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IIASA Working Paper

WP-94-008

April 1994

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IIASA International Institute for Applied Systems Analysis □ A-2361 Laxenburg □ Austria
Telephone: +43 2236 807 □ Fax: +43 2236 71313 □ E-Mail: info@iiasa.ac.at

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Sten Nilsson
Anatoly Shvidenko
*Alexander Bondarev**
*Igor Danilin**

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* V.N. Sukachev Institute of Forest and Wood, Siberian Division of the Russian Academy of Sciences, Krasnoyarsk, Russia

IIASA

*International Institute for Applied Systems Analysis □ A-2361 Laxenburg Austria

Telephone: +43 2236 715210 □ Telex: 079137 iiasa a □ Telefax: +43 2236 71313

Foreword

Siberian Forestry is a topic which recently has gained considerable international interest. Many statements on the subject have been published in the Western press. Unfortunately, though, we can conclude that many of them are inaccurate. This is a result of a situation where it is difficult to access relevant existing information and the fact that there is a general lack of information on Siberian Forestry.

IIASA, the Russian Academy of Sciences and the Federal Russian government have signed an agreement to carry out a large-scale study on *Forest Resources, Environment and Socio-Economic Development of Siberia*. This paper is the result of some of the first steps of this study. In order to establish a framework for the study and to better understand Siberian Forestry, we have used initial and official data to describe Siberian Forestry. We know that some of the data employed is not consistent, lacks reliability and is not always general. But in order to set up the framework of the study and to get a better understanding of the problems, we have to start with the available information. This is the only way through. In the ensuing steps of the study we hope to be able to verify or reject in a quantitative manner the conclusions presented so far in this paper.

TABLE OF CONTENTS

0. PREFACE

The forests of Siberia and the Far East region of the Russian Federation are of both national and global importance. They consist of about 20% of the world's forested areas and 15-20% of the growing stocks. Their biospheric role is significant: in the wood biomass alone nearly 30,000 million tons of carbon is sequestered. According to recent estimates, the net carbon sink of Siberia's forest ecosystems seems to be about 500 million tons annually, and it is highly possible to improve the biospheric role of the Siberian forests under conditions of amending the current structure and status of forests and implementing a rational forest management.

Taking into account the vital importance of the Siberian forest ecosystems for the world economy and the global environment, the International Institute for Applied Systems Analysis and the Russian Academy of Sciences supported by the Ministry of Ecology and Natural Resources of Russian Federation have made an agreement to carry out a study on forest resources, environment and socio-economic development of Siberia taking into account the following overall tasks (Nilsson and Isaev, 1992):

- to analyze the present state and resource-ecological role of Siberian forests on the basis of specifically generated databases for ecological-economic regions of Siberia;
- to assess the biospheric role of Siberian forests, their influence on global change, the greenhouse gases composition of the atmosphere and carbon circulation;
- to study the problem of biodiversity in Siberia and to develop the strategy of its protection and use;
- to develop a dynamic tool to perform analyses of the Siberian forests and to produce scenarios of their future development and multi-purpose functions;
- to identify the suitable strategies for sustainable development of the forest resources, and for the required development of the industry, the infrastructure and the society;

- to carry out a detailed study on forest utilization and socio-economic development of a specific industrial region in order to identify the most efficient way for implementation of up-to-date forest management.

This paper is a result of one of the study's preliminary steps. It contains some initial data and estimates of the Siberian forest sector and the forest management in Siberia and is mainly based on official sources. A major portion of the information given below is presently uknown to western countries.

1. INTRODUCTION

Siberia, which we consider as the Asian part of the Russian Federation, is a vast region, encompassing the area from the Urals to the Pacific Coast (from 60° to 170° east of Greenwich longitude -- about 8,000 km) and from the Chinese and Mongolian borders to the Arctic islands (from 48° to about 80° north latitude -- nearly 3,500 km). The total area of Siberia is 1,280 million hectares, which is about 30 percent larger than the US continental territory. About 605 million hectares are covered with constituting stands (forested areas); these areas make up about 48 percent of the total area. Nearly 450 million hectares are covered with coniferous species. The total growing stock of stemwood is 61.4 billion m^3 of which 51 billion m^3 is made up of coniferous species. About 38.5 billion m^3 (nearly 63 percent) of the growing stock are classified as mature and overmature forests. The forested area of Siberia constitutes about 20 percent of the total world forested area and nearly 50 percent of the total world coniferous forested area. Nearly 65 percent of the Siberian forests are growing in areas with permafrost and more than 60 percent of the forested areas are classified as mountain forests. A majority of the indigenous Russian people (nearly 40 different tribal groups) live in the Siberian forests.

The woody biomass of the Siberian forests has been estimated to sequester nearly 30,000 million metric tons of carbon. Kolchugina et al. (1992) have estimated the contribution of the Siberian forests to the global carbon cycle. They suggest that the Siberian forests constitute a net sink of about 400 million metric tons of carbon annually. Shvidenko et al. (1994a) have estimated a net sink of nearly 500 million tons of carbon for this region, which may be significantly increased by implementation of rational forestry in Siberia (Shvidenko et al., 1994b).

As a result of the Siberian forests' global significance and taking into consideration both the history of communist exploitation of the natural resources as well as the deep transitions in Russia, the Siberian forests have recently become an important topic for public debate. This debate is concerned with the future development of forest resources. Rosencrantz and Scott (1992) fear that the ongoing economic transition will result in an increased harvest which will stimulate the sagging Russian economy but further degenerate the environment and break down indigenous cultures. Knight (1992) indicates that after three decades of relentless and uncontrolled exploitation of the natural resources, the bills are now due in one of the world's last great natural frontiers. Stanglin (1992) states that Siberia has become something like the "wild west", in that local authorities are expanding the exploitation of natural resources without any type of restrictions. Gusewelle (1992) reports that 4 million hectares of taiga are depleted every year. Cejka (1992) states that two hectares of forests in Siberia are lost every minute. WWF (1992) fears that international timber companies will erode the original forests of the Far East. Feshbach and Friendly (1992) point out that no other industrial civilization has so systematically, or for so long, poisoned its natural resources and people as the USSR has. Critical views on Siberian forest management have also been expressed in many recent Russian publications (Petrenko, 1990; Isaev, 1991a and others).

In our opinion, these estimates seem in principle to be true although more thorough analytical analyses are required. One of the necessary prerequisites of IIASA's Siberian Forest Study is to collect the necessary data to estimate the state of the Siberian forests and the forest management used there. The objective of this paper is to present currently available data on the Siberian forests in a condensed form on a macrolevel based on official data presented in materials from former Soviet ministries and governmental agencies as well as from numerous Russian scientific publications. The accuracy of these data is not always known, but in many cases the official data is the only available information.

The Siberian forest resources have been monitored; but the inventory methods differ, and some of the inventory data are not accurate. By the end of 1990, about 55 percent of the Forest Fund area (for definition see section 3) had been inventoried by acceptable on-site methods and about 24 percent had been measured by a combination of remote-sensing and on-site sampling measurements. About 21 percent of unmanaged and unexploited areas (in the extreme north and northeast) had been inventoried between 1948 and 1954 by an aerial method which was not very precise. These latter areas are now being re-inventoried using more precise methods and the inventory should be completed by 1995. All data on forest statistics given in the following are from the Forest State Account (dated 1.01.1988).

2. GENERAL CHARACTERISTICS

Due to the great diversity in climatic and soil conditions as well as economic and social conditions both in latitudinal and longitudinal directions, different regionalizations (climatic, botanical, vegetational, etc.) are used for Siberia (Lavrenko, 1950; Sochava, 1953; Kolesnikov, 1969; Kurnaev, 1973; and others). According to Kurnaev (1973) there are 7 different latitudinal, climatic, vegetational zones; (Table 1, Figure 1) present in the Forest Fund territories (2 additional zones are the arctic desert and the semi-desert in South). The most common unit of forest vegetational regionalization by Kurnaev is by province (16 in Siberia including 5 provinces for the tundra zone). Provinces are further divided into districts (*okrugs*).

Table 1. Distribution of the Siberian forests over vegetational zones. Expressed in percentage. Unpublished data by VNIIZ Lesresurs, 1988[1].

	Forest Fund (FF)[2]	Forest Land (FL)[2]	Forested Area (FA)[2]
Tundra	11.3	1.0	-
Forest tundra	3.8	3.0	3.2
Total taiga	76.8	86.9	87.4
· sparce taiga	16.5	20.4	16.2
· northern taiga	8.2	7.2	6.5
· middle taiga	33.6	38.8	43.6
· southern taiga	18.5	20.5	21.1
Mixed forests	2.5	3.2	3.3
· northern	1.6	2.0	2.0
· southern	0.9	1.2	1.3
Deciduous forests	1.9	2.2	2.5
Forest-steppe	1.6	1.6	1.6
Steppe	0.5	0.6	0.5
Meadow and sparce forests	1.6	1.5	1.5
Total	100.0	100.0	100.0

[1] The unpublished data employed in Tables 1,6, and 8 have been calculated by Dr. A. Kusmitchev and a scientific group of VNIIZLesresurs based on the Forest State Account of 1988.
[2] See explanation in next section.

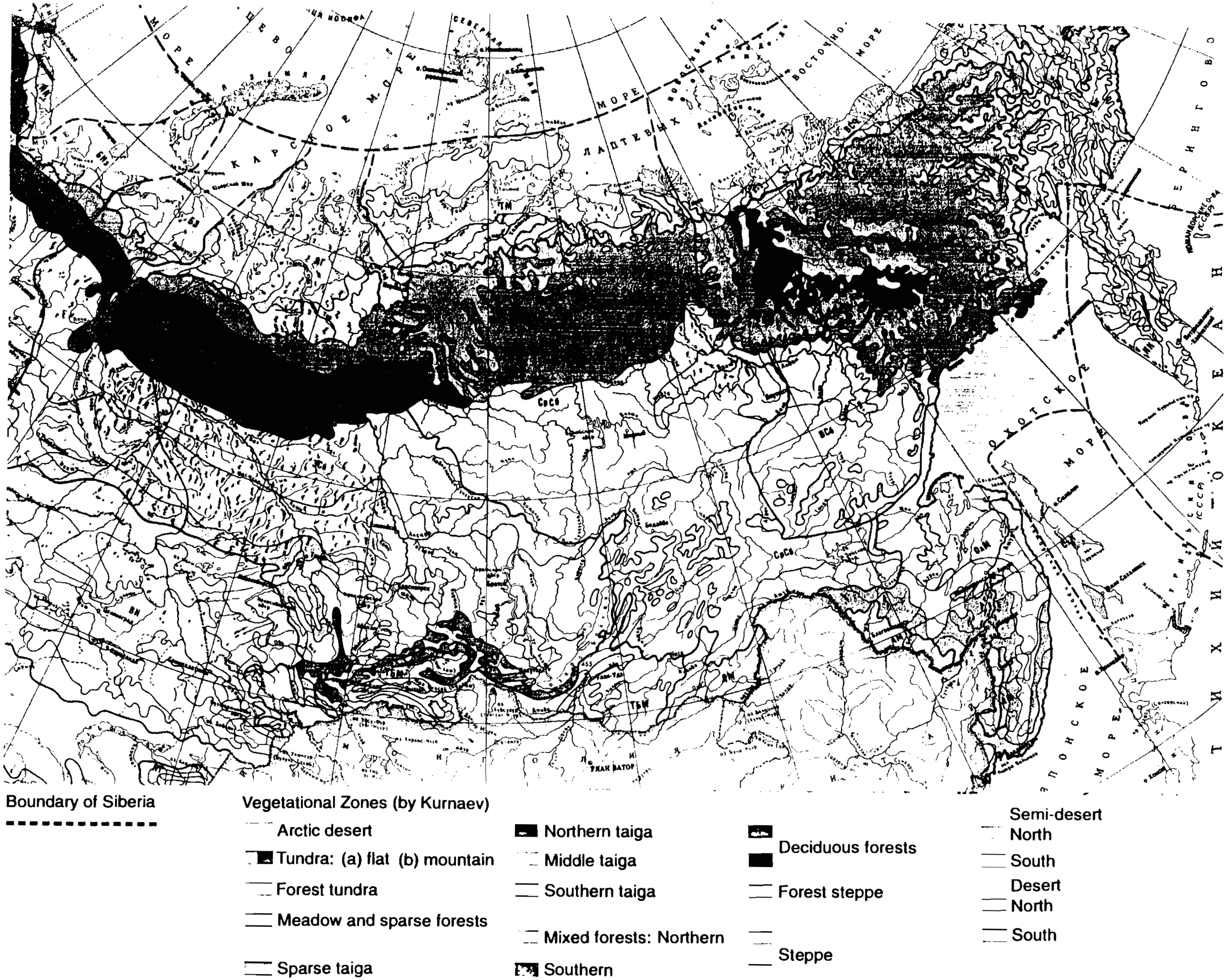

Figure 1. Vegetational zones of Siberia. After Kurnaev 1973.

The general climatic indexes by basic zones are shown in Table 2. The climatic continentality increases from the west to the center of Siberia and then decreases towards the Pacific Coast. There is a northern hemisphere pole of extremely cold weather in Yakutia (Ojmjakon). The northern boundary of the forests corresponds to the isotherm of the temperature sum of ($\Sigma t^\circ > 10^\circ C$) = 400-600°. The transfer from north to middle taiga follows the isotherm $\Sigma t^\circ >$ 10° 1300-1400°. The major types of soils in the northern taiga are podsols and frozen taiga soils, and, in general, with permafrost. The soils are also very moist. The northern boundary of the southern taiga is along isotherm $\Sigma t^\circ > 10^\circ$ = 1400 - 1600°, the southern boundary is defined by the atmospheric humidity factor isoline (Kh = 0.45) which means that there is a balance between precipitations and transpirations. Located south of the southern taiga is the forest-steppe, although areas of these forests are small. The meadow and sparce forest zone is situated along the Pacific Coast. The climate of this zone is moist. In the extreme south-west of the Far East of Russia the climate is becoming one of monsoon characteristic (precipitation 700-1000 mm and more, $\Sigma t^\circ > 10^\circ$ = 2000-2600).

The primary basis for descriptions, analyses and forest management of the Siberian forests is the division of the Forest Fund into districts (termed as forest-vegetational regionalization).

The regionalization of the Forest Fund is driven by a classification of hierarchical units which are homogeneous by forest-vegetational conditions, ecological and environmental properties, forest topological structure, productivity and composition of forests, and by the economical and social importance of the forests (Decision..., 1978). The basic types of regionalization are forest-vegetational, forest-economical and forest management ones.

The forest vegetation regionalization serves as a natural and historical basis for development of the regional forest management system.

The current forest vegetation regionalization of the territories of West Siberia, East Siberia and Jakutia includes 10 regions (oblast), 29 provinces and 68 districts (okrug). The forest management regionalization encompasses 5 regions (oblast), according to the type of forestry management, 17 groups of districts (okrug) and 49 forest management districts (Kolesnikov, 1955, 1969; Lebkov, 1967; Popov, 1969; Smagin et al. 1976, 1977, 1978; Smolonogov, Vegerin, 1969; Sheingaus et al. 1980, 1985 and others).

The forest vegetational regionalization of the Far East includes 12 regions (oblasts), 27 okrugs and 50 districts (Sheingauz et al., 1985).

Maps of forest management regionalization of Siberia and the Far East as well as a list of the corresponding hierarchial units are shown in Appendix 1.

The regionalization of the forest management in the Far East employs a three-level classification: 8 oblasts (regions), with 22 okrugs and 44 districts (Sheingauz et al., 1980; Korjakin, 1990). Descriptions of different forest systems and their ecological roles as well as classification schemes for Siberia and the Far East of Russia are quite well developed (Ageenko et al., 1969; Busikin, 1977; Bugajev, Kosarev, 1988; Polikarpov et al., 1986; Posdnjanov, 1986; Semechkin et al., 1985; Krilov et al., 1983; Lebedev et al., 1979; Sherbakov, 1975; Smagin et al., 1976, 1977, 1978; Manko, Voroshilov, 1978; Panarin, 1977; Protopopov, 1975; Starikov, 1958; and others).

Table 2. General climatic indexes by basic vegetational zones in Siberia.

Zones	Location	K	Temperature				Moisture			BP
			$\Sigma t>10°$	V	T_+	T_-	P_1	Kh	S	
Tundra	—	12-160	<600	<50	0-12	-23-40	150-400	0.40-0.60	20-80	<33
Forest-tundra-North taiga	WS	167-198	400-1300	36-92	10-16	-20-35	300-500	0.60	45-95	22-72
	ES	232-251	400-1200	32-84	10-16	-36-38	150-400	0.25-0.60	30-60	22-55
	FE	108-196	400-1200	30-80	10-15	-10-25	600-1000	0.45-0.60	60-100	22-63
Middle taiga	WS	181-194	1100-1700	74-113	15-18	-18-26	400-500	0.49-0.60	60-85	61-93
	ES	199-226	1000-1400	75-97	15-17	-23-33	350-500	0.45-0.60	55-95	55-77
	JAK	238-283	1000-1500	71-100	14.5-17	-29-45	200-350	0.22-0.45	40-50	45-64
South taiga	WS	184-199	1500-1850	100-122	16-18	-17-22	400-500	0.42-0.55	60-90	82-96
	ES	217-228	1400-1600	90-104	16-18	-21-27	300-400	0.35-0.45	30-50	64-85
	FE	191-274	1000-2600	76-146	14-22	-8-32	500-1000	0.45-0.60	30-60	110-139
Forest steppe	WS	189-208	1800-2250	107-137	17-20	-17-20	300-400	0.30-0.45	40-60	96-99
	ES	197-233	1400-2000	93-129	17-19	-17-25	300-700	0.30-0.50	30-100	66-99
Steppe	ES	215-263	1400-2000	94-122	17-21	-19-30	200-400	0.20-0.35	15-40	57-85

Source: Kashtanov (1983).

