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Foreword

This is the time 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 has now moved 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, is a contribution to the analyses of the topic of greenhouse gas balances. The methodology developed in this paper for phytomass estimates in Ukraine has also been employed in estimating phytomasses in Siberia and Russia.

Contents

1 Introduction

In order to manage the forest resources of Ukraine in a sustainable manner a number of problems have to be solved. The solutions have to be based on both economic and environmental functions of the resources. Estimates on the roundwood production in Ukraine exist and are of rather high quality but the research on biomass has so far been fragmentary. On this item there is also a lack of consistant scientific approaches for the analyses. The work in this report has as an objective to present such a scientific approach and employ the same on experimental data in order to estimate the major phytomass parameters for the major forest species of Ukraine.

2 Background and Definitions

The forested area of Ukraine is 8.6 million ha. The forests cover 14.3 percent of the land surface. However, the forest cover varies a lot between different regions of Ukraine. In the Carpathians it reaches 40.2 percent and in the steppe region only 4.0 percent. The productivity, expressed as annual increment, is 4.2 m^3 per ha and year. The forests of Ukraine are dominated by young forests and the average age is 45 years.

In order to solve a number of ecological problems in Ukraine a new demand on phytomass estimates has been raised in Ukraine quite recently. Some initial investigations in this field were conducted by Ukrainian biologists and foresters in the 1970s within the so-called International Biological Program and by Polovnikov (1970), Golubets (1978), Golubets and Polovnikov (1975), Mjakushko (1978), Chernjavsky (1979) and Sirik (1991). However, this research did not aim at generating estimates of different phytomass components. The data collected were of a descriptive nature.

A series of research based on experimental data has recently been carried out in Ukraine (Koziakov, 1984; Lakida, 1988 and 1990; Polovnikov and Pitikin, 1982; and Telishevsky, 1986). The mentioned work aims at estimates of the amounts of twigs, needles, and bark for different species. However, the work is fragmentary and the calculations are based on different methodologies.

The work in this report is based on experimental data from four major forest species in Ukraine: pine (natural stands and plantations in Polesje and plantations in the forest-steppe region and in the Lower Dnieper Sands), spruce (plantations in Carpathia), oak (plantations in the forest-steppe region and in Polesje) and beech (natural stands in Carpathia). The sample of experimental data corresponds to some 75 percent of the major forest species distribution in Ukraine.

Prior to the description of the analytical approaches employed some definitions will be introduced. In this work we have followed the definitions employed by Bazilevich (1993).

Phytomass: is a living organic plant substance aboveground and belowground of a forest stand with a division into the following components:

- the green assimilative components
- the stemwood
- the stembark
- the wood of the crown
- the bark of the crown

- the belowground components

  The components are measured in ton dry matter per ha.

Mortality mass: is a dead vegetative organic substance, including dead stems, dry branches in the crown, litter and dead belowground substances. It is measured in ton dry matter per ha.

Production: is the annual produced vegetative substance with a division into:

- the green assimilative organisms (leaves and needles)
- the stemwood
- the bark of the stem
- the wood of the crown
- the bark of the crown
- the belowground substances

  It is measured in ton dry matter per ha.

In order to clarify the methodology used some additional definitions are required:

Twigs: are small-sized shoots from the crown or stem of diameter size of up to 1 cm. Twigs as a phytomass component includes both the assimilative components and the woody part.

Small-sized branches: are living shoots from the crown.

Dead branches: are dry branches located on the stem or in the crown.

Stem phytomass: is the mass of the stem over bark.

Crown phytomass: is the total mass of the living branches of the crown over bark. The generative parts and fruits are in this case included in the category twigs.

The following qualitative parameters for the phytomass fractions have been used:

Raw density: is the ratio of the mass and volumes in raw state, expressed in kg per m^3.

Basic density: is the ratio between the mass in absolute dry state and the volume in the raw state, expressed in kg per m^3.

Absolute dry matter: is the ratio between the mass in absolute dry state and the mass in a raw state, expressed in kg per kg.

3 Methodologies for Phytomass Estimation

Up-to-date methodologies for estimation of the phytomass of trees can be divided into several different approaches:

1. Direct weighing of phytomass fractions of the trees in the forests (Rodin *et al.*, 1968; Semechkina, 1978; Utkin, 1975; and Usoltsev, 1985). This method is rather simple from a technical point of view but labor-consuming. The results obtained are mainly of a descriptive nature.
2. Determination of volumetric parameters for stems and branches with subsequent calculations of mass units by employing density values for wood and bark (Babich, 1989; Gagoschidze, 1983; Gusev and Sokolov, 1973; Dzebisashvili and Aptsiauri, 1988; and Uspensky, 1982). This method is less labor-consuming and allows to combine the results of the phytomass estimation directly with forest inventory information.
3. A combination of methodologies 1 and 2 (Pozdnjakov *et al.*, 1969; Lakida, 1989; Tokmurzin, 1977; Aldred and Alemdag, 1988). As a rule, the stem phytomass components and big branches are estimated in volumetric units with subsequent calculation of the data of mass units by employing density values for wood and bark. The small-sized branches and assimilation organs are usually weighed. Samples of specific phytomass fractions are collected for estimation of the density and extent of absolute dry matter.
4. Employment of pipe models for the estimation of the phytomass for the crowns (Shinozaki *et al.*, 1964; Usoltsev, 1993; Utkin *et al.*, 1988). The employment of the pipe-model theory has its limitations. It is less suitable for estimation of phytomass fractions of a stand, which has been illustrated by Utkin *et al.* (1988) and Usoltsev (1993).
5. Employment of air-space methodologies for the estimation of the aboveground forest phytomass (Danilin, 1993). These methods are rather new and are uncertain and generate rather big uncertainties in the estimations.
6. Analysis of data collected by other studies (Uspensky, 1982; Bazilevich, 1993). This method has been employed in countries and regions where experimental data on bioproductivity have been collected earlier. This approach is normally used for regional and global estimates of forest biomasses.

An important methodological issue concerning stand phytomass estimation is the method for selection and collection of samples of phytomass from sample trees of the sample plots. For determination of the samples at the different levels, different methods have been employed (Gorbatenko and Protopopov, 1971; Makarenko, 1982 and 1985; Utkin, 1975; Utkin *et al.*, 1988; Semechkina, 1978; Usoltsev, 1984; Hase *et al.*, 1985; Babich, 1989; Babich and Vasiljev, 1992).

The result from the above references concerning the sample approach is that the usage of the average tree approach in the samples is not recommended. The average tree of a stand approach has been recommended by Rodin *et al.* (1968). Serious criticism of the average tree approach has been raised by Utkin (1986). The inaccuracy of the average tree method is experimentally confirmed by Atkin (1974) and Babich (1989). They show a systematic error in the estimates of the phytomass of the pine crowns of –9 to –19 percent by using the average tree approach. The reason for the underestimate by the average three approach is the wide distributions of stem diameters and volumes

of crowns in the existing stands (Semechkina, 1978). The sample method recommended is the so-called step-proportional sample approach.

The design of the sample technique is also heavily dependent on the objective of the study carried out concerning the phytomass estimation. It can also be concluded from earlier studies that a good accuracy for a number of stands at a limited scale does not guarantee similar accuracy for large regions. Forest inventory and survey approaches have reached a kind of consensus concerning the approach to use for estimation of the stemwood of the growing stock. Similar consensus does not exist concerning bioproductivity and phytomass estimation.

An additional problem is connected with the statistical and mathematical analyses of the collected data. Currently, three major approaches are used:

1. Graphical analyses of paired connections (Ievin and Dikelson, 1962; Molchanov, 1972; and Smirnov, 1971).
2. Multiple regression analyses (Satoo and Madgwick, 1982; Smoljanov, 1985; Usoltsev, 1985; Utkin *et al.*, 1987; Yarie and Mead, 1989).
3. Other applied mathematical methods are:
   - simulation (Mirkin and Rozenberg, 1978; and Rozenberg, 1984)
   - grouped registration of arguments
   - biophysical analyses (Gutman and Uspensky, 1987).

The geographical analytical approach can, to a large extent, be regarded as obsolete today. Concerning the development of multiple regression analyses a crucial task is the design of the regression model. The design of the model must correspond to a biological process underlying the formation of the phytomass. Unfortunately, many of the developed phytomass regression models have not taken these problems into account.

Very often regression analyses are used to estimate the phytomass for larger regions based on a limited sample (Utkin, 1982; Rojdestvensky *et al.*, 1985). Another limitation in regression analyses used so far is the use of only one argument in the equation, namely the diameter at breast height (Gusev and Sokolov, 1973; Lemke, 1983; Babich, 1989; Kadeba, 1991). Such approach may lead to biased results due to the fact that the phytomass development is dependent on several parameters. Even if multiple arguments are used, the arguments used can be mutually correlated (Usoltsev, 1985 and 1988; Punko, 1993). A recurrent system of regression equations can be used where the recurrent system represents a broken down multidimensional dependence (Usoltsev, 1988; Gulbe *et al.*, 1991). In most analyses, the volumes of tree functions are considered as a function of diameter and height of the tree (Spank, 1982; Georgiev, 1984; Petras *et al.*, 1985; Harding and Grigal, 1985; Rodnjansky and Smoljanov, 1992).

The accuracy of the estimates is also dependent on the type of mathematical function used. Paraboles of second and third orders (Babich, 1989; Utkin *et al.*, 1988) and allometric dependencies (Spank, 1982; Harding and Grigal, 1985; and Lakida, 1989) are frequently recommended. The latter form seems to be most attractive as it reflects the biological processes better and does not require left-hand restrictions and are easy to interpret. In most of the current phytomass estimates, based on regression models, there is a lack of descriptions of the growing conditions of the stands analyzed. The general growing conditions are important for the development of the tree crowns.

Analyses by other applications of applied mathematics (simulation and biophysical models) aim at describing the dynamics of the biological productivity. These methods can be used to simulate the biological productivity of stands and growth functions.

Currently, there are difficulties to judge the applicability of these approaches to entire phytomass estimates. The simulation of biological productivity of stands requires data on changes in density and contents of absolute dry matter in wood and bark over time. The density parameters normally collected in wood science, which can be used in ecological research, are natural and conditional densities (GOST 16483, 1–84). As shown by Semechkina (1978), volumes of freshly harvested and moisture-saturated samples are practically identical. For the bark fraction the maximal moisture saturation of fibers has not yet been quantified. For phytomass estimation, the values for the average conditional density of wood and bark of stems are of special importance, as the multiplication of volume by conditional density parameters gives the mass of the absolute dry matter. These parameters have been studied by several scientists (Poluboyarinov, 1976; Isaieva, 1978; Uspensky, 1980; Smoljanov, 1980; Usoltsev, 1983; Jakovleva, 1991; Lakida and Juditsky, 1993; Giefing and Jablonski, 1989).

The general approach has been to describe the biological productivity of stands over age distributions. This approach is based on the development of traditional yield tables, concerning stemwood development. A lot of research has been carried out during the last 100 years following this concept. But concerning the development of the different components of phytomass, research efforts have been made first during the last 20 years (Ivanchikov, 1971; Tokmurzin and Nurpeisov, 1976; Usoltsev, 1988; Lakida, 1986; Dimitrov, 1984; Bisch, 1987). Estimates on the dynamics of phytomass in the form of bioproductivity tables, average extent and changes of phytomass fractions, and annual production figures are presented by Ivanchikov (1974). In some cases the above discussed technique has been misused by combining the dynamics of the phytomass from one region with yield tables from other regions, where the biological conditions are quite different (Usoltsev, 1988).

4 Methodology used in this work

The objects of the analyses in this work have been individual trees and stands for different species divided on origins (natural versus plantation) and for different geographical locations (Lakida, 1990). The analytical scheme used in the analyses is presented in *Figure 1* and the scheme is based on a simulation approach. The simulation approach includes the following steps:

A. Simulation of aboveground phytomass parameters for stands based on single tree information and for the removed parts of stands (thinnings).
B. Simulation of the diameter distribution within stands and removed parts by employment of the Weibull function.
C. Based on tree phytomass models, diameter distributions within stands and normal stocking information (Strochinsky *et al.*, 1991), the static phytomass parameters are calculated.
C. The dynamics of biological productivity is estimated with the help of inventory information from fully stocked stands (Shvidenko, 1987), forest management programs (Strochinsky *et al.*, 1991), and different models for phytomass parameter estimation.

The above scheme is different from systems used earlier (such as Rodin *et al.*, 1968; Utkin, 1975). In this case the whole complex of phytomass parameters is calculated on a uniform basis, namely, in the form of phytomass models of trees.

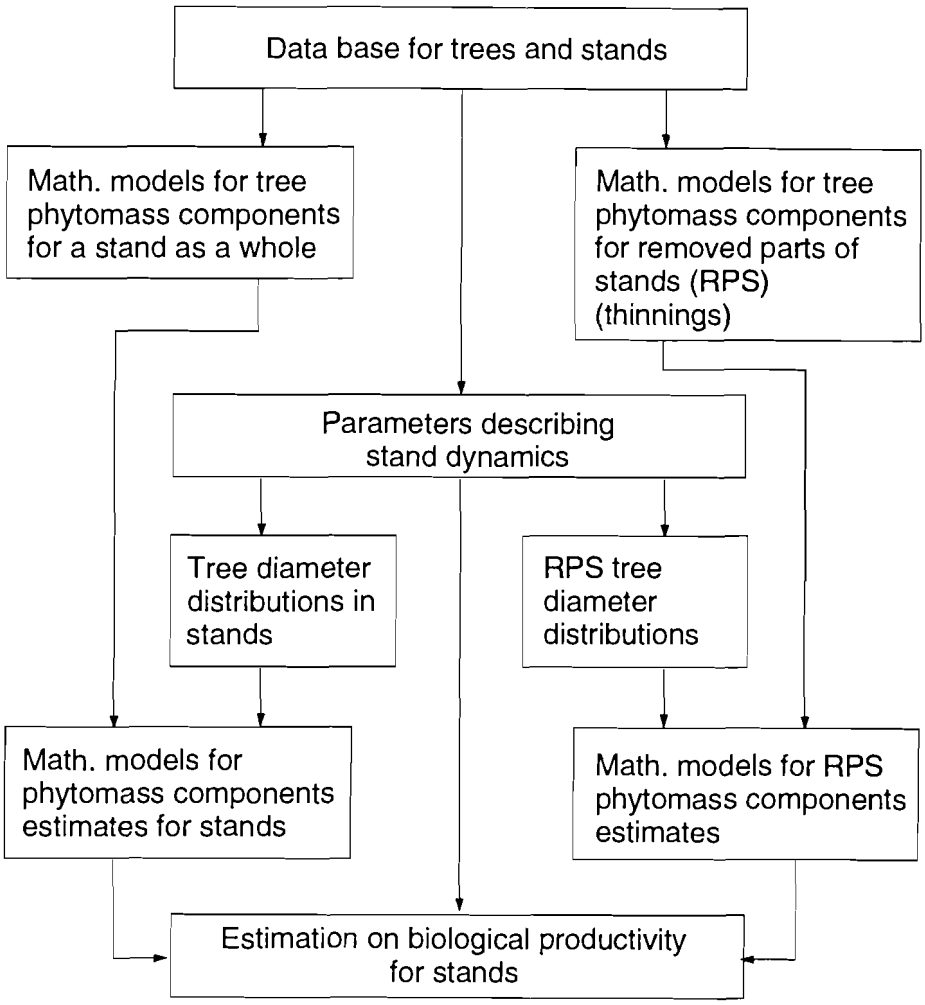

Figure 1. Analytical scheme for estimates of biological productivity.

4.1 Field data collection

The procedure for the field data collection has been the following:

A. Sample plots are sampled in the prevailing types of forest stands with a maximum range of age and growing stock. (The characteristics of the sample plots are described in Appendix 1.)
B. The breast-height diameter is measured for all trees in the sample (with a separation of layers and species). The measures are made in 1, 2, respectively 4 cm classes depending on the average stand diameter.
C. Exact diameters and heights for 3–12 trees of each tree layer and species are measured. These measurements are the basis for the generation of the height curve over diameter.
D. The selection of model trees is made on the basis of a proportional diameter representation of the trees (see A). For single species stands the sample is 3–15 trees and 3–5 trees in mixed stands.
E. Two perpendicular diameters of the crown of the model trees are measured.
F. At the felling and cutting of the model trees, the following measurements are taken:

- the length of the stem (measured from the stump)
- the height of the stump
- the length of the branchless part of the stem
- the age of the tree
- the increment of the height during the last 10 years
- the diameter over bark, the thickness of the bark and the diameter increment during the last 10 years at stump, and at sections of the tree. The length of the sections varied between 0.5–2.0 m depending on the length of the stem.
- For each model tree, the twigs and branches less than 3 m of length are weighed. For branches longer than 3 m the length, diameter over bark and thickness of bark are measured. The thickness of the bark is measured at the bottom, middle and top of the branch length. Branches with a length over 8 m are divided into two sections and length, diameter over bark, and thickness of the bark are measured at the bottom and middle of each section.

G. For estimation of the density parameters for wood, bark, branches, and for the estimation of needle and leave contents, the following samples are made:

- disk cuts (2–3 cm thick) of the stem are made at the bottom, at the breast height, and at the following relative heights of the stem: 0.1 h, 0.25 h, 0.5 h, and 0.75 h.
- random selection of model branches from the bottom, middle, and top layers of the crown are made for the estimation of needle, leave, and twig contents
- disk cuts (2–3 cm thick) are made from living branches with different lengths and from different layers of the crown. A similar procedure is adopted for dead branches from the bottom of the crown.

The selected samples are marked, packed into moisture-proof sacks and sent to the laboratory for further analysis. The field data have been collected during the period 1982–1993 throughout Ukraine. The extent of collected field data is presented in *Table 1.*

Table 1. Basic data collection.

Wood species, origin, region	Number of sample plots	Number of model trees	
		Total	With phytomass estimates
Pine plantations in Polesje and the forest-steppe	111	1404	609
Pine plantations in the Lower Dnieper Sands	53	420	160
Natural stands of pine in Polesje	26	349	164
Spruce plantations in Carpathia	37	368	226
Oak plantations in the forest-steppe and Polesje	32	219	213
Natural stands of beech in Carpathia	17	167	167
Total	276	2927	1539

4.2 Laboratory measurements

For estimation of the density parameters of wood, bark, and branches of the model trees a special technique is employed (Lakida, 1993).

