions from various Siberian regions. The main **GIS layers** of the information system are: Forest Enterprises of the Russian Federal Forest Service, Russian Ecoregions and Landscapes, Russian Soil-Carbon map, and various digital maps of the endangered animal and plant species as well as the main medicinal plant species. The total size of the Study relational database is close to 400 Megabytes, and the size of the various GIS data layers totals to 610 Megabytes.

The **IIASA Study application environment** was setup for fulfilling the needs of database and GIS management for the expert users, as well as the needs of simple querying and visualization for a normal scientific end-user. The application environment has proved its efficiency and usability during past two years, especially during the IIASA 1995 and 1996 Young Summer Scientist Programs.

MOST IMPORTANT FINDINGS: The key achievement of this activity 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 Russian forests, forest industry, ecology and socio-economics.

TITLE: The Development of the Russian Forests

BACKGROUND: 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 ha. Poor forest management, insufficient forest protection, substantial losses by anthropogenic disturbances, and huge losses of wood at harvests and during wood processing have repeatedly been reported and illustrations of the exhaustive nature of forest utilization in Russia in recent decades are plentiful. However, explicit conclusions on the state and development of forest 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. However, the inventory data employed must be reliable and accurate.

TASK: To analyze the consistency, accuracy and reliability of Russian inventory data, forest inventory methods, and the dynamics over time of the Russian forest resources.

APPROACH: For the analyses the basic data from the Forest State Account from 1961-1993 have been used. Concerning the validation of the inventory methods, a number of control inventory studies have been employed.

RESULTS: The Forest Inventory and Planning method (FIP) underestimates the growing stock in mature and overmature forests by 5-15%, and sometimes more. The aerotaxation method, used widely during the 1950s and 1960s, overestimated the growing stock by 20-25% and sometimes by as much as 30-50%. The third method used in the Russian inventory is remote-sensing, which is estimated to have a standard error of ±3% at 95% probability for the growing stock of a forest enterprise and employed for large areas.

After adjusting for changed inventory instructions and redistribution of forests between different agencies over time, we get a development of the Russian forest resources according to the official statistics as presented in Tables 1-3.

Table 1. Development of different categories of forest areas and growing stock in all Russian forests between 1961 and 1993. Areas in million ha and growing stock in billion m^3.

Indicators	1961	1966	1973	1978	1983	1988	1993	Relative change 1993 to 1961
Forest Fund (FF), x 10^6 ha	1162.9	1161.9	1161.4	1186.2	1187.7	1182.6	1180.9	1.02
Forest Land (FL), x 10^6 ha	848.1	863.0	862.1	872.3	880.5	884.1	886.5	1.05
Forested Area (FA), x 10^6 ha	695.5	705.6	729.7	749.5	766.6	771.1	763.5	1.10
FA in European Russia, x 10^6 ha	148.9	161.3	158.8	163.5	164.4	166.0	166.6	1.12
FA in Asian Russia, x 10^6 ha	546.6	544.3	570.8	586.0	602.2	606.1	597.0	1.09
Total FA available for harvest,x 10^6 ha	295.6	342.9	338.6	345.6	385.3	406.2	351.1	1.19
Total FA as a percentage of total land area, %	40.8	41.3	42.8	43.9	44.9	45.2	44.7	1.10
Total Growing stock (GS), x $10^9 m^3$	77.5	77.0	78.7	80.7	81.9	81.7	80.7	1.04
GS in European Russia, x $10^9 m^3$	16.3	17.0	17.4	18.7	19.3	20.3	21.1	1.29
GS in Asian Russia, x $10^9 m^3$	61.2	60.0	61.3	62.0	62.6	61.4	59.6	0.97
GS total in mature and overmature coniferous forests, x $10^9 m^3$	51.1	48.0	46.4	45.3	43.0	40.0	35.3	0.69

Table 2. Development of different categories of forest areas in Russia under state forest management between 1961 and 1993, including long-term leases[1], and in million ha (x10^6 ha).

Indicators	1961	1966	1973	1978	1983	1988	1993	Relative change 1993 to 1961
Forest Fund (FF)	1110.6	1105.6	1103.4	1123.0	1119.7	1115.8	1110.5	1.00
Total Forested Area (FA)	652.0	657.4	678.9	694.3	708.5	713.5	705.8	1.08
FA of CON[2]	499.5	489.6[3]	508.3	512.7	526.5	526.4	507.7	1.04
FA of HD[2]	34.2	24.2[3]	17.6	17.0	17.5	17.1	17.3	0.51
FA of SD[2]	102.5	111.8[3]	108.2	108.5	110.8	109.7	113.2	1.10
Total FA covered by mature stands	437.1	381.9	407.1	387.8	376.7	357.3	340.1	0.78
Accumulated area of forest plantations transferred to FA	2.0	5.9	9.7	11.7	14.5	16.5	17.3	8.65
Unforested Area (UFA) of which	152.6	144.2	124.8	116.1	106.7	106.2	74.1[4]	—
•unregenerated harvested areas	14.0	13.3	9.5	10.2	8.6	8.6	8.5	0.61
•burns, dead stands and grassy glades	70.6	68.4	51.5	43.9	36.8	34.9	31.9	0.45
•sparse forests	68.0	62.5	63.8	62.0	61.3	62.7	33.7[4]	—
Non-Forest Land (NFL)	311.4	300.8	296.8	309.0	300.5	292.2	285.3	0.92

1) Forest management transferred to agencies other than forest agencies, normally to agricultural agencies for temporary use.
2) CON, HD, SD — stands dominated by coniferous (CON), respectively hard deciduous (oak, beech, hornbeam, stone birch, etc.) species (HD) and soft deciduous (aspen, birch) species (SD).
3) Data given without long-term leases.
4) The 1993 inventory divided sparse forests (a part of unforested areas) into natural sparse forests (growing under severe climatic conditions, e.g. on the tree line in the north or in subalpine zones) with an area of 41.4 million ha and anthropogenic sparse forests which are subject to reforestation.

Table 3. Development of growing stock and its utilization in Russian forests under state forest management, including long-term leases.

Indicators	1961	1966 [2)]	1973	1978	1983	1988	1993	Relative change 1993 to 1961
Growing stock x $10^9 m^3$ (GS)	74.1	73.5	74.0	74.7	75.4	74.7	73.0	0.99
of which - CON	62.8	60.7	61.0	60.6	61.3	60.2	57.7	0.96
- HD	1.6	1.5	1.8	1.8	1.8	1.8	1.9	1.19
- SD	8.7	9.5	10.2	10.7	10.9	11.3	12.1	1.39
Total GS in mature forests, x $10^9 m^3$	56.1	52.8	52.5	51.5	49.1	46.3	42.0	0.75
GS in mature coniferous, x $10^9 m^3$	48.8	45.6	44.6	44.3	41.8	38.7	34.2	0.70
AAI[1)], x $10^6 m^3$	789.2	792.1	821.1	855.0	874.2	844.1	830.0	1.05
AAC[1)], x $10^6 m^3$	648.9	608.5	600.9	610.0	613.6	615.0	529.0	0.77
Final Fellings, x $10^6 m^3$	321.2	331.1	335.5	318.1	299.0	319.6	174.2	0.52
Thinnings, x $10^6 m^3$	13.6	15.4	24.0	24.8	25.9	26.9	19.9	1.46

1) AAI (annual average increment is defined as an average ratio between growing stock and age weighted by area), AAC (annual allowable cut, i.e. long-term norm for sustainable harvest level) as well as final fellings and thinnings are all accounted in m^3 of commercial wood. The official conversion factor for conversion of commercial wood to growing stock is 1.12% (Goscomles SSSR, 1991).

2) The Forest State Account (FSA) from 1966 did not account for growing stock in long-term leased forests.

From 1961 to 1993, the Forested Areas of Russian forests increased by 68 million ha, mainly in forests under state forest management. From 1961 to 1993 the total growing stock of all forests increased by 3.2 billion m^3, but 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 the 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. Thus, factors other than harvests have been driving the decline of growing stock in Siberia.

If we take into account the systematic errors in the inventory and adjust for the same, we get a development which is illustrated in Table 4.

Table 4. Reconstructed development of total growing stock in all Russian forests from 1961 to 1993.

Indicators	1961	1966	1973	1978	1983	1988	1993
Percentage of FF area inventoried by FIP in European Russia	36	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 m3 during the studied period, but we still have a severe decline in Siberia during 1983-1993 (2 billion m3).

MOST IMPORTANT FINDINGS: The analyses presented make it difficult to justify the premise that Russian forests are disappearing from a global and quantitative perspective.

POLICY RECOMMENDATIONS:

- There is no doubt 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 quality of the Russian forests in all respects.

- The causes for decline in mature and overmature coniferous forests in Siberia during 1983-1993 have to be clarified in order to take the necessary policy measures against a continued decline.

TITLE: Current Increment and Mortality of Russian Forests

BACKGROUND: Current state, productivity and vitality of forests, as well as some important interactions between forests and major geobiogeochemical cycles, can only be reliably described in a quantitative mode based on knowledge of current increment (gross and net growth). The Russian forest inventory does not directly measure the current increment in inventoried stands, and any official regional or aggregated data have never been published.

TASK: To estimate the increment for dominant species at an ecoregional level, as well as for the subjects of the Russian Federation indicators of the current increment. The indicators studied are gross growth dTV (i.e., total amount of stem wood produced by forests stands currently), net growth dGS and (current) mortality dM, dM=dTV-dGS.

APPROACH: The indicators have been evaluated with the help of a special modeling system developed within the framework of IIASA's Forest Study. (see details in a SYSTEM FOR EVALUATION OF GROWTH AND PRODUCTIVITY OF RUSSIAN FORESTS). Aggregated data of the Forest State Account (growing stock, age, site index, density by dominant species) have been used in the calculations. Taking into account the specifics of the system mentioned above, some corrections of the results could be done based on regional modeling and expert estimates of the decline in increment due to current environmental stress. These corrections decrease the initial calculations for the total country by 6.7% (and the Asian part by 4.0%).

RESULTS: Gross growth (dTV) for all of Russia has been estimated to be 1750.9 million m^3 of which 717.9 million m^3 (or 41%) are located in the European part. About 68% of both dTV and dGS are generated by coniferous, 28% by soft deciduous species and 3% by hard deciduous species. Total net growth is estimated to be (dGS) 905.6 million m^3 of which 41.8% is in the European part. Mortality is estimated at 845.3 million m^3 of which some 60% is located in the Asian part. The data given above only represent the estimate for forested areas. The indicator dM does not include mortality caused by stand-replacing disturbances (e.g., clear cut, crown and peat fires, etc.). Mortality includes natural, pathological and mechanical mortality, which varies significantly for different species and regions. The estimates of the increments for the economic regions are presented in Table 1.

Table 1. Gross growth (dTV), net growth (dGS) and mortality (dM) over economic regions of forested areas in Russia expressed in million m^3 per year

Region	dGS	dM	dTV
Prtibaltijsky	1.15	0.91	2.06
Northern	100.78	104.94	205.72
North-Western	26.30	23.83	50.13
Central	71.26	56.19	127.45
Volgo-Vjatskiy	45.32	37.60	82.92
Central-Chernozjemniy	15.81	14.89	19.90
Northern Caucasus	12.27	10.97	23.24
Ural	99.10	85.24	184.34
Total-European part	378.6	339.	717.9
West Siberia	108.46	113.32	221.78
East Siberia	240.67	212.28	452.95
Far East	177.86	180.43	358.29
Total-Asian part	527.0	506.0	1033.0
Total Russia	905.6	845.3	1750.9

MOST IMPORTANT FINDINGS AND RECOMMENDATIONS: The estimates presented above are a first aggregated intermediate estimates of current increment and mortality for the Russian forests. The rather high level of mortality (48.2% of total productivity) is explained by anthropogenic and natural disturbances.

The regional and aggregated data are extremely important for forest management as reference data for reaching sustainable development of the Russian Forests. Due to the fact that dTV is the (stem) woody part of Net Primary Productivity and dGS is the (stem) woody part of Net Ecological Productivity, they help can to clarify the interaction between the Russian forests and the global carbon budget.

TITLE: Phytomass of the Russian Forests

BACKGROUND: The storage and dynamics of phytomass are important biological indicators which are relevant for the quantitative description of several criteria for sustainable forest development. Two examples of such indicators are the biological productivity of forest ecosystems and the impact of forests on the carbon budget. A systematic analysis of the inventories of vegetation phytomass in forests was started at the beginning of IIASA's Forest Study in Russia.

TASKS: To conduct three steps of analysis:
1) To develop a Data Base on forest vegetation phytomass fractions over basic characteristics of forest stands (species, age, site index, forest type, geographical location, etc.) including all available and carefully cross-checked data; 2) To generate a unified set of regression models for the estimation of phytomass fractions by dominant species and geographical regions; 3) To evaluate current stock and the recent dynamics of the phytomass fractions by administrative units of Russia.

APPROACH: The following phytomass components were included in the analyses: foliage (needles), branches (wood and bark of the crown branches), stem (wood and bark of the stems), understory phytomass (forest floor phytomass + undergrowth + bushes), and below ground forest stand phytomass. The total phytomass of the forest ecosystem vegetation was calculated as the sum of the components listed above. Due to the fact that data from the Forest State Account was intended to be used as the basic initial data, the ratio $R_{v(fr)} = V_{fr} / V_{st}$, where V_{fr} is the weight of a phytomass fraction in megagrams, and V_{st} is the growing stock in cubic meters, was used in the calculations. Multiple regression approaches, which were adapted specifically for forest biometric calculations, were used in the search for adequate analytical models, employing the following parameters: age, average diameter, average height, site index and relative stocking.

RESULTS: The developed data base includes about 2500 sample plots with direct measurements and different statistical aggregations. Regression models for $R_{v(fr)}$ were developed for the main forest forming species covering about 90% of the Russian forested area. The equations included (at 5% level of significance) age and site index and had a good fit for the majority of phytomass fractions for given species and a given region. Complex exponential equations were used in the analysis. The results were validated by statistical methods based on the significance of multiple non-linear correlation coefficients and different published data of direct measurements and statistical evaluations. The calculations on the storage of forest phytomass fractions $R_{v(fr)}$, used age, site indices and the growing stock by dominant species parameters.

