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

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Professor Lakida is with the Ukrainian State Agricultural University in Kiev; Professors Nilsson and Shvidenko are from the International Institute for Applied Systems Analysis, Laxenburg, Austria.

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Foreword

Siberia's forest sector has recently gained considerable international interest. IIASA, the Russian Academy of Sciences, and the Russian Federal Forest Service, in agreement with the Russian Ministry of the Environment and Natural Resources, signed agreements in 1992 and 1994 to carry out a large-scale study on the Siberian forest sector. The overall objective of the study is to focus on policy options that would encourage sustainable development of the sector. The goals are to assess Siberia's forest resources, forest industries, and infrastructure; to examine the forests' economic, social, and biospheric functions; with these functions in mind, to identify possible pathways for their sustainable development; and to translate these pathways into policy options for Russian and international agencies.

The first phase of the study concentrated on the generation of extensive and consistent databases for the total forest sector of Siberia and Russia. The study is now moving into its second phase, which will encompass assessment studies of the greenhouse gas balances, forest resources and forest utilization, biodiversity and landscapes, non-wood products and functions, environmental status, transportation infrastructure, forest industry and markets, and socio-economic problems. This report, by Dr. Lakida from the Ukrainian State Agricultural University in Kiev and Professors Nilsson and Shvidenko from the study's core team, is a contribution to the analyses of the topic of greenhouse gas balances. The reason for studying the phytomass characteristics for the investigated region is that limited information is available on the phytomass fractions for Siberia.

1. Introduction and Objectives

During the last 10–20 years, it has become clear that forests are crucial for a number of global change aspects. Among other things, forests act as stabilizers for both global and regional climates and play an important role in the global carbon balance. In order to introduce relevant policies and management regimes for forest utilization with respect to the carbon balance, estimates on bioproductivity must be available. The extent of forest phytomass is one of the most important indicators of bioproductivity.

A number of studies on the phytomass content have been carried out and published for Western Europe (see e.g., Hakkila, 1989 and 1991; Lundström, 1994; Marklund, 1981 and 1987; Nilsson, 1993; Schopfhauser, 1993). However, so far estimates on the extent of phytomass in the former USSR (FSU) have had limited publication in western literature. The objective of this study is to present first cut estimates on the current extent of the forest biomass in some countries of the former USSR. The countries studied are, Estonia, Latvia, Lithuania, Belarus, Ukraine, Moldova, Georgia, Armenia, and Azerbaijan. Some information on the forest characteristics for the countries studied is presented in *Tables 1* to *4*. The information in the tables is based on the Forest State Account for 1988.

Table 1. State forests in the countries studied, in 1000 ha.

Country	*Forest fund*	*Forested area*	*Coniferous*	*Hard deciduous*	*Soft deciduous*
Estonia	2362.6	1810.5	1136.9	18.1	652.1
Latvia	3208.9	2648.0	1574.9	26.9	1046.2
Lithuania	2145.2	1823.1	1074.6	77.9	670.7
Bjelarus	8054.8	7027.7	4756.4	273.1	1996.9
Ukraine	9942.5	8620.9	3937.3	3488.2	1162.4
Moldova	380.0	315.4	8.7	281.3	15.2
Georgia	2991.1	2757.6	452.5	1853.7	295.6
Armenia	482.1	329.4	23.5	285	8.1
Azerbaijan	1217.1	991.8	13.7	868.4	36.7
Total	30784.3	26324.4	12978.5	7172.6	5883.9

Table 2. Growing stock in the countries studied, in million m^3.

Country	*Total*	*Coniferous*	*Hard deciduous*	*Soft deciduous*
Estonia	259.1	174.8	2.3	80.9
Latvia	434.2	273.2	4.2	156.9
Lithuania	297.3	197.2	10.7	89.5
Bjelarus	921.3	646.7	34.7	240.0
Ukraine	1319.9	718.8	484.1	116.5
Moldova	34.8	0.3	32.1	2.1
Georgia	421.6	119.9	270.5	19.0
Armenia	38.9	0.7	37.1	0.6
Azerbaijan	127.6	0.4	120.1	3.1
Total	3854.5	2132.0	995.8	708.6

Table 3. State forests in the countries studied, in 1000 ha.

Country	*Total growing stock*	*Total coniferous*	*Pine*	*Spruce*	*Fir*	*Larch*
Estonia	164.2	113.2	76.5	36.6	–	–
Latvia	290.6	196.7	149.3	47.4	–	0.1
Lithuania	220.4	153.9	97.8	56.1	–	–
Bjelarus	806.0	568.6	456.2	112.4	–	0.1
Ukraine	1053.6	575.1	392.5	151.2	30.6	0.8
Moldova	33.1	0.2	0.2	–	–	–
Georgia	367.0	115.7	13.1	31.1	71.4	–
Armenia	36.7	0.7	0.5	–	–	–
Azerbaijan	117.2	0.4	0.1	–	–	–
Total	3087.8	1724.5	1186.2	434.8	102.0	1.0

Table 4. The distribution of growing stock by dominant deciduous species, in million m^3.

	Hard deciduous			*Soft Deciduous*			
Countries	*Total*	*Oak*	*Beech*	*Total*	*Birch*	*Aspen*	*Alder*
Estonia	0.9	0.5	–	50.0	43.0	3.3	2.2
Latvia	2.0	0.7	–	91.9	72.7	10.1	6.2
Lithuania	6.7	3.0	–	59.9	38.1	7.9	11.2
Belarus	31.8	28.2	–	205.6	124.9	16.7	57.8
Ukraine	402.4	233.4	133.7	75.1	33.9	5.8	27.6
Moldova	30.9	21.0	0.1	2.0	–	–	–
Georgia	239.7	18.1	204.7	11.6	3.4	1.3	6.0
Armenia	35.5	9.6	19.8	0.6	0.1	–	–
Azerbaijan	114.9	28.0	59.7	2.0	0.1	0.3	0.8
Total	864.8	342.5	418.0	498.7	316.2	45.4	111.8

The forests have a rather high level of production in the countries studied and play an important ecological role. The forests are all assumed to be strongly influenced by air pollutants (Nilsson *et al.*, 1992b; EC-UN/EU, 1994). As seen in the tables the forests are dominated by coniferous forests in all countries except for Moldavia, Georgia, Armenia, and Azerbaijan where the deciduous forests are dominant. In the Caucasian countries uneven-aged forests dominate with mature and overmature forests. In the other countries young, middle-aged and evenaged forests dominate.

2. Data

The data used in the analyses was collected from experimental research plots dealing with studies on forest ecology and productivity in the countries studied. The objective of the original research and the methods for data collection vary substantially among the different individual experimental sample plots. The experimental data can be divided into three major groups:

- Sample plots in the countries studied belonging to individual research programs on forest productivity (e.g., Rodin *et al.*, 1968).
- Sample plots for specific analyses of phytomass components of trees and stands. The data is limited to estimates on individual phytomass components and do not permit true estimates on the weight of phytomass.
- Sample plots in the individual countries for estimation of phytomass dynamics.

Below we present the original experimental data studied and finally evaluated in the analyses.

The Baltic Countries

Investigations on the phytomass for the major species are reported, among others, by Ievin and Gejne (1966), Grjazin (1968), Shtibe (1967), Rokjanis (1978), Tamm and Ross (1979 and 1980) and Tjabera (1981). However, several of these works could not be used for our analyses due to the fact that they are reported in volume units. The most applicable studies for our purposes are the above-ground phytomass estimates for aspen (Tamm and Ross, 1980), for black alder (Kapustinskaite, 1978) and for spruce (Rokjanis, 1978).

Belarus

Investigations on the extent of phytomass are numerous within Belarus. The most detailed analyses were carried out by Bojko *et al.* (1975), Yurkevitsh and Jaroshevitsh (1974), Smoljak *et al.* (1977), Bojko and Kirkovsky (1986), and Ermakov and Asutin (1988). In the studies by Smoljak *et al.* (1977) and Bojko and Kirkovsky (1986) the above-ground phytomass parameters are measured as well as the dynamics of the same in pine and oak stands. The most detailed phytomass investigation for pine was carried out by Yurkevitsh and Jaroshevitsh (1974). However, careful analysis of the initial data show that the density of the wood is extremely high and exceeds the average density value for pine and the region substantially. The density figures reported for pine in the study by Smoljak *et al.* (1977) are more in line with the average for the region.

Ukraine

Studies in the Ukraine on phytomass are also numerous. The major studies are carried out by Polovnikov (1970), Odinak and Borsuk (1977), Kalinin (1978, 1983, and 1991), Mjakushko (1978), Odinak *et al.* (1987), Lakida (1989 and 1990), and Koziakov (1984). In addition some 250 test plots have been especially established for analysis of the forest phytomass components (Lakida *et al.*, 1995).

Moldova

In Moldova the basic analyses were carried out with a limited amount of experimental data. As an example, the Lazu (1970) analysis of oak is based on one single sample plot.

Caucasian Countries

The phytomass studies in this region are mainly carried out in Georgia. The most complete studies are carried out by Adamija (1965), Darakhvelidze (1975), Gagoshidze (1980), and Dzebisashvili and Aptsiauri (1988). However, the majority of the studies are presented in volume units.

Table 5. Experimental sample plots used for the estimation of forest phytomass.

	Number of sample plots by main species						
Region	*Pine*	*Spruce*	*Oak*	*Beech*	*Birch*	*Aspen*	*Alder*
Baltic countries		3				6	8
Belarus	85	8	51				
Ukraine	246	41	32	18	8		
Moldova			1				
Caucasian countries	3	3					
Total:	334	55	84	18	8	6	8

The total amount of experimental sample plots used for our forest phytomass estimation is 513 and their distribution over countries and species is presented in *Table 5*. A more detailed description of the sample plots is presented in Appendix I.

3. Methodology

The following components of the forest phytomass have been separated in the analyses:

- stem wood over bark,
- wood and bark of the crown,
- the green phytomass (leaves and needles),
- wood and bark of the stump.

There are two different ratios usually used in the former Soviet Union for estimation of the phytomass and its fractions:

1. The ratio between the phytomass and the mass of stem wood over bark,

$$R_m = M_{fr} / M_{st} \quad , \tag{1}$$

where R_m is the ratio of the phytomass and the growing stock of stem wood over bark in absolute dry conditions; M_{fr} is the weight of phytomass in tons; M_{st} is the weight of stem wood over bark in tons.

The application of the ratio R_m for direct evaluation of individual phytomass components as a function of the growing stock assumes the following relationship:

$$M_{fr} = R_m \cdot V_{st} / p_{st} \quad , \tag{2}$$

where V_{st} is the growing stock of stem wood over bark in m^3; p_{st} is the density of stem wood over bark in ton/m^3.

Thus, to obtain R_m by using equations (1) and (2) do not allow to a direct estimate of the phytomass based on the growing stock information. By just using average means for the density of stem wood over bark, without taking account of the variation with age and other stand parameters, will reduce the accuracy of the results. There is limited information available in the former Soviet Union on the average density of stem wood over bark.

2. *The ratio between phytomass and the mass of the growing stock over bark:*

$$R_v = M_{fr} / V_{st} \quad , \tag{3}$$

where R_v is the ratio of stand phytomass fraction (foliage, roots, etc.); M_{fr} is the weight of phytomass, and the V_{st} is the growing stock in ton/m^3.

It should be pointed out that the ratio for stem wood over bark $R_v = p_{st}$ expresses the density of the stem wood over bark. This makes it possible to control the reliability of the experimental data employed due to the fact that the ratio varies only slightly for different species under similar climatic conditions.