The basal area, volume over and under bark of each disk (in fresh-cut condition) is measured by using a special radial grid tool. This tool is made in the form of a circle of transparent glass, which is divided into 18 sectors. Fixed to the center of the circular tool is a rotating measuring ruler, made of the same material. The grid tool is placed on the collected disk cuts and the radiuses are measured over and under bark. The results of the measurements are recorded on a special form. The diameter is measured in four different perpendicular directions. The volume of the disk cut (over and under bark) is calculated as the sum of volumes of sectors by the following formula:

$$V = \frac{\pi}{18} \sum_{i=1}^{18} {r_i}^2 t_i \quad , \tag{1}$$

where V is the volume of the disk cut; r_i is the length of the ith size of a sector; and t_i is the thickness of the disk cut within the ith sector.

The mass of wood and bark is estimated in fresh condition and in the form of absolutely dry wood and bark. For the estimation of leave or needle content the branches are weighed with leaves or needles and the weighing is repeated without leaves or needles.

For the estimation of the dry matter content of leaves and needles 3–5 samples from each tree of 20 g each are prepared. Each sample is express-dried for 25–30 minutes at a temperature of +105°C. After the drying the weighing of the samples is repeated. The results of the field and laboratory measurements are recorded in special forms and are processed with the help of special computer programs:

- DERTA – is a program for processing the data from the sample plots of the stands. The results of the calculations are stand volumes and volumes and increments for the so-called model trees.
- ZRIZ – is a program for calculation of the volumes over and under bark for the disk cuts from stems and branches.
- GIL – is a program for calculation of the volumes of branches of less than 8 m length. The volumes are calculated over and under bark with the help of Simpson's formula.
- PAS – is a program for calculation of the volumes of branches of more than 8 m length. The volumes are calculated over and under bark with the help of Simpson's formula.
- WEIB – is a program for calculation of the a, b, c parameters in the Weibull function for the stand diameter distribution.

5 Models for Estimation of the Wood Density by Dominant Species in Ukraine

Simulation of the biological productivity of major species in Ukraine have earlier been carried out by Poluboyarinov (1976), Savich *et al.* (1978), and Biley and Vintoniv (1983). These studies employed different techniques and in most cases data for stembark and crown fractions were missing.

In this study models for stemwood and bark density were developed based on data of sample disks from 97 model trees (33 from pine plantations, 18 from spruce plantations,

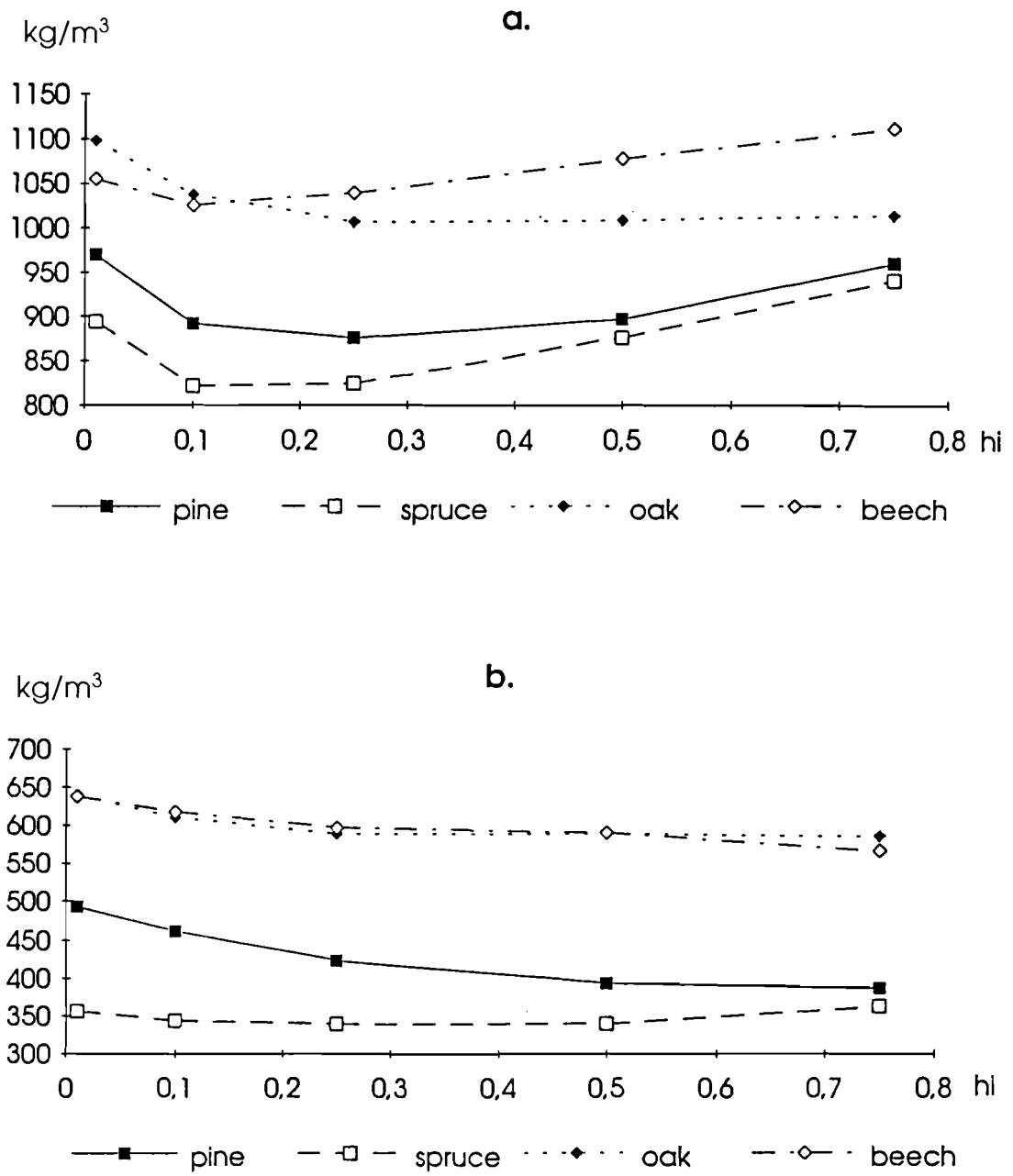

Figure 2. Dependency of wood (a = fresh, b = dry) density over tree length for different species.

30 from oak plantations, and 16 from natural beech stands). The modeling of the wood and bark density was carried out with two different tasks in mind:

- to describe the variation of the densities over the tree length; and
- to estimate the average density for stemwood, bark, and crown branches of individual species.

The analyses of the variation of the densities along the tree length were carried out in order to use the results for the estimation of the average tree density.

Figures 2 and *3* illustrate the natural (a) and dry (b) densities for stemwood and bark of the different species and the dependence of the densities of the tree length. The dry density of wood for pine, oak, and beech gradually decreases from the bottom to the top of the tree. But for spruce the density is following a hyperbolic function with the

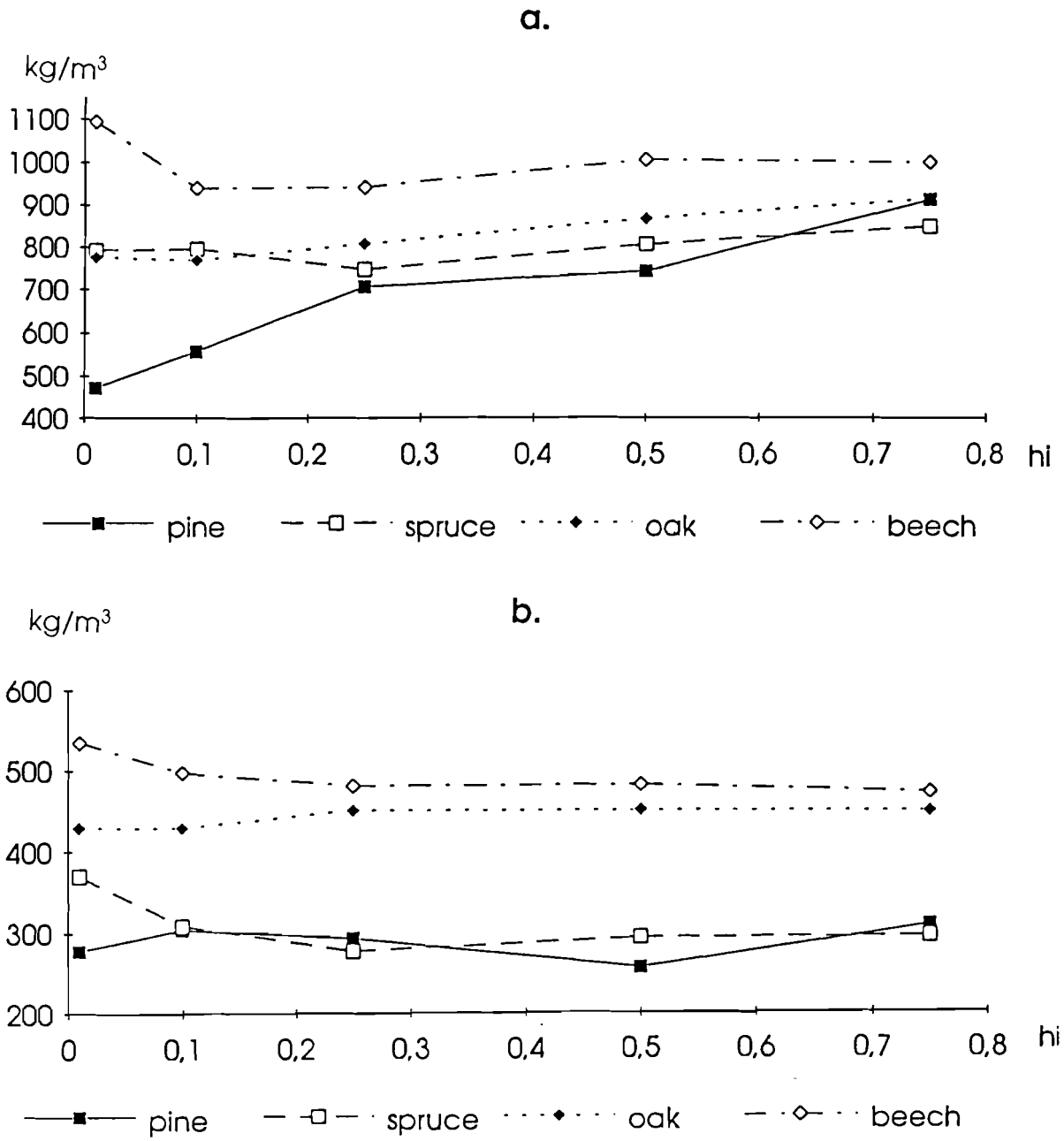

Figure 3. Dependency of bark (a = fresh, b = dry) density over tree length for different species.

minimum value at the middle of the stem. Similar results have earlier been presented by Poluboyarinov (1976) for spruce.

The density of bark follows a similar pattern as for density of stemwood concerning the dependence of the tree length. The deviations of the wood and bark estimates are less in the absolute dry conditions in comparison with the fresh conditions. The estimation of the average densities of stemwood and bark was conducted by the help of the computer program PLOT based on the sample densities and relative heights estimated according to the technique developed by Lakida and Juditsky (1993). The platform for these calculations is the average density (natural and dry) of stemwood and bark based on

Table 2. Average wood and bark density for stemwood.

	Density ($p \pm m_p$), km/m^3				
	Fresh condition			Dry condition	
Species	Wood	Bark	Wood+bark	Wood	Bark
Pine	909±12	578±16	876±10	427± 8	277± 6
Spruce	849±20	779±16	833±16	346± 8	299±11
Oak	1031±10	819±13	985± 9	602± 6	436± 6
Beech	1054±17	983±38	1038±19	603±12	486±27

relation of the integrals for masses and volumes. Thus, the estimation of the average density of the stem phytomass components is calculated according to function (2):

$$p = \frac{7p_0d_0^2 + 32p_{0.25}d_{0.25}^2 + 12p_{0.5}d_{0.5}^2 + 32p_{0.75}d_{0.75}^2}{7d_0^2 + 32d_{0.25}^2 + 12d_{0.5}^2 + 32d_{0.75}^2} \tag{2}$$

where p is the average density of a stem phytomass component; $p_0, \ldots, p_{0.75}$ is the density of a stem phytomass component on the relative heights of $0h, \ldots, 0.75h$; and $d_0, \ldots, d_{0.75}$ is the stem diameter on the relative heights of $0h, \ldots, 0.75h$.

For statistical analysis of the average density parameters by regression models the following dependent parameters of the model trees were employed: age (a), breast-height diameter (d), height (h). The analyses were conducted by the computer program REGALA (Shvidenko and Juditsky, 1983). The statistical processing resulted in estimates on the average densities of stemwood and bark in fresh and absolute dry conditions (*Table 2*). For fresh conditions also the average density of stemwood over bark was calculated. This latter measure has been used as a help parameter to estimate the average densities for stemwood and bark, and to estimate the weight of the stemwood.

Several regression analyses for the average density of phytomass components were carried out for the general inventory information. It can be concluded that the dry density of wood is most dependent on the tree age. However, the developed equations have a rather low statistical significance. The average dry density for stemwood is most adequately described by equation (3):

$$p_{d1} = a^{A_1} * \exp(A_0 + A_2 * a) \ , \tag{3}$$

where a is age of tree, number of years; and A_0, A_1, A_2 are coefficients of equations.

Table 3 illustrates the estimated parameters for equation (3) and the estimate on average dry density for stemwood over ages between 10 and 80 years. There is a variation of the dry density of wood with the geographical location. Uspensky (1980) studied the wood density for pine and found a tendency for decreasing density from the west to the east.

In *Figure 4*, the dry wood density for pine over age is presented. The results presented in *Figure 4* correspond well with the results presented by Uspensky (1980).

Regression analyses for estimation of the densities of the different stem phytomass components over age and wood density at breast height were carried out. Equation (4) and the estimated parameters (*Table 4*) were used to estimate the average dry density of stemwood for different species. Equation (4) employs age and the dry density of stem wood at the height of 1.3 m ($P_{di(1.3)}$).

$$p_{d1} = \exp(A_0 + A_1 * a)a^{A_2}p_{d1(1.3)}^{A_3} \ . \tag{4}$$

Table 3. Estimation of equation (3) parameters and dry mean wood density over age.

Equation parameters and age	Species			
	Pine	Spruce	Oak	Beech
	Coefficients			
A_0	5.620	6.374	5.836	5.737
A_1	0.097	−0.234	0.237	0.250
A_2	0.016	0.007	−0.007	−0.005
Q	0.75	0.89	0.51	0.66
	Dry mean wood density, kg/m^3			
10	350	368	549	522
20	380	337	602	588
30	402	329	616	616
40	420	331	612	627
50	436	338	600	627
60	451	349	582	622
70	465	362	561	612
80	478	377	538	599

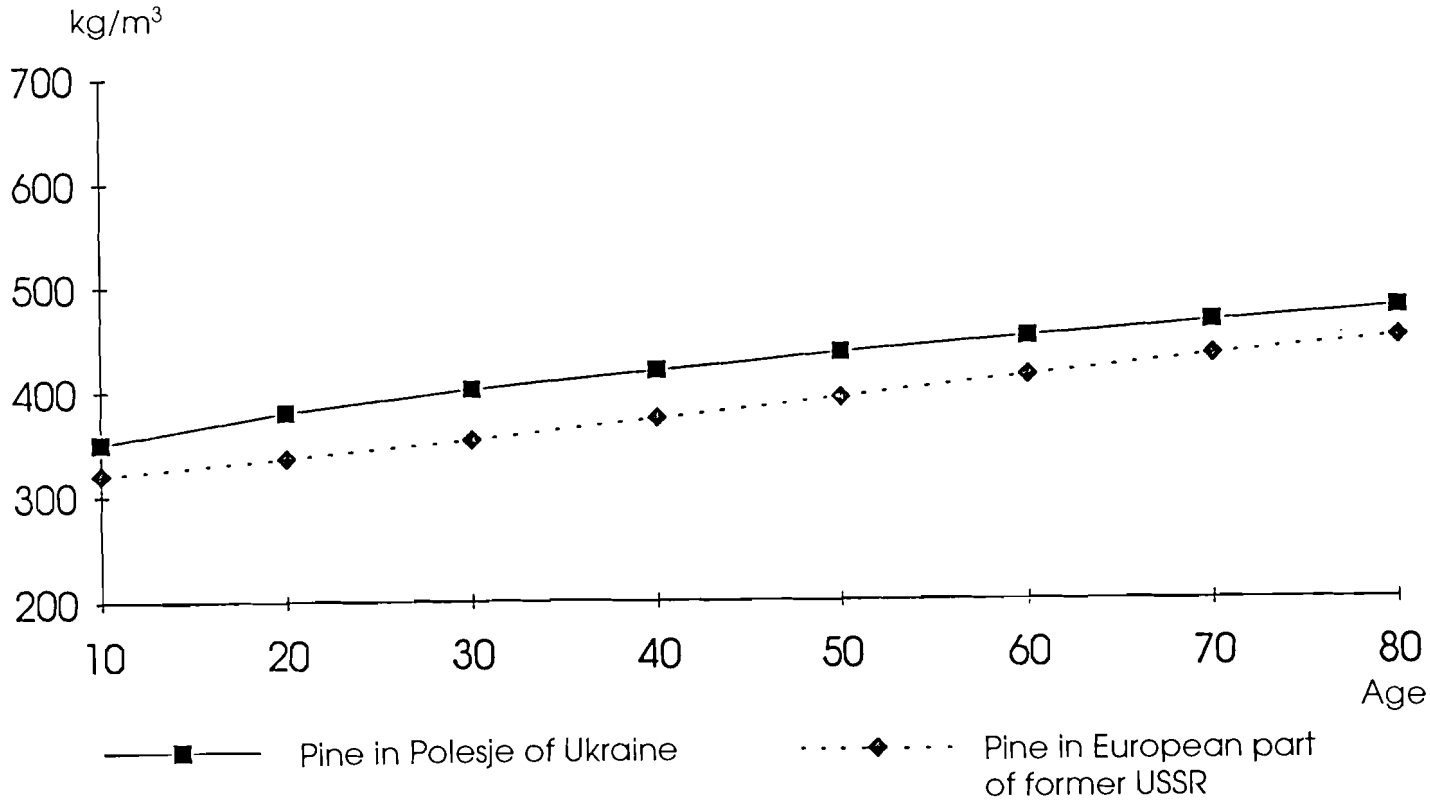

Figure 4. Dry mean wood density for pine over age.