Abbreviations: K-koefficient of continuality by Ivanov, percent, K = A.100/0.334, A-annual amplitude of temperature, L-longitude; V-duration of vegetation period, days, T+ and T- — temperatures of the first warm and cold months, respectively; P_1-total pecipitations, Mm/year; Kh-koefficient of humidity, Kh=P/Σd, P-precipitation, Σd-transpiration, S-high of snow, cm; BP-biological productivity of vegetation, percent; BP is ratio of productivity of estimated location to average productivity of south taiga subzone. WS = West Siberia, ES = East Siberia, FE = Far East.

3. THE EXTENT OF FOREST RESOURCES IN SIBERIA

Siberia is divided into 3 major economic regions, namely West Siberia, East Siberia and the Far East. The percentage of forest cover of the regions (Forest Fund) are 52.9; 56.9 respectively 45.1%. These regions are illustrated in Figure 2.

ECONOMIC REGIONS AND GROWING STOCK

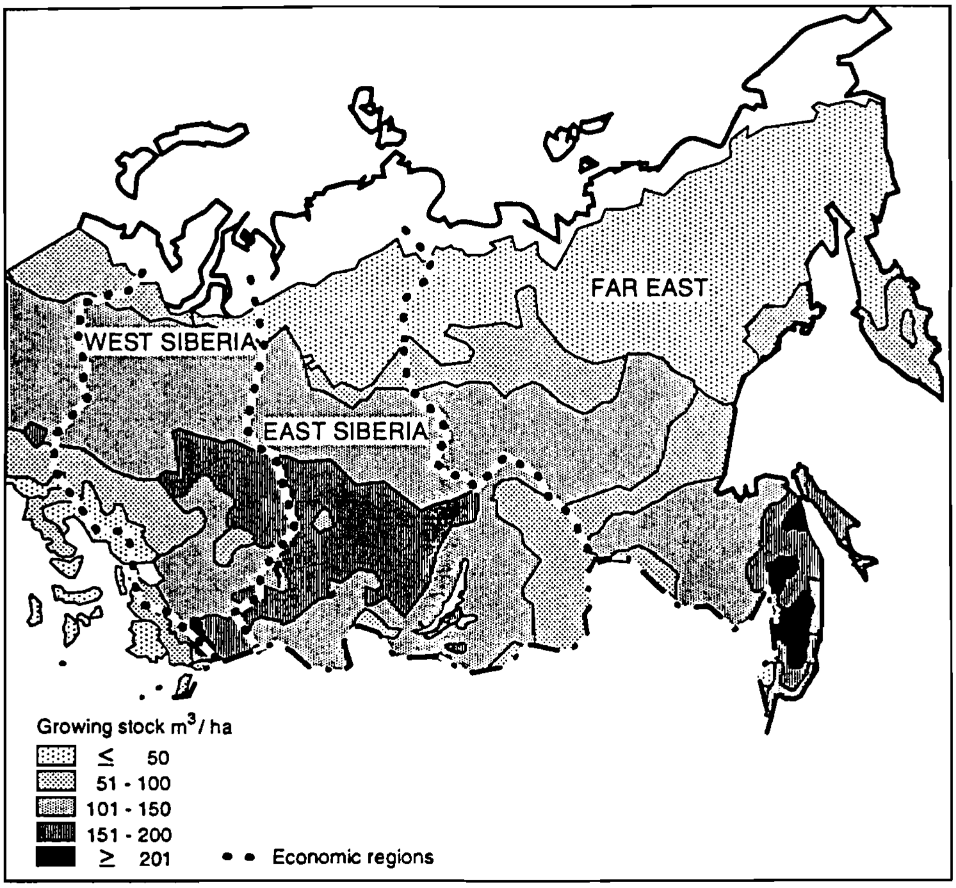

Figure 2. Map of major economic regions of Siberia.

The forest resources are classified in different ways in Russian statistics. The Forest Fund (FF) is made up of areas covered by forests and those not covered by forests but which could be used for forestry production under certain conditions. The Forest Fund is divided into forest land (FL), which is either covered by closed forests (called forested area, FA) or areas temporarily not covered areas (unforested area like harvested areas and burned areas), and nonforest land (NFL), which includes the following:

- o Areas which are not suitable for forest production under current conditions.
- o Areas with other land-use functions such as pastures, arable lands, peat production, farmsteads, etc.

These two areas must be managed by a forest authority in order to be classified as nonforest land.

In Table 3 we have attempted to illustrate the links between the different forest classifications according to the forest state account in January 1988. The different forest areas are given in million hectares and the growing stock is expressed in billion m^3. The forest categories (FF, FL, and FA) are divided into three groups according to the function of the forests:

- o Group I: Mainly protected forests which include 25 protective categories.
- o Group II: Protected forests with restricted possibilities for industrial exploitation.
- o Group III: Forests for industrial exploitation.

The distribution of different forest groups is also presented in Table 3. From this table it can be seen that 92 percent of the Siberian forest was, at the end of 1988, under state forest management and about 80 percent belonged to forests designated for industrial exploitation.

Of the 544.4 million hectares classified as forested area and managed by forest authorities, 271.6 million hectares are classified as commercial forests in operations, 179.0 million hectares are not utilized due to unfavorable economic conditions, and 93.8 million hectares are excluded from industrial exploitation. Thus, about 50 percent of the forested area is currently available for industrial exploitation.

Table 3. Extent of the Siberian forest resources. Areas expressed in million ha and growing stock in billion m^3. After Goskomles 1990 and 1991.

Category	Total Russia	Total Siberia	West Siberia	East Siberia	Far East
TA	1707.5	1276.6	242.7	412.3	621.6
FF	1182.6	973.2	150.6	315.4	507.2
FL	884.4	710.6	95.5	255.2	359.9
FA	771.4	605.1	90.1	234.4	280.6
GS	81.6	61.4	10.8	29.3	21.3

By form of management

	State Forest Mgmt.	Other Ministries	Colchoses	Sovchoses
FF	938.0	16.2	5.9	13.1
FL	680.3	11.4	5.9	13.0
FA	576.8	10.3	5.7	12.3
GS	58.2	1.2	0.6	1.4

	Forest Authority	Long-term lease
FF	847.0	91.0
FL	635.9	44.4
FA	544.4	32.4
GS	56.2	2.0

By groups of forests

Forest Authority:

	I	II	III
FF	133.1	17.6	696.3
FL	85.2	15.9	534.8
FA	76.2	14.9	453.3

Long-term lease:

	I	II	III
FF	23.0	0.1	67.9
FL	8.2	0.0	36.2
FA	5.5	0.0	26.9

TA = Total Area, FF = Forest Fund, FL = Forest Land, FA = Forested Area, GS = Growing Stock

The characteristics of unforested areas and non-forest lands are shown in Table 4.

Table 4. Distribution of unforested areas and non-forest under state forest management, million hectares. After Goskomles, 1990 and 1991.

Region	Unforested area					Non-forest land				
	Total	Including				Total	Including			
		Sparce Wood	Post fire	Glade	Clear Cutting		Arable lands	Bogs	Unprod-uctive areas	Sands
Russia	94.1	55.1	26.6	4.0	8.4	239.5	6.7	122.0	90.2	2.1
Siberia total	90.2	55.0	26.3	3.6	5.3	211.2	5.2	102.0	88.0	1.9
West Siberia	4.5	2.3	1.0	0.3	0.9	51.1	1.5	40.8	3.8	0.1
East Siberia	19.4	7.9	8.9	0.7	1.9	57.2	2.1	28.8	21.8	0.3
Far East	66.3	44.8	16.4	2.6	2.5	102.9	1.6	32.4	62.4	1.5

The distribution of forested area and growing stock over major species under state forest management is presented in Table 5.

Table 5. Distribution of Forested Area and growing stock over major species. Forested Area (FA) is expressed in million ha and growing stock (GS) in billion m^3. After Goskomles 1990 and 1991. Numbers are rounded off.

Species	Abbre-viation	West Siberia		East Siberia		Far East		Total	
		FA	GS	FA	GS	FA	GS	FA	GS
Coniferous (total)		56.4	6.8	180.2	24.9	199.7	17.7	436.3	49.3
· Pine	Pn	28.7	3.0	32.1	5.5	12.0	1.2	72.9	9.7
· Spruce	Sp	5.4	0.6	12.4	1.8	13.7	2.4	31.5	4.8
· Fir	F	3.8	0.5	9.4	1.6	1.8	0.3	15.0	2.4
· Larch	L	5.9	0.6	102.8	11.6	168.8	12.9	277.5	25.1
· Cedar	C*)	12.5	2.1	23.5	4.4	3.4	0.8	39.4	7.3
Hard Deciduous (total)		-	-	-	-	11.6	1.1	11.6	1.1
· Beech	Be	-	-	-	-	6.6	0.6	6.6	0.6
· Oak	O	-	-	-	-	4.0	0.3	4.0	0.3
Soft Deciduous (total)		21.9	2.8	31.4	2.7	15.2	1.1	68.2	6.6
· Birch	Bi	17.0	2.0	26.4	2.1	11.6	0.7	55.0	4.8
· Aspen	As	4.7	0.8	4.8	0.7	1.1	0.1	10.6	2.5
Total		78.3	9.6	211.6	27.7	227.6	2.0	516.4	56.9

*)According to Russian nomenclature constituted by Pinus sibirica and Pinus koraiensis

Table 5 shows discrepancies with Table 3 which is explained by the fact that Table 5 includes only major species and does not take into account shrubs and other coppice, which are accounted for in Table 3 . According to the inventory definitions of the former USSR, shrubs are regarded as forested areas only in regions where closed forests are unable to grow due to climatic conditions.

In Table 5, it can be seen that coniferous species is the dominant species group throughout Siberia. Pine is the main species in West Siberia, and in other regions larch dominates. In total, larch is the most common species in Siberia. It can also be seen that soft deciduous (mainly birch and aspen) are quite well represented throughout Siberia. Hard deciduous species are only present in the Far East region. Average species distribution by the basic vegetational zones and economic regions are shown in Table 6.

Table 6. Average species distribution expressed in tenths. Unpublished data from VNIIZlesresurs 1991.

Economic regions	Administrative Unit	Distribution of the Growing Stock by Species							
		Pn	Sp	Fi	La	Cd	Bi	As	Oa
		Sparce taiga and forest-tundra							
WS	Tjumen	2	1	-	3	4	-	-	-
FE	Jakutia, Khabarovsk	-	-	-	10	-	-	-	-
		North taiga							
WS	Tjumen	4	2	-	-	1	2	1	-
ES	Krasnoyarsk	2	2	2	2	-	1	1	-
FE	Jakutia	-	-	-	10	-	-	-	-
		Middle taiga							
WS	Tjumen, Tomsk	5	1	-	-	2	2	-	-
ES	Krasnoyarsk	2	2	2	2	-	1	1	-
	Irkutsk	2	1	-	5	2	-	-	-
	Burjatia	2	1	1	5	1	-	-	-
FE	Amur	-	-	-	10	-	-	-	-
	Jakutia	2	-	-	8	-	-	-	-
	Khabarovsk	-	3	-	7	-	-	-	-
	Sachalin	-	4	-	6	-	-	-	-
		South taiga							
WS	Kemerovo	-	-	7	-	1	1	1	-
	Novosibirsk	2	-	-		2	5	1	-
	Tomsk, Omsk	2	1	1	-	2	3	1	-
	Tjumen	3	2	-	-	-	4	1	-
ES	Krasnoyarsk	5	1	4	-	-	-	-	-
	Irkutsk	5	1	-	1	1	1	1	-
	Chita, Burjatia	4	-	-	5	-	1	-	-
FE	Chabarovsk	-	3	-	5	1	1	-	-
	Jakutia	1	-	-	9	-	-	-	-
	Sachalin	-	7	1	2	-	-	-	-
	Kamtschatka	2	-	-	6	-	2	-	-
		Mixed forests							
FE	Khabarovsk	-	4	-	3	2	1	-	-
	Amur		1	-	6	-	2	-	1

		Deciduous forest							
WS	Novosibirsk	2	-	1	-	1	4	2	-
	Omsk	-	-	-	-	-	9	1	-
	Tomsk	1	-	2		1	4	2	-
	Tjumen	2	-	-	-	-	8	-	-
ES	Krasnoyarsk	-	1	3	-	-	1	5	-
FE	Pimorskij	-	2	-	-	3	-	-	5
		Forest steppe							
WS	Novosibirsk	4	-	-	-	-	5	1	-
	Omsk, Tomsk	-	-	-	-	-	10	-	-
WS	Krasnoyarsk	4	1	2	1	-	1	1	-
	Irkutsk	6	1	-	2	-	1	-	-
FE	Primorskij	4	-	-	1	4	1	-	-
	Khabarovsk	3	-	-	1	3	1	-	2
	Amur	2	-	-	4	-	2	-	2

Note: Pn - pinus (mainly Pinus sibirica and Pinus sylvestris), Sp - spruce (Picea sibirica and Picea ajanensis), Fi - fir (Abies sibirica), La - larch (Larix sibirica, Larix dahurica and oth.), Cd - cedar (Pinus sibirica in WS and ES, Pinus koraiensis - in FE), Bi - birch, As - aspen, Oa - oak. Figures in Table 6 illustrate tenths of the total growing stock, i.e. 2 corresponds to 20% of the regional growing stock: WS - West Siberia, ES - East Siberia, and FE - Far East.

The Siberian forests are growing under rather severe climatic conditions and are, in many cases, poorly stocked. Data on the distributions of forests over site indices and density classes are presented in Table 7. The site indices in Russia are determined by the stand's average height, age, and type of regeneration. The site index is given for five main classes, where index I is the best and V the worst; indices I^a, I^b,... and V^a, V^b are also used. The density is determined by the relation of basal area of monitored stands and the basal area for a theoretical optimal stand under actual site conditions.

The information in Table 7 includes only major species and excludes shrubs and other coppice. From this table it can be seen that more than 30 percent of the forested area has a low density (0.3--0.5), the majority of which is located in East Siberia and the Far East. It can also be seen that more than 40 percent of the forests are growing on poor sites (site indices V and Va), of which the main part being located in the Far East region. Average site indices and densities by the economic regions for coniferous are respectively: WS - 3.6 and 0.53; ES - 3.7 and 0.57, FE - 3.1 and 0.51.

The average growing stock (m^3 of stemwood per hectare) for different species and different longitudes for forested area is presented in Table 8, which also lists some of the vegetational types discussed earlier. As can be seen from this table there is quite a variation in the growing stock between different species and different locations in Siberia.

Site index	Density	West Siberia			East Siberia			Far East			Total Siberia			
		Total	Coni-fer-ous	Soft Deci-dous	Total	Coni-fer-ous	Soft Deci-dous	Total	Coni-fer-ous	Soft Deci-dous	Coni-fer-ous	Hard Deci-dous	Soft Deci-dous	Total
II and higher	0.8-1.0	2.1	0.6	1.5	2.5	1.5	1.0	0.7	0.4	0.3	2.4	0.0	2.8	5.2
	0.5-0.7	5.9	1.8	4.1	6.2	4.1	2.1	3.3	1.8	1.3	7.7	0.1	7.5	15.4
	0.3-0.4	1.4	0.5	0.9	1.3	0.8	0.5	1.1	0.5	0.5	1.8	0.0	1.9	3.8
III	0.8-1.0	2.2	0.8	1.5	15.4	12.8	2.6	3.6	2.5	0.9	16.1	0.2	4.9	21.2
	0.5-0.7	9.4	4.9	4.5	53.1	43.7	9.4	16.2	11.8	3.5	60.4	0.9	17.4	78.8
	0.3-0.4	2.5	1.4	1.1	29.1	27.5	1.6	7.7	6.0	1.3	34.9	0.4	3.9	39.3
IV	0.8-1.0	2.0	1.3	0.7	9.1	7.2	1.9	8.0	6.9	0.8	15.5	0.3	3.4	19.1
	0.5-0.7	11.5	8.6	2.9	37.5	31.8	5.7	36.0	31.3	3.0	71.7	1.6	11.6	84.9
	0.3-0.4	3.3	2.5	0.7	11.4	10.1	1.3	17.7	15.9	1.1	28.5	0.7	3.2	32.4
V	0.8-1.0	1.1	0.8	0.3	4.2	3.5	0.7	7.5	6.6	0.3	10.8	0.7	1.3	12.8
	0.5-0.7	12.0	10.3	1.7	21.2	18.7	2.5	43.6	39.6	1.0	68.6	2.9	5.2	76.7
	0.3-0.4	7.3	6.6	0.7	10.0	9.2	0.8	31.4	29.7	0.4	45.6	1.3	2.0	48.8
Va and lower	0.8-1.0	0.8	0.7	0.1	1.3	1.0	0.2	2.7	2.4	0.1	4.0	0.3	0.5	4.8
	0.5-0.7	9.1	8.4	0.7	6.1	5.3	0.8	21.3	19.4	0.4	33.1	1.5	1.9	36.5
	0.3-0.4	7.7	7.2	0.5	3.2	2.8	0.3	25.8	24.9	0.2	34.9	0.7	1.0	36.7
Total		78.3	56.4	21.9	211.6	180.2	31.4	226.6	199.7	15.2	436.3	11.6	68.5	516.4

Table 7: Distribution of Forested Area (FA) over major species, site indexes and density classes expressed in million ha. After Goskomles 1990 and 1991.

Table 8. Average growing stock (m^3 stem wood per ha) for different stands of predominant species and longitudes within Forested Areas (FA) for premature, mature and overmature stands. Unpublished data from VNIIZ Lesresurs, 1988.