A practical application of R_v for the calculation of the forest phytomass and its fractions in a stand can be described by the equation:

$$M_{fr} = V_{st} \cdot R_v \quad . \tag{4}$$

The ratio R_v has been calculated for the following major phytomass components in the analysis: $R_{v(f)}$ is foliage; $R_{v(kr)}$ is the crown as a whole (foliage, wood, and bark of branches); $R_{v(ab)}$ is above-ground phytomass; $R_{v(bl)}$ is below-ground phytomass.

Based on the calculations for R_v for the major phytomass components mentioned above, some other indicators can be calculated additionally:

$$R_{v(br)} = R_{v(kr)} - R_{v(f)} \quad , \tag{5}$$

where $R_{v(br)}$ is the wood and bark of the crown branches;

$$R_{v(st)} = R_{v(ab)} - R_{v(kr)} \quad , \tag{6}$$

where $R_{v(st)}$ is the wood and bark of stems;

$$R_{v(tot)} = R_{v(ab)} + R_{v(bl)} \quad , \tag{7}$$

where $R_{v(tot)}$ is the total phytomass.

The above approach has been used on the experimental data described earlier. For the generation of the above equations the experimental data were tested in a standard multiple regression analysis program. The major phytomass fractions were tested against the following forest stand parameters: average age (A), average diameter (D), average height (H), site class index (B) and the relative stocking of the stand (P). The original experimental data were used for the above parameters except for the site index. The originally reported site indexes were based on local and regional classifications. Therefore, a uniform reclassification of the site indexes had to take place according to a modified so-called Orlov scale

Table 6. Site class indexes by Orlov and corresponding average stand height.

	Site index by M.M.Orlov										
Origin of stands	*Id*	*Ic*	*Ib*	*Ia*	*I*	*II*	*III*	*IV*	*V*	*Va*	*Vb*
Seed	47	43.0	39	35.0	31	27.0	23	19.0	15	11.0	7
Vegetative	39	35.5	32	28.5	25	21.5	18	14.5	11	7.5	4

(Shvidenko *et al.*, 1987). In this reclassification the original local site class classifications have been done in digital codes, which correspond to the average system based on the average height of the stand at 120 years of age for seed origin stands and 60 years of age for vegetation origin species. The coding system is presented in *Table 6*.

The statistical analyses of the experimental data show that the best fit from a statistical point of view (significance) was achieved by using the parameters average age of species, and site class index. Thus, the models employed in the statistical analyses are:

$$R_v = a_0 A^{a_1} \tag{8.I}$$

and

$$R_v = a_0 A^{a_1} B^{a_2} \quad , \tag{8.II}$$

where A is the average age of the stand in years; B is the site index class; a_0, a_1, a_2 are regression coefficients.

4. Results

The results of the analyses are presented for the major species and regions analyzed.

4.1 Pine

Pine is the dominating species in the European part of the former Soviet Union. The estimated equations for the different phytomass fractions of pine are presented in *Table 7*.

Several of the above estimated equations cannot be accepted from a statistical point of view. In the validation tests others showed serious discrepancies with the real dynamics of the phytomass accumulation. In the case of the Ukraine, the estimated equations for natural stands are very weak from a statistical point of view, and because some 60% of the pine forests stem from plantations, we recommend the use of the plantation equations.

Thus, based on our validation tests we suggest that the following equations could be used for phytomass estimations for pine in the regions studied:

- Belarus: equations 7.1–7.6, 7.11;
- Ukraine: equations 7.26–7.32, 7.33–7.38.

Table 7. Estimated equations for phytomass fractions of pine.

Source	Ratio R_v	Equation	No. of equation	Coefficients a_0	a_1	a_2	Multiple concentration coefficient Q
	Belarus						
Smoljak *et al.*	R_v(f)	8.I	7.1	1.462	-0.925	–	0.81
(1977),		8.II	7.2	66.35	-0.925	-1.200	0.99
$n = 54$	R_v(kr)	8.I	7.3	2.363	-0.798	–	0.80
		8.II	7.4	78.61	-0.798	-1.103	0.99
	R_v(ab)	8.I	7.5	1.581	-0.248	–	0.87
		8.II	7.6	3.450	-0.248	-0.245	0.98
Yurkevitsh and	R_v(f)	8.I,II	No dependency was found				
Jaroshevitsh,	R_v(kr)	8.I	7.7	0.242	-0.256	–	0.62
(1974),		8.II	7.8	0.924	-0.338	-0.308	0.71
$n = 31$	R_v(ab)	8.I	7.9	0.854	-0.065	–	0.57
		8.II	7.10	0.869	-0.066	-0.004	0.57
	R_v(bl)	8.I	7.11	0.381	-0.059	-0.233	0.47
	Ukraine						
Mjakushko	R_v(f)	8.I	7.12	0.493	-0.786	–	0.84
(1978)		8.II	7.13	18.62	-0.778	-1.046	0.86
– plantations,	R_v(kr)	8.I	7.14	0.889	-0.665	–	0.77
$n = 27$		8.II	7.15	25.66	-0.657	-0.968	0.79
	R_v(ab)	8.I,II	No dependency was found				
	R_v(bl)	8.I	7.16	0.033	0.230	–	0.41
		8.II	7.17	0.273	0.235	-0.613	0.43
– natural	R_v(f)	8.I	7.18	0.558	-0.858	–	0.46
stands,		8.II	7.19	2719.0	-0.926	-2.438	0.87
$n = 29$	R_v(kr)	8.I	7.20	0.743	-0.636	–	0.37
		8.II	7.21	1055.0	-0.695	-2.084	0.89
	R_v(ab)	8.I	7.22	0.410	0.059	–	0.31
		8.II	7.23	1.429	0.050	-0.358	0.84
	R_v(bl)	8.I	7.24	0.029	0.297	–	0.30
		8.II	7.25	1.688	0.264	-1.169	0.55
Kalinin (1991), $n = 10$	R_v(bl)	8.I	7.26	0.188	-0.236	–	0.87
Lakida *et al.* (1995)	R_v(f)	8.I	7.27	3.920	-1.391	–	0.85
		8.II	7.28	197.5	-1.299	-1.223	0.90
– plantations	R_v(kr)1	8.I	7.29	4.602	–	–	0.87
in Polesje		8.II	7.30	412.7	-1.056	-1.389	0.94
and Forest-	R_v(ab)	8.I	7.31	0.962	-0.195	–	0.64
steppe,		8.II	7.32	4.521	-0.162	-0.478	0.77
$n = 111$							

Table 7. Continued.

Source	Ratio R_v	Equation	No. of equation	Coefficients a_0	a_1	a_2	Multiple concentration coefficient Q
– plantations	R_v(f)	8.I	7.33	0.573	-0.646	–	0.42
in Lower		8.II	7.34	409.1	-0.964	-1.681	0.83
Dnieper	R_v(kr)	8.I	7.35	0.713	-0.418	–	0.32
Sands,		8.II	7.36	264.3	-0.703	-1.514	0.80
$n = 53$	R_v(ab)	8.I	7.37	0.590	-0.014	–	0.46
		8.II	7.38	3.787	-0.103	-0.476	0.74
– natural	R_v(f)	8.I	7.39	0.092	-0.474	–	0.45
stands in		8.II	7.40	0.795	-0.599	-0.492	0.49
Polesje and	R_v(kr)	8.I	7.41	0.209	-0.366	–	0.36
Forest-steppe,		8.II	7.42	0.574	-0.416	-0.242	0.35
$n = 26$	R_v(ab)	8.I	7.43	0.256	0.158	–	0.85
		8.II	7.44	0.266	0.156	-0.009	0.85
	Georgia						
Darakhvelidze	R_v(f)	8.I	6.45	13.85	-1.358	-	0.87
(1975),	R_v(kr)	8.I	6.46	0.002	0.915	–	0.99
$n = 3$	R_v(ab)	8.I	6.47	0.016	0.817	–	0.98

4.2 Spruce

The estimated equations for the different phytomass fractions of spruce are presented in *Table 8*.

Based on the validation tests the conclusion is that all of the estimated equations can be used for phytomass estimations. For spruce stands in the Ukrainian Carpathian the equations 8.21–8.27 seem to be expedient for phytomass estimations.

4.3 Oak

Oak is a major species in Belarus, Ukraine, and Moldova. However, the available experimental data for Moldova (Lazu, 1970) are not sufficient from a statistical point of view. The estimated equations for the different phytomass fraction of oak are presented in *Table 9*.

Based on the validation test, all of the equations presented in *Table 9* can in general be used for phytomass estimation of oak. For Belarus, we suggest that equations 9.1–9.6 and 9.11–9.12 be employed.

4.4 Beech

The major areas covered by beech are the Ukrainian Carpathian (*Fagus silvatica*), Crimea, and Caucasia (*Fagus orientalis*). However, there are only experimental data available from the Carpathian region, the estimated equations for the different phytomass fractions of beech are presented in *Table 10.*

Tests based on 21 year-old stands in an experiment conducted by Odinak and Borsuk (1977) support the above presented equations, which proved to be relevant in the validation tests.

Table 8. Estimated equations for phytomass fractions of spruce.

Source	*Ratio R_v*	*Equation*	*No. of equation*	*Coefficients* a_0	a_1	a_2	*Multiple equation coefficient Q*
	Latvia						
Rokjanis (1978), $n = 3$	R_v(f)	8.I	8.1	0.121	-0.205	–	0.98
		8.II	8.2	0.008	-0.217	0.804	0.99
	R_v(kr)	8.I	8.3	0.302	-0.298	–	0.95
		8.II	8.4	816.100	-0.263	-2.310	0.99
	R_v(ab)	8.I	8.5	0.727	-0.081	–	0.94
		8.II	8.6	4.477	-0.073	-0.532	0.99
	R_v(bl)	8.I	8.7	0.202	-0.112	–	0.88
		8.II	8.8	10.080	-0.095	-1.143	0.99
	Belarus						
Ermakov and Asutin (1988), $n = 8$	R_v(f)	8.I	8.9	21.720	-1.533	–	0.79
		8.II	8.10	3.511	-1.730	0.751	0.79
	R_v(kr)	8.I	8.11	3.068	-0.679	–	0.96
		8.II	8.12	2.821	-0.688	0.035	0.96
	R_v(ab)	8.I	8.13	1.653	-0.231	–	0.97
		8.II	8.14	1.493	-0.242	0.042	0.97
	R_v(bl)	8.I	8.15	0.164	0.138	–	0.98
		8.II	8.16	0.168	0.141	-0.011	0.99
	Ukraine						
Polovnikov (1970), $n = 4$	R_v(f)	8.I	8.17	1.702	-0.916	–	0.96
	R_v(kr)	8.I	8.18	0.641	-0.470	–	0.78
	R_v(ab)	8.I	8.19	0.325	0.087	–	0.99
	R_v(bl)	8.I	8.20	0.135	-0.147	–	0.39
Kalinin (1991), $n = 10$	R_v(bl)	8.I	8.21	0.762	-0.601	–	0.94
Lakida *et al.* (1995), $n = 37$	R_v(f)	8.I	8.22	17.260	-1.593	–	0.87
		8.II	8.23	729.900	-1.304	-1.368	0.86
	R_v(kr)	8.I	8.24	19.590	-1.404	–	0.88
		8.II	8.25	646.900	-1.126	-1.289	0.86
	R_v(ab)	8.I	8.26	2.058	-0.383	–	0.72
		8.II	8.27	7.658	-0.278	-0.484	0.72
	Georgia						
Darakhvelidze (1975), $n = 6$	R_v(all)	No dependency was found					

Table 9. Estimated equations for phytomass fractions of oak.