Table 4. Estimation of equation (4) parameters.

	Coefficients				
Species	A_0	A_1	A_2	A_3	Q
Pine	1.948	0.003	−0.110	0.711	0.90
Spruce	3.098	0.003	−0.116	0.516	0.96
Oak	2.227	−0.005	0.152	0.595	0.78
Beech	1.094	0.002	−0.041	0.836	0.95

Table 5. Average wood and bark densities of branches.

	Density ($p \pm m_p$), kg/m^3				
	Fresh condition			Dry condition	
Species	Wood	Bark	Wood+bark	Wood	Bark
Pine	931±13	993±30	938±12	396± 9	344±12
Spruce	990±12	984±18	986±10	557± 9	428±12
Oak	995±12	949±25	980± 9	601± 7	498±13
Beech	1038±15	1007±38	1029±13	568± 6	478±20

The estimates on the average densities of wood and bark of branches for different species are presented in *Table 5*.

By comparing the estimates on dry average densities for stem wood and bark (*Table 2*) and the corresponding estimates for branches (*Table 5*) it can be concluded that branches of pine and beech have significantly lower densities than stemwood. For spruce, the branches have a higher density than the stemwood. Similar results are presented by Poluboyarinov (1976) for spruce in the St. Petersburg area. The equations generated for the estimation of the densities of wood and bark of branches have low statistical significance. Therefore it is recommended to use the average estimates presented in *Table 5*. The estimations presented in *Tables 3*, *4* and *5* have been used as the platform for the phytomass estimations presented below.

6 Models for the Estimation of the Aboveground Phytomass

The estimation of the aboveground phytomass for trees and stands was carried out according to the scheme presented in *Figure 1*. The analyses included the accumulated growing stock in a stand and the parts removed by thinning. At the single tree level the following estimations were carried through:

- Volume of stem over bark and percentage of bark
- Mass of twigs
- Mass of branches
- Phytomass components for stem (wood and bark), crown (branches over bark and leaves and needles) and for the whole tree.

In *Figure 5* the scheme for the detailed aboveground phytomass calculations for single trees in fresh respectively dry conditions is presented. The estimations as volumes and bark percentages for individual trees of the major species were calculated from earlier collected data (Assortment Tables for Survey of Young and Middle Stands, 1993). About 5,800 trees were used for the calculations. The breast-height diameter over bark (f) and

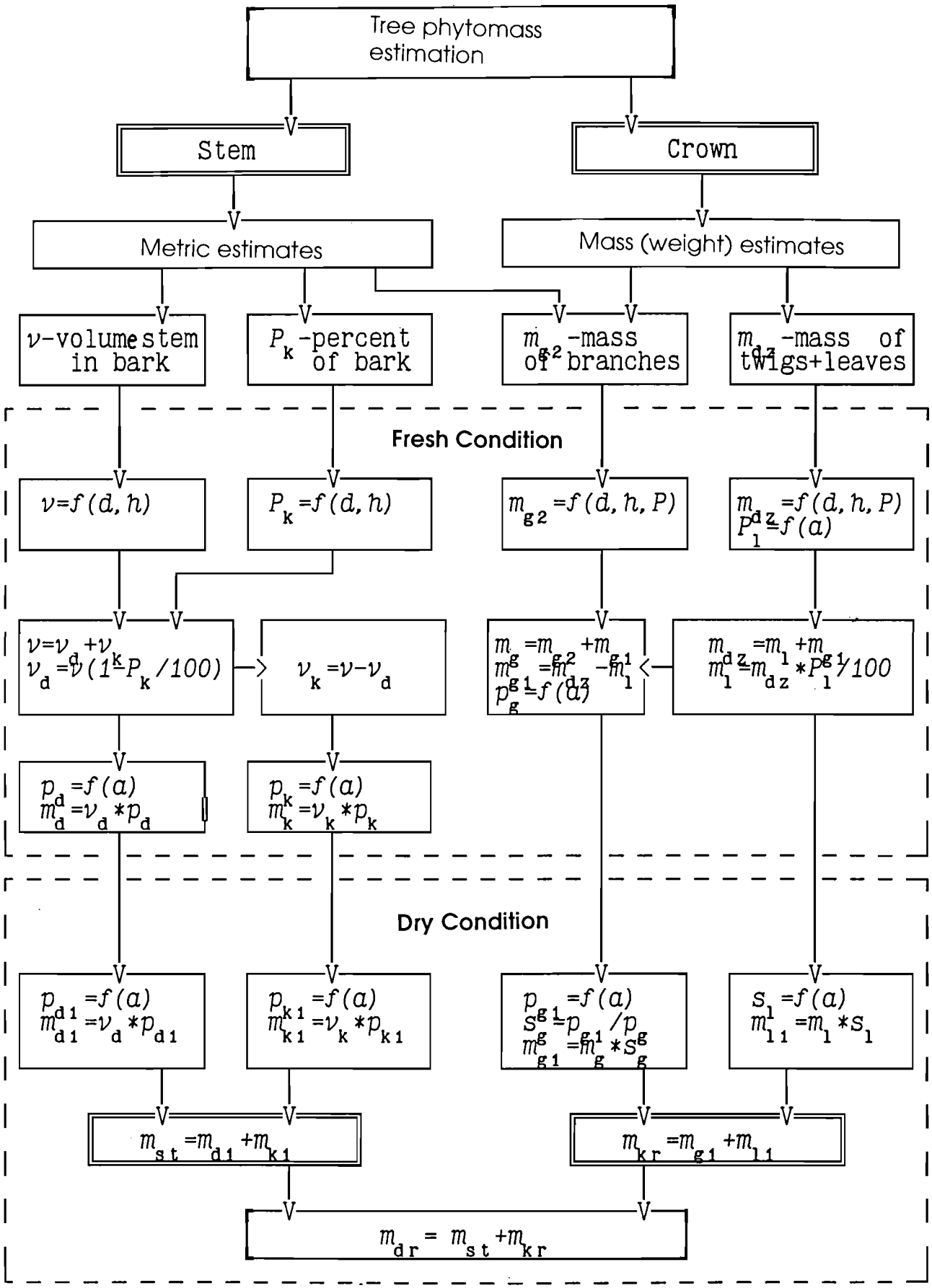

Figure 5. Scheme for the aboveground phytomass estimation for single trees.

percentage of bark (Pb) are described by regression allometric equations as functions of the breast-height diameter (d) and height (h) of the tree:

$$f = A_0 * d^{A_1} * h^{A_2} \quad , \tag{5}$$

$$Pk = A_0 * d^{A_1} * h^{A_2} \quad , \tag{6}$$

The above generated equations are rather aggregated. The estimates on the crown phytomass parameters were based on the weight of crown parameters in fresh condition (mass of twigs and living branches), stem data (age, diameter, height, volume over bark, percentage of bark, increments) and tree data (the same as for the stem plus surface and volume of the crown). The detailed statistics of initial average data are presented in *Table 6*. In *Table 6* the following acronyms are used: X = Average, S = Dispersion, A = Asymmetry, E = Excess, m_{dz} = mass of twigs, m_{g2} = mass of living branches, d_{kr} = diameter of the crown, l_{kr} = length of the crown, a = age, d = diameter, h = height, and P = the relative stocking for pine and oak plantations in linear form (first line of the table) and in logarithmic form (second line of the table).

The linear distribution for the mass of twigs and living branches has for both species high values of asymmetry and excess. In the linear form the parameters m_{dz} and m_{g2} show a rather low accuracy. The logarithmic form shows in general a better accuracy.

Table 7 illustrates the matrices of correlation coefficients and correlation ratios for pine and oak. The correlation matrices presented indicate a nonlinear relationship between crown phytomass parameters and the parameters describing individual trees or stands. Based on the correlation matrices presented it can be concluded that models for the estimation of phytomass parameters should follow the logarithmic form. Analyses by different models for the twig estimation show that the diameter and length of the crown and the absolute and relative stocking strongly influence the values of m_{dz}. The following equation (7) is chosen for the estimation of the parameter m_{dz}:

$$m_{dz} = A_0 * d^{A_1} * h^{A_2} * p^{A_3} \quad , \tag{7}$$

where P is relative stocking of a stand; and $A_0, \ldots, A_3$ are regression coefficients.

The characteristics of the parameters of equation (7) are presented in *Table 8*. For the estimation of the mass of twigs removed by thinnings (m'_{dz}) equation (8) was identified as the most adequate one:

$$m'_{dz} = A_0 * d^{A_1} * d^{A_2} \quad . \tag{8}$$

The characteristics of the parameters of equation (8) is shown in *Table 9*.

An important component of the crown phytomass is the living branches. They make up some 5–40 percent of the aboveground phytomass of a tree. In this study the mass of the living branches (m_g) was estimated as two components: as small-sized branches (m_{g1}) and as large branches (m_{g2}). Thus, the total mass of living branches is considered to be the sum:

$$m_g = m_{g1} + m_{g2} \quad . \tag{9}$$

The following equation (10) was identified as the best (except for beech) for the estimation of m_{g2}:

$$m_{g2} = A_0 * d^{A_1} * h^{A_2} * P^{A_3} \quad . \tag{10}$$

The characteristics of the parameters of equation (10) is shown in *Table 10*.

Table 6. Statistics for tree and stand parameter distributions.

Species	Parameters	Statistics of distribution X	S	A	E
Pine (n=602)	a, yr	30.00	14.46	1.66	3.79
		3.26	0.47	−0.02	0.24
	d, cm	12.00	6.17	1.03	1.26
		2.35	0.54	−0.07	0.37
	h, m	12.20	5.60	0.63	0.27
		2.38	0.51	−0.67	0.31
	m_{dz}, kg	11.30	11.89	2.25	6.30
		1.94	1.03	−0.20	−0.31
	m_{g2}, kg	11.20	20.18	5.59	43.31
		1.60	1.29	−0.04	−0.10
	d_{kr}, m	2.00	0.94	1.72	4.74
		0.61	0.44	−0.12	0.89
	l_{kr}, m	5.20	2.04	1.12	1.95
		1.57	0.39	−0.19	0.37
	P	0.74	0.18	−0.37	−0.17
		−0.33	0.28	−1.30	2.53
Oak (n=213)	a, yr	27.50	14.43	1.15	1.27
		3.18	0.51	0.07	−0.72
	d, cm	11.10	7.37	0.95	0.32
		2.17	0.72	−0.24	−0.80
	h, m	11.60	5.21	0.39	−0.98
		2.23	0.54	−0.34	−0.83
	m_{dz}, kg	8.50	11.36	2.38	6.31
		1.33	1.39	−0.36	−0.02
	$_{g2}$, kg	25.00	45.56	3.08	9.93
		1.46	1.72	−0.11	−0.51
	d_{kr}, m	2.60	1.45	1.40	2.22
		0.74	0.56	−0.28	0.45
	l_{kr}, m	5.50	1.40	0.80	0.10
		1.58	0.50	−0.23	−0.49
	P	0.76	0.27	0.45	0.08
		−0.34	0.37	−0.40	−0.42

First line = linear; second line = logarithmic.

The crown of beech has a different characteristic in comparison with the other analyzed tree species. The mass of crown branches of beech is similar to the mass of the stemwood of beech. For the estimation of the parameter m_{g2} for beech the following equation (11) was found to be most suitable:

$$m_{g2(\text{beech})} = \exp(-2.248 + 0.059d)d^{2.489}h^{-0.857}p^{-0.115} \quad , \quad Q = 0.92 \quad . \tag{11}$$

For beech equation (12) is regarded as the most relevant one for the estimation of m'_{g2} for the removed parts by thinning:

$$m'_{g2} = A_0 * d^{A_1} * h^{A_2} \quad . \tag{12}$$

The characteristics of the parameters of equation (12) is shown in *Table 11.*

The models developed for twigs are required for the estimation of the production over time by twigs. For this purpose the dynamics of the leave and needle percentage

Table 7. Correlation matrices of studied parameters.

Parameters		r*100							
		a	d	h	m_{dz}	m_{g2}	d_{kr}	l_{kr}	P
					Pine				
	a	–	78	89	45	31	30	53	30
	d	78	–	89	78	59	52	77	33
	h	91	90	–	58	43	33	68	45
	m_{dz}	48	85	63	–	81	59	76	13
η*100	m_{g2}	50	83	63	91	–	49	59	8
	d_{kr}	29	58	38	66	71	–	55	2
	l_{kr}	56	80	70	78	79	59	–	24
	P	43	43	52	22	16	−1	17	–
					Oak				
	a	–	84	87	62	61	66	68	15
	d	84	–	92	80	80	84	83	22
	h	89	94	–	72	74	73	81	22
	m_{dz}	69	89	80	–	70	69	66	16
η*100	m_{g2}	74	90	81	85	–	78	67	17
	d_{kr}	63	80	70	82	78	–	76	4
	l_{kr}	71	85	83	80	80	75	–	15
	P	24	31	35	18	29	3	9	–

r = coefficient correlation; η = correlation ratio.

Table 8. Characteristics of the parameters of equation (7).

Species	Coefficients				Q
	A_0	A_1	A_2	A_3	
Pine plantations in Polesje and the forest-steppe	0.224	2.814	−1.360	−0.223	0.79
Pine plantations in the Lower Dnieper Sands	0.153	2.521	−0.854	−0.055	0.94
Natural stands of pine in Polesje	0.084	2.493	−0.881	−0.333	0.74
Spruce plantations in Carpathia	0.724	2.820	−1.671	−0.314	0.84
Oak plantations in the forest-steppe and Polesje	0.108	2.201	−0.597	−0.345	0.80
Natural stands of beech in Carpathia	0.288	2.073	−0.790	−0.168	0.88

(P_1) were further analyzed. This factor (P_1) for spruce and deciduous species is rather constant and does not vary much with age. For pine an increase in P_1 could be observed over age but the increase is not statistically significant. Thus, it is recommended to use the average values for the factor P, for the different species studied. In a similar way, only average values for the dry matter of leaves and needles (S_1) seem to be suitable to use for the different species studied. The estimated average values for P_1 and S_1 are presented in *Table 12*.

The final stage of the phytomass component estimation was the development of regression models for the estimation of volume and mass of phytomass of a tree in a stand taking stocking density into account. A special computer program was developed for these analyses (TREE) and the program estimates the following parameters.

Table 9. Characteristics of the parameters of equation (8).

Species	Coefficients			
	A_0	A_1	A_2	Q
Pine plantations in Polesje and the forest-steppe	0.323	2.872	−1.559	0.84
Pine plantations in the Lower Dnieper Sands	0.598	1.961	−0.957	0.78
Natural stands of pine in Polesje	0.152	2.371	−1.031	0.71
Spruce plantations in Carpathia	1.262	2.207	−1.298	0.72
Oak plantations in the forest-steppe and Polesje	0.104	2.403	−0.714	0.85
Natural stands of beech in Carpathia	0.226	2.153	−0.809	0.80

Table 10. Characteristics of the parameters of equation (10).

Species	Coefficients				
	A_0	A_1	A_2	A_3	Q
Pine plantations in Polesje and the forest-steppe	0.031	3.457	−1.423	−0.809	0.69
Pine plantations in the Lower Dnieper Sands	0.062	3.173	−1.204	−0.099	0.96
Natural stands of pine in Polesje	0.332	2.754	−1.658	−0.160	0.82
Spruce plantations in Carpathia	0.035	3.025	−1.002	0.540	0.80
Oak plantations in the forest-steppe and Polesje	0.014	2.759	−0.185	−0.839	0.86

Table 11. Characteristics of the parameters of equation (12).

Species	Coefficients			
	A_0	A_1	A_2	Q
Pine plantations in Polesje and the forest-steppe	0.070	3.460	−1.694	0.65
Pine plantations in the Lower Dnieper Sands	0.204	2.340	−0.960	0.69
Natural stands of pine in Polesje	0.354	2.736	−1.684	0.82
Spruce plantations in Carpathia	0.024	0.936	0.880	0.68
Oak plantations in the forest-steppe and Polesje	0.028	3.653	−1.366	0.78
Natural stands of beech in Carpathia	0.049	3.367	−1.112	0.85

Table 12. Average values for P_1 and S_1.

Indicators	Species			
	Pine	Spruce	Oak	Beech
P_1, %	66.7±1.5	66.3±1.5	57.9±1.6	54.2±1.5
S_1	0.43±0.02	0.56±0.01	0.41±0.02	0.44±0.02

A. Tree phytomass in a stand

1. stemwood
2. stembark
3. stem over bark
4. twigs
5. leaves (needles)
6. crown branches over bark
7. aboveground part of stem
8. ratio between phytomass of the aboveground part of the tree and the volume of the stem over bark.

B. Tree phytomass for removed parts by thinning in a stand

1. twigs
2. leaves or needles
3. crown branches over bark
4. aboveground part of the stem
5. ratio between phytomass of the aboveground part of the tree and the volume of the stem over bark

The original data allow to generate the parameters under A for different stockings of a stand. *Table 13* illustrates the ratio between tree phytomass and the stem volume expressed in ton/m^3. Appendix 2 presents a detailed list of the phytomass components estimates for pine plantations in Polesje and the forest-steppe of Ukraine.

Table 13. Ratio between tree phytomass and stem volume, ton/m^3. Pine plantations in Polesje and forest-steppe.

Diameter	Height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	0.54	0.45	0.43									
6	0.64	0.51	0.45	0.43								
8		0.57	0.49	0.45	0.43	0.43						
10		0.63	0.52	0.47	0.45	0.44	0.43					
12		0.69	0.56	0.50	0.46	0.45	0.44	0.44				
14			0.60	0.52	0.48	0.46	0.45	0.44	0.44			
16			0.64	0.54	0.49	0.47	0.46	0.45	0.45	0.45		
18				0.57	0.51	0.48	0.46	0.45	0.45	0.45	0.45	
20				0.59	0.53	0.49	0.47	0.46	0.46	0.45	0.45	0.45
22					0.55	0.51	0.48	0.47	0.46	0.46	0.46	0.46
24					0.57	0.52	0.49	0.48	0.47	0.46	0.46	0.46
26						0.53	0.50	0.48	0.47	0.47	0.46	0.46
28						0.55	0.51	0.49	0.48	0.47	0.47	0.46
30						0.56	0.52	0.50	0.48	0.48	0.47	0.47
32							0.54	0.51	0.49	0.48	0.47	0.47
34							0.55	0.52	0.50	0.49	0.48	0.47
36								0.53	0.51	0.49	0.48	0.48
38								0.54	0.51	0.50	0.49	0.48
40									0.52	0.50	0.49	0.48
42										0.51	0.50	0.49
44										0.52	0.50	0.49

Table 13. Continued. Pine plantations in Lower Dnieper Sands.