Aggregated results on the phytomass of the Russian forested areas are presented in Table 1. The total C content of the forest vegetation in 1993 was estimated to be 32.09 Pg C of which 7.96 Pg C, or 25%, were stored in the European part of Russia. The average C density is estimated to be 4.04 kg C/m^2 in the Asian part and 4.79 kg C/m^2 in the European part. The total average C density for Russia is 4.20 kg C/m^2. The regional variation of the density is in the range of 3.33 (East Siberia) to 7.80 kg C/m^2 (Northern Caucasus). By using the average regional ratio $R_{v(fr)}$ (which at average is 0.398 Mg C/m^3 for all Russia) and forest inventory data it could be shown that from 1961-1993 the stock of phytomass in forest vegetation increased: 1) if official statistical inventory data are used: from 30.93 to 32.09 Pg C (the increase is 3.8%), and 2) if a "reconstructed" dynamics of growing stock (in which systematic errors of forest inventory data are deleted) is used: the phytomass is estimated to have increased from 29.92 to 33.73 Pg C or 12.7%. If we consider the last ten year period (1983-1993) the phytomass stock decreased slightly (by -1.6%) based on the official data and did not change at the application of the "reconstructed" dynamics.

Table 1. Phytomass and carbon content of the forest vegetation in forested areas of Russia in 1988.

Regions	Stock of phytomass		Carbon content		$R_{v(fr)}$
	Total, Tg	Density, Mg/m^2	Total, Tg	Density, Mg/m^2	
Pre-Baltiisky	35.0	12.86	17.4	6.40	0.373
Northern	6721.1	8.87	3306.7	4.37	0.417
North-Western	1096.4	10.85	543.4	5.38	0.343
Central	2145.6	10.30	1063.2	5.10	0.342
Volgo-Vjatskiy	1304.7	9.72	646.0	4.81	0.347
North-Chernozjomniy	164.4	11.05	80.6	5.42	0.377
Povolshskiy	430.3	9.00	213.6	4.47	0.358
North-Caucasian	585.6	15.68	291.3	7.80	0.440
Uralskiy	3635.6	10.14	1799.0	5.02	0.353
Total-European part	16118.7	9.70	7961.2	4.79	0.377
West Siberia	8374.6	9.30	4187.3	4.65	0.382
East Siberia	21241.5	9.32	10620.7	4.66	0.384
Far East	18637.7	6.67	9318.9	3.33	0.445
Total-Asian part	48253.8	8.08	24126.9	4.04	0.405
Total-Russia	64372.5	8.43	32088.1	4.20	0.398

MOST IMPORTANT FINDINGS AND RECOMMENDATIONS: There is evidence of a decreasing phytomass development during the last 10 years. These tendencies are connected with the high level of disturbances in the Russian forests, basically caused by other factors than harvests, It means that future forest management in Russia should pay much more attention to forest protection against fire and outbreak of insects and pests.

The results of the calculations are crucial for the evaluation of the carbon budget of the Russian forests.

TITLE: Disturbances in Russian Forests

BACKGROUND: Anthropogenic and natural disturbances, defined as any external impact, which change the natural – i.e. evolutionary successional dynamics of a forest ecosystem – can significantly influence the state, productivity, and biodiversity of forests. In spite of the fact that Russia is one of the few countries which possess vast areas of natural and virgin forests, the rate of disturbance is still high. Specifically in the boreal zone of Russia. Evidently, disturbances must be closely monitored and evaluated in a quantitative manner.

TASK: (1) To develop a relevant classification system of the disturbances and a set of relevant indicators for their description, and (2) to collect data and evaluate the impact of disturbances on successional dynamics, productivity and major biogeochemical fluxes.

APPROACH: Analyses of the disturbances are related to two basic objects, namely forest biogeocensis and landscape. Classification of the disturbances must be closely linked with criteria used for the assessment of sustainable development and sustainable forest management. Several different classifications have been used; by genesis, by the type of the disturbance (biotic, abiotic and anthropogenic disturbances), and by successional dynamics (e.g. stand-replacing and non-stand replacing disturbances).

The indicators used to describe the disturbances at an ecosystem level are; extent, frequency, intensity, synergetic impacts, and successional time. The indicators at the landscape level are loss of productivity and changes in forest cover.

To make quantitative estimates of the different disturbances by ecoregions, data from the national forest inventory, regional surveys, and numerous publications have been employed.

Results: The total Forest Fund area that is significantly impacted by disturbances is estimated at 10 million ha annually. Five major groups of disturbances – fire, outbreaks of insects and diseases, harvest, industrial exploitation (such as oil and gas exploitation), and pollution – contribute by some 90% of the severe disturbances to the Russian forests.

These disturbances are crucial for the successional dynamics of the forests in the European North, West Siberia, East Siberia and the Far East. The consequences of the disturbances are a decreased share of virgin and natural forests, expansion of secondary forests, and losses of productivity.

Under optimal ecological conditions the relative stocking for large regions in Siberia is in the range of 0.75-0.85 but the current relative stocking is in the range of 0.5-0.6. The losses of potential productivity due to disturbances is estimated to be 30-50% for major taiga regions.

Estimates indicate that the expected climate change will increase the disturbances substantially in the Russian forests mainly by increased forest fires and increased outbreaks by insects and pests.

POLICY RECOMMENDATIONS: There is an urgent need to improve the current forest monitoring system with respect to disturbances, specifically in Siberia and the Far East. Remote sensing methods present one possibility to achieve operative and reliable data on disturbances in Northern Regions of Russia. But it is also important to collect information on the productivity which should be measured at 3 levels: actual, achievable (corresponding to the principles of sustainable development), and potential.

TITLE: Soil and Litter Carbon

BACKGROUND: Soil cover represents the largest reserve of carbon in terrestrial ecosystems. The role of soils in global cycling is crucial. However, soils still remain one of the least studied carbon sinks. There are only scattered quantitative analyses available which, to a large extent, is a result of a lack of commonly accepted methods for soil carbon assessments. This is especially true for the evaluation of stable and labile compounds of organically-bound carbon.

TASK: To determine soil carbon estimates for Russia supported by an extensive database including both organically-bound and carbonate-bound carbon, carbon stored in litter, and the stone content in different soil types. Also, to represent the soil carbon estimates in a digitized map.

APPROACH: An extensive database on soil types and corresponding carbon content for Russia was created. Special assessments were carried out on the bulk density of soils, content of stones, and content of coarse organic fragments. These data were employed in the estimation of the Russian soil carbon.

RESULTS: The estimate shows a total pool of 453,367 million tons of carbon in the 0-100 cm layer of Russian soils. From this total carbon pool, 25% (or 111,279 million tons) are in the form of carbonates, and 75% (or 342,089 million tons) are in the form of organic carbon. Of the organic carbon, some 35% (or 119,461 million tons) are accumulated in peat and litter.

For each of the layers 0-20 cm, 0-50 cm, 0-100 cm digitized maps of the carbon content have been constructed.

MOST IMPORTANT FINDINGS: The most important finding may be that the total carbon pool estimate for Russian soils is substantially higher than earlier published estimates. This can be explained by better data, more thorough assessments, and the inclusion of the carbonates in the estimate.

POLICY RECOMMENDATIONS: It is clear that Russian soils play a crucial role in the global carbon cycle. Therefore, it is extremely important that Russian authorities establish policies for land-use and forest management that can support a sustainable or increased development of the soil carbon pool in Russia.

TITLE: Carbon Cycle and Forest Management

BACKGROUND: Analyses of the state and structure of the Russian Forest Fund allows us to conclude that forest management regimes complying to the criteria of sustainable forest management will significantly increase the sequestration of carbon by the Russian forest ecosystems. Russia has some important advantages with respect to increased carbon credit offset due to: 1) vast areas available for large-scale reforestation; 2) low cost of lands; 3) stability of Russian temperate and boreal forests is rather high, and 4) major forest forming species have relatively long life spans.

TASK: To develop, at the ecoregional level, a scenario of forest management options within the framework of sustainable development, which could provide a significant increase in carbon sequestration by Russian forests during the next century.

APPROACH: The developed scenario is based on the following basic prerequisites: 1) the cost of 1 ton additionally sequestered carbon should not exceed 3 US $ (1992 year's dollar value); 2) it should be possible to realize the scenario with current available labor and technologies; 3) the period of scenario implementation is 40 years, and all impact calculations should be made for 100 years following the year of the start of the scenario implementation. The scenario includes 3 major components: 1) increase of forest productivity through improvement of the state of forests and structure of the Forest Fund (large-scale afforestation, reconstruction of less productive stands, partial replacement of soft deciduous and "climax" forests and intensified thinning); 2) decreased carbon losses of forest ecosystems by improved protection of forests and improved forest product utilization; 3) improved landscape management (agroforestry, urban and industrial ecological management). The additional sequestration of carbon has been estimated as the difference between carbon storage after the realization of the above options and the carbon storage of current stands.

RESULTS: The basic results are presented in Table 1. An implementation of proposed measures will significantly increase the carbon sequestration: the average estimate of additional carbon sequestration is 600 Tg C annually although uncertainties of the estimates are rather high - the range is from 345 Tg C/year to 845 Tg C/year. The extent of future uncertainties significantly depend upon future social, political and economic developments in Russia. However there are no doubts that Russia has substantial potential towards increased carbon sequestration.

Table 1. Possible increase of carbon sequestration due to improved forest management in Russia during next 100-years period.

Options	Area involved at the end of 40 years period	Annual rate, million ha	Additional sequestration Pg C	Total carbon sink, Pg, by version	
				low	high
Large-scale reforestation of unforested areas	64	1.6	9.8	6.9	14.0
Reforestation of burned areas and clear cuts	20	0.5	3.1	2.1	4.4
Reconstruction of low-stocked forests	60	1.5	6.7	4.0	12.0
Rehabilitation of “climax” stands	25	0.6	2.7	2.2	5.1
Implementation of appropriate intermediate stand treatment	75	6.0	-	-	3.0
Improvement of forest protection	1010	-	0.3	8.5	19.5
Decreased impact of abiotic factors	-	-	4.1	2.6	9.5
Agroforestry	60	1.5	13.3	8.2	17.0
Total for the scenario			**40.0**	**34.5**	**84.5**

RECOMMENDATIONS: Currently Russia does not have the economic means for a complete realization of the scenario. Some of the measures, which are vital in existing forest management regimes (agroforestry, forest fire protection, forest regeneration, etc.) are currently provided to a small extent. In the initial period of transition to sustainable development the implementation of pilot projects in specific territories (with areas from hundred thousands to million hectares) would be relevant. Such projects could be supported by large domestic and foreign companies if the selected regions have a strong forest industrial structure and appropriate conditions for forest investments. Foreign governments (e.g., in the framework of such initiatives as the “Model Forest”) could support such activities. However sufficient and improved forest protection is an obligatory prerequisite for carbon forest management.

TITLE: Russian Forests and the Global Carbon Cycle

BACKGROUND: Some 20% of the world's closed forests and nearly 80% of the total boreal forests are located in Russia. These huge areas of Russian forests play an important role in global biochemical cycles and also consequently play a crucial role in the mitigation of estimated future climate change. Forests can act as a sink or source of greenhouse gases depending on the state, productivity, species, age structure, and rate and extent of disturbances. The forests' capability to maintain global ecological cycles is one of the criteria for sustainable forest management.

In light of the fact that Russia has signed the Climate Convention, an estimate of the Russian forests' current contribution to the global carbon budget is of vital political importance.

TASK: The overall task has been to investigate the interaction between the Russian forests and the global carbon cycle. These investigations include:

- evaluating the current role of Russian forests in the global carbon budget;

- evaluating the possibilities of the Russian forest sector to mitigate global climate change through improved forest management (See Forest Management of Russia and the Carbon Budget); and

- evaluating future dynamics of the forests and their impact on the carbon budget as a result of climate change.

APPROACH: The carbon budget is a dynamic process and estimates can only be done for a specific period of time or for a specific point in time. Estimates on the interaction between forests and the carbon cycle have been carried out for the period 1961-1993, with special analyses for the period 1983-1993.

An approach developed by Canadian scientists for carbon analyses of the boreal forests has been employed, but with significant changes based on the specifics of the forests and forest management in Russia. This approach includes structuring of the carbon pools of the Russian Forest Fund (five initial pools were considered: carbon in living phytomass, in detritus, in soil, in peat and in forest products), estimations of the size of the pools, estimation of the fluxes between the pools and the atmosphere, and water reservoirs. Carbon pools are estimated based on the State Forest Account used within the framework of the IIASA Study, and digitized maps (vegetation, soils, landscapes). Fluxes are calculated following two approaches:

- model estimates based on the productivity of terrestrial biota of different land cover categories of the Forest Fund and impacts of disturbances.

- model estimates based on long-term forest inventory data (1961-1993).

RESULTS: Based on the model approaches, the Russian forests are estimated to be a modest net sink of carbon in the early 1990s — a sink of roughly 100 million tons C per year. The Net Ecosystem Productivity of the Forest Fund (without taking stand replacing disturbances into account) is estimated to 330 million ton C per year and emissions caused by disturbances is estimated to 230 million ton C per year.

Analyses of forest inventory data for the period 1961-1993 allow us to estimate that the average carbon sink for this period was 140 million ton C per year, of which 110 million ton C were sequestered in wood.

During the period 1983-1993 the total Russian forests changed from a net sink to a net source of carbon. The forests of the European part of Russia were still a net sink, but the Asian forests were a major net source due to a strong decline of the growing stock caused by disturbances.

RECOMMENDATIONS: The transition of the Russian forest sector to sustainable development is necessary to increase the role of the Russian forests in the global carbon budget. There are many forest management options available for increasing carbon sequestration but the first option would be to improve the protection of the Russian forests.

TITLE: Assessment of Methane Fluxes from the Russian Soils

BACKGROUND: Methane is involved in many chemical reactions connected with atmospheric gases and thus strongly influences the Earth's energy balance (the greenhouse effect). A molecule of methane (CH_4) is 21 times more radiatively active than one of carbon dioxide (CO_2).

The global atmospheric concentration of methane has increased from a relatively stable level of 0.7 ppm to 1.7 ppm during the last 300 years. The rate of increase has accelerated during the last 100 years.

