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IS SUSTAINABLE DEVELOPMENT OF THE RUSSIAN FOREST SECTOR POSSIBLE?

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PREFACE

The current situation of the Russian forest sector is very contradictory. On the one hand, Russia's vast forest resources provide not only Russia but the whole world with a great economic and ecological potential. On the other hand, the many unresolved problems have led to a situation in which the sustainable development of the Russian forest sector is seriously endangered.

In their timely article Sten Nilsson and Anatoly Shvidenko emphasise that the world has seen too many forests used as a short-term cash crop without regard for the long-term negative consequences. The challenge is to avoid the same happening in Russia.

In addition to describing the Russian forest sector and identifying its problems, Nilsson and Shvidenko suggest policy actions that might lead to an ecologically, economically and socially sustainable development. A special feature of this article is that it includes several valuable maps depicting the forest sector of the Russian Federation. The results are mainly based on the work carried out at the International Institute for Applied Systems Analysis (IIASA) in collaboration with many Russian institutions.

In its publication activities IUFRO intends to put an increasing emphasis on synthesis and state-of-knowledge reports. Therefore, I hope that this article also serves as a good example of a synthesis report on the whole forest sector at a country level.

Both authors have a long tradition in IUFRO and are well respected in their fields. Anatoly Shvidenko currently acts as a Coordinator of Working Party 4.02.06, Resource Data in the Boreal Regions. Sten Nilsson was a Coordinator of S4.07.05, Economic Evaluation of Forest Damages.

Risto Seppälä
IUFRO Vice President for Programme

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1. Introduction

Russia's vast forests are a natural resource of global importance, both economically and ecologically. They already serve Russia and the world as a source of wood, a symbol of wilderness, and a critical stabilizer of the global climate.

Sprawling over 11 time zones, from the Baltic Sea to the Pacific Ocean, Russia has 23% of the world's forest areas ["forest area" defined according to the Food and Agriculture Organization (FAO), 1995]. These forest areas host 21–22% of the world's growing stock (Shvidenko and Nilsson, 1996; 1997) and contain 11% of the world's live forest biomass (Shvidenko, 1997). This biomass has about the same amount of carbon as the total tropical forest biomass in Asia (FAO, 1995). In addition, Russian forests contain more than 55% of the world's growing stock of coniferous species (UN, 1992; Shvidenko and Nilsson, 1996). According to recent estimates by the World Resource Institute (Bryant *et al.*, 1997), about 26% of the world's last frontier forests are in Russia.

Everyone has a stake in the intelligent, sustainable development of this resource. From a political point of view, the former Soviet Union paid reasonable attention to the forest sector and its development. Forest management principles were built on classical European forestry, advanced forest science, and more than 200 years of forest practice. The heart of Russian forestry has been and continues to be oriented toward ecosystem and landscape management, which are crucial components of the sustainable development concept. However, authoritarian political regimes, strongly centralized management, and the lack of a sound economy made the forest sector's development insufficient. By the early 1990s, huge problems accumulated in the Soviet forest sector, and the transition explicitly revealed and enforced these problems.

Change in Russia brings unprecedented opportunities and risks. In spite of Russia's mineral and timber wealth, it suffers from a weak economy and severe social problems. Careless exploitation of Russian forests could hold back Russia's economic renewal, permanently scarring the local environment and destabilizing the global climate. Conversely, healthy forests and forest industries could help revitalize

Russia's economy and society, open a new source of timber for global markets, and improve the ecological well-being of the entire world.

Restructuring Russia's forest industry will be difficult and costly. Massive industrial developments, obsolete technology, low productivity, and poor-quality products characterize the historical legacy. The majority of wood is located far from main world markets. It would take a concerted effort to overcome these difficulties. The world has seen too many forests used as a short-term cash crop, without regard for the long-term economic, environmental, and social consequences. The challenge is to avoid the same in Russia.

The aim of this paper is to describe the Russian forest sector and identify its problems. The results are based mainly on analyses of the Forest Resources Project at the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, in collaboration with numerous Russian forest scientific institutions.

2. The Forest Resource

Russia's forest resources are huge. The general opinion among the public and the scientific community worldwide is that Russian forests are "disappearing" (Barr and Braden, 1988; for a review of this opinion see Shvidenko and Nilsson, 1997). However, explicit conclusions on the state and the development of forest areas and the growing stock of Russian forests can only be based on a numerical analysis of changes in inventory data of forests over an extended period. The principal source of information for the total Russian forests is the State Forest Account (SFA), an accounting inventory that is updated every five years. This accounting inventory is based on three different methods: forest inventory and planning (FIP, a ground inventory of managed forests); aerial inventory methods; and remote sensing. A number of studies (see Shvidenko and Nilsson, 1997) show that the FIP method underestimates the growing stock in mature and overmature stands by 5–15%. Vast areas in the north are unmanaged and unused forest territories. To inventory these areas, aerial inventory methods were introduced in 1948 and continued until the 1960s. Later assessments of these methods (see Shvidenko and Nilsson, 1997) show that they overestimated the growing stock in remote northern areas by up to 20–25%, and sometimes up to 30–50%. After the 1960s this method was replaced by remote sensing methods with a standard error of ±3 at a 0.95 probability for the growing stock of individual forest enterprises. By 1995, areas that were initially inventoried solely through aerial inventory methods accounted for roughly 90 million ha in the extreme northern sparse taiga, forest tundra, and in pure tundra areas. The current state of these forests is unknown, but the impact of these areas on trends and aggregated data on Russian forests is negligible.

In spite of the shortcomings illustrated above, it should be pointed out that aggregated Russian forest inventory data are at least of the same quality as those in other countries of the boreal zone (Raile, 1994) and can be used to estimate the development of the Russian forests from the 1960s through the early 1990s.

Inventory manuals have been changed since 1964 with respect to classifications and definitions, as well as quantitative requirements for several important indicators. Nevertheless, the SFA data of 1961–1993 are rather solid for the main parameters, and can be used for comparative analysis. We have tried to account for these changes and to present the development of different categories (see *Box 1* for further explanation) of forest areas and growing stock in all Russian forests from 1961–1993 based on the SFA (*Table 1*). For more detailed development information concerning different forest categories see Federal Forest Service of Russia (1995a,b), All-Russian Research and Information Centre for Forest Resources (ARICFR) (1997), and Shvidenko and Nilsson (1997).

Box 1. Russian Forest Categories

One of seven basic land-cover categories used in the former Soviet Union (and currently in Russia) is the Forest Fund (FF), which is, according to Russian legislation (1997), all forests and all land allocated for forest purposes. The FF is divided into Forest Land (FL) and Nonforest Land (NFL). FL is land designated for forest growth and includes Forested Areas (FA) and Unforested Areas (UFA). FA are areas covered by forests with relative stocking rates of 0.4 or more for young stands and relative stocking rates of 0.3 and more for other stands. UFA are regions that are temporarily with no forests and include burned areas, dead stands, sparse forests, unregenerated harvesting areas, and grassy glades. NFL includes two land types: (1) areas that are unacceptable for forest growth under current conditions (mires, rocks, tundra areas, sands, etc.); and (2) lands set aside for special purposes (roads, hayfields, and etc.). The latest Russian inventory manual further divides the FL into nonclosed planted forests, forest plantations and nurseries, and natural sparse forests. The main forest-forming species include three groups of tree species: (1) coniferous (pine, larch, spruce, fir, and Russian cedar – *Pinus sibirica* and *P. koraiensis*); (2) hard deciduous (oak, hornbeam, ash, stone birch, etc.); and (3) soft deciduous species (basically birch and aspen).

In addition, each forest category is divided into three groups depending on the social purposes and the utilization of the forests:

Group I = Protective forests that mainly fulfill environmental and social functions with very strong limitations on the industrial harvest.

Group II = Mainly protective forests with restricted industrial use.

Group III = Forests with several functions but whose principal function is production of industrial wood.

In 1993, from the total FF area, forests of Group I covered 17.9%, Group II, 6.2%; and Group 3, 75.9%; this distribution is evidence of the well-developed concept of multifunctional destination of forests.

Forests of Group I are divided into protective categories (a total of 20 categories) and forests of Group III, into exploitable and reserved forests.

Based on information in *Table 1* and in detailed tables presented by Shvidenko and Nilsson (1997) we can make the following conclusions.

From 1961 to 1993 forested areas increased by 68 million ha (9.8%)**,** mainly in forests under state forest management (in 1993, 94% of the total FF areas were under state forest management). During the same period the total growing stock of all forests increased by 3.2 billion m^3, although growing stock of forests under state forest management decreased by 1.1 billion m^3. A significant decrease in the growing stock, some 5 billion m^3 , is observed in coniferous forests under state forest management. A significant decrease in the growing stock of all mature and overmature coniferous forests took place between 1983 and 1993. The total decrease corresponds to 7.7 billion m^3 with the largest decline occurring in the Asian part of the country (Siberia). This latter decline cannot be explained by harvests: other factors have contributed to the decline of total growing stock in Asian Russia (for further details see Shvidenko and Nilsson, 1997).

Table 1. Development of different categories of forest areas and growing stock in all Russian forests between 1961 and 1993 (areas are given 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), 10^6 ha	1162.9	1161.9	1161.4	1186.2	1187.7	1182.6	1180.9	1.02
Forest land (FL), 10^6 ha	848.1	863.0	862.1	872.3	880.5	884.1	886.5	1.05
Forested area (FA), 10^6 ha	695.5	705.6	729.7	749.5	766.6	771.1	763.5	1.10
FA in European Russia, 10^6 ha	148.9	161.3	158.8	163.5	164.4	166.0	166.6	1.12
FA in Asian Russia, 10^6 ha	546.6	544.3	570.8	586.0	602.2	606.1	597.0	1.09
Total FA available for harvest, 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), $10^9 m^3$	77.5	77.0	78.7	80.7	81.9	81.7	80.7	1.04
GS in European Russia, $10^9 m^3$	16.3	17.0	17.4	18.7	19.3	20.3	21.1	1.29
GS in Asian Russia, $10^9 m^3$	61.2	60.0	61.3	62.0	62.6	61.4	59.6	0.97
GS total in mature and overmature coniferous forests , $10^9 m^3$	51.1	48.0	46.4	45.3	43.0	40.0	35.3	0.69

Source: Data from the State Forest Account of 1961, 1966, 1973, 1978, 1983, 1988 and 1993.

An indicator that is probably moderately free from bias is the average growing stock by age group and species. There is a significant increase in the average growing stock (ranging between 20% and 50%) observed for all age groups and species during 1961–1993, with two exceptions. These exceptions are mature and overmature coniferous species (owing to the forestry policy to harvest the best and most productive forests), and young deciduous species (due to natural post-fire and post-harvest regeneration).

We have already identified that systematic errors exist in the inventory data of the SFA. Based on a specially developed expert system, we have made adjustments for these errors (Shvidenko and Nilsson, 1997) and reconstructed the development of the growing stock in *Table 2*.

In this case we obtain a total increase of growing stock of 9.8 billion m^3 during 1961–1993 for all Russian forests. For this period, the increase in European Russia can be estimated to be 5.8 billion m^3 and that in Asian Russia to be 4 billion m^3. But even in this calculation a severe decline of 2 billion m^3 in the total growing stock of Asian Russia can be identified for the period 1983–1993. Another conclusion is also that during the period 1961–1993 the phytosynthetic capacity of the Russian forests increased by some 15% (Shvidenko and Nilsson, 1996). The developments presented so far make it difficult to justify the premise that from a global perspective, Russian forests are disappearing, with respect to areas and growing stock. However, this is far from the complete picture. There is no doubt that alongside the above developments there has been a serious qualitative impoverishment of the Russian forests, mainly in regions with intensive harvesting. This will be illustrated using two important regions, namely, the European North and the Far East of Russia.

Overharvesting by clear-cutting (which authorities accepted for several decades) has led to the depletion of forests in the European part of Russia, worsening of ecological conditions over vast areas, and losses of highly productive sites. This is partly a result of the fact that natural resources were the "common property" of all Soviet people: being no one's property, they were under no one's protection (Kotov and Nikitina, 1993). This development ultimately resulted in a decreased supply of wood to the industry. Examples of overharvesting in 1988 are presented in *Table 3*.

Table 2. 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, $10^9 m^3$	16.4	16.5	17.3	18.3	19.9	21.4	22.2
Reconstructed GS in Asian Russia, $10^9 m^3$	58.6	59.2	60.2	62.1	64.6	64.2	62.6
Total reconstructed GS for Russia, $10^9 m^3$	75.0	75.7[a]	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

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

Table 3. Overharvesting of coniferous stands in 1988 (1,000 m^3).

Region	Number of investigated enterprises	Annual allowable cut	Actual harvest
Archangelsk	13	3,440.1	3,831.4
Vologda	13	747.0	1,154.7
Karelian republic	14	1,132.1	1,282.4
Komi republic	15	3,305.7	4,139.6
Kostroma	7	280.4	307.7
Kirov	8	188.4	597.2
Perm	22	1,957.0	2,243.6
Sverdlovsk	5	131.8	299.3
Irkutsk	10	1,544.3	3,067.6
Magadan	1	21.0	25.0
Total[a]	108	12,747.8	17,128.5

Source: Pisarenko and Strakhov, 1996.
[a] Overharvest by about 35%.

The overharvested areas in European Russia have a low potential for increased production. The resources were exploited in a very unsustainable manner. The most productive coniferous stands were exploited, while the less productive ones and deciduous species stands were hardly used at all. As a result, huge areas of soft deciduous secondary forests were generated and a steady increase of swampy forests of lower site classes occurred. By 1990, for example, the growing stock of mature forests could provide sustainable harvest levels at (1990 levels) for an additional 25 years in the Vologda oblast, for 36 years in Karelia, and for 40–45 years in the Murmansk oblast (Isaev, 1991a). Thus, even though only 82% of the total annual allowable cut (AAC) was harvested between 1970 and 1990 in European Russia, the AACs were violated for individual species and species groups, and at subregional levels.

In the Russian Far East the situation has been somewhat different. Only large trees were harvested, and the removal from harvested areas was roughly 45–65% of the growing stock of mixed stands dominated by coniferous species in this region. The total forested areas increased by 8.1% or 17.5 million ha in the Far East under state management between 1966 and 1993, although cedar forests (*Pinus koraiensis*) in Khabarovsk kray decreased by some 60% (from 1.46 to 0.56 million ha). Between 1965 and 1988 roughly 8 million ha of the most productive stands were harvested (mainly as clear-cuts) in the Far East. In 1988, 34% of this area was classified as unregenerated harvested areas (Sheingauz, 1989a). The same tendency toward a significant increase of low-value secondary forests after harvests is typical for other regions (e.g., in coniferous-broadleaved forests of the Russian Far East). The Russian forests have also been greatly affected by land-use changes during the past 20–30 years (See *Box 2*).

Box 2. Impact of land-use changes on forests in Tjumen oblast (West Siberia) during the 1970–1990s.

Nowhere in Russia (and very probably in the Northern Hemisphere at all) has the industrial pressure on fragile northern forest ecosystems been so intensive as in some regions of West Siberia. More than 5 x 10^9 tons of oil and condensates and 5 x 10^{12} m^3 of gas have been extracted during the past 30 years of industrial development in the Tjument oblast. Five towns each with a population of more than 100,000 inhabitants, have been established in previously unsettled areas (Kulikov, 1993). By the early 1990s, the area destroyed by technogenesis had reached 24.2% of the land area, on only one-quarter of which restoration was carried out. The oil and gas exploitation does not use updated exploitation technology, resulting in larger impacted areas than necessary (European Commission, 1994; Scott, 1994). Some 27,000 ha of FF areas in the Tjumen oblast were transferred to oil and gas exploitation annually between 1973 and 1982 (plus a further 60,000 ha in 1984; 75,000 in 1985; and about 100,000 ha in 1990). Transferred lands have been losing their productivity for many decades. Forest experts estimate that areas heavily damaged by exploitation exceed officially reported areas transferred to oil and gas exploitation 10-fold. The long period of forest degradation due to exploitation is caused by (1) soil contamination by oil products, drilling solution, chemical agents, and mineralizing water; and (2) heat impact and pollution from burning of by-products, water regime changes, and paludification. Some 17 million m^3 of wood are known to have been cut on the exploited areas, of which 4 million m^3 have been removed with the remainder destroyed or abandoned. The primary regions for oil and gas exploitation in the FF (north of Tjumen oblast) consists of a total area of 50 million ha with only 50% under fire protection.

Thus, it can be concluded that the quality of Russian forests was seriously impoverished between 1961 and 1993 (with a decrease in the extent of valuable tree species, decreased tree sizes, regional overharvesting, etc.). A second negative development of the Russian forests is an undesirable change in the distribution of dominant species, especially in the European North. In this region, secondary birch and aspen forests of indigenous spruce and pine sites exceed 30 million ha and are projected to increase to 60–70 million ha during the next 15–20 years.

To get an overview of the degree of transition of the Russian forests, we have divided the forests into three categories:

- Virgin (or pristine) forests – forests that have not been influenced by catastrophic events (such as forest fires or insect and disease outbreaks) during the most recent (2–3) rotation periods.
- Natural forests – forests which have been influenced by catastrophic natural events that have caused partial or total destruction of the stands or changed successional types during the most recent rotation periods. Natural forest stands have not been subject to any forest management or any other negative anthropogenic impacts.
- Anthropogenic forests – forests resulting from anthropogenic disturbances (mainly forest management and harvests).

Aggregated analysis shows that the Forested Areas (for definition, see *Box 1*) of the Russian forests are composed of 27% virgin forests, 47% natural forests, and 26% anthropogenic forests (see Appendix 1). The latter group encompasses some 195 million ha, of which approximately 125 million ha are a result of harvests.

Production in these secondary anthropogenic forests caused by harvests is, as a rule, 20–30% lower than that in virgin forests. For the reasons stated above, these forests have a low ecological value and a low economic value due to lower productivity and quality and undesirable species composition.

Two options exist for these forests, namely restoration or development without intervention and acceptance of their low economic and ecological values. Carrying out the required restoration will be expensive: Restoration costs are estimated at US$200/ha (Far East Forestry Research Institute, 1997).

Features and characteristics of the Russian forests can be described in many dimensions, but doing so would require a lot of space. Therefore, we have decided to describe some features of the forests in map form, which are presented in *Figures A2–A7*.

3. Environmental Significance

3.1. Productivity

Productivity of forest ecosystems is an important criterion for sustainable development of landscapes, biochemical cycles, biodiversity, and forest management.

3.1.1. Live Biomass and Coarse Woody Debris

An important indicator of productivity is total forest phytomass density (kg/m^2). Results from the most current and detailed inventory and calculation of the Russian forest phytomass are presented in *Table 4* and *Figure A8* (for a summary see Shvidenko, 1997; results of previous inventories are presented by Alexeyev and Birdsey, 1994; Isaev *et al.*, 1995).

Table 4. Live biomass and carbon in forest ecosystems of total forested areas of Russia (in Tg).

	Forest ecosystem biomass component, dry matter Tg							Carbon content	
Economic region	Stemwood over bark	Crown wood	Roots	Foliage	Under-story	Total[a]	Biomass density (kg/m^2)	Total (Tg)	Density (kg/C m^2)
European Russia									
PRI	21.8	3.5	6.6	1.5	1.4	35.0	12.86	17.4	6.40
NOR	3,660.6	721.3	1,263.4	548.9	526.9	6,721.1	8.87	3,306.7	4.37
NW	700.2	86.2	213.1	47.2	49.8	1,096.4	10.85	543.4	5.28
CEN	1,355.7	166.8	431.1	93.0	99.0	2,145.6	10.30	1,063.2	5.10
VOV	816.9	105.9	256.2	61.6	64.1	1,304.7	9.72	646.0	4.81
CEC	106.1	20.8	25.6	5.3	6.7	164.4	11.05	80.6	5.42
POV	284.6	39.1	74.2	14.2	18.4	430.3	9.00	213.6	4.47
NOC	361.2	107.2	86.4	14.3	16.5	585.6	15.68	291.3	7.80
URA	2,245.9	308.8	705.0	194.9	181.1	3,635.6	10.14	1,799.0	5.02
Total	9,553.0	1,559.6	3,061.6	980.9	963.9	16,118.7	9.70	7,961.2	4.79
Asian Russia									
WES	5062.6	898.2	1,329.6	365.9	706.4	8,374.6	9.30	4,187.3	4.65
EAS	13,044.3	1,792.4	3,969.0	768.2	1,384.3	21,241.5	9.32	10,620.7	4.66
FEA	10,441.0	1,394.3	3,576.6	509.7	1,609.2	18,637.7	6.67	9,318.9	3.34
Total	28,547.9	4,084.8	8,875.3	1,643.8	3,699.8	48,253.8	8.08	24,126.9	4.04
Russia									
Total	38,100.9	5,644.4	11,936.9	2,624.7	4,663.7	64,372.5	8.43	32,088.1	4.20

Abbreviations: PRI: Pribaltisky; NOR: Northern; NW: Northwestern; CEN: Central; VOV: Volgo-Vjatskiy; CEC: Central-Chernozjomny; POV: Povolshsky; NOC: North-Caucasus; URA: Ural in Russian Europe; WES: West Siberia; EAS: East Siberia; FEA: Far East in Asian Russia.

[a] The total for the Asian part of Russia includes the biomass of closed forests and the biomass of shrubs, which are accounted for as forested areas in regions with severe climatic conditions in Russia where closed forests cannot grow. In WES there is 11.9 Tg of dry matter; in EAS, 283.3 Tg; and in FEA, 1106.9 Tg; the shrubbery phytomass is mainly represented by the biomass of ecosystems dominated by Dwarf pine *(Pinus pumila)*.

There are large variations in biomass density, especially for Asian Russia. The total biomass of Russian forests is estimated to be 64,373 Tg of dry matter, with 24.8% in European Russia and 75.2% in Asian Russia (Shvidenko, 1997). This is some 10% more than the total forest biomass of tropical Asia. As stated in Section 2, serious negative tendencies in forest dynamics recently identified in Asian Russia have also negatively influenced the phytomass density and productivity.