Diameter	Height (m)											
(cm)	2	4	6	8	10	12	14	16	18	20	22	24
						Stocking – 0.7						
2	1.12	0.52										
4		0.70	0.49	0.47								
6		0.89	0.60	0.50	0.46							
8		1.06	0.68	0.55	0.49	0.46						
10			0.76	0.59	0.52	0.48	0.45					
12			0.83	0.63	0.54	0.50	0.47	0.45				
14			0.91	0.68	0.57	0.51	0.48	0.46				
16				0.71	0.59	0.53	0.49	0.47	0.45			
18				0.75	0.62	0.55	0.51	0.48	0.46	0.45		
20				0.79	0.64	0.57	0.52	0.49	0.47	0.46		
22					0.67	0.58	0.53	0.50	0.48	0.46		
24					0.69	0.60	0.54	0.51	0.48	0.47	0.45	
26					0.72	0.62	0.56	0.52	0.49	0.47	0.46	
28						0.63	0.57	0.53	0.50	0.48	0.46	0.45
30						0.65	0.58	0.54	0.51	0.48	0.47	0.46
32							0.59	0.54	0.51	0.49	0.47	0.46

Table 13. Continued. Natural pine stands in Polesje.

Diameter	Height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	0.54	0.44	0.42									
6	0.65	0.49	0.44	0.42								
8		0.54	0.48	0.44	0.44	0.42						
10		0.58	0.50	0.46	0.44	0.44	0.43					
12		0.62	0.52	0.48	0.46	0.45	0.44	0.44				
14			0.55	0.50	0.47	0.46	0.45	0.45	0.44			
16			0.57	0.52	0.49	0.47	0.46	0.46	0.45	0.45		
18				0.53	0.50	0.48	0.47	0.46	0.46	0.46	0.45	
20				0.55	0.51	0.49	0.48	0.47	0.46	0.46	0.46	0.46
22					0.52	0.50	0.49	0.48	0.47	0.47	0.46	0.46
24					0.54	0.51	0.49	0.48	0.48	0.47	0.47	0.47
26						0.52	0.50	0.49	0.48	0.48	0.48	0.47
28						0.53	0.51	0.50	0.49	0.48	0.48	0.48
30						0.54	0.52	0.50	0.49	0.49	0.48	0.48
32							0.53	0.51	0.50	0.49	0.49	0.49
34							0.53	0.52	0.51	0.50	0.49	0.49
36								0.52	0.51	0.50	0.50	0.50
38								0.53	0.52	0.51	0.50	0.50
40									0.52	0.51	0.51	0.50
42										0.52	0.51	0.51
44										0.52	0.52	0.51

Table 13. Continued. Spruce plantations in Carpathia.

Diameter	Height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	0.91	0.60	0.47	0.40	0.38							
6	1.10	0.72	0.52	0.45	0.40	0.38						
8		0.82	0.58	0.47	0.42	0.39	0.38					
10		0.92	0.63	0.51	0.44	0.41	0.39	0.38				
12		1.02	0.68	0.53	0.46	0.42	0.39	0.38	0.37			
14			0.74	0.57	0.48	0.43	0.40	0.39	0.38	0.38		
16			0.79	0.60	0.50	0.45	0.41	0.40	0.39	0.38	0.38	
18			0.85	0.63	0.52	0.46	0.42	0.40	0.39	0.38	0.38	0.38
20				0.67	0.54	0.47	0.44	0.41	0.39	0.39	0.38	0.38
22				0.70	0.57	0.49	0.45	0.42	0.40	0.39	0.39	0.38
24				0.74	0.59	0.51	0.46	0.43	0.41	0.40	0.39	0.39
26					0.62	0.53	0.47	0.44	0.41	0.40	0.39	0.39
28					0.65	0.55	0.48	0.45	0.42	0.41	0.40	0.39
30						0.57	0.50	0.46	0.43	0.41	0.40	0.39
32						0.59	0.51	0.47	0.44	0.42	0.41	0.40
34						0.61	0.53	0.48	0.45	0.43	0.41	0.40
36							0.55	0.49	0.46	0.43	0.42	0.41
38							0.57	0.51	0.47	0.44	0.42	0.41
40								0.52	0.48	0.45	0.43	0.42
42								0.54	0.49	0.46	0.44	0.42
44									0.50	0.47	0.44	0.43

Table 13. Continued. Oak plantations in forest-steppe.

Diameter	Height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	0.77	0.71	0.67									
6	0.85	0.75	0.70	0.67								
8		0.79	0.73	0.70	0.67	0.65						
10		0.83	0.76	0.72	0.69	0.67	0.66					
12		0.86	0.79	0.74	0.71	0.68	0.67	0.65				
14			0.81	0.76	0.73	0.70	0.68	0.66	0.65			
16			0.84	0.78	0.74	0.71	0.69	0.67	0.66	0.64		
18			0.86	0.80	0.75	0.72	0.70	0.68	0.67	0.65	0.64	
20				0.82	0.77	0.74	0.71	0.69	0.67	0.66	0.64	0.63
22				0.83	0.79	0.75	0.72	0.70	0.68	0.66	0.65	0.63
24				0.85	0.80	0.76	0.73	0.71	0.69	0.67	0.65	0.64
26					0.81	0.77	0.74	0.72	0.69	0.67	0.66	0.64
28					0.83	0.78	0.75	0.72	0.70	0.68	0.66	0.64
30						0.79	0.76	0.73	0.71	0.68	0.66	0.65
32						0.80	0.77	0.74	0.71	0.69	0.67	0.65
34						0.81	0.78	0.74	0.72	0.69	0.67	0.65
36						0.82	0.78	0.75	0.72	0.70	0.67	0.65
38							0.79	0.75	0.72	0.70	0.67	0.65
40							0.80	0.76	0.73	0.70	0.68	0.65
42								0.77	0.73	0.70	0.68	0.65
44								0.77	0.74	0.71	0.68	0.65

Table 13. Continued. Natural beech stands in Carpathia.

Diameter	Height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	0.90	0.76	0.68	0.67	0.67	0.65						
6		0.84	0.75	0.71	0.69	0.68	0.66					
8		0.92	0.79	0.73	0.71	0.69	0.67	0.67				
10		0.99	0.84	0.76	0.72	0.71	0.69	0.68	0.67			
12			0.88	0.79	0.75	0.72	0.70	0.69	0.68	0.67		
14			0.93	0.83	0.77	0.74	0.72	0.70	0.69	0.68	0.67	
16			0.99	0.87	0.80	0.76	0.73	0.71	0.70	0.69	0.67	0.66
18				0.91	0.83	0.78	0.75	0.73	0.71	0.70	0.68	0.67
20				0.96	0.87	0.81	0.77	0.75	0.73	0.71	0.70	0.68
22				1.02	0.91	0.84	0.80	0.77	0.74	0.72	0.71	0.69
24					0.96	0.88	0.83	0.79	0.76	0.74	0.72	0.71
26					1.01	0.92	0.86	0.82	0.78	0.76	0.74	0.72
28						0.97	0.90	0.85	0.81	0.78	0.76	0.74
30						1.02	0.94	0.88	0.84	0.80	0.78	0.75
32							0.99	0.92	0.87	0.83	0.80	0.77
34							1.04	0.96	0.91	0.86	0.83	0.80
36								1.02	0.95	0.90	0.86	0.82
38									1.00	0.94	0.89	0.85
40										0.99	0.93	0.89
42										1.04	0.98	0.93
44										1.10	1.03	0.97

7 Modeling and Estimation of the Aboveground Phytomass for Stands

The steps carried out for the estimation of the aboveground phytomass of a stand are:

1. Estimation of the aboveground phytomass parameters of trees.
2. Estimation of stand parameter distributions.
3. Estimation of the aboveground phytomass of a stand in static conditions.

The first step has been discussed earlier in the text and will not be repeated here.

7.1 Stand parameter distributions

Analyses of the stand parameter distributions have been carried out by many scientists (Atroshchenko, 1988; Ganina, 1984; Svalov, 1982 and 1985). A debate is going on concerning the most suitable functions to use for the stand parameter distributions. Some authors prefer a three-parametrical function of Weibull form, others argue that a four-parametrical function of Pirson Beta-distribution form is better (Ganina, 1984; Svalov, 1985). Svalov (1985) points out that the Pirson Beta-distribution can more correctly describe experimental series but an increase in the number of model parameters will also increase the errors in the parameter estimations. The authors cited above conclude that for purposes like this study a Weibull distribution is to prefer.

Table 14. Characteristics of the parameters of equation (14).

Species	Parameters of Weibull function	Coefficients A_0	A_1	A_2	Q
Pine plantations	a	0.153	0.971	−0.172	0.90
in Polesje and	b	1.390	0.584	−0.382	0.50
forest-steppe	c	0.063	0.936	0.664	0.84
Pine plantations	a	1.098	1.243	−0.495	0.83
in Lower	b	1.380	0.184	0.063	0.22
Dnieper Sands	c	0.074	0.554	1.167	0.79
Natural pine	a	1.298	0.530	0.278	0.82
stands in	b	1.013	0.020	0.301	0.42
Polesje	c	0.030	1.722	0.006	0.87
Spruce planta-	a	0.816	1.141	−0.191	0.96
tions in	b	1.390	0.571	−0.420	0.50
Carpathia	c	0.148	0.629	0.558	0.76
Oak plantations	a	0.914	1.136	−0.268	0.94
in forest-steppe	b	1.202	0.209	0.024	0.56
and Polesje	c	0.115	0.652	0.766	0.91
Natural beech	a	0.745	0.815	0.145	0.93
stands in	b	2.195	0.377	−0.431	0.23
Carpathia	c	0.302	1.797	−0.770	0.90

The distribution of the causal values which corresponds with Weibull's theoretical distribution can be described as follows:

$$f(x) = \left(\frac{b}{a}\right)\left(\frac{x-c}{a}\right)^{b-1} \exp\left(-\left(\frac{x-c}{a}\right)^{b}\right), \quad \text{for} \quad x \geq c \ , \tag{13}$$

where a, b, c are the parameters of scale, form and shift accordingly.

To obtain integrated theoretical models of stand structures, within the limits given by the basic data for each species, experimental series on the distribution of stem diameters were processed. Additional experimental data were also employed for the estimation of the parameters a, b, c of the Weibull function. Further research was also carried out in order to study the regularities of the changes of these parameters by using forest stand inventory data (age, average diameter and height, number of stems, and stocking density). The search for factors affecting changes of the parameters a, b, c was performed by using multiple regression analysis.

It can be concluded that changes of the parameters a, b, c for the studied species are significantly influenced by the average diameter (D) and height (H) of a stand. The following regression function for the parameters of the Weibull function was obtained:

$$ki = A_0 D^{A_1} H^{A_2} \ , \tag{14}$$

where ki are parameters of the Weibull function; a is scale, b is form, and c is shift; and A_0, A_1, A_2 are coefficients of the equation.

Characteristics of the parameters of equation (14) are shown in *Table 14*.

From the above equations it can be concluded that parameter b is characterized by a low correlation coefficient for all species. The regression equation for estimation of

Table 15. Ratio between aboveground phytomass of a stand and wood volume (fresh conditions) over bark, ton/m^3. Pine plantations in Polesje and forest-steppe.

Mean diameter	Mean height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	0.55	0.46										
6	0.67	0.52	0.45	0.42								
8	0.78	0.58	0.49	0.45	0.43							
10		0.64	0.53	0.48	0.45	0.43						
12			0.57	0.50	0.47	0.44	0.43					
14				0.53	0.48	0.46	0.45	0.44				
16					0.51	0.47	0.46	0.45	0.44			
18						0.49	0.47	0.46	0.45	0.45		
20							0.48	0.47	0.46	0.45	0.45	
22							0.50	0.48	0.47	0.46	0.46	0.45
24								0.49	0.48	0.47	0.47	0.46
26								0.50	0.49	0.48	0.47	0.47
28									0.50	0.49	0.48	0.47
30										0.49	0.49	0.48
32										0.50	0.50	0.49
34										0.51	0.50	0.49
36											0.51	0.50

the parameters a, b, c of the Weibull function has been used for the estimation of the phytomass components of a stand both in static and dynamic conditions.

7.2 Aboveground phytomass estimation for a stand

The models developed and described above on the aboveground phytomass estimation in a static condition have been linked with the standards for the silvicultural management (Strochinsky, 1991). The entries used from these standards are: the relative stocking, average diameter and height. The steps taken for calculation of the aboveground phytomass components at a given relative stocking (P), average diameter (D) and average height (H) of a stand are:

1. Absolute stocking of a stand (b) is calculated based on the standards for basal area (G) and species for given relative stocking (P) and average height (H).
2. The number of stems are calculated based on the given G and D.
3. The parameters a, b, c of the Weibull function are estimated and the distribution of 2 cm diameter classes is calculated.
4. For each diameter class the aboveground phytomass component estimation was carried out according to the description made earlier in Sections 4 and 5 and are added up to be valid for a complete stand. In these calculations the height for each diameter class is estimated from specific tables (Assortment Tables for Survey of Young and Middle Stands, 1993).

Table 15 illustrates the results for the ratio between the aboveground phytomass at stand level and the wood volume at stocking density of 0.7. A detailed list of the estimation of the phytomass components for pine plantations in Polesje and the forest-steppe is presented in Appendix 3.

Table 15. Continued. Pine plantations in Lower Dnieper Sands.

Mean diameter	Mean height (m)											
(cm)	2	4	6	8	10	12	14	16	18	20	22	24
						Stocking – 0.7						
2	1.23											
4		0.72										
6		0.96	0.60									
8			0.70	0.54								
10			0.81	0.60	0.52							
12				0.66	0.55	0.50	0.47					
14				0.71	0.59	0.52	0.48	0.46				
16					0.62	0.55	0.50	0.48				
18					0.66	0.57	0.53	0.49	0.47			
20						0.60	0.55	0.51	0.48	0.47		
22						0.63	0.56	0.53	0.50	0.48		
24						0.65	0.59	0.54	0.51	0.49	0.48	
26							0.60	0.56	0.52	0.50	0.49	0.47
28							0.62	0.57	0.54	0.51	0.50	0.48

Table 15. Continued. Natural pine stands in Polesje.

Mean diameter	Mean height (m)											
(cm)	2	4	6	8	10	12	14	16	18	20	22	24
						Stocking – 0.7						
4	0.53	0.43										
6	0.62	0.48	0.42	0.40								
8		0.53	0.46	0.43	0.41							
10		0.57	0.49	0.45	0.43	0.42						
12			0.52	0.47	0.45	0.43	0.42					
14				0.49	0.47	0.45	0.44	0.43				
16					0.48	0.46	0.45	0.44	0.43			
18						0.48	0.46	0.45	0.45	0.44		
20							0.47	0.46	0.46	0.45	0.45	
22							0.49	0.47	0.47	0.46	0.46	0.45
24								0.49	0.48	0.47	0.46	0.46
26								0.50	0.49	0.48	0.48	0.47
28									0.50	0.49	0.49	0.48
30										0.50	0.49	0.49
32										0.51	0.50	0.50
34										0.52	0.51	0.51
36											0.52	0.52

Table 15. Continued. Spruce plantations in Carpathia.

Mean diameter	Mean height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	1.01	0.68										
6	1.16	0.78	0.57									
8		0.87	0.61	0.50	0.44							
10		0.96	0.66	0.53	0.45	0.41						
12			0.71	0.55	0.47	0.43	0.40					
14				0.58	0.49	0.44	0.41	0.39	0.38			
16					0.51	0.46	0.42	0.40	0.38	0.38		
18						0.47	0.43	0.41	0.39	0.38	0.37	
20							0.44	0.42	0.40	0.39	0.38	0.37
22								0.42	0.40	0.39	0.38	0.38
24									0.41	0.40	0.39	0.38
26										0.40	0.39	0.39
28										0.41	0.40	0.39
30											0.40	0.39
32											0.41	0.40
34												0.40
36												0.40

Table 15. Continued. Oak plantations in forest-steppe.

Mean diameter	Mean height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	0.82	0.68										
6	0.91	0.77	0.70									
8		0.83	0.75	0.70	0.67							
10		0.88	0.79	0.72	0.69	0.67						
12			0.81	0.75	0.71	0.69	0.67					
14				0.77	0.73	0.70	0.68	0.67				
16				0.78	0.74	0.71	0.69	0.68	0.66			
18					0.75	0.72	0.70	0.68	0.67			
20					0.76	0.72	0.70	0.69	0.67	0.66		
22						0.73	0.70	0.69	0.67	0.66	0.65	
24							0.71	0.69	0.67	0.66	0.65	
26							0.70	0.69	0.67	0.66	0.65	0.64
28								0.69	0.67	0.66	0.65	0.64
30								0.68	0.67	0.65	0.64	0.63
32									0.66	0.65	0.64	0.62
34									0.66	0.64	0.63	0.63
36									0.66	0.64	0.63	0.62

Table 15. Continued. Natural beech stands in Carpathia.

Mean diameter	Mean height (m)											
(cm)	4	6	8	10	12	14	16	18	20	22	24	26
						Stocking – 0.7						
4	1.01	0.81	0.72									
6		1.19	0.87	0.76	0.71	0.69						
8			0.95	0.81	0.75	0.72	0.69					
10				0.88	0.79	0.74	0.72	0.70	0.69			
12					0.84	0.78	0.74	0.72	0.71	0.70		
14						0.82	0.77	0.75	0.73	0.71	0.70	
16							0.81	0.77	0.75	0.73	0.72	0.70
18							0.85	0.80	0.77	0.75	0.73	0.72
20								0.84	0.80	0.77	0.75	0.73
22								0.88	0.83	0.80	0.77	0.75
24									0.87	0.83	0.80	0.77
26									0.91	0.86	0.82	0.80
28										0.91	0.86	0.83
30											0.91	0.86
32											0.96	0.90
34												0.96
36												1.02

8 Conclusion

A specific package of mathematical tools has been developed for estimation of the phytomass components of trees and stands for the major species of Ukraine. The developed package seems to be able to estimate the dry and natural densities and the dry matter of the major phytomass components in a relevant way.