Longitude Species	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	141-150	151-160
	Middle taiga									
Pine			107	212	193	138	148	172	-	-
Spruce			201	200	190	131	148	182	214	
Fir			222	228	192	193	-	129	136	
Cedar			223	174	181	157	198	100	-	
Larch			98	183	168	128	129	160	176	
Birch			125	103	87	75	75	100	102	
Aspen			154	192	148	151	106	125	175	
	Southern taiga									
Pine	210	130	158	188	199	141	135	145	-	-
Spruce	220	189	223	173	158	122	162	202	200	193
Fir	246	215	222	214	202	-	-	230	174	-
Cedar	170	211	210	163	196	161	200	257	-	-
Larch	216	183	181	171	187	139	135	186	142	181
Oak	-	-	-	-	-	-	54	150	100	-
Birch	165	143	122	100	117	79	82	127	94	76
Aspen	186	180	147	193	160	94	151	157	84	168
	Deciduous forests									
Pine	273	93	147	-	-	-	-	122	-	-
Spruce	240	226	182	-	-	-	-	208	-	-
Fir	284	292	206	-	-	-	-	193	-	-
Cedar	372	188	181	-	-	-	-	247	-	-
Larch	211	220	119	-	-	-	-	225	-	-
Oak	130	-	-	-	-	-	-	105	-	-
Birch	130	119	142	-	-	-	-	115	-	-
Aspen	156	149	163	-	-	-	-	128	-	-
	Forest steppe									
Pine	231	148	195	184	164	140	175	-	-	-
Spruce	-	130	142	202	175	116	200	204	-	-
Fir	-	-	178	262	181	-	259	198	-	-
Cedar	-	224	186	198	147	111	157	211	-	-
Larch	140	183	129	175	148	131	117	155	-	-
Oak	-	-	-	-	-	-	77	105	-	-
Birch	110	102	101	131	88	76	79	122	-	-
Aspen	115	117	126	194	104	108	160	119	-	

Currently, there is no inventory data for the total biomass of the Siberian forests available. However, assuming that the underground biomass is about 25 percent of the stemwood, and that the crowns constitute about 20 percent of the volume for stemwood (Sagreev *et al.*, 1992), we get a total of woody biomass of living trees of about 92 billion m^3 in Siberia. There is no systematic inventory available on dead wood. Different estimates exist and range between 12 billion and 18 billion m^3, which indicates a total woody biomass of about 110 billion m^3 in Siberia.

4. DEVELOPMENT OF THE FORESTED AREAS (FA) AND GROWING STOCKS (GS)

In Table 9 we present the official statistics on the development of the forested areas managed by the forest authority in Siberia at an aggregated level. There are difficulties in analyzing the development of the forests over time in Siberia (and in Russia). Inventory instructions, definitions, and other standards have changed; these changes make an accurate comparison over time difficult. However, most of the changes in the instructions took place in 1964 and were implemented during the 1970s.

According to the data in Table 9, the decline in growing stock was 1.4 billion m^3 of the forested areas for all of Siberia during the period from 1966 to 1988 in spite of an increased area. But these development figures are somewhat misleading. During this period the average yearly felling was less than 150 million m^3. This gives a total felling for the whole period of about 3 billion m^3. The minimum average net increment is estimated to be 1.2 m^3 per hectare for each year. Thus, the total increment during the period studied was about 13 billion m^3. The total loss of the growing stock can then be estimated to be 10-12 billion m^3 for the period 1966 to 1988.

Thus, according to this calculation nearly all of the increment during the period studied is lost for one reason or another. Even if we take into consideration that nearly 40% of the forests are poorly managed and practically unused in addition, large territories are constituted by unevenaged forests; the losses of the growing stock can be estimated to be at least 6-7 billion m^3. By this simple calculation we can illustrate that the growing stock losses during 1966-1988 are significant in Siberia and correspond to a loss of about 10-20 percent of the existing

Siberian growing stock. Sheingaus (1989) has estimated the total losses in the Far East region to be 4.6 billion m^3, which is roughly seven times more than the felled volume for the studied period.

Table 9. Development of forested areas, growing stocks, and other forest measures during the period from 1966 to 1988. The forested areas presented include only major species which are managed by a forest authority (see Table 3). Forested areas under long-term leases are not included. After Goskomles, 1989.

	West Siberia				East Siberia				Far East				Total Siberia				Difference 1983-1988
	1966	1973	1983	1988	1966	1973	1983	1988	1966	1973	1983	1988	1966	1973	1983	1988	
Forested Area (million ha)	72.7	75.9	74.4	73.2	203.2	207.7	215.0	211.4	194.8	202.6	209.0	212.5	470.7	486.2	498.4	497.1	-1.3
coniferous	47.4	52.0	51.7	51.9	172.5	176.6	182.9	180.1	175.2	181.1	186.8	188.2	395.1	407.7	421.4	420.2	-1.2
pine	23.8	26.6	25.9	26.3	32.3	32.8	32.1	32.1	9.3	9.8	10.7	11.3	61.4	69.2	68.7	69.7	+1.0
spruce and fir	8.2	8.2	8.1	8.6	18.8	20.8	22.0	21.7	15.3	15.0	15.4	15.0	42.3	44.0	45.5	45.3	-0.2
cedar	10.7	12.5	13.0	11.6	22.0	22.6	23.7	23.5	4.0	3.7	3.2	3.4	36.7	38.8	39.9	38.5	-1.4
Total growing stock (billion m^3)	8.7	9.7	9.5	9.2	27.3	27.0	27.7	27.6	20.8	20.3	19.4	18.6	56.8	57.0	56.6	55.4	-1.2
coniferous	6.2	6.8	6.6	6.4	24.7	24.4	25.0	24.9	19.2	18.5	17.7	16.6	50.1	49.7	49.3	47.9	-1.4
growing stock mature and overmature stands (billion m^3)	6.5	7.0	6.5	6.1	20.6	20.1	19.3	18.6	15.6	14.9	13.3	11.7	42.7	42.0	39.1	36.4	-2.7
Unforested area (million ha)	11.2	9.1	6.1	4.5	25.4	21.9	16.8	19.4	74.0	72.1	64.5	66.3	110.6	103.1	87.4	90.2	+2.8
Plantations (million ha)	0.4	0.7	1.1	1.3	0.2	0.5	1.1	1.4	0.1	0.2	0.5	0.6	0.7	1.4	2.7	3.3	+0.6
Annual Allowable Cut (million m^3)	99.5	101.9	103.2	103.5	149.3	159.7	174.2	175.6	113.8	102.4	103.9	106.9	362.6	364.0	381.3	386.0	+4.7
Actual final felling (million m^3)	19.4	20.4	18.5	20.3	58.3	61.5	61.9	69.7	26.4	33.4	34.5	36.5	104.1	115.3	114.9	126.5	+11.6
Actual Thinning (million m^3)	1.3	2.1	2.2	2.3	0.9	1.8	2.4	2.6	0.5	1.0	1.3	1.4	2.7	4.9	5.9	6.3	+0.4
Average growth, m^3/ha and year	1.3	1.5	1.5	1.4	1.3	1.3	1.3	1.2	1.0	1.0	0.9	0.9	1.17	1.20	1.16	1.10	-0.06

The losses are more evident if we study some of the subregions during the period from 1983 to 1988. The developments of the forested area and growing stock for some Siberian subregions are presented in Table 10.

Table 10. Development of forest areas (FA) and growing stocks (GS) in some Siberian subregions. Forested area is expressed in million hectares and the growing stock in billion m^3. Source: Goskomles, 1989.

Region	1983		1988		Difference 1983-1988	
	FA	GS	FA	GS	FA	GS
Yakutsk	128.2	9.8	125.6	8.8	-2.6	-1.0
Tyumen	43.1	5.1	41.8	4.7	-1.3	-0.4
Irkutsk	54.5	8.6	51.8	8.6	-2.7	--
Krasnoyarsk	112.0	13.9	111.3	13.8	-0.7	-0.1
Total	**337.8**	**37.4**	**330.5**	**35.9**	**-7.3**	**-1.5**

During this five-year period there has been an average loss of 2 percent of the forested area and of 4 percent of the growing stock. These developments may also indicate that the rate of losses has increased during the 1980s, although it partially may be explained by changed inventory instructions and classifications during this period.

5. FOREST MANAGEMENT

5.1. FINAL FELLING

As seen from Table 9 the Annual Allowable Cut (AAC, which in Russia is only given for final felling and for commercial wood (industrial wood + fuel wood) changed slightly (363-368 million m^3) during 1966-1988. The actual harvests were about 30-33% of the AAC. The AAC was 382 million ha in 1990 (from forests managed by the forest authority) and was distributed as follows: coniferous 261 million m^3, hard deciduous 6 million m^3, and soft deciduous 115 million m^3. The actual harvest in 1990 was 125.6 million m^3 (Table 11). The forecast of the AACs for each 5-year period until 2010 is shown in Table 12.

Table 11. Actual harvest of commercial wood in 1990 in Siberia, expressed in million m[3(1)].
Source: Unpublished data from Goskomles, 1991.

Forest Groups	Forested Area in mill. ha[2)]	Total Final Felling	Industrial wood[3)]	Distribution of final felling by species groups			Thin-nings	Other Fellings
				Conif.	Hard Decid-uous	Soft Decid-uous		
I	76.4	2.5	1.6	1.8	---	0.7	2.7	2.7
II	14.9	7.5	5.1	5.3	0.1	2.1	1.1	0.5
III	453.2	115.6	85.3	101.0	1.0	13.6	3.0	10.5
Total	**544.4**	**125.6**	**92.0**	**108.0**	**1.1**	**16.4**	**6.8**	**13.7**

1) Forested Area under management of a forest authority.
2) Forested Area under management of a forest authority.
3) Industrial wood is accounted under bark, fuel-wood over bark.

Table 12. Predicted AAC levels for 1995-2010 (commercial wood in million m^3).
Source: Isaev, 1991b.

Region	PREDICTED AAC LEVELS BY PERIOD							
	1991-1995		1996-2000		2001-2005		2006-2010	
	Total	Conif.	Total	Conif.	Total	Conif.	Total	Conif.
Russia	560.4	345.0	552.6	338.7	536.7	328.4	524.9	320.3
Siberia	353.8	238.0	348.6	233.6	363.4	225.4	329.4	221.0
West Siberia	86.3	32.7	85.9	32.7	79.8	29.9	77.2	29.9
East Siberia	159.6	116.3	156.6	113.5	152.4	109.9	148.8	106.9
Far East	108.0	88.9	106.1	87.5	104.2	85.6	103.4	84.2

Data in Table 12 do not consider Russian cedar stands as well as recent losses of spruce stands during the last three years caused by forest fires and draughts.

For Siberia and the Far East a 10% reduction in the AAC (for hard deciduous forests - 20%) is expected. In the Far East, the AAC for coniferous forests is estimated to be maintained at the present level and for the soft deciduous forests it is projected to increase by 29%.

Group III forests are divided into commercial forests (271.6 mln ha in Siberia and Far East) and reserves (179.0 mln ha). The latter will not likely be harvested in the next 20 years, but will instead continue to produce non-timber benefits. The calculations concerning AAC only employ the commercial forests. This is one of the main reasons for low AACs in relation to the existing growing stock of the Siberian forests.

There are other significant problems with the current forest exploitation. First, the areas harvested are concentrated along developed transportation networks. For example, the coniferous stands along the Transiberian railway are systematically being overcut. Second, there were and still are few incentives or penalties in the system of administration to improve forest utilization. The stumpage fee was and is extremely low merely because volumes and penalties for poor utilization were and are minimal. Third and finally, the costs of labor and investments in the forest enterprises are increasing which results in "high-grading" of the forest for its best timber resources in order to increase the profit.

On average, approximately 1 million hectares of forest are cut in Siberia every year by final felling. Ninety-five percent of the harvest is carried out in the form of largescale clear cuts.

The main harvest takes place in populated areas of the southern part of Siberia and the Far East where timber resources are overexploited. In some districts there is a serious overcutting of the AAC. In particular, the pine forests are significantly affected by the overharvest. In contrast, the larch (which dominates in Siberia) and the deciduous forests are underutilized. The result is a steady increase in the deciduous proportion of the forests and there is no silviculture program currently in place to reverse this trend.

'High-grading' has a bad influence on the future species composition of the forests. Large amounts of waste on the felling areas result in a significant increase in insect, diseases and fire damage. In recent years the areas harvested in the form of largescale clearcuts have increased.

Harvesting technologies have a significant impact on the development of the forests. The use of heavy harvesting equipment causes damage to the undergrowth, changes the soil moisture regime, increases surface water run off, increases soil compaction, and other ecological processes. This harvesting equipment has a particularly negative impact in mountain and permafrost regions. For example, the skidding trails are not capable of regeneration for a period of at least ten years or more and frequently cause significant erosion problems.

Overcutting in the southern part of Siberia has serious ecological and social impacts. The large stock of logging equipment is underutilized and manufacturing plants are no longer operating at full capacity. The equipment and plants are not transferable to other regions, which simply means that people currently employed would be unemployed causing great social disruption in many industrial towns which rely strictly on the utilization of timber resources.

With the huge integrated manufacturing plants, problems are just as acute. When the timber supply is exhausted they must continue to haul timber longer and for longer distances or face shut-downs. The people laid off have limited options to move elsewhere. Siberia and the Far East are heavily dependent on the timber economy and therefore unsustainable practices of the forests have serious ecological, social and economic consequences. According to official statistics (Goskomstat, 1990), in 1989 the average distance of one way round wood transportation was 1784 kilometers in the former Soviet Union.

The losses of wood in connection with harvesting are enormous. Falaleev et al. (1985) estimated the average waste of industrial coniferous wood by harvesting in Siberia to range between 30 to 68 m^3 per harvested hectare. The conclusion made by Sheingauz (1989) from a number of sources and local investigations for the Far East is that: for every 3 m^3 of wood felled one is left on the cutting site and further losses by transportation can reach up to 60%. In the Far East more than 70 m^3 wood per hectare are left after clear cuts. An additional 20 m^3 per hectare in the form of other biomass are left on the sites. The "State program for reforestation" (1990) refers to data concerning waste volumes as shown in Table 13.

Table 13. Examples of wood waste in harvesting of timber in Siberia. Source: State program for reforestation (1990).

Region	Average growing stock in harvestable stands m^3/ha	Average removed commercial wood volume m^3/ha
Primorsky kraj	184	82
Khabarovsk kraj	143	98
Amur Region	131	80

Based on the figures in Table 13 it can be seen that about 40 percent of the harvested volume is left in the forests. According to Zvetkov and Ivanova (1985) on clear cut areas of spruce-fir forests located in the southern taiga (Krasnoyarsk Kray), there were about 30-40 t/ha of stem wood abandoned, 8-14 t/ha of slash woody debris, i.e. nearly to 90-100 m^3 of wood are left on the ground. Nilsson et al, (1992) have presented figures for wood waste (harvesting, transportation and industry) to be in the size of 20 percent of the felled volume on average for all of Russia.

The relative losses under selective felling are close to the values presented for clear cuts. In addition, the selective felled stands are often damaged due to inappropriate harvesting methods.

5.2. Intermediate Stand Treatment

Intermediate Stand Treatment includes thinning (in Russia – 4 types of thinning related to age: 2 types of precommercial thinning in young stands, and 2 types of commercial thinning) and selective sanitation harvests. The primary aims in using these treatments are:

- select, preferred species composition
- improve wood quality
- reduce risk of loss due to fire, insect and diseases
- secure future wood requirements.

The forested area on which intermediate treatment should be carried out comprises 11.2 mln ha (Table 14) of which 30% - is pre-commercial thinning. Moreover, commercial wood from sanitation harvest could yield 0.6 billion m^3.

Table 14. Required intermediate stand treatments (conditions January, 1990).

Region	Forested areas requiring thinnings from a silviculture perspective, thousands ha		Sanitation harvests (commercial wood, mill m^3)
	pre-commercial thinnings	commercial thinnings	
West Siberia	786	1885	110
East Siberia	1434	4057	319
Far East	1189	1869	149
Total	3409	7811	578

Not all volumes of the required commercial thinnings are currently economically accessible (Table 15). The most significant factors which decrease the economic accessibility are: no transportation network, no market for small sized wood, high transportation costs, thinning areas widely scattered, long distances to manufacturing plants and others. Thus, from a possible annual thinning volume of 96 mln m^3 only 8% are accessible under present economic conditions. The areas accessible for treatment are about 50% for pre-commercial thinnings and 5% for selection sanitation harvest.

Table 15. Annual silvicultural requirements and economically accessible commercial wood volumes from different kinds of forest thinnings. (mln m^3). Source: Isaev, 1991b.

Region	Possible commercial wood volumes by thinning type mln m^3							
	pre-commercial thinnings		commercial thinnings		selective sanitation harvests		total intermediate stand treatment	
	from silvicultural perspective	economically accessible	from silvicultural perspective	economically accessible	from silvicultural perspective	economically accessible	from silvicultural perspective	economically accessible
West Siberia	0.1	0.1	4.0	1.5	17.6	1.0	21.8	2.5
East Siberia	0.3	0.1	8.0	1.2	41.3	2.3	49.6	3.6
Far East	0.6	0.3	2.9	0.5	21.0	0.7	24.5	1.5
Total	1.0	0.5	14.9	3.2	79.9	4.0	95.9	7.6

Table 16 shows the actual thinnings and sanitation harvest for the years 1975-1988. For Siberia and the Far East the volume of intermediate stand treatments increased by 27% with fluctuations in different regions. Actual intermediate stand treatment makes up only 7% of the possible volume according to silvicultural requirements and 87% of the economically accessible volumes (see Table 15).

Table 16. Volumes from intermediate stand treatments, mill m^3.

Region	Actual volumes by years			Intermediate treatment of total harvesting by years. in percentage		
	1975	1985	1988	1975	1985	1988
West Siberia	2.1	2.2	2.3	6.5	7.1	6.5
East Siberia	2.0	2.5	2.8	3.0	3.9	3.8
Far East	1.1	1.4	1.5	3.0	3.9	3.9
Total	5.2	6.1	6.6			

Nearly 5% of the total harvested volume is from intermediate stand treatment with a distribution over regions as follows (1988 year's data):

— West Siberia - 6.5%
— East Siberia - 3.8%
— Far East - 3.9%.

Figure 3 presents the actual and predicted stand treatment volumes in Siberia and the Far East in 5-year periods (1990-2010 y.y.). There are two projections for each intermediate stand treatment in each region. The first projection takes into account the development of intermediate stand treatments during the last 10-15 years and the need for thinnings in more valuable stands. To some extent this projection also takes into account the accessibility of the forests. The second projection assumes an increase in silvicultural activities and the expansion of the forest road network and the industrial capacity.