Assessments of coarse woody debris (defined as dead woody residuals that have a top diameter exceeding 1 centimeter and have lost their morphological structure) estimate the carbon content at 6.28 Pg (or 19.6% of the phytomass of closed forests) of which the above-ground carbon comprises 85.7% of the total (Shvidenko and Nilsson, 1998).

3.1.2. Increment and mortality of stemwood

Increment and mortality of stemwood are important components of productivity and important criteria for sustainable biochemical cycles and forest management (and economic wood supply analyses).

Current increment is not monitored by the Russian inventory system. Based on a specially developed system, existing Russian growth models, and experimental data, the IIASA Forest Study has been able to provide the first aggregated estimates on the primary indicators of the current increment of the Russian forests (Shvidenko *et al.*, 1995b; 1996a,b). The estimates on gross growth, mortality, and net growth for forested areas in Russia presented in *Table 5* are based on Shvidenko *et al.* (1997b).

Table 5. Gross, net increment and mortality for total forested areas in Russia.

Economic region	Forested areas (thousand ha)	Growing stock (million m^3)	Net growth (million m^3/yr)	Mortality (million m^3/yr)	Gross growth (million m^3/yr)
European Russia					
PRI	271.9	46.6	1.31	1.00	2.30
NOR	75,742.4	7,935.4	114.52	119.24	233.77
NW	10,105.7	1,583.9	29.22	26.48	55.70
CEN	20,834.5	3,109.6	77.46	61.08	138.55
VOV	13,426.5	1,862.7	48.28	40.00	88.28
CEC	1,487.3	213.8	7.14	5.62	12.75
POV	4,781.0	596.8	17.19	15.31	32.50
NOC	3,735.8	662.3	13.06	11.68	24.74
URA	35,838.6	5,099.4	108.90	93.67	202.57
Total	166,223.7	21,110.9	417.08	374.08	791.16
Asian Russia					
WES	90,011.5	10,950.3	112.98	118.04	231.02
EAS	227,836.0	27,658.2	250.07	227.13	477.20
FEA	279,429.6	20,957.0	185.27	188.90	374.17
Total	597,277.1	59,565.5	548.32	534.08	1,082.39
Russia					
Shrubbery (Asian Russia)	–	–	0.91	5.30	6.21
Total	763,500.8	80,676.4	966.31	913.45	1879.76

Note: Gross growth is defined as the amount of stemwood over bark produced by a stand for a specific year (m^3 per year), and net growth is the annual change of the growing stock. Thus, mortality is calculated as the difference between gross and net growth. For an explanation of the abbreviations see *Table 4*.

Russian forested areas were estimated to generate a total gross growth of 1,880 million m^3 per year in the beginning of the 1990s, of which the net growth was 966 million m^3 per year. Mortality (including natural, mechanical, and mainly pathological, i.e., the consequences of non-stand-replacing disturbances) was 914 million m^3 per year.

The net growth in Europe (excluding European Russia) is estimated to be some 630 million m^3 per year (UN, 1996). The gross annual increments of exploitable forests in the USA and Canada are estimated to be 765 million m^3 and 208 million m^3 per year, respectively.

The Russian Federal Forest Service (VNIIZLR, 1995) has estimated the so-called average growth (defined as the ratio between growing stock and age weighted by areas) in Russia to be 822 million m^3 per year for forests under state management. An approximate estimate for all Russian forests corresponds to 900 million m^3 per year, or 7% less than the IIASA estimate on net growth. However, for individual subregions of Russia, the difference between average and net growth can reach ±30%, which supports the conclusion that the average increment is insufficient to characterize the current productivity of the Russian forests.

From *Table 5* it can be seen that mortality constitutes some 49% of the gross growth. This is extremely high, but can be explained by huge areas in Russia with unexploited and overmature forests, as well as a significant extent of non-stand-replacing disturbances, such as forest fires, insect outbreaks, etc. Thus, mortality is very high in these forests and hardly any thinning takes place, which would reduce this kind of mortality.

It could be interesting to compare the current productivity of Russian forests with an achievable productivity under a given ecological structure and sustainable forest management. The latter productivity can be estimated using maps of the Russian terrestrial biota productivity produced by Bazilevich (1993). Regional comparisons show good correspondence between current and achievable productivity in the western and central parts of European Russia. Current productivity in large territories in the European North, Siberia, and the Far East is only 45–70% of achievable productivity.

3.1.3. Disturbances and protection

Only 60% of the Russian forests are protected against large-scale disturbances. Thus, any estimates on the extent of large-scale disturbances include assumptions and expert estimates. There is no doubt that primary large-scale disturbances affect more than 10 million ha of forested areas annually (Federal Forest Service of Russia, 1992, 1993, 1994; Shvidenko, 1997). However, this does not mean that all of these forests are destroyed. The World Bank (1997a) states that 2 million ha are destroyed annually by large-scale disturbances (another 1 million ha are destroyed through harvesting). Our estimates (see below) indicate that the average annual forested areas destroyed by large-scale disturbances cannot exceed 1 million ha.

Forest fires

There is no fully covering forest fire monitoring system in Russia (about 40% of forested areas are not monitored). Current state statistics for the period 1988–1993 on forest fires in fire-protected areas indicate an average annual burnt area of 1.1 million ha of the Forest Fund, of which 0.9 million ha are located in forested areas. Officially reported annual burnt areas are shown in *Figure 1*. There is much evidence that even the data for fire protected areas are underestimated. Data prior to 1988 were deliberately falsified and are probably underestimated by 3–4 times. Based on evaluations made by the IIASA Forest Study, the average annual area impacted by different types of fires is estimated to be some 3.5 million ha between 1988 and 1992, of which 3 million ha are located in the Forest Fund and 0.5 million ha in the tundra area of the State Land reserve. Fires in the forested areas (FA) impacted 1.5 million ha annually. Areas of stand-replacing forest fires are estimated to be about 0.5 million ha.

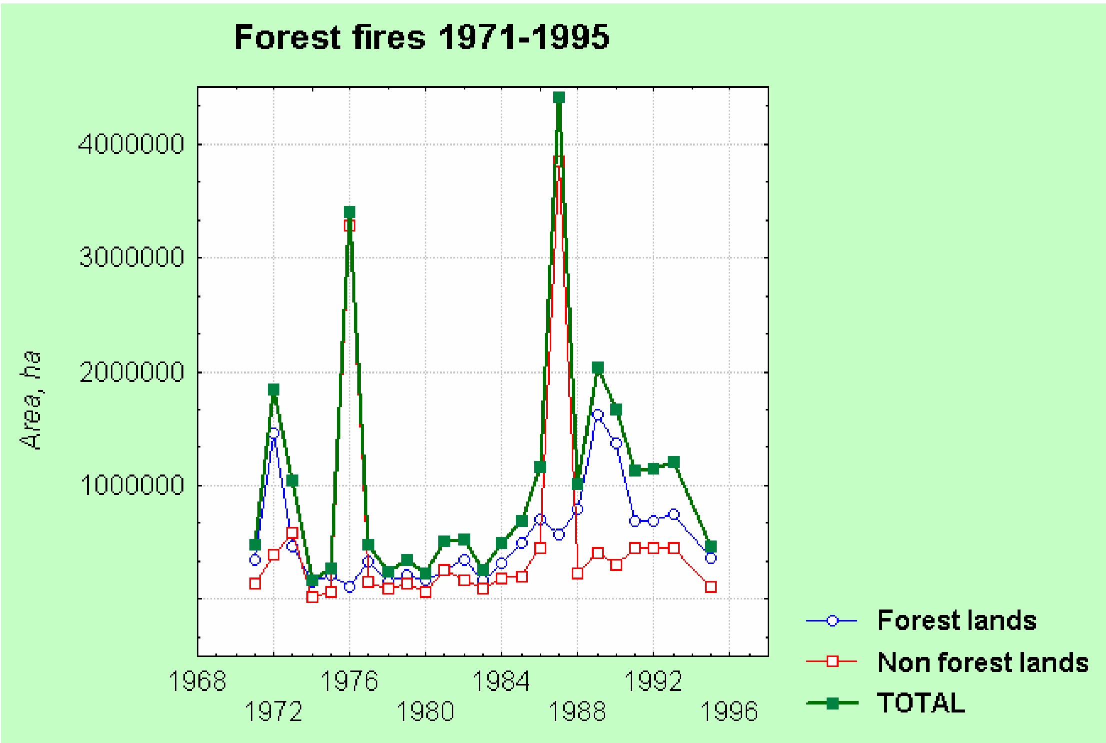


Figure 1. Forest fires, 1971–1995 (official statistics).

Pests, diseases, other biotic factors

A comprehensive, detailed inventory of these disturbances does not exist in Russia. The annual average areas (mainly managed forests), significantly affected by pests and diseases, during the period 1973–1993 were estimated to be 2.37 million ha (Isaev, 1991a). Based on available information, the total average annual areas affected by captioned factors are estimated to be about 4 million ha.

Abiotic impacts

Industrial pollution, land-use changes, and unfavorable climatic conditions are the most important abiotic impacts. Complete surveys of the extent and intensity of these processes do not exist. Based on regional data and expert estimates, the area affected by these factors is estimated to be 2–3 million ha per year.

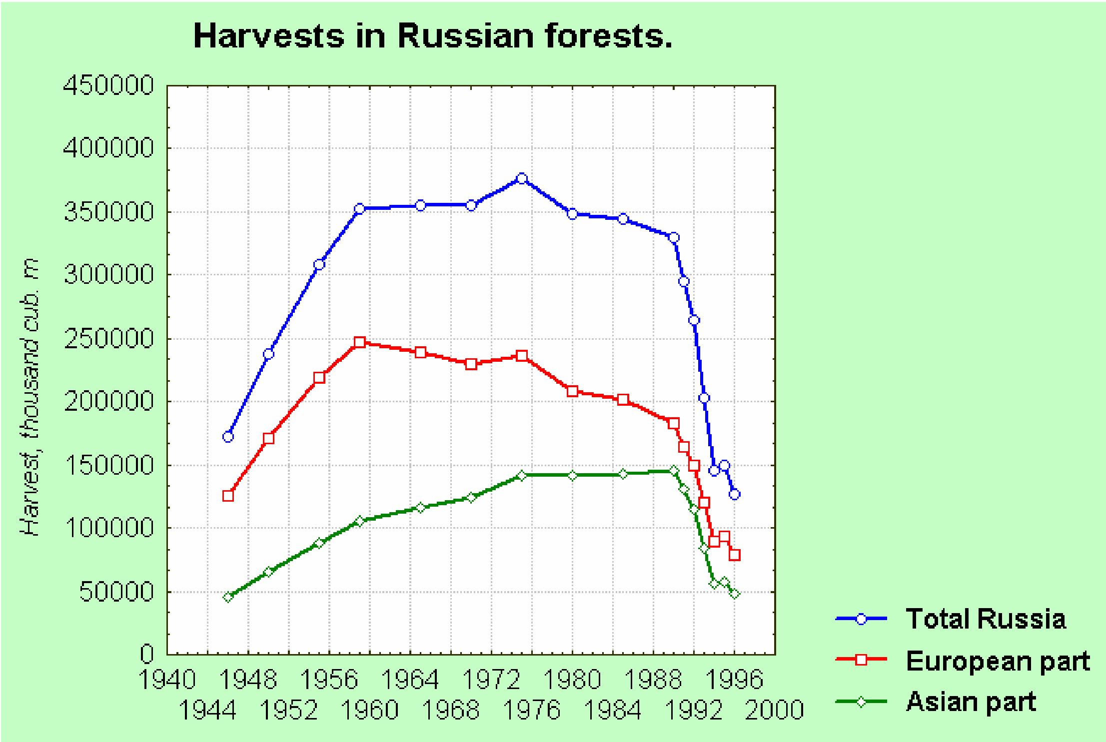


Figure 2. Harvests of commercial wood (industrial plus fuelwood).

Harvests

During the 51-year period between 1946 and 1996, there was an accumulated harvest (including thinnings) of some 16 billion m^3 of commercial wood (industrial wood plus fuelwood), or an average harvest of 313 million m^3 per year in Russia. A significant decline in the harvest is observed during the period 1991–1996 (see *Figure 2*). Data on net growth (presented above) and annual harvests allow us to roughly estimate a wood balance for the past 51 years in Russia. If we assume an annual net growth of 0.8 billion m^3 year (we have decreased the original estimate due to changes in age structures over time), we arrive at an accumulated net growth of 41 billion m^3 for the study period. An accumulated harvest of 16 billion m^3 corresponds to about 20 billion m^3 of growing stock. During the period 1961–1993, the growing stock decreased by some 3 billion m^3. This means that during the past 50 years, the annual losses due to large-scale disturbances (in addition to harvests) have been at least 0.5 billion m^3. Our calculation is only an approximation, but it characterizes one of the most important features of the Russian forests during the past 50 years.

As previously stated, there are uncertainties concerning the estimations presented above resulting from shortcomings in the Russian inventory and monitoring systems.

To provide sufficient data for implementing sustainable forest management, a new nationwide forest monitoring system needs to be established in Russia. This new system must encompass accurate measurements for productivity, ecological functions of forests, the extent of large-scale disturbances, etc. The Russian Federal Forest Service and various other scientists (e.g., Strakhov *et al.*, 1995; Sukikh, 1995; Sedykh, 1995) have identified this problem and have outlined a new monitoring system that seems to be relevant. However, these suggested approaches are being implemented slowly and inadequately whereas the need for them is urgent. A second much-needed activity is carrying out decent impact analyses of disturbances with respect to ecology, economy, and social features.

3.2. Greenhouse gas balances

One of the most important global change aspects of the Russian forest ecosystems is the greenhouse gas balance.

3.2.1. Carbon budget

Based on biomass and the forest inventory data estimates presented above, we have estimated the dynamics of the carbon content in the forest ecosystem vegetation for the period 1961–1993 (*Table 6*) (Shvidenko, 1997).

Table 6. Dynamics of carbon content in Russian forests, 1961–1993.

Indicators	1961	1966	1973	1978	1983	1988	1993
Dynamics based on data of official forest statistics							
C in phytomass, Pg	30.933	30.711	31.388	32.162	32.631	32.522	32.088
C in European Russia	6.147	6.411	6.562	7.052	7.278	7.655	7.961
C in Asian Russia	24.786	24.300	24.826	25.110	25.353	24.867	24.127
Dynamics based on "reconstructed" growing stock							
C in phytomass, Pg	29.920	32.201	30.908	32.054	33.670	34.074	33.728
C in European Russia	6.184	6.222	6.524	6.901	7.504	8.070	8.372
C in Asian Russia	23.736	23.979	24.384	25.153	26.166	26.004	25.356
Deviation (%) between "reconstructed" and official C storage	-3.3	-2.2	-1.5	-0.0	+3.2	+4.8	+5.1

If we employ the data from Table 6 together with the impact of disturbances already presented and aggregated C fluxes calculated from data for net increment, we can estimate the role of the Russian forests in the carbon cycle. From 1961–1993, Russian forests (forested areas) were an average net sink of 168 Tg C per year, although after 1988 Russian forests were neither a net sink nor a source of carbon (with reconstructed dynamics), but became a net source (of 54 Tg C/year) if official statistics are used (Shvidenko, 1997 & Shvidenko and Nilsson, 1998). Uncertainties in the conclusions are due to shortcomings in the SFA data, but these uncertainties cannot alter the direction of the results presented.

The Russian forest sector has significant possibilities to increase carbon sequestration during the next century through improved forest management. These possibilities include reforestation of unforested areas, reforestation after disturbances, reconstruction of low-stocked forests, etc. What we judge as realistic scenarios for these options result in an additional sink of some 270 Tg C/year during the next 100 years (Shvidenko *et al*., 1997a).

In a similar way, the carbon budget of the Russian forests could be substantially improved through better forest protection (e.g., from fires, insects, diseases, etc.). If the protection measures achieved, in Canada, for example, could be achieved in Russia, the carbon sequestration by Russian forests would increase by some 150–170 Tg per year (Shvidenko *et al*., 1995a).

3.2.2. Soil carbon

In the boreal zone, a large proportion of carbon is sequestered by the soil, some 70–90% (Karjalainen and Liski, 1997). In addition, a substantial proportion of the soil carbon is located in peatlands.

Dixon *et al.* (1994) estimated the total carbon sequestered in the soil of the boreal forests to be 471,000 Tg. We have produced new soil carbon estimates and a new soil organic carbon map for the total Russian soils (Roshkov *et al.,* 1996a; *Figure A9*). These estimates indicate a total pool of 453,367 million tons of carbon in the 0–100 cm layer of the Russian soils. From this total carbon pool, 25% is in the form of carbonates and some 75% is in the form of organic carbon. Of the organic carbon, 35% is accumulated in peat and litter. Carbon storage in the Russian wetlands, mainly located in the tundra and the taiga zones, is estimated to be 118 Pg (Roshkov *et al*., 1997). Similar estimates are presented by Vompersky (1995).

This new estimate on soil carbon storage in the Russian soils indicates that there is much more than estimated earlier – nearly the same as the total estimated for the boreal zone by Dixon *et al.,* 1994.

Carbon of soils in forested areas was estimated by overlaying several digitized maps (Shvidenko and Nilsson, 1998). The assessment is that the soils of the Russian forested areas sequester 129.6 Pg of organic carbon and 30.1 Pg of carbon of carbonates in the top 1 meter layer. The total amount of carbon in litter (in forested areas) is estimated at 8.72 Pg or 11.4 Mg C per ha.

The future of soil carbon sequestration by the Russian forests will depend on future soil disturbances and degradation. Stolbovoi (1997) estimates that some 9%, or 93 million ha, of forest land (for definition see *Box 1*) are currently under degradation. The principal forces driving this degradation are inappropriate harvesting technologies and forest fires. A special problem is soil thaw in permafrost soils caused by disturbances (or climate change). Estimates indicate that the net carbon losses can be 0.3–0.4 ton carbon per ha per year (Goulden *et al.,* 1997; 1998) due to soil thaw. However, more work is needed to understand the processes and the full extent of Russian forest soil disturbances and degradation.

3.2.3. Methane fluxes

Methane is involved in many chemical reactions connected with atmospheric gases and thus strongly influences the Earth's energy balance. A molecule of methane is 21 times more radiatively active than that of carbon dioxide. The global atmospheric concentration of methane has increased from a relatively stable level of 0.7 ppm to 1.7 ppm during the past 300 years. The total annual global flux of methane to the atmosphere is estimated to be 357–715 Tg. There is great uncertainty surrounding not only methane fluxes, but also the process of methane formation and consumption.

We have carried out two studies on methane fluxes from Russian ecosystems; the net fluxes are estimated to be 25–40 Tg annually (Rozanov, 1995; Zelenev, 1996; *Figure A10*). The northern Siberian lakes are estimated to contribute 1.5 Tg per year to the methane fluxes (Zimov *et al.*, 1997). The Russian ecosystem fluxes correspond to a total of 3–10% of the gross global fluxes and are of the same size as the global net fluxes.

3.2.4. International agreements

Russia has signed several governmental agreements to decrease greenhouse gas emissions to the atmosphere. Nevertheless, the Russian forest sector has not yet developed or implemented any consistent programs to adapt the Russian forests to global climate change, nor have any greenhouse gas mitigation programs been developed. The few implemented activities in this field have occurred more by chance than by design. Russia has several state programs for forest sector development. The major ones are the programs "Forests of Russia", on forest fire protection, and for reforestation that could play an important role in fulfilling the country's greenhouse gas obligations if the programs receive a substantial increase in funding.

3.3. Forest biodiversity

We believe there are three fundamental ways to conserve forest biodiversity: (1) through protected areas; (2) through biodiversity-sensitive forest management where timber is harvested; and (3) through efficient landscape management.

In this paper, "protected areas" refer to those forest areas where timber harvesting is not permitted. According to Klever *et al.* (1994), Russia has an outstanding established network in the form of so-called *zapovedniks*, or strictly protected areas. These areas are, relatively speaking, large and numerous (77 in total), and are often surrounded by territory that is effectively wilderness (See *Figure A6*). At present, the Russian Federation has 97 state natural reserves with a total area of 32.6 million ha. By 1996, Russia had 33 national parks, two-thirds of which were established during the past five years. The total area of the national parks is 6.6 million ha (0.39% of Russia's territory). There are plans to establish 40 additional parks, which would mean an additional area of 10 million ha (Center of Wild Nature Protection, 1997; Chebakova, 1997; Sokolov *et al.*, 1997). Practically all national parks are located in

Forest Fund areas (for definition see *Box 1*) and are managed by state forest authorities. In addition, the Russian Federation has 52.5 million ha of game parks; the forestry organizations administer 11.5 million ha of wildlife areas; and the forest territory has about 1 million ha of so-called unique natural items.

The total area of specially protected areas is about 5% of the total forest resource areas in Russia (Sokolov, 1997a). These protected areas conserve more than two-thirds of the rare and endangered species listed in the *Russian Red Data Book* (Klever *et al.,* 1994). Russia's conservation of forest biodiversity using protected areas seems rather advanced – at least on paper – and relative to what other countries have achieved (Klever *et al.,* 1994). However, the economic decline during the transition has seriously deteriorated the management capacities of protected areas.

Biodiversity conservation efforts in protected areas are fundamentally important (Noss, 1990; 1995), but a full program of forest biodiversity conservation must also deal with forests subjected to timber harvesting and other interventions. Biodiversity conservation treatments include leaving mature and dead trees at harvesting, regenerating with mixed species, and refraining from clear-cutting in all-aged stands of shade-tolerant species.

Biological diversity refers to the variability among living organisms from all sources, including, *inter alia*, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and within and between ecosystems (Glowka *et al.,* 1994). To make biodiversity an operational concept, a relevant unit for biodiversity indicators and operational management must to be selected. Noss (1990) placed the forest landscape as the highest element in his hierarchy of ecosystem levels. We feel that landscape is a relevant unit for understanding the biodiversity concept. Therefore, we also include conservation of forest biodiversity in the landscape concept.