References

Aldred, A.H., and Alemdag, I.S. (1988). Guidelines for forest biomass inventory. Inform. Rep. PI-X-77. Petawawa Nat. For. Inst., Can. For. Serv., 134 pp.

Assortment tables for survey of young and middle stands, (1993). In: Strochinsky, A.A. (Ed.), USHA publication, Kiev, 464 pp. (in Russian).

Atkin, A.S. (1974). Accuracy of estimates on phytomass fractions of young pine stands. In: "Forests and wood species of Northern Kazachstan". Nauka publication, Leningrad, pp. 57-63 (in Russian).

Atroshchenko, O.A. (1988). Statistical analysis of stand diameter structure. In: "Forest taxation and forest inventary", LitSHA publication, Kaunas, pp. 14-24 (in Russian).

Babich, N.A. (1989). Estimates of phytomass fractions of Pinus silvestris L. in pine plantations. Rastitelnye resursy Journal, Vol. 25, No. 1, pp. 39-42 (in Russian).

Babich, N.A. (1989). Accuracy of estimates on aboveground phytomass of pine plantations. Lesnoj Journal, No. 1, pp. 112-115 (in Russian).

Babich, N.A., and Vasiljev A.V. (1992). Potential amount of aboveground phytomass of the pine. Lesnoj Journal, No. 1, pp. 20-24 (in Russian).

Bazilevich, N.I. (1993). Biological productivity of the ecosystems of Northern Europe and Asia. Nauka publication, Moscow, 293 pp. (in Russian).

Biley, P.V., and Vintoniv I.S. (1983). Moisture of European beech growing in Ukrainian Carpathia. Lesnoj Journal, No. 1, pp. 73-76 (in Russian).

Bisch, J.L. (1987). Un exemple de conversion d'une table de production en volume en tables de production en biomasse: Le chêne dans le secteur ligerien. Ann. Sci. Forest. Journal, Vol. 44, No. 2, pp. 243-257 (in French).

Chernjavsky, N.B. (1979). Structures of phytomass and stands of beech-fir-spruces forests in Ukrainian Carpathia. In: "Results and perspective of scientific researches in areas of forest economy", Paper presented at the Workshop in VNIILM, 13-15 February, 1979, Pushkino, pp. 212-213 (in Russian).

Danilin, I.M. (1993). Determination of aboveground phytomass parameters of stands by aerial photographs. Lesnoje khoziaystvo Journal, No. 1, pp. 35-36 (in Russian).

Dimitrov, E.P. (1984). Biomass yield tables for highproductive spruce stands. Gorskostopanska Nauka Journal, Vol. 21, No. 3, pp. 37-44 (in Bulgarian).

Dzebisashvili, G.S., and Aptsiauri, S.A. (1988). The evaluation of phytomass of crowns of coniferous species in the mountain forests of Zakavkazje. In: "Forest survey and forest inventory", LitSHA publication, Kaunas, pp. 60-69 (in Russian).

Ganina, N.V. (1984). Estimation of distributions of trees diameters by Weibull's function. Lesovedenie Journal, No. 2, pp. 65-70 (in Russian).

Georgiev, D. (1984). The aboveground biomass of pine plantations. Gorskostopanska Nauka Journal, Vol. 21, No. 5, pp. 56-61 (in Bulgarian).

Giefing, D.F., and Jablonski, K. (1989). The relation between crown extent and wood moisture in living pine trees. Sylwan Journal, Vol. 133, No. 1-2, pp. 75-82 (in Polish).

Golubets, M.A. (1978). The spruce stands of Ukrainian Carpathia. Naukova dumka publication, Kiev, 264 pp. (in Russian).

Golubets, M.A., and Polovnikov, L.I. (1975). Regularity in the accumulation of phytomass in spruce forests. In: "Biological productivity of spruce forests of Carpathian". Naukova dumka publication, Kiev, pp. 4-64 (in Ukrainian).

Gorbatenko, V.M., and Protopopov, V.V. (1971). Accuracy of calculation of phytomass of crowns and needles of pine stands. Lesnoje Khoziaystvo Journal, No. 4, pp. 39-41 (in Russian).

Gulbe, T.A., Rojdestvensky, S.G., and Utkin, A.I. (1991). Experiences of evaluation of the mass of crowns of softwood stands. Lesovedenie Journal, No. 2, pp. 48-57 (in Russian).

Gusev, I.I., and Sokolov N.N. (1973). Volume and weight of twigs in spruce stands of the North. Lesnoj Journal, No. 3, pp. 25-30 (in Russian).

Gutman, A.L., and Uspensky, V.V. (1987). Simulation of the extent of phytomass of pine stands. In: "The experimental and mathematical simulation of the biogeocenosis of forests and bogs", Paper presented at the Workshop 4-6 August 1987. Western Dvina, Moscow, pp. 92-94 (in Russian).

Harding, R.B., and Grigal, D.F. (1985). Individual tree biomass estimation equations for plantation-grown white spruce in northern Minnesota. Can. J. For. Res., Vol. 15, No. 4, pp. 738-739.

Hase, H., Foelster, H., and Lindheim, M. (1985). On the accuracy of estimating aboveground tree biomass in an evergreen forest near Manaus, Brazil. A simulation study. Biotropica Journal, Vol. 17, No. 3, pp. 191-195.

Ievin, I.K., and Dikelson E.O. (1962). Mass of crowns of aspen, birch and spruce in Lithuania. Lesnoje Khoziaystvo Journal, No. 4, pp. 20-23 (in Russian).

Isaieva, L.N. (1978). A method for calculation of density of absolutely dry wood in stems of pine and larch. Lesovedenie Journal, No. 4, pp. 90-94 (in Russian).

Ivanchikov, A.A. (1971). Biological and economic productivity of pine stands of Karelia. In: "Forests resourses of South Karelia", Karelia publication, Petrozavodsk, pp. 78-85 (in Russian).

Ivanchikov, A.A. (1974). Phytomass of pine stands in Karelia and its dependence of age. In: "Forest vegetative resourses of Karelia". The Karelian branch of AS USSR, Petrozavodsk, pp. 37-51 (in Russian).

Kadeba, O. (1991). Aboveground biomass production and accumulation in a Pinus caribaea stand. Forest Ecol. and Manag. Journal, Vol. 41, No. 3-4, pp. 237-248.

Koziakov, S.N. (1984). The scientific basis for calculation of nonwood vegetative material of the forest inventory. USHA, Kiev, 50 pp. (in Russian).

Lakida, P.I. (1986). Models for growth and productivity of pine plantations in Polesje UkrSSR. USHA, Kiev, 239 pp. (in Russian).

Lakida, P.I. (1988). Simulation of twig dynamics in pine plantations in Polesje UkrSSR. In: "Improving of directing of forest economy and protective forestation", USHA, Kiev, pp. 90-92 (in Russian).

Lakida, P.I. (1989). Estimation of tree biomass parameters. In: "Young scientists for forest economy", Paper presented of the Workshop in VNIILM, Moscow, pp. 104-105 (in Russian).

Lakida, P.I. (1990). Simulation of stands biomass components dynamics. In: "Improving the economy of the forests in Ukraine and Moldavia", Paper presented Workshop at USHA, Kiev, pp. 132-134 (in Russian).

Lakida, P.I. (1993). Method for investigation of biometric characteristics of stems. Lisoviy Journal, No. 3, pp. 22-23 (in Ukrainian).

Lakida, P.I., and Juditsky, J.A. (1993). Estimations of average density of fractions of stemwood. Lisoviy Journal, No. 6, pp. 25-26 (in Ukrainian).

Lemke, J. (1983). Tables for estimation of needle and twig contents of pine. Sylwan Journal, Vol. 127, No. 2, pp. 21-30 (in Polish).

Makarenko, A.A. (1982). Structure of forest stands. Kajnar publication, Alma-Ata, 70 pp. (in Russian).

Makarenko, A.A. (1985). The aboveground phytomass of young pine stands in Kazakhstan. Lesovedenie Journal, No. 3, pp. 11-19 (in Russian).

Mirkin, B.M., and Rozenberg, G.S. (1978). Phytocenology: Principles and methods. Nauka publication, Moscow, 212 pp. (in Russian).

Mjakushko, V.K. (1978). Pine forests of the plain of the UkrSSR. Naukova dumka publication, Kiev, 256 pp. (in Russian).

Molchanov, A.A. (1972). Productivity of the organic mass in forests of various zones. Nauka publication, Moscow, 276 pp. (in Russian).

Petras, R., Kosut, M., and Oszlanyi, J. (1985). Foliage biomass of spruce, pine and beech. Lesn. Chas. Journal, Vol. 31, No. 2, pp. 121-136 (in Czech).

Polovnikov, L.I. (1970). Age-dynamics of biological productivity of phytomass components in spruce cenosis of Chornogora. Ukrainsky Botanichny Journal, Vol. 27, No. 5, pp. 619-624 (in Ukrainian).

Polovnikov, L.I., and Pitikin, A.I. (1982). Methodologies for determination of the elements of phytomass in spruce forests in Carpathia, Paper presented at the Workshop in LTI, February 1989, Dep. in VNIIClesresurs 06.04.92., No. 895-LII92, pp. 44-46 (in Russian).

Poluboyarinov, O.I. (1976). Density of wood. Lesnaja Promyshlennost publication, Moscow, 160 pp. (in Russian).

Pozdnjakov, L.K., Protopopov, V.V., and Gorbatenko, V.M. (1969). Biological productivity of forests of Middle Siberia and Jakutija. Krasnoyarsk Publishing House, Krasnoyarsk, 156 pp. (in Russian).

Punko, B.M. (1993). The use of regression analyses for estimation of the accumulation of aboveground phytomass. Lesnoj Journal, No. 1, pp. 5-8 (in Russian).

Rodin, E.L., Remezov, N.P., and Bazilevich, N.I. (1968). Methodical instructions for studies of dynamics and biological rotations in phytocenosis. Nauka publication, Leningrad obtail, 145 pp. (in Russian).

Rodnjansky, A.M., and Smoljanov, A.N. (1992). Research on aboveground phytomass of spruce-fir stands in the Permskoj oblasti. Lesnoj Journal, No. 2, pp. 31-35 (in Russian).

Rojdestvensky, S.G., Iljina, N.A., and Gulbe, J.I. (1985). Evaluation of the fitness of regression equations for different kinds of approximations of phytomass. In: "The stability and efficiency of the forests ecosystems", Paper presented at the Workshop in Tartu, 29-31 October, 1985, Tartu, pp. 113-115 (in Russian).

Rozenberg, G.S. (1984). Models in phytocenology. Nauka publication, Moscow, 265 pp. (in Russian).

Satoo, T., and Madgwick, H.A.I. (1982). Forest biomass. M.Nijhoff / Dr. W.Junk Publ., 152 pp.

Savich, J.N., Ovsjankin, V.N., and Polubojarinov, O.I. (1978). Growth, productivity and stability of pine plantations created at various density of planting. In: "Questions of forest taxation", Scientific paper, USHA, Kiev, Publ. 213, pp. 27-38 (in Russian).

Semechkina, M.G. (1978). Structure of phytomass of pine stands. Nauka publication, Novosibirsk, 166 pp. (in Russian).

Shinozaki, K., Yoda, K., Hozumi, K., and Kira, T. (1964). A quantitative analysis of plant form: The pipe model theory. 1. Basic analyses. Japan. J. Ecol. Vol. 14, No. 3, pp. 97-105.

Shvidenko, A.Z. (Ed.) (1987). Standards for surveys of Ukrainian and Moldavian forests. (1987). Urozhaj publikation, Kiev. 560 pp. (in Russian).

Shvidenko, A.Z., and Juditsky, J.A. (1983). A programm for multiple regression analysis: REGANA. USHA, Kiev, 14 pp. (in Russian).

Sirik, A.A. (1991). Productivity of the aboveground phytomass of oak stands. Lesnoje Khoziaystvo Journal, No. 11, pp. 49-51 (in Russian).

Smirnov, V.V. (1971). Organic masses in some forest phytocenosis of the European part of the USSR. Nauka publication, Moscow, 362 pp. (in Russian).

Smoljanov, A.N. (1980). Density of wood and its application in estimations of the aboveground phytomass in oak plantations. Lesnoj Journal, No. 6, pp. 68-71 (in Russian).

Smoljanov, A.N. (1985). Questioning aboveground phytomass estimations in young oak stands by regression analysis. In: "The Forest taxation and inventory", Krasnoyarsk, pp. 50-56 (in Russian).

Spank, G. (1982). Zur Schätzung der Kronen- und Nadelmasse in Reinbeständen der Baumart Kiefer (Pinus silvestris L.). Beitr. Forstwirt., Vol. 16, No. 3, pp. 129-139 (in German).

Strochinsky, A.A., Berezivsky, L.M., and Kashpor, S.M. (1991). Basal areas and growing stocks of stands at a stocking density 1.0. USHA publication, Kiev, 18 pp. (in Ukrainian).

Svalov, S.N. (1982). Estimation of Weibull's distribution for description of stand structure. In: "Scientific papers of Moscow Forestry Institute", Moscow, No. 139, pp. 172-174 (in Russian).

Svalov, S.N. (1985). Application of statistical methods in forestry. In: "Forest science and forestry", VINITI, Moscow, Vol. 4, 164 pp. (in Russian).

Telishevsky, D.A. (1986). Complex uses of nonwood forest production. Lesnaja Promishlennost publication, Moscow, 261 pp. (in Russian).

Tokmurzin, T.C. (1977). The choice of calculation method for estimation of stand phytomass. In: "Actual questions of forest economy in Kazakhstan", Alma-Ata, pp. 71-76 (in Russian).

Tokmurzin, T.C., Nurpeisov and K.H. (1976). Yield tables for phytomass of pine stands in Priirtishja. Scientific paper KazSHI, Alma-Ata, Vol. 19, No. 3, pp. 127-136 (in Russian).

Usoltsev, V.A. (1983). Dynamics of density and contents of dry substance of wood in aspen stands. Lesovedenie Journal, No. 6, pp. 42-49 (in Russian).

Usoltsev, V.A. (1984). Accuracy of regression estimations of phytomass of forest stands. Vesnik selskokhozyaistvennoj nauki Kazakhstana Journal, No. 9, pp. 77-83 (in Russian).

Usoltsev, V.A. (1985). The simulation of structure and dynamics phytomass of the stands. Krasnoyarskij University publication, Krasnoyarsk, 192 pp. (in Russian).

Usoltsev, V.A. (1985). The use of diameter and radial increment on different heights of a stem for estimation of the phytomass of forest stands. In: "The mathematical simulation in biocenology", Paper presented the Union School in Petrozavodsk, 14-19 October, 1985, Petrozavodsk, pp. 51-53 (in Russian).

Usoltsev, V.A. (1988). Growth and structure of phytomass of forest stands. Nauka publication, Novosibirsk, 253 pp. (in Russian).

Usoltsev, V.A. (1993). The application of invariant interrelations at estimation mass of crowns of trees: Part 1. ULTI, Ekaterinburg, 37 pp. (in Russian).

Uspensky, V.V. (1980). The variability of density of pine wood and its use in weight estimation. Lesnoj Journal, No. 6, pp. 9-12 (in Russian).

Uspensky, V.V. (1982). Calculation of volumes of the branches of pine forests. Lesnoj Journal, No. 2, pp. 17-20 (in Russian).

Utkin, A.I. (1975). The biological productivity of forests (study methods and results), Lesovedenie and Lesovodstvo: The results of science and engineering. Moscow, VINITI, Vol. 1, pp. 9-189 (in Russian).

Utkin, A.I. (1982). The methodollgy of research on the primary biological productivity of forests. In: "The biological productivity of forests in Povolzja", Nauka publication, Moscow, pp. 59-72 (in Russian).

Utkin, A.I. (1986). Studies of the vertical and fractional distribution of phytomass. In: "Vertical-fractional distribution of phytomass in forests", Nauka publication, Moscow, pp. 10-14 (in Russian).

Utkin, A.I., Kaplina, N.F., and Iljina, N.A. (1987). Refinement of the applications of regression analysis for studies of the biological productivity of forest stands. Lesovedenie Journal, No. 1, pp. 40-53 (in Russian).

Utkin, A.I., Rojdestvensky, S.G., Gulbe, J.I., and Kaplina, N.F. (1988). Production variation of forest stands. Lesovedenie Journal, No. 2, pp. 12-23 (in Russian).

Yarie, J., and Mead, B.R. (1989). Biomass Regression Equations for Determination of Vertical Structure of Major Understory of Southeast Alaska. Northwest Science Journal, Vol. 63, No. 5, pp. 221-231.

Appendix 1: Characteristics of the Sample Plots

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT[a] Total 10	Number of MT[a] Of which with phytomass estim. 11
Pine plantations of the Ukrainian Polesje										
182001	7P3O+B	24	9.1	9.9	2467	16.1	90	B2	15	5
182002	10P	29	9.2	9.6	2675	18.0	103	B2	15	5
182003	10P	23	6.8	6.3	2547	9.2	38			
182005	9P1O+B	29	12.4	12.0	2154	24.7	168	B3	15	5
182008	10P+S	38	15.1	13.8	1320	23.7	182	B3	15	5
182012	8P1O1B+Al	34	15.4	16.0	1611	25.6	217	B3	15	5
182014	9P1O	58	24.4	22.4	840	38.4	434	B3	13	5
182015	10P	16	6.7	6.9	5560	18.4	80	B3	15	5
182016	10P+O,B	28	8.6	9.2	3730	21.3	111	B2	15	5
182017	7P3O	28	11.9	12.9	2372	24.3	165	B3	15	5
182018	8P2O	33	10.6	11.3	2811	24.0	161	B2	15	5
182019	10P+O,B	32	9.9	11.2	3039	23.2	155	B3	15	5
182020	9P1O	75	31.0	22.9	683	41.0	377	B3	13	5
182022	10P+O	19	7.5	8.8	3085	13.4	67	B2	15	5
182023	9P1B	33	14.4	14.3	1623	27.4	216	B2	15	5
182027	10P	30	15.2	13.8	1141	20.8	161	B2	15	5
182031	10P	20	11.1	10.5	2342	22.7	120	B3	15	5
182032	10P+B	19	6.9	7.1	4364	14.0	60	B3	14	5
182033	9P1B	22	9.5	9.8	2322	14.5	73			
182040	8P2B	11	4.7	4.3	3914	6.4	15			
182041	10P+B	25	10.8	9.2	1019	9.3	51			
182043	10P+B	46	19.6	17.8	878	25.4	262	B2	13	5
182047	10P	21	7.9	7.0	3200	15.8	69			
182048	10P	25	11.4	10.7	3268	33.7	222	B2	15	5
182049	10P	25	13.2	12.3	2217	30.1	227			
182050	10P	26	8.7	7.5	1317	7.8	36			
182051	10P	22	11.8	10.9	1606	17.6	114			
182056	10P	22	9.9	9.4	1992	15.3	79	B2	15	5
182058	10P	30	12.8	12.5	2014	25.9	189	B2	13	5

[a]MT = Measured trees.