Source	Ratio R_v	Equation	No. of equation	Coefficients a_0	a_1	a_2	Multiple correlation coefficient Q
	Belarus						
Bojko and Kirkovsky (1986) $n = 47$	R_v(f)	8.I	9.1	0.094	−0.408	–	0.93
		8.II	9.2	0.471	−0.404	−0.494	0.97
	R_v(kr)	8.I	9.3	0.263	−0.164	–	0.89
		8.II	9.4	0.567	−0.163	−0.236	0.93
	R_v(ab)	8.I	9.5	0.851	−0.032	–	0.86
		8.II	9.6	0.869	−0.031	−0.006	0.86
Bojko *et al.* (1975), $n = 4$	R_v(f)	8.II	9.7	208564	−1.422	−3.168	0.83
	R_v(kr)	8.II	9.8	786266	−1.432	−2.936	0.92
	R_v(ab)	8.I	9.9	2.082	−0.231	–	0.86
		8.II	9.10	14.30	−0.406	−0.359	0.88
	R_v(bl)	8,I	9.11	0.592	−0.252	–	0.87
		8.II	9.12	0.330	−0.198	0.109	0.87
	Ukraine						
Lakida *et al.* (1995), $n = 32$	R_v(f)	8.I	9.13	1.813	−1.279	–	0.87
		8.II	9.14	12.680	−1.276	−0.572	0.90
	R_v(kr)	8.I	9.15	1.020	−0.555	–	0.62
		8.II	9.16	5.227	−0.552	−0.480	0.66
	R_v(ab)	8.I	9.17	1.039	−0.104	–	0.50
		8.II	9.18	1.491	−0.103	−0.106	0.53
Kalinin (1991), $n = 10$	R_v(bl)	8.I	9.19	1.496	−0.698	–	0.90

Table 10. Estimated equations for phytomass fractions of beech.

Source	Ratio R_v	Equation	No. of equation	Coefficients a_0	a_1	a_2	Multiple correlation coefficient Q
	Ukraine						
Lakida *et al.* (1995), $n = 17$	R_v(f)	8.I	10.1	1.899	−1.320	–	0.80
		8.II	10.2	1951.000	−1.354	−1.928	0.96
	R_v(kr)	8.I	10.3	1.040	−0.581	–	0.66
		8.II	10.4	105.900	−0.603	−1.285	0.75
	R_v(ab)	8.I	10.5	0.956	−0.068	–	0.42
		8.II	10.6	3.275	−0.074	−0.342	0.56

4.5 Birch, Aspen, and Alder

The major areas with soft deciduous species in the regions studied are the Baltic states, Belarus, and the Ukraine. The estimated equations for different phytomass fractions of birch, aspen, and alder are presented in *Table 11.*

Table 11. Estimated equations for phytomass fractions of birch, aspen, and alder.

Source	*Ratio R_v*	*Equation*	*No. of equation*	*Coefficients* a_0	a_1	a_2	*Multiple variation coefficient Q*
	Ukraine (birch)						
Lakida *et al.* (1995), $n = 8$	R_v(f)	8.I	11.1	0.158	–0.726	–	0.66
		8.II	11.2	542.100	–0.657	–2.266	0.83
	R_v(kr)	8.I	11.3	1.409	–0.853	–	0.77
		8.II	11.4	856.000	–0.798	–1.784	0.87
	R_v(ab)	8.I	11.5	1.040	–0.157	–	0.83
		8.II	11.6	3.289	–0.147	–0.321	0.91
	Estonia (aspen)						
Tamm and Ross (1980), $n = 6$	R_v(f)	8.I	11.7	13.080	–2.003	–	0.97
		8.II	11.8	0.008	–2.524	2.841	0.99
	R_v(kr)	8.I	11.9	8.723	–1.485	–	0.96
		8.II	11.10	1.002	–1.637	0.827	0.97
	R_v(ab)	8.I	11.11	2.074	–0.484	–	0.95
		8.II	11.12	0.097	–0.699	1.172	0.98
	Lithuania (alder)						
Kapustinskaite (1978), $n = 8$	R_v(f)	8.I	11.13	0.043	–0.358	–	0.48
		8.II	11.14	0.051	–0.363	–0.049	0.48
	R_v(kr)	8.I	11.15	0.113	–0.171	–	0.45
		8.II	11.16	0.075	–0.159	0.117	0.46
	R_v(ab)	8.II	11.17	1.485	–0.048	–0.260	0.47
	R_v(bl)	8.II	11.18	0.482	–0.020	–0.393	0.45

4.6 Understory Phytomass

The experimental data for the understory phytomass estimations has been collected from studies carried out by Polovnikov (1970), Bojko *et al.* (1975), Yurkevitsh and Jaroshevitsh (1974), Mjakushko (1978), and Rokjanis (1978). The analysis of the data shows that the understory phytomass only constitute 2–10% of the total phytomass of a stand and is characterized by a significant variability depending on growth conditions, tree species, stock, age, etc.

Statistical analyses were only possible for oak (data from Bojko *et al.*, 1975) and for pine plantations (data from Mjakushko, 1978). For the other species no statistical dependency could be identified concerning the understory phytomass. The estimated equations for estimates on the understory phytomass related to the growing stock for pine plantations and oak are:

Table 12. Statistics of residuals for the equations recommended.

No. of equations	$\bar{x}$	σ	r_3	r_4
6.2	0	0.004	–0.63	7.90
6.4	0	0.009	0.99	6.94
6.6	0	0.018	–0.42	1.34
6.11	0.001	0.017	0.73	0.02
6.26	0.001	0.010	0.53	–0.24
6.28	0.004	0.025	2.51	9.24
6.30	0.006	0.036	1.02	2.01
6.32	0.003	0.060	1.65	5.28
7.10	–0.004	0.047	–1.41	0.77
7.12	0	0.029	0.33	–0.30
7.14	0	0.023	0.84	–0.49
7.16	0	0.004	–0.55	–1.15
7.21	0.003	0.021	0.75	–0.11
7.23	0.019	0.078	2.72	8.48
7.25	0.028	0.125	2.52	6.71
7.27	0.019	0.169	2.17	5.61
8.2	0	0.001	1.17	3.01
8.4	0	0.005	0.01	1.59
8.6	0	0.007	1.84	7.36
8.12	0	0.012	–0.52	1.86
8.14	0.002	0.013	0.95	2.57
8.16	0.010	0.059	0.00	–0.86
8.18	0.003	0.064	–0.03	–0.75
8.19	0.007	0.050	1.73	2.19
9.2	0.002	0.010	0.72	0.40
9.4	0.011	0.064	1.39	1.52
9.6	0.002	0.062	1.26	1.13
10.2	0	0.004	–0.53	–0.85
10.4	0.001	0.024	–0.36	–1.03
10.6	0	0.021	–0.26	–1.51
10.8	0.002	0.008	0.77	–0.92
10.10	0.012	0.042	1.06	–0.58
10.12	0.003	0.038	0.13	–1.84
10.14	0.001	0.005	0.60	–1.04
10.16	0.001	0.012	0.12	–0.61
10.17	0.001	0.042	–0.11	–1.78
10.18	0.001	0.017	–0.61	–0.26

Pine plantations:

$$R_{v(us)} = 0.146\,A^{-0.519} \quad , \tag{9}$$

Oak stands:

$$R_{v(us)} = 2.489\,A^{-0.997} \quad . \tag{10}$$

Under the current conditions we suggest the use of equation (9) for coniferous understory phytomass estimations and equation (10) for deciduous species for the countries of the former European USSR. This generalization will have limited influence on an estimate of the total phytomass for the region studied.

4.7 Adequacy of recommended equations

The statistics for the residuals distribution for the recommended equations ($\bar{x}$ is average value; σ is the standard deviation; r_3 and r_4 are third and fourth basic moments of the distributions) are presented in *Table 12*. The equations have no significant systematic errors (at the significance level of 0.05) and have a good fit with the experimental data.

5. Estimates of the Forest Phytomass for the Region Studied

In order to come up with a phytomass estimate for the whole region, aggregated data from the Forest State Account of the former Soviet Union for 1988 have been employed. These aggregated data describe species, age, site class, stocking, etc., distribution for subregions of the individual countries of the region studied. The Forest State Account data have been applied to the functions presented in *Tables 7* to *11*. In the calculations we worked with the following generalizations:

- Average site indexes of dominant species for the individual countries were employed.
- The distribution of the individual species for different age groups were aggregated for coniferous, soft deciduous, and hard deciduous species.
- For countries with missing equations for the estimation of phytomass fractions (see *Tables 7–11*), the equation with the most relevant geographical and biological growth conditions was chosen from the generated set of equations.

From the calculations made there is also a possibility to estimate the carbon accumulated by the forest stands in the region studied. For this latter calculation Matthews' (1993) estimate on the carbon content for absolute dry phytomass was used, namely 50% for the woody parts and 45% for needles and leaves.

The results for the total forest biomass estimate and the carbon sequestered by the forests are presented in *Table 13*.

From *Table 13* it can be seen that the total forest phytomass density varies between 9.1–12.7 kg/m^2 and the total carbon content between 4.5–6.3 kg/m^2. The total forest phytomass in the region studied is estimated to be nearly 3000 Tg and the carbon sequestration nearly 1500 Tg.

6. Uncertainties

There are a number of uncertainties built into the results. These uncertainties are caused by three major factors:

- incompleteness and inaccuracy of initial data;
- uncertainties of the Forest State Account;
- simplifications and assumptions employed in the analyses.

The accuracy and statistical reliability of the initial data cannot be estimated by only formal mathematical analyses. The same can be said about the forest inventory information of the Forest State Account. A number of detailed investigations of the Forest State Account in the

Table 13. The forest phytomass and carbon content of the European countries of the FSU.