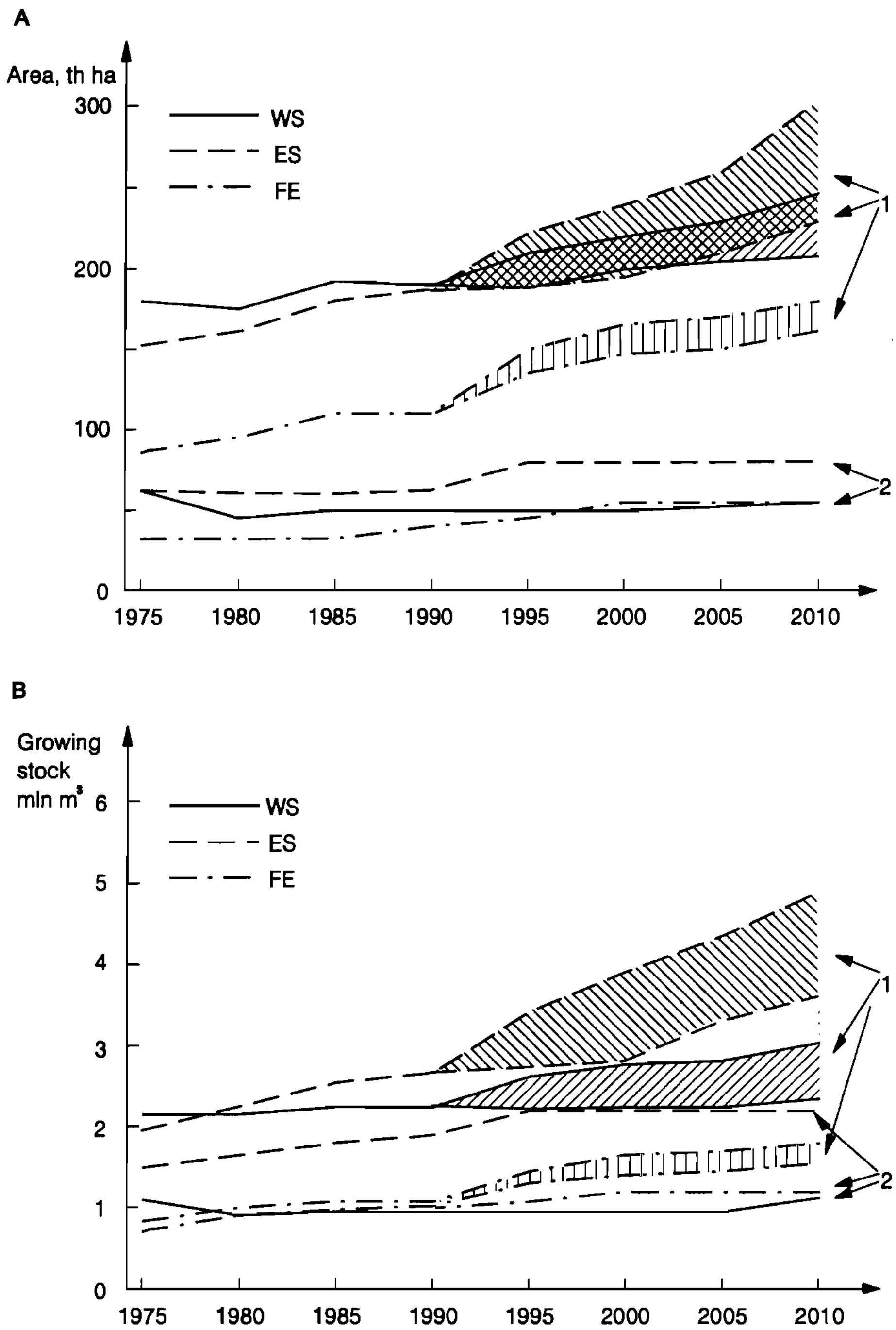

Figure 3. Forecast of the annual intermediate treatment levels in 1995-2010. A - areas, B - harvesting volume (commercial wood), mln m^3; 1 - total, 2 - selective sanitary harvests.

On the whole, by the year 2010, according to this forecast, an increase in thinnings and sanitation harvests by 48% (compared with 1975) is expected using the first projection and by 90% in the second projection. The major increase in thinnings is expected in the East-Siberian region. The rate of change in selective sanitation harvests is expected to increase at a rate of 16% and in the first scenario and by 34% in the second scenario (in Figure 3 only the second projection is shown). There is a stabilization of the possible thinning volumes in West Siberia according to both projections. It is expected by the year 2010 that the sanitation harvests will be 50% of total intermediate stand treatments according to the first projection and 45% according to the second projection (instead of 63% in 1975).

5.3 Forest Regeneration

The presence of huge unforested areas in Siberia has been discussed earlier. In addition, about 800,000 hectares are harvested as clear cuts annually. The majority of the harvested stands are suitable for natural regeneration by coniferous (Pisarenko et al., 1992). As a general rule the relations between natural regeneration and plantations are (State program...1991) in;

northern and middle taiga	70:30
southern taiga	50:50
mixed forests	30:70
forest steppe	5:95
steppe	0:100.

The exclusions from this rule of thumb are the Novosibirsk and Omsk regions where plantations have to cover 60-70% of the reforestation areas.

However, the natural regeneration is often insufficient due to inappropriate logging methods destroying the undergrowth, inadequate assistance of natural regeneration, and inefficient forest fire protection.

The forest regeneration system in Siberia includes: 1. establishment of forest plantations, in stands where natural regeneration of coniferous or hard deciduous is not expected. 2.

assisting natural regeneration of the forest understory. 3. exposure of mineral soils to promote natural regeneration. 4. encouraging the natural regeneration of commercially valuable tree species and 5. converting soft deciduous young forests to coniferous or hard deciduous.

The rate of artificial reforestation in Siberia is low. This is illustrated by Table 17.

Table 17. Artificial reforestation in Siberia (expressed in thousands of ha). Source: Isaev, 1991b.

Region	Accumulated total reforestation	Reforestation (planting and seeding) in years:	
	By January 1988	1985	1988
West Siberia	1261	82	80
East Siberia	1393	78	77
Far East	641	56	56
Total	**3295**	**214**	**213**

The rate of survival of the reforestation is low due to the low quality of planting and also forest fires. During the period 1983—85 over 300,000 ha of the reforested areas were destroyed, which corresponds to about 10 percent of the accumulated reforested areas. In the Far East region, only about 50 percent of the planted areas have survived.

Two fundamental reports on the reforestation of the former Soviet Union (FSU) have been presented by the former USSR State Forest Committee: "Forecast of the utilization and reproduction of forest resources by economic regions of the USSR up to 2010" (Isaev, 1991b) and "State programme of the forest regeneration" (1990). Based on these documents it can be concluded that the necessary increase of the regeneration in Siberia is 1.2-1.5 times above the current level (Figure 4a). The assistance of natural regeneration should at least be stabilized at the current level (Figure 4b), but with increased efficiency.

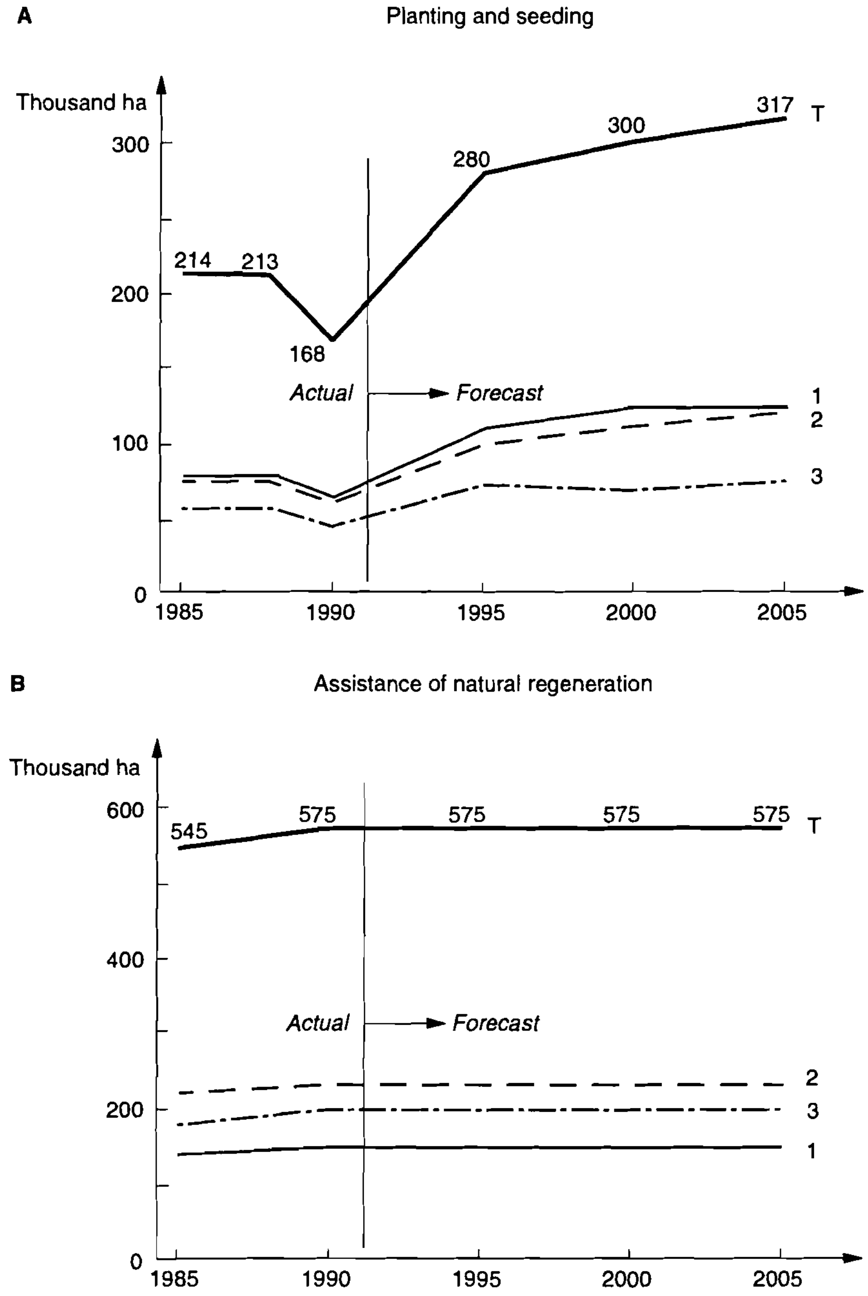

Figure 4. Required planting and seeding (A) and assistance of natural regeneration (B) in Siberia: T - total, 1 - West Siberia, 2 - East Siberia, 3 - Far East, areas in thousand hectares.

The Siberian Forest Fund has a potential for large-scale reforestation, in the form of carbon sequestration programmes. The estimates made, based on a scenario of realistic forest management programs, are of a reforestation program of 50 to 80 mln ha during the next 40 years which would result in an annual carbon sequestration of nearly 2.5 tC/ha/year (Shvidenko et al., 1994b).

An important part of reforestation is the restoration of forest lands destroyed by direct industrial influences including coal, ore, peat, oil and gas exploitation.

Total areas of such lands are unknown but are estimated to be nearly 10 mln ha. In 1988, planting and sowing on these lands consisted of less than 1000 ha in the entire territory of Siberia.

There are large areas of stands with forests of limited value from a market point of view and with low densities in Siberia which are subject to reconstruction. According to inventory data, areas requiring reconstruction are 238,000 ha in the Far East, 107,000 ha in East Siberia, 76,000 ha in West Siberia. Although in 1988 only 35,000 ha of such stands were reconstructed (8% of the required), and 72% of that area was in the Far East region.

5.4. Harvest of Non-Wood Products

In the Siberian Far East forests there are many non-wood products: fruits, berries, mushrooms, nuts, tree sap and medicinal plants. Other non-timber functions include production of herbs from hay, grazing, beekeeping, hunting, fishing and recreation. The production of these non-wood products is about 5-7 mln ton/year (which seems to be a low estimate), of which fruits and berries eqals 2 mln ton, mushrooms - 1.5-4 mln ton, nuts - 0.8-1.2 mln ton. Approximately 50% of these resources are accessible for human consumption. The current harvested volume of these stocks by forestry enterprises is less than 1% of the total harvestable stock. Other government enterprises use another 2% of the stock. Experts estimate that a further 3% is harvested by the Russian people. Thus, the total harvested volume of non-wood products in these regions do not exceed 6-7% of its total stock.

Russian cedar forests, are very important for nut production. About 80% of the total nut harvest in the former USSR was collected in cedar forests, although the actual harvest of cedar nuts does not exceed 2-3% of the production. The average harvest of cedar nuts reaches about 1 mln ton annually. The area of cedar forests is less than 6% of all Siberian forests, yet they provide half of the total harvest of sable and squirrel's fur which are very important to the fur trade. For example, on 1000 ha of cedar taiga there is 17 times more fur collected, than on 1000 ha of larch forests.

About 45% of all medicines in Russia are produced from plants. In the forests and bogs of West Siberia alone there are more than 700 medical plant species. West and East Siberia have 37 species of fur animals. During the last 10 years these two regions supplied nearly 90% of the total fur amount in the FSU (Kovalev, 1988). There is a substantial population of wild animals which are important for the food supply in Siberia. The populations were estimated for the period 1966-1977 to be the following for West and East Siberia (including Yakutia): elk 168000, northern deer 554000, roe 241000. The populations are estimated to have increased between the mid 1970s and the mid 1980s. For example, the elk population was estimted to have increased to 260-300000 in the middle of 1980s (Kovalev, 1988) in spite of a harvest between 1974-1984 of about 180000 elks.

About 300 million ha of the northern tundra and the forest tundra are used as deer pastures. During the last decades the areas of pasture covered by iceland moss (the basic deer pasture) have decreased by about 2% annually in Siberia (Kovalev, 1988).

In Table 18, actual and projected volume of harvested non-wood products is shown (Isaev, 1991b). The basis for the predicted volumes was: assessment of present needs, actual volumes harvested, the resources produced through the cultivation of berries and nuts and finally, labor supply.

To increase the non-wood products resources and their subsequent processing, the following measures should be taken: establishment of more plantations, better organization of storage and manufacturing facilities, mechanization of the collection of plants, and improved harvesting equipment.

Table 18. Actual and projected volume of harvested non-wood products (in million tons). Source: Isaev, 1991b.

Regions	Volume Actual Harvesting			Forecast of harvest by years			
	1980	1985	1990	1995	2000	2005	2010
Fruits and Berries							
West Siberia	0.19	0.30	1.07	1.10	1.20	1.30	1.40
East Siberia	0.22	0.09	0.39	0.40	0.45	0.47	0.50
Far East	0.23	0.48	0.64	0.72	0.82	0.90	1.00
Total	0.64	0.87	2.10	2.22	2.47	2.67	2.90
Mushrooms							
West Siberia	0.03	0.11	0.27	0.30	0.35	0.37	0.40
East Siberia	0.13	0.08	0.12	0.13	0.14	0.15	0.16
Far East	0.04	0.09	0.20	0.20	0.21	0.22	0.23
Total	0.20	0.28	0.59	0.66	0.70	0.74	0.79
Nuts							
West Siberia	0.14	0.07	0.61	0.65	0.90	1.00	1.20
East Siberia	0.81	0.36	0.87	1.00	1.50	1.70	2.00
Far East	0.02	0.66	0.32	0.35	0.50	0.70	1.00
Total	0.97	1.09	1.80	2.00	2.90	3.40	4.20
Vegetational raw materials for medical applications							
West Siberia	0.61	0.91	0.89	1.00	1.20	1.30	1.40
East Siberia	0.10	0.17	0.13	0.19	0.20	0.21	0.22
Far East	0.30	0.37	0.32	0.45	0.50	0.55	0.65
Total	1.01	1.45	1.34	1.64	1.90	2.06	2.27

5.5. Forest Fire Protection

Forest fires are still the main factor, which determines the long-term dynamic of forests and also negatively influences the natural resources in Siberia and the Far East region. In the 973 mln ha Forest Fund area, 590 mln ha (61%) are under some form of fire protection which is distributed as follows: West Siberia - 78%; East Siberia - 66%; Far East - 52%. On the non-protected areas active fire fighting is done only in exceptional cases, such as real danger to commercial objects. Fires which occur in non-protected areas are not documented and not entered into any fire statistics. According to the current State Forest Account (January, 1988) the total area of burnt and dead stands is around 30 million hectares (26 mln ha - under State Forest Management, see Table 3). On the area protected from forest fires there are 10–15,000 fires annually and about 1.0–1.5 million ha of Forested Area are destroyed every year. Statistics on forest fires before 1988 are not reliable. Information about forest fires for 1989 and 1990 is presented in Table 19.

Table 19. Forest fires in Siberia for 1989 and 1990. Unpublished data from the former USSR State Forestry Committee.

Region	Number of fires	Burned area in thousand ha				Burned timber in million m^3
		Forest Land (FL)	Forested Area (FA)	Non-forest Land (NFL)	Forest Fund (FF)	
1989						
West Siberia	6625	1128	1106	279	1407	46.9
East Siberia	4420	69	46	11	80	1.0
Far East	2349	397	319	118	515	16.5
Total	13394	1594	1471	408	2002	64.4
1990						
West Siberia	2638	34	31	30	64	0.5
East Siberia	7661	715	691	47	762	11.9
Far East	2958	608	586	226	834	10.9
Total	13257	1357	1308	303	1660	23.3

Based on the forest fires statistics for 1989 and 1990 it can be concluded that each fire causes a loss of about 100 hectares of Forested Area and 2000—5000 m^3 of timber. But the main losses are caused by large forest fires (10-15% of the total number) which are responsible for 80-85% of the burned areas. About 50 to 95 percent of the burned areas are located in regions with extreme weather conditions. For example, in 1989 it was estimated that about 3500 fires with a total area of 0.81 million hectares took place in the Tjumen region; respectively 900 and 0.47 in the Tomsk region; 100 and 0.22 in the Sachalin region; 100 and 0.17 in the Khabarovsk Kray. This means that 80% of the forest fires took place in the territories of four administrative units.