Abbreviations of wood species: Abbreviations of wood species: P = pine; S = spruce; F = fir; O = oak; Bc = beech; A = ash; Mp = maple; El = elm; H = hornbeam; Ch = cherry; Pr = pear; Ld = linde; B = birch; As = aspen; Al = alder. P = pine; S = spruce; F = fir; O = oak; Bc = beech; A = ash; Mp = maple; El = elm; H = hornbeam; Ch = cherry; Pr = pear; Ld = linde; B = birch; As = aspen; Al = alder.

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT	
									Total 10	Of which with phytomass estim. 11
182084	10P	19	8.2	8.2	1760	9.4	35			
182089	10P	18	7.7	7.2	4520	21.2	69			
182090	10P	39	13.6	14.4	2055	30.0	240			
182096	10P	24	11.2	12.5	2860	28.3	193			
182098	10P	18	8.3	8.6	4550	24.3	116	B2	14	3
182099	10P	22	7.2	7.3	5430	22.3	84			
183001	9P1B	26	10.3	12.3	3363	29.2	207	B2	15	5
183002	9P1B	26	10.7	11.6	2831	26.1	171			
183003	10P	43	24.3	21.8	769	35.5	379	B2	13	4
183004	10P+B	50	20.3	18.6	833	27.6	274	B2	13	4
183005	10P+B	24	8.6	10.7	4125	23.5	141	B2	15	5
183006	10P	33	16.1	15.1	1353	27.6	219	B2	15	5
183007	8P2B	8	2.5	2.6	3165	1.7	6	B2	15	5
183008	5P5B	20	8.5	8.8	2235	13.5	70	B2	15	5
183009	10P+B	10	4.7	4.0	4850	4.9	14			
183011	10P	48	17.8	16.4	1042	26.0	220	B2	15	5
183012	10P	25	12.2	10.9	1329	15.4	88			
183013	10P	29	13.2	12.5	1707	23.4	169	B2	15	5
183014	10P	21	9.2	9.4	2975	19.6	114	B2	15	5
183017	9P1O	43	20.9	18.9	1069	30.8	291	B2	13	4
183018	10P	32	17.4	16.7	1540	36.7	314	C2	15	5
183023	10P	15	7.3	6.1	3200	13.5	49			
183024	9P1B	17	7.3	6.5	3633	16.0	60			
183025	10P	43	19.3	20.3	1167	34.0	353	B2	13	3
183026	9P1B	21	8.0	9.3	3233	21.4	129	B2	15	5
183027	10P	43	20.3	21.0	983	31.9	326	B2	13	3
183028	10P+B	74	27.8	25.5	526	31.6	381	B2	11	3
183031	9P1B	37	17.0	18.2	1289	30.0	292	B2	15	5
183032	9P1B	24	11.4	12.4	2928	31.6	215	B2	15	5
183033	10P	35	16.4	17.1	1528	32.1	282	B2	15	5
183034	10P	34	13.2	14.0	2229	30.6	238	B2	15	5
183035	10P+B,S	19	8.1	8.6	4575	23.0	109	B2	15	5
183037	9P1B	26	11.4	12.9	2600	27.1	205	B2	15	5
183038	10P	56	19.7	20.3	1117	34.0	346	B2	13	3

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT	
									Total 10	Of which with phytomass estim. 11
183039	10P	60	22.8	24.4	822	33.5	412	B2	13	3
183040	9P1B+O	23	10.3	11.6	3675	31.4	216	B2	15	5
183041	10P+O	44	22.1	23.2	1170	44.4	489	B2	13	3
183042	10P	35	13.9	14.8	2508	38.0	297	B2	15	5
183045	10P+B	24	12.3	12.4	2105	24.9	173	B2	15	5
183046	10P+O	27	10.4	11.3	2625	22.3	157	B2	15	4
183047	10P+B	35	16.3	18.1	1677	35.1	344	B2	13	3
183048	7P3B	17	8.2	7.1	3213	17.3	66	B2	15	5
183049	10P+O	43	16.2	19.1	1870	38.8	400	B2	15	5
183052	10P+B	21	7.3	8.9	6210	26.3	143	B2	15	4
183053	7P3B	11	3.4	3.1	4950	5.0	13	B2	15	3
183054	10P	43	12.3	12.7	2021	24.1	178			
183055	8P2O	72	32.3	27.1	565	35.7	445	C2	11	3
183056	9P1O	32	15.6	16.4	2696	39.0	310	C2	15	5
183057	8P2O	35	23.8	20.5	1414	41.0	379	C2	11	3
183058	10P+O	31	17.2	18.4	1959	45.9	437	C2	15	5
183059	7P3O	21	10.7	11.9	3093	28.7	190	C3	15	5
187002	10P	41	20.1	18.1	1008	30.1	268	B2	7	7
187003	10P	13	6.2	5.0	3322	10.0	32	C2	7	7
187004	10P	10	4.1	3.5	4052	5.4	16	C2	10	10
187005	10P	27	15.3	13.6	1531	28.2	202	C2	9	9
187006	10P	18	10.0	8.9	2286	17.8	85	C2	8	8
187007	10P	15	7.4	6.3	3182	13.8	52	C2	8	8
187008	10P	31	16.2	15.9	1518	31.4	263	B3	7	7
188001	9P1O	83	35.3	29.1	523	45.7	507	B2	9	9
191001	10P	30	14.5	15.2	2453	40.4	300	B2	10	10
191002	10P	28	14.2	14.2	2213	35.2	251	B2	10	10
191003	10P	26	12.0	13.7	3217	36.4	246	B2	10	10
191004	10P	40	15.8	19.3	1670	32.7	304	B2	10	10
191005	10P	18	11.7	8.4	2690	28.9	122	B2	10	10
191006	10P	28	12.9	12.1	2380	31.2	189			
192001	10P	32	14.4	15.4	1120	18.3	164	B2	1	1
192002	10P	35	17.4	16.1	1132	26.8	245	B2	1	1
593001	8P2O	17	10.6	10.6	3750	28.8	160	C2	9	3

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT Total 10	Number of MT Of which with phytomass estim. 11
593002	9P1O+Ld	22	15.7	13.1	2674	26.0	152	B2	10	3
193001	8P2B	10	4.2	3.6	4200	6.3	20			
193002	10P	18	7.6	8.1	3970	17.8	78	B2	10	10
193003	10P	38	15.5	15.2	1592	29.9	210	B2	5	5
193004	10P	55	25.5	26.2	822	41.6	510	C2	5	5
Pine plantations of the Ukrainian forest-steppe										
188002	10P	43	17.3	14.8	1078	25.0	187	B2	5	5
188003	10P	23	12.8	11.1	1552	20.0	119	B2	8	8
188004	10P	38	19.8	18.7	1305	40.0	360	B2	7	7
188006	9P1O	50	21.5	18.5	495	19.2	175	B2	3	3
188007	10P	75	27.3	22.2	642	37.6	383	B2	3	3
188010	9P1B	19	9.7	8.3	2255	16.0	74	B2	15	15
188011	10P	11	5.0	4.0	3920	7.5	22	C2	15	15
188012	10P	29	12.7	14.0	3281	36.8	238	C2	15	15
188013	10P	34	14.2	16.2	2771	39.9	296	C2	15	15
Pine plantations of the Ukrainian Lower Dnieper Sands										
108701	10P	28	10.9	10.3	3042	28.3	164		11	2
108702	10P	28	10.8	10.1	3273	29.9	167		9	3
108703	10P	28	10.8	10.3	2292	21.0	118		11	3
108704	10P	28	10.7	9.9	2940	26.4	140		11	3
108705	10P	28	9.3	7.9	2735	18.7	84		11	3
108706	10P	28	10.8	9.3	1877	17.1	84		10	3
108707	10P	28	12.5	11.4	2529	31.3	190		11	3
108708	10P	28	11.8	12.3	2722	29.6	197		11	3
108709	10P	28	11.1	10.0	2404	23.3	115		11	3
108710	10P	28	12.0	10.4	2535	28.8	148		10	3
108711	10P	28	10.9	10.7	3774	35.0	198		10	3
108712	10P	28	10.0	9.0	2890	22.7	111		12	3
108713	10P	28	11.3	10.9	2385	23.8	130		10	3
108714	10P	34	11.1	9.8	2048	19.7	101		12	3

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT	
									Total 10	Of which with phyto-mass estim. 11
108715	10P	26	10.7	9.4	2512	22.4	110		11	3
108716	10P	26	11.1	9.2	2730	26.3	132		10	3
108717	10P	31	11.6	10.9	2663	28.1	132		2	2
108718	10P	31	10.5	8.9	2107	18.2	63		2	2
108719	10P	28	12.7	10.5	1576	19.9	94		2	2
108720	10P	28	11.9	9.0	1915	21.4	90		2	2
108721	10P	32	10.3	7.7	1888	15.7	54		8	4
108722	10P	24	11.9	9.7	1936	21.4	101		9	8
108723	10P	29	11.1	7.9	1457	14.0	49		9	4
108724	10P	29	10.8	8.5	1515	13.8	59		7	3
108725	10P	22	5.1	4.5	2314	4.8	13		7	6
108801	10P	20	9.7	8.1	2121	15.6	64		10	3
108802	10P	32	13.1	12.6	1775	24.1	142		6	3
108803	10P	26	14.1	12.3	1352	21.0	128		8	3
108804	10P	27	13.0	11.8	1190	15.9	96		7	3
108805	10P	29	16.5	12.5	905	19.4	124		7	3
108806	10P	30	13.1	12.4	1697	22.9	133		8	3
108807	10P	32	10.3	10.6	2157	18.0	86		7	3
108808	10P	31	14.4	10.9	366	6.0	33		3	3
108818	10P	31	10.4	7.8	2087	17.7	65		7	3
108819	10P	30	16.0	13.0	1150	23.2	157		6	3
108820	10P	30	13.0	12.6	1725	23.0	135		8	3
108821	10P	26	13.2	11.6	1124	15.3	91		7	3
108822	10P	25	14.1	12.3	1340	20.8	139		8	3
108827	10P	35	10.9	9.9	1982	18.5	93		12	3
108828	10P	27	11.0	9.3	2625	25.0	127		10	3
108857	10P	68	20.0	12.5	826	25.9	174		1	1
108859	10P	65	26.5	21.2	675	37.4	452		1	1
108860	10P	65	21.5	11.2	639	23.3	142		1	1
108901	10P	32	10.3	7.8	1788	14.8	50		8	3
108902	10P	24	11.9	9.8	1808	20.0	97		8	3
108903	10P	30	11.2	8.0	1409	13.9	48		9	3
108904	10P	29	10.8	8.7	1411	13.0	56		7	3
108905	10P	22	5.2	4.6	2160	4.5	12		8	4

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT	
									Total 10	Of which with phytomass estim. 11
108906	10P	18	5.2	4.6	2600	5.6	15		9	4
108907	10P	31	10.7	8.4	1516	13.6	58		9	3
108908	10P	29	10.9	7.7	1455	13.7	49		9	3
108909	10P	23	11.8	9.5	2050	22.4	106		9	3
108910	10P	31	10.2	7.6	1940	16.0	55		8	3
Pine stands of the Ukrainian Polesje										
182004	7P2O1B	69	24.4	22.7	838	35.5	404	C2	13	5
182007	10P+B	50	17.5	17.1	1033	24.8	228	B2	15	5
182009	10P	59	23.2	18.9	638	27.0	246	B3	15	5
182010	10P	125	24.3	20.7	594	27.6	280			
182011	9P1O+B	34	11.7	12.9	3170	27.2	208	B3	15	5
182013	10P+B	55	20.0	19.7	1220	36.9	365			
182021	10P+O	41	16.1	14.9	1727	34.9	263	B3	13	5
182024	10P	65	30.7	24.8	435	32.2	365	B2	15	5
182026	10P	91	33.7	24.1	232	20.6	232	B2	13	5
182028	9P1Al+B	82	25.6	20.1	890	38.1	334	B3	13	5
182030	10P+B	32	12.6	12.2	1778	20.4	138			
182034	10P+B	55	18.7	20.5	1053	28.3	302	B3	14	5
182044	8P2B	34	17.4	16.0	945	18.5	159	B3	14	5
182063	10P	53	19.2	16.5	1008	28.6	237			
182064	10P+O	58	22.1	18.3	800	29.0	250	B3	15	5
182065	10P+B	33	15.4	15.7	1236	22.6	194	B3	12	12
182066	10P+B	52	23.3	22.8	750	31.0	327	B2	12	12
182067	9P1B	46	21.5	23.1	1054	36.9	408	C3	12	12
182069	9P1B	50	21.1	21.8	672	22.8	251	B3	12	12
182073	7P3B	32	14.2	14.9	1310	19.2	146	C3	12	12
182077	10P	71	14.2	14.7	1303	20.5	160	B5	12	12
182082	10P	32	10.1	10.8	3736	29.9	178			
182085	10P	39	13.0	12.1	2370	31.4	198			
182095	10P	41	20.6	20.1	935	31.2	303	B2	13	3
183050	10P	87	29.0	25.5	530	35.0	425	B3	12	3
183051	10P	58	24.6	23.9	876	41.5	471			

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT Total 10	Number of MT Of which with phytomass estim. 11
Spruce plantation of the Ukrainian Carpathia										
387001	10S	90	38.5	36.5	454	50.7	778	D3	8	3
387002	10S	64	35.0	31.4	516	48.4	734	D3	9	3
387003	10S+Bc	30	21.7	19.1	1160	40.2	372	D3	7	3
387004	10S	38	24.8	22.9	1128	53.1	575	D3	9	3
387005	8S2Bc+F	82	48.3	36.0	402	49.6	742	D3	9	3
387006	8S1F1Bc	70	34.6	32.6	582	41.9	682	D3	9	3
387006	10S	45	26.6	25.3	1049	45.6	537	C3	11	3
387008	9S1F+Bc	82	33.2	30.9	560	43.9	679	D3	11	3
387008	8S2F	68	32.0	29.0	781	52.0	741	D3	6	3
387010	9S1Bc	32	17.0	18.4	1971	33.7	338	D3	9	1
387011	8S2Bc	32	15.5	17.8	2716	35.5	310	C3	10	3
387012	10S+F	16	7.6	6.3	3400	9.7	32	C3	9	3
387015	10S+F,Bc	28	10.8	11.9	3850	34.7	219	D3	10	3
387016	9S1F	33	10.1	9.6	3985	41.9	187	D3	11	3
387017	6S3F1B+Bc	30	8.3	7.9	5400	34.2	162	D3	12	3
387503	7S1F1Bc1A	104	46.4	38.6	242	36.8	556	D3	5	2
388001	7S2Bc1Mp	20	6.7	7.8	5653	16.2	63	D3	9	5
388010	10S	33	10.4	12.2	3248	27.5	196	D3	12	4
388014	10S	35	13.3	13.9	2065	28.2	212	B3	6	4
388017	5S4F1Bc	17	4.3	3.8	7420	7.8	27	C3	3	3
389001	7S3F	26	10.8	10.6	2740	24.5	142	D3	6	4
389002	10S+F	33	13.8	16.3	2900	40.9	374	D3	7	4
389003	9S1F	35	14.7	17.2	3360	48.0	419	D3	6	4
389005	7S3F	31	12.2	12.2	3167	34.2	207	D3	5	4
391001	10S	12	6.0	5.1	2650	6.9	23	D3	15	15
391002	10S	19	6.9	6.2	4150	13.6	52	D3	15	15
391003	10S	11	3.7	3.1	2600	2.7	9	D3	12	12
391004	10S	17	5.8	4.8	2417	6.0	20	D3	15	15
391005	10S	22	9.1	8.9	3813	18.0	93	D3	9	9
391006	9S1Mp	42	23.0	21.3	1708	48.1	511	C3	10	10
391007	10S+Bc,Mp	135	39.5	31.2	512	51.1	649	C3	7	7

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT Total 10	Number of MT Of which with phytomass estim. 11
391008	10S	41	20.4	21.8	1280	37.0	403	C3	7	7
391009	9S1B	23	7.8	6.6	3453	14.6	57	C3	12	12
391010	9S1Bc	32	15.5	15.7	4607	55.3	399	C3	23	23
391011	8S2Bc	59	24.5	23.4	1035	34.5	384	C3	21	21
391012	10S+B	48	17.5	19.3	2136	35.6	326	C3	11	11
391013	10S	95	30.8	31.1	892	60.2	872	C3	12	12
Oak plantation of Ukraine										
591001	9O1P	74	26.5	20.8	422	20.8	214	C2	6	6
591002	8O1P1Ch	27	11.0	11.2	1795	18.7	96	C2	8	8
591003	9O1P	49	20.2	18.0	990	31.8	300	C2	6	6
591004	6O3P1H	44	20.6	18.2	1050	33.4	310	C2	6	6
591005	9O1P	39	13.9	13.6	1254	20.1	143	C2	7	7
591006	4O5P1B	17	5.2	7.1	4790	13.3	69	C3	10	10
592001	2O5H1Ld2B	9	2.4	3.1	14400	6.3	17	C2	7	7
592002	3O3H2Ld2Mp	28	15.2	14.7	2450	23.9	176	C2	6	6
592003	5O4H1As	19	4.8	6.8	6222	11.0	46	C2	7	7
592004	7O1Mp2S	46	24.7	19.6	560	22.8	201	C2	5	5
592005	3O3H4Ld	15	6.2	8.1	6533	15.6	79	C2	8	8
592006	5O3H2Ld	39	17.9	17.7	1930	27.1	198	C2	5	5
592007	10O+Ld	46	22.1	19.6	684	25.0	238	C2	6	6
592008	4O3H3Ld	28	13.4	14.9	2189	20.9	159	C2	6	6
592009	7O3A	24	6.7	7.3	2190	7.5	35	D2	10	10
592010	8O2Mp	29	10.1	11.2	1463	12.4	60	D2	12	12
592011	8O2A	29	8.2	8.4	1530	8.2	35	D2	8	8
592012	8O2Mp	15	4.3	5.0	1900	2.7	9	D2	9	9
593001	2O8P	17	6.9	8.3	3750	28.8	160	C2	9	6
593002	1O9P+Ld	22	5.1	6.7	2674	26.0	152	B2	10	7
593003	5O2Mp1H1El	11	4.6	5.1	2664	3.9	11	D2	15	15
593004	5O3H1Pr1S	14	4.2	4.6	3572	3.8	11	D2	12	12
593005	4O4H1Mp1A	23	12.3	13.2	1006	10.3	66	D2	3	3
593006	4O5H1Mp	28	14.2	13.8	1255	17.3	117	D2	6	6
593007	4O4H1Bc1A	34	18.0	16.0	1009	25.2	199	D2	4	4