The total annual global flux of methane to the atmosphere is estimated to be 374-714 Tg. Thus, there is not only great uncertainty surrounding methane fluxes, but also in the processes of methane formation and consumption.

TASK: To develop consistent estimates of the total methane fluxes from the land of Russia.

APPROACH: Two studies have been carried out on this issue. In the first study, the FAO/UNESCO Soil Map of the World was used as a basis for analyses. Each methane producing soil unit was specified with assigned methane fluxes. Estimation of the specific fluxes was made according to directly measured values of emission rates from sites corresponding to specific soil units. The methane emission rate from a certain soil unit was only linked to the length of the period of biological activity in a simple way, namely: permafrost or non-permafrost areas. It was assumed that the emission of methane could only take place during a period of biological activity.

In the second study, the Soil Map of the World was again used as a basis for analyses. But in this case much more direct measurements of data on soil specific fluxes were employed. In addition, the fluxes for different soil units were estimated based on their geographical location and environmental conditions. An attempt was also made to estimate not only the emissions of methane, but the methane consumption by different Russian soils. A specific methane fluxes database for Russia was developed.

RESULTS: The first study resulted in an estimate of the net methane fluxes from the Russian soils to be an average of 39 Tg annually. The second study, which was more detailed resulted in an estimate of annual average fluxes of 24Tg, which is thus substantially lower.

MOST IMPORTANT FINDINGS: The results indicate that the fluxes from the Russian soils generate 3-10% of the global net annual fluxes of methane. This estimate is based on 60% of the land area in Russia with site and soil type specific fluxes and a detailed estimate of the biological active period. The missing 40% of the land areas in the estimate are constituted by soils which are assumed not to influence the total flux estimate.

POLICY RECOMMENDATIONS: The dominating net methane emitting soils are histosols (39%), negosols (33%), and gleysols (19%). In order to reduce the net methane emissions from the Russian soils, emission reducing management plans for these soils must be established.

The majority of soil units with no direct field measurements on the methane fluxes are wetlands and wetsoils. Intensified measurements of fluxes from these soils have to be carried out.

TITLE: A System for Evaluation of Growth and Productivity of the Russian Forests

BACKGROUND: Normative Reference Data (NRD) used to estimate growth and productivity of the Russian forests play a crucial role in many forest and ecological management implementations in Russia. The existing NRD in Russia are presented by numerous models in analytical, and more often, in numerical forms (yield tables of different types, models of current increment etc.). In spite of much effort to arrange these NRD into one consistent system during the 1980s and 1990s in Russia, most of it is inaccessible for large-scale applications (both for the total country, and large-scaled regions such as Siberia etc.) due to:

- Territorial and parametric incompleteness of the NRD (models and tables have not been developed for certain regions and species),
- Use of different definitions and classifications for similar types of tables, and
- Inaccessibility to basic data for computerized analyses.

TASK: To develop a modeling system to estimate growth and productivity of the Russian forests. The basic principles followed for the model development are:

- Spatial and parametric representation
- Regional tables having priority over general tables and model tables having priority over normal tables
- Unified and simple model system
- The accuracy of the estimates from the growth and productivity system should be within ±10% of observed values.

APPROACH: The basic data for the modeling effort includes all available models and tables that describe the growth and productivity of the former Soviet Union (yield tables of different types for fully-stocked stands and models on current increment from actual stands), data provided by various Russian institutes on increment and mortality, and different publications dealing with the subject. The basic classification units are site index and type of age stand structure. The modeling of growth – average height and diameter, basal area, and growing stock – is based on Richard Chapman's non-linear growth function. The basic function is modified in order to handle the dynamics of degenerating phases of evenaged stand development. From the work done it is proven that sets of coefficients from the Chapman function can be rearranged by regression applications to a function of site index classes and densities of growing stock that allow a spatial extension of the model applications.

RESULTS: The modeling system developed includes 2- and 3-dimensional models:

- Stand growth of different Forest Forming Species (FFS) based on general and regional models for fully-stocked stands as well as on regional yield tables for model stands. Growth estimates are available for 17 major forest forming species.

- Models that estimate the productivity of the main FFS (dynamics of growing stock, total productivity, net and gross growth) as a function of site indexes and densities.

- Auxiliary models and expected estimates for unevenaged and mixed stands. The system also includes an algorithm to estimate missing regions and species in the basic data.

MOST IMPORTANT FINDINGS: This is the first time that a system of this kind has been developed for Russia and the Russian forests, making it possible to estimate the current productivity (increment) of the forests. The system can be used in numerous applications in forest management (national forest inventory system, estimation of sustainable harvest etc.) as well as in different ecological evaluations, e.g. for the carbon budget.

It has been suggested that the system be published in numerical form in Russia for wide-scale use after being evaluated and approved by the Federal Forest Service of the Russian Federation.

TITLE: Modeling the Forest Fund's Natural and Anthropogenic Dynamics

BACKGROUND: Quantification of a strategy for sustainable forest management, and sustainable structures of environmental and economic values is impossible without long-term forecasts of the Forest Fund dynamics, taking into account the influence of the entire complex of anthropogenic and natural factors. A useful method to achieve such quantifications is mathematical modeling of the dynamic processes of forest ecosystems in the various regions of Russia. Mathematical modeling also makes it possible to make trajectories of the Forest Fund development, for different regimes of forest resources use, protection and reproduction.

TASK: To develop a mathematical model which allows the formation of trajectories of the Forest Fund development, appropriate for the evaluation of strategies of forest management and the estimation of future forest resource potential. The model formulation is based on available forest inventory data, accumulated knowledge of the main dynamic processes of the Forest Fund, as well as current norms and rules of operation, which regulate forest protection, forest use and reproduction of forests.

APPROACH: The Forest Fund dynamics, i.e. change in time of the structure of forest land cover, species composition and age structure of forests is considered as the result of the biological growth and management impacts. Impacts of forest fires, insects and forest diseases, other anthropogenic and natural factors are referred to as disturbance factors. Influences by harvest, forests reproduction, protection and conservation measures, are referred to as management influences.

Depending on the availability or absence of management two types of Forest Fund dynamics are considered - natural respectively anthropogenic (controlled). Natural dynamics are determined by biological processes of the stand development, such as the natural stand succession, processes of destruction and mortality under influence of biotic and abiotic factors, and natural reproduction of forests on burnt areas and other categories of unforested lands. Anthropogenic Forest Fund dynamics are simulated by imposing management interventions on the natural dynamics of the forest ecosystems. The following types of management interactions are considered: final felling (clear, selective and gradual fellings), thinnings, reconstruction harvests, forest plantations, measures of support for natural regeneration, and measures for forest protection and conservation.

The model developed makes it possible to illustrate the Forest Fund development based on different strategies for forest management. Each strategy is set by a definite regime of forest utilization, level of forest protection and conservation, and regime of forest regeneration. From a set of forest management strategies and connected Forest Fund development one can choose a strategy, which satisfies the ecological and economic restrictions, and provides satisfactory sizes of a sustainable harvest.

Protection of species composition diversity and representation of the main forest forming species in the Forest Fund are considered as environmental restrictions. A non-deterioration in the structure of species composition is considered as a major restriction.

RESULTS: Calculations of the natural and anthropogenic dynamics of the Forest Fund were carried out for each individual ecoregion of Siberia (65) based on the following strategies of forest management: with existing and increased levels of forest protection and conservation; with different degrees of forest regeneration (and on some sites only by natural regeneration); and with restrictions and without restrictions on the required species structure of the forests by the end of the forecasting period (200 years).

MAJOR FINDINGS:

1. The major factors determining the natural dynamics of the Forest Fund in individual ecoregions are the processes of natural succession in the forest ecosystems, the extent of forest destruction after fires, insects and other disturbances, and the nature of the forest forming processes on burnt areas and other unforested areas.

2. The impact of anthropogenic dynamics on species structure of the exploitable Forest Fund is determined by the selected strategy of forest management and the ecological restrictions included in the model.

3. At the current extent of disturbances, the dynamic processes of the forest ecosystems do not lead to irreversible changes in the species composition and the age structure of the forests of Siberia and the Far East. At a constant level of disturbances the Forest Fund comes close to an equilibrium state, at which the age structure of species and unforested areas are stabilized.

4. A realization of the strategies for currently discussed sustainable forest management does not lead to irreversible changes in the species structures of the forests. The forest age structure resulting from anthropogenic dynamics, is accompanied by a current reduction of available growing stock and an increase of the future stock accumulation.

TITLE: Estimation of the Maximum Sustainable Allowable Harvest

BACKGROUND: Current methods to evaluate the sustainable allowable harvest (Annual Allowable Cut - AAC) in Russia do not consider some of the central dynamic processes of the Forest Fund, as well as the ecological and economic requirements of sustainable forest management. Some examples of important dynamic processes affecting the resource potential and the ecological status are forest fires, insect outbreaks, natural succession, and regeneration of burnt areas and unforested lands.

The impact of these processes on the harvest level and required forest regeneration as well as the required measures for conservation and protection of forests dictate the need for new methods to evaluate forest potential under different strategies of forest management.

TASK: To estimate the sustainable annual allowable harvest and illustrate the harvest levels associated with different scenarios on future forest management.

APPROACH: The approach used is described in the Summary Sheet “Modeling the Forest Fund’s Natural and Anthropogenic Dynamics”.

RESULTS: The maximum sustainable annual harvest was estimated for each of the ecoregions employed by the IIASA Study using different forest management strategies. These strategies include scenarios with the existing and with an improved level of forest conservation and protection, with forest plantations and without them, and with constraints on species composition respectively without such constraints.

MAJOR FINDINGS:

1. Anthropogenic dynamics of the Forest Fund in the ecoregions of Siberia and the Far East are significantly dependent on forest management strategies, defined as regimes for forest exploitation, forest regeneration, and the level of forest protection and conservation. Tree species composition of the forests is determined by the ecological constraints set in the model, while the age structure is mainly dependent on the rate of clearcutting.

2. The Forest Fund for each ecoregion is progressively stabilized over time by using a strategy of sustainable forest exploitation. A stable state of the Forest Fund means a stable species and age composition of forests

and unforested lands under constant levels of disturbances and control regimes.

3. Stabilization of the age structure in forests by using final fellings to achieve high sustainable harvest levels leads to a decrease of the growing stock in ecoregions with a substantial amount of mature and overmature stands. The decrease is partly compensated by an increase of the future net increment in these ecoregions.

4. An ecologically determined final harvest does not necessarily cause destructive changes in the species composition and the age structure of the forests.

5. The maximum sustainable allowable harvest in each of the ecoregions in Siberia and the Far East is to a large extent dependent on the initial state of the Forest Fund and the employed forest management strategies. The level of conservation and protection also play a very important role. In areas seriously disturbed (between 0 and 1% of the area annually), the level of annual allowable harvest can decrease by a factor of two for the final harvest. Implementation of systematic forest plantations can increase the sustainable allowable harvest by 10%.

6. A strict ecological constraint based on the species composition can lead to a considerable decrease in the sustainable harvest level, and even a complete elimination of clear fellings. Without employing such species composition constraints, a significant increase in the sustainable harvest level can be achieved.

7. The current level of conservation and protection of forests, the current dominance of natural regeneration, and the current absence of constraints on species composition result in sustainable harvest levels which are lower than the current established allowable harvests for the majority of the Siberian and Far Eastern ecoregions. This is due to the fact that methods currently employed for estimating the allowable harvest in Russia do not take into account stand mortality caused by forest fires and other natural processes, natural stand succession, real regeneration times, and ecological constraints.

TITLE: Economic Wood Supply

BACKGROUND: Due to rapidly changing prices the geographic pattern of roundwood production in Russia has changed considerably. Inefficient allocation of harvesting activities are revealed. An increasing number of enterprises have entered the "dead-zone" of economic accessibility leading to social strain in declining logging towns.

The forest sector has proved to be one of the most successful sectors in helping to restructure the economy of The Russian Federation. Presently there is no doubt that the forest industry will continue to gain relative importance and thus generate increased income and employment. The latter is particularly true for harvesting operations.

TASK: Tailor a Decision Support System for analyses of the Economic Wood Supply using both engineering and economic expert knowledge and taking advantage of the large database of the IIASA Study. The final tool will be able to give sensible answers to the following questions:

- What are the realistic market scenarios?
- How will the geographic pattern of harvest evolve?
- What is the most likely future pattern of employment?
- What if harvesting technology changes?
- What happens if product, production and transportation prices change?
- What can governmental policy interventions do?

APPROACH: Forecasts of national and international demand and prices are calculated by the latest developed econometric approaches using panel data. Harvesting operations are described by engineering models and using individual enterprise data. Productivity of harvesting depends on *inter alia* average log-volume, terrain conditions and snow cover. The geographic distribution of producers is determined by simulation of tender auctions. The model is calibrated with real data. The approach taken allows maximum use of the IIASA Study databases and integrates modeling results from other teams of the vast IIASA scientific network which has been gradually built over the years. These informational links are unique and allow transnational interdisciplinary research.

RESULTS AND RECOMMENDATIONS: Numerical results are not yet presented due to necessary refinements in the data structure. However, it has become apparent in the building process of the modeling tool that:

- Asian countries will be the major buyer markets. Cost competitiveness is the most decisive force in these markets.

- Increasing the market power of Asian buyer countries will result in a higher concentration in the Siberian Forest Sector. Due to the fact that the woodworking industry will have to take advantages of *economies of scale*, harvesting will be scattered around large woodworking plants or strategically placed in the vicinity of transportation ports for export.

- Harvesting activities will have to be abandoned in less competitive regions and new activities will start in others. A better infrastructure to facilitate factor mobility should be financed.

- Contract-uncertainty decreases the total traded volume and leads to inefficient production patterns, thus competitiveness in the entire sector declines. Programs to improve the business environment should immediately come into place.

- Regardless of technological choice and increasing future output, harvesting will have to be less labor intensive. Labor productivity is six times lower than in comparable Western regions.

- Currently the obsolete areas for harvesting from an economic point of view are mainly determined by transportation costs. The uncertainty of future transportation costs is most harmful to any economic action in the harvesting sector.

- Support to the forest industry should only target economically efficient projects. Helping the forest industry in areas where harvesting and subsequent processing are economically inefficient harms the industry and binds labor and other productive factors which could more effectively be employed elsewhere.