Russia has a long tradition of working with different levels of landscapes thus has an excellent platform for real biodiversity management (see *Figure A11* and Roshkov *et al.,* 1996b). Biodiversity can be dealt with at the level of the established network of *zapovedniks,* other protected areas, and the landscape concept. However, Russia has not taken any steps to conserve biodiversity through biodiversity-conserving forest management.

Over 600 vascular plants are considered rare, threatened, or endangered. The Russian forests contain some 400 tree and 950 bush species in Russia (USSR Academy of Sciences, 1984). Five percent of these are trees and bushes; the remainder are grass species (Venevskaia, 1996). There are some 50 endangered animals inhabiting forest ecosystems in Russia (USSR Academy of Sciences, 1985).

Approximately 40% of all medicines used in Russia are derived from plants. Some 140 plant species are currently used for medicinal purposes.

We have carried out first-cut quantitative analyses of the forest biodiversity of the Russian boreal forests (Duinker *et al*., 1996). From these analyses the following can be concluded:

- Exploitation of land for timber or other purposes seriously threatens the forest biodiversity.
- However, in large-scale uniform landscapes, careful forest management can increase biodiversity.
- Fire suppression may decrease biodiversity.
- More protected areas and a more efficient distribution of protected areas are required to maintain biodiversity.
- The forest biodiversity is directly scale-dependent, and future policies on biodiversity must take into account the interaction between different scales of ecosystems.

Russia needs to carry out a complete nationwide assessment of the biodiversity issues in its forests. Based on this assessment and subsequent analyses, a biodiversity policy that integrates conservation (protection) and management of the forest ecosystems and landscapes should be established.

3.4. Water and Soil Protection

There are two very important dimensions of regional and local ecological functions of the Russian forests: (1) protection of water and soils at the landscape level, and (2) the impact on the hydrological regime (water protection and water regulation). The hydrological regime strongly impacts the forests' ability to fulfill their biospheric functions (carbon and nitrogen budgets of forests); to produce; to regenerate; to balance natural disturbances; and to control water quality of rivers and lakes. Russia has a special protective category of so-called water protective forests (mainly constituted by belts along rivers and lakes) with a total area of roughly 88 million ha. Agroforestry plays a crucial role in sustainable development of agricultural landscapes in central and southern regions of Russia. The ongoing decrease of forest cover, unfavorable climatic conditions in the majority of arable lands, and insufficient land-use systems have led to widespread wind and water erosion and the impoverishment of arable land. This is especially true for irrigated lands. The annual average loss of humus from arable lands is 0.62 Mg/ha^{-1}, and the total loss for Russia is 81.4 million $Mg/year^{-1}$. The amount of organic matter in Russian arable lands has decreased by 30–40% during the past 100 years (Stepanov, 1996). Protective forest stands, specifically forest shelter belts, are one of the most important tools for protecting agricultural land. Russia needs 6.95 million ha of protective forest stands to protect 90 million ha of arable land, including 2.9 million ha of shelter belts (Isaev, 1991a). Russia has established 1.2 million ha of shelter belts, which protect 15 million ha. This means that protective forest stands should be generated to protect 75 million ha of arable lands, namely some 6 million ha of shelter belts.

Calculations on the hydrological balance for Russian ecological regions (Youchnovskii *et al.*, 1996) show that evapotranspiration in the Russian boreal zone constitutes from 25–30% (in tundra and forest tundra) to 65% (in forest steppe) of the total precipitation. Runoff is 65% and 35%, respectively. From an average precipitation for Siberia of 532 mm per year, the evapotranspiration was estimated to be 286 mm (53.8%) and the runoff 246 mm (46.2%). The construction of large water reservoirs in Russian rivers and the development of infrastructure (specifically on permafrost areas in the north) have led to negative changes in the hydrological regimes of large areas, for example, increased water tables (so-called *podtoplenie*, which have affected about 1 million ha).

3.5. Pollution stress on Russian forests

There are many reports (both Russian and international) documenting the environmental problems in Russia and how these problems influence the development of the Russian forests (Gusewelle, 1992; Knight, 1992; Stanglin, 1992; Danilov-Danilian and Kotljanov, 1993; Tracy, 1994; European Parliament, 1995; Feshbach, 1995; Goskompriroda, 1995, 1996; Newell and Wilson, 1996). Kotov and Nikitna (1993) report that 15% of the country's territory, home to 20% of the total population, qualifies as an environmental disaster zone. We have tried to quantify how serious the threats of air pollutants and radionuclide contamination are for Russian forests.

Within the Convention on Long-range Transboundary Air Pollution program, Russia has carried out single critical load estimates and exceedances of critical loads for European Russia with respect to sulfur and nitrogen (Downing *et al.,* 1993; Posch *et al.,* 1993). From these analyses, it can be concluded that in the taiga forests of European Russia the critical loads are seldom exceeded at existing levels of atmospheric depositions, although the region has a low buffering capacity. Potentially dangerous effects of eutrophication were identified. Based on analyses of combination impacts of sulfur and nitrogen, Hettelingh *et al.* (1995) confirm the findings identified earlier with respect to exceedance of the critical loads in European Russia. We have overlaid the extent of exceedances of critical loads with our IIASA Forest Study database (Blauberg, 1996) with respect to the forest resources (*Table 7*). We have also carried out similar analyses for Siberia based on the same concept (Kharuk *et al.*, 1996; Nilsson *et al.*, 1997). The forested area and growing stock at risk from sulfur and nitrogen depositions in Russia are presented in *Table 7*.

Table 7. Forest area and growing stock at risk from sulfur and nitrogen depositions in Russia.

	Forested area (in million ha)	Growing stock (in billion m^3)
Sulfur		
European Russia	21.5	2.8
Asian Russia	210.0	24.5
Total	231.5	27.3
Nitrogen		
European Russia	1	0.2
Asian Russia	87	11.4
Total	88	11.6

In the calculations on the exceedance of critical loads, there are some 230 million ha of forested areas at risk from sulfur depositions, which is 30% of the total forested area (an area larger than the total exploitable forests of the USA [196 million ha]). The corresponding figures for the growing stock at risk from sulfur depositions are 27.3 billion m^3, approximately 35% of the total growing stock. The areas and growing stock at risk from nitrogen depositions are substantially lower. It can also be concluded from *Table 7* that the problem of sulfur and nitrogen depositions is greatest in Asian Russia. This may seem surprising but can be explained by the higher sensitivity of ecosystems in Asian Russia. In Asian Russia a number of regions have been seriously damaged by air pollutants, such as Norilsk and Bratsk (Kharuk *et al.*, 1996).

With respect to heavy metals, it can be concluded that Russia's depositions are below the critical loads for forests set by Russian experts (Nilsson *et al.*, 1997), except in the vicinity of emitters of heavy metals. Hence, we currently estimate that heavy metal pollution does not seem to be an overwhelming problem for the Russian forests. However, further development of the critical loads for heavy metals is necessary. It should also be pointed out that there are many other pollutants emitted in Russia (Blauberg, 1996), whose impacts have not yet been analyzed.

Official data on radionuclide contamination in Russia derive from different sources and have different degrees of reliability. The radioactive conditions are determined by the following: global radioactive background, natural radioactivity, radioactive outbreaks and underground nuclear explosions, and nuclear industry and nuclear waste storage. To the best of our knowledge, we have examined all available information with respect to contaminated forests in Russia. For more information the reader is directed to see Kharuk *et al.* (1996). The information available is sparse, but based on our investigations we can only conclude that there are serious risks to human beings from radionuclide contamination, although contaminated forested areas and forest ecosystems at risk from nuclear radiation seem to be limited (at least in Asian Russia, Kharuk *et al.*, 1996). In terms of radioactive contamination, the problems at the nuclear complex in Mayak (southern Ural) are probably the most serious in Asian Russia. A number of accidents at this facility caused contamination in an area of 0.7

million ha, affecting some 270,000 people. There are no satisfactory estimates on the possible impacts on the ecosystems for this area (Segerstahl *et al.*, 1997). The accident at the Chernobyl nuclear power station led to the contamination of roughly 1 million ha of forests in European Russia [Garayev *et al.* (1997) claim that 1.23 million ha of forests were contaminated], mainly by Cesium-137; contamination in 86.5% of this area is in the range of 1–5 Ki/km^2; 10.4% is in the range of 5–15; 2.9% is in the range of 15–40 Ki/km^2; and 0.2% shows levels of more than 40 Ki/km^2 (Goskomecolodgy, 1997). This contamination has caused many difficulties and restrictions in forest utilization in these areas. Garayev *et al.* (1997) estimate that an additional 0.27 million ha of Russian forests are contaminated as a result of testing of nuclear weapons.

There is a high potential risk for future radioactive accumulations in the Russian forest ecosystems because of current nuclear waste storage. This high-risk condition requires further investigation.

Russia needs to establish an efficient nationwide system for monitoring pollutant depositions (air and water pollutants and radionuclide depositions). In parallel, critical loads for different pollutants in various ecosystems must be developed. Only then can a proper assessment of the ecosystems at risk from pollution take place.

4. Economic Significance

The development of the Russian forest sector is to a large extent defined by the macroeconomic development and overall economic policies implemented. During the transition, Russia has suffered from a number of severe economic crisis. The economic decline in Russia during the period 1992–1997 is claimed to a large extent to be the result of failed economic policies (Glasiev, 1997). The principle results of the economic liberalization are claimed to have resulted in the depreciation of society's incomes and savings and a dramatic redistribution of capital to a small group of people, the so-called “new Russians”. This group of people gained control over former state properties and the financial flows and by that also control over the price-mechanism in Russia (Glasiev, 1997; Manevich and Kozlova, 1997).

The economic liberalization has also resulted in a dramatic decline in investments. The Council of the Russian Federation (1998a,b) claims that just maintaining the Russian economy (without any growth) an investment volume of 600 trillion rubles (old rubles, before the denomination in January 1998) is required annually. The investments in 1996 were 370 trillion rubles and in 1997 409 trillion (in nominal values).

In the following section, we will not go into any deeper discussion on the macro-economic conditions in Russia but will concentrate on the economic dimension of the forest sector.

4.1. Prices and costs

Several key factors will impact the future structure of the Russian forest sector. First and foremost are the levels of prices and costs; because these values are highly uncertain, they preclude direct consideration in quantitative analyses. The great uncertainty concerning current price and cost levels, the degree to which they represent scarcities, and the extent to which buyers and sellers have accurate information on which to base their decisions reduce the utility of financially based policy tools. An indication of the effect of prices and costs on future prospects of the Russian forest sector can be achieved by a model structure developed by Backman (1993; 1997).

4.2. Markets

Domestic demand for forest products decreased dramatically between 1990 and 1995. Consumption of forest products in 1995 was only some 30% of that in 1990. According to expert estimates, the current paper and board consumption in Russia is 19 kg per capita per year, compared with 35–36 kg per capita per year in the late 1980s (Goridko, 1997). The coniferous lumber consumption was 50.6 million m^3 in 1990 but had declined to 17.3 million m^3 in 1995 (Strakhov, 1998). Domestic producers are now also facing strong competition from imported high-quality forest products (Burdin and Ryzhenkov, 1997).

The future demand for forest products in Russia and the former republics of the USSR is highly dependent on the likely trends in economic activity. Based on the analyses carried out by Backman (1997), the most plausible scenario seems to be one in which domestic demand in Russia will start to pick up during the next five years (*Table 8*). Thus, the domestic demand for forest products is estimated to have a strong increase in the mid-term future. Some analysts (e.g., Komiev, 1997; Setälä, 1997) estimate that Russian pulp and paper mills will be able to supply only a fraction of the paper products needed by a recovering economy, and that Russia will soon be a strong net importer of pulp and paper products.

Table 8. Average domestic annual demand for selected forest products (from Backman, 1997).

Russia	1989	1994–1998	2004–2008	2024–2028	2039–2043
Lumber (million m^3)	63.5	30.0	58.5	116.2	117.1
Panels (million m^3)	8.1	5.4	10.5	39.5	48.7
Pulp (million tons)	8.3	0.6	0.6	0.4	0.3
Paper + board (million tons)	6.6	3.2	5.9	20.8	37.9

It also seems plausible that there will be a strong increase in demand over time for lumber and panels in Kazakstan and other Central Asian republics. For these areas, paper consumption may reach 1.4 million tons by the year 2040. In the European part of the former USSR republics (Baltics, Transcaucasus, and southwestern USSR) there may be a substantial increase in the demand for panels, but it seems that lumber consumption will not reach the 1989 level by the year 2040. The paper and board consumption may reach 11 million tons in the same time frame (for further details on demand, see Backman, 1997).

Although domestic demand supports almost two-thirds of the fiber supply produced in Russia and up to 75–80% of the output of different manufactured products, export markets could play an increasing role in refinancing the sector.

Eastern Russian enterprises (the Far East) will concentrate on the markets in the Pacific Rim, including Japan and South Korea. Although markets in China collapsed in the early 1990s, recent events suggest that trade levels in forest products will rise very quickly as both Russian and Chinese governments strive to increase bilateral trade between the two countries. Kazakstan and Central Asian republics will provide a growing market for the forest sectors located in East and West Siberia.

The European republics of the former USSR and the Baltic region are currently in a surplus situation vis-à-vis fiber supply and can support a forest sector based on exports. A successful economic recovery in these regions will lead to fiber shortages and failures to meet even domestic demand within two decades. The forest sector located in European Russia would be well positioned to exploit the market opportunities of these two regions in addition to the traditional European market.

The additional export potential in the year 2020 for some export markets is summarized in *Table 9*. This table shows that a huge export potential is forecasted for Russia. The current export of Russian forest products corresponds to about 30 million m^3 (roundwood equivalents) (Burdin, 1997). It means a total future export potential of some 75–85 million m^3 per year.

Trade supported almost 30% of the forest sector activity in 1989. This figure was already below 25% by 1992, and at the same time Russian total production had decreased substantially.

Table 9. Estimates of additional export potential in the year 2020, in million m^3 roundwood equivalents (derived from Kakizawa, 1994, 1996; Tak, 1994a,b, 1996; Poliakov, 1995; Backman, 1995a, 1996b; Backman and Zausaev, 1998; Waggener *et al.*, 1996; Waggener and Backman, 1997).

	Export potential
Baltic republics	3.0
Transcaucasus	2.5
Former Southwestern USSR	16.0
Central Asia	4.0
Kazakstan	3.0
China	5–10
Japan	7–10
South Korea	3–5
Traditional European Markets	>10
Total	53.5–63.5

Barter trade is a significant component of the Russian economy. Between 1990 and 1991, barter trade served as a primitive exchange of goods, but in the mid-1990s, barter trade began to serve as a money surrogate. This resulted in two pricing systems, a barter price and a cash price, the latter being 30–50% lower than the barter price. Barter trade in the Russian economy was estimated at 40% in 1996 (US State Department, 1997). In Krasnoyarsk barter trade is currently estimated to constitute 90% of all money exchanges in trade (DN, 1997). Russian industry faces significant barriers to export markets linked to its inability to supply consistent high quality manufactured products. The Russian forest sector needs to add capital and management in order to secure an increasing market share in the markets for more manufactured forest products markets.

4.3. Wood supply

As illustrated above, the Russian forests can be credited with an annual net growth of nearly 1 billion m^3. However, much of this potential is and cannot be realized by the forest industry due to environmental constraints, low standing volume stands, the remoteness of forests from domestic and international markets, the absence of a transportation network, and technological limitations. Strakhov (1998) estimates that the exploitable forests comprise 55% of the forested areas under state forest management and 60.7% of the growing on that area for total Russia. The corresponding figures for European Russia are 84.7% respectively 83.9%.

The annual allowable cut (AAC) set by the Federal Forest Service and based on a sustainable biological supply is illustrated in *Table 10*.

The AACs only consider final felling and commercial wood (industrial wood plus fuelwood) in forests under state forest management. The AAC is based on the status of the forest inventory, forest regulation, and silvicultural handbooks. As discussed above, there is a very high natural mortality rate of Russian forests (nearly 50%). Thus, there are balancing problems concerning the liquidation rate of overmature and uneven-aged forests. As illustrated by Nilsson *et al.* (1992), many sustainable liquidation profiles exist. Nilsson *et al.* (1992) show that one possibility, based on modern silviculture handbooks, would be to increase the harvest level rather dramatically (to 2–3 times the current AAC) during the next 50 years in some regions of Russia in order to balance the forest structure and decrease the natural mortality. An additional reason to follow a rapid liquidation path is the high rate of losses in the current harvest due to rotten wood. The World Bank (1997a) estimates that the loss in current harvests due to rotten and dead wood is 34% of the gross harvest.

Table 10. Annual allowable cut in Russia, 1965–1995 (in million m^3). Derived from Pisarenko and Strakhov, 1995; Kukuev, 1997.

	1965	1970	1975	1980	1985	1990	1993	1996
Total	603.9	605.6	620.4	619.0	617.2	603.0	529.0	511.7
Coniferous	402.1	388.1	398.1	395.5	390.1	381.9	315.0	305.4

Table 11. Harvest in Russia and estimated unaccounted harvest (in million m^3). Derived from Backman, 1997; Burdin, 1997.

	1989	1992	1993	1994	1995	1996
Official harvest	338	238	175	119	115	94
Unaccounted[a]	101	87	76	56	50	36
Total	439	325	251	175	165	130

[a] Harvest linked to the forests not part of the jurisdiction of forest agencies based on an estimate by Backman (1995b).

There are also substantial losses of wood in the process from stump to final product. Nilsson *et al.* (1992) estimated these losses to be on average 20% of the gross harvest.

The harvests in recent years are presented in *Table 11*.

From these figures it can be concluded that the harvest has been substantially below the estimates for a sustainable harvest level.

Sheingauz *et al.* (1996) claim that, according to various evaluations, wood production is actually 1.5–2 times higher than current official data due to the shadow economy, intentional underestimates of the production rates in order to evade taxes, and "loss" by statistical agencies (all small and some medium-sized businesses).

At present, lease holders (mainly former state-owned logging companies) have at their disposal forest tracts with an allowable cut of 85 million m^3 per year. In addition, stumpage auctions have been introduced, constituting 1.7 million m^3 in 1996. Earlier stumpage revenues covered all forestry costs, but in 1996 forestry revenues only amounted to 30% of the costs of forestry (Giryaev, 1997). In the same year, the federal budget allocation for forest management and protection corresponded to 0.34% of the costs of forestry (Strakhov, 1998).

At IIASA, we have developed detailed databases and models to estimate the AAC (including thinnings). By employing more intensive forest management (regeneration, protection, and thinnings) than is executed in Russia today, but still following the principles of Russian forest management manuals, we estimate an AAC of physically accessible wood of 240 million m^3/year in European Russia, which is substantially higher than the current AAC of 187 million m^3. This difference can be explained by the fact that the IIASA results include intensified forest management and the Russian AAC excludes thinnings. The corresponding figures for Asian Russia are 245 million m^3/year (increasing to 315 million m^3 after 150 years) according to IIASA (including increased forest management) and 325 million m^3 according to the current Russian AAC. The IIASA results are 80 million m^3 less than the official Russian AAC for Asia. This difference can be explained by the fact that in the IIASA studies more environmental concerns are considered and more long-term dynamic analyses are carried out. However, this comparison does not consider a balancing of the forest structure through increased liquidation of overmature forests in the European North, the Urals, and the majority of the Asian regions (Nilsson *et al.*, 1992). With this latter approach, the total AAC in these regions could be substantially increased during the next 40–50 years.

An estimate of economic accessibility is full of uncertainty given the fluctuating exchange rate, inflationary tendencies, and fluctuating price and cost matrix characteristic of Russia at the present time. Harvesting levels today are not representative of the levels that will be possible when the domestic price and cost matrixes achieve some stability with the international level and choices among suppliers and demanders become more widespread. In spite of these uncertainties, we have carried out a number of model analyses on the future economic supply (Backman, 1995b; 1996a; 1997; Backman and Blam, 1997; Korovin *et al.*, 1998).

These analyses indicate that with the current infrastructure, the economic commercial harvest (industrial wood plus fuelwood) level could amount to some 235 million m^3 (including firewood and harvest losses) for total Russia in the short to medium term. But with a 10% increase in the relative price for roundwood, the commercial harvest level would increase to 305 million m^3 in the short to medium term. In the medium term, with technological or infrastructural development (but no relative price increase), the economic harvest level could increase to 325 million m^3. With the additional technological and infrastructural development and a 10% increase in the relative price for roundwood, the economic harvest level could increase to 435 million m^3 in the medium to long term, which can be compared with the current official AAC of some 510 million m^3. Thus, we have a range of 235–435 million m^3 for the estimated sustainable economic harvest levels of commercial wood, depending on the economic developments. But the economic sustainable supply of industrial wood is substantially lower than the estimated supply of commercial wood (75–145 million m^3 less, depending on the economic development). The deciduous harvest constitutes 38% in European Russia and 28% in Asian Russia of the total harvest. Thus, the above analyses do not assume any drastic changes in the liquidation profile of overmature forests, but a rather smooth harvesting pattern over time. The analyses are summarized in *Table 12*.

Thus, the above estimates are based on a stable or increased harvest level during the next 200 years. However, because huge areas of the Russian forests are constituted by mature and overmature forests, a different (but still sustainable) harvesting profile could be employed. These overmature forests are at high risk for large-scale disturbances by fires, insects, and diseases; they have low productivity, and are degenerating in the form of rotten wood. Thus, much could be gained by a more rapid liquidation of these forests. We have applied an accelerated harvest during the next 40–50 years in the regions with overmature forests. These calculations indicate that we could add additional volumes to the figures presented in *Table 12*. For European Russia, this means an additional 40 million m^3 per year of commercial wood during the next 40 years (28 million m^3 of industrial wood). For Asian Russia, this means an additional 100 million m^3 per year of commercial wood for this period, and 65 million m^3 per year of industrial wood.

Table 12. Estimated Sustainable Economic Industrial Wood Supply respectively Commercial (industrial wood + fuelwood) Wood Supply (in brackets). In million m^3 per year.