Continuation Appendix 1

Code of test area 1	Species composition 2	Age (yr) 3	Mean diameter (cm) 4	Mean height (m) 5	Number of trees per ha 6	Basal area (m^2/ha) 7	Growing stock (m^3/ha) 8	Site type 9	Number of MT Total 10	Number of MT Of which with phytomass estim. 11
593008	5O4H1A	35	18.1	17.8	808	21.7	193	D2	3	3
593009	7O2El1H	42	16.7	14.3	867	16.6	121	D2	3	3
593010	7O2H1A+Mp	48	28.5	19.5	714	32.9	265	D2	2	2
593011	8O1H1A+Ld	17	9.0	7.1	2579	11.7	40	D2	8	8
593012	8O1H1Mp+Ld	62	24.9	16.4	1350	37.0	312	D2	3	3
593013	7O1H1A1Mp	27	11.8	10.2	3761	24.4	126	D2	6	6
593014	7O2H1Mp+Ld	44	19.5	17.9	3320	42.1	413	D2	3	3
Beech stands of the Ukrainian Carpathia										
892001	9Bc1Mp	62	19.2	19.8	1917	47.6	435	D2	8	8
892002	9Bc1Mp	63	25.3	25.7	994	45.2	438	D3	7	7
892003	10Bc	45	16.7	21.3	1642	34.9	342	D3	10	10
892004	8Bc2Mp	31	12.1	14.7	3000	34.0	218	D3	10	10
892005	9Bc1Mp	21	8.8	9.8	3211	20.2	94	D3	13	13
892006	9Bc1H	51	21.4	23.1	1213	36.8	340	D3	12	12
892007	10Bc+Mp	11	1.9	3.5	51800	13.8	36	D2	15	15
892008	8Bc2Mp	18	6.5	9.3	5950	16.6	83	C2	15	15
892009	10Bc+H	22	6.6	10.1	5000	17.2	99	C2	13	13
892010	10Bc+H	25	8.7	13.2	4173	24.7	165	D2	14	14
892011	9Bc1B	10	5.7	6.6	4275	11.3	41	C3	8	8
892012	9Bc1Mp	20	8.7	11.4	3638	22.5	119	C3	7	7
892013	9Bc1S	32	14.4	15.3	1420	23.5	163	C3	7	7
892014	7Bc3S	38	16.9	17.1	925	23.4	203	C3	7	7
892015	9Bc1F	41	17.1	18.3	1042	25.2	236	C3	7	7
892016	9Bc1Mp	45	17.7	19.5	1271	32.2	314	C3	7	7
892017	9Bc1O	51	18.7	21.0	1125	31.5	314	C3	7	7

Appendix 2

I. The Fresh-Cut State of Phytomass

(A) The phytomass parameters of trees for stands as a whole

Table 1. Pine plantation: The phytomass of stem wood (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0003	0.0007												
4		0.0033	0.0038	0.0045										
6		0.0075	0.0085	0.0102	0.0122									
8			0.0152	0.0182	0.0217	0.0254	0.0293							
10			0.0236	0.0283	0.0337	0.0395	0.0455	0.0517						
12			0.0339	0.0405	0.0482	0.0564	0.0650	0.0738	0.0828					
14				0.0548	0.0651	0.0762	0.0878	0.0996	0.1117	0.1239				
16				0.0712	0.0845	0.0988	0.1137	0.1290	0.1446	0.1604	0.1763			
18					0.1062	0.1241	0.1428	0.1619	0.1814	0.2012	0.2211	0.2411		
20					0.1301	0.1520	0.1748	0.1982	0.2221	0.2462	0.2705	0.2950	0.3197	
22						0.1825	0.2099	0.2379	0.2664	0.2953	0.3244	0.3538	0.3833	
24						0.2156	0.2477	0.2808	0.3144	0.3484	0.3828	0.4174	0.4522	
26							0.2885	0.3268	0.3659	0.4055	0.4454	0.4856	0.5260	0.5667
28							0.3319	0.3760	0.4209	0.4663	0.5122	0.5584	0.6048	0.6515
30							0.3781	0.4282	0.4792	0.5309	0.5830	0.6356	0.6884	0.7415
32								0.4833	0.5408	0.5991	0.6579	0.7171	0.7767	0.8365
34								0.5413	0.6056	0.6708	0.7366	0.8028	0.8695	0.9364
36									0.6736	0.7460	0.8191	0.8927	0.9667	1.0411

Table 2. Pine plantation: The phytomass of stem bark (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0001	0.0002												
4		0.0008	0.0008	0.0008										
6		0.0016	0.0016	0.0017	0.0018									
8			0.0026	0.0028	0.0031	0.0033	0.0035							
10			0.0039	0.0042	0.0046	0.0049	0.0052	0.0055						
12			0.0054	0.0058	0.0063	0.0068	0.0072	0.0076	0.0079					
14				0.0076	0.0083	0.0089	0.0095	0.0100	0.0104	0.0108				
16				0.0096	0.0104	0.0113	0.0120	0.0127	0.0132	0.0137	0.0141			
18					0.0128	0.0138	0.0148	0.0156	0.0163	0.0169	0.0174	0.0178		
20					0.0154	0.0166	0.0177	0.0188	0.0196	0.0204	0.0210	0.0215	0.0220	
22						0.0196	0.0210	0.0222	0.0232	0.0241	0.0249	0.0255	0.0260	
24						0.0228	0.0244	0.0258	0.0270	0.0281	0.0290	0.0298	0.0304	
26							0.0280	0.0296	0.0311	0.0323	0.0334	0.0343	0.0351	0.0357
28							0.0318	0.0337	0.0353	0.0368	0.0380	0.0391	0.0400	0.0407
30							0.0358	0.0379	0.0398	0.0415	0.0429	0.0441	0.0451	0.0459
32								0.0423	0.0445	0.0464	0.0480	0.0494	0.0505	0.0515
34								0.0469	0.0493	0.0514	0.0533	0.0548	0.0561	0.0572
36									0.0544	0.0567	0.0588	0.0605	0.0620	0.0632

Table 3. Pine plantation: The phytomass of stem and bark (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0004	0.0009												
4		0.0041	0.0046	0.0053										
6		0.0091	0.0101	0.0119	0.0140									
8			0.0178	0.0210	0.0248	0.0287	0.0328							
10			0.0275	0.0325	0.0383	0.0444	0.0507	0.0572						
12			0.0393	0.0463	0.0545	0.0632	0.0722	0.0814	0.0907					
14				0.0624	0.0734	0.0851	0.0973	0.1096	0.1221	0.1347				
16				0.0808	0.0949	0.1101	0.1257	0.1417	0.1578	0.1741	0.1904			
18					0.1190	0.1379	0.1576	0.1775	0.1977	0.2181	0.2385	0.2589		
20					0.1455	0.1686	0.1925	0.2170	0.2417	0.2666	0.2915	0.3165	0.3417	
22						0.2021	0.2309	0.2601	0.2896	0.3194	0.3493	0.3793	0.4093	
24						0.2384	0.2721	0.3066	0.3414	0.3765	0.4118	0.4472	0.4826	
26							0.3165	0.3564	0.3970	0.4378	0.4788	0.5199	0.5611	0.6024
28							0.3637	0.4097	0.4562	0.5031	0.5502	0.5975	0.6448	0.6922
30							0.4139	0.4661	0.5190	0.5724	0.6259	0.6797	0.7335	0.7874
32								0.5256	0.5853	0.6455	0.7059	0.7665	0.8272	0.8880
34								0.5882	0.6549	0.7222	0.7899	0.8576	0.9256	0.9936
36									0.7280	0.8027	0.8779	0.9532	1.0287	1.1043

Table 4. Pine plantation: The phytomass of twigs (t).

Diameter (cm)	Height (m) 2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.0006	0.0002												
4		0.0017	0.0010	0.0007										
6		0.0053	0.0030	0.0021	0.0015									
8			0.0068	0.0046	0.0034	0.0027	0.0022							
10			0.0128	0.0086	0.0064	0.0050	0.0040	0.0034						
12			0.0214	0.0144	0.0107	0.0083	0.0067	0.0056	0.0048					
14				0.0223	0.0165	0.0128	0.0104	0.0087	0.0074	0.0064				
16				0.0325	0.0240	0.0187	0.0152	0.0126	0.0108	0.0093	0.0082			
18					0.0334	0.0261	0.0211	0.0176	0.0150	0.0130	0.0114	0.0101		
20					0.0449	0.0350	0.0284	0.0237	0.0202	0.0175	0.0154	0.0137	0.0122	
22						0.0458	0.0372	0.0310	0.0264	0.0229	0.0201	0.0179	0.0160	
24						0.0585	0.0475	0.0396	0.0337	0.0292	0.0257	0.0228	0.0205	
26							0.0595	0.0496	0.0422	0.0366	0.0322	0.0286	0.0256	0.0232
28							0.0732	0.0611	0.0520	0.0451	0.0396	0.0352	0.0316	0.0285
30							0.0889	0.0742	0.0632	0.0547	0.0481	0.0427	0.0383	0.0346
32								0.0889	0.0758	0.0657	0.0577	0.0512	0.0460	0.0415
34								0.1055	0.0899	0.0779	0.0684	0.0608	0.0545	0.0493
36									0.1055	0.0915	0.0803	0.0714	0.0640	0.0579
							Stocking – 0.7							
2	0.0007	0.0003												
4		0.0018	0.0011	0.0007										
6		0.0057	0.0033	0.0022	0.0016									
8			0.0074	0.0050	0.0037	0.0029	0.0023							
10			0.0138	0.0094	0.0069	0.0054	0.0044	0.0036						
12			0.0231	0.0156	0.0115	0.0090	0.0073	0.0061	0.0052					
14				0.0241	0.0178	0.0139	0.0113	0.0094	0.0080	0.0069				
16				0.0351	0.0259	0.0202	0.0164	0.0137	0.0117	0.0101	0.0089			
18					0.0361	0.0282	0.0229	0.0191	0.0163	0.0141	0.0124	0.0110		
20					0.0486	0.0379	0.0308	0.0257	0.0219	0.0189	0.0166	0.0148	0.0133	
22						0.0496	0.0402	0.0335	0.0286	0.0248	0.0218	0.0193	0.0173	
24						0.0634	0.0514	0.0429	0.0365	0.0316	0.0278	0.0247	0.0221	
26							0.0644	0.0537	0.0457	0.0396	0.0348	0.0309	0.0277	0.0251
28							0.0793	0.0661	0.0563	0.0488	0.0429	0.0381	0.0342	0.0309
30							0.0963	0.0803	0.0684	0.0593	0.0521	0.0463	0.0415	0.0375
32								0.0963	0.0820	0.0711	0.0624	0.0555	0.0498	0.0450
34								0.1142	0.0973	0.0843	0.0741	0.0658	0.0590	0.0534
36									0.1143	0.0990	0.0870	0.0773	0.0693	0.0627

Table 5. Pine plantation: The phytomass of needles (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.0004	0.0002												
4		0.0011	0.0006	0.0004										
6		0.0035	0.0020	0.0014	0.0010									
8			0.0046	0.0031	0.0023	0.0018	0.0014							
10			0.0085	0.0058	0.0043	0.0033	0.0027	0.0022						
12			0.0143	0.0096	0.0071	0.0056	0.0045	0.0038	0.0032					
14				0.0149	0.0110	0.0086	0.0069	0.0058	0.0049	0.0043				
16				0.0217	0.0160	0.0125	0.0101	0.0084	0.0072	0.0062	0.0055			
18					0.0223	0.0174	0.0141	0.0117	0.0100	0.0087	0.0076	0.0068		
20					0.0299	0.0234	0.0190	0.0158	0.0135	0.0117	0.0102	0.0091	0.0082	
22						0.0306	0.0248	0.0207	0.0176	0.0153	0.0134	0.0119	0.0107	
24						0.0390	0.0317	0.0264	0.0225	0.0195	0.0171	0.0152	0.0136	
26							0.0397	0.0331	0.0282	0.0244	0.0214	0.0191	0.0171	0.0154
28							0.0488	0.0407	0.0347	0.0301	0.0264	0.0235	0.0210	0.0190
30							0.0593	0.0495	0.0421	0.0365	0.0321	0.0285	0.0256	0.0231
32								0.0593	0.0505	0.0438	0.0385	0.0342	0.0306	0.0277
34								0.0704	0.0599	0.0519	0.0456	0.0405	0.0364	0.0329
36									0.0704	0.0610	0.0536	0.0476	0.0427	0.0386
							Stocking – 0.7							
2	0.0004	0.0002												
4		0.0012	0.0007	0.0005										
6		0.0038	0.0022	0.0015	0.0011									
8			0.0049	0.0033	0.0025	0.0019	0.0016							
10			0.0092	0.0062	0.0046	0.0036	0.0029	0.0024						
12			0.0154	0.0104	0.0077	0.0060	0.0049	0.0041	0.0035					
14				0.0161	0.0119	0.0093	0.0075	0.0063	0.0053	0.0046				
16				0.0234	0.0173	0.0135	0.0110	0.0091	0.0078	0.0067	0.0059			
18					0.0241	0.0188	0.0153	0.0127	0.0108	0.0094	0.0083	0.0073		
20					0.0324	0.0253	0.0205	0.0171	0.0146	0.0126	0.0111	0.0099	0.0088	
22						0.0331	0.0268	0.0224	0.0191	0.0165	0.0145	0.0129	0.0116	
24						0.0423	0.0343	0.0286	0.0244	0.0211	0.0185	0.0165	0.0148	
26							0.0429	0.0358	0.0305	0.0264	0.0232	0.0206	0.0185	0.0167
28							0.0529	0.0441	0.0376	0.0326	0.0286	0.0254	0.0228	0.0206
30							0.0642	0.0536	0.0456	0.0395	0.0347	0.0309	0.0277	0.0250
32								0.0642	0.0547	0.0474	0.0417	0.0370	0.0332	0.0300
34								0.0762	0.0649	0.0562	0.0494	0.0439	0.0394	0.0356
36									0.0762	0.0660	0.0580	0.0515	0.0462	0.0418

Table 6. Pine plantation: The phytomass of branches (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.0003	0.0001												
4		0.0011	0.0007	0.0004										
6		0.0039	0.0022	0.0014	0.0011									
8			0.0054	0.0036	0.0026	0.0020	0.0017							
10			0.0111	0.0074	0.0054	0.0042	0.0034	0.0029						
12			0.0199	0.0134	0.0098	0.0075	0.0061	0.0050	0.0043					
14				0.0219	0.0160	0.0124	0.0101	0.0083	0.0071	0.0060				
16				0.0338	0.0247	0.0191	0.0154	0.0128	0.0108	0.0094	0.0082			
18					0.0362	0.0281	0.0226	0.0188	0.0159	0.0137	0.0120	0.0106		
20					0.0512	0.0396	0.0319	0.0265	0.0224	0.0193	0.0170	0.0150	0.0133	
22						0.0541	0.0436	0.0361	0.0306	0.0264	0.0231	0.0204	0.0182	
24						0.0720	0.0579	0.0480	0.0407	0.0351	0.0307	0.0272	0.0243	
26							0.0753	0.0624	0.0529	0.0457	0.0400	0.0353	0.0316	0.0285
28							0.0962	0.0798	0.0676	0.0582	0.0510	0.0450	0.0403	0.0363
30							0.1208	0.1000	0.0848	0.0731	0.0639	0.0566	0.0505	0.0455
32								0.1239	0.1050	0.0904	0.0791	0.0699	0.0626	0.0563
34								0.1513	0.1282	0.1105	0.0967	0.0855	0.0763	0.0688
36									0.1549	0.1335	0.1167	0.1033	0.0923	0.0831
							Stocking – 0.7							
2	0.0004	0.0001												
4		0.0013	0.0007	0.0005										
6		0.0047	0.0026	0.0018	0.0013									
8			0.0067	0.0045	0.0032	0.0025	0.0020							
10			0.0138	0.0092	0.0067	0.0052	0.0042	0.0035						
12			0.0248	0.0166	0.0121	0.0094	0.0075	0.0062	0.0053					
14				0.0274	0.0200	0.0155	0.0125	0.0103	0.0088	0.0076				
16				0.0425	0.0310	0.0240	0.0193	0.0160	0.0135	0.0117	0.0103			
18					0.0156	0.0353	0.0284	0.0236	0.0200	0.0172	0.0150	0.0134		
20					0.0646	0.0499	0.0402	0.0333	0.0282	0.0244	0.0213	0.0188	0.0169	
22						0.0684	0.0551	0.0456	0.0386	0.0333	0.0291	0.0258	0.0230	
24						0.0911	0.0733	0.0608	0.0514	0.0444	0.0389	0.0343	0.0307	
26							0.0956	0.0792	0.0671	0.0579	0.0506	0.0448	0.0400	0.0360
28							0.1222	0.1013	0.0858	0.0739	0.0647	0.0572	0.0511	0.0460
30							0.1537	0.1273	0.1079	0.0930	0.0813	0.0719	0.0642	0.0579
32								0.1578	0.1337	0.1152	0.1007	0.0891	0.0796	0.0717
34								0.1931	0.1635	0.1410	0.1232	0.1090	0.0973	0.0877
36									0.1979	0.1706	0.1491	0.1319	0.1178	0.1061