TITLE: Biodiversity of Siberian Forests: Concepts, Preliminary Analyses, and Proposed Research Directions

BACKGROUND: Worldwide concern for both forests and biodiversity is now being expressed loud and clear. At the global level, all three of the agreements reached at UNCED in 1992 - i.e., climate, biodiversity and forests - have a major focus on forests. Indeed, much of the global biodiversity debate focuses on forests, and much of the forest sustainability debate focuses on biodiversity conservation. Major attention to forest biodiversity is not reserved only for the threatened, species-rich tropical rainforests, nor for the spectacular temperate rainforests of North America's west coast. It extends to all types of forest ecosystems around the globe, not the least of which are the boreal forests.

Concern for biodiversity in boreal forests is most acute when the timber in those forests is aggressively harvested. Others have described the history of forest exploitation in Siberia. Forest management to date, consistent with practices throughout the world, have not been implemented with a watchful eye toward conservation of biodiversity. Thus, policies for future management of Siberian forests need adjustment so that critical elements of forest biodiversity may be protected while timber continues to be harvested.

TASK: Given our analytical resources, we were modest in setting out goals for the initial analyses of biodiversity conservation in Siberian forests. Our main objective was to use databases acquired by and assembled by the IIASA study to try to understand the broad biodiversity patterns across Siberia at three scales: (a) all Siberia, using an ecoregional database; (b) one ecoregion, using a "forest-fund" database; and (c) one enterprise, using a detailed forest inventory. In addition, we attempted to assemble additional data concerning red-listed fauna and flora, to be used later in further biodiversity analyses.

APPROACH: For forest biodiversity at various spatial scales, the main approach was to use a Geographic Information System to analyze forest-cover patterns and their determination by natural and anthropogenic forces. At the pan-Siberia level, we tried to find relationships between climatic and edaphic factors and the broad patterns of forest types (ecosystem diversity) across Siberia. At the ecoregional level, we used several biodiversity-related indicators to chart effects of management and exploitation on forest sustainability. At the enterprise level, we used various landscape ecological metrics to compare zones of intensive timber harvest with zones of no timber-harvest activity.

RESULTS AND PRINCIPAL FINDINGS: Using broad, continent-scale patterns of temperature, precipitation and soil classes as abiotic driving variables, and phytomass production, dominant-species abundance and distribution, and forest age-class structures as response variables, we showed that the ecoregional database assembled by Russian collaborators for the IIASA study can provide some sound relationships. In particular, vegetation diversity can be modeled as a response to air and soil temperature, heat sums, and intensity of human disturbance.

At the examination of major threats to forest biodiversity in the Angara-Lena ecoregion of south-central Siberia the following indicators were used: forest cover diversity, forest age diversity, critical habitats, forest fragmentation, forest cover extent, and forest disturbance extent. Using these indicators, we were able to identify that threats to forest biodiversity were relatively high in the western half of the ecoregion, due mainly to a lack of protected areas and to high degrees of timber exploitation. In the east half, by contrast, threats to biodiversity are relatively low, due mainly to low levels of timber harvest and a large area of protected landscapes.

We investigated changes in forest biodiversity conditions by comparing logged and unlogged portions of the Katinsky forest enterprise in the Angara-Lena ecoregion. We found logged forests to have a much younger age-class structure and to be highly fragmented compared to unlogged forests. Such patterns have obvious implications for flora and fauna that require unfragmented old-forest habitats.

POLICY IMPLICATIONS: The results of analyses carried out so far at IIASA regarding Siberian forest biodiversity are not directly usable in redirecting policies for operational forest management. However, they do point to potential undesirable effects on forest biodiversity of insensitive exploitation for timber. Clearly, the extent of such effects, and the means to ameliorate them, requires much greater depth of analysis than carried out so far at IIASA. Accordingly, the results have fulfilled two functions: (a) they underscore the importance of examining landscape- and ecoregional-scale problems of conserving biodiversity during intensive forest use and management; and (b) they exemplify promising avenues for a much broader set of further analyses that can be used directly in policy reformulation. The work has generated a proposal for such further analyses, including:

(a) simulation-based analysis of biodiversity-conservation implications of alternative strategies for forest management, at the enterprise level using enterprises in West and East Siberia and the Far East;

(b) pan-Siberian forest biodiversity analysis using augmented databases for ecoregions, landscapes, and forest enterprises;

(c) definition of biodiversity-sensitive forest-management strategies, based on professional experience, research data, and results of forest-level simulation analyses (as above); and

(d) policy assessments for biodiversity conservation.

However, even at this stage, the initial analyses give some broad policy indications:

- in large-scale uniform landscapes forest management will not necessarily decrease the biodiversity, but increase it;
- fire suppression may decrease the diversity;
- a more efficient distribution of protected areas is required from a biodiversity point of view; and
- the biodiversity is directly scale dependent and future policies on biodiversity have to take into account the interaction between the different scales.

TITLE: Landscapes and Bioproductivity

BACKGROUND: The idea of a landscape approach has dominated Russian schools of natural sciences for a long time. The first attempts to regionalize the territory of Russia into landscapes were made already in the middle of the 19th century.

Recent scientific findings underscore the importance of examining landscapes of different scales in ecological forestry research, e.g. the biodiversity complex.

TASK: The tasks of the work carried out have been to generate a database of Siberian landscapes, which could be used for quantitative parameterization of landscapes and for generation of a digitized map of the same. In addition, corresponding estimates of the bioproductivity of the landscapes should be carried out.

APPROACH: All existing landscape classifications in Russia were compiled with the objective to integrate different landscape concepts into a unified system. The work followed the theory of enumerative classifications.

The unified landscape description was used to improve bioproductivity estimates by overlaying Basilevich's maps of vegetation and bioproductivity on the landscapes. Bioproductivity estimates can also be generated by combining the unified landscapes with forest succession data.

RESULTS: The formalized landscape description allowed us to represent so-called Natural Area Complexes (NAC) determined by different authors in a unified data space. The landscapes (or NACs) could be represented in a digitized map form.

The currently identified set of large-scale landscapes in Siberia (or "landscape types" or "regions"), based on the analyses, and currently employed by the IIASA Study, consists of 347 landscapes to be used in Biodiversity analyses.

A more detailed division of landscapes is under development (more than 2,000 landscapes and about 4,000 map polygons) for consistent analyses of bioproductivity and forest succession.

MOST IMPORTANT FINDINGS: Maybe the most important finding so far was that it is possible to unify all existing landscape concepts in Russia into one consistent system.

POLICY RECOMMENDATIONS: The work presented is an excellent tool for analyses of policies affecting forest dynamics, forest productivity and biodiversity.

TITLE: Endangered Species

BACKGROUND: Loss of biodiversity and the growing number of endangered species is increasingly becoming an international problem. Numbers of species of plants and animals are declining rapidly and, in many cases, exactly what is being lost is unknown. Other than the intrinsic value of life, many species have economic or social potential as medicinal or food resources, as wood or paper products or genetically to be combined with weaker agricultural species.

Asia has a strong history of using plants with medicinal properties both in the home and as part of manufactured medicines which are produced and sold. Currently 40% of all medications used in Russia are of plant origin. These species are important both socially and economically throughout the regions in which they are found and for the country as a whole.

TASK: An initial step towards formation of policy regarding species biodiversity is to identify and catalogue the distribution and abundance of species. With a focus on endangered plants (including vascular and non-vascular), animals (including mammals, birds and reptiles) and plants with medicinal value the purpose of this aspect of the study is to list the species found in the Russian Siberian forest, establish some basic ecological requirements and map current habitat ranges. These ranges should be compared with protected areas and used as part of management strategies for the future.

APPROACH: Using information from a variety of sources, including Russian text concerning rare and medicinal species, a list of 145 endangered plants, 120 medicinal plants and 43 endangered animals was made. Information concerning ecological requirements, degree of endangerment, medicinal value and part of plant used pharmaceutically was included and a spreadsheet compiling this information was formed. Maps of current ranges for individual species were drawn using ARC/INFO (geographical information systems) and have now been included in the IIASA Study's database.

RESULTS: Although statistical analysis concerning ranges and concentration of species has not been conducted yet, it is obvious that a large percentage of endangered species are found in the Far East, in particular in the Primorski Kray and Sakhalin Oblast regions. There are also fairly large concentrations around lake Baikal, in the Buryat Republic, and in the northern Magandan Oblast region.

In general the medicinal plants have larger ranges. They are often found throughout the steppe, tundra or even in the entire forested area. These large ranges, however, may be deceiving as information concerning present numbers available and harvest requirements is not known. It is possible, if proper management is not enforced, that many of these species may also become endangered.

MOST IMPORTANT FINDINGS: There are currently not enough reserves, given the land mass, to sustain or protect the growing numbers of rare and endangered species. There are relatively large areas of reserves around lake Baikal and in the central northern regions but it is obvious that not enough attention has been paid to Primorski Kray, where diversity is extremely high, or the Far East as a whole. Many species can survive in non protected areas but for this to occur forestry and agriculture practices must be monitored and management must be changed.

POLICY RECOMMENDATIONS: With an increasing interest by forest companies for investments in Russian timber resources, current forest management strategies need analysis. This analysis should not only include type and area of reserves but also areas used for timber harvest and agriculture. There should be a strong emphasis on sustainability both in terms of resources and forest species. Endangered species and non-wood products, such as medicinal plants, need to be taken into account and factors such as ecological requirements and buffer zones on the outskirts of reserves should be considered. In particular, areas of rare or endangered species concentration, such as the Far East, should be given specific attention.

TITLE: The Influence of Forest Exploitation on Species Biodiversity in the Russian Far East

BACKGROUND: Deforestation is one of the primary causes of habitat loss and the large decline in population number and distribution size of forest-dwelling animal species. The Russian Far East (RFE) is one of Russia's richest regions in both biodiversity and natural resources. It is a junction between the northern boreal and the southern subtropical ecosystems and, as a result, contains a complex of flora and fauna which are representative of both. A combination of not enough reserves, an increase in industrial expansion, and a flux of money toward development of the timber industry has put a strain on much of the biodiversity in the region.

TASK: To assess the effect of forest exploitation on species development, analyses of the keystone species: the Amur tiger, the Amur leopard, the Himalayan black bear, and four endangered bird species from the region were carried out. From this assessment a projection for the future could be made and protection needs for species conservation could be identified.

APPROACH: A detailed analysis of the keystone species has been carried out by using historical trends in distribution and population size, current status and future trends, main factors of disturbances, relationships to forest practices, and existing and future protection measures. Reports of different international, national and regional organizations, personal communication with natural reserve staff and specialists in the area, and personal knowledge has been used in the assessment.

RESULTS: The major factor effecting the loss of biodiversity and, in particular, of the keystone species in the RFE is the loss of habitat, due to industrial development and timber harvest, although poaching does also play a crucial role. The current system for protection contains many problems including degeneration of the centralized administration, lack of coordination and control, lack of united management and planning structure, lack of funding and public awareness and poor regional planning. In terms of loss of habitats due to timber harvest, the Korean pine/cedar forests have been extracted rapidly and have changed in many areas from primary to secondary conifer-broadleaf forest. The primary methods of harvest have been high-grading and conventional clear-cutting, both of which disturb the natural environment and result in a loss of species diversity.

While there are many threatened species in the RFE, the Amur Tiger (current population of 200-250 individuals) and the Amur leopard (current population of 25-30 individuals) are under particular threat. A national strategy and conservation action plan has been developed for the Amur Tiger and should be implemented. The Amur leopard however, is in a critical situation and special efforts, including possible creation of farms where the leopards could breed in semi-wild conditions and genetic research on the viability of the population, have to be made.

Habitat destruction and fragmentation is the primary long-term threat to the survival of forest dependent species.

MOST IMPORTANT FINDINGS: The existing system of protected areas in the RFE cannot support the maintenance of a sustainable biological diversity. By December 1994, Russia had 88 *Zapovedniks* (strictly protected scientific reserves), 28 national parks, and more than one thousand regional *Zakazniks* (special purpose reserves) and nature monuments. However, these protected areas occupy only approximately 3% of the total Russian territory which is extremely low compared with 8% in Europe and 11% in North and Central America and the protected areas in Russia do not have an efficient distribution.

POLICY RECOMMENDATIONS:

- The number and areas of *Zapovedniks* should be increased and combined with provisional reserves. The optional distribution of these areas must be investigated further. The existing management rules for these areas should be assessed and changed.

- A set of national parks should be established in the RFE to increase the protected areas network.

- The strategy of industrial development in the forest sector should be changed in accordance with the needs of a sustainable biodiversity status of the region.

- Strong legislative and fiscal measures should be undertaken against all illegal cutting, man-made fires, and poaching.

- Areas of leopard and tiger habitats should be designated as the highest category of protection.

- Special attention should be given to areas of unique biodiversity, including Bikin, Samarga, Bol'shaya Ussurka and Khor river watersheds.

- A three sided agreement on the principles of forest exploitation should be elaborated and signed between major forestry investment groups, international biodiversity conservation projects and the Far Eastern government.

- The Amur Tiger Conservation plan should be approved by the Russian government and it's implementation should be supported by local authorities.

- A Leopard Conservation plan should be developed by coordinative efforts of international ecologists and governmental authorities.

TITLE: Non-Wood Products from the Russian Forests

BACKGROUND: The Russian forests supply many products and functions other than wood. These non-wood products have played an important role in Russian households over time and could continue to play a crucial role if the Russian forests are managed in a sustainable manner.

TASK: To attempt to quantify what kind, to what extent, and under what ecological conditions important non-wood products are produced in the Russian forests.

APPROACH: Our approach has been to use all available information on non-wood products in Russia to map the volume produced and the conditions of production for these products. Special databases on these issues have been established.

RESULTS: In the following, we present the production of different non-wood products in Russia.

Wild Fruits and Berries

The average biological annual yield is estimated at 5.1 million tons. But the resources accessible for consumption are estimated to be 580,000 tons annually. The largest commercial and accessible resources in Russia are in East Siberia – (27%) and in the Far East – (18%). The average annually traded harvest is around 55,000 tons – (some 10% of the accessible resources) and the harvest for household consumption is some 123,000 tons (some 20% of the accessible resources). This means that the total harvest of the accessible resources corresponds to about 30%.