	European Russia	Asian Russia	Total
Official Russian AAC	133 (187)	219 (325)	352 (512)
Base scenario economic supply (with existing infrastructure and relative prices)	90 (135)	70 (100)	160 (235)
With 10% increase in relative prices in forest products	105 (160)	100 (145)	205 (305)
Investments in infrastructure	110 (165)	105 (160)	225 (325)
With relative price increase of 10% + investments in infrastructure	130 (195)	160 (240)	290 (435)

It should be pointed out that we are not arguing for the liquidation of all overmature forests. Overmature forests are up to 80% uneven-aged forests, and, as such, they are one of the crucial components of a sustainable landscape.

Russia needs to introduce modern dynamic wood supply analysis that takes into account ecological, economic, and social constraints. It must also make a strategic choice on the future liquidation profile. These analyses should be the platform for setting official AACs in Russia in the future.

4.4. Forest management

In the long term, the forest management approach used will influence the economic harvest level of mature and overmature forests similarly to the selected liquidation profiles. The forest management regimes employed will also influence the environmental values of the forest resource.

The most intensively utilized forests are in European Russia. In 1992 and 1993 there were, on average, 4.1–5.2 ha of final felled areas per 1,000 ha of forested areas. In Asian Russia, the corresponding figure was 0.9–1.2 ha. Since 1988, there has been a reduction of the final felling areas in Russia, from 2.1 million ha in 1988 to 1.1 million ha in 1993. Between 1988 and 1993, clear felling was carried out in a total area of 8.8 million ha. Of this harvested area, artificial regeneration took place on 2.65 million ha (or 30%), and natural regeneration took place on 4.55 million ha (52%). In the remaining harvested area (18%) no regeneration was carried out.

Between 1966 and 1989 artificial regeneration was carried out in 33.2% of the final harvested areas, natural regeneration took place in 52% of the areas, and in 18% of the areas there was no regeneration. In 1993, the unforested areas had reached 68.4 million ha and 16.5 million ha required artificial reforestation. The total planted area of forests under state forest management in Russia in 1993 was 17.3 million ha.

Reforestation activities are by now down to 0.04–0.05% of forest lands annually (European Russia 0.17–0.21% and Asian Russia 0.01–0.02%). A sustainable reforestation activity is estimated to be 0.14% (0.55% for European Russia and 0.08% for Asian Russia) (Strakhov, 1998).

Russia applies an index generated as quotas of the area of coniferous forests in the first age class (young forests) divided by the area of final harvest of mature and overmature coniferous forests. A relation larger than one indicates positive reproduction of coniferous forests and a value less than one indicates a decrease of the coniferous resources (*Table 13*).

Table 13. Index for the relation between area of young coniferous forests (first age class) and areas of final harvested mature and overmature coniferous forests in Russia over time. Derived from Strakhov and Pisarenko, 1995.

Time period	Index
1966–1973	2.2
1977–1978	1.3
1979–1983	0.17
1984–1988	0.03
1989–1993	0.03

As can be seen from *Table 13,* there has been a strong decline in the index over time. This decline indicates that during the past 20 years the new areas of satisfactorily stocked young coniferous forests (first age class) far from compensate coniferous areas taken out of production by final harvest.

To establish healthy and productive forests, the qualitative structure of the forests must be improved through intensified thinnings. The thinning rate is very low in Russia and has decreased over time (*Table 14*).

Based on the information in *Tables 11* and *14,* it can be concluded that the thinning rate is only 7–9% of the total harvest.

Precommercial thinnings have decreased from 1.1 million ha in 1990 to 0.9 million ha in 1993 (Pisarenko and Strakhov, 1996). This decreased development in the thinning volume will influence the availability of quality timber resources in Russia in the long term.

Table 14. Thinning and sanitary fellings of commercial wood in Russia (area expressed in million ha, volume in million harvested m^3).

	European part		Asian part		Total Russia	
Year	Area	Volume	Area	Volume	Area	Volume
1980	1.99	19.9	0.43	5.7	2.42	25.6
1985	1.96	20.3	0.48	6.1	2.44	26.4
1990	1.93	20.8	0.48	6.7	2.41	27.5
1993	n.a.	15.3	n.a.	4.6	n.a.	19.9
1994	n.a.	13.9	n.a.	3.8	n.a.	17.7
1995	n.a.	15.2	n.a.	4.2	n.a.	19.4
1996	n.a.	14.6	n.a.	4.7	n.a.	19.3

Note: n.a. = Not available.

All signs indicate the need for intensified forest management in Russia, but in reality the intensity is currently decreasing from an already low level (Nilsson, 1995).

In the wood-supply scenarios presented in Section 4.3, intensified forest management is assumed in the future.

New official forest management manuals need to be developed based on new economic realities and regional conditions in order to displace previous centralized management rules.

4.5. Transportation

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

The density of the transportation network (all road and railway but no waterway transportation) varies between 1.05 m/ha (European North) and 6.5 m/ha (Central Chermozyomny) in European Russia (Nilsson *et al.*, 1992). In the Far East and East Siberia, the density is 0.2 and 0.5 m/ha, respectively, and in West Siberia it is 0.8 m/ha (Nilsson *et al.*, 1994). Many of the routes are almost exclusively winter roads and are rarely used during the summer. The majority of roads lack hard surfaces and are generally in poor condition due to neglect. Only a fraction of roads built during the past 50 years are in operation today (about 20% of the forest roads).

Russia has the largest inland waterway transportation system in the world, estimated by Blaha and Kahn (1991) to be 146,000 km. In European Russia, especially, there is a unique and efficient system of channels.

Railway shipments encounter huge problems. These problems are caused by a lack of capital investment, aging rolling stock, a shortage of approximately 1 million freight cars, out-of-date locomotives, and substandard railroad tracks.

Table 15. Transportation tariffs on the Russian railway system (Krasnoyarsk–Nakhodka: 5,350 km). Derived from Backman, 1997.

	Average for the year								
	1991	1992	1993	2 Jan 92	12 Jun 92	1 Jan 93	1 Jan 94	15 Jun 94	1 Sep 95
Price index (1991 = 1.00)	1.00	53.00	856.00	9.40	47.70	162.20	1794.00	4733.00	13185.90
Exchange rate (rubles per US$)	0.63	202	963	215	126	417	1247	1916	4422
Cost (ruble) per railway wagon (capacity 63 tons)	1061	56,233	908,216	9.973	50,610	172,094	1,903,434	5,021,713	13,990,240
Cost (ruble) per railway wagon (capacity 48 tons)	1000	53,000	856,000	9400	47,700	162,200	1,794,000	4,733,000	13,185,900
Cost (ruble) per m^3 roundwood (63 ton car)	21	1125	18,164	199	1012	3442	28,069	100,434	279,805
Cost (ruble) per m^3 plywood (48 ton car)	18	946	15,286	168	852	2896	32,036	84,518	235,463
Railway wagon (capacity 63 tons)	1698	278	943	46	402	413	1526	2621	3164
Railway wagon (capacity 48 tons)	1600	262	889	44	379	389	1439	2470	2982
Cost (US$) per m^3 roundwood (63 ton car)	33.95	5.57	18.86	0.93	8.03	8.25	30.53	52.42	63.28
Cost (US$) per m^3 plywood (48 ton car)	28.57	4.69	15.87	0.78	6.76	6.95	25.69	44.11	53.25

The infrastructure for loading and unloading in the transportation network is far from sufficient.

Prices in the transportation sector followed the general economic trend until 1993, after which they began to escalate more rapidly. By 1994, transportation prices had increased almost twice as much as prices in the economy as a whole and in the forest sector. This price development is illustrated for railway transportation tariffs in *Table 15* (derived from Backman, 1997). During the period 1990–1997, railway tariffs increased by a factor of 20,917 and forest product prices increased by a factor of 4,732. The growth rate for fuel and electricity prices exceeded the growth rate for prices of forest products by a factor of three. Goridko (1997) points out that the Regional Power Commissions set unjustifiably high tariffs on the energy supply. Russian customers are currently unable to afford wood or forest products that have been transported by rail (Burdin, 1997).

There are three major routes out of Russia for waterway exports of forest products; the Baltic and White Seas, the Pacific Ocean, and the Black Sea. Export volumes of forest products through these major routes are presented in *Table 16*.

Table 16. Export volumes of forest products and trade routes in Russia (in million tons). *Source*: World Bank (1997a).

	Export volumes	
Trade routes	Before 1991	1995
Baltic and White Seas	7.5	3.9
Pacific Ocean	7.1	6.5
Black Sea	2.0	2.2
Total	16.6	12.6

Thus, there is not only an obsolete and insufficient transportation network in Russia, but also inefficient price setting in the transportation sector. It can be stated that the transportation sector has moved from an underpriced and subsidized monopoly to an overpriced monopoly market. This development greatly hinders development of the forest sector.

Russia needs to invest substantially to upgrade the transportation infrastructure. It must also actively introduce fully market-oriented price setting in the transportation sector.

4.6. Forest industry

Currently, there are 2,830 large and medium-size enterprises in the Russian forest industrial sector, of which 153 are pulp and paper mills, 18 are wood chemical industries, 1,384 are major wood mechanical mills, and 1,277 are logging companies. To create financially stronger units, 47 holding companies have been established, bringing together approximately 600 of the forest-industrial companies. Some 95% of the enterprises have been converted into stock companies and other commercial structures. The pulp and paper capacities are currently estimated as follows: pulping, 8,035,000 tons (of which 2,947,000 are market pulp); paper production, 4,845,000 tons; and paperboard, 3,146,000 tons (Goridko, 1997). The location of the forest industry is presented in *Figure A12*.

Before the collapse of the USSR in 1989, some 70% of lumber output, 75% of pulp output, and nearly 90% of the panel, paper, and paperboard production took place in the western part of Russia (European part plus West Siberia). East Siberia and the Far East produced the remainder and hence had a rather marginal role in total production.

By the mid-1990s, lumber production had declined to some 40% in West Russia and to 25% in East Russia compared with the 1989 levels. Pulp production had fallen to 35–40% of the 1989 levels in both West Russia and East Russia. Paper and paperboard production had declined to 40% of the 1989 levels in West Russia and to 25–30% of the same levels in East Russia.

Another way to approach industrial production changes is to study capacity utilization in the industry. World Bank (1997a) estimates of capacity utilization for 1994 are shown in *Table 17*.

Table 17. Capacity utilization in the Russian forest industry in 1994. *Source*: World Bank (1997a).

Capacity	Harvesting (million m^3)	Lumber (million m^3)	Panels (million m^3)	Pulp (million tons)	Paper (million tons)	Paperboard (million tons)
1 Jan 1994	205.7	56.3	8.35	8.66	6.01	3.40
1 Jan 1995	184.0	52.5	8.49	8.78	6.17	3.40
Capacity utilization as of 1 Jan 1994 (%)	58	55	45	39	40	36

As seen in *Table 17*, the fastest deterioration of capacities occurred in harvesting. Within one year the harvesting capacity declined by more than 10%. Harvesting is declining because the existing harvesting capacity is becoming obsolete and there is no capital to replace the rundown equipment. Capacity utilization in the industry is between 35% and 55%. There are limited possibilities to turn the economy in a positive direction with these kinds of utilization rates.

Hence, there has been a dramatic decline in forest-industrial production during the past 5–6 years, which has had serious economic and social implications. To their critics, the semi-monopolies and monopolies in the industry seem to have learned the best way to survive during the transition (Rutland, 1997). Huber *et al.* (1996) point out that concentration of the forest industry has become even greater during the transition.

The reasons for the decline in production are collapsed markets, both domestic markets and some of the traditional export markets (the Baltic republics, former COMECON countries, and Central Asian republics); a lack of wood raw material (to a large extent resulting from the increased transportation costs); and outdated industry.

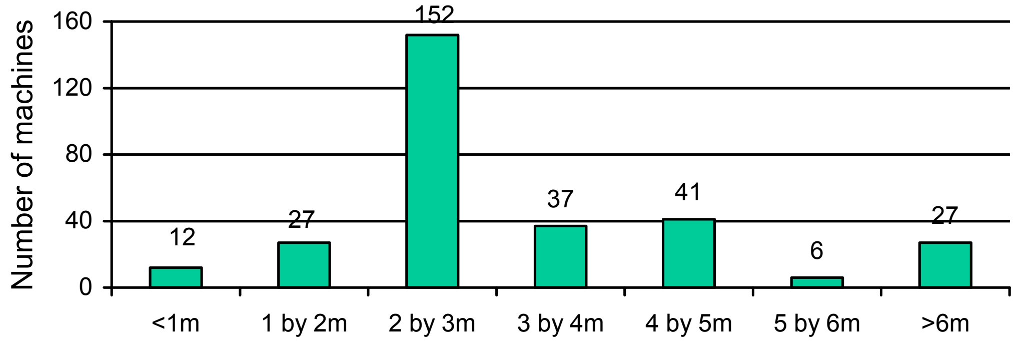


Figure 3a. Paper and board machines: Wire width distribution

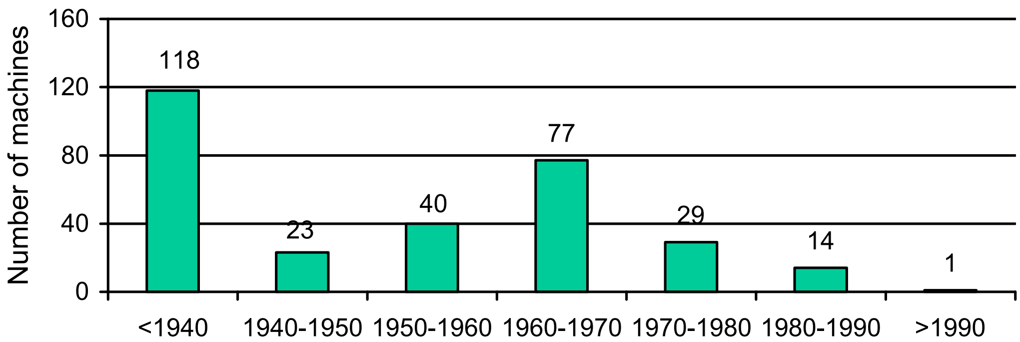


Figure 3b. Paper and board machines: Age distribution

In 1992, Simons (1992) carried out a review of the Russian forest industry (individual mills) and concluded that the employment rate is much higher in Russian mills than in Western mills. Russian mills have difficulties obtaining a skilled work force; the production quality of forest industry products is, in most cases, insufficient to meet existing consumer demand; compared with the West, the Russian forest industry is not very advanced in matters pertaining to environmental protection; and since 1975 the Russian forest industry has seen minimal capital expenditure and no real greenfield construction, which means that the state of the industry itself is such that most mills are not of world-class size or sophistication. Bond (1997) stresses that the relics of Soviet gigantism the Russian forest industry are massive facilities, hugely inefficient and polluting mills, patchy physical conditions and product quality, overmanned production lines, lack of a traditional system of financial control, and the burden of social liabilities. The Russian paper machines are mostly small and old.

Figures 3a and 3b show the distribution of the initial start-up year and the width of paper machines, which are the best indicators of machine age and size. A total of 302 machines were analyzed (Setälä, 1997).

Akim (1997a) points out that due to the heritage of the former USSR, there are great ecological problems connected to Russian pulp and paper mills. The World Bank (1997a) points out that the Russian forest industry must overcome the serious comparative disadvantages it faces with respect to high transportation costs, rapid deterioration in technology, inability to produce products that meet international standards, and lack of capital, all of which stem from an underdeveloped domestic credit network and unprofitable enterprises. Burdin and Ryzhenkov (1997) stress that there has been a dramatic increase in insolvency in the forest industry and a serious deterioration of the social infrastructure and living standards in "forest towns" during the transition, which hampers the development of the forest industry. It has been claimed that the financial crisis in the sector is mainly due to insolvent domestic customers (Goridko, 1997).

The forest industry is ridden with debt. It is estimated that the enterprises' current debts to the federal government are in the range of US$4 billion, and that some 60% of the enterprises are on the brink of bankruptcy.

However, it should be pointed out that the basic education level of employees in Russian pulp and paper companies is relatively high. The share of university graduates is approximately 10%, compared with 5% in Scandinavia (Westberg, 1997).

The future of the Russian forest industry will be based on three major overriding factors (Backman and Blam, 1997a and b). First, the extent to which domestic demand rebounds will depend on the expected introduction of links between the different components of the overall economy, which will provide a basis for the future consumption level. A moderate growth scenario assumes a growth rate in consumption of 2.5% per year. However, even if there is a sound recovery in domestic consumption of forest products, there is no guarantee that domestic production will increase. This can be illustrated by the consumption of printing papers. There is a substantial increase in the demand for printing papers in Russia, but the printing industry is obsolete, largely still centrally controlled, and insufficient at meeting customer demand with respect to run lengths, pagination, and color. This resulted in the import worth $350 million of printed paper products in 1996 (Leach, 1997). Similar examples exist for most grades of forest-industrial products. The overall infrastructure needed to support domestic demand through domestic production does not exist.

Russia is not and will not be a low-cost forest industrial producer, and it will probably not influence the export markets markedly during the next 10 years (Setälä, 1997). Therefore, the key concern with respect to the development of the Russian pulp and paper industry will be the domestic market. A number of industrialists have confirmed that domestic and international interest in the Russian forest sector centers, not on the export potential available, but on the domestic market with its huge pent-up demand and rapid development (Astemark, 1997; Bond, 1997; and Sojakka, 1997). Therefore, the development of the domestic market is crucial for the development of the total Russian forest sector.

Second, fiber availability to support domestic manufacturers and consumption and possible export is crucial in order to provide raw material for processing. The fiber base can be expanded in the following ways. With rising relative prices for forest products, the economic accessibility of currently accessible resources can be expanded; however, as illustrated earlier, this can also be achieved through changes in the harvesting profile in mature and overmature forests. Additional technology to utilize lower-quality wood or inferior species and to enable more efficient wood utilization can be developed. Suitable resources located far from the existing transportation infrastructure are available and could be made accessible through investments in infrastructure. Secondary fiber such as chips from sawmills and wastepaper could be used in an efficient way. Finally, a sound market mechanism could be established for the price setting in transportation.

Third, capital must be invested in the forest sector to replenish existing capital stock and add to the manufacturing capacity to meet rebounding domestic demand and seize export opportunities. Setälä (1997) is of the opinion that most of Russia's pulp and paper mills are obsolete and must be replaced by new mills. The capital requirements of the forest sector are enormous, not only for replenishing existing capital structure, but for adding capacity to meet future demand opportunities. Even meeting the demands brought on by a moderate growth scenario for the increase in gross domestic product (GDP) requires enormous quantities of capital, amounting to some US$30 billion in the first 5-year period and US$15–60 billion in each of the following four 5-year periods. With an aggressive investment strategy the investment needs are more than US$100 billion per 5-year period (Backman and Blam, 1997). Where this capital will come from is unclear.

Thus, the Russian forest industry needs to improve product quality to meet different customer demands, improve productivity and capacity utilization, and secure required fiber supply. The industry also needs to become strongly market oriented and have more business-minded management approaches in order to attract much-needed large volumes of investment capital required to replenish and upgrade industrial capacities (Setälä, 1997). This is a challenge for both the industry and the Russian government in an environment with an insufficient financial infrastructure. In many regions in Russia, stable financial institutes make up less than 30% of the financial market (Shadrin, 1997).

It can be concluded that the Russian forest industry (and by extension the forest sector) is in a catch-22 situation. Bond (1997) concludes that the Russian forest industry has limited possibilities to develop without the aid of multinational companies with respect to financing, market knowledge, and technology. He states that independent Russian facilities cannot survive in the long term, but will be forced to join foreign companies or form multi-facility groups. As illustrated earlier, the investment needs are tremendous. But at the same time the international forest industry is hesitating to invest in the Russian forest sector because of the extremely time-consuming bureaucracy, legislation, taxes, duties, security matters, etc. (e.g., Sojakka, 1997). We call these latter factors the institutional framework or aspects; they are further discussed in Section 6.

4.7. Non-wood products

Many products other than wood come from the forests and are of substantial economic importance for the Russian society. Under Russian forest legislation, harvesting of gum or resin, stumps, bark, twigs, hay, tree saps, wild fruits, mushrooms, berries, etc., is allowed.

Non-wood products are important for people living in the forested regions in Russia. The population's dependence on the forests in these regions is illustrated by an example presented by Metzger (1996). The regional population's dependence on non-wood products was estimated to be as follows: hunting – 8.6%; fishing – 31.9%; fur trapping – 5.2%; firewood collection – 21.1%; recreation – 44.3%; mushroom and berry picking – 61.1%; and other – 5.4%. The non-wood forest products used by individual residents from the Far East were as follows: nuts – 53.5%; mushrooms – 69.1%; berries – 59.4%; meat – 12.9%; schizandra – 15.1%; fern fronds – 15.1%; and brier – 9.7%.

The following description of the potential of non-wood products is based on Pisarenko and Strakhov (1996) and Strakhov and Pisarenko (1996).

Gum or resin tapping

The resources used for tapping of gum or resin are mature and overmature stands of pine, spruce, Siberian pine, and larch assigned for final or regeneration felling. This kind of harvesting peaked at the end of the 1980s, reaching 100,000–115,000 tons annually. Due to the economic transition, this type of production currently has almost ceased.

Tree saps

The most popular tree saps in Russia is birch sap. The average annual commercially harvested volume in Russia during the 1980s was 10,000–15,000 tons. There are about 16 million ha of forests suitable for sap tapping, but production of sap has nearly vanished today.

Medicinal raw material

Over 2,000 species of higher plants with medicinal properties are growing in Russian forests. Of the 600 of them that could be used by the pharmaceutical industry, only some 200 species are currently used. Thus, this resource is underutilized. The utilization of medicinal raw materials is very profitable. The purchase of medical raw material for commercial organizations by the Russian Federal Forest Service peaked during the 1980s at approximately 2,500 tons annually. Other organizations and private households also collect medicinal plants.

Honey

To collect honey, apiaries have been established in the forests and are managed by bee masters. Russian forests are rich in honey-supplying plant species. During the 1970s and early 1980s, around 750 tons of honey were produced by enterprises of the Russian Federal Forest Service per year and total honey production by commercial organizations was 25,000 tons per year. During the 1990s, production by the Federal Forest Service decreased to a few hundred tons annually suggesting that the total production of commercial honey today is probably in the range of 10,000 tons.