In 1991 forest fires were observed on less areas – 970 thousand hectares of Forest Fund area and 570 thousand hectares of Forest Lands for the entire territory of Russia. Ninety-five percent of the forest land fires were in Siberia: 73000 hectares in West Siberia, 68000 hectares in East Siberia, and 397000 hectares in the Far East. The estimated loss of wood was 7.7 million m^3 (Review..., 1992).

The main reason for the increase in forest fires is public abuse of forest fire regulations (80% of total number of forest fires). In some individual taiga regions most forest fires are caused by thunderstorms (Tomsk region – more than 70%, Jakutia – more than 60% of total fires).

The protection of forests from fire is the responsibility of the Forest Protection Service and the Forest Fire Service in other ministries connected with forests. Aerial control is the main kind of forest fire control. About 85% of all control in Siberia and about 90% in the Far East is regulated through regional Aerial Forest Control Bases. The current systems of aerial and ground forest control do not provide accurate forest fire protection. Early warning systems which locate fires for early extinguishment are not in place. As a result, fires often spread to large areas. Only 45-50% of all forest fires in Siberia and Far East are discovered and extinguished in time. The main reasons for the low level of forest fire protection are: lack of sufficient funds, scarce and poor technical equipment for both aerial and ground forest fire protection, and imperfect organizational structure and administration.

Figure 5 illustrates an estimate on areas possibly protected by different kinds of fire control up to year 2010. To meet this objective the decisionmakers would need to: enlarge the actively guarded areas, improve early fire detective devices, and reduce the time for fire extinguishment by 10-15%.

As the projections in Figure 5 indicate, the area under control is supposed to increase to 887 mln ha (91% of the Siberian Forest Fund) by 2010. This control will primarily be aerial, and with aerial forest fire suppression. The on-ground forest fire protection area is estimated to be stable during the entire period: total 28 mln ha, of which 9.6 mln ha are in West Siberia, 12.5 mln ha in East Siberia, and 5.9 mln ha in the Far East.

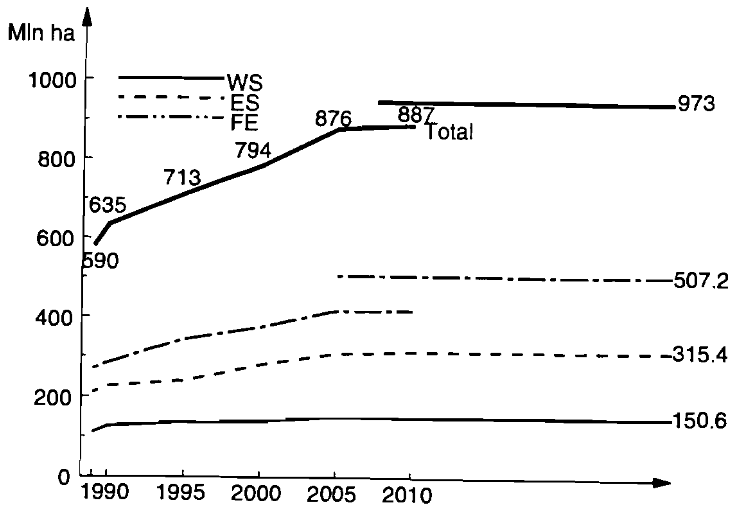

Figure 5. Projections of Siberian Forest Fund areas controlled by Forest Fire Protection measures by year 2010. (Figures on the right are designated to the total forest fund area in 1988.)

5.6 Protection from Pests and Diseases

The increase in pest problems and the spread of forest diseases in recent years seems to be the result of the increasing influence of anthropogenic factors. Rapid change in forest ecosystems under the influence of human activities, is often associated with the loss of biological stability. This can lead to severe forest protection problems. Insects and diseases have the ability to quickly multiply and spread to large forest areas. The most important human factors for the development are:

- intensive final fellings
- pollution
- changed hydrological pattern
- pressure from recreation.

For example, timber waste after final fellings provides ideal conditions for insect and disease outbreaks. The largest area in the former USSR with pest and disease damaged forests are in Siberia and in the Far East. Periodical drying of fir-spruce stands is observed in the southern part of the Far East since 1926, large areas were especially registered in 1954-1960, 1968, 1977-1980, 1984. Extensively accurate data does not exist but various estimates are from hundreds to several million hectares. The areas seriously attacked by the insect Siberian bombyx were nearly 1.5 mln ha during the periods 1950-54, 1973-77, 1976-88 in cedar stands of the Amur and Khabarovsk regions; by the width-strip bombyx – in larch and in dwarf pine *(Pinus pumila)* – 2 mln ha (during 1942-47, 1956-58).

According to official statistics, about 1 million hectares of forested area are reported to be seriously affected by insects and diseases annually (Table 20). In 1991 areas attacked only by defoliators (leaf–damaging insects) were reported to be 1.98 mln ha (0.07 mln ha in West Siberia, 0.09 mln ha in East Siberia, 1.82 mln ha in the Far East); this amount includes 1.2 mln ha attached by the unpaired bombyx *(Limantria dispar)* (Review..., 1992).

Table 20. Forested Areas (FA) attacked by insects and diseases requiring sanitation measures. Source: Isaev, 1991b.

Region	Affected areas in 1000 ha				
	1975	1980	1985	1988	Average 1975-1988
West Siberia	202	326	505	91	266
East Siberia	1690	209	24	93	590
Far East	124	99	42	104	183
Total	**2016**	**634**	**571**	**288**	**1039**

Unfortunately the forest pathological information (especially in Siberia) suffers from serious shortcomings due to the absence of a forest health monitoring system, non-coordination and sometimes contradictions between different information sources. State statistics contain only data about dead stands (Table 21), and it is almost certain that these data are underestimates for Siberia. A second estimate on the distribution of areas attacked by insects and diseases is shown in Table 22.

Table 21. The main driving force for forest death in 1991.

Regions	Dead stands, thousand hectares							
	Total	Driving forces:						
		Forest fire	Unfavor-able weather	anthropo-genic influence	air pollution	insects	disease s	wild animals
Total Russia	419.3	213.4	184.7	0.9	0.3	8.8	1.9	9.2
Siberia	375.2	193.9	168.1	0.2	-	7.3	0.6	5.1
West Siberia	42.3	28.5	1.3	-	-	7.3	0.6	4.6
East Siberia	35.3	34.0	1.1	0.2	-	-	-	-
Far East	297.6	131.4	165.7	-	-	-	-	0.5

The distribution of these factors causing the death of forest stands for different economic regions of Russia is shown in Figure 6.

Table 22. Distribution of the areas substantially attacked by insects and diseases by the end of 1991. Source: Review..., 1992.

Region	Insects				Diseases				
	Total thous.ha	Including			Total thous. ha	Including thous. ha			
		Defoliators	Other	Area[x)]		Root rot	Stem rot	Others	Area[x)]
Russia	2868.9	2701.0	167.9	379.9	161.9	49.7	79.0	53.2	48.6
Siberia	2039.5	1979.6	59.9	107.0	59.5	n.a.	43.3	15.5	n.a.
West Siberia	126.1	71.4	54.7	42.0	6.1	0.7	3.7	1.7	0.4
East Siberia	91.3	86.3	5.0	53.0	36.7	n.a.	23.1	13.6	n.a.
Far East	1822.1	1821.9	0.2	12.0	16.7	n.a.	16.5	0.2	n.a.

x) Areas requiring sanitation from economic point of view.

As seen from Figure 6, after forest fires, unfavorable weather conditions are the most important cause for the death of forest stands (Review..., 1992). However the current information is incomplete and inaccurate. The basic cause for forest death under unfavorable weather conditions is strong winds (more than 17 meters per second) - wind speeds of 25-40 m/sec result in huge compact wind-falls. Such winds are observed constantly in West Siberia and the Far East. Other contributing factors not discussed in Table 21 are droughts and surplus soil moisture.

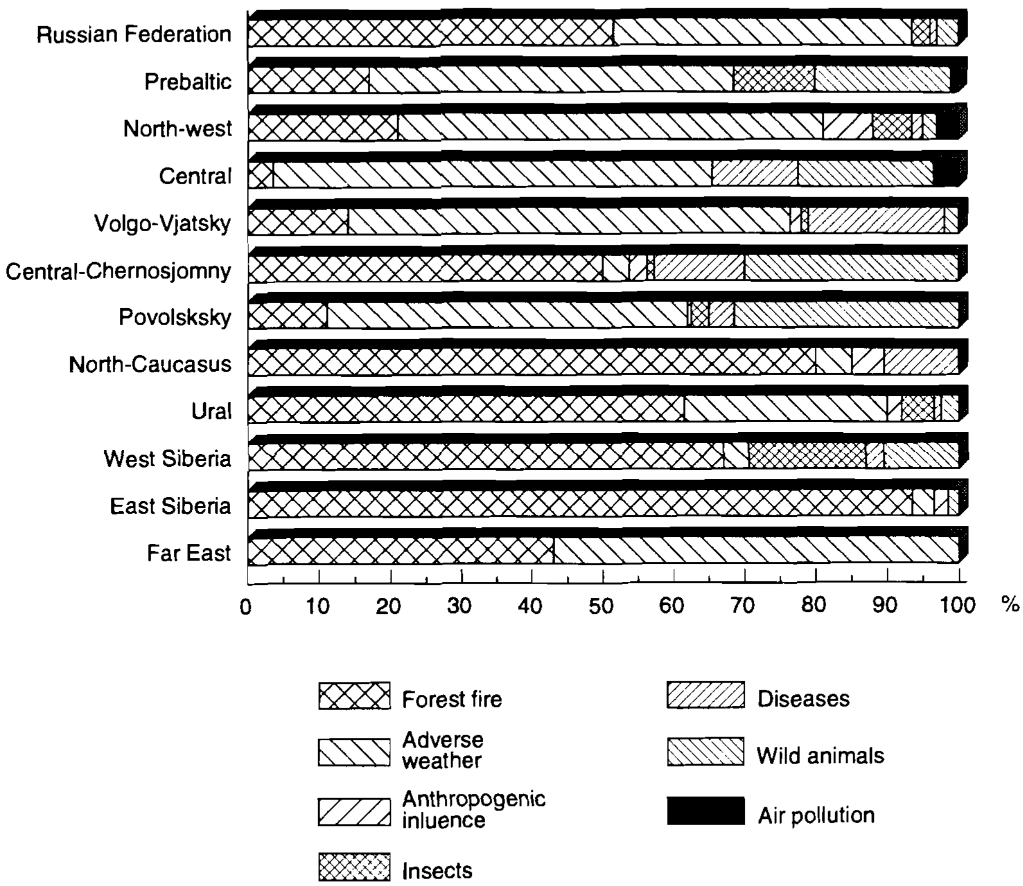

Figure 6. Primary causes for forest death in 1992 by economic regions of Russia.

Damage caused by wild animals, primarily by elks, is observed in mainly young stands or forest plantations. This damage influences the state of stands, species formation and development of coniferous forests.

From 1975-1988 sanitation methods for combating diseases and insects have been implemented in Siberia on about 60 thousand hectares annually (70% by biological methods in 1988). A forest pathological survey has been carried out on areas totalling about 1 million hectares each in West Siberia and East Siberia, and about 285000 hectares in Far East (Isaev, 1991b).

5.7 Air Pollution, Soil and Water Contamination

Average annual emissions from stationary sources in Siberia (Table 23) per area unit are less than in the European part of the former Soviet Union, although the ecological conditions around large industrial centers are critical due to:

1) the concentration of the population;
2) the location of industry which is sometimes located in sensitive ecological areas (mountain regions, forest tundra regions, permafrost regions), and
3) the ecosystems resilience in Siberia being less than those in the European part of Russia.

Table 23. Annual emission from stationary sources in Siberia to the atmosphere. Source: Goskomgidromat, 1990.

Region	Solid matter (mln t)	Sulphurous anhydride (mln t)	Nitrogen oxides (mln t)	Sulphuric acid (th t)	Hydrogen sulfate (th t)	Lead (th t)	Mercury (th t)
West Siberia	1.200	0.712	0.552	1.388	3.090	0.064	0.103
East Siberia	0.924	2.763	0.173	31.735	5.887	0.059	3.357
Far East	0.823	0.397	0.129	0.191	1.272	0.059	0.005
Siberia	2.947	1.872	0.854	33.314	10.249	0.182	3.465

Another ecological phenomena is the long distance transportation of air pollutants from the industrial centers in the European-Ural part of Russia to Siberia. Of the 100 worst cities worldwide suffering from pollution, 18 are in Siberia and the Far East. These 18 cities produce 30% of all major industrial pollutants in the former USSR (Feshbach and Friendly, 1992).

The concentrations of emissions (SO_2, SO, CO, CO_2, N_2O, NO_2 and NO, heavy metals) are sometimes above the allowable emission standards by 10 to 100 times in Siberia. In 1991, high concentrations of these pollutants were observed in Krasnoyarsk, Ust-Ilimsk, Khabarovsk, Chita, Irkutsk, Norilsk and other cities of Siberia; Norilsk is claimed to be the most polluted city in the world. Norilsk's metallurgical group of enterprises (NMGE) situated in the forest tundra emits more than 4 million tons of pollutants of which 2.2 million tons are sulphur dioxide (1980 – 1.6 mln t) annually. There is a technogenic desert 50 kilometers in length from Norilsk in direction to the south. In 1993 NMGE paid nearly 1.1 billion rubles in penalties for destroying the vegetation in the Forest Fund territory. Rough estimates indicate that the total forest area damaged by air pollutants is roughly 7 million hectares in Russia (Isaev, 1991b).

Water contamination is also essential. The entire length of the Ob River is polluted by oil products and phenols. The Yenisey River at places such as Krasnoyarsk is polluted by very toxic pollutants and acids. Bratsk and Ust-Ilimsk water reservoirs are strongly polluted by forest industrial enterprises. Concentrations of methylmerkapthans and hydrogen sulphide are more than 100-fold above the critical allowable concentrations (CAC). The Amur River's water contains copper and chromium compositions 5-15 fold above CAC, and the total amount of pollutants in the Lena River is 1-7 times above the CAC. In 1991, 230 million m^3 of sewage water were thrown into Lake Baikal polluting 169 million m^3 of water (Ministry of Ecology..., 1992).

Water pollution is increasing. The Angara River, which flows from Lake Baikal, is a good example. As recently as 10 years ago, the people living along the river relied upon the fish resource as an important component of their diet. Now every year 257,000 tons of chlorides, 140,000 tons of sulfates, over 30,000 tons of organic wastes and 10,000 tons of nitrates are deposited in this river from factories along its banks.

Every year the transport of logs in booms along the rivers lead to further deposition of organic wastes. The long-distance water transportation of wood, mainly floating and rafting, constituted nearly 70 percent of the harvested wood during the 1970s in Siberia (Timofeev, 1967). Another example of pollution is the establishment of water reservoirs on forest lands. The flooded standing trees are decaying and creating pollution problems. For example, each cubic meter of submerged wood generates nearly 20 kg of pollutants. According to rough expert estimates, in 1984 in the Kamschatka River there were 400-500,000 cubic meters of sunk larch wood.

The specific cold water fauna in the rivers dislike both the deposition of pollutants and the changes in water temperature from human activities. For example, Lake Baikal is a unique reservoir of clean water but is threatened because integrated wood processing facilities were built with poor systems for water cleaning. The conditions have worsened with the building of the Baikal-Amur railroad, which initiated the development of industries in the northern part of the lake. The lake is now saved only by its big reservoir of water.

Soil contamination is observed in many regions of Siberia but primarily in regions with intensive oil- and gas-production. For example, during recent years the amount of Forest Fund area reallocated for oil production in the Tjumen region reached 130,000-150,000 hectares annually. Areas affected by oil and gas exploration in this region (i.e. destroyed territories, contaminated soils, changed water regime, etc.) are estimated to be a couple of million hectares.

6. RAIL AND ROAD NETWORK

The road network density and its condition largely determines the feasibility for implementation of silvicultural measures and exploitation of the forests. Railways and roads in the Forest Fund area of Siberia and the Far East are approximately 340,000 km in length (Table 24), or 36% of all railways and roads in the Russia Forest Fund area. Roads constitute 95% of the rail and road network, and only about 15% have hard surfaces. Many of the roads may be used only in winter and very occasionally in the summer. The Far East and Siberian regions have a very low road density (0.04 km per km^2) but West Siberia is closer to the average Russian density (0.08 km per km^2)[1]. The road density for roads with hard surfaces is .005

[1]For comparative purposes the Central Chernozyomny region of the European part of Russia has a road density of 1.77 km per km^2.

km per km^2. Between 1986-1990 approximately 18,000 km of roads were built in the Far East and Siberia. About 7% of this new network was forest fire protection roads (Table 24). Road standards are very low, and this is to some extent explained by the neglected maintenance.

One of the most important improvements required in the transportation infrastructure in Siberia is the reconstruction (upgrading) of the existing road network. During the last 50 years more than 200000 kilometers of roads (rough estimation) have been built in the Siberian forests for timber removals. From this total amount, only 15 percent are recognized as suitable for utilization today.

Table 24. Current road network in the Siberian & Far East Forest Fund. Source: Isaev, 1991b.

Regions	km				Density km per km^2		
	Total	Railways	Roads		Rail and Roads	Roads	Roads with hard surface
			Total	with hard surface			
West Siberia	106,073	5,547	100,526	14,290	0.08	0.073	0.009
East Siberia	143,187	5,877	137,310	22,094	0.05	0.043	0.007
Far East	90,308	6,921	83,387	10,875	0.02	0.017	0.002
Total	339,568	18,345	321,223	47,259	0.04	0.037	0.005

Table 25. Costs for road construction during 1986-1990. Source: Isaev, 1991b.