Mushrooms

The total commercial or accessible yield is estimated to be around 507,000 tons (fresh weight) for all of Russia. The total biological yield is estimated to be 6.6 million tons. West Siberia has 15% of all accessible reserves. The corresponding figures for East Siberia and Far East are 33% and 16% respectively. The actual total harvest is some 25% of the accessible reserves.

Nuts

The commercial harvest of nuts was an average of 3,500 tons during the 1990s, with about 90% of the harvest taking place in Siberia.

Hunting
The average number of animals harvested by game management units, in Russia during the 1990s are: Ungulates 134,000 (with 47% in Siberia), fur-bearing animals 2.7 million (with 61% in Siberia), Game birds 53,000 (with 39% in Siberia), and Water fowl 3.5 million (with 41% in Siberia). Nearly 90% of the furs traded by commercial organizations stem from Siberia.

Resin Tapping
During the second half of the 1980s, the annual resin or gum tapping corresponded to 110,000-115,000 tons. The production has decreased dramatically during the 1990s due to changed market conditions: 76,000 tons in 1992; 36,000 tons in 1993, and 13,000 tons in 1994.

Medicinal raw material
The potential to produce medicinal raw material is high in Russia; the average annual biological yield is estimated at 3.3 million tons. The commercial trade carried out by the Russian Federal Forest Service is 2.3-2.5 million tons annually (with nearly 60% taking place in Siberia).

Honey, hay and tree saps
Honey purchased by enterprises of the Federal Forest Service was 763 tons on average for the period 1970-77, 440 tons in 1991, but only 197 tons in 1994. Hay production has a similar development path with a production of 205,000 tons in 1991 and 120,000 tons in 1994. The average harvest of tree sap in Russia was about 11,000 tons during the 1980s. This harvest has currently nearly vanished.

MOST IMPORTANT FINDINGS: The potential for non-wood forest products in Russia is huge. An interesting result is that a large portion of the production of the various non-wood products has decreased during the economic transition in the 1990s. During difficult economic conditions, the opposite development would be expected. Thus, the decline in production is a result of the transition to a market economy, meaning that a substitution of products has come into the market.

The situation for the indigenous people, living from non-wood products, is critical in many places. The current situation is due to the fact that the society is changing, ecological degeneration, loss of pastures, loss of land due to exploitation, and competition by amateur and professional hunters for game.

POLICY RECOMMENDATIONS: In order to guarantee a sustainable production of non-wood products, the forest management manuals have to be adjusted in this respect. It is equally important however to make analyses on the future possible demands of non-wood products in order to formulate relevant forest management policies and secure these resources for the future.

In order to secure the livelihood for the groups of indigenous people concrete plans have to be developed on how traditional activities can be sustained.

TITLE: Some Aspects of Hydrology of Siberian Forests

Background: In an ecosystem study it is important to generate an understanding of the role of water and the hydrological cycle. In the case of IIASA's Forest Study it is important in terms of global change and, more specifically, to understand the function of the terrestrial boreal ecosystems with which the study is concerned. There are many different models available simulating the hydrological cycle or it's elements; however, quantitative estimates at an ecosystem level for the Siberian forests have only been produced partially. It has been established that moisture has a large influence on the distribution and type of forest succession; however, the forest's influence on moisture is also significant. The problem consists of finding the balance between the two and thus better understanding the entire hydrological cycle.

Task: The primary target of this work is to quantify the importance of forest ecosystems for the hydrological balance. Many processes which take place in the hydrological cycle are controlled by land-surface-atmosphere exchanges, in particular the exchange of carbon and nutrients. As a result, special attention has been paid to water turnover in relation to the carbon cycle.

Approach: To study the hydrological relationships mathematical models of water balance for the entire Siberian landscape were employed. In order to describe the hydrological process, including a summary of total evapotranspiration and water runoff, a simple model was developed. This development was followed by a more complicated model based on the quantitative and qualitative indexes including climatic data, soil characteristics and disturbances.

The common evapotranspiration index was used for calculation of evaporation, transpiration and interception. The seasonal dynamic was taken into account using the Thornthwaite's equation, which accounts for mean monthly temperatures and heat index. Actual evapotranspiration was calculated by using the Frankfurt Biosphere Model, in which the soil water dependent term was represented by the soil water content derived as a hyperbolic tangent. For the runoff estimations, the general Annual-Turc model was used, taking into account the zonal and spatial distribution of the ecoregions of Siberia.

Results: By using aridity and humidity indexes, water balance zones were established for aggregated ecoregions. There are six main types of water balance zones in Siberia which are distinguished by hydroclimatic differences (aridity index) as well as by variation in topography and soil permeability. The water balance zones are:

1. Heavily moistened plain polar-tundra regions of tundra, northern taiga and sparse taiga. They include West-Siberian, East-Siberian, Chukotskaja, Anadirskaja, West-Kamchatskaja provinces (humidity index by Ivanov-Visotsky is more than 1,33; aridity index between 2 and 3).

2. Heavily moistened mountain regions of Sakhalin island, Kamchatka peninsula, Pacific East Coast (humidity index by Ivanov-Visotsky is more than 1,33; aridity index between 2 and 3).

3. Medium moistened lower mountain regions of Central West Siberian Lowland, the Ural mountains, and the lower mountains in the south of Siberia and the Far East. They include West-Siberian, Middle-Kamchatskaja, Central Siberian, Lena-Viluyskaja, Zeysko-Nizneamurskaja, Bureinskaja, Amuro-Ussuriyskaja provinces (humidity index by Ivanov-Visotsky between 1... 1,33; aridity index between 1,5 and 2).

4. Mountain-plain complexes of South-Western Siberia (Putorano-Anadirskaja, Verchovjansko-Cherskaja, Zabaykalsko-Altauskaja, East-Sachalinskaja, Yuzno-Zabaykalskaja,Yuzno-Uralskaja provinces and heavily moistened plains of the Forest-Steppe zone in Central and East Siberia (humidity index by Ivanov-Visotsky between 0,7...1; aridity index between 1 and 1,5).

5. Moderately moistened plains in the lowlands of Forest-Steppe and Steppe zones of Siberia which include Zauralskaja, Predaltayskaja, East-Siberian (insular) provinces (humidity index by Ivanov-Visotsky between 0,45...0,7; aridity index around 1).

6. Arid plains in major parts of the Steppe zone and the Southern regions (humidity index by Ivanov-Visotsky less than 0,45; aridity index less than 1).

The partitioning of precipitation between storage, evaporation, infiltration, groundwater recharge and runoff varies widely between catchments, depending upon climatic and catchment characteristics. Vegetation cover has a large effect on water and energy balances, particularly through interception and evaporation. The three major types of hydrological regimes found in Siberia are: snow-dominated, humid, and semi-arid/arid.

In the first regime a significant proportion of the precipitation falls as snow and is stored on the surface until it melts in the spring. The southern boundary between the snow-dominated and humid hydrological regimes runs from west to east passing through Payer, Solechard, Novy Urengoy, Samburg, Dudinka, Volochanka, Cheta, Amankinsky, Kusur, Ust-Deputatsky, Chersky, Markovo and Anadir. The humid regime occupies most of the rest of the huge territory where rainfall infiltrates into the soil and reaches the stream network by a variety of routes and over different time scales. The humidity index, by Ivanov-Visotsky, is near or greater than one. In the semi arid/arid regime, rainfall is short-lived and generally very intense. High intensity combined with thin soil results in that the majority of the water runs directly off the surface and infiltrates into deeper soils at the bottom of slopes or along river banks. This regime occupies areas below Dopeysk (ecoregion 11522), a small region below Barnaul and Biysk up to the Altay mountains (ecoregion 11013), and below Kiyzil around Erzin (ecoregion 11931).

The hydrological balance of forest ecosystems has an important role in the natural carbon cycle. Vegetation and soil carbon storage have been calculated by using models including annual actual evapotranspiration, site disturbances, annual soil moisture deficit, stand age and net primary productivity. The annual rate of accumulation of vegetation and total (vegetation and soil) carbon storage changes in the zones in a decreasing order: Taiga Mountain ➟ Taiga Mixed ➟ Forest Steppe ➟ Taiga Middle ➟ Taiga Southern ➟ Taiga Northern ➟ Taiga Sparse ➟ Tundra.

MOST IMPORTANT FINDINGS: The hydrological calculations constitute a platform for further analysis in determining sustainable forest management regimes for different zones or ecoregions in Siberia.

POLICY RECOMMENDATIONS: The percentage of forest cover is generally 80-90% of the land area in Siberia. This allows a high water retention, particularly in northern rivers. In the opinion of Rakhmanov (1984), the forest cover could be further reduced without influencing the climate or water resources. However, the harvest methods employed influence the hydrological balance and must be taken into consideration. Industrial and clear cutting should be avoided in the highlands and in hilly areas. Cutting areas and clearing roads should be aligned across slopes which will prevent the appearance of streams. Cutting on slopes should be avoided in the summer during heavy rains. Special care should be given to transportation of wood and measures towards saving the litter and the understory should be taken.

TITLE: Anthropogenic Stress Factors to Forests in Siberia

BACKGROUND: Many articles in the popular press and Western scientific literature stress the severe environmental conditions in Russia and Siberia. The general pollution is described in many cases to be close to a disaster. There are limitations in the availability of consistent data for the anthropogenic stress factors on the Siberian forests, both from a registration point of view (extent of data) and from a methodological point of view.

TASK: The objective of the current research activity has been to attempt, based on existing data and studies in Russia, to estimate the extent of anthropogenic stress factors on the Siberian forests. In order to fulfill this task, the following activities have been carried out: estimations of emissions and depositions of the major pollutants, estimations of the radionuclide contamination, and analyses of the current forest decline in Siberia.

APPROACH: The basic information used for this work were scientific reports, and reports by different State Committees. The information collected has been recalculated in order to try to achieve as consistent a picture as possible.

RESULTS: From the results, the following can be highlighted.

- Russian analyses of the so-called self-cleaning ability of air and river dissipation show that the dominant part of Siberia is characterized by a low capability for self-cleaning.

- The Siberian territory, especially the Eastern part, is considered to possess a rather high activity of accumulation of pollutants due to the low buffering potential.

- The main sources of emissions of pollutants are industrial centers located in southern Siberia and the Norilsk industrial combine. In addition, long distance transported pollutants are coming in from European Russia.

- There is no reliable data on the total sulfur depositions in Siberia (only on the sulfate depositions). The largest sulfate depositions take place in southern West Siberia, the Irkutsk region, and in the Norilsk area, where concentrations reach 1,000-3,000 kg $km^{-2}yr^{-1}$. The distribution of nitrogen depositions has a similar pattern with the highest loads in southern West Siberia and in the Norilsk zone (500-1,000 kg $km^{-2}yr^{-1}$).

- The highest depositions of heavy metals are in Norilsk, the Irkutsk region, and the southern part of the Far East. In the vicinities of the emitters there are high depositions of both dry and wet heavy metals.

- Russia is in the process of developing single critical loads for sulfur and nitrogen based on the concept developed within the framework of the Convention on Long-range Transboundary Air Pollution Program. Russia has however so far only been able to produce strongly simplified calculations of this framework. Separate calculations are presented for European Russia and Siberia.

- Winter space images detecting chronic contamination by pollutants, and a potential risk for forest decline, show that most affected areas are in the southern part of Siberia, but there are high-risk spots spread out over the entire region. It can also be seen that Siberia is substantially less contaminated than the European part of Russia.

- The Russian approach of calculating the pollution impact by so-called noospheric concentration coefficients support the above conclusion that the anthropogenic pressures are concentrated in Southern Siberia.

- Based on the current critical load calculations it can be seen that critical loads for sulfur are seriously exceeded in the Ural and Altai Mountains, in the boundary regions with Kazakhstan, the Norilsk region, southern Far East, Sakhalin, and the southern Kurilean islands.

- The exceedance of critical loads for nitrogen are most serious in the Urals, in the boundaries to Kazakhstan, Norilsk, and in the Far East.

- Based on Russian estimates of the critical loads for heavy metals and forests, it can be concluded that even the highest depositions of heavy metals (30-41 kg $km^{-2}yr^{-1}$) are below the critical loads. However, in the vicinities of the emitters the critical loads are substantially exceeded.

- Field investigations (mainly in the heavily contaminated Norilsk region) show in spite of substantial nitrogen depositions since 1944, there are no signs of eutrophication and in spite of extremely high sulfur depositions, there is no significant soil acidification.

- Official data on radio nuclide contamination in Siberia stems from different sources and are of different reliability.

- Based on the existing data for radioactivity, a tentative conclusion is that soil contamination and contaminated forest ecosystems do not seem to be a dramatic problem from an area point of view. However, there are concerns which have to be sorted out for the Irkutsk region and the Yenisey river basin.

- Currently, based on existing data, the nuclear industry can not be considered a significant source of nuclear contamination in Siberia. Contaminated spots have been identified, but not any huge coherent areas. However, concerns remain for the Yenisey river basin and the Irkutsk region, which requires further investigation.

- The storage of nuclear waste is a high potential risk for future large-scale radioactive contamination. This high risk condition requires further investigation.

- There is no data available which supports the idea that forest ecosystems in Siberia are currently under substantial risk of damage.

- Radionuclides are accumulated primarily in foliage and branches (80-90% in the bark). Only 3-5% seem to be accumulated in wood. Accumulation in soil takes place primarily in the top 5 cm layer and thus mainly affects small roots.

- In 1993, the officially reported figures on severely damaged or dead forests by air pollutants were 832,5000 ha for all of Russia, with the most damaged areas in the Irkutsk region and the Norilsk area. But from data in other literature it can be concluded that the extent of serious damage by air pollutants could be as high as 3-3.5 million ha only in Siberia.

- Based on current knowledge there are no overall large-scale dramatic “acid rain” problems in Siberia. However, serious regional problems do exist.

- The major cause for the existing forest decline does not seem to be sulfur, but SO_2 and its derivatives. These occur in gaseous or aerosol forms.

MOST IMPORTANT FINDINGS: Based on the existing information, (which has concerns) from an area point of view, the contamination by traditional pollutants, as well as by radionuclides, seems to be less than expected.