				Phytomass components, Tg							*Carbon sequestration*	
Country	*Group of forest forming species*	*Total forested area, thou. ha*	*Total growing stock, mil. m^3*	*Foliage*	*Crown wood*	*Stem-wood*	*Stump and roots*	*Under story*	*Total*	*Phyto-mass density, kg/m^2*	*Total, Tg*	*Denisty, kg/m^2*
Estonia	Total	1810.5	259.1	10.30	27.90	122.80	42.00	9.50	212.60	11.74	105.30	5.82
	coniferous			7.01	16.46	80.50	27.73	3.14	134.83	11.86	66.91	5.89
	hardwood			0.05	0.28	1.43	0.49	0.11	2.35	12.99	1.17	6.45
	softwood			3.28	11.19	40.90	13.78	6.24	75.38	11.50	37.22	5.68
Latvia	Total	2648.0	434.2	13.50	32.10	206.80	65.60	16.30	334.30	12.62	165.60	6.26
	coniferous			9.35	16.49	125.98	38.98	4.75	195.54	12.42	97.07	6.16
	hardwood			0.08	0.51	2.68	0.93	0.24	4.43	16.48	2.20	8.18
	softwood			4.07	15.06	78.18	25.67	11.32	134.29	12.84	66.38	6.34
Lithuania	Total	1823.1	297.3	10.20	22.90	141.70	45.50	10.80	231.00	12.67	114.5	6.28
	coniferous			7.90	13.96	91.41	28.91	3.73	145.91	13.58	72.37	6.73
	hardwood			0.20	1.25	6.60	2.28	0.58	10.90	13.99	5.41	6.94
	softwood			2.09	7.69	43.66	14.28	6.52	74.24	11.07	36.69	5.47
Belarus	Total	7027.7	921.3	42.90	82.60	452.90	141.30	37.80	757.50	10.78	374.70	5.33
	coniferous			35.83	54.75	311.28	94.06	13.76	509.68	10.72	252.36	5.31
	hardwood			0.67	4.12	21.57	7.60	2.10	36.07	13.21	17.90	6.55
	softwood			6.42	23.75	120.00	39.60	21.93	211.70	10.59	104.43	5.23
Ukraine	Total	8620.9	1319.9	42.10	108.30	637.80	119.20	49.20	956.70	11.10	473.80	5.50
	coniferous			31.65	45.25	289.35	55.03	14.63	435.93	11.07	215.65	5.48
	hardwood			7.81	53.44	290.05	45.78	24.80	421.88	12.09	209.31	6.00
	softwood			2.66	9.65	58.42	18.38	9.78	98.90	8.27	48.83	4.08
Moldova	Total	315.4	34.8	0.50	3.60	19.80	3.20	1.60	28.70	9.09	14.20	4.51
	coniferous			0.02	0.03	0.12	0.03	0.01	0.22	2.50	0.11	1.23
	hardwood			0.40	3.25	18.55	2.84	1.48	26.52	9.13	13.17	4.53
	softwood			0.08	0.29	1.08	0.34	0.15	1.94	12.74	0.96	6.29
Georgia	Total	2757.6	421.6	7.00	38.40	246.00	27.90	11.50	330.80	12.00	164.50	5.96
	coniferous			3.24	4.95	48.25	6.10	1.64	64.19	14.18	31.85	7.04
	hardwood			3.38	32.20	188.56	18.97	8.60	251.70	12.53	125.25	6.23
	softwood			0.37	1.25	9.23	2.83	1.23	14.92	5.05	7.38	2.50
Armenia	Total	329.4	38.9	0.70	5.20	25.20	2.70	1.30	35.10	10.65	17.40	5.29
	coniferous			0.05	0.09	0.30	0.06	0.02	0.51	2.15	0.25	1.06
	hardwood			0.57	4.99	24.65	2.56	1.17	33.94	11.40	16.88	5.67
	softwood			0.03	0.13	0.28	0.11	0.07	0.63	7.72	0.31	3.79
Azerbaijan	Total	991.8	127.6	1.80	15.10	81.00	10.10	4.80	112.90	11.38	56.10	5.66
	coniferous			0.02	0.04	0.18	0.03	0.01	0.28	2.05	0.14	1.01
	hardwood			1.76	14.96	79.52	9.65	4.64	110.54	11.74	54.95	5.84
	softwood			0.03	0.12	1.33	0.42	0.17	2.08	5.66	1.03	2.80
Total and average		26324.4	3854.5						2999.60	11.40	1487.00	5.60

region show that the growing stock is underestimated by 7 to 10% (Antanaitis and Repshis, 1973; Fedosimov, 1986).

It is well known that the density for different species varies significantly according to the local conditions (Uspensky, 1980; Lakida *et al.*, 1995). The regional variation of the used density of the former European USSR is studied in detail by Polubojarinov (1976) and these latter results are presented in Appendix II. Our average estimates correspond well with these data. We have tried to carry out a quantification of the uncertainties in the analyses and conclude that there is probably an underestimate of the total phytomass of the region by some 7% and there is a standard error of some 10–12% in the overall results.

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Appendix I

The experimental data

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m³/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
					Latvia					
					Spruce (Rokjanis, 1978)					
10	4.1	4.1	31.0	1.00	368.0	164.4	0.074	0.16	0.61	0.16
48	20.9	19.9	35.0	1.00	890.0	382.7	0.058	0.08	0.51	0.12
89	40.2	27.8	31.0	1.00	955.0	409.4	0.046	0.09	0.52	0.13
					Estonia					
					Aspen (Tamm and Ross, 1980)					
9	1.9	4.5	21.5	0.29	14.0	5.2	0.200	0.44	0.81	–
19	6.8	10.2	21.5	0.49	60.0	20.6	0.022	0.08	0.42	–
32	10.5	16.5	25.0	0.59	161.0	51.6	0.016	0.05	0.37	–
38	17.2	21.2	28.5	0.63	233.0	72.0	0.010	0.03	0.34	–
49	22.5	27.2	28.5	0.66	358.0	107.6	0.004	0.02	0.32	–
57	29.5	27.1	28.5	0.79	364.0	106.1	0.005	0.04	0.33	–
					Lithuania					
					Alder (Kapustinskaite, 1978)					
45	12.0	13.9	18.0	1.02	188.0	98.3	0.009	0.06	0.58	0.15
50	14.8	17.0	18.0	1.08	227.0	125.2	0.015	0.06	0.61	0.15
55	19.9	19.8	21.5	0.91	230.0	121.8	0.020	0.08	0.61	0.16
14	6.7	10.2	28.5	0.97	109.0	53.7	0.020	0.08	0.57	0.13
44	15.0	18.8	21.5	0.96	279.0	128.2	0.006	0.04	0.50	0.10
25	10.0	12.6	21.5	0.98	138.0	66.6	0.011	0.06	0.54	0.13
66	26.0	26.1	25.0	0.88	356.0	177.4	0.009	0.06	0.56	0.13
70	26.2	25.0	25.0	0.85	361.0	157.8	0.008	0.05	0.48	0.12
					Belarus					
					Pine (Yurkevitsh and Jaroshevitsh, 1974)					
35	6.3	7.2	19.0	0.77	87.9	50.5	0.017	0.11	0.68	0.14
36	7.7	9.4	23.0	1.00	141.9	80.9	0.024	0.11	0.68	0.14
28	5.9	7.3	23.0	0.92	85.1	48.6	0.024	0.11	0.68	0.14
105	22.1	19.8	23.0	0.98	337.0	193.9	0.023	0.08	0.65	0.12
95	22.6	22.2	23.0	0.73	266.4	152.9	0.023	0.08	0.65	0.12
82	24.2	21.4	27.0	0.74	283.9	167.2	0.024	0.06	0.65	0.13
56	12.2	16.3	27.0	0.91	251.5	148.4	0.024	0.08	0.68	0.13
105	25.7	23.9	27.0	0.74	303.4	179.0	0.023	0.06	0.65	0.13
48	15.6	16.8	27.0	0.98	260.4	153.7	0.025	0.11	0.70	0.14
75	19.5	20.3	27.0	0.77	280.0	166.0	0.024	0.07	0.66	0.13
41	9.9	12.8	27.0	0.98	195.0	115.1	0.025	0.12	0.71	0.14
66	21.8	20.4	27.0	0.89	292.9	172.8	0.024	0.08	0.67	0.14
53	14.4	18.2	27.0	0.73	215.0	126.9	0.025	0.08	0.67	0.15
64	20.2	22.5	31.0	0.88	330.6	195.0	0.024	0.08	0.67	0.14
82	22.8	24.4	31.0	0.79	392.2	231.4	0.025	0.09	0.68	0.15
85	24.1	21.9	27.0	0.72	281.2	165.8	0.025	0.10	0.69	0.15
35	6.4	10.6	27.0	1.07	210.6	123.9	0.026	0.09	0.68	0.19
90	28.2	29.4	31.0	1.00	515.3	304.1	0.018	0.07	0.66	0.13
87	26.3	27.0	31.0	0.86	410.0	226.4	0.022	0.06	0.61	0.13
67	27.6	27.3	35.0	0.78	467.0	259.2	0.023	0.08	0.63	0.14
75	34.9	27.5	31.0	0.88	467.0	236.1	0.02	0.05	0.56	0.11
56	19.6	18.1	31.0	0.79	246.0	136.4	0.024	0.08	0.63	0.16
45	17.5	19.0	31.0	0.96	275.0	151.1	0.013	0.08	0.63	0.16
53	17.8	21.6	31.0	0.89	372.5	206.7	0.024	0.10	0.65	0.14
74	25.2	26.1	31.0	0.73	377.0	209.3	0.022	0.08	0.64	0.12

Age (years)	*Average mean Diameter (cm)*	*Average mean Height (m)*	*Site index (m)*	*Relative stocking*	*Growing stock (m^3/ha)*	*Stemwood (t/ha)*	*Ratio of phytomass components and growing stock: Foliage*	*Crown*	*Above-ground*	*Below-ground*
47	16.4	19.0	31.0	0.93	295.1	163.8	0.024	0.10	0.66	0.13
97	33.3	29.1	31.0	0.98	469.4	247.2	0.021	0.06	0.59	0.11
130	16.0	15.5	15.0	0.93	211.0	111.4	0.023	0.08	0.61	0.17
220	16.3	14.2	15.0	1.00	222.6	120.2	0.024	0.08	0.62	0.18
100	9.0	9.8	11.0	0.62	96.0	50.7	0.023	0.08	0.61	0.15
138	10.1	8.2	11.0	0.42	50.0	26.4	0.023	0.08	0.61	0.17
Pine (Smoljak, Rusalenko, and Petrov, 1977)										
20	9.8	10.3	35.0	0.85	124.0	66.2	0.057	0.14	0.68	–
30	13.8	15.0	35.0	0.85	194.0	100.7	0.038	0.1	0.62	–
40	17.5	19.2	35.0	0.85	269.0	133.3	0.028	0.08	0.57	–
50	21.0	23.0	35.0	0.85	347.0	164.5	0.023	0.06	0.54	–
60	24.3	26.0	35.0	0.85	421.0	190.9	0.019	0.05	0.51	–
70	27.3	28.4	35.0	0.85	490.0	215.0	0.017	0.05	0.49	–
80	30.1	30.3	35.0	0.85	550.0	233.7	0.015	0.05	0.47	–
90	32.8	31.8	35.0	0.85	604.0	248.8	0.014	0.04	0.45	–
100	35.3	33.0	35.0	0.85	650.0	261.5	0.013	0.04	0.44	–
20	8.1	8.6	31.0	0.85	96.0	52.0	0.069	0.17	0.71	–
30	11.4	12.4	31.0	0.85	149.0	78.4	0.047	0.12	0.65	–
40	14.6	16.0	31.0	0.85	206.0	106.2	0.036	0.09	0.61	–
50	17.8	19.1	31.0	0.85	264.0	128.9	0.028	0.08	0.57	–
60	21.0	21.8	31.0	0.85	320.0	150.6	0.024	0.07	0.54	–
70	23.8	24.0	31.0	0.85	374.0	170.2	0.021	0.06	0.51	–
80	26.5	25.9	31.0	0.85	425.0	187.4	0.018	0.05	0.49	–
90	29.2	27.5	31.0	0.85	470.0	200.9	0.017	0.05	0.48	–
100	31.4	28.8	31.0	0.85	507.0	212.4	0.016	0.05	0.47	–
20	6.8	7.0	27.0	0.85	74.0	40.1	0.084	0.20	0.74	–
30	9.6	10.3	27.0	0.85	114.0	61.4	0.057	0.14	0.68	–
40	12.4	13.3	27.0	0.85	156.0	81.7	0.043	0.11	0.64	–
50	15.2	15.9	27.0	0.85	200.0	100.7	0.035	0.09	0.60	–
60	18.0	18.3	27.0	0.85	246.0	119.1	0.029	0.08	0.56	–
70	20.6	20.4	27.0	0.85	290.0	137.0	0.025	0.07	0.54	–
80	23.0	22.2	27.0	0.85	331.0	151.7	0.022	0.06	0.52	–
90	25.3	23.7	27.0	0.85	367.0	163.0	0.02	0.06	0.50	–
100	27.5	25.0	27.0	0.85	397.0	172.3	0.02	0.06	0.49	–
20	5.8	5.4	23.0	0.85	57.0	28.7	0.102	0.24	0.74	–
30	8.2	8.2	23.0	0.85	86.0	45.9	0.071	0.18	0.71	–
40	10.6	10.8	23.0	0.85	119.0	62.4	0.065	0.17	0.69	–
50	12.9	13.1	23.0	0.85	153.0	79.4	0.044	0.11	0.63	–
60	15.3	15.1	23.0	0.85	188.0	94.0	0.036	0.10	0.60	–
70	17.7	17.0	23.0	0.85	223.0	108.1	0.031	0.08	0.57	–
80	20.0	18.7	23.0	0.85	256.0	122.5	0.025	0.07	0.55	–
90	22.1	20.2	23.0	0.85	285.0	130.8	0.024	0.07	0.53	–
100	24.1	21.4	23.0	0.85	308.0	138.1	0.023	0.06	0.51	–
20	4.9	4.2	19.0	0.85	43.0	20.8	0.121	0.28	0.77	–
30	7.1	6.6	19.0	0.85	68.0	34.9	0.083	0.20	0.72	–
40	9.2	8.8	19.0	0.85	93.0	48.6	0.065	0.16	0.68	–
50	11.3	10.6	19.0	0.85	118.0	60.9	0.053	0.14	0.65	–
60	13.3	12.4	19.0	0.85	144.0	73.2	0.045	0.12	0.63	–
70	15.3	13.8	19.0	0.85	170.0	83.5	0.039	0.10	0.59	–
80	17.3	15.1	19.0	0.85	195.0	93.5	0.034	0.09	0.57	–
90	19.2	16.3	19.0	0.85	215.0	100.9	0.031	0.09	0.55	–
100	21.1	17.4	19.0	0.85	232.0	106.3	0.028	0.08	0.54	–