Nuts

Forest trees and brush species that produce nuts are a valuable resource in Russia. Important pine species for nut production are *Pinus sibirica*, *P. koraiensis*, and *P. pumila*. There are about 70 million ha of these forests currently at fruit-bearing age. Other important nut species are walnut and chestnut. The current commercial collection of tree nuts in Russia is about 3,500 tons annually, which is roughly half the collection during the Soviet period.

Edible mushrooms

The Russian forests are rich in edible mushrooms. Production of this commercial resource is estimated to be 500,000 tons per year. In the early 1980s, the harvest by commercial organizations was 18,000–20,000 tons annually, a harvest that has now declined to 7,000–8,000 tons per year.

Fruit and berries

For the period 1982–1990, the commercially accessible yearly production of fruit and berries was estimated to be 580,000 tons. The corresponding commercial harvest was 55,000 tons and the harvest by private households was 125,000 tons per year.

Hunting

Russian boreal forests are the main habitats of many valuable game animal species. Special game management units have been established, which, as a rule, are not the principal users of the land.

An estimate of the population of major game animals and the official harvest for 1993 is presented in *Table 18*.

Table 18. Estimate of the proportion and harvest of major game animals in game management units in Russia in 1993.

Species	Population	Official harvest	Harvest (%)
Ungulates	671,000	134,000	20
Fur-bearing animals	13,900,000	2,730,000	20
Game birds	41,900,000	4,000,000	10

These are the official figures, but it is known that substantial overharvesting and illegal harvesting also take place. The World Bank (1997a) reported that during 1993–1994, 2,000 muskdeer were harvested in Krasnoyarsk kray, despite its being a completely protected species. The World Bank (1997) also reported that beaver and deer were overharvested at levels 500–800% above the quota.

Uphyrkina (1996) makes it clear that poaching is one of the major threats to endangered animal species. Kotov and Nikitina (1993) support this conclusion.

Thus, Russian forests are rich in non-wood products and to a large extent have been underutilized in this capacity during the current transition. Conversely, there is a documented overharvest of animal species, including protected species, that seriously threatens the sustainability of biodiversity.

The production and utilization of non-wood products in the forest sector are not efficiently monitored in Russia. Efficient monitoring as well as management manuals must be implemented, which will secure sustainable production of these products.

5. Social Significance

5.1. Economic importance

The forest sector in the former USSR had a high political profile from the late 1940s to the early 1970s (see, for example, Stalin's transformation plan during 1948–1952) (Koldanov, 1992). For unknown reasons, this profile started to decline after the-mid 1970s. Since then, the forest sector has not been able to gain the same importance as before. The president of the Komi republic, Yuri Spiridonov, points out that the forest sector is probably the most forsaken sector in Russia today (Zhvirblis, 1997). Krylov (1997) points out that the most important step for rebuilding the Russian forest sector is increasing the sector's political profile.

It is difficult to use GDP estimates in Russia for historical comparisons. Therefore, we use industrial output as a measure of the aggregated production. In 1987, the share of the forestry, mechanical wood industry, and pulp and paper industry was the seventh largest sector in Russia with an output of 5.62% of total industrial output. It has now declined to ninth position with an output of 4.76% of the total industrial output (Huber *et al.*, 1996). However, it should be pointed out that Kaufmann (1997) estimates the share of the unofficial economy to be 40% in Russia in 1996. From an output aspect, the most important forest regions are Irkutsk, Arkhangelsk, Karelia, Krasnoyarsk, Perm, Komi, Moscow, Moscow Region, Sverdlovsk and Leningrad (in this order; Huber *et al.*, 1996). The statistics show that during the transition the central regions (from a geographical point of view) have lost more in output than regions having seaports and communication links.

5.2. Regional development and forest communities

Analyses of welfare indicators in Russia show that resource-rich and forest-rich regions seem to have a better ranking than other regions from the aspect of welfare

(Lundquist *et al.*, 1997). In this study, it was identified that regions with large exploitable forest areas, high AACs, and high production of forest output are located in regions with the best performance in economic and employment welfare factors during the transition, namely, North European Russia, West Siberia, East Siberia, and the Far East. In contrast, these resource-rich regions have the worst ranking from an environmental aspect. There are different beliefs concerning the possible advantages of natural resources with respect to regional development. One school of thought argues that natural-resource-dependent regions face difficulties in developing other vital sectors (e.g., Auty, 1993; *The Economist*, 1995). The other school of thought argues that natural resource- rich regions have advantages in the form of better foreign exchange and alternative strategies for new industrialization (e.g., Bradshaw and Lynn, 1996).

Studies carried out in Russia (Bandman *et al.*, 1995; Bradshaw and Lynn, 1996; Malov, 1996; and Lundquist *et al.*, 1997) conclude that natural-resource-based production (including the forest sector) could at least provide medium-term survival strategies and thus lead to improved regional welfare and living standards. It can also be concluded that in many regions the only option for development and improved living standards is further development of the forest sector.

Bradshaw and Lynn (1996) have also found that resource-producing regions have been allowed greater local autonomy than many other regions in Russia during the transition.

The World Bank (1997a) estimates that some 18% of the people working in or directly dependent on the forest sector live in remote logging and forest industry towns that have been hit hard by the decline in wood production and the resulting decline in social services. According to the World Bank (1995), the regional poverty has increased substantially since 1991.

The firm was a central institution in the former USSR society, providing employment, producing goods and services, and offering a large variety of social assets to be used by employees and the local population. The transition has forced firms to be much more economically efficient; with no subsidies, firms have been forced to substantially downsize social functions. In most forestry communities this transition has been severe. With the phaseout of subsidies, these communities have been left to fend for themselves and lack basic supplies and services.

A quantitative analysis of individual firms (Wörgötter *et al.*, 1996) shows that there has been substantial shedding of social functions. Siberia seems to be most affected, with no system established to take over these lost functions.

5.3. Employment

The Russian forest sector is a significant employer that directly accounted for more than two million employees in Russia in 1990. While the number of employees that depended indirectly on the activities of the forest sectors is uncertain, World Bank (1997a) estimates put the figure at 10 million. This means that almost 10% of the work force and total population were supported by the activities of the forest sector (Nilsson, 1997b).

The number of people directly employed by the forest sector fell from 2.0 to 1.8 million people between 1990 and the mid-1990s. 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, falling to less than half the 1990 level by 1994. Despite the declining productivity, expressed as productivity per employee, employment has decreased substantially.

The official unemployment rate in the forest sector has risen substantially. The official unemployment rate is lowest in European Russia; 7% in the forest industry and 23% in forestry and harvesting. Corresponding figures for West Siberia are 24% and 37%; East Siberia, 22% and 32%; and in the Far East, 42% and 39%, respectively. These figures can be compared with an estimated general rate of unemployment in the Russian society of some 9% in 1997 (US Dept. of Commerce, 1997).

5.4. Indigenous people

The World Bank (1997a) divides indigenous people in Russia into three groups: aboriginal (also known as "small-in-numbers people of the North"); other indigenous groups; and migrant groups. Most of the aboriginal people belong to the Mongoloid race. Other indigenous groups arrived later and practice nomadic pastoralism or mixed farming (old Russian settlers). The migrant groups are predominantly post–World War II ethnic Russians.

There are some 30 different aboriginal groups with a population of some 200,000 people (Pisarenko and Strakhov, 1996). The communities of these people were the first to suffer from the general transition and especially from the transition in the forest sector (the main customer of their products). Maintaining these communities' traditional activities (hunting, fishing, reindeer breeding) is critical for their economic survival and for the preservation of their cultural identities. At present, the situation is very critical for the aboriginal people. Traditional activities are disappearing one by one from the Russian scene. This development is a result of increased ecological degeneration, loss of reindeer pastures, loss of economically significant land due to ongoing industrial exploitation, increased costs for equipment and transportation, and ousting of the "people of the North" from hunting and trade with hunting products by amateur and professional hunters. This conflicts with the special land-use privileges these groups were granted in the late 1920s.

The birth rate among the aboriginal people is 2–2.5 times higher than the national average. However, the infant mortality rate is also extremely high in this group. The average infant mortality rate in Russia is about 18 per 1,000 births; this figure is 30 per 1,000 births among the aboriginal people. The percentage of people who die before the age of 60 is 70% in the aboriginal groups, whereas it is 30% at the national level.

Other indigenous groups and migrant peoples do not suffer from the transition and assimilation processes to the same extent as the aboriginal people (The World Bank, 1997a).

5.5. Human resources

There are many dimensions and aspects of human resources in Russia that deserve thorough analyses and discussion. We feel it is necessary to highlight one specific dimension of human resources, namely, demographics.

Based on analyses by Granåsen *et al.* (1997), it can be claimed that the demographic development is a cause for serious concern. Births per 1,000 inhabitants dropped to nearly 50%, from 17.2 to 9 during the period 1987–1996. During the same period, deaths per 1,000 inhabitants increased by nearly 50%, from 10.5 to 14.4. In 1997 the death rate was estimated to be 15 persons per 1,000 inhabitants (Goskomstat, 1997). During the period 1992 to 1996, the number of deaths exceeded the number of births by 3.5 million people (Osipov *et al*., 1997). Natural growth per 1,000 inhabitants (deaths less births) is used to measure the population development in demographics. In 1987 there was a positive natural growth of 968,000 people, which had developed into a deficit of 662,000 people in 1996. Life expectancy for the male population at birth has decreased from 64.8 years in 1987 to 57.7 years in 1994. The corresponding figures for females are 74.2 and 71.2 years, respectively (WHO, 1996). Russian sources estimated the life expectancy in 1997 to be 57.5 years for males and 70.4 for females and in the major Siberian forest regions to be 49–55 years for males and 55–63 years for females (Glasiev, 1997). These figures indicate a decline in the total population of 1,158,000 people between 1991 and 1996, despite a positive migration to Russia (Granåsen *et al*., 1997). Russian sources estimated the losses due to premature deaths and decreased birth rates during the period 1992–1996 to 8 million people (Goskomstat, 1996; Gerasimenko, 1997).

These declining trends in the demographic development are the same in most regions of Russia, except in Kaliningrad, which is affected by a net migration, and in agricultural regions. There is much speculation on the causes of this decline. The State Statistics Committee of Russia claims that the decline is an effect of the collapse of the former USSR, which brought about a general decline in living standards. Others (e.g., Eberstadt, 1993; and Poljan, 1997) claim that the roots for the decline were laid down from the mid-1960s to the late 1980s during the Soviet era by the inability to cope with relevant policies, administrative incapacity, and an erosion of the state's governing power. If these latter scientists are correct, the drastic negative population development had already started in the former USSR and was exacerbated by the transition during Russia in the 1990s.

From our attempts to continue detailed forest sector information with detailed regional/population developments, we conclude that a prospering forest sector would be able to contribute to the social development in those oblasts and republics for 50–65% of the population who are experiencing a decline in their population development (Granåsen *et al*., 1997).

6. Institutional Aspects

The economic and political transition in Russia is extremely difficult due to what scholars call *patrimonialism*. Patrimonialism can be defined as the case where a sovereign of a patrimonial state regards himself or herself as both the ruler of the country and its proprietor. "Political authority is seen as an extension of the rights of property ownership, with both land and people at the Sovereign's disposal" (Jensen, 1997). Russia has a long tradition of patrimonialism. Before 1917, the tzar "owned" the nation, its vast resources, and its people. During the Soviet era, the state and party owned everything. The Russia of today has to take care of this inheritance to achieve a sound transition. Jensen (1997) shows examples of ongoing patrimonialism in Russia, namely, the manner in which privatization is carried out, the infamous "trans-for-shares" transactions, and the state's reliance on nominally privately authorized banks to handle large amounts of the state's money. Jensen (1997) concludes, "patrimonialism fosters a close relationship between business and politics." The government holds large chunks of stock in key industries, and state efforts to regulate entrepreneurial activities are half-hearted. "Patrimonialism means that political authority often depends on a leader's business contacts and leads to the dominance of clan politics, whereby politicians and business men, media entrepreneurs, and security forces use the political process to vie for control over the economy." Jensen (1997) states, "the patrimonialism also drives white-collar crime, such as bribery, embezzlement, and the extortion of protection money." Kaufmann (1997) points out that the macroeconomic fundamentals seem to be in place in Russia; however, in spite of this, the country seems to be unable to embark on a path to recovery. We think that a major explanation for this may be unsatisfactory development of what we call *institutional aspects* (or the institutional framework). Included in this expression is the formal structure organizing the sectors', which also includes the sets of rules by which the sectors are managed (Ostrom *et al.*, 1994).

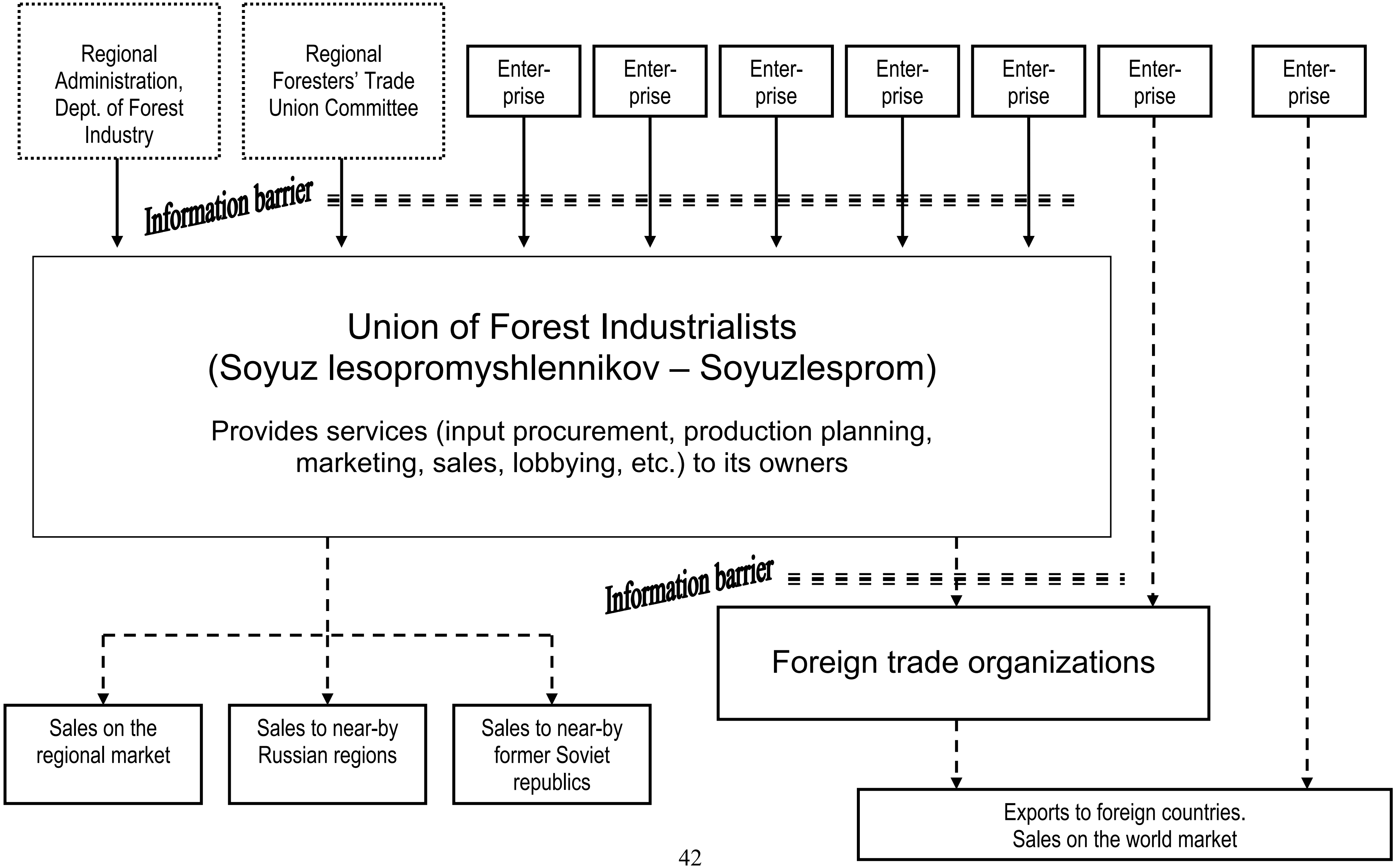
These conditions also heavily influence the management, control, and efficiency of the forest sector. Examples of the institutional aspects of the forest sector are the forest sector organization, the legacy of the overuse of forest resources, inconsistencies in legislation, difficulties in meeting environmental commitments, allocation of forest use and taxation, privatization, corruption, etc. These aspects will be discussed briefly in the following subsections.

6.1. Forest sector institutions

We do not include the official organizational charts of the Russian forest sector in this paper. In reality, however, what counts are not official organizational charts, but how information and funds actually flow and how decisions are made.

In current work by the IIASA Forest Study, we try to see beyond official charts. In *Figure 4*, we illustrate tentative findings from our case study in Tomsk oblast in an attempt to understand the actual conditions (Carlsson and Olsson, 1998). The enterprises in the top row of boxes are the owners of the Union of Forest Industrialists. The regional administration is part of the Union, and the Union

Figure 3. The current organizational structure of the Tomsk oblast forest sector.



probably makes use of the regional administration to achieve its goals. Among the formal owners of the enterprises of the Union are public institutions, regional banks, trade unions, forestry-oriented enterprises, etc. However, the real owners of these enterprises, and, by extension, also owners of the Union, are, to a large extent, the managers of the enterprises together with the regional administration and financial leaders. The enterprises in the top row (and the Union) do not have direct access to the world market. Export markets and seaports are entirely controlled by central organizations in Moscow.

This structure allows the regional Union to realize profits generated in individual enterprises. It also allows Moscow-based forest sector organizations to realize profits generated at the regional level. Those profits generally are not channeled back into production in individual enterprises as investments.

Regional and local governments are less controlled by voters than the national government is. The former *nomenklatura* (the elite class of the communist era) most often controls the power of local structures and is one part of the group of "new Russians." Therefore, decentralization has given local elite greater independence from the national government (Kotov and Nikitina, 1993; Goble, 1997) and more influence on the forest sector. However, the local leaders are dependent on federal financial measures for survival and, therefore, cannot act completely independently.

This provides a very good example of patrimonialism in the forest sector of Russia. However, it is not only the formal structure of the forest sector organization, as stated earlier, that is included in the expression "institutional aspects."

6.2. Legacy of the overuse of forest resources

Historically, forest management in Russia (and the former USSR) has been marked by a forest mining approach and a lack of available financial funds for sustainable resource development. Forest authorities regarded regional overuse of forest resources as a legitimate way to secure the supply of resources to the forest industry (Shvidenko and Nilsson, 1997). This tradition of uses and rules will hamper the transition to sustainable forest management.

6.3. Inconsistencies in forest legislation

According to the World Bank (1997a), the interim principles of the Russian forest legislation are in line with current international social, economic, and environmental thinking about sustainable forest development, but they lack specificity in administrative and fiscal processes and leave many interested parties with control over forest resources without properly defining their responsibilities. The new Forest Code declares all forests of the State Forest Fund to be federal property, but uses language that allows the possibility of regional ownership of forests.

Sheingauz *et al.* (1995) carried out assessments of the Russian forest legislation based on case studies. From these analyses, the following can be concluded:

- The current framework of forest legislation is still largely based on a centrally planned institutional framework.
- 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 for implementation.
- Due to the lack of mechanisms to implement legislation, there are many loopholes, opening the way for corruption.
- There are clauses allowing participation by the people in the implementation of the laws, but no mechanism exists for their doing so.
- Severe contradictions influencing the administration of natural and forest resources exist within the overall Russian legislative framework.

Teets and Saladin (1996) claim that the primary criticism of the interim principles of the forest legislation is that it "contradicts and undermines existing environmental legislation and greatly expands potential conflicts of interest for the Federal Forest Service between conservation and exploitation." Sedjo (1997) illustrates that the joint responsibilities of the federal government and regional governments in many cases develop and invite conflicts. A constitutional court case (9 January 1997) did not manage to solve the conflict between the federal and regional governments with respect to ownership and management of the forest resources (RFE/RL Newsline, 1998).

Astemark (1997) claims that legal and bureaucratic issues are generally the main problems preventing foreign investment in the Russian forest sector and that the legal institutions in Russia are much weaker than in the West – despite numerous acts of legislation and decrees –with a larger gray zone between legal and illegal activities. Gunther (1997) holds a similar opinion.

6.4. Difficulties in meeting environmental commitments

Porifieriev (1997) concludes that the expectation that a drastic drop in industrial production in Russia would bring about corresponding reductions in pollution and contamination has not been realized. In reality, these problems are as acute now as before the transition. This can be explained by obsolete industrial technology, lack of investments in environmental protection measures, and other factors that keep pollution levels substantially higher in Russia than in the West. Annual national Russian reports on the environmental status support this conclusion.

Russia has made a number of international environmental commitments with respect to forestry. The World Bank (1997a) states that, due to a weak national forest management policy, Russia has difficulties fulfilling these commitments. The inefficiency of environmental control resulting from a lack of resources and inefficient organizations is well-documented (World Bank, 1997a). Kotov and Nikitina (1993) claim that Russian authorities are too weak to ensure compliance with environmental legislation and adequate mechanisms and institutions for effective implementation are simply absent. Violations of environmental regulations are commonplace and seem to be part of the tradition in uses and rules. For example, Krasnoyarsk kray reports 4,500 violations of wildlife management rules per year (World Bank, 1997a).

Teets and Saladin (1996) stress that the lack of compliance with, and implementation and enforcement of environmental standards can be traced to three related factors: (1) the process by which laws are made, which allows little dialogue with stakeholders and thus builds little political will for implementation; (2) the institutional structures responsible for implementation and enforcement, which have limited resources and ambiguous mandates; and (3) the substantive standards themselves, which are sometimes unrealistic and frequently unclear.