POLICY RECOMMENDATIONS:

The following policy recommendations require immediate attention:

- A system which can measure the total sulfur depositions must be established in Russia.
- Work to develop complete critical load calculations for all the major pollutants in Siberia has to be strongly intensified.
- A reliable system for measuring radioactive contamination in Siberia has to be established.
- A risk evaluation of current nuclear waste storage (risk for leakages) and a possible migration of radionuclides from these storages has to be carried out in the very near future.
- There is no reliable monitoring-system for vitality estimates of the Siberian forests. It is possible that the official figures of severe forest decline caused by air pollutants has been underestimated by 3-4 times. Thus, a reliable monitoring system of the forest health in Siberia has to be established immediately.

  Reliable estimates on the health status will influence the policysetting on forest management, annual allowable cuts, policies concerning greenhouse gases, and environmental policies with respect to pollution abatement.

TITLE: Transportation Infrastructure

BACKGROUND: The transportation network influences a region's ability to access forest resources and to realize potential industrial and socio-economic development. However, it may also negatively influence the ecological functions of the Siberian and Russian forest ecosystems.

For example, the forest fund area of Siberia has approximately 340,000 km of railways and roads serving an area of 973 million hectares. Although roads constitute 95% of the rail and road network, only about 15% of the roads have hard surfaces. Many of the routes are exclusively winter roads and are rarely traveled during the summer.

The Far East and Siberia have a very low road density (0.04 km per km^2); West Siberia has a density of 0.08 km per km^2. Siberian roads are in generally poor condition because of neglect. During the last 50 years, more than 200,000 km of roads have been constructed in Siberia; however, only 15% are estimated to be usable today. Waterways are another component of Russia's transportation network. In the late 1980s, 45% of all harvested wood in Siberia was moved via some means of water transportation.

Weak infrastructure is a bottleneck for the further development of Siberia and Russia. A major concern for the forest sector is the poor transportation system. If a product can not reach its market, no transactions will occur.

TASK: To analyze the current transportation infrastructure as it pertains to the forest sector and determine how it can be improved.

APPROACH: Analyses of the transportation network as it pertains to the forest sector is primarily performed with the use of the GIS system developed by the IIASA Study. The GIS supports the analyses of the infrastructure considering the distribution of forest resources, non-wood functions of the forests, the market and industry, as well as socio-economic aspects and conditions in Siberia and Russia. The major activities are to digitize the transportation networks and to identify bottlenecks within them.

Results: The IIASA Study has been able to digitize the road and railroad networks. This is illustrated in the attached maps for the Lake Baikal region. The digitized information is used as input for different quantitative analyses within the framework of the study.

Figure 1.

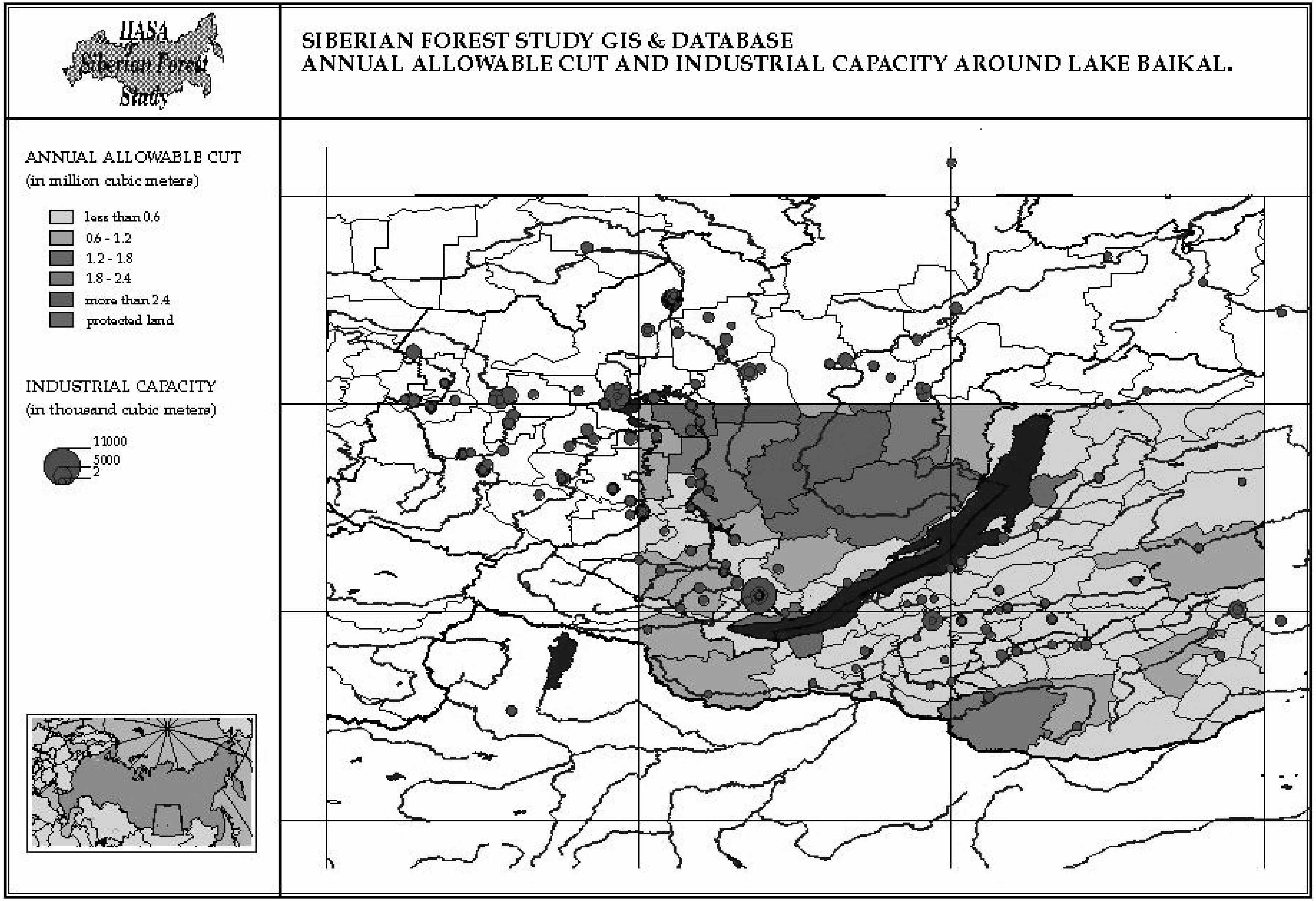
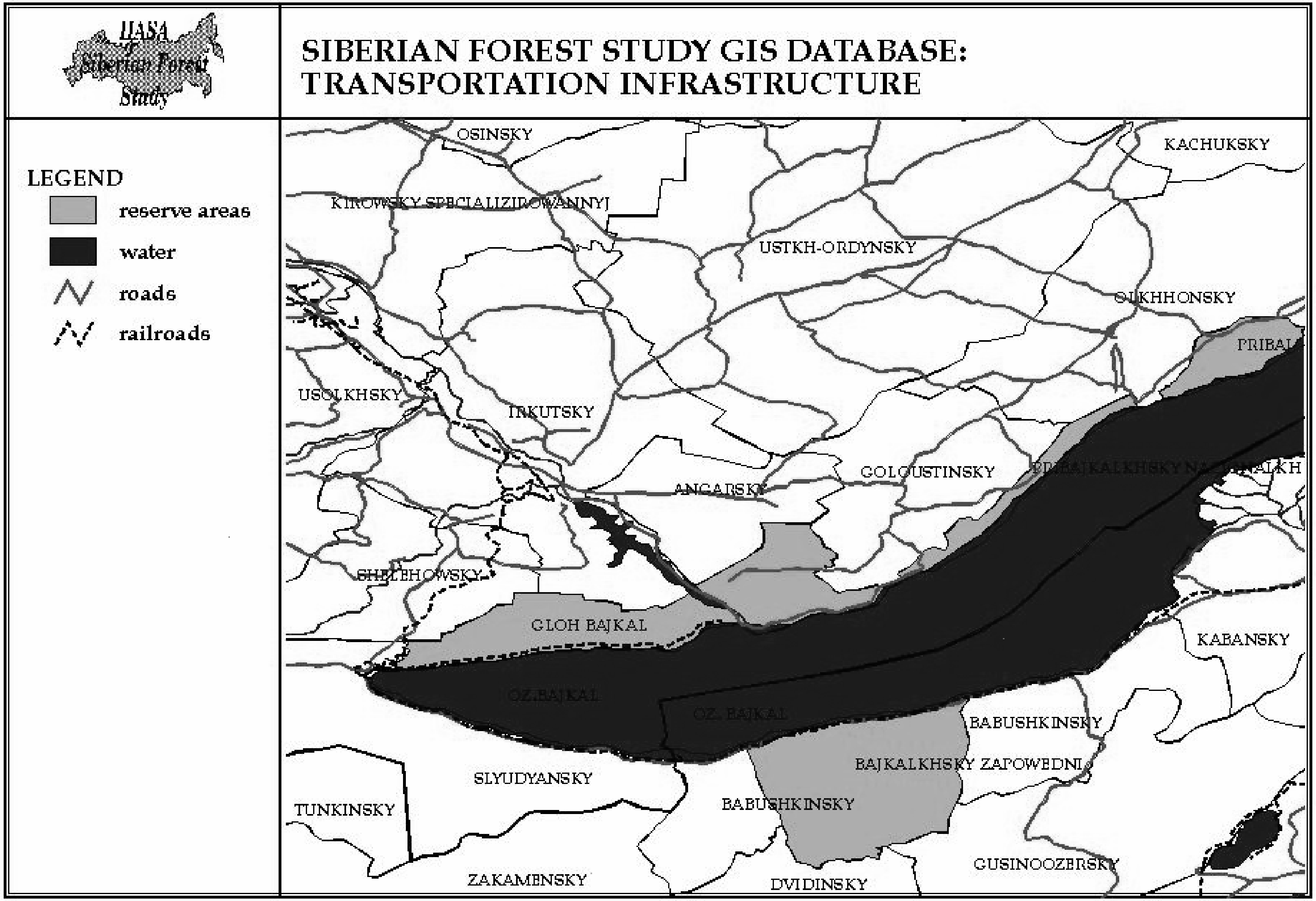

IIASA
Siberian Forest
Study
SIBERIAN FOREST STUDY GIS & DATABASE
ANNUAL ALLOWABLE CUT AND INDUSTRIAL CAPACITY AROUND LAKE BAIKAL.
ANNUAL ALLOWABLE CUT
(in million cubic meters)
less than 0.6
0.6 - 1.2
1.2 - 1.8
1.8 - 2.4
more than 2.4
protected land
INDUSTRIAL CAPACITY
(in thousand cubic meters)
11000
5000
2

Figure 2.


IIASA Siberian Forest Study
SIBERIAN FOREST STUDY GIS DATABASE:
TRANSPORTATION INFRASTRUCTURE
LEGEND
reserve areas
water
roads
railroads
OSINSKY
KACHUKSKY
KIROWSKY SPECIALIZIROWANNYJ
USTKH-ORDYNSKY
OLKHHONSKY
PRIBAL
USOLKHSKY
IRKUTSKY
GOLOUSTINSKY
ANGARSKY
SHELEHOWSKY
GLOH BAJKAL
KABANSKY
OZ.BAJKAL
OZ. BAJKAL
BABUSHKINSKY
BAJKALKHSKY ZAPOWEDNI
SLYUDYANSKY
TUNKINSKY
BABUSHKINSKY
GUSINOOZERSKY
ZAKAMENSKY
DVIDINSKY

TITLE: Trade and Marketing

BACKGROUND: As late as 1990, 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. Taking into consideration 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. Of the 2 million forest industry 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 COMECON countries of Eastern Europe. Despite the decline in the traditional markets, net exports still consumed nearly one-quarter of the fiber supply (10 percent commercial roundwood, 16 percent lumber, 17 percent panels, 21 percent pulp, and 21 percent paper and paperboard). By 1994, while Near Abroad markets continued their decline, Far Abroad markets remained 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 which was a similar volume to that in 1993. Some 30 percent of workers in the forest industry, and forestry sectors, depended on markets external to Russia. Future market opportunities are bound to return in the Near Abroad while market opportunities in the Pacific Rim and Europe will undoubtedly rise in response to tightening supplies of wood raw material world wide.

TASK: Potential markets for forest products need to be assessed along the periphery of Asian Russia, including European Russia, the Near Abroad, China, and other Pacific Rim countries. Factors which have limited penetration in Pacific Rim markets need to be identified and considerations affecting the long-term ability of producers in Asian Russia to seize market opportunities should be illuminated.

APPROACH: Country reports provide an indication of the opportunities for Russian producers in Japan and South Korea. However, a country report for China highlighted the size and difficulty in accessing this large and latent market. Long-term outlook for forest product markets in the Near Abroad and Western Russia was completed using a forest sector assessment model.

RESULTS: In the near to medium term, markets for sawlog material in Japan are expected to amount to between 4 and more than 7 million m^3. In addition, a thirst for raw material to supply pulp and paper mills will lead to demand for lower quality wood material. There is a poorly developed market for lumber which is linked to factors similar to those existing for roundwood.

A number of problems are linked to increasing penetration of the Japanese market by Russian suppliers, including quality of delivered wood, unstable supply and price, and resistance of the Japanese consumer to change. To address these problems, grading and inspection of roundwood should be completed in Russia while a marketing office should be established in Japan.

In South Korea price is a more determining factor, however, the different grading standards between South Korea and Russia were also identified as causing concern. The Russian enterprises need to be more attentive to service, paying attention to consistent quality, meeting commitments, and developing a conflict resolutions process. Addressing these issues could lead to Russia capturing 30 to 50 percent of the short-term softwood log imports (2.4 to 4 million m^3), versus less than 1 million m^3 if these issues are not dealt with.

China, a looming market, has not been a major factor for the Russian forest enterprises in recent years. Falling from more than 2 million m^3 of imported roundwood in the late 1980s, the early 1990s witnessed less than 500 thousand m^3 in trade. Reasons identified included poor quality, lack of dependability, contract disputes, and difficulties linked to financing and credit. However, by 2025 China could face a wood deficit of some 200 million cubic meters, providing a latent market for Russian producers in East Siberia and the Far East. These markets however cannot be taken for granted. Not only do the Chinese buyers prefer North American timber because of the higher quality, better reliability, financing and a dispute resolution process, but meeting the market demand will involve substantial investments in infrastructure and production capacity on the part of Russian producers.