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m^3/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
20	4.1	3.2	15.0	0.85	32.0	14.7	0.145	0.34	0.8	–
30	6.1	5.0	15.0	0.85	51.0	24.1	0.1	0.24	0.71	–
40	8.0	6.6	15.0	0.85	69.0	33.5	0.079	0.19	0.68	–
50	9.9	8.2	15.0	0.85	88.0	44.0	0.066	0.17	0.66	–
60	11.7	9.6	15.0	0.85	107.0	53.7	0.056	0.15	0.65	–
70	13.3	10.9	15.0	0.85	127.0	63.3	0.049	0.13	0.63	–
80	15.0	12.0	15.0	0.85	145.0	69.9	0.043	0.12	0.6	–
90	16.7	12.9	15.0	0.85	160.0	75.0	0.039	0.11	0.57	–
100	18.3	13.7	15.0	0.85	172.0	79.4	0.036	0.1	0.56	–
Spruce (Ermakov and Asutin, 1988)										
15	2.3	3.8	23.0	0.86	32.0	13.4	0.228	0.44	0.86	0.24
27	5.2	8.8	27.0	0.77	105.0	46.3	0.164	0.34	0.78	0.25
30	6.7	10.2	27.0	0.73	122.0	54.1	0.158	0.36	0.80	0.26
35	10.0	14.1	31.0	0.62	194.0	87.2	0.112	0.27	0.72	0.27
51	15.9	19.4	31.0	0.64	299.0	133.9	0.067	0.21	0.66	0.28
62	24.6	23.1	31.0	0.61	363.0	162.5	0.031	0.18	0.63	0.29
75	25.1	26.7	35.0	0.58	421.0	186.6	0.026	0.15	0.59	0.30
90	27.7	33.2	39.0	0.51	438.0	196.1	0.019	0.15	0.60	0.30
Oak (Bojko *et al.*, 1975)										
140	25.8	21.6	19.0	0.84	207.0	108.3	0.015	0.11	0.64	0.18
100	22.2	21.8	23.0	0.63	183.0	119.0	0.017	0.12	0.77	0.17
60	19.8	22.6	31.0	0.73	101.0	69.2	0.011	0.09	0.77	0.22
60	19.6	18.2	27.0	0.67	128.0	88.4	0.018	0.14	0.83	0.21
Oak (Bojko and Kirkovsky, 1986)										
30	10.3	12.2	31.0	1.00	146.0	88.7	0.024	0.15	0.76	–
40	14.3	15.7	31.0	1.00	212.0	132.7	0.018	0.13	0.75	–
50	18.4	18.7	31.0	1.00	273.0	171.6	0.016	0.12	0.75	–
60	22.2	21.3	31.0	1.00	328.0	202.8	0.016	0.13	0.75	–
70	26.1	23.5	31.0	1.00	376.0	234.1	0.015	0.13	0.75	–
80	29.9	25.3	31.0	1.00	417.0	259.1	0.014	0.12	0.75	–
90	33.5	26.8	31.0	1.00	451.0	280.7	0.014	0.12	0.74	–
100	37.1	28.1	31.0	1.00	482.0	300.0	0.013	0.12	0.74	–
110	40.6	29.2	31.0	1.00	509.0	314.5	0.013	0.12	0.74	–
120	43.8	30.1	31.0	1.00	531.0	327.4	0.012	0.12	0.73	–
130	46.6	30.8	31.0	1.00	549.0	337.2	0.012	0.11	0.73	–
140	48.8	31.4	31.0	1.00	564.0	345.6	0.012	0.11	0.73	–
150	50.8	31.9	31.0	1.00	577.0	352.6	0.011	0.11	0.72	–
160	52.6	32.3	31.0	1.00	586.0	358.3	0.011	0.11	0.72	–
170	54.0	32.6	31.0	1.00	594.0	363.9	0.011	0.11	0.72	–
180	55.3	32.8	31.0	1.00	600.0	356.5	0.011	0.11	0.72	–
30	8.9	10.0	27.0	1.00	107.0	66.2	0.024	0.15	0.77	–
40	11.9	13.1	27.0	1.00	162.0	99.3	0.020	0.14	0.75	–
50	15.6	15.8	27.0	1.00	215.0	130.4	0.018	0.14	0.74	–
60	19.3	18.2	27.0	1.00	262.0	158.9	0.019	0.14	0.74	–
70	23.0	20.3	27.0	1.00	306.0	187.2	0.017	0.13	0.74	–
80	26.3	22.1	27.0	1.00	345.0	211.2	0.016	0.13	0.74	–
90	29.2	23.6	27.0	1.00	380.0	232.5	0.015	0.13	0.74	–
100	32.0	25.3	27.0	1.00	412.0	258.0	0.015	0.13	0.74	–
110	35.1	26.2	27.0	1.00	438.0	271.3	0.014	0.12	0.74	–
120	38.0	27.1	27.0	1.00	459.0	282.1	0.014	0.12	0.74	–

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m^3/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
130	40.6	27.8	27.0	1.00	476.0	293.2	0.013	0.12	0.74	–
140	42.9	28.4	27.0	1.00	490.0	300.6	0.013	0.12	0.73	–
150	44.8	28.9	27.0	1.00	502.0	307.4	0.013	0.12	0.73	–
160	46.6	29.2	27.0	1.00	509.0	313.0	0.013	0.12	0.73	–
170	48.0	29.4	27.0	1.00	514.0	314.0	0.012	0.11	0.72	–
180	49.1	29.5	27.0	1.00	517.0	314.2	0.012	0.11	0.72	–
30	7.8	8.7	23.0	1.00	85.0	53.4	0.029	0.17	0.80	–
40	10.2	11.4	23.0	1.00	132.0	80.2	0.024	0.15	0.76	–
50	13.5	13.6	23.0	1.00	174.0	104.4	0.021	0.14	0.74	–
60	16.5	15.8	23.0	1.00	214.0	129.6	0.019	0.14	0.74	–
70	19.7	17.6	23.0	1.00	250.0	152.0	0.017	0.13	0.74	–
80	22.9	19.1	23.0	1.00	281.0	170.9	0.016	0.13	0.74	–
90	25.8	20.4	23.0	1.00	309.0	188.3	0.015	0.13	0.74	–
100	28.6	21.6	23.0	1.00	334.0	204.0	0.015	0.12	0.73	–
110	31.2	22.6	23.0	1.00	356.0	217.3	0.014	0.12	0.73	–
120	33.5	33.5	23.0	1.00	376.0	229.4	0.014	0.12	0.73	–
130	35.4	24.2	23.0	1.00	392.0	239.7	0.013	0.12	0.73	–
140	37.0	24.8	23.0	1.00	406.0	248.2	0.013	0.12	0.73	–
150	38.6	25.3	23.0	1.00	417.0	255.1	0.013	0.12	0.73	–
160	39.8	25.6	23.0	1.00	424.0	259.2	0.013	0.12	0.73	–
170	41.0	25.8	23.0	1.00	429.0	261.6	0.013	0.12	0.73	–
					Ukraine					
					Pine natural (Mjakushko, 1978)					
50	11.1	11.2	19.0	0.6	35.0	15.4	0.110	0.24	0.68	0.20
80	18.3	9.4	15.0	0.4	60.0	28.8	0.070	0.23	0.71	0.12
20	7.4	6.8	27.0	0.8	84.0	32.1	0.068	0.16	0.54	0.09
50	14.1	16.0	27.0	0.9	219.0	95.4	0.016	0.04	0.48	0.08
75	26.8	25.1	31.0	0.9	474.0	223.9	0.016	0.04	0.51	0.05
80	24.8	25.3	31.0	0.8	484.0	231.4	0.012	0.04	0.52	0.05
50	16.1	16.3	27.0	0.8	229.0	99.8	0.020	0.05	0.48	0.09
90	20.5	22.9	27.0	0.8	291.0	143.4	0.010	0.03	0.52	0.17
25	7.6	13.3	27.0	0.8	125.0	49.0	0.030	0.11	0.50	0.08
40	18.0	13.5	27.0	0.9	183.0	77.0	0.019	0.08	0.50	0.10
60	17.6	19.2	27.0	0.8	281.0	126.7	0.018	0.04	0.49	0.13
100	33.4	24.7	27.0	0.6	310.0	156.3	0.009	0.04	0.55	0.20
80	23.4	17.5	23.0	0.8	211.0	100.9	0.023	0.11	0.59	0.31
105	27.2	22.0	23.0	1.2	345.0	176.2	0.014	0.04	0.55	0.15
10	4.2	5.0	35.0	0.8	42.0	14.7	0.057	0.11	0.46	0.05
45	18.8	19.0	35.0	0.9	287.0	122.8	0.018	0.06	0.48	0.06
60	36.7	27.8	35.0	0.8	453.0	204.3	0.014	0.06	0.51	0.07
70	26.0	23.0	31.0	0.8	301.0	139.9	0.019	0.06	0.52	0.10
75	24.2	24.9	31.0	0.7	381.0	179.6	0.010	0.03	0.50	0.09
78	33.7	30.2	35.0	0.8	410.0	195.1	0.004	0.02	0.49	0.09
40	20.7	19.5	35.0	1.0	164.0	68.9	0.021	0.07	0.49	0.07
110	38.5	31.5	31.0	0.6	226.0	117.1	0.008	0.04	0.56	0.10
73	31.3	24.3	31.0	1.0	274.0	128.7	0.007	0.03	0.50	0.09
65	36.6	25.7	35.0	0.8	246.0	112.7	0.007	0.04	0.51	0.10
95	31.4	28.8	31.0	0.6	256.0	127.4	0.020	0.06	0.55	0.10
88	36.0	33.1	39.0	0.6	278.0	135.9	0.009	0.03	0.52	0.09
86	39.7	30.5	31.0	0.4	212.0	102.9	0.010	0.04	0.52	0.10
98	36.6	30.8	31.0	0.6	300.0	150.8	0.007	0.03	0.54	0.09
101	41.4	30.8	31	0.6	403	203.8	0.012	0.03	0.53	0.10