A tremendous effort has been put into developing criteria and indicators for sustainable development of the temperate and boreal forests through the so-called Montreal and Helsinki processes. Criteria are defined as the essential components of forest management against which sustainability may be assessed. Each criterion relates to a key element and can be characterized by one or more quantitative, qualitative, or descriptive indicators. The development of criteria and indicators was identified as being one of the major tasks for the Intergovernmental Panel on Forests (IPF). Russia has subscribed both to the Montreal and Helsinki processes and has developed tentative criteria and indicators, which have been approved by the Russian Federal Forest Service (Strakhov, 1997). However, implementation is lacking due to administrative hindrances and insufficient financial resources. In the beginning of 1998, the head of the Federal Forest Service issued a special decree on the implementation of the criteria and indicators developed in practice.

Another important decision for Russia to make is the geographical unit at which the criteria and indicators should be applied. As illustrated earlier, the most relevant unit would be landscapes, although forest management is based on administrative divisions.

6.5. Allocation of rights for forest utilization and taxation

Licenses to use forests are granted by district authorities, with participation from the regional Committee of Forestry, through direct negotiations, auctions, or contests. The rules for allocation in this process are not transparent enough (Sheingauz *et al.*, 1995). There are still substantial harvesting rights allocated to Russian companies with no processing facilities at all (Westberg, 1997).

Forest sector enterprises in Russia claim that the tax burden is too high (up to 90% of the profit) and there are no reasons to continue conducting business or to start entrepreneurial activities. The existing taxation system does not encourage normal business operations in Russia or new investments (Westberg, 1997; Sojakka, 1997). Taxation rules are also very complicated and rarely understood by Russian managers.

In reality, tax recovery is very poor in the forest sector. However, the World Bank (1997a) argues that the potential for tax revenue from the forest sector is substantial through stumpage charges, taxes on harvesting companies, and industrial enterprises. The World Bank (1997a) estimates the tax potential to be between US$1 billion and US$5.5 billion per year (depending on production level), which can be compared with tax collection from the forest sector in 1994 of US$180 million.

6.6 Privatization

Some 80% of all enterprises in the Russian Federation (and 95% of those in the forest industry) no longer formally belong to the state, although in reality very few are privately owned. The new "owners" are largely managers from the old era who consider their new possessions to be like collective farms of the past. They do not attempt to gain profits from their firms, but rather to maximize personal wealth. The World Bank (1997b) points out that "robber baron" capitalism in Russia today is fundamentally different from the "robber baron" capitalism in the USA a century ago. The World Bank points out that in the US case, the "robber barons" built huge industrial complexes (by flaunting the law) of real value for the society. But in the Russian case, former officials and managers have privatized the industry into their own hands, selling off assets rather than building up new ones and exporting capital instead of creating new capital. In 1996, Russia transferred some US$29 billion abroad (Gunther, 1997). Glasiev (1997) estimates the capital flight in 1997 to US$50 billion.

This overall development in the Russian economy is also evident in the forest sector.

6.7. Corruption

The EBRD (1997) states that corruption in the countries of the Commonwealth of Independent States (CIS), including Russia, is higher than in any other region of the world and that "public corruption and arbitrary government behavior continue to be major impediments to private sector development." Gunther (1997) reports that in a survey on obstacles to business, 84% of the respondents reported corruption as a strong obstacle to business. This is 30% higher than reported for developing countries. A study done by the Center for Strategic and International Studies (CSIS, 1997) reports that the Russian Ministry of Interior estimates that 40% of private businesses, 60% of state-owned enterprises, and between 50% and 85% of banks are controlled by organized crime. The study also concludes that, "corruption has infected every level of the Russian bureaucracy." Russia was ranked the 4th most corrupt country of the 52 investigated with respect to corruption in a study carried out by Transparency International (Garayev, 1997).

Corruption also affects the Russian forest sector. Gareyev *et al.* (1997) illustrate that some 60% of the delivered wood costs for wood exported from European Russia to Finland is linked to corruption.

6.8. Financial information

To transform the Russian forest sector, transparent financial information is crucial. The Russian accounting systems for different components of the Russian forest sector are far from being sufficient. The pictures given by the accounting systems are normally rosier than the reality; in their design, the accounting systems are solely driven by the existing tax systems (in other words, their goal is to avoid taxes). In most cases, the accounting systems are not computerized, which makes it very difficult to verify the accounts. Linked to the inefficient accounting systems is the lack of management information systems in the forest sector. Another feature of the Russian forest sector is a reluctance to disclose information (especially financial) on individual enterprises (Rhodes, 1997).

6.9. Research

Strong goal-oriented research is needed for the transition of Russia's forest sector. The World Bank (1997a) stresses that there is a serious lack of goal orientation, priority setting, and coordination in forest sector research, which makes it difficult or impossible to gain support for the ongoing transition. Akim (1997b) identifies a strong need for the Russian scientific community to analyze the impacts of possible investment programs in the forest sector during the transition, an activity that, to a large extent, is missing today. Gokhberg *et al.* (1997) stress that "it is easy to develop a long list of problems in Russian applied R&D" and to get R&D to play an important role in the transition requires "moving away from widespread support of numerous R&D institutions inherited from the Soviet era to a system more consistent with a market economy." *Nature* (1997) points out that the academics "must face up to the need for radical change" and another problem is the fact that the Russian Academy of Sciences continues in its conviction "that it remains best placed to decide on the strategic distribution of scientific resources to meet the country's needs." *The Economist* (1997) stresses that Russian science, as a whole, is still producer- rather than a consumer-driven, a trait inherited from the communist era. This makes it difficult to steer research to practical applications in the government's "priority objectives" (among which the forest sector is not included). In addition, the majority of forest science is still centralized and funded by the federal government, but the forests (according to the new forest code) are controlled by the regions. Therefore, there is a strong need to develop interlinked federal and regional policy-oriented forest research programs matching the new realities. However, "the counter-reformist lobby is constantly struggling for the preservation of the status quo in Russia's research system" (*Science*, 1997), which makes it difficult to implement reforms.

However, it should also be pointed out that a tremendous amount of excellent information and knowledge on Russian forest resources has been generated by Russian scientists. However, this information is only organized and coordinated to a limited extent, whereby it can be used in a relevant policy setting today.

6.10. Conclusion: Institutional Aspects

The factors discussed above heavily influence the management, control, and efficiency of the forest sector. Bond (1997) points out that the key to transforming the Russian forest sector is a change in the current management mentality. The above discussed factors also affect the needed foreign investments by driving investors to regret investments made in the Russian forest sector (DI, 1997). So far, foreign investments in the Russian forest sector seem to be characterized by disappointments, frustration, delays, and financial strain (Garayev *et al.*, 1997). Based on the work we have carried out so far on the Russian forest sector, we can conclude that the sector is at a crossroads and it is most unlikely that a forest sector for sustainable development can be achieved, unless new policies and a new package covering the "institutional aspects" are implemented in Russia. The key words in this necessary change are transparency and predictability (Hägglund, 1997). In our opinion, *the future of the Russian forest sector will depend on how successfully Russia tackles these issues*.

7. Regional Development of the Forest Sector

The development of regional forest sectors is suffering heavily due to factors discussed earlier in the text. To illustrate the decline and the problems experienced in regional sectors, we have chosen Khabarovsk kray in Russia's Far East. This illustration is presented in *Appendix B*.

8. Required Policy Actions

In this section, we highlight some of the policy actions urgently needed to move the Russian forest sector toward sustainable development.

8.1. Overall aspects

- Forest sector policies must be developed that are consistent with the overall environmental, economic, and social objectives of the government and the economic reform already under way (World Bank, 1997a).
- The Russian forest sector's potential contributions toward global, national, and regional environmental and socioeconomic sustainable development must be identified; in doing so, the political status of the forest sector can be increased and concrete objectives for the sector can be set (Nilsson, 1997a).
- "Institutional aspects," as defined above, constitute a major bottleneck in the development of the Russian forest sector. A completely new institutional aspects package needs to be developed. This development must start with existing problems in the forest sector and society, and the package must be fully transparent for all of the forest sector's interest groups and for the major players in the society.
- Sufficient and rapid recovery and development of the forest sector require substantial capital investments. Abusow (1996) points out that the current unsatisfactory situation in the Russian forest sector is primarily due to

uncertainties in the legal and policy framework that hinder the international forest industry from making needed investments in Russia.

8.2. Forest monitoring

- To achieve sustainable development there is an urgent need to establish efficient monitoring of Russia's forests (in a broad context). This monitoring system must be organized around the problems to be solved and objectives to be achieved in the forest sector and society – it should not merely replicate the current system of primarily collecting data. The structure of such a system is well understood in Russia; the problem is the need for its urgent practical implementation.
- This new resource-monitoring system must be transparent and must enable each interest group in the forest sector to gain access to data for its own analyses. This means that a regionally distributed information system should be developed and implemented. The latest Forest Code (ARICFR, 1997) states that official forest information is state-owned property, which cannot be considered a satisfactory development.
- The data collected by the new monitoring system should be used for policy setting. A mutual understanding of the data by primary interest groups is needed to achieve efficient policy setting.

8.3. Sustainable forest management

To develop sustainable forest management regimes, Russia must

- Evaluate the forest sector's possibilities to mitigate global climate change through improved forest management and implement a long-term strategy for mitigation and adaptation of the Russian forest sector to climate change;
- Employ landscape approaches and establish an additional set of and distribution of protected areas in order to maintain biodiversity;
- Evaluate the forest sector's possibilities for maintaining sustainable production of non-wood products and functions and improving federal and regional policies in this respect;
- Develop a regionally distributed system of sustainable management regimes based on the landscape concept, taking into account the forests' ecological, economic, and social functions.
- Assess the sustainable economic wood supply taking the above components into account.

Ultimately, today's forest management and conservation regimes are determined by current power relationships, culture, tenureship, and ethical concerns in Russia (WCFSD, 1997).

8.4. Protection of resources

To protect the forest resources with respect to their environmental and economic values, Russia needs to establish

- An efficient monitoring and protection system for natural disturbances. It is crucial for such a system to have components to combat forest fires and insect outbreaks. Taking into account possible future climate change impacts on Russian forest ecosystems and the high probability of catastrophic fires, the system should be highly anticipatory.
- A new system for monitoring pollutant depositions in forest ecosystems based on a reconsidered system of critical load estimates.

8.5. Transportation sector

To start developing the forest sector, Russia must

- Introduce strong and efficient strategic programs to improve the transportation infrastructure;
- Introduce state policies for complete market price setting in the transportation sector.

8.6. Markets and trade

To be competitive on international markets Russia must:

- Initiate training courses for enterprises that address quality production, market services, and legal trading aspects;
- Establish trade promotion offices in those markets the sector would like to target.
- Provide technologies making it possible to meet the quality demands of the market.

8.7. Forest industry

National and regional policies that aim at stimulating the forest industry should be directed toward

- Preserving human and material capital in the regions;
- Stimulating infrastructure development;
- Developing regional vertical and horizontal links within the economy;
- Developing the financial infrastructure of the forest industry (e.g., bridge funding).

8.8. Welfare

The Russian government should urgently start to

- Evaluate and establish forest sector policies that would contribute to sustainable regional development and increased regional living standards. In many regions of Russia the forest sector is the only hope for development (Bradshaw and Lynn, 1996).

- Evaluate how the forest sector can mitigate the ongoing negative demographic development in Russia;
- Implement efficient social programs. The restructuring of social assets in Russian enterprises has gone through a dramatic change during the past few years, especially in forest communities. These assets are crucial for a functional society and for industrial development;
- Establish employment programs in the forest sector. High social costs and risks are connected with current unemployment in the forest sector. There is a strong need for an employment program directed toward increased and improved forest management, including retraining of unemployed workers. An additional program should deal with entrepreneurship in the forest sector.

8.9. Aboriginal people

The Russian Federal and regional governments have to

- Strongly formalize the aboriginal people's land rights (World Bank, 1997a). The current regulations are not followed.

- Define policies for forest management and resource allocation for the aboriginal communities.

- Secure the social welfare needs of the aboriginal people and mitigate the negative impacts of the ongoing transition.

8.10. Research

The Russian government must reorganize and restructure forest sector research to be problem- and goal-oriented, and establish new research programs concentrating on the immediate problems to be solved in the forest sector. The new programs must pay special attention to the social, economic, and regional dimensions of the Russian forest sector. This means a strong redirection of current research from traditional, basic research toward a social-oriented problem-solving research agenda.

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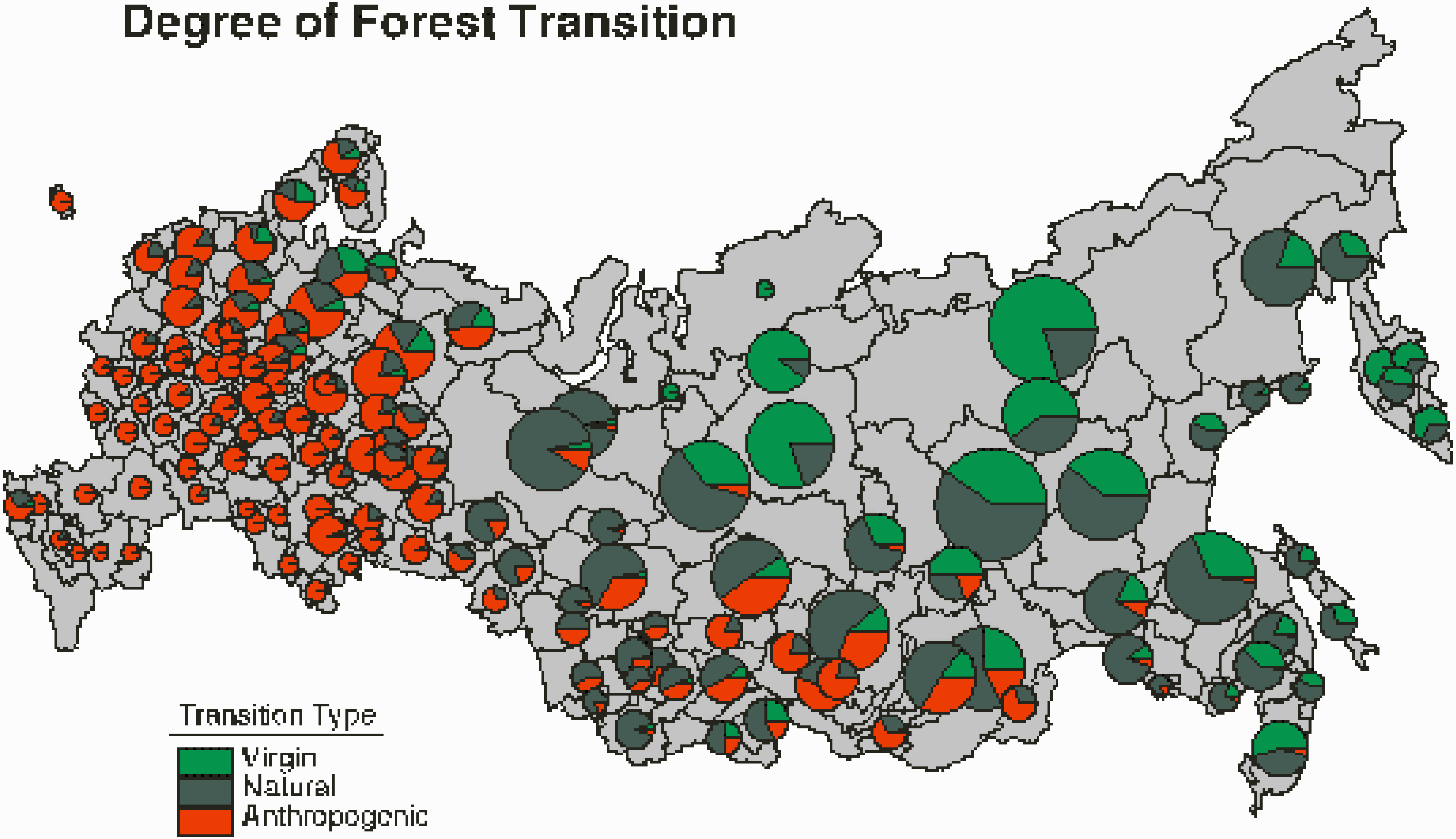
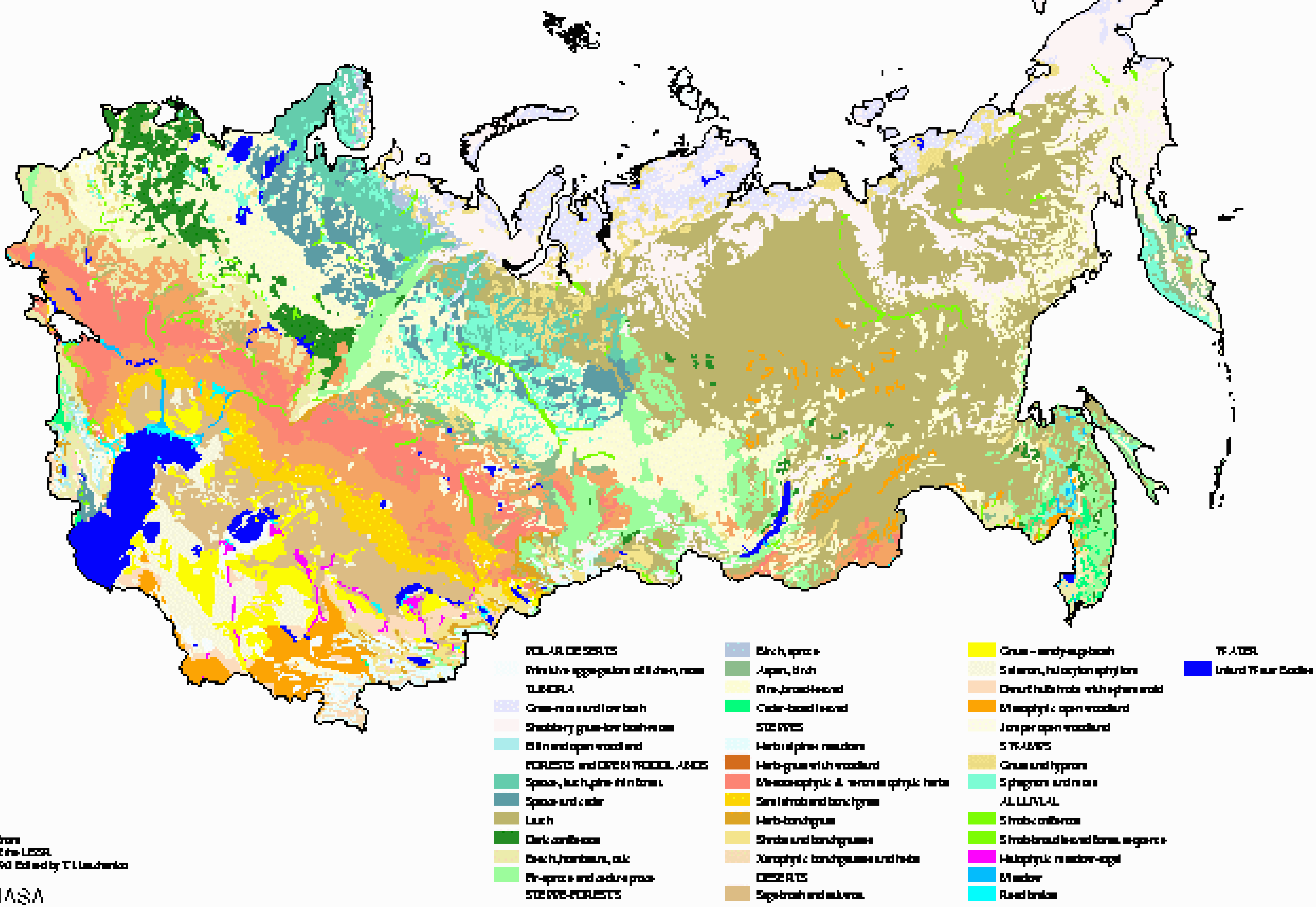
APPENDICES