Region	Operating costs				Investments in roads for timber transporation mln. rubles
	forestry roads		forest fire protection roads		
	km	mln. rubles	km	mln. rubles	
West Siberia	1585	26.9	3204	0.8	10.1
East Siberia	1597	3.6	3306	0.9	3.3
Far East	1983	4.2	6210	1.3	0.8
Total	5165	34.7	12720	3.0	14.2

Note: costs are given in 1988 prices.

Two projections have been made for road construction up to the year 2010 (Isaev, 1991b). The first projection assumes that the previous demand on the road construction will continue. The second includes the assumption that the forest enterprises needs to increase the forest renewal. In the first projection 1991-2010, 22,000 km of new roads (11,000 km with hard cover) will be built during 1991-2010 in Siberia; the second projection estimates that 44,000 km of new roads (23,000 km with hard cover) have to be constructed.

According to the first projection, the investment costs will be 389.2 mln rubles; according to the second projection, 1071.2 mln rubles (in 1988 rubles). Considering the state of existing road networks and the intensity of current use, significant repairs will also be needed in the future. For 1991-2010, the amount of needed road repairs are estimated to be 19,000 km at the cost of 267.7 mln rubles (in 1988 rubles).

One of the most utilized forms of wood transportation is by water, a combination of floating and rafting. In 1965, the total amount of wood transported by water was 128 mln m^3 in the former USSR, 100 mln m^3 of which was rafted on small rivers. This constitutes about 50% of the harvested wood, the corresponding figures for West and East Siberia respectively, Far East is about 70-80%. Rafting of wood is now prohibited in the majority of the Siberian forest regions by current legislation. According to official statistics, internal water transport of wood by ships and floats was in 1985 – 68.6 mln m^3, 1987 – 66.4 mln m^3, 1989 – 60.8 mln m^3 (Goskomstat SSSR, 1990) in the former U.S.S.R.

7. FOREST ENTERPRISES

The forest enterprises are owned by the state forest authority (former Goskomles SSSR, now Federal Forest Service of Russia). In addition to silvicultural work and forest management, they are also involved in some industrial production. The volumes of timber supplied to the industry by the forest enterprises are shown in Table 26.

Table 26. Removed timber by forest enterprises.

Region	Volume of removed timber[x)], in million m^3		
	1985	1987	1988
West Siberia	2.4 / 2.9	2.5 / 3.0	2.4 / -
East Siberia	0.4 / 1.1	0.5 / 1.0	0.4 / -
Far East	0.1 / 0.3	0.2 / 0.3	0.2 / -
Total Siberia	2.9 / 4.3	3.1 / 4.4	2.9 / -

[x)]upper line - After transfer of part of the forestry enterprises to the Ministry of forest industry in 1989, lower line – All enterprises belonging to the Russian Ministry of Forestry in 1988.

The distribution of industrial product centers owned by the forest enterprises in the Far East and Siberian regions is not homogeneous. The West-Siberian region produces 60% of all manufactured forest products. The Far East region produces only 16% of all manufactured products. The wood products manufactured by the forest enterprises mainly stem from intermediate fellings.

8. LABOR RESOURCES

The total number of workers employed by forest enterprises in Siberia and the Far East in 1985 was about 82000 (Table 27). More than 50% of them were employed in West Siberian forest enterprises.

Table 27. Estimate on the number of workers in forest management, silviculture, and wood products production by forest enterprises. (Isaev, 1991b)

Region	Number of workers in thousands						
	1985	1988	1990	1995	2000	2005	2010
West Siberia	42.8	40.1	37.9	36.0	34.4	32.8	31.2
East Siberia	23.9	23.7	22.8	21.8	21.7	21.6	21.6
Far East	14.9	14.4	14.2	14.1	13.9	13.5	13.4
Total Siberia	81.6	78.2	74.9	71.9	70.0	67.9	66.2

In recent years, there is a downward trend in the number of persons employed in the forest enterprises. The main reasons are: low salary levels, bad working and living conditions, and physically demanding work. This trend varies for different regions and activities. The greatest reduction of workers in the labor force is foreseen in West Siberia, mainly in special wood product sectors. In East Siberia and the Far East, the number of workers is expected to decrease by 10%. The special wood products personnel share of the total labor force is as follows:

— West Siberia - 77%

— East Siberia - 79%

— Far East - 82%.

The proportion of workers in relation to all personnel employed by the forest enterprises is:

- West Siberia - 87%
- East Siberia - 88%
- East Siberia - 86%.

In silviculture, the share of full-time work is about 55%. The reasons are the seasonal nature of the work, the low prestige of the work, inability to attract young people, and high employment turnover. Table 28 shows the structure of the employment by the forest enterprises in forest management and silviculture.

Table 28. Structure of employment in forest management and silviculture in forest enterprises (1987 year). (Isaev, 1991b)

Region	Total thousand	Full-time & part-time workers		Full-time workers		Part-time workers		Foresters		Proportion of employment	
		thousand	%	thousand	%	thousand	%	thousand	%	Full-time %	Part-time %
West Siberia	8.3	6.9	84	4.3	52	2.6	32	1.4	16	62	38
East Siberia	7.9	6.1	78	4.2	53	1.9	25	1.8	22	68	32
Far East	6.5	5.1	78	3.7	57	1.4	21	1.4	22	72	28
Total	22.7	18.1	80	12.2	54	5.9	26	4.6	20	67	33

The proportion of part-time employed foresters is similar to the proportion for part-time employed workers. Table 29 shows salary levels of the personnel.

Table 29. Average monthly salary of full-time silviculture and special wood products workers (in 1988 rubles). (Isaev, 1991b)

Region	Average monthly salary, rubles (1988)	
	full-time special wood products workers	full-time workers in silviculture
West Siberia	221	179
East Siberia	252	209
Far East	320	265

If the wages of part-time workers and foresters are included in the calculations the average calculated wages will be 10% lower than that indicated in Table 29.

The total number of managers and specialists in all Siberian regions is 13,300. The majority of them (80%) have a higher or technical secondary education. There is a general trend to reduce the number of managers and specialists in recent years (Table 30). This is a result of administrative staff reductions and difficulties in recruitment due to lack of prestige in the silviculture work.

Table 30. Number and qualifications of managers and specialists in silviculture. (Isaev, 1991b)

Region	Years	Number employed			
		Total	In percent		
			with higher education	with secondary technical education	practical workers
West Siberia	1980	6340	20.6	56.5	22.9
	1985	6667	23.6	58.3	18.1
	1989	5870	24.0	57.6	18.4
East Siberia	1980	5146	23.8	57.2	19.0
	1985	5294	25.9	59.7	14.3
	1989	4488	26.8	54.5	18.7
Far East	1980	4318	29.9	53.1	17.0
	1985	4403	30.0	57.3	12.7
	1989	2936	36.8	53.8	9.4
Total	1980	15804	24.2	55.8	20.0
	1985	16364	26.1	58.5	15.4
	1989	13294	28.0	52.5	19.5

There are 22 higher forestry educational schools in Russia which educate forestry professionals (the research institutions are not taken into account) although only 3 of them are situated in Siberia.

9. INVESTMENTS AND OPERATING EXPENDITURES IN FORESTRY

The total amount of investments and operational expenditures in the former Soviet Union (1252 million hectares of Forest Fund, 814 million hectares of Forested Area for forest management under state forest administration) is presented in Table 31.

Table 31. Annual investments and operational expenditures for forest management under state forest administration in the former U.S.S.R. (Isaev, 1991b)

Period	Investments				Operational Expenditures	
	Total		Forest Management			
	million rubles	Percent	million rubles	Percent	million rubles	Percent
1966-1970	183.2	100	89	100	520	100
1971-1975	239.4	131	120	135	680	131
1976-1980	290.7	159	154.8	174	840	162
1981-1985	411	224	236	254	960	187
1986-1990[1)]	430	235	220	236	1026.4	191

[1)] For 1989 the exchange rate is estimated to 4.7 Rubles per US$.

The average investments were nearly 51 rubles/100 ha of Forest Land in the FSU for the period 1986-1990, for Russia – 38.1, and in more developed regions the investment could reach 900 rubles/100 ha of Forest Land (such as the Central - Chernoziomny region).

The lowest rates of investment in Russia were in the Far East and East Siberia. The following investments were allocated in the budget for 1990 for the Siberian regions:

- West Siberia - 34.3 rubles/100 ha of forest land
- East Siberia - 8.7 rubles/100 ha of forest land
- Far East - 5.2 rubles/100 ha of forest land.

Future investments estimated by the State Forest Committee of the Former Soviet Union in 1991 are shown in Figure 7. The level of investments in West Siberia is close to the average investment for Russia.

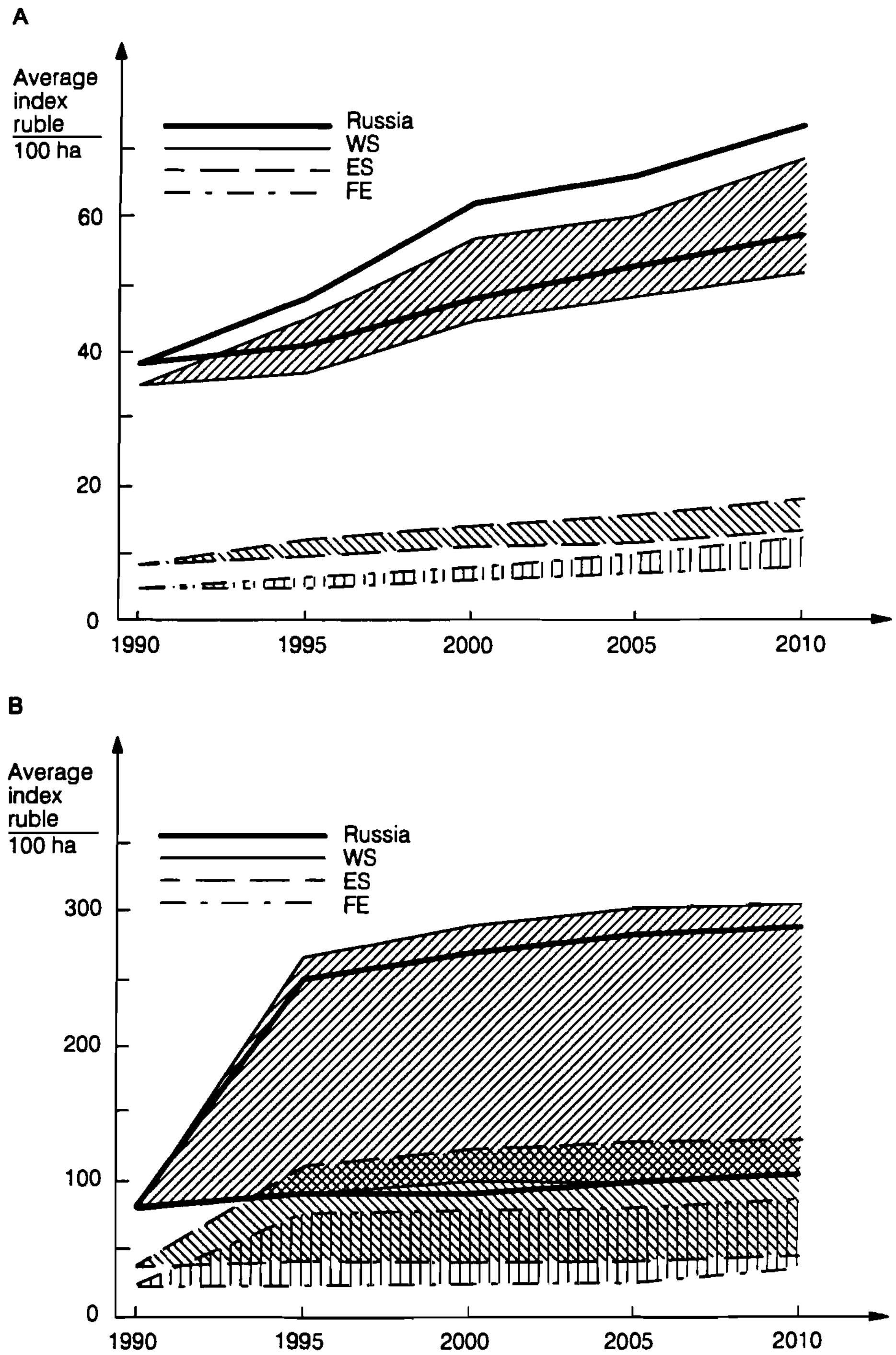

Figure 7. Estimate on future investments (A) and operational expenditures (B) in forest management in Siberia (costs are in 1989 rubles). (Isaev, 1991b)

The lower level of the projections is based on extrapolation of existing trends in timber harvests and renewal of timber resources which are conditioned by limited investments. The higher level of the projections assumes retaining the same tree species, providing sufficient financial support for reforestation of non-forested areas, improvement of stand quality, and increased forest productivity. The average yearly investments by the end of the period was 198 mln rubles for the lower level, and 305 mln rubles for the higher level. The largest real increase in investments in all projections is expected in West Siberia.

Table 32 shows the capital requirements for each region in 1990. The main share (73%) of the investments are in industrial buildings and transmission equipment, which all have a low depreciation rate.

Present forestry enterprises have less than 30% of the assets needed. In spite of this, the available assets in the forest enterprises are currently not used effectively. The major reasons for this are: the assets are old, lack of repair facilities, inadequate and poor quality of the road network and lack of proper incentives.

Table 32. Major asset requirements,in mln rubles. (Isaev, 1991b)

Region	Major assets						
	Total	For ground control	Categories				
			buildings, transmission equipment	machinery and equipment	transport	tools, implements, stock	others
West Siberia	198.1	29.6	146.2	28.4	12.8	4.5	6.2
East Siberia	234.1	37.2	161.3	32.7	17.7	9.7	12.7
Far East	256.5	43.5	195.5	25.7	17.2	4.9	13.2
Total	688.7	110.3	503.0	86.8	47.7	19.1	32.1

Evidently, the existing levels of investments and current operating budgets are not enough even for the renewal of forest resources in Siberia and the Far East. The eventual result seems to be increased prices of forest products as they become more scarce and due to replacement and required investments in equipment.

The level of investment per person employed in silviculture is less than 20% of the average investment per person in all other industries. The problem is exacerbated by the fact that production of goods and services in forest enterprises requires higher initial investment than in many other branches in the national economy. The investments in forestry are unique due to multi-purpose function, forestry work is of seasonal nature, the biophysical conditions vary widely, and forest equipment is highly specialized.

At the present there are intentions (a technical rearmament) in forest enterprises to replace old machinery and equipment with new. But unfortunately, in reality, no technological improvement is taking place. The majority of forest enterprises in Siberia and the Far East are characterized by extremely poor machinery and equipment, which is one of the reasons for the unsatisfactory quality of silviculture and losses of forest resources.

Most of the investments in the forest enterprises are allocated to forest felling, forest transportation equipment, wood manufacturing, and equipment for log landings (storing, bucking, unloading).

The operational expenditures for forest management in Siberia and the Far East have the same features as for the investments. They are the lowest in Russia. In 1990 (the planned operational expenditures/100 ha of Forest Area) were in West Siberia - 76 rubles, in East Siberia - 35 rubles, in the Far East - 21 rubles. The average operational expenditures for Russia were 80 rubles, and in Central-Chernozemny region - 1529 rubles. This disparity indicates insufficient expenditures in silviculture in Siberia. It also indicates the structure of expenditures for forest regeneration. For example, in the Far East and East Siberia the share of aerial forest control is up to 50% of operational expenditures, the share for silviculture is only about 15%. The expenditures for reforestation are only 9.5% in the Far East and 10.5% in East Siberia. In the Central- Chernozemny region reforestation expenditures are up to 31% of the operational expenditures. The consequence is low quality reforestation and poor plantation maintenance in Siberia.

An estimate of the distribution of the operational expenditures on forest management activities up to the year 2010 is presented in Table 33.

Table 33. Estimate of the distribution of operational expenditures on forest management activities up to the year 2010 in percentage. (Isaev, 1991b).

Region	Expenditures in total	Silviculture	Reforestation projects	Control and protection of forest	Others
West Siberia	100	17	11	32	40
East Siberia	100	11	8	36	45
Far East	100	18	8	49	25
Total	100	16	9	39	36

10. CONCLUSION

The Siberian Forestry has the following major features:

POLICIES

- *Forest legislation.* In the middle of 1993 the Russian Federal forest legislation was approved, although the problem of property rights concerning the forests were not clearly determined.
- *State control.* The public agencies responsible for the management of forests have experienced a continued weakness of their control resulting in a local over-exploitation of the forest resources.
- *Rights and responsibilities.* Current laws in Russia create uncertainties in the relationship between the forest harvesting enterprises and the forest enterprises. This does not provide a sound basis for the required silvicultural expenditures.
- *Currency instability.* An extremely low value of the rouble creates difficulties in generation of investments in the manufacturing sector and in the forest themselves.
- *Human migration.* Skilled workers and families are moving out of northern regions as a result of insufficient social conditions and inadequate policy of the labor renumeration.

FORESTS

- *Low productivity.* More than 2/3 of the region is occupied by stands of low productivity. About 50% of the region has a stock of 50 to 100 m^3/ha. The remaining proportion has less than 50 m^3/ha.

- *Fire losses.* Annually, large areas of forest are lost due to inefficient fire control measures.
- *General sanitary state.* Large territories have an insufficient sanitary state due to attacks by insects and diseases, unecological final harvesting, air pollution, etc.
- *Species change.* The employment of the clearcut harvesting method combined with fire losses is changing up to 50% of the post fire areas and clear cutting areas from coniferous to soft deciduous species. Without significant silvicultural intervention the change to less desirable species will increase.
- *Silviculture.* The silvicultural measures are currently not adequate resulting in an inefficient forest renewal program.
- *Utilization.* The highgrading of timber resources is widespread.
- *Research.* There is little or no application of research findings in the operational forestry
- *Harvesting areas.* There is a significant increase in the rate of harvesting areas in remote regions.
- *General dynamics.* The forest resources are deteriorating slowly but significantly in Siberia. Generally, the development of the Siberian forests cannot be considered as sustainable.