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m^3/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
Pine natural (Lakida, 1994)[1]										
69	24.2	22.7	31.0	0.75	404.0	181.0	0.010	0.03	0.48	–
50	17.5	17.1	27.0	0.59	228.0	94.0	0.022	0.06	0.48	–
59	23.2	18.9	27.0	0.62	246.0	105.0	0.015	0.04	0.47	–
125	24.3	20.7	19.0	0.76	280.0	145.0	0.009	0.03	0.55	–
34	11.7	12.9	27.0	0.75	208.0	81.0	0.027	0.06	0.45	–
55	20.0	19.7	31.0	0.83	365.0	154.0	0.019	0.05	0.47	–
41	16.1	14.9	27.0	0.89	263.0	105.0	0.023	0.06	0.46	–
65	30.7	24.8	35.0	0.66	365.0	162.0	0.017	0.06	0.5	–
91	33.7	24.1	27.0	0.43	232.0	111.0	0.009	0.04	0.52	–
82	25.6	20.1	23.0	1.06	334.0	156.0	0.016	0.06	0.53	–
32	12.6	12.2	31.0	0.58	138.0	53.0	0.021	0.05	0.44	–
55	18.7	20.5	31.0	0.62	302.0	130.0	0.011	0.03	0.46	–
34	17.4	16.0	35.0	0.45	159.0	62.0	0.027	0.09	0.48	–
53	19.2	16.5	27.0	0.69	237.0	99.0	0.018	0.06	0.48	–
58	22.1	18.3	27.0	0.67	250.0	107.0	0.015	0.04	0.47	–
33	15.4	15.7	35.0	0.56	194.0	76.0	0.012	–	–	–
52	23.3	22.8	35.0	0.66	327.0	138.0	0.006	–	–	–
46	21.5	23.1	39.0	0.78	408.0	170.0	0.006	–	–	–
50	21.1	21.8	35.0	0.49	251.0	106.0	0.014	–	–	–
32	14.2	14.9	35.0	0.49	146.0	57.0	0.019	–	–	–
71	14.2	14.7	19.0	0.62	160.0	71.0	0.008	–	–	–
32	10.1	10.8	27.0	0.91	178.0	68.0	0.016	–	–	–
39	13.0	12.1	27.0	0.89	198.0	78.0	0.012	–	–	–
41	20.6	20.1	39.0	0.69	303.0	121.0	0.017	–	–	–
87	29.0	25.5	31.0	0.71	425.0	201.0	0.020	0.08	0.56	–
58	24.6	23.9	35.0	0.86	471.0	204.0	0.009	0.02	0.46	–
Pine plantations (Mjakushko, 1978)										
19	5.8	6.2	27.0	0.90	69.0	26.1	0.047	0.14	0.52	0.08
40	15.6	16.0	31.0	0.80	169.0	71.0	0.023	0.08	0.50	0.07
55	16.6	16.0	27.0	0.80	237.0	105.2	0.020	0.07	0.52	0.07
63	24.7	24.6	31.0	0.90	325.0	148.3	0.023	0.04	0.50	0.08
98	38.7	29.0	31.0	0.50	321.0	161.2	0.025	0.06	0.56	0.10
19	6.8	10.1	35.0	0.96	80.0	30.3	0.034	0.07	0.45	0.07
40	13.6	17.5	35.0	0.80	236.0	99.0	0.025	0.06	0.48	0.06
60	25.7	24.1	35.0	0.70	307.0	138.6	0.042	0.08	0.53	0.10
90	30.2	26.6	31.0	0.70	335.0	165.0	0.014	0.04	0.54	0.08
12	5.3	4.4	31.0	0.90	67.0	23.9	0.097	0.18	0.53	0.10
20	9.1	8.7	31.0	1.40	148.0	56.5	0.074	0.18	0.56	0.03
40	16.0	19.2	35.0	1.00	381.0	160.1	0.024	0.12	0.54	0.08
75	25.7	26.9	31.0	0.60	412.0	194.6	0.020	0.09	0.56	0.06
22	10.2	13.0	35.0	0.90	330.0	127.2	0.067	0.12	0.51	0.06
46	21.8	21.5	35.0	0.70	409.0	175.9	0.027	0.11	0.54	0.04
48	21.8	21.1	35.0	0.80	376.0	163.0	0.027	0.15	0.58	0.07
15	8.4	7.1	31.0	1.00	72.0	26.5	0.071	0.19	0.56	0.07
41	22.3	19.4	35.0	1.00	172.0	72.5	0.027	0.06	0.48	0.11
74	33.4	23.4	31.0	0.70	303.0	142.2	0.009	0.04	0.51	0.16
15	5.9	7.8	35.0	1.00	28.0	10.2	0.050	0.18	0.54	0.07
23	11.6	12.2	35.0	1.00	154.0	59.7	0.028	0.06	0.45	0.06
50	24.5	19.4	31.0	0.90	165.0	72.0	0.021	0.04	0.48	0.13
70	33.8	29.0	35.0	0.80	404.0	188.0	0.014	0.04	0.50	0.13
84	38.6	32.5	35.0	0.9	286.0	138.0	0.018	0.05	0.53	0.10

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m^3/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
33	19.5	17.6	39.0	0.9	275.0	112.0	0.021	0.07	0.48	0.05
42	18.0	22.6	39.0	0.9	454.0	192.0	0.015	0.05	0.47	0.05
80	37.5	34.6	39.0	0.7	337.0	161.3	0.011	0.03	0.51	0.10
				Pine plantations (Lakida, 1991)[1]						
24	9.1	9.9	31.0	0.58	90.0	33.0	0.041	0.10	0.48	–
29	9.2	9.6	27.0	0.67	103.0	39.0	0.058	0.15	0.53	–
23	6.8	6.3	23.0	0.46	38.0	14.0	0.073	0.18	0.55	–
29	12.4	12.0	31.0	0.79	168.0	64.0	0.034	0.08	0.46	–
38	15.1	13.8	27.0	0.70	182.0	72.0	0.030	0.08	0.48	–
34	15.4	16.0	35.0	0.70	217.0	85.0	0.019	0.05	0.44	–
58	24.4	22.4	31.0	0.9	434.0	185.0	0.014	0.04	0.47	–
16	6.7	6.9	31.0	0.91	80.0	28.0	0.085	0.18	0.54	–
28	8.6	9.2	27.0	0.81	111.0	41.0	0.047	0.11	0.48	–
28	11.9	12.9	35.0	0.75	165.0	63.0	0.025	0.07	0.45	–
33	10.6	11.3	27.0	0.80	161.0	62.0	0.026	0.07	0.45	–
32	9.9	11.2	27.0	0.78	155.0	59.0	0.034	0.08	0.46	–
75	31.0	22.9	27.0	0.96	377.0	169.0	0.009	0.03	0.48	–
18	7.5	8.8	31.0	0.53	67.0	24.0	0.071	0.14	0.50	–
33	14.4	14.3	31.0	0.79	216.0	84.0	0.044	0.10	0.49	–
30	15.2	13.8	35.0	0.61	161.0	62.0	0.030	0.08	0.47	–
20	11.1	10.5	35.0	0.79	120.0	44.0	0.062	0.18	0.54	–
19	6.9	7.1	27.0	0.64	60.0	21.0	0.074	0.15	0.50	–
22	9.5	9.8	23.0	0.53	73.0	27.0	0.030	–	–	–
11	4.7	4.3	27.0	0.46	15.0	5.0	0.228	–	–	–
25	10.8	9.2	27.0	0.35	51.0	19.0	0.058	–	–	–
46	19.6	17.8	31.0	0.66	262.0	107.0	0.025	0.10	0.51	–
21	7.9	7.0	27.0	0.73	69.0	25.0	0.091	0.22	0.59	–
25	11.4	10.7	31.0	1.16	222.0	84.0	0.038	0.10	0.48	–
25	13.2	12.3	35.0	0.95	227.0	86.0	0.048	0.15	0.52	–
26	8.7	7.5	23.0	0.34	36.0	13.0	0.054	–	–	–
22	11.8	10.9	35.0	0.60	114.0	42.0	0.054	–	–	–
22	9.9	9.4	31.0	0.57	79.0	29.0	0.046	0.13	0.5	–
30	12.8	12.5	31.0	0.81	189.0	73.0	0.045	–	–	–
19	8.2	8.2	31.0	0.39	35.0	12.0	0.037	–	–	–
18	7.7	7.2	27.0	0.96	69.0	25.0	0.034	–	–	–
39	13.6	14.4	27.0	0.86	240.0	96.0	0.006	–	–	–
24	11.2	12.5	35.0	0.88	193.0	71.0	0.019	–	–	–
18	8.3	8.6	35.0	0.97	116.0	41.0	0.026	–	–	–
22	7.2	7.3	27.0	1.00	84.0	30.0	0.067	–	–	–
26	10.3	12.3	35.0	0.92	207.0	78.0	0.041	0.10	0.48	–
26	10.7	11.6	31.0	0.85	171.0	64.0	0.046	0.10	0.48	–
43	24.3	21.8	39.0	0.84	379.0	156.0	0.020	0.10	0.51	–
50	20.3	18.6	31.0	0.70	274.0	115.0	0.031	0.10	0.51	–
24	8.4	10.7	31.0	0.81	141.0	52.0	0.038	0.08	0.45	–
33	16.1	15.1	35.0	0.78	219.0	85.0	0.031	0.07	0.46	–
8	2.5	2.6	23.0	0.31	6.0	2.0	0.320	0.69	1.02	–
20	8.5	8.8	31.0	0.53	70.0	25.0	0.047	0.11	0.47	–
10	4.7	4.0	31.0	0.38	14.0	5.0	0.125	0.31	0.65	–
48	17.8	16.4	27.0	0.70	220.0	91.0	0.021	0.05	0.47	–
25	12.2	10.9	31.0	0.52	88.0	33.0	0.059	0.16	0.54	–
29	13.2	12.5	31.0	0.73	169.0	64.0	0.039	0.10	0.48	–
21	9.2	9.4	31.0	0.74	114.0	42.0	0.052	0.13	0.50	–