Appendix A–Map Figures

Degree of Forest Transition

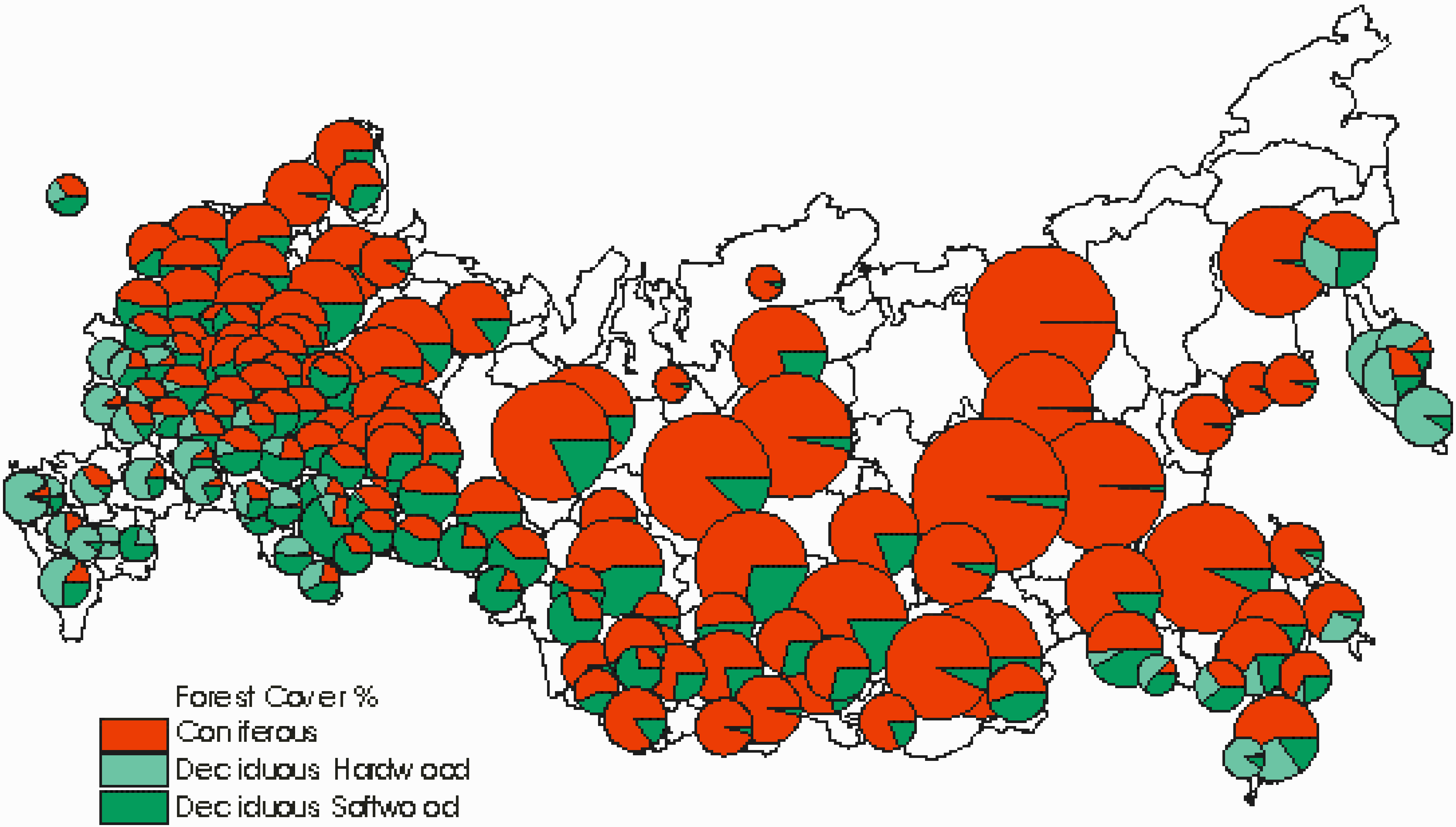


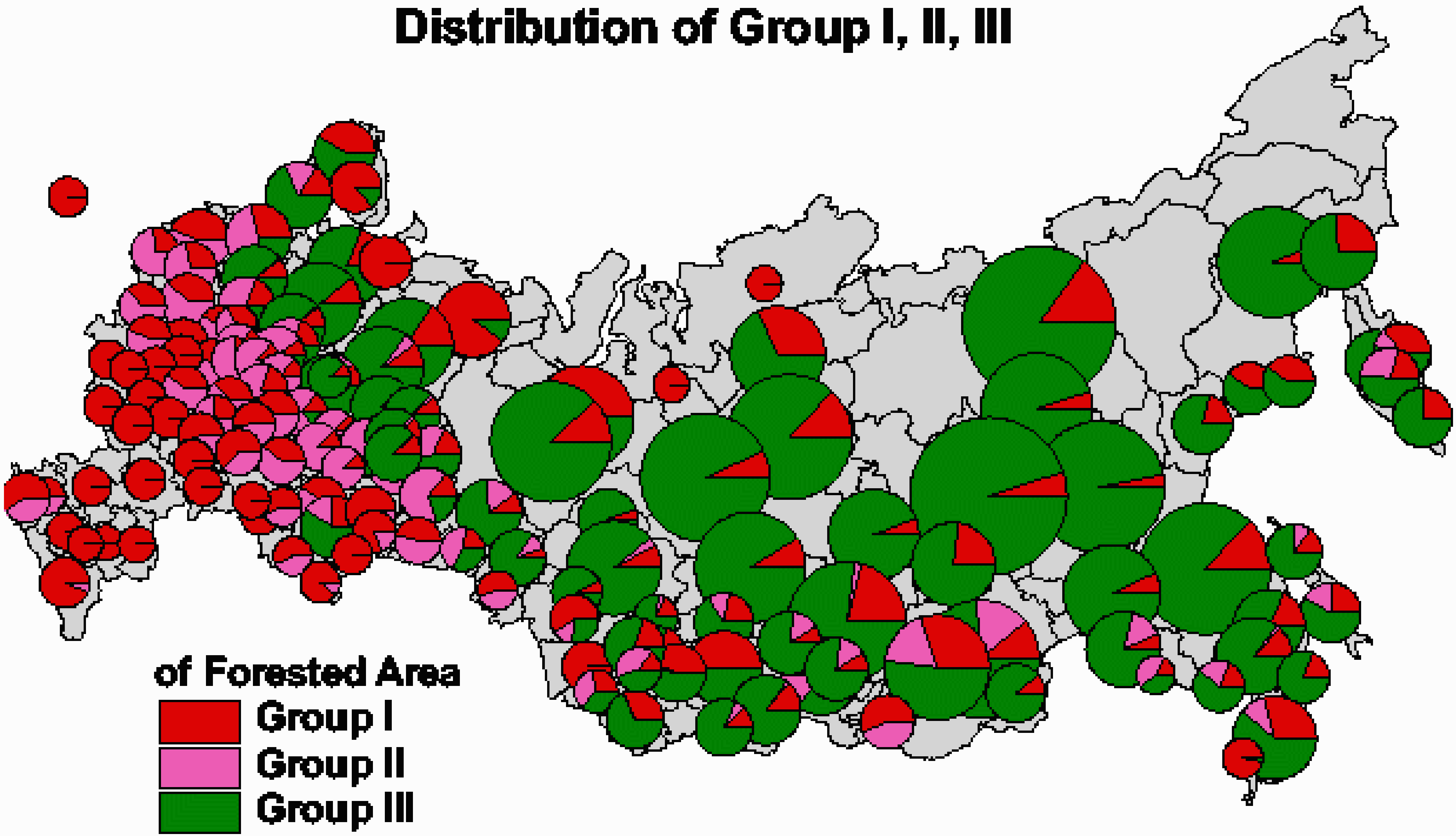
Vegetation of the Former USSR



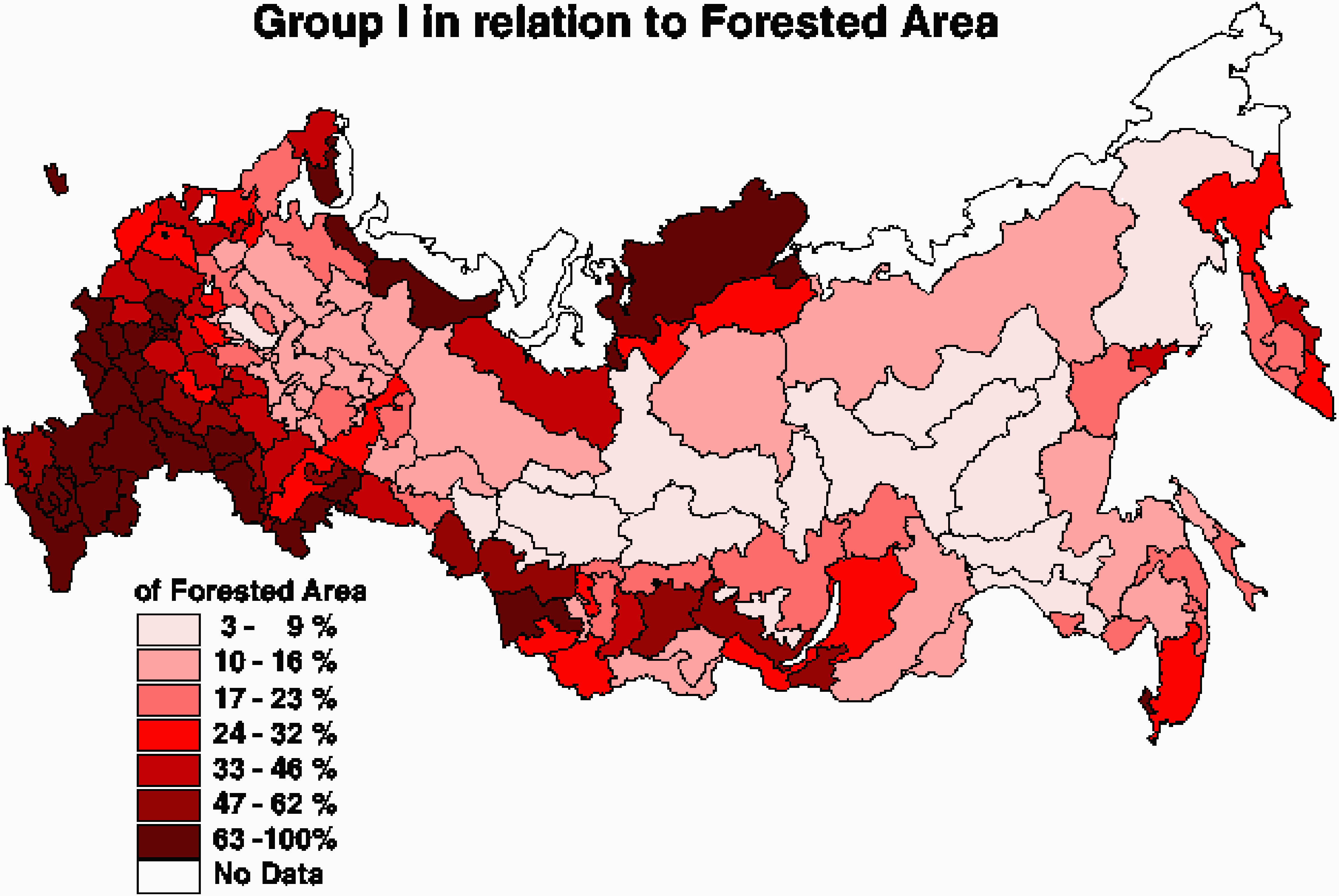
Generalized from
Vegetation of the USSR

Main Species Coverage of Forested Area

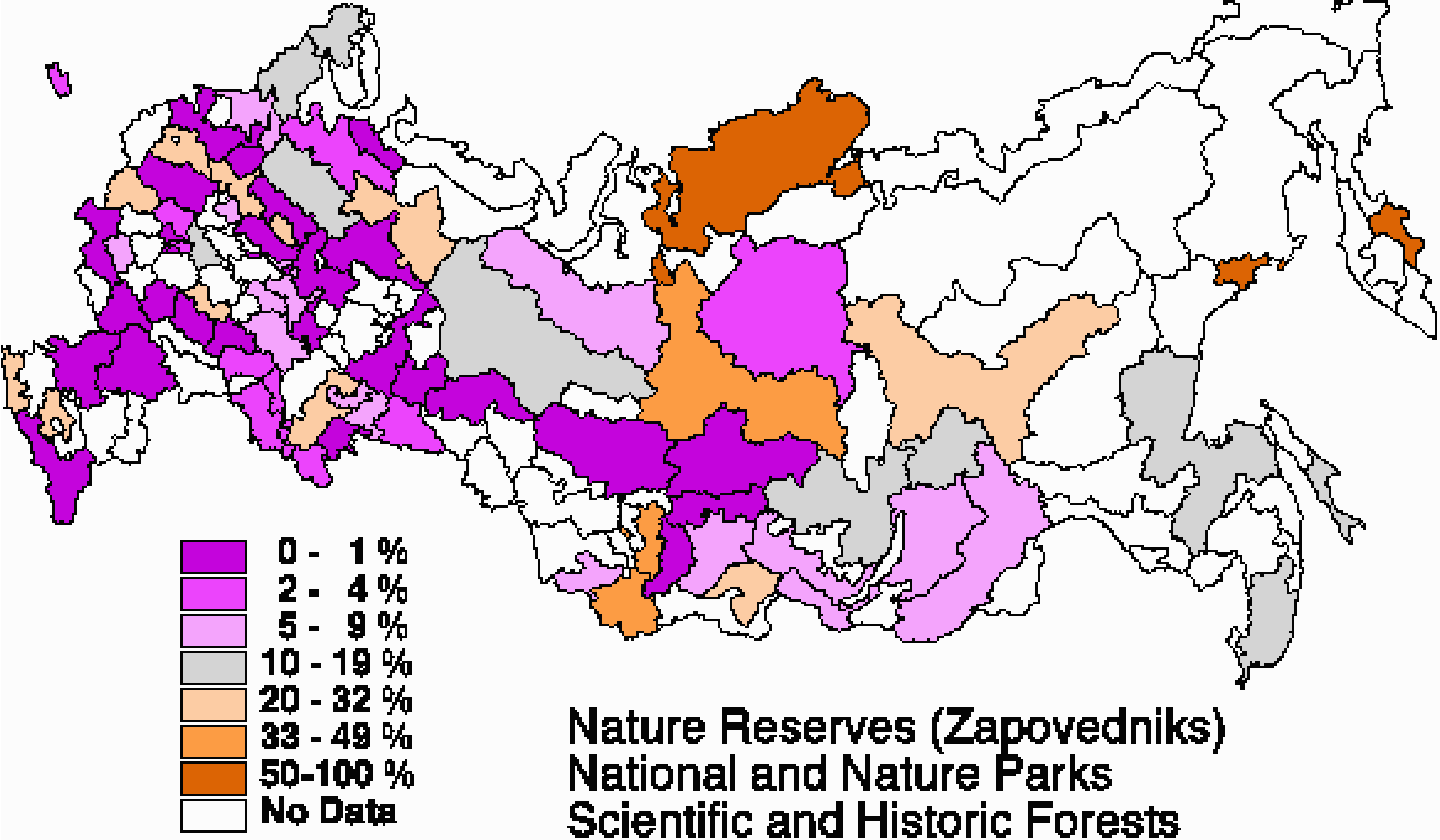



Distribution of Group I, II, III
of Forested Area
Group I
Group II
Group III

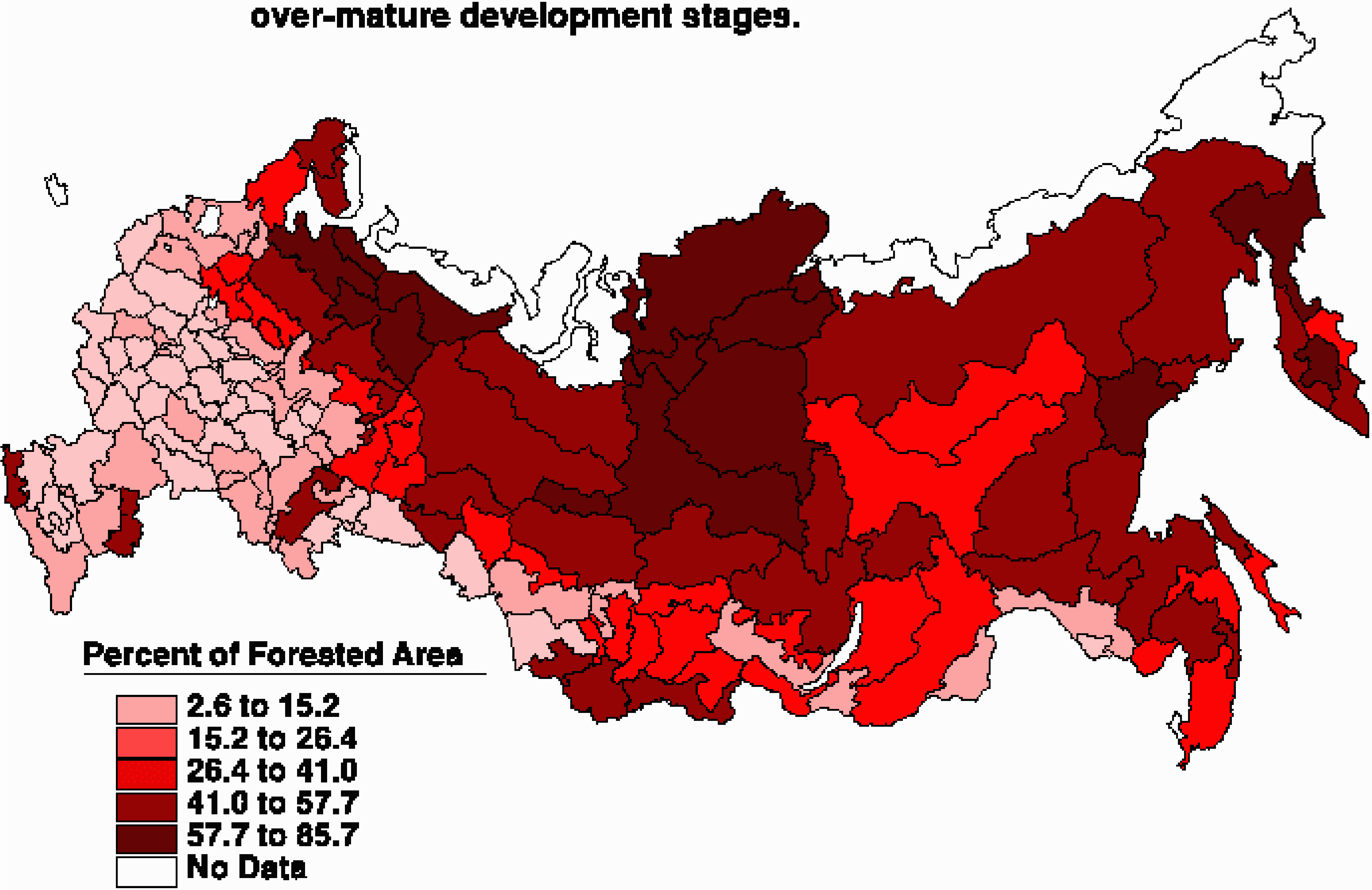
Group I in relation to Forested Area



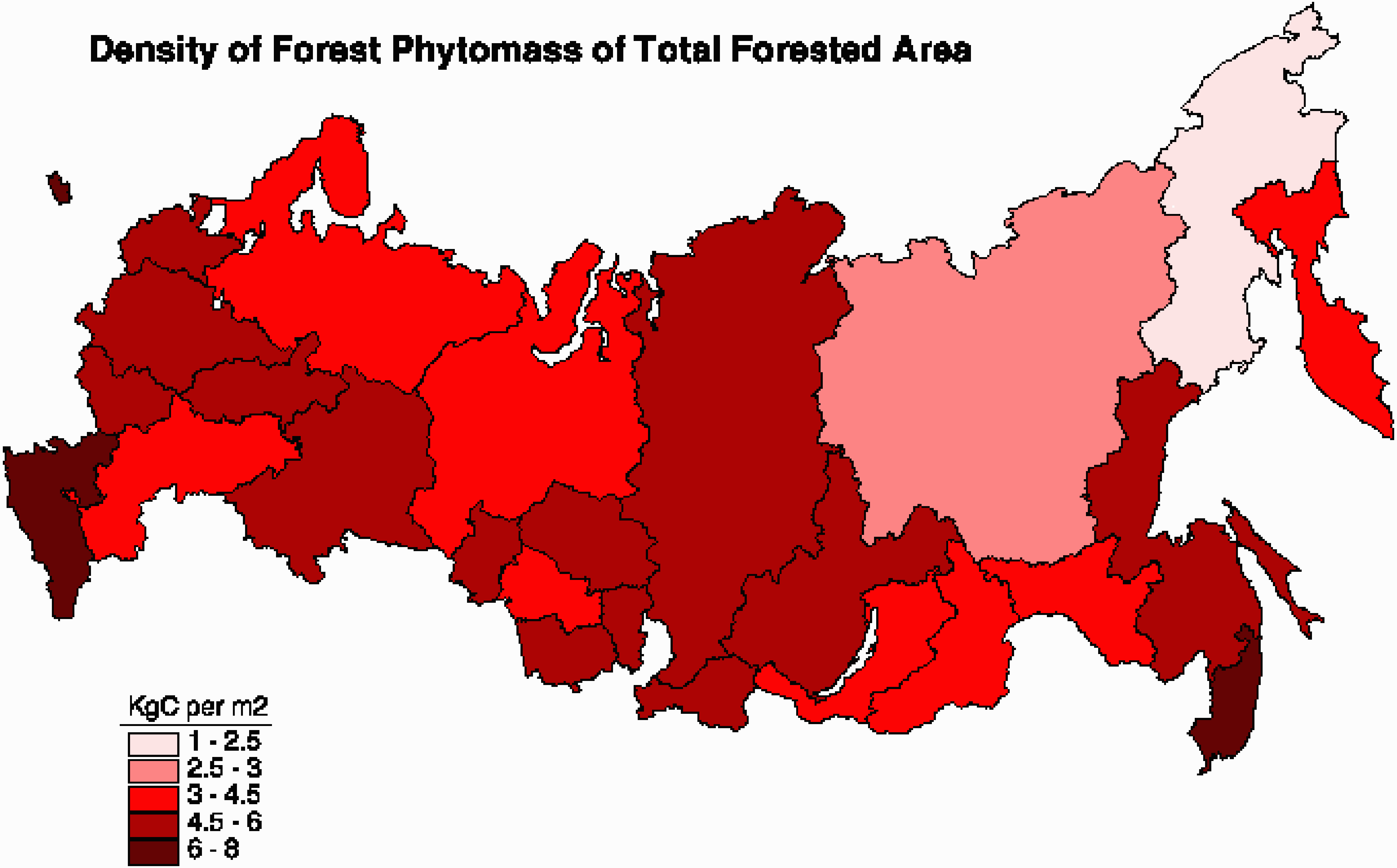
Share of Specially Protected Forests of Group I Forests



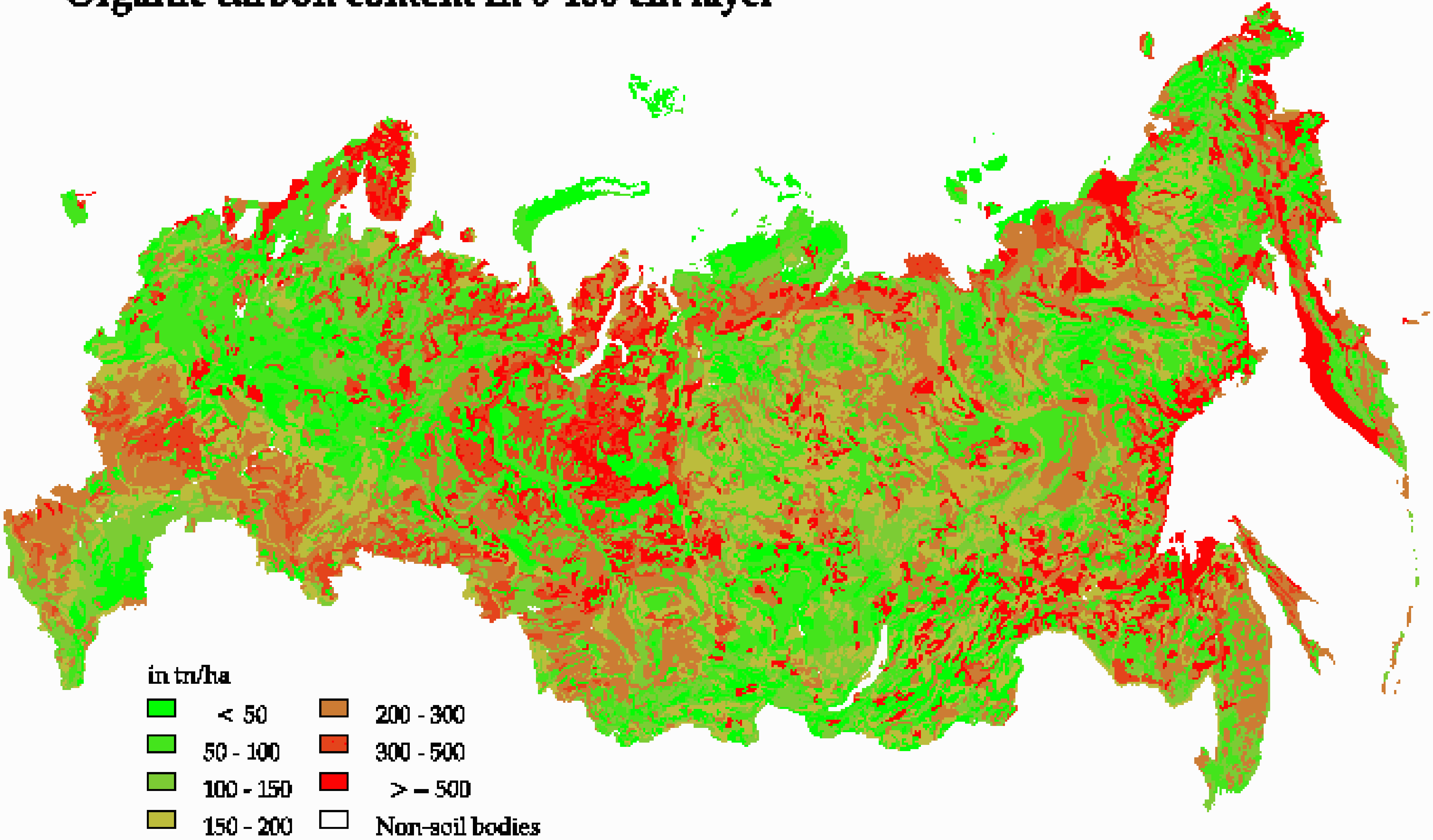
Percentage of Forested Area with all species in mature and over-mature development stages.