Current markets in the Near Abroads have collapsed with the Baltic region, now a net exporter, and the Southwest region, approaching a balance between exports and imports. It will not be until the first two decades of the next century that rebounding economies will lead to the need for substantial import of forest products. Small markets currently exist in Central Asia and Kazakhstan, which lend themselves as obvious market opportunities for firms in East and West Siberia. By the year 2025, markets for forest products could be as high as 39 million m^3 of fiber annually. Furthermore, depending on economic growth assumptions, Western Russia (European part and West Siberia), while currently a net exporter will become increasingly dependent on forest products beginning as early as in the second decade of the next century. However, the ability of enterprises in Eastern Russia to take advantage of these opportunities depends on attracting capital and developing the potential of the resource.

MOST IMPORTANT FINDINGS: In the case of Japan and South Korea, the major limiting factors for market penetration are items linked to service and quality of the delivered product, both of which can be successfully addressed by the Russian forest sector. In addition, market development in Japan was identified as being extremely useful in order to overcome traditional resistance on the part of Japanese consumers for Russian wood. Financing did not appear to be a major problem, with respect to South Korea and Japan, as it did with China. Quality problems, absence of a dispute resolution process and absence of trade financing appeared to be the most serious factors affecting the willingness of China to import Russian wood.

Long-term development of the market potential in Pacific Rim countries requires a concerted effort to attract capital and develop the forest resource. Not only does the potential resource need to be developed in the eastern parts of the country, but the transportation infrastructure supporting large scale movement of forest products to China, and to other Pacific Rim countries, should be assessed to identify bottlenecks which could effectively deprive enterprises of participating in these opportunities.

POLICY RECOMMENDATIONS: The Russian forest sector should create, in Japan, South Korea, and other suitable Pacific Rim countries, trade promotion offices which are focused completely on the forest sector. The needs of the customer in each of these countries should be clearly understood in order to identify the major factors affecting a buying decision. A mechanism to resolve trade disputes should be developed. It should focus on the long term relations and the benefits to both buyer and seller in continuing and strengthening the relationship. Particular attention should be paid to encourage manufacturing activities in the Eastern part of Russia, in order to increase the share of value added products which are exported, instead of primarily roundwood. Since capital is a major factor affecting the future of the forest sector, the ability of the domestic financial sector to successfully process large sums of money needs to be addressed. This includes developing expertise in trade financing including for example insurance. Since capital is essential to developing the forest sector, the investment environment needs to be cultivated so that investors do not demand large risk premiums for investing in Russia, let alone the forest sector.

While the long-term future of the forest sector in eastern Russia lies in developing the potential fiber supply, that in European Russia lies in improving the management of the forest resource. Although it is difficult to predict, productivity of the European forest resource could be increased by at least 10 percent. A closer examination of the assumptions underlying the calculation of the AAC could lead to sharply higher permissible harvests. Furthermore, an increasing concern on the part of consumers in European countries over the stewardship of the forest resource from which the raw material is drawn must be met by a marketing effort to demonstrate that Russian forests are indeed being managed in a responsible way. Failure to do so could lead to sharply lower export opportunities as consumers factor the perceived absence of stewardship into their buying decision.

TITLE: Industrial Structure

BACKGROUND: By 1994, the Russian forest sector output had fallen sharply to levels only 45 percent of those existing in 1990, even though forest industrial employment had declined by nearly 15 percent. The economy was less affected, falling by nearly 40 percent during the same time frame, while total employment declined by only 9 percent. The fall in output has been more sharply felt in the Asian part of the country, particularly West Siberia and the Far East, which has absorbed a higher proportional share of the decline in all forest product outputs.

Although the Russian forest sector has been a major exporter of forest products, it has relied on roundwood and lumber as the principal export products. Together they account for three-quarters of exported fiber volume. Furthermore, the pulp and paper component of the forest sector has been relatively undeveloped in terms of domestic consumption of paper products. Even up to the demise of the USSR it lagged significantly behind those of other developed countries. By 1994, under the new economic conditions, the domestic consumption of forest products had fallen by some 60 percent in the case of lumber and 70 percent in the case of paper and paperboard, though only by one-half in the case of panel products. Roundwood and lumber still account for an overwhelming, and similar, share of the exported fiber volume.

TASK: The current structure of the forest sector including differences which exist regionally needs to be revealed. Capital requirements linked to re-equipping the forest sector need to be identified, including the degree to which fiber can support the construction of higher manufacturing enterprises. Looming fiber shortages need to be delineated.

APPROACH: Data describing the forest sector is used to develop an appreciation of the current structure of the industry throughout the country including changes which have taken place since the collapse of the former USSR. A forest sector assessment model is then used to identify shifts in production likely to take place over the next 5 decades.

RESULTS: The output of forest products at a national level has declined broadly across the spectrum of forest products since 1990. The decline has been more sharply felt in the output of delivered commercial harvest (68 percent) than in reconstituted products such as panels (52 percent). Lumber (62 percent) and paper and paperboard (60 percent) fell more steeply than panels though less than commercial harvest.

The decline has not been evenly distributed regionally, with an increasing share of total output taking place in European Russia. By 1994, European Russia accounted for 62 percent of the delivered harvest versus 58 percent in 1990, 67 percent of the lumber production versus 59 percent in 1990, 92 percent of the paper and paperboard versus 86 percent in 1990. Production in East Siberia remained decidedly constant, except for lumber which decreased and for pulp which increased.

The consumption of paper products lagged that of other countries even up to the demise of the former USSR, particularly that of the USA (45 kilograms versus 300 kilograms for the U.S.A.). The consumption of lumber was less noticeably smaller (0.429 m3 versus 0.51 m3 for the U.S.A.), while the consumption of panel products was more than one-third that of the U.S.A. (0.55 m3 versus 0.16 m3 for the U.S.A.). By 1994, per capita consumption had plummeted from even these low levels. Lumber consumption amounted to 0.165 m3 while panels fell to 0.026 m3 and paper and paperboard consumption fell to 13.2 kilograms.

The forest resource in the European part of Russia consists of nearly equal shares of deciduous and coniferous components. While the deciduous resource dominates the fiber in West Siberia it is a minor component in East Siberia and the Far East where it accounts for one-quarter and one-sixth respectively of the fiber believed to be accessible with the current technology and infrastructural development. One half of the coniferous resource and three-fifths of the deciduous resource are located in European Russia. While European Russia lacks significant “reserves of fiber”, dependent on additions of technology and infrastructure, Asian Russia can effectively double its harvest potential. Virtually all of the “reserve fiber” is in coniferous stands.

Since 1990, the share of commercial wood fell from 85 percent to 77 percent by 1994. Although output of paper and paperboard products fell, the efficiency with which paper products could be manufactured increased, with increases in the order of between 5 percent to 15 percent.

Privatization has continued in the forest sector. Wages have fallen relative to levels similar to those in 1990. While located close to the average salary for industry in 1990, by 1994 average monthly wages in the harvesting and woodworking industries had fallen to 77 and 76 percent of the monthly average. In 1990, wages were 100 and 96 percent of the average. It is only in the pulp and paper industry where wages have kept pace with the industrial average, where they represent 111 percent versus 104 percent in 1990. Not only has there been a change in the wages of the forest sector relative to industry as a whole, but wages of office workers have risen faster than those in the worker level. In 1990, the office worker was receiving 120 percent of the working wage while by 1994, the gap had widened to 165 percent. Similar relations are evident within the three departments of the forest sector. Although forestry employees made 80 percent of the industrial average in 1994, average monthly wages in the forest sector amounted to only 83 dollars, the distribution was: 77 in field workers and 128 in office workers.

There has been a sharp increase in the number of enterprises in the forests sector, rising from, 4,011 in 1990 to 16, 767 by 1994. While increases in the harvesting sector have been modest, there has been a large change in the wood working industry which witnessed an increase from 1,587 to 8,417 between 1990 and 1994. By 1994 small enterprises accounted for 86 percent of all enterprises in the forest industrial sector while middle sized enterprises accounted for 8 percent and larger enterprises for 6 percent. Small enterprises however contributed only 14 percent of the sectoral production while middle enterprises contributed 17 percent. Large enterprises produced 70 percent of the output.

Prices in the forest sector have increased broadly across a range of products since 1990, though, following the demise of the former USSR in 1991, it was not until 1993 that the increase exceeded the industrial average. From 1991 through 1994, prices in industry in general increased 3.4, 33.8, 10.0, and 3.3 times based on December of the previous year. In 1991 increases ranged from 2.7 for plywood to 6.8 for chemical pulp. In 1992, increases varied from 7.5 for chemical pulp to 13.5 for plywood. In 1994, increases varied from 2.8 for roundwood to 6.4 for chemical pulp. During the same period, transportation costs increased more steeply, placing a large weight on those enterprises located far from the market place. This helps to explain the sharp decline in production observed in the Asian part of Russia. Furthermore, as late as 1993, the forest sector for at least roundwood seemed to be pricing at marginal cost.

MOST IMPORTANT FINDINGS: Rapid increase in the price of transportation has disadvantaged the enterprises located towards the center and eastern parts of the country. Indeed, this shows up in the sharp decline in output experienced in the Asian part of Russia. Decline has been less in East Siberia, though this is in part due to the large manufacturing complexes which are able to produce value added products capable of sustaining the higher transportation tariffs.

Capital attraction is essential if the forest sector is to meet rising demand and seize export opportunities brought on by a successful transition to a market based economy. The scarcity of the forest resource that requires infrastructural development in Western Russia (European Russia and West Siberia) suggests that the forest sector in the more developed portions of Russia may wish to concentrate on improving the forest resources to support fiber flow. This would postpone the reliance on forest products generated in the eastern reaches of the country which entail higher transportation costs and environmental costs that are not clearly understood. The forest sector of Eastern Russia (East Siberia and the Far East) will undoubtedly focus increasingly on events taking place in the Pacific Rim particularly China. However, the possibilities to bring the products to the markets and increase the accessibility of the forest resources depend on the investment in capital.

POLICY RECOMMENDATIONS: A new transportation policy as a tool to encourage industrial development of the forest sector in the Asian part of the country has to be considered. Many communities are entirely, or nearly entirely, dependent on one industry, in this case the forest industry. Long term stability may not be possible unless there is an active strategy to attract investments. In the short term, producing products which can support higher tariffs may keep communities alive and provide some time to implement policies to promote industrial development. Displaced workers could be given meaningful employment through creation of a forest renewal program. Short term focus for the forest sector in Eastern Russia should be on the export markets in the Pacific Rim. Provision of incentives for entrepreneurs to initially develop roundwood exports should be established. As cash flow is generated, incentives for adding manufacturing facilities may come along. The major and initial target should be on those markets which have the ability to pay. Opportunities in China should be further investigated. Transportation bottlenecks need to be addressed so that development opportunities 25 years hence are not lost due to the inability to transport goods to the market.

TITLE: Relocation of Russian Industry

BACKGROUND: Industrial production fell by about 50% in Russia during the last decade. During the same time period prices increased by over 30,000%. This output loss has been associated with declines in real wages, the emergence of unemployment and a deterioration of the standard of living in Russia. There has also been significant stratification of output changes across regions and industries. This study is about the effects reforms have had on industry's regional dispersion in Russia.

TASK: To address three issues: Have there been significant changes in the localization of industries and have the changes been associated with concentration or diversification? Are there significant changes in the relative productivity of industries in studied regions? Is there a connection between productivity changes and changes in localization?

APPROACH: We developed three scenarios of, what one could realistically expect to happen to localization, in socialist economies, once they enter systemic transformation. The first is based upon the assumption that the location of industrial production was inefficient, meaning that production did not take place in those regions where returns would be highest, and that industry was overly localized, or more concentrated in particular regions than might be optimal. If relocation of industry was associated only with undoing these “legacies of the past” we would expect deconcentration to be one of the “stylized facts” of regional relocation.

The second scenario draws its inspiration from the fact that systemic transformation changes the “optimal location” of industry. Changes in localization in socialist countries, in contrast to western economies, are not due to investments in a particular industry or region, but rather to differences in output decline of particular industries across regions. Thus transition itself through relative price changes, institutional reforms, foreign trade liberalization and privatization changes the optimal location of industry. If these forces were at the center of changes in location it may be that no clear pattern of relocation would result.

The third scenario is based upon historical findings, dating back to the writings of Alfred Marshall, that comparative advantages may be a side product of concentration. The claim is that, industries concentrated in a single region, may become a source of increasing returns to scale, since a) the local labor pool acquires industry specific skills, b) industry specific services may be provided in these regions and c) localization provides informational advantages. In this scenario large producers profit most from the reforms.

We used data from 1987-1993 on regional production by industry to consider which scenarios best fit the changes in the division of labor among Russian regions.

RESULTS: Our findings suggest that there are a number of “stylized facts” suggesting that a theory that rests exclusively on the assumption that relocation is simply undoing legacies of the past misrepresents the actual relocation process in Russian regions. In contrast our evidence supports the view that Russian regions are quickly redefining their comparative advantages. In particular we established four facts:

1. Changes in the geographical composition of industrial output lack a clear sectorial pattern and include all types of industries (resource dependent, heavy industry and consumer oriented). At the same time there is no clearly visible pattern that industries more affected by the overall output decline have experienced faster changes in geographical composition of output.

2. Changes in the geographical composition of output are typically associated with an increase in geographical concentration. Large producers are thus increasing their share of output.

3. Relative productivity has changed more rapidly across regions than has the regional composition of output.

4. Large producers (regions) have managed to increase their productivity more than small ones.

The evidence that larger regions are increasing their efficiency while smaller regions (in terms of industry output) are falling behind, suggests that increased spatial concentration will be a feature of the years to come and asks the question of what forces have been working towards increased concentration.

POLICY RECOMMENDATIONS: Our findings suggest that locational economies are an important aspect which influence regional industrial development in Russia. This suggests that policy makers should pay attention to the economies of location. In particular, if the transitionary recession results in a complete erosion of the human and material capital base of a regional economy, a negative effect on the long-term growth path of this region can be expected. Thus policy measures that preserve the capital base in transitionary recession are justifiable. The problem in formulating such a policy, however, is that it may interfere with the aim of allowing flexibility in the necessary restructuring of the regions.