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m^3/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock Foliage	Crown	Above-ground	Below-ground
43	20.9	18.9	31.0	0.80	291	118.0	0.022	0.09	0.49	–
32	17.4	16.7	39.0	0.98	314	123.0	0.028	0.07	0.46	–
15	7.3	6.1	31.0	0.69	49	17.0	0.085	0.17	0.52	–
17	7.3	6.5	27.0	0.78	60	21.0	0.059	0.13	0.48	–
43	19.3	20.3	35.0	0.83	353	154.0	0.022	0.06	0.47	–
21	8.0	9.3	31.0	0.81	129	47.0	0.071	0.14	0.51	–
43	20.3	21.0	39.0	0.77	326	132.0	0.021	0.06	0.46	–
74	27.8	25.5	31.0	0.71	381	174.0	0.013	0.04	0.49	–
37	17.0	18.2	35.0	0.77	292	117.0	0.026	0.06	0.46	–
24	11.4	12.4	35.0	0.99	215	81.0	0.043	0.10	0.48	–
35	16.4	17.1	35.0	0.85	282	111.0	0.021	0.05	0.44	–
34	13.2	14.0	31.0	0.90	238	93.0	0.034	0.09	0.48	–
19	8.1	8.6	31.0	0.92	109	39.0	0.062	0.15	0.50	–
26	11.4	12.9	35.0	0.83	205	77.0	0.042	0.10	0.47	–
56	19.7	20.3	31.0	0.83	346	148.0	0.023	0.06	0.49	–
60	22.8	24.4	35.0	0.76	412	179.0	0.012	0.03	0.47	–
23	10.3	11.6	35.0	1.03	216	80.0	0.052	0.11	0.48	–
44	22.1	23.2	39.0	1.03	489	200.0	0.020	0.05	0.46	–
35	13.9	14.8	31.0	1.08	297	117.0	0.030	0.07	0.46	–
24	12.3	12.4	35.0	0.78	173	65.0	0.045	0.10	0.48	–
27	10.4	11.3	31.0	0.74	157	59.0	0.053	0.12	0.50	–
35	16.3	18.1	39.0	0.91	344	136.0	0.021	0.04	0.44	–
17	8.2	7.1	31.0	0.79	66	23.0	0.107	0.23	0.58	–
43	16.2	19.1	35.0	0.97	400	165.0	0.019	0.05	0.46	–
21	7.3	8.9	31.0	1.02	143	52.0	0.038	0.08	0.44	–
11	3.4	3.1	23.0	0.64	13	4.0	0.320	0.50	0.84	–
43	12.3	12.7	23.0	0.75	178	73.0	0.046	0.12	0.53	–
72	32.3	27.1	31.0	0.79	445	201.0	0.011	0.04	0.49	–
32	15.6	16.4	35.0	1.05	310	122.0	0.033	0.10	0.49	–
35	23.8	20.5	43.0	0.99	379	151.0	0.023	0.07	0.47	–
31	17.2	18.4	43.0	1.17	437	170.0	0.019	0.05	0.43	–
21	10.7	11.9	39.0	0.93	190	79.0	0.048	0.11	0.48	–
41	20.1	18.1	35.0	0.77	268	109.0	0.023	0.07	0.47	–
13	6.2	5.0	27.0	0.60	32	11.0	0.230	0.42	0.76	–
10	4.1	3.5	27.0	0.54	16	5.0	0.267	0.46	0.80	–
27	15.3	13.6	35.0	0.84	202	77.0	0.039	0.11	0.48	–
18	10.0	8.9	35.0	0.70	85	30.0	0.065	0.16	0.52	–
15	7.4	6.3	31.0	0.69	52	18.0	0.118	0.24	0.59	–
31	16.2	15.9	39.0	0.85	263	102.0	0.023	0.06	0.44	–
83	35.3	29.1	35.0	1.00	507	234.0	0.008	0.03	0.49	–
30	14.5	15.2	35.0	1.13	300	115.0	0.026	0.06	0.44	–
28	14.2	14.2	35.0	1.06	251	95.0	0.024	0.06	0.43	–
26	12.0	13.7	35.0	1.08	246	92.0	0.026	0.06	0.43	–
40	15.8	19.3	35.0	0.81	304	122.0	0.012	0.03	0.43	–
18	11.7	8.4	31.0	1.17	122	44.0	0.051	0.12	0.48	–
28	12.9	12.1	31.0	0.99	189	72.0	0.023	0.05	0.43	–
32	14.4	15.4	35.0	0.51	164	64.0	0.020	0.07	0.45	–
35	17.4	16.1	35.0	0.73	245	97.0	0.027	0.09	0.49	–
17	10.6	10.6	43.0	0.93	160	57.0	0.048	0.12	0.48	–
22	15.7	13.1	43.0	0.81	152	56.0	0.052	0.12	0.49	–
10	4.2	3.6	27.0	0.60	20	7.0	0.172	0.41	0.75	–
18	7.6	8.1	31.0	0.74	78	28.0	0.075	0.18	0.54	–
38	15.5	15.2	31.0	0.84	210	83.0	0.026	0.08	0.47	–

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m³/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
55	25.5	25.2	39.0	0.93	510.0	216.0	0.012	0.04	0.46	–
43	17.3	14.8	27.0	0.71	187.0	75.0	0.051	0.13	0.53	–
23	12.8	11.1	35.0	0.67	119.0	44.0	0.066	0.14	0.51	–
38	19.8	18.7	35.0	1.01	360.0	144.0	0.028	0.06	0.46	–
50	21.5	18.5	31.0	0.49	175.0	74.0	0.031	0.08	0.50	–
75	27.3	22.2	27.0	0.88	383.0	175.0	0.028	0.08	0.54	–
19	9.7	8.3	31.0	0.66	74.0	27.0	0.101	0.24	0.60	–
11	5.0	4.0	27.0	0.59	22.0	7.0	0.258	0.46	0.80	–
29	12.7	14.0	35.0	1.08	238.0	91.0	0.031	0.07	0.45	–
34	14.2	16.2	35.0	1.08	296.0	116.0	0.020	0.05	0.44	–
Pine plantations on sands in the Lower Dnieper areas (Lakida, 1994)[1]										
28	10.9	10.3	27.0	1.00	164.0	62.0	0.051	0.12	0.50	–
28	10.8	10.1	27.0	1.07	164.0	62.0	0.105	0.23	0.60	–
28	10.8	10.3	27.0	0.74	118.0	44.0	0.050	0.12	0.49	–
28	10.7	9.9	27.0	0.96	140.0	53.0	0.079	0.20	0.58	–
28	9.3	7.9	23.0	0.79	84.0	31.0	0.073	0.18	0.55	–
28	10.8	9.3	27.0	0.65	84.0	32.0	0.060	0.16	0.53	–
28	12.5	11.4	31.0	1.04	190.0	72.0	0.062	0.17	0.55	–
28	11.8	12.3	31.0	0.94	197.0	75.0	0.038	0.09	0.47	–
28	11.1	10.0	27.0	0.84	115.0	43.0	0.080	0.21	0.58	–
28	12.0	10.4	27.0	1.01	148.0	56.0	0.057	0.14	0.52	–
28	10.9	10.7	31.0	1.20	198.0	76.0	0.035	0.10	0.48	–
28	10.0	9.0	27.0	0.88	111.0	42.0	0.063	0.18	0.55	–
28	11.3	10.9	31.0	0.81	130.0	49.0	0.053	0.13	0.51	–
34	11.1	9.8	23.0	0.72	101.0	39.0	0.064	0.17	0.56	–
26	10.7	9.4	27.0	0.84	110.0	42.0	0.042	0.12	0.49	–
26	11.1	9.2	27.0	1.04	132.0	50.0	0.067	0.17	0.55	–
31	11.6	10.9	27.0	0.96	132.0	52.0	0.060	0.15	0.54	–
31	10.5	8.9	23.0	0.71	63.0	24.0	0.088	0.25	0.63	–
28	12.7	10.5	27.0	0.69	94.0	35.0	0.069	0.18	0.55	–
28	11.9	9.0	27.0	0.83	90.0	34.0	0.070	0.18	0.56	–
32	10.3	7.7	23.0	0.68	54.0	21.0	0.120	0.34	0.73	–
24	11.9	9.7	31.0	0.79	101.0	38.0	0.069	0.20	0.58	–
29	11.1	7.9	23.0	0.59	49.0	19.0	0.083	0.27	0.65	–
29	10.8	8.5	23.0	0.56	59.0	23.0	0.084	0.21	0.60	–
22	5.1	4.5	19.0	0.31	13.0	5.0	0.119	0.31	0.67	–
20	9.7	8.1	31.0	0.65	64.0	23.0	0.078	0.19	0.55	–
32	13.1	12.6	31.0	0.75	142.0	55.0	0.035	0.12	0.51	–
26	14.1	12.3	35.0	0.66	128.0	49.0	0.043	0.13	0.51	–
27	13.0	11.8	31.0	0.51	96.0	37.0	0.057	0.15	0.53	–
29	16.5	12.5	31.0	0.61	124.0	48.0	0.045	0.12	0.51	–
30	13.1	12.4	31.0	0.72	133.0	51.0	0.054	0.15	0.53	–
32	10.3	10.6	27.0	0.62	86.0	34.0	0.067	0.17	0.56	–
31	14.4	10.9	27.0	0.20	33.0	13.0	0.062	0.17	0.56	–
31	10.4	7.8	23.0	0.76	65.0	25.0	0.083	0.21	0.61	–
30	16.0	13.0	27.0	0.71	157.0	61.0	0.050	0.15	0.54	–
30	13.0	12.6	27.0	0.71	135.0	52.0	0.055	0.15	0.54	–
26	13.2	11.6	31.0	0.50	91.0	35.0	0.062	0.17	0.55	–
25	14.1	12.0	35.0	0.66	139.0	53.0	0.044	0.12	0.50	–
35	10.9	9.9	23.0	0.67	93.0	36.0	0.061	0.17	0.56	–
27	11.0	9.3	27.0	0.94	127.0	48.0	0.066	0.17	0.55	–

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m^3/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
68	20.0	12.5	19.0	0.81	174.0	75.0	0.038	0.12	0.55	–
65	26.5	21.2	31.0	0.90	452.0	203.0	0.025	0.10	0.55	–
65	21.5	11.2	19.0	0.78	142.0	62.0	0.055	0.16	0.60	–
32	10.3	7.8	23.0	0.63	50.0	20.0	0.096	0.25	0.64	–
24	11.9	9.8	31.0	0.73	97.0	37.0	0.065	0.17	0.55	–
30	11.2	8.0	23.0	0.58	48.0	18.0	0.091	0.24	0.62	–
29	10.8	8.7	23.0	0.51	56.0	22.0	0.074	0.20	0.58	–
22	5.2	4.6	19.0	0.30	12.0	4.0	0.131	0.31	0.67	–
18	5.2	4.6	23.0	0.37	15.0	5.0	0.136	0.35	0.70	–
31	10.7	8.4	23.0	0.55	58.0	23.0	0.075	0.20	0.59	–
29	10.9	7.7	23.0	0.59	49.0	19.0	0.087	0.23	0.61	–
23	11.8	9.5	31.0	0.83	103.0	40.0	0.064	0.17	0.54	–
31	10.2	7.6	23.0	0.70	55.0	21.0	0.097	0.27	0.66	–
				Spruce (Polovnikov, 1970)						
35	9.8	9.8	23.0	1.13	184.0	53.7	0.074	0.15	0.44	0.10
50	14.7	14.4	23.0	1.24	376.0	148.1	0.041	0.08	0.46	0.06
80	21.8	19.8	23.0	1.02	470.0	193.5	0.029	0.07	0.48	0.06
120	33.4	23.4	23.0	0.97	528.0	219.1	0.023	0.08	0.49	0.08
				Spruce plantations (Lakida, 1994)[1]						
90	38.5	36.5	43.0	0.78	778.0	305.0	0.018	0.04	0.44	–
64	35.0	31.4	43.0	0.78	734.0	258.0	0.015	0.04	0.39	–
30	21.7	19.1	43.0	0.83	372.0	121.0	0.045	–	–	–
38	24.8	22.9	43.0	0.99	575.0	188.0	0.038	0.10	0.42	–
82	48.3	36.0	43.0	0.76	742.0	281.0	0.016	0.04	0.41	–
70	34.6	32.6	43.0	0.67	682.0	245.0	0.011	0.03	0.39	–
45	26.6	25.3	43.0	0.81	537.0	178.0	0.023	0.05	0.38	–
82	33.2	30.9	35.0	0.71	679.0	257.0	0.025	0.06	0.44	–
68	32.0	29.0	39.0	0.87	741.0	264.0	0.014	0.03	0.39	–
32	17.0	18.4	39.0	0.71	338.0	110.0	0.046	0.11	0.44	–
32	15.5	17.8	39.0	0.77	310.0	101.0	0.061	0.13	0.46	–
16	7.6	6.3	31.0	0.5	32.0	11.0	0.353	0.75	1.08	–
28	10.8	11.9	31.0	1	219.0	71.0	0.053	0.12	0.44	–
33	10.1	9.6	23.0	1.43	187.0	61.0	0.077	0.17	0.50	–
30	8.3	7.9	23.0	1.4	162.0	53.0	0.079	0.20	0.53	–
104	46.4	38.6	43.0	0.56	556.0	234.0	0.035	0.09	0.51	–
20	6.7	7.8	27.0	0.67	63.0	21.0	0.117	0.24	0.57	–
33	10.4	12.2	31.0	0.75	196.0	63.0	0.059	0.12	0.44	–
35	13.3	13.9	31.0	0.72	212.0	69.0	0.034	0.08	0.41	–
17	4.3	3.8	19.0	0.82	27.0	9.0	0.256	0.48	0.81	–
26	10.8	10.6	31.0	0.77	142.0	46.0	0.078	0.16	0.49	–
33	13.8	16.3	35.0	0.94	374.0	122.0	0.035	0.08	0.41	–
35	14.7	17.2	35.0	1.06	419.0	136.0	0.03	0.06	0.39	–
31	12.2	12.2	31.0	0.96	207.0	67.0	0.064	0.14	0.46	–
12	6.0	5.1	31.0	0.45	23.0	8.0	0.408	0.62	0.96	–
19	6.9	6.2	27.0	0.72	52.0	17.0	0.258	0.41	0.74	–
11	3.7	3.1	27.0	0.42	9.0	3.0	0.718	1.15	1.50	–
17	5.8	4.8	23.0	0.41	20.0	7.0	0.382	0.61	0.95	–
22	9.1	8.9	31.0	0.66	93.0	30.0	0.173	0.29	0.61	–
42	23.0	21.3	39.0	0.94	511.0	168.0	0.034	0.08	0.41	–
135	39.5	31.2	31.0	0.83	649.0	323.0	0.024	0.06	0.56	–
41	20.4	21.8	35.0	0.71	403.0	132.0	0.034	0.07	0.40	–