Density of Forest Phytomass of Total Forested Area



Organic carbon content in 0-100 cm layer



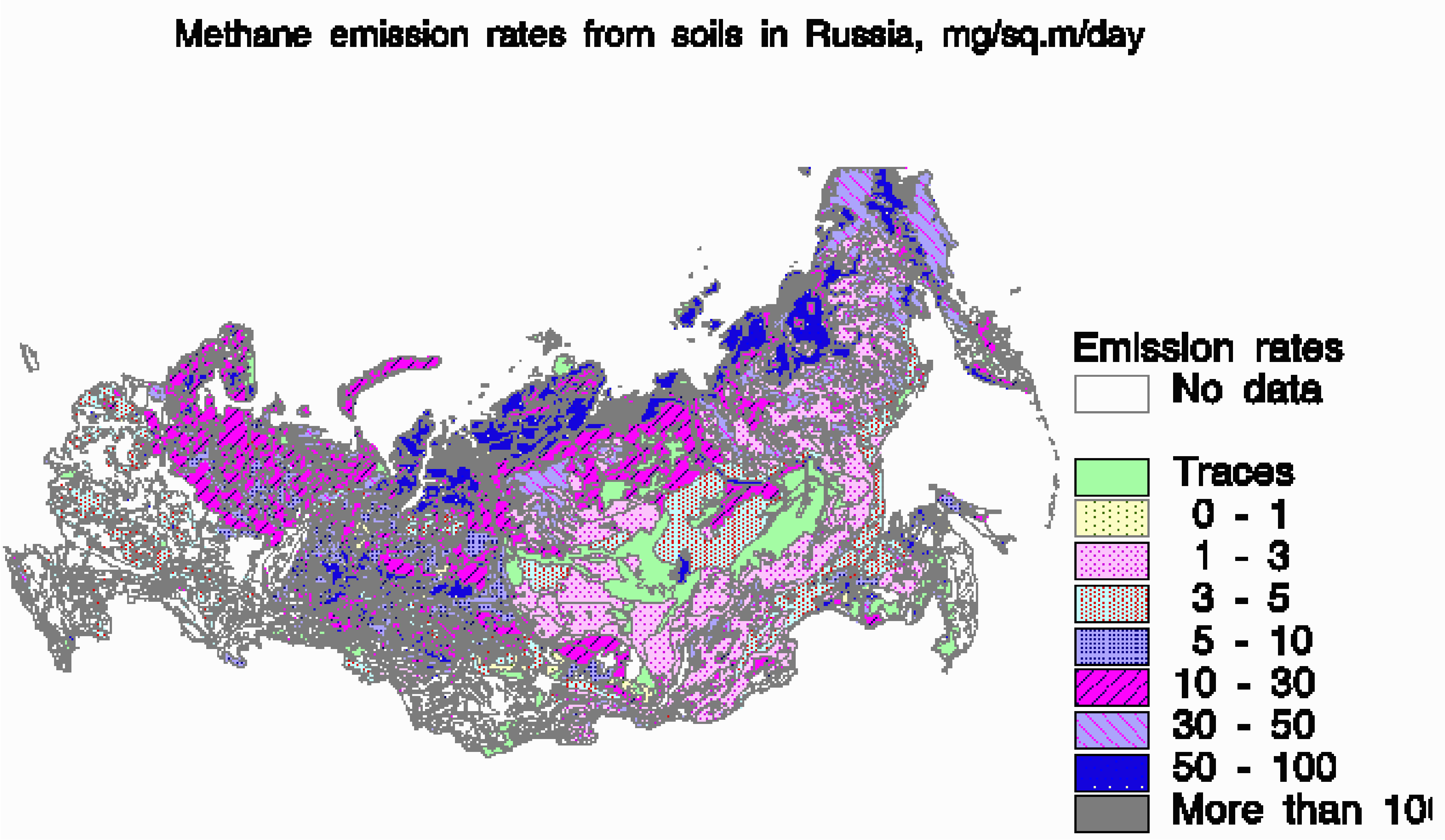
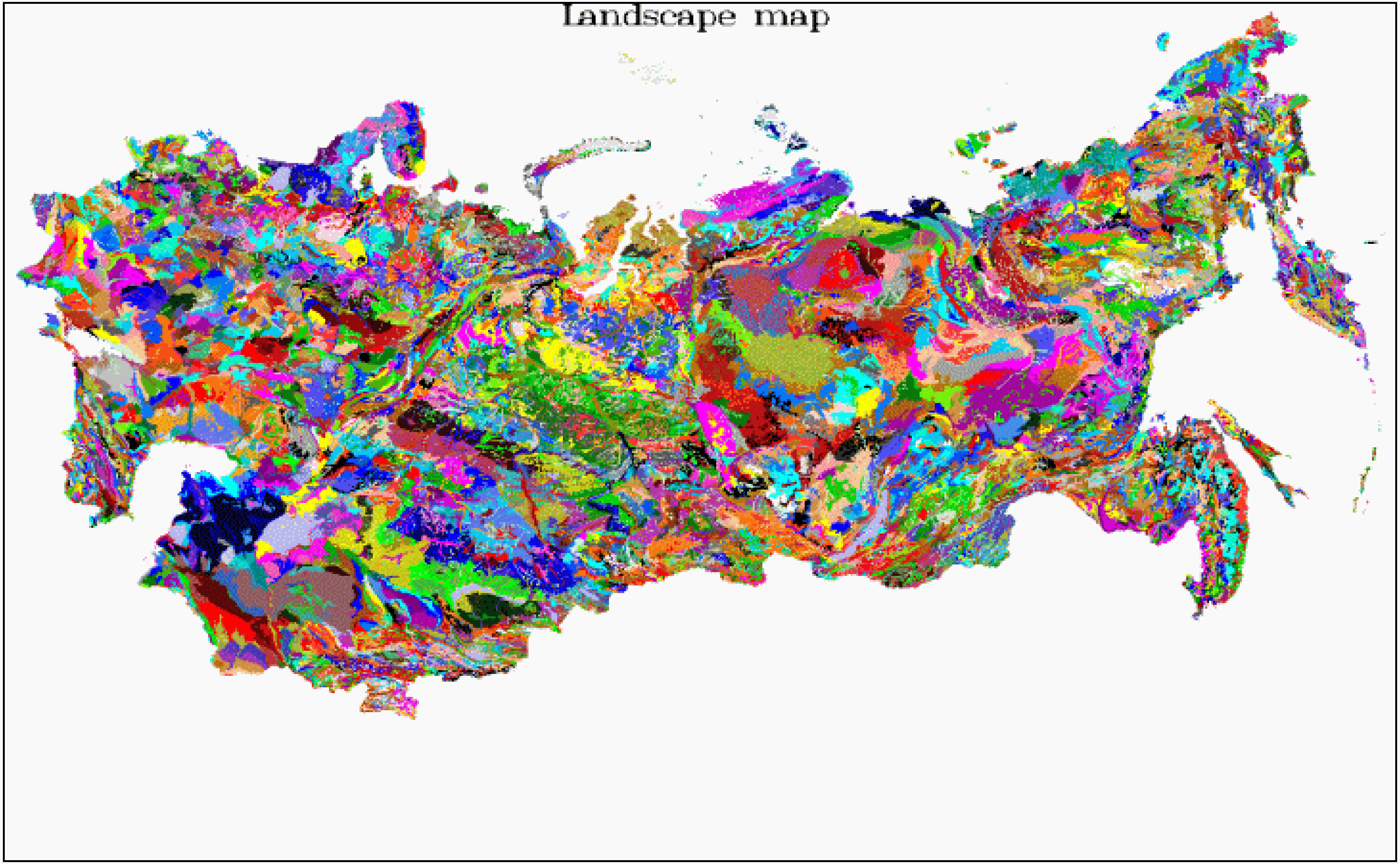
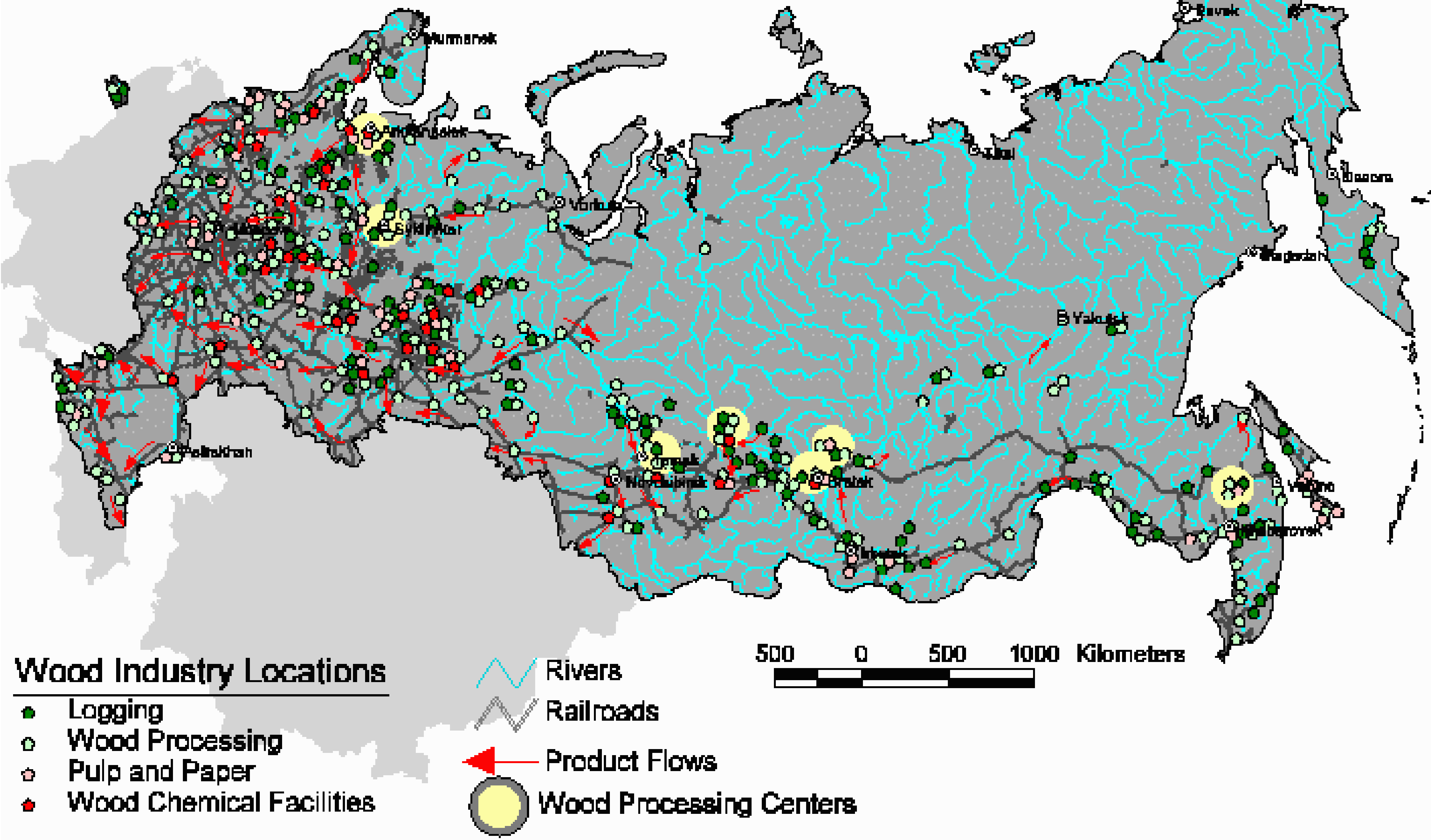

Methane emission rates from soils in Russia, mg/sq.m/day
Emission rates
No data
Traces
0 - 1
1 - 3
3 - 5
5 - 10
10 - 30
30 - 50
50 - 100
More than 10

Figure A11: Landscape Species of the Former Soviet Union. (There are about 3,500 initial typological units indicated in the computer version of the map which represent more than 27,000 polygons.)



Wood Industry Locations and Wood Flow Patterns of the Russian Federation



Appendix B

The Regional Impact of the Economic Transition – The Example of Khabarovsk Kray

Khabarovsk kray is a typical taiga region with rich and industrially valuable forest resources, namely, 47.3 million ha of forested area and 4.9 billion m^3 of growing stock. The forest cover percentage is 61.4%; in 1993, the annual allowable cut (AAC) was 33.3 million m^3. The forest industry sector plays a significant role in the regional economy. In 1993 it made up 9.8% of the total industrial output and employed 28.5% of the total labor force. During the period 1981–1990, the accumulated harvest was 148 million m^3 and the harvesting peak in 1979 was 16.8 million m^3. After 1993, the harvest did not exceed 25% of the AAC (8 million m^3).

The economic decline after 1991 has been dramatic and much more acute in the forest sector than in other industrial branches. However, a recession in the sector in Khabarovsk kray had already started in 1986. According to official statistics, in 1995 the harvest of industrial wood was 24.4% and production of lumber was 17.8% of the 1991 levels. Some experts claim that these data are underestimated 1.5- to 2-fold due to the black market, premeditated understating of real production in order to decrease the level of taxes, and insufficient statistics for all small and some medium-sized forest industry enterprises. During the transition period, the forest industry sector has become predominately a raw material supplier. During 1985–1990, the structure of the forest industry sector output was 40% harvest, 41% mechanical wood processing, 16% pulp and paper industry, and about 3% forest chemistry. In 1995, the harvest comprised about 80% of the output, with only 20% of output from all other forest industry branches. Capital investments in forest industry decreased to an eighth between 1991 and 1994. The average forest sector output in 1994 was 360 m^3 per worker, compared with 680 m^3 in the mid-1980s. Forest management activities (98.5% of forests are managed by regional bodies of the Federal Forest Service) have declined significantly: in 1994 the total operational costs allocated for forest management were US$ 0.14 per 1 ha of forest land, only 11,000 ha of forests were planted, and only 69% of FF territory had any fire protection.

There are many overall and regional reasons for the crises. A major factor is the political and economic underestimation of the forest sector's importance by the federal government, which has led to social decline and wrongly allocated and negligible investments in the forest sector. Additionally, some regional peculiarities have strongly impacted the process (Sheingauz *et al.*, 1996) such as (1) impoverishment of the most accessible forest resources and lack of substantial investments in infrastructure in underdeveloped regions; (2) obsolete technology in the forest-industrial complex; (3) a principal change of the ownership system, causing conflicts between private forest industry and state-owned forests; (4) an inconsistent forest policy including manipulation through the taxation system and numerous reorganizations of the forest sector; (5) decreased competitiveness of regional forest products due to unjustified increases in transportation and energy costs; (6) a collapse of the Russian domestic products market and a significant decrease of the regional market; (7) loss of international market share mainly due to chaotic Russian internal politics and failure to meet the international quality requirements; (8) insufficient reproduction of forest resources; (9) an increase in the number of ecological restrictions; and (10) an inconsistent and incomplete legislative framework.

The taxation system is complicated and tangled. Forest-industrial enterprises must pay numerous federal and regional taxes. At the end of 1995, the federal taxes were (1) a tax on profit (35% of profit); (2) a tax on owned property (2% of the estimated property value); (3) a value-added tax (20% of price of produced products); (4) a land tax (5% of the stumpage price of annually harvested wood); (5) a road tax (0.4% of the gross income and 0.03% of the commodity values traded); (6) social insurance (5.4% of salary costs); (7) employment support (2% of salary costs); (8) medical insurance (3.6% of salary costs); and (9) a pension fund (28% of salary costs). Different regional taxes take up 5–10% of the total income (Sheingauz *et al.*, 1996). The tax policy is inconsistent. For instance, in 1992 the kray established a special fund for forest regeneration with taxes of 7–8% of the costs for harvested wood; starting 1 January 1993 the tax level was 20%; in August 1993 the level was decreased to 5%, and in May 1995 it was canceled completely.

Unlike the federal administration, the kray administration has understood that the forest resources are one of the cornerstones of the regional economy. To protect the forests, more than 20 different regional forest legislative bills were implemented between 1991 and 1996. They address practically all aspects of forest utilization, forest lease, regional taxes, certification, etc. Some of them do not completely correspond to the new Federal Forest Code (ARICFR, 1997). Many important and much-needed forest legislative bills have not yet been developed.

After management of the forest industry was decentralized in 1991, the majority of the forest-industrial enterprises were transformed into private firms or firms with mixed (state-private) forms of ownership (by 1 January 1995, 87% of the forest-industrial enterprises had been privatized on paper). During the transition period, the number of forest-industrial enterprises doubled. In 1993, the federal and regional governments began intensive activities to restore the centralized management system in the forest industry using (1) privileged loans and subsidies; (2) newly organized regional financial-industrial groups (so-called FIGs) with governmental shareholding; and (3) administrative measures on the allocation of forest resources to the industry. For instance, forest company Dallesprom has a cross-ownership of shares with forest-industrial enterprises that were formerly state managed and were the property of the kray administration, and in this way protects the allocation of wood to the company. The new FIG–holding company now manages a majority of the forest-industrial sector of the kray, including practically all the forest-industrial enterprises of the former Ministry of Forest Industry of the USSR.

The second stage of privatization (financial privatization), which began in 1995, significantly increased the risks. There are many examples of owners who did not invest any money into reconstructing the enterprises, but merely used the new ownership for speculation (Amursky pulp and board enterprise, Bikinsky mill, etc.).

Although the federal forest legislation requires the allocation of rights on forest utilization to take place at so-called open forest auctions, by the end of 1995 no such auctions had taken place in the Russian Far East. All forest utilization rights were allocated by regional and district authorities in the old, traditional administrative manner. This method of allocating rights provides the administration with a powerful tool for controlling forest utilization. The main reasons for the control are that (1) administrations own a significant part of the shares of the forest-industrial enterprises and (2) forest-industrial enterprises play a crucial role in many regions –they are the principal source of employment and often support all existing social liabilities in infrastructure settlements and territories. The latter should be taken care of by the administration, but its finances are insufficient for doing so. This also explains the very low stumpage price (which did not exceed 0.5% of the price of delivered forest products before 1995, and was expected to increase to 2% in 1996); the administration and local legislators consider it necessary to support and to protect the forest industry under conditions of economic and financial crises. In reality, this "support" leads to decreased local budgets and misuse of the forest resources by the enterprises.

In 1994 and 1995, the share of forest products in total exports was US$233 million and US$403 million, respectively, and forest product generated 45.2% and 54.0% of the total export from the kray, respectively. Increasing exports represents the most realistic way to overcome the financial crises, but this requires reluctant foreign companies. There are many difficulties in operating enterprises with foreign capital and joint ventures. In 1994, 14 joint harvest ventures and 21 ventures dealing with wood processing were registered in Khabarovsk kray. The experiences of joint ventures during the past five years have been basically negative, due to political and legislative instability, the insolvency of Russian enterprises, a lack of encouraging policy with respect to foreign capital, a complicated tax system with a high level of taxes, insufficient control of trade and capital flows, unjustifiably high transportation costs, etc. For instance, the free economic zone of Nakhodka has existed six years, but all custom and tax privileges were canceled in 1994, which completely undermined the idea of a free economic zone.

Nevertheless, to foster the economic revival of the forest sector the regional administration has been trying to solve a large number of problems through investments, decreases in transportation and energy costs, and improvements in the institutional framework, etc. The administration of the Khabarovsk kray introduced tax privileges for enterprises with foreign capital in 1993. The federal government approved a complex program for stimulating domestic and foreign investments (October 1995), on which the development of regional programs is based on. The opinion of economic and forest experts is that there are possibilities for a real restoration of the forest sector in the Khabarovsk kray. But there is also the real understanding that the forest sector will not be able to emerge from the crises on its own – the overall economic conditions must be improved.

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