EXPLOITATION

- *Transportation network.* The forests of Siberia have a poorly developed transportation network; and the existing network is badly maintained.
- *Harvesting pattern.* Overcutting of tirnber has occurred along the main railway transportation routes and close to the manufacturing centers.
- *Markets.* Siberian forest products are far from markets and not easily distributed to the markets by existing transportation networks.
- *Utilization.* There are serious losses of wood in the transportation from the stump to the consumers.

WOODWORKING INDUSTRY

- *Timber utilization.* The lumber recovery factor is often very low in sawmills.
- *Facilities.* There is a lack of small manufacturing plants capable of processing low

quality, small sized, and deciduous timber.

- *Products.* Only a small proportion of manufacturing output is high value-added products.
- *Maintenance.* Plants often lack the necessary equipment and spare parts for repair and maintenance.
- *Revenue.* The governmental revenue generated by taxes in the industry are not allocated back to forestry.

LABOR

- *Working conditions.* Salaries are very low providing little compensation for hardship.
- *Professional development.* Generally very little effort is made to improve the skills of the workforce.
- *Stability.* The community infrastructure is poorly developed thereby providing unstable working conditions.

The key issue in Siberian forestry is to establish a sustainable form of management and development of the forest resources from an ecological, economic and social point of view.

REFERENCES

Ageenko, A.S. (ed), 1969, Forests of the Far East. Lesnaja promishlenhost publ., Moscow, 390 pp. (in Russian).

Backman, Charles A. and Waggener, Thomas R., 1991. Soviet Timber Resources and Utilization: An Interpretation of the 1988 National Inventory. Working Paper 35, CINTRAFOR, University of Washington, Seattle, WA.

Busikin, A.J. (ed), 1977, Forests of the middle Angara region. Nauna publ., Novosibirsk, 263 pp. (in Russian).

Bugajev, V.A., Kosarev, N.G., 1988, Forestry in the strip pine stands of Altaj kray. Altaj book publication, Barnaul, 312 pp. (in Russian).

Cejka, R., 1992, Vom Kahlschlag Getroffen, Ein Bericht aus der Taiga. Öko-Test-Magazin 7/92.

Falaleev, E.N., Smolianov, A.S., Golikova, A.V., 1985. The State of the Harvested Wood Utilization in Siberia. In "Up to date problems of the Siberian forest combines". Siberian Division of the USSR Academy of Sciences, Krasnoyarsk, pp. 55-60 (In Russian).

Feshbach, M. and Friendly, A., 1992, Ecocide in the USSR. Basic Books, Aurum Press, United Kingdom.

Forest Committee of the Ministry of Ecology and Natural Resources of Russian Federation, 1992, Sanitary state of the Russian forests. All-Russia Information and Research Center for Forest Resources, Moscow (in Russian).

Goskomles SSSR, 1989, Dynamics of Forests under State Forest Management by Main Species in 1966-1988 (Excluding the Long-Term Forest Leases). 1989, State Forestry Committee of the USSR, Moscow, 160 pp. (in Russian).

Goskomles SSSR, 1990 (v.1) and 1991 (v.2), Forest Fund of the USSR. State Forestry Committee of the USSR, Moscow, V.1: 1006 pp., V.2:1021 pp. (in Russian).

Goskomstat SSSR, 1990, Forest Management in the USSR. The USSR State on Statistics, Moscow, 135 pp. (in Russian)

Gusewelle, C.W., 1992, World Forests, Siberia on the Brink. American Forest May/June 1992.

Isaev, A.S. (ed.), 1991a, Forestry at the boundary of the XXI century. Ecology, Moscow, 333 pp. (in Russian).

Isaev, A.S. (ed.), 1991b, Forecast of the utilization and reproduction of the forest resources by economic regions of the USSR. Academy of Sciences of the USSR and State Forestry Committee of the USSR, Vol. 1; 508pp, Vol. 2; 509-994 pp. (in Russian).

Kashtanov, A.N. (ed.), 1983, Natural and agricultural division and utilization of the USSR land fund. "Kolos" publication, Moscow, 336 pp. (in Russian).

Knight, R., 1992, Northern Exposure, The bills are due for 30 years of Communist exploitation. U.S. News & World Report, March 30, 1992.

Kolchugina, T.P., Shvidenko, A.Z., Vinson, T.S., Dixon, R.R., Kobak, K.I., Botch, M.S., 1992, Carbon balance of forest biomes in the former Soviet Union. Paper presented at the IPCC AFOS Workshop 11-15 May 1992, Univ. of Joensuu, Finland.

Kolesnikov, B.P., 1955, Review of the Far East vegetations. Khabarovsk, 104 pp. (in Russian).

Kolesnikov, B.P., 1969, Forest management provinces of the USSR taiga zone and system of the forestry in the long-term forecast framework. In: "Information report of the all-around taiga territories development". Scientific Council, N2, Irkutsk, pp. 3-39 (in Russian).

Korjakin, V.N., 1990. Reference book for the inventory of the Far Eastern forests. The Far East Forest Institute, Khabarovsk, 526 pp. (in Russian).

Kovalev, R.V., 1988, Biological resources of Siberia. Siberian Division of the USSR Academy of Sciences, Novosibirsk, 334 pp. (In Russian).

Krilov, G.V., Talanzev, N.K., Kosakova, N.F., 1983, Cedar. Lesnaja promishlemnnost, Moscow, 216 pp. (in Russian).

Kurnaev, S.F., 1973, Forest vegetational regionalization of the USSR. Nauka publishing, Moscow, 202 pp. (in Russian).

Lavrenko, E.M., 1950, Basic features of botanical and geographical regionalization of the USSR and adjacent countries, In: "Botanical problems". The USSR Academy of Sciences, Moscow-Leningrad (in Russian).

Lebedev, A.V., Gorbatenko, V.N., Krasnoshekov, Yu. N., Reshetkova, N.B., and Protopopov, V.V., 1979, Environmental role of the Bajkal basin forests. Nauka publishing, Novosibirsk, 256 pp. (in Russian).

Lebkov, V.F., 1967, Implementation of forest management in mountain forests of southern Siberia. Krasnoyarsk Book Publication, Krasnoyarsk, 288 pp. (in Russian).

Manko, J.I., and V.P. Voroshilov, 1978. Spruce forests in Kamtschatka. Nauka Publ., Moscow, 256 p. (in Russian).

Ministry of Ecology and Natural Resources of the Russian Federation, 1992, State Report about State of Environment of Russian Federation. Moscow (in Russian).

Nilsson, S. and Isaev, A., 1992, Forest Resources, Environment and Socio-Economic Development of Siberia, A research proposal. IIASA, Laxenburg, Austria, unpublished manuscript, 50 pp.

Nilsson, S., Sallnäs, O., Hugosson, M. and A. Shvidenko, 1992. Forest Resources of the Former European USSR. Parthenon Publishing Ltd., Lancs. UK., 407 pp.

Panarin, J.J., 1977, Forests of Chita Bajkal coast. Nauka publication, Novosibirsk, 232 pp. (in

Russian).

Petrenko, E.S. (ed.), 1990, Forest complex of Siberia. Institute of Forest and Wood, Siberian Division, Russian Academy of Sciences, Krasnoyarsk, 125 pp. (in Russian).

Pisarenko, A.I., G.I. Redko, and M.D. Merslenko, 1992. Artificial forests. Forest Committee of Russian Federation, Moscow, Vol. 1, 307 pp. (in Russian).

Polikarpov, N.P., Chebakova, N.M., and Nasimova, D.I., 1986, Climate and mountain forests of South Siberia. Nauka publication, Novosibirsk, 225 pp. (in Russian).

Popov, L.V., 1969, Forest Management Division of the Middle Siberia. In: "Information report fo the all-around taiga territories". Development Scientific Council, No.2, Irkutsk, pp. 74-82 (in Russian).

Posdpjakov, L.K., 1986, Forestry in frozen ground areas. Nauka publication, Novosibirsk, pp. 192, (in Russian).

Protopopov, V.V., 1975, The environmental impact of dark coniferous forests. Nauka publication, Novosibirsk, 328 pp. (in Russian).

Russian Forest Committee, 1992, Review of sanitary state of the Russian forests in 1991, 1992. Russian Forest Committee, Moscow, 41 pp. (in Russian).

Rosencrantz, A. and Scott, A. 1992, Siberia's threatened forests. Nature, **355**:293-294, Jan. 22, 1992.

Sagreev, V.V., Sukhikh, V.I., Shvidenko, A.Z., Gusev, N.N. and Moshkalev, A.G. 1992, All-Union standards and normatives for the forest inventory. Kolos publication, Moscow, 495 pp. (in Russian).

Semetchkin, J.V., Polikarpov, N.P., and Iroshnikov, A.J., 1985, Cedar forests of Siberia. Nauna publication, Novosibirsk, 257 pp. (in Russian).

Sheingauz, A.S., 1989, Forest Resources of the Far Eastern economic regions: state, utilization, reproduction. Far Eastern Forestry Institute, 41 pp. (in Russian).

Sheingauz, A.S., Dorofeeva, A.A., Efremov, D.F., and Sapojnikov, A.P., 1980, Complex forest management regionalization. Far East Book Publication, Vladivostok, 141 pp. (in Russian).

Sheingauz, A.S., Dorofeeva, A.A. Efromov, D.F., Sapojnikov, A.P., and Chibukova L.L., 1985, Forest vegetational regionalization of the Far East. Far Eastern Forestry Institute, Khabarovsk, 47 pp., (in Russian).

Sherbakov, J.P., 1975, Forest cover of the USSR North-East. Nauka publication, Novosibirksk, 344 pp. (in Russian).

Shvidenko, A., Nilsson, S. and Roshkov, V. 1994a, New estimates on the impacts of the Siberian forests on the carbon cycle. (In press).

Shvidenko, A., Roshkov, V., and Nilsson, S., 1994b, Possibilities to increase a carbon sequestration by rational forest management in the territories of the Former Soviet Union. (In press).

Smagin, V.N., and Polikarpov, N.P., 1976, Forest management districts and types of forests of the BAM zone. Institute of Wood and Timber, Siberian Division of the Russian Academy of Sciences, Krasnoyarsk, 63 pp. (in Russian).

Smagin, V.N., and Ilinskaja, S.A., 1977, Forest-vegetational regionalization of Siberia. In: "First All-Union meeting on problems of the USSR Forest Fund division into districts". Institute of Wood and Timber, Siberian Division of the Russian Academy of Sciences, Krasnoyarsk, pp. 8-11 (in Russian).

Smagin, V.N., Semechkin, J.V., Polikarpov, N.P., Tetenkin, A.E., and Busikin, A.I., 1978, Forest Management Regionalization of Siberia. In: "Forest vegetational resources of Siberia", Institute of Wood and Timber, Siberian Division of the Russian Academy of Sciences, Krasnoyarks, pp 5-23. (in Russian).

Sochava, V.B., 1953, Vegetation of forest zone. In: "The animal world of the USSR, Vol.4", The Russian Academy of Sciences, Moscow (in Russian).

Stanglin, D., 1992, Toxic Wasteland. U.S. News & World Report, April 13, 1992.

Starikov, G.F., 1958, Forests of Magadan region. Magadan publication, Magadan, pp. 176, (in Russian).

State Forestry Committee, 1990, State program for reforestation (project). 1990, State Forestry Committee of the USSR, Moscow, 188 pp. (in Russian).

Timofeev, N.V. (ed.), 1967, Forests – a national resource of the Soviet people. Lesnaja promishlennos, Moscow, 311 pp. (in Russian).

VNILM "Application of the modern scientific achievements for the Forest Fund regionalization". 1978, VNIILM, Pushkino, 7 pp. (in Russian).

WWF, 1992, Forests in Trouble. WWF International, Gland, Switzerland.

Zvetkov, P.A., and Ivanova, V.V., 1985, Estimation of clear cutting woody slash caused by the aggregate harvesting equipment. In: "Forest Fire and consequences of them". Krasnoyarsk, Forestry Institute of the Siberian Division of the Russian Academy of Sciences, pp. 124-132. (in Russian).

APPENDIX I

MAPS OF FOREST MANAGEMENT REGIONALIZATION OF SIBERIA AND THE FAR EAST AND CORRESPONDING HIERARCHICAL UNITS

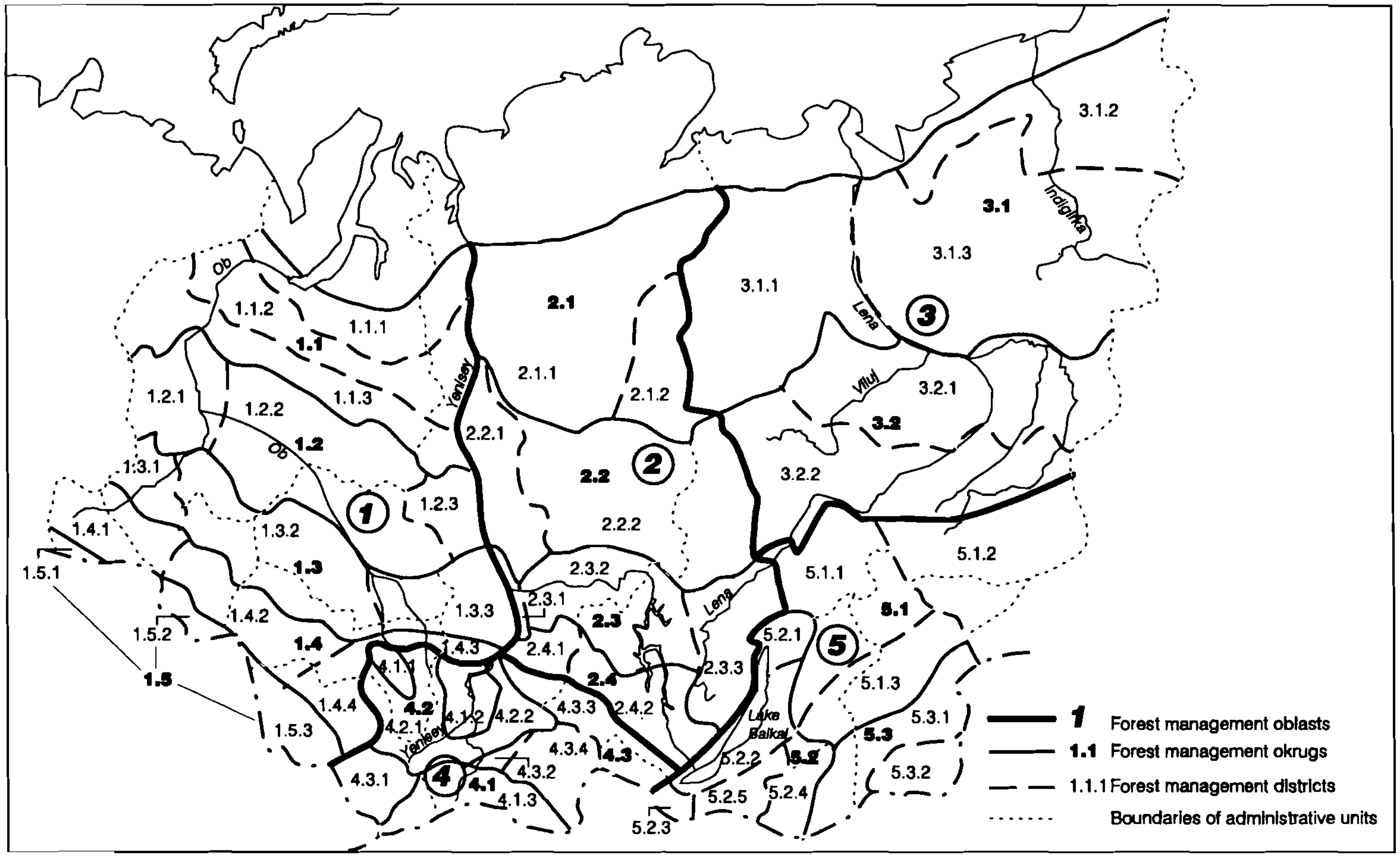

Figure A-1. Regions of West and East Siberia.

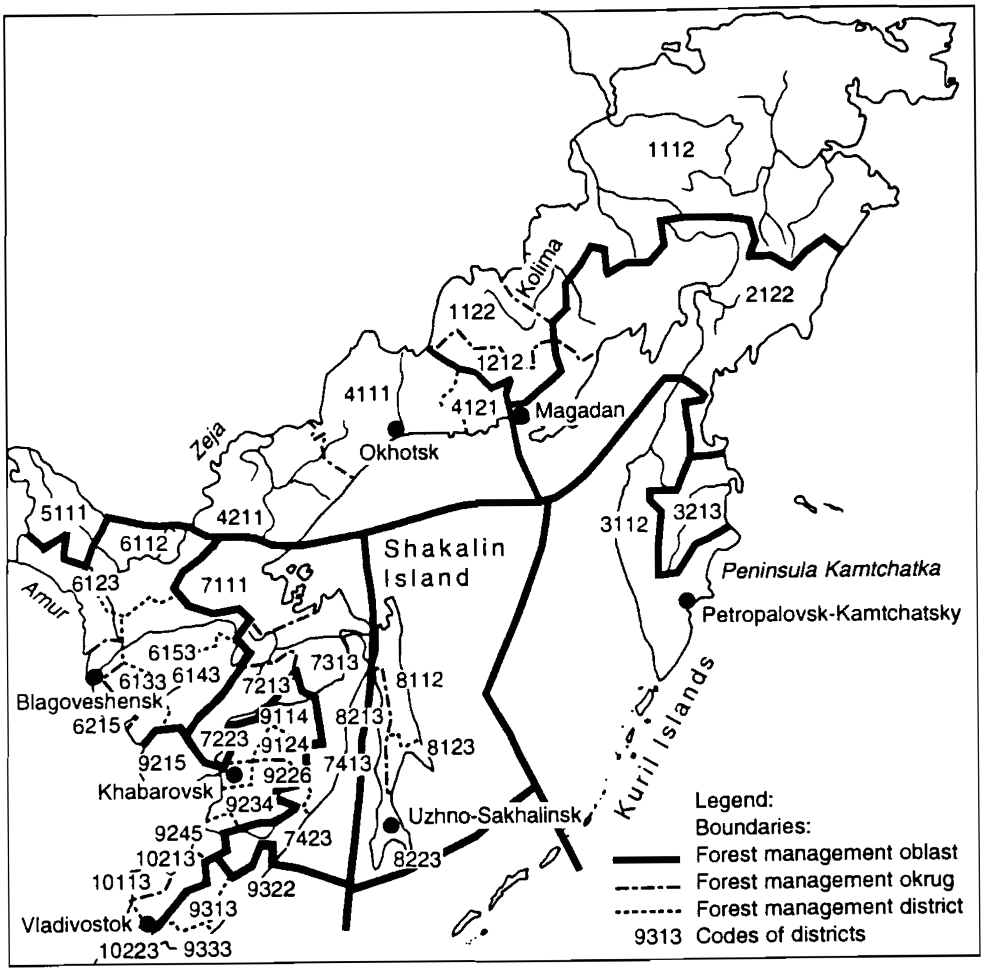

Figure A-2. Regions of the Far East.