	Average mean		Site		Growing		Ratio of phytomass components and growing stock			
Age (years)	Diameter (cm)	Height (m)	index (m)	Relative stocking	stock (m^3/ha)	Stemwood (t/ha)	Foliage	Crown	Above-ground	Below-ground
23	7.8	6.6	23.0	0.72	57.0	19.0	0.229	0.50	0.83	–
32	15.5	15.7	35.0	1.30	399.0	130.0	0.063	0.18	0.50	–
59	24.5	23.4	35.0	0.64	384.0	133.0	0.025	0.07	0.42	–
48	17.5	19.3	31.0	0.73	326.0	109.0	0.035	0.09	0.42	–
95	30.8	31.1	35.0	0.98	872.0	351.0	0.011	0.03	0.43	–
Oak plantations (Lakida, 1994)[1]										
74	26.5	20.8	27.0	0.60	422.0	221.0	0.004	0.06	0.58	–
27	11.0	11.2	31.0	0.86	96.0	54.0	0.020	0.19	0.75	–
49	20.2	18.0	31.0	1.01	300.0	169.0	0.011	0.12	0.69	–
44	20.6	18.2	31.0	1.05	310.0	177.0	0.008	0.12	0.69	–
39	13.9	13.6	27.0	0.79	143.0	81.0	0.012	0.14	0.70	–
17	5.3	7.1	31.0	0.96	69.0	38.0	0.021	0.14	0.68	–
9	2.4	3.1	27.0	1.47	17.0	9.0	0.135	0.28	0.79	–
28	15.2	14.7	35.0	0.88	176.0	101.0	0.044	0.20	0.78	–
19	4.8	6.8	27.0	0.83	46.0	26.0	0.048	0.14	0.70	–
46	24.7	19.6	35.0	0.69	201.0	112.0	0.027	0.15	0.71	–
15	6.2	8.1	35.0	0.98	79.0	43.0	0.038	0.10	0.64	–
39	17.9	17.7	35.0	0.87	198.0	115.0	0.027	0.15	0.73	–
46	22.1	19.6	35.0	0.75	238.0	136.0	0.019	0.13	0.70	–
28	13.4	14.9	35.0	0.76	159.0	91.0	0.031	0.13	0.70	–
24	6.7	7.3	27.0	0.52	35.0	20.0	0.052	0.31	0.89	–
29	10.1	11.2	31.0	0.57	60.0	35.0	0.028	0.25	0.83	–
29	8.2	8.4	23.0	0.49	35.0	21.0	0.030	0.27	0.85	–
15	4.3	5.0	27.0	0.29	9.0	5.0	0.058	0.34	0.86	–
17	6.9	8.3	35.0	0.93	15.0	8.0	0.042	0.17	0.72	–
22	5.1	6.7	23.0	0.81	7.0	4.0	0.048	0.22	0.78	–
11	4.6	5.1	35.0	0.42	11.0	6.0	0.084	0.33	0.85	–
14	4.2	4.6	27.0	0.46	11.0	6.0	0.113	0.32	0.86	–
23	12.3	13.2	39.0	0.41	66.0	38.0	0.023	0.19	0.77	–
28	14.2	13.8	35.0	0.67	117.0	68.0	0.030	0.24	0.82	–
34	18.0	16.0	35.0	0.87	199.0	117.0	0.016	0.14	0.73	–
35	18.1	17.8	35.0	0.70	193.0	113.0	0.008	0.07	0.65	–
42	16.7	14.3	27.0	0.62	121.0	69.0	0.023	0.15	0.73	–
48	28.5	19.5	31.0	0.99	265.0	152.0	0.010	0.19	0.77	–
17	9.0	7.1	31.0	0.84	40.0	22.0	0.038	0.19	0.75	–
62	14.9	16.4	27.0	1.26	312.0	173.0	0.018	0.09	0.65	–
27	11.8	10.2	27.0	1.22	126.0	73.0	0.020	0.09	0.67	–
44	19.5	17.9	31.0	1.34	413.0	238.0	0.013	0.09	0.66	–
Beech (Odinak and Borsuk, 1977)										
21	5.2	8.9	31.0	0.77	97.0	51.0	0.024	0.160	0.69	–
Beech (Lakida, 1994)[1]										
62	19.2	19.8	27.0	1.31	435.0	266.0	0.009	0.10	0.72	–
63	25.3	25.7	35.0	1.12	438.0	268.0	0.010	0.19	0.80	–
45	16.7	21.3	35.0	0.93	342.0	212.0	0.010	0.10	0.72	–
31	12.1	14.7	35.0	1.09	218.0	133.0	0.023	0.17	0.78	–
21	8.8	9.8	35.0	0.84	94.0	55.0	0.056	0.37	0.95	–
51	21.4	23.1	35.0	0.95	340.0	211.0	0.013	0.17	0.79	–
11	1.9	3.5	27.0	1.64	36.0	19.0	0.155	0.39	0.91	–
18	6.5	9.3	35.0	0.74	83.0	47.0	0.051	0.24	0.81	–
22	6.6	10.1	35.0	1.00	99.0	58.0	0.032	0.17	0.76	–

Age (years)	Average mean Diameter (cm)	Average mean Height (m)	Site index (m)	Relative stocking	Growing stock (m^3/ha)	Stemwood (t/ha)	Ratio of phytomass components and growing stock: Foliage	Crown	Above-ground	Below-ground
25	8.7	13.2	35.0	0.84	165.0	98.0	0.023	0.13	0.73	–
10	5.7	6.6	39.0	0.62	41.0	21.0	0.057	0.23	0.75	–
20	8.7	11.4	39.0	0.85	119.0	69.0	0.024	0.11	0.69	–
32	14.4	15.3	35.0	0.74	163.0	100.0	0.011	0.07	0.68	–
38	16.9	17.1	35.0	0.69	203.0	125.0	0.014	0.10	0.72	–
41	17.1	18.3	35.0	0.72	236.0	146.0	0.013	0.09	0.71	–
45	17.7	19.5	35.0	0.89	314.0	195.0	0.010	0.08	0.70	–
51	18.7	21.0	35.0	0.85	314.0	194.0	0.014	0.09	0.71	–
				Hornbeam (Odinak *et al.*, 1987)						
36	9.6	13.6	31.0	1.18	158.0	105.4	0.018	0.15	0.82	0.22
50	13.5	17.6	31.0	0.64	143.0	100.3	0.019	0.17	0.87	0.21
				Birch (Lakida, 1994)[1]						
29	15.1	17.1	39.0	0.66	138.0	73.0	0.016	0.09	0.62	–
20	7.7	10.7	35.0	0.69	77.0	41.0	0.029	0.17	0.70	–
12	3.4	7.3	39.0	0.55	39.0	21.0	0.032	0.20	0.73	–
23	13.2	15.0	43.0	0.78	133.0	71.0	0.015	0.09	0.63	–
23	8.9	13.4	39.0	0.50	88.0	47.0	0.017	0.09	0.62	–
35	18.7	19.4	39.0	0.81	202.0	107.0	0.01	0.06	0.59	–
23	16.4	18.4	47.0	0.94	214.0	114.0	0.012	0.08	0.61	–
11	4.1	7.0	39.0	0.50	31.0	17.0	0.020	0.14	0.68	–
				Moldova						
				Oak (Lazu, 1970)						
93	39.2	22.8	27.0	–	131.0	77.0	0.015	0.17	0.76	–
				Hornbeam (Lazu, 1970)						
63	18.0	15.7	27.0	–	194.0	113.0	0.031	0.41	0.99	–
				Linden (Lazu, 1970)						
71	19.0	18.5	27.0	–	165.0	98.0	0.015	0.12	0.72	–
				Georgia						
				Pine (Darakhvelidze, 1975)						
105	–	–	–	0.77	168.0	101.4	0.023	0.11	0.71	–
118	–	–	–	0.76	144.0	89.8	0.024	0.12	0.74	–
148	–	–	–	0.97	601.0	46.9	0.015	0.15	0.93	–
				Spruce (Darakhvelidze, 1975)						
88	–	–	–	0.87	172.0	149.2	0.051	0.14	1.01	–
65	–	–	–	0.87	100.0	52.9	0.069	0.15	0.68	–
92	–	–	–	0.84	91.0	63.7	0.055	0.13	0.83	–
106	–	–	–	0.84	107.0	67.9	0.073	0.12	0.76	–
187	–	–	–	0.87	346.0	253.1	0.051	0.13	0.86	–
86	–	–	–	0.87	2.0	1.7	0.058	0.10	0.95	–

[1] Material from unpublished manuscripts by Lakida.

Appendix II

The wood density of the major species of the European part of the former USSR (except Russia). Source: Polubojarinov, 1976.

Wood species	*Latin name*	*Region of growth*	*Density, kg/m³*
Pine	*Pinus silvestris*	Latvia	415
		Lithuania	405
		Belarus	456
		Ukraine	428
Spruce	*Picea exelsa*	Lithuania	366
		Belarus	363
		Ukraine	342
Fir	*Abies alba*	Ukraine	342
Oak	*Quercus robur*	Latvia	532
		Belarus	564
		Ukraine	580
		Georgia	484
		Azerbaijan	582
Beech	*Fagus silvatica*	Ukraine	
		– Lvov region	563
		– Carpathian	525
		Armenia	517
		Azerbaijan	556
Ash	*Fraxinus exelsior*	Latvia	540
		Belarus	540
		Ukraine	580
Maple	*Acer platanoides*	Belarus	548
		Ukraine	548
Linde	*Tilia cordata*	European part	378
	Tilia platyphyllos	Azerbaijan	394
Hornbeam	*Carpinus betulus*	Belarus	626
		Ukraine	626
		Armenia	602
	Carpinus caucasica	Azerbaijan	664
		Armenia	582
Elm	*Ulmus scabra*	Ukraine	548
		Azerbaijan	595
	Ulmus laevis	European part	436
Aspen	*Populus tremula*	Latvia	381
		Belarus	397
		Ukraine	420
		Armenia	422
Alder	*Alnus glutinosa*	Latvia	421
		Lithuania	421
		Belarus	421
		Ukraine	429
	Alnus incana	European part	363

Wood species	*Latin name*	*Region of growth*	*Density, kg/m³*
Birch	*Betula pendula and*	Estonia	503
	Betula pubescens	Latvia	530
		Belarus	479
		Ukraine	509
Poplar	*Populus alba*	European part	334
	Populus pyramidalis	Armenia	381
	Populus nigra	European part	373
		Ukraine	429
Willow	*Salix alba*	European part	334
	Salix fragilis	Ukraine	389