Two policy measures which allow for both increased flexibility of firms and avoid excessive capital erosion are investments in infrastructure development and policies designed to develop vertical and horizontal links within the economy. Infrastructure development, first of all could reduce the currently high transport costs - a factor which reduces competitiveness in more resource bound Russian industries abroad - and could thus increase competitiveness in industry across regions. Secondly, it could increase the ease of internal communication flows within regions which in turn increases locational economies.

Developing vertical and horizontal ties between local industries, by state provided institutions, rather than state provided subsidies, will also increase information flow and thus help to accentuate localized externalities across industries. Furthermore, if such a policy is formulated with the strategic goal of increasing exports, it may help to reduce potential conflicts of interest between local producers competing in their home markets.

TITLE: Restructuring of Social Assets in Russian Enterprises

BACKGROUND: The firm has been a central institution in the Russian 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, forcing them to substantially downsize social functions.

TASK: To study in a quantitative manner how the downsizing of social functions has, and continues to, take place during the transition.

APPROACH: The analyses are based on data collected in late 1995. In total, 97 industrial companies throughout Russia were visited and social assets held by each enterprise between 1989 and 1995 were investigated.

RESULTS: The changes in the number of social establishments during the period 1989-1995 were dramatic.

There seems to be regional differences in the changes and, to some extent, more changes in Siberia. The most dramatic decline of social establishments has occurred in the very large firms. It could be concluded that firms are trying to shed all types of traditional social establishments, but on the other hand, some firms have already started to provide new and different social services.

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

This changing situation with respect to social establishments is estimated to continue.

POLICY RECOMMENDATIONS: Many of the social functions shed by industrial companies are crucial for a functional society and competitive regions. Therefore, there is a strong need to develop concrete plans for the society's future responsibilities of these assets which are shed by the firms. If this problem is not resolved, there is a high risk for future social unrest and a decline in the regions' competitive position.

TITLE: Employment in the Forest Sector

BACKGROUND: The Russian forest sector is a significant employer which directly accounted for more than 2 million employees in Russia in 1990. While it is uncertain the number of employees which depended indirectly on activities in the forest sector for their livelihood, up to an additional 6 million employees (12 million people including dependents), almost 10 percent of the workforce and total population of Russia, could be indirectly supported by activities in the forest sector. Regionally, the forest sector can be the major employer, making communities heavily dependent on it for their existence. Behavior in the sector thus can have important impacts on the regional economic, social, and political landscapes.

TASK: With such a large number of people dependent on the forest sector for livelihood, up until the demise of the former USSR, the regional distribution of employment and the importance of the forest sector as an engine for the creation of jobs needs to be highlighted. Second, the amount of unemployment and the potential increase in unemployment linked to a long-term reconstruction in the forest sector may provide a reserve of workers which could be used to improve the conditions of the forest as a resource. Thus, some indication of the current and potentially numbers of unemployed workers in the sector, as well as, the indirect employment generated through activity in the forest sector needs to be developed.

APPROACH: Using publicly available sources, the distribution of general employment on a regional basis is described. The number of employees which are directly supported by the forest sector regionally is determined based on the share of physical output taking place in each of the geographic regions. Current unemployment levels in the forest sector are related to the employment levels in 1990 being set to 100 percent. Potential unemployment is determined assuming that productivity evident in 1989 could be sustained.

RESULTS: Total employment has been falling steadily since 1990, when 74 million people were employed within Russia. Industrial employment accounted for 23 million, or slightly less than one-third of the total employed. By 1993 total employment had declined by 5 percent while industrial employment had declined by almost 10 percent. By 1994, total employment had declined by 10 percent in comparison to 1990 levels, and in industry by nearly 20 percent of those existing in 1990. European Russia accounts for slightly more than three-quarters of total employment and industrial employment with West Siberia, East Siberia, and the Far East accounting for respectively 10 percent, 5 percent, and 5 percent. Forest sector employment fell from 2.0 and 1.8 million people between 1990 and 1994.

Every industrial worker supports either between 1.9 and 3.2 other employees, or between 1.2 and 2.0 employees, depending on the assumptions made for inclusion within the category of direct employment. The lower range assumes that direct employment includes industry, agriculture, and forestry. The higher range assumes only industry is in the direct category.

There has been a decrease in the number of indirect employees since 1990 as service oriented activities, hitherto part of the enterprise, have been placed outside of enterprise control. Furthermore, using a group of 24 forest industrial enterprises in Krasnoyarsk Kray as an example, production employment as a share of total employment has risen between 1989 and 1993 from 0.68 to 0.76, even as total employment in these same enterprises dropped by 20 percent.

Although employment in the forest sector has fallen, it has not fallen as steeply as the physical output. As a result, productivity per employee has plummeted to less than half between 1990 and 1994. Despite the declining productivity per manday, unemployment in the forest sector has risen to at least 14 percent, almost 30 percent if focusing solely on the harvesting sector. Unemployment levels are lower in European Russia where they are respectively 7 percent (forest sector) and 23 percent (harvesting sector). Corresponding figures in West Siberia are 24 percent and 37 percent; East Siberia - 22 percent and 32 percent; and in the Far East - 42 percent and 39 percent.

MOST IMPORTANT FINDINGS: Forest enterprises are shedding non-production workers at a faster rate than production workers. Not all of these people remain unemployed as activities hitherto performed by the industrial enterprise are absorbed by other or new organizations. Indirect employment supported by industry or a combination of industry, agriculture and forestry has been rising steadily since 1990 as tasks performed hitherto by the enterprises are being performed by independent organizations. Unemployment in the forest sector is more pronounced in Asian Russia than in European Russia. Unemployment in the harvesting component of the forest sector is generally higher.

POLICY RECOMMENDATIONS: Identify alternate forms of employment which the current and potentially unemployed forest workers could perform. Consider creating an “army” of unemployed which can perform useful forestry work in regions most affected by adverse employment conditions. Furthermore, with most of the unemployed located in Asian Russia, particularly East Siberia and the Far East, finding useful tasks for these people to perform would, in the short term, provide some stability since alternatives may not be readily available. There are definite social costs connected with large scale migration while alternative solutions are found. In regards to forestry work, prepare a plan identifying types of work, the manpower required, location and the types of remuneration necessary to provide basic support for the unemployed and their dependents. After having identified the skills resident in the forestry unemployed, develop a re-training program designed to prepare these people for re-entering society. In those regions lying close to export markets, consider introducing incentives to entrepreneurs willing to invest in infrastructure, re-equipping of enterprises and operations for the export markets.

TITLE: Welfare Indicators

BACKGROUND: In order to achieve a sustainable society, welfare must reach a critical minimum level. This level is also crucial to achieve 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.

TASK: To study the distribution of welfare in different regions of Siberia by analyzing a large number of different indicators.

APPROACH: The welfare indicators have been identified and analyzed through different statistical analyses of the detailed socio-economic database of the IIASA Study covering the period from 1987-1993.

RESULTS: From our analyses, we are not in a position to demonstrate the final results for the welfare indicators studied. However, a few examples can be given.

The welfare indicators studied can be aggregated into the following groups: Economy, Employment, Material Standard, Housing Conditions, Health, Education, Consumption, and Environment. In the following, we will present the results for these indicators within the mentioned groups for the year 1993.

<u>Relative Production of Consumer Goods</u>
Production of consumer goods seems to be concentrated in the European part of Russia. There are big regional differences, with less production in the vast and less populated regions.

<u>Relative Gross Agricultural Production</u>
As expected, agricultural production is concentrated in the agricultural regions of European Russia, with less production in the regions of Siberia and the European North. Such production patterns require an efficient distribution system in order to secure an adequate food supply to all regions.

<u>Relative Communication Infrastructure</u>
Telecommunications is an important component for an efficient social communication infrastructure. There are great differences in the relative accessibility to telephones between the regions.

Housing Space per Inhabitant
There is more housing space in the European part and less in the vast rural regions.

Relative Output of Specialists from Higher Educational Establishments
The educational level, measured by the output of specialists from higher educational establishments, varies substantially between different regions and is concentrated in the European part (Moscow and St. Petersburg regions) of Russia.

Relative Expenditures on Goods and Services
The expenditures made for consumption of goods and services also vary by region, but there is a tendency for higher spending in the regions rich with natural resources.

The system developed by the Study on welfare indicators can be used as a tool to check the efficiency of new policies to increase the regional welfare in Siberia.

MOST IMPORTANT FINDINGS: The most important finding is perhaps that there are substantial differences in welfare distribution between different regions. Differences which were not expected in a former centrally planned economy.

POLICY RECOMMENDATIONS: Due to the fact that there are substantial differences in welfare between the regions, regional administration and politicians must do the following:

- further investigate reasons for these regional differences in welfare,
- establish policies which will improve welfare conditions, especially in lagging regions, and
- investigate how the forest sector can contribute to increased welfare in the future.

An acceptable level of welfare is a prerequisite for the sustainable development of societies and regions.

TITLE: Demographic Development

BACKGROUND: In order to achieve a sustainable regional and national development, sound demographic development is required. A number of alarming reports have appeared during the transition in Russia concerning changes in the population structure.

TASK: To quantify the demographic changes taken place in Russia at a regional and national level from 1987-1995.

APPROACH: With the help of different statistical approaches, detailed data on the Russian population from 1987-1995 (the socio-economic database of the IIASA Study) have been analyzed.

RESULTS: Birth rates for the entire Russian Federation have decreased every year during the period 1987-1993. There is almost a 50% decrease during this period, which is dramatic for the short time span considered.

Death rates for the entire Federation have increased yearly during the studied period 1987-1993. This increase has not been as rapid as the decline of birth rates, but reached nearly 40%, which is dramatic considering the time frame. The pattern is the same for the entire Federation, but the levels and speed vary for different oblasts.

The natural growth rate is defined as the difference between birth and death rates. The two negative trends identified above will 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 (-5%) in 1993 and continued to decrease in 1995.

Normally, life expectancy would move very slowly from year to year. In this case, there has been a dramatic decline in life expectancy during a very short period of time (-5 years over a 4 year period).

Most remarkable is the trend break around 1991 from an increasing to a decreasing total population.

In spite of a net immigration of 600,000 people to Russia the total population decreased by 728,000 during 1991 and 1995.

MOST IMPORTANT FINDINGS: The most interesting finding is the quantification of the dramatic changes that have taken place in Russia during the transition. These changes are of a level never registered before anywhere in modern times.

POLICY RECOMMENDATIONS: The negative population development and those of a number of key demographic parameters have been dramatic in Russia during the transition. Therefore,

- investigations have to be started immediately in order to find the direct causes of these negative developments,
- after identifying the driving forces of the negative developments efficient countermeasures have to be taken,
- based on presented demographic developments, projections should be carried out for future population changes at a regional scale with respect to total population, and distribution of age classes and sexes,
- knowledge about future demographic conditions is crucial for designing measures to stimulate sustainable regional development for the future.

TITLE: Russian Forest Legislation

BACKGROUND: There is no one-to-one relation between the size of a natural resource and its economic value. The situation in a great number of developing countries illustrates this fact. Due to political, organizational and technological factors, resources do not contribute to the well-being of people. Accordingly, forests are not resources *per se*. Only within the framework of institutional arrangements can a forest resource be regarded as an economic asset.

One key component of an efficient institutional framework for the Russian forest sector is forest legislation. The capability of Russian forest legislation to address all important societal issues connected with the forest resources has been, and still is, seriously debated. Much of the resource mismanagement within the country has been blamed on Russian forest legislation.

TASK: To attempt to illustrate how efficient legislation can address important forest policies and societal issues in Russia.

APPROACH: In order to understand the current state of forest legislation in Russia, its historical development must be examined. The development of forest legislation since 1918 has been reviewed and, in order to identify efficiency or bottlenecks, nine case studies have been carried out.

RESULTS: Based on the analyses, the following conclusions can be made:

- The current framework of forest legislation is still largely based on a centrally planned institutional framework.
- The forest legislation is not modeled based on ecological, forest sector, or economic problems in Russia; it is built as a centralized “control” device.
- The forest legislation does not cover all functions of the Russian forest resources, and not even all Russian forests.
- The forest legislation, in the form of a matrix of legislative executive bodies, is extremely complex and difficult to administer and implement.
- The forest legislation is, to a large extent, normative and descriptive, and lacks efficient mechanisms of implementation.
- Due to the lack of mechanisms to implement legislation, there are many loopholes through which corruption can take place.

- There are clauses allowing participation by the people in the implementation of the laws, but no mechanism exists for their doing so.

- Severe contradictions that influence the administration of the natural and the forest resources exist within the overall Russian legislative framework. These include contradictions:
    - ◊ between the constitution and the legislation,
    - ◊ between introduced regulations and laws,
    - ◊ between regulations on natural resources and forest resources for indigenous people, and
    - ◊ between presidential decrees and the legislation.

MOST IMPORTANT FINDINGS: The overall Russian legislative framework is a mixture of interests of old and new society, of totalitarian and democratic systems, of centrally planned and market economies, and of exploitation of natural and forest resources versus their sustainable utilization.

POLICY RECOMMENDATIONS:

- The overall Russian legislative framework needs to be revised to allow natural and forest resources to be treated consistently throughout the entire legislative process.

- The forest legislation needs to be revised in order to reflect the current ecological and economic problems in Russia, to cover all functions of the forests and all Russian forests, to define an efficient mechanism for the implementation of the legislation, and to find a mechanism for participation of the people in implementing the legislation.

- Probably, a new institutional framework for the forest legislation has to be established.

4. Publications List

In the following we present the publications list of the IIASA Study during 1993-1996. These publications served as the basic foundation for production of the summary sheets.

Ågren, G.I., Jonas, M., Kellomäki, S., Linker, S., McMurtrie, R., Nilsson, S., Petoukhov, V. and Sallnäs, O. (1993). An Integrated Assessment of Climate Change Impacts on European Forests (ICCF). (January 1993). A Research Plan, International Institute for Applied Systems Analysis, Laxenburg, Austria. 19 pp.

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Virtanen, Y. and Nilsson, S. (1993). *Environmental Impacts of Waste Paper Recycling.* Earthscan Publications Ltd., London. pp. 166, ISBN 1-85383-160-3.

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