Forest Management Regionalisation

A1. Forest Management Regionalisation of East & West Siberia (including Republic Sakha - Jakutia). Abbreviation see the end of the appendix

Source: Smagin et.al. 1978

Oblasts and okrugs (group of districts)	Districts	Basic forest assosiations	Short descriptions by okrugs
1 (WS) West Siberia plain oblast			
1.1 Northern taiga forest and sparse forest okrug (O)	1.1.1 Forest tundra frozen 1.1.2 Northern taiga frozen 1.1.3 Northern taiga	S-L forest tundra sparse forests L and dark coniferous (S,C) frozen partial marshy forests P partial marshy forests	PFC 25-30%, heavily marshy S,C,P and L forests, Bon V-Va, AGS 50-100m3/ha, H 0.1 m3/ha,
1.2 Middle taiga O	1.2.1 Zauralsk 1.2.2 Central 1.2.3 Priyeniseisk	P,S-C, WB partial marshy forests Dark coniferous (C,S), and P,WB heavily partial marshy forests P,dark coniferous (C,S) and B partial marshy forests	PFC 40-50%, heavily marshy lands,P,WB,S-C forests, Bon IV-V, AGS 100-150 m3/ha, H 0.3m3/ha
1.3 Southern taiga O	1.3.1 Zauralsk	WB,P and dark coniferous partial marshy forests	PFC 45-55%,heavily partial marshy lands,

2.3 O of southern taiga and mountain taiga forests	2.3.1 Yenisey mountain 2.3.2 Priangara plateau 2.3.3 Verkhne-Lena plateau	Mountain taiga and subtaiga DC and P forests Southern taiga P, L, and soft decidious forests with dark coniferous areas P and L subtaiga forests and S-F-C mountain taiga forests	PFC 80-85%, P and L forests, Bon III(II-IV), AGS 200-250 m3/ha, in mountain west and east parts - C-S-F forests, Bon IV, AGS 150-200 m3/ha , H 1.0 m3/ha
2.4 Subtaiga-forest steppe O	2.4.1 Krasnojarsk-Kansk 2.4.2 Tuluno-Irkutsk	Subtaiga and forest steppe P and WB forests Subtaiga and forest steppe P,WB, and L forests	PFC 60-65%, P,B, and L forests, Bon II-IV, AGS 150-200 m3/ha, H 2.1 m3/ha
3 (ES) East Siberia mountain-plain frozen oblast			
3.1 O of sparse forests and northern taiga forests	3.1.1 Oleneksk plateau 3.1.2 Indigirka-Kolima plain 3.1.3 Jana mountain	Northern taiga F and sparse forests Forest tundra and north taiga L forests and sparse forests Sub-alpine-taiga dwarf-L forests and sparse forests	PFC 20-40%, L forests, Bon V-Va in mountain, Bon IV-V on plateau, AGS 50-100m3/ha, in northern part less than 50 m3/ha, large areas covered by Dwarf P, H less than 0.1m3/ha
3.2 Middle taiga O	3.2.1 Central Jakutia plain 3.2.2 Sredne-Lena plateau	"Alas" - middle taiga L forests L forsts with areas of P, simetimes C northern taiga forests	PFC 55-85%, L and P (less) forests, AGS 100-150 m3/ha, in southern-west part 150-200 m3/ha, Bon IV-V, H 0.1 m3/ha

	1.3.2 Central	WB,P, and dark coniferous heavily partial marshy forests	WB,P, and C-S forests, Bon 111-V, AGS 100-150m3/ha, H 1.0 m3/ha
	1.3.3 Priyeniseisk	Dark coniferous (C-S-F), P and partial marshy forests	
1.4 Forest steppe O	1.4.1 Pritobolsk	"Island" dry P and WB forests in steppe, subtaiga P and WB forests	PFC 10-20%,P and WB forests, Bon 11-111, AGS 100-150 m3/ha, H 1.4 m3/ha
	1.4.2 Barabinsk	"Island" WB and As forests	
	1.4.3 Achinsk-Mariininsk	WB,P,F, and As taiga-forest steppe forests	
	1.4.4 Verkhne-Ob	Tract and band dry P forests	
1.5 Steppe O	1.5.1 Pritobol	"Island" soft leaves forests in dry steppe	PFC 1-5%, in areas of band dry P forests about 50%, P,WB and As forests, Bon II-III, AGS 50-100 m3/ha, H 0.5 m3/ha
	1.5.2 Irtish	The same	
	1.5.3 Kulundinsk	Band dry P forests in dry steppe	
2 (MS) Middle Siberia plateau oblast			
2.1 Sparse taiga and taiga frozen O	2.1.1 Putoran mountain	Subtundra and forest tundra S-L forests and L sparse forests	PFC 30-40%, L and north (less) S forests, Bon V-Va, on permafrost, AGS 50 m3/ha, in south 50-100 m3/ha, H less than 0.1 m3/ha
	2.1.2 Kotuisk	Northern taiga L, F and sparse forests	
2.2 Middle taiga O	2.2.1 Zayenisesk	Dark coniferous (S,C,F) and L forests	PFC 60-70%, L and P, in west part S and C forests, Bon IV-V, AGS 100-120 m3/ha, H 0.1 m3/ha
	2.2.2 Tungus frozen	L forests with P and S areas	

4 (A-S) Altaj-Sajan mountain oblast

4.1 Mountain forest steppe O	4.1.1 Kuznetsk	Subtaiga-forest steppe WP,B, As, and F forests	PFC 5-25%, P, L, WB forests, in 4.1.3-L and C, Bon: for P II-III, for L III-IV, for L and C in Tuva V-IV, AGS 100-150m3/ha, H 0.1-0.2 m3/ha
	4.1.2 Khakassk-Minusinsk	Subtaiga-forest steppe P,WB, L, and taiga L and F-C forests	
	4.1.3 Altaj-Tuva	Subtaiga-forest steppe, mountain taiga and sub-alpine taiga L and C in dry mountain steppe	
4.2 Mountain blacken ("chernevoj") O	4.2.1 Telezk-Kuznetsk	Blacken, mountain taiga and sub-alpine DC (F,C) forests and subtaiga-forest steppe P and L forests	PFC 60-80%, F and C forests,Bon III-II, sometimes I or IV, AGS 150-200 m3/ha, H 0.7-0.8 m3/ha
	4.2.2 Sajan	Taiga blacken, mountain taiga and sub-alpine C and F forests	
4.3 Mountain taiga O	4.3.1 Altaj	Mountain taiga and sub-alpine L and C forests with areas of F, subtaiga forst steppe L forests of intermountain depressions	PFC 50-75%,C,L,rarely P and F, forests, Bon III-IV, AGS 150-200 m3/ha, in eastern part 100-150 m3/ha, H from 0.7-0.8 m3/ha in East Sajan, Irkutsk, Krasnojarsk up to 0.1-0.3 m3/ha in Tuva, South Altaj
	4.3.2 West Sajan	Mountain taiga and sub-alpine taiga C and L forests, subtaiga -forest steppe I forests of intermountain depressions	
	4.3.3 East Sajan	Mountain taiga and sub-alpine C and L forests with areas of taiga blacken C-F forests and subtaiga-forest steppe L and P forest	
	4.3.4 Todga	Mountain taiga, sub-alpine taiga C and L forests with areas of P forests	

5.3 South-Zabaikalsk O	5.3.1 Daursk mountain taiga	Mountain taiga and subtaiga-forest steppe L forests with areas P and WB forests	PFC 50-70%, in southern part 5-10%, L and P forests, Bon IV-V, rarely III,AGS 100-150 m3/ha, in east part 50-100 m3/ha, H 0.3-1.0 m3/ha
	5.3.2 Daursk steppe	Mountain-"island" L,WB and P forests	

A2. Forest management regionalisation of the Far East

Source: Sheingauz et.al. 1980

Forest management oblast (Ob), okrug (O) and district (D)			Charakteristics of units of regionalisation PFC	Average SC	AGS m3/ha	Bon	H m3/ha
1000		Kolima - Chukotka Ob	22	7L 3DP	31	1V,6	0.02
1100		Kolima-Anadir O	21	7L 3DP	32	1V,6	0.01
	1110	Anadir D	20	7L 3DP	33	1V,5	0.09
	1120	Verkhne Kolima D	23	7L 3DP	24	1V,8	0.02
1200	1210	Tenkinsky O and D	32	6L 4DP	25	1V,7	0.05
2000	2100	Gizhiginsk-Koriak Ob and O	32	6DP 3L 1SB + Pp	33	1V,4	0.02
	2110	Magadan D	29	5DP 4L 1P	37	1V,3	0.04
	2120	Koriak D	34	7DP 2SB 1L + Pp	31	1V,5	0.004

5 (ZMF) Zabaikalsk mountain frozen oblast			
5.1 North Zabaikalsk O	5.1.1 North Zabaikalsk	Mountain taiga and sub-alpine taiga L and Dwarf P forests and sparse forests with areas of subtaiga P forests	PFC 40-60%,L forests, in western part Bon IV, in eastern V-Va, AGS, respectively, 100-150 and 50-100 m3/ha, H less than 0.1, in BAM zone near 0.2 m3/ha
	5.1.2 Verkhne Aldan	Mountain taiga and sub-alpine L forests with areas Dwarf P, P and S forests	
	5.1.3 Verkhne-Vitim-Olekminsk	Mountain taiga and sub-alpine taiga L and Dwarf P forests	
5.2 Baikalsk	5.2.1 North-Pribaikalsk	Mountain taiga and sub-alpine-L and Dwarf P forests and sparse with areas of subtaiga P forests	PFC 40-75%, L, P, and DC (C,F,S) forests, Bon IV-V,rarely III, AGS 100-150 m3/ha, H 0.5 m3/ha
	5.2.2 South-Pribaikalsk	Mountain taiga, blacken and sub-alpine-taiga DC (C,F) forests with areas Dwarf P and L forests, and subtaiga-forest steppe P and WB forests	
	5.2.3 Dgidginsk mountain taiga	Mountain taiga and sub-alpine-taiga L, C, and WB forests, and subtaiga-forest steppe L,WB, and P forests	
	5.2.4 Chikoi mountain taiga	Mountain taiga and sub-alpine-taiga L and C, subtaiga-forst steppe L, P, and WB forests	
	5.2.5 Selenga pinewood-forest steppe	Subtaiga-forest steppe and taiga P,L, and WB forests	

3000		Kamchatka Ob	47	6SB 1S 1L 1WB 1DP	72	1V,3	0.08
3100	3111	Kamchatka-Pribrezhny O and D	43	8SB 2DP + WB	61	1V,5	0.02
3200	3211	Central Kamchatka O and D	54	4SB 3L 1DP 1S 1WB	93	1V,1	0.2
4000		Djugdjur Ob	36	8L 1DP 1S + Pp,P	46	1V,1	0.02
4100		Jana-Okhotsk O	22	7L 3DP + Pp,W	41	1V,2	0.03
	4110	Okhotsk D	18	6L 4DP	39	1V,1	0.03
	4120	Tauisk D	39	7L 3DP + Pp	49	1V,5	0.03
4200	4210	Ajansk O and D	51	9L 1S + DP	52	1V,0	0.004
5000	5100	Stanovoi Ob,	66	9L 1WB + P,DP	85	14,0	0.02
	5110	O and D					
6000		Sredne Amur Ob	63	7L 2WB 1S + P	99	111,9	0.4
6100		Amur-Zeja O	63	7L 2WB 1S + P,C,As	101	111,9	0.4
	6111	Zeja-Selemdga D	63	9L 1WB + S,P	104	1V,0	0.1
	6122	Tigdinsk D	75	7L 2WB 1P + O	63	111,9	0.6
	6132	Belogorsk	44	5L 3WB 1S 1F + O,As,Lm	80	111,7	0.2
	6142	Urgal D	69	7L 2S 1WB +As,DP	123	111,8	1.1
	6152	Obluchensk D	67	2S 2C 1L 1Lm 1F 1SB 1WB 1O	124	111,7	0.3
6200	6213	Zeja-Bureja	33	4O 3L 2WB 1P + SB	33	1V,3	0.06
		O and D					
7000		Amur-Sikhote-Alin Ob	69	5S 4L 1C + WB,SB	148	111,9	0.3
7100	7110	Chumikan O and D	60	8L 2S + DP	111	111,9	0.003

7200		Badjalsky O	67	5L 3S 1C 1WB	136	111,8	0.3
	7211	Amgun D	70	6L 3S 1WB	133	111,9	0.2
	7222	Kur-Urmy D	59	3L 3S 2C 1WB 1SB + O	143	111,7	0.5
7300	7312	Nizhne- Amur O and D	67	5L 5S + WB	68	111,9	0.4
7400		Sredne-Sikhote-Alin O	78	5S 2L 2C 1SB + E,F	175	111,8	0.3
	7411	Sovgavansky D	68	6S 4L + F,WB	175	111,7	0.4
	7421	Sukpaj D	81	7S 1L 1C !SB + F,WB	173	111,6	0.1
	7431	Samarga-Bikin D	87	4S 3C 2L 1WB + F,O,E,YB	176	111,8	0.3
8000		Sakhalin Ob	59	4S 3L 2F 1SB + DP	143	1V,1	0.9
8100		Tim-Poronai O	56	5S 4L 1F +SB,DP	146	1V.1	0.9
	8112	North-Sakhalin D	56	5S 4L 1SB + DP,F, WB	145	1V.1	0.7
	8123	Poronai D	55	6S 2F 1L 1SB	149	1V.1	1.7
8200		Tatarsko-Anivsky O	67	4F 4S 1L 1SB	138	1V.1	0.7
	8213	West-Sakhalin D	71	6S 2F 1L 1SB	163	1V.1	1.3
	8223	South-Sakhalin D	62	7F 2SB 1S	113	1V.0	0.2
9000		Primorsko-Ussuriisk Ob	70	3C 3S 2F 1O 1L + SB,WB	159	111.8	0.8
9100	9112	Komsomolsk O and D	58	4S 2L 2C 1SB 1WB + F, F,As	171	111.8	0.7
9200		Bidjan-Ussuriisk O	65	4C 1S 1SB 1O 1Lm 1Ash 1L +WB,F,As,W	150	111.7	0.7
	9212	Octjabrsk D	38	2C 2O 1Lm 1S 1As 1L	112	111.8	1.2

			1WB 1SB			
9223	Birobidjan D	22	3O 1C 1As 1S 1WB 1F 1A 1SB + Lm	104	111.6	0.08
9234	Khabarovsk D	59	3F 2As 1C 1SB 1S 1L 1O + WB,Ash,Lm	108	111.3	0
9242	Nizhne-Ussuriisk D	75	4C 2S 2SB 1Ash 1Lm + F, L, O,E,WB	166	111,7	1.1
9253	Dalnerechensk D	80	5C 1O 1S 1SB 1L 1Ash + Lm,As,WB	165	111.8	0.7
9300	South-Sikhote-Alin O	84	4C 3S 1O 1WB 1SB + L,F,Ash,Lm	158	111,8	0.8
9313	Verkhne-Ussuriisk D	87	4C 3S 1SB 1O 1Lm + Ash,WB	183	111.9	1.4
9322	Olginsky D	86	3C 2S 3O 1L 1WB	135	111.7	0.2
9333	Nakhodka D	77	3O 2S 2C 1Lm 1WB 1SB	120	111.9	0.1
10000	Khasan-Khankai Ob	45	3O 3C 2L 1Ash 1S + WB,SB,As,F	109	111.8	0.2
10100 10113	Khankai O and D	42	8O 1As 1C + F, WB	54	1V.0	0
10200	Ussuri-Razdolnensk O	45	3C 3O 2Lm 1S 1Ash + SB,F,WB	121	111.8	0.3
10213	Spassk D	47	3C 2Lm 2O 1Ash 1S 1SB + WB	157	111.8	0.7
10223	Khasan D	44	6O 1C 1Lm 1F 1SB + S,L,WB,Ash	94	111.8	0
10234	Vladivostok D	43	6O 2Lm 1Ash 1F + WB	130	111.8	0
11000 11100 11111	South Kuril Ob, O and D	48	5SB 2F 2S 1DP	81	111.8	0.002

Note:

1.C - cedar (Pinus sibirica, Pinus korejansis), P - pine (Pinus silvestris),
S - spruce (Picea sp.), F - fir (Abies sp.), DP - dwarf pine (Pinus pumila), L - larch (Larix sp.), O - oak, As - aspen, Lm - lime-tree, SB - stone birch (Betula Ermani), WB - white birches, W - willow (Salix sp.), DC - dark coniferous (S,F,C) forests

2. PFC - Percentage of forest cover (ratio forested areas to total area of land)

3. AGS - average growing stock (m3/ha)

4. SC - species composition (f.e. 7L 3DP means that 70% of growing stock (GS) is in stands in wich larch is a dominated species, and 30% - stands with dwarf pine ; sign + means that growing stock of a species is between 2 and 5 %

5. H - harvested volume (m3/ha.year)

6. Bon - site index