Table 7. Pine plantation: The phytomass of trees (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.0011	0.0012												
4		0.0063	0.0059	0.0061										
6		0.0165	0.0143	0.0147	0.0161									
8			0.0278	0.0277	0.0297	0.0325	0.0359							
10			0.0471	0.0457	0.0480	0.0519	0.0568	0.0623						
12			0.0735	0.0693	0.0714	0.0763	0.0828	0.0902	0.0982					
14				0.0992	0.1004	0.1061	0.1143	0.1237	0.1341	0.1450				
16				0.1363	0.1356	0.1417	0.1512	0.1629	0.1758	0.1897	0.2041			
18					0.1775	0.1834	0.1943	0.2080	0.2236	0.2405	0.2581	0.2763		
20					0.2266	0.2316	0.2434	0.2593	0.2776	0.2976	0.3187	0.3406	0.3632	
22						0.2868	0.2993	0.3169	0.3378	0.3611	0.3858	0.4116	0.4382	
24						0.3494	0.3617	0.3810	0.4046	0.4311	0.4596	0.4896	0.5205	
26							0.4315	0.4519	0.4781	0.5079	0.5402	0.5743	0.6098	0.6463
28							0.5087	0.5302	0.5585	0.5914	0.6276	0.6660	0.7061	0.7475
30							0.5940	0.6156	0.6459	0.6820	0.7219	0.7648	0.8096	0.8560
32								0.7088	0.7408	0.7797	0.8235	0.8706	0.9204	0.9720
34								0.8099	0.8430	0.8846	0.9322	0.9836	1.0383	1.0953
36									0.9533	0.9972	1.0482	1.1041	1.1637	1.2260
							Stocking – 0.7							
2	0.0012	0.0012												
4		0.0066	0.0060	0.0063										
6		0.0176	0.0149	0.0152	0.0164									
8			0.0294	0.0288	0.0305	0.0331	0.0364							
10			0.0505	0.0479	0.0496	0.0532	0.0578	0.0631						
12			0.0795	0.0733	0.0743	0.0786	0.0846	0.0917	0.0995					
14				0.1059	0.1053	0.1099	0.1173	0.1262	0.1362	0.1469				
16				0.1467	0.1432	0.1476	0.1560	0.1668	0.1791	0.1925	0.2066			
18					0.1887	0.1920	0.2013	0.2138	0.2285	0.2447	0.2618	0.2796		
20					0.2425	0.2438	0.2532	0.2674	0.2845	0.3036	0.3239	0.3452	0.3674	
22						0.3036	0.3128	0.3281	0.3473	0.3692	0.3929	0.4180	0.4439	
24						0.3718	0.3797	0.3960	0.4172	0.4420	0.4692	0.4980	0.5281	
26							0.4550	0.4714	0.4946	0.5221	0.5526	0.5853	0.6196	0.6551
28							0.5388	0.5551	0.5796	0.6096	0.6435	0.6801	0.7187	0.7588
30							0.6318	0.6470	0.6725	0.7049	0.7419	0.7825	0.8254	0.8703
32								0.7476	0.7737	0.8081	0.8483	0.8926	0.9400	0.9897
34								0.8575	0.8833	0.9194	0.9625	1.0105	1.0623	1.1169
36									1.0021	1.0393	1.0850	1.1366	1.1927	1.2522

Table 8. Pine plantation: Ratio of tree phytomass and stem volume (t/m^3).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	1.92	1.19												
4		1.31	1.10	0.97										
6		1.54	1.21	1.05	0.98									
8			1.34	1.13	1.03	0.97	0.94							
10			1.47	1.21	1.08	1.01	0.97	0.94						
12			1.61	1.29	1.13	1.04	0.99	0.96	0.93					
14				1.37	1.18	1.08	1.02	0.98	0.95	0.93				
16				1.46	1.24	1.12	1.04	1.00	0.96	0.94	0.93			
18					1.30	1.16	1.07	1.02	0.98	0.96	0.94	0.92		
20					1.35	1.19	1.10	1.04	1.00	0.97	0.95	0.93	0.92	
22						1.23	1.13	1.06	1.01	0.98	0.96	0.94	0.93	
24						1.28	1.16	1.08	1.03	1.00	0.97	0.95	0.94	
26							1.19	1.11	1.05	1.01	0.98	0.96	0.94	0.93
28							1.22	1.13	1.07	1.02	0.99	0.97	0.95	0.94
30							1.25	1.15	1.09	1.04	1.00	0.98	0.96	0.94
32								1.18	1.11	1.05	1.02	0.99	0.97	0.95
34								1.20	1.12	1.07	1.03	1.00	0.98	0.96
36									1.14	1.09	1.04	1.01	0.99	0.97
							Stocking – 0.7							
2	2.10	1.19												
4		1.37	1.12	1.00										
6		1.64	1.26	1.09	1.00									
8			1.41	1.18	1.06	0.99	0.95							
10			1.57	1.27	1.12	1.03	0.98	0.95						
12			1.74	1.37	1.18	1.08	1.01	0.97	0.95					
14				1.47	1.24	1.12	1.04	1.00	0.96	0.94				
16				1.57	1.31	1.16	1.08	1.02	0.98	0.96	0.94			
18					1.38	1.21	1.11	1.05	1.00	0.97	0.95	0.93		
20					1.45	1.26	1.14	1.07	1.02	0.99	0.96	0.94	0.93	
22						1.31	1.18	1.10	1.04	1.00	0.98	0.96	0.94	
24						1.36	1.22	1.12	1.06	1.02	0.99	0.97	0.95	
26							1.25	1.15	1.09	1.04	1.00	0.98	0.96	0.94
28							1.29	1.18	1.11	1.06	1.02	0.99	0.97	0.95
30							1.33	1.21	1.13	1.07	1.03	1.00	0.98	0.96
32								1.24	1.15	1.09	1.05	1.01	0.99	0.97
34								1.27	1.18	1.11	1.06	1.03	1.00	0.98
36									1.20	1.13	1.08	1.04	1.01	0.99

(B) The phytomass parameters of trees for part of stands removed by thinning

Table 9. Pine plantation: The phytomass of twigs (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0008	0.0003												
4		0.0020	0.0011	0.0007										
6		0.0064	0.0034	0.0022	0.0015									
8			0.0078	0.0049	0.0035	0.0026	0.0021							
10			0.0147	0.0094	0.0066	0.0050	0.0039	0.0032						
12			0.0248	0.0159	0.0112	0.0084	0.0066	0.0054	0.0045					
14				0.0247	0.0174	0.0131	0.0103	0.0084	0.0070	0.0059				
16				0.0362	0.0256	0.0193	0.0151	0.0123	0.0102	0.0087	0.0075			
18					0.0359	0.0270	0.0212	0.0172	0.0144	0.0122	0.0105	0.0092		
20					0.0486	0.0366	0.0287	0.0233	0.0194	0.0165	0.0142	0.0124	0.0110	
22						0.0481	0.0378	0.0307	0.0255	0.0217	0.0187	0.0163	0.0144	
24						0.0617	0.0485	0.0394	0.0328	0.0278	0.0240	0.0209	0.0185	
26							0.0611	0.0496	0.0413	0.0350	0.0302	0.0264	0.0233	0.0207
28							0.0756	0.0614	0.0511	0.0433	0.0373	0.0326	0.0288	0.0256
30							0.0921	0.0748	0.0622	0.0528	0.0455	0.0398	0.0351	0.0313
32								0.0900	0.0749	0.0636	0.0548	0.0478	0.0422	0.0376
34								0.1072	0.0892	0.0757	0.0652	0.0569	0.0503	0.0448
36									0.1051	0.0892	0.0769	0.0671	0.0592	0.0528

Table 10. Pine plantation: The phytomass of needles (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0005	0.0002												
4		0.0013	0.0007	0.0005										
6		0.0043	0.0023	0.0014	0.0010									
8			0.0052	0.0033	0.0023	0.0018	0.0014							
10			0.0098	0.0063	0.0044	0.0033	0.0026	0.0021						
12			0.0166	0.0106	0.0075	0.0056	0.0044	0.0036	0.0030					
14				0.0165	0.0116	0.0088	0.0069	0.0056	0.0047	0.0039				
16				0.0242	0.0171	0.0128	0.0101	0.0082	0.0068	0.0058	0.0050			
18					0.0239	0.0180	0.0142	0.0115	0.0096	0.0081	0.0070	0.0061		
20					0.0324	0.0244	0.0192	0.0156	0.0130	0.0110	0.0095	0.0083	0.0073	
22						0.0321	0.0252	0.0205	0.0170	0.0145	0.0125	0.0109	0.0096	
24						0.0412	0.0324	0.0263	0.0219	0.0186	0.0160	0.0140	0.0123	
26							0.0407	0.0331	0.0275	0.0234	0.0201	0.0176	0.0155	0.0138
28							0.0504	0.0409	0.0341	0.0289	0.0249	0.0217	0.0192	0.0171
30							0.0614	0.0499	0.0415	0.0352	0.0304	0.0265	0.0234	0.0209
32								0.0600	0.0500	0.0424	0.0366	0.0319	0.0282	0.0251
34								0.0715	0.0595	0.0505	0.0435	0.0380	0.0335	0.0299
36									0.0701	0.0595	0.0513	0.0448	0.0395	0.0352

Table 11. Pine plantation: The phytomass of branches (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0005	0.0001												
4		0.0015	0.0008	0.0004										
6		0.0054	0.0028	0.0018	0.0012									
8			0.0071	0.0044	0.0031	0.0022	0.0017							
10			0.0147	0.0091	0.0063	0.0047	0.0036	0.0029						
12			0.0265	0.0165	0.0114	0.0085	0.0066	0.0053	0.0043					
14				0.0274	0.0190	0.0140	0.0109	0.0087	0.0071	0.0061				
16				0.0425	0.0293	0.0218	0.0168	0.0135	0.0111	0.0093	0.0080			
18					0.0433	0.0320	0.0248	0.0199	0.0163	0.0138	0.0117	0.0102		
20					0.0613	0.0453	0.0351	0.0281	0.0231	0.0194	0.0166	0.0143	0.0126	
22						0.0621	0.0481	0.0385	0.0317	0.0266	0.0227	0.0197	0.0172	
24						0.0828	0.0641	0.0514	0.0422	0.0354	0.0303	0.0262	0.0230	
26							0.0836	0.0670	0.0551	0.0462	0.0395	0.0341	0.0299	0.0265
28							0.1069	0.0857	0.0704	0.0591	0.0505	0.0437	0.0382	0.0338
30							0.1345	0.1077	0.0886	0.0744	0.0634	0.0549	0.0481	0.0424
32								0.1335	0.1097	0.0921	0.0786	0.0680	0.0595	0.0526
34								0.1633	0.1343	0.1127	0.0962	0.0832	0.0729	0.0644
36									0.1624	0.1363	0.1163	0.1006	0.0881	0.0779

Table 12. Pine plantation: The phytomass of trees (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0014	0.0012												
4		0.0069	0.0061	0.0062										
6		0.0188	0.0152	0.0151	0.0162									
8			0.0301	0.0287	0.0302	0.0327	0.0359							
10			0.0520	0.0479	0.0490	0.0524	0.0569	0.0622						
12			0.0824	0.0734	0.0734	0.0773	0.0832	0.0903	0.0980					
14				0.1063	0.1040	0.1079	0.1151	0.1239	0.1339	0.1447				
16				0.1475	0.1413	0.1447	0.1526	0.1634	0.1757	0.1892	0.2034			
18					0.1862	0.1879	0.1966	0.2089	0.2236	0.2400	0.2572	0.2752		
20					0.2392	0.2383	0.2468	0.2607	0.2778	0.2970	0.3176	0.3391	0.3616	
22						0.2963	0.3042	0.3191	0.3383	0.3605	0.3845	0.4099	0.4361	
24						0.3624	0.3686	0.3843	0.4055	0.4305	0.4581	0.4874	0.5179	
26							0.4408	0.4565	0.4796	0.5074	0.5384	0.5716	0.6065	0.6427
28							0.5210	0.5363	0.5607	0.5911	0.6256	0.6629	0.7022	0.7431
30							0.6098	0.6237	0.6491	0.6820	0.7197	0.7611	0.8050	0.8507
32								0.7191	0.7450	0.7800	0.8211	0.8664	0.9149	0.9657
34								0.8230	0.8487	0.8854	0.9296	0.9788	1.0320	1.0879
36									0.9605	0.9985	1.0455	1.0986	1.1563	1.2174

Table 13. Pine plantation: Ratio of tree phytomass and stem volume (t/m^3).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	2.45	1.19												
4		1.43	1.14	0.98										
6		1.75	1.28	1.08	0.99									
8			1.45	1.17	1.05	0.98	0.94							
10			1.62	1.27	1.11	1.02	0.97	0.94						
12			1.80	1.37	1.16	1.06	1.00	0.96	0.93					
14				1.47	1.23	1.10	1.02	0.98	0.95	0.93				
16				1.58	1.29	1.14	1.05	1.00	0.96	0.94	0.92			
18					1.36	1.18	1.08	1.02	0.98	0.95	0.93	0.92		
20					1.43	1.23	1.11	1.04	1.00	0.97	0.94	0.93	0.92	
22						1.28	1.15	1.07	1.02	0.98	0.96	0.94	0.92	
24						1.32	1.18	1.09	1.03	0.99	0.97	0.95	0.93	
26							1.21	1.12	1.05	1.01	0.98	0.96	0.94	0.93
28							1.25	1.14	1.07	1.02	0.99	0.96	0.95	0.93
30							1.29	1.17	1.09	1.04	1.00	0.97	0.95	0.94
32								1.20	1.11	1.05	1.01	0.98	0.96	0.95
34								1.22	1.13	1.07	1.03	0.99	0.97	0.95
36									1.15	1.09	1.04	1.01	0.98	0.96

II. The Dry State of Phytomass

(A) The phytomass parameters of trees for stands as a whole

Table 14. Pine plantation: The phytomass of stem wood (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0001	0.0003												
4		0.0013	0.0015	0.0019										
6		0.0029	0.0035	0.0043	0.0053									
8			0.0061	0.0076	0.0094	0.0113	0.0133							
10			0.0095	0.0118	0.0145	0.0174	0.0205	0.0238						
12			0.0136	0.0168	0.0206	0.0247	0.0291	0.0338	0.0386					
14				0.0226	0.0277	0.0333	0.0392	0.0454	0.0518	0.0585				
16				0.0293	0.0358	0.0429	0.0505	0.0585	0.0668	0.0754	0.0843			
18					0.0449	0.0538	0.0632	0.0732	0.0835	0.0942	0.1053	0.1166		
20					0.0548	0.0657	0.0772	0.0893	0.1019	0.1149	0.1284	0.1422	0.1563	
22						0.0787	0.0924	0.1069	0.1219	0.1374	0.1535	0.1699	0.1868	
24						0.0927	0.1088	0.1258	0.1435	0.1617	0.1805	0.1999	0.2197	
26							0.1265	0.1461	0.1666	0.1877	0.2095	0.2319	0.2549	0.2784
28							0.1452	0.1677	0.1912	0.2154	0.2403	0.2660	0.2923	0.3192
30							0.1651	0.1906	0.2172	0.2447	0.2730	0.3020	0.3318	0.3624
32								0.2148	0.2447	0.2755	0.3074	0.3400	0.3735	0.4078
34								0.2401	0.2735	0.3080	0.3435	0.3799	0.4173	0.4556
36									0.3037	0.3419	0.3812	0.4216	0.4631	0.5055

Table 15. Pine plantation: The phytomass of stem bark (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0001	0.0001												
4		0.0003	0.0003	0.0004										
6		0.0007	0.0007	0.0007	0.0008									
8			0.0011	0.0012	0.0013	0.0014	0.0016							
10			0.0017	0.0018	0.0020	0.0021	0.0023	0.0025						
12			0.0024	0.0025	0.0027	0.0029	0.0032	0.0035	0.0038					
14				0.0033	0.0035	0.0039	0.0042	0.0046	0.0049	0.0053				
16				0.0041	0.0045	0.0049	0.0053	0.0058	0.0062	0.0067	0.0072			
18					0.0055	0.0060	0.0065	0.0070	0.0076	0.0082	0.0088	0.0094		
20					0.0066	0.0072	0.0078	0.0084	0.0091	0.0098	0.0105	0.0112	0.0119	
22						0.0084	0.0092	0.0099	0.0107	0.0115	0.0123	0.0131	0.0140	
24						0.0098	0.0106	0.0115	0.0124	0.0133	0.0143	0.0152	0.0162	
26							0.0122	0.0132	0.0142	0.0153	0.0163	0.0174	0.0185	0.0196
28							0.0138	0.0150	0.0161	0.0173	0.0185	0.0197	0.0209	0.0222
30							0.0155	0.0168	0.0181	0.0194	0.0207	0.0221	0.0235	0.0249
32								0.0187	0.0201	0.0216	0.0231	0.0246	0.0261	0.0277
34								0.0207	0.0223	0.0239	0.0255	0.0272	0.0289	0.0306
36									0.0245	0.0263	0.0280	0.0299	0.0317	0.0336

Table 16. Pine plantation: The phytomass of stem and bark (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0002	0.0004												
4		0.0016	0.0018	0.0023										
6		0.0036	0.0042	0.0050	0.0061									
8			0.0072	0.0088	0.0107	0.0127	0.0149							
10			0.0112	0.0136	0.0165	0.0195	0.0228	0.0263						
12			0.0160	0.0193	0.0233	0.0276	0.0323	0.0373	0.0424					
14				0.0259	0.0312	0.0372	0.0434	0.0500	0.0567	0.0638				
16				0.0334	0.0403	0.0478	0.0558	0.0643	0.0730	0.0821	0.0915			
18					0.0504	0.0598	0.0697	0.0802	0.0911	0.1024	0.1141	0.1260		
20					0.0614	0.0729	0.0850	0.0977	0.1110	0.1247	0.1389	0.1534	0.1682	
22						0.0871	0.1016	0.1168	0.1326	0.1489	0.1658	0.1830	0.2008	
24						0.1025	0.1194	0.1373	0.1559	0.1750	0.1948	0.2151	0.2359	
26							0.1387	0.1593	0.1808	0.2030	0.2258	0.2493	0.2734	0.2980
28							0.1590	0.1827	0.2073	0.2327	0.2588	0.2857	0.3132	0.3414
30							0.1806	0.2074	0.2353	0.2641	0.2937	0.3241	0.3553	0.3873
32								0.2335	0.2648	0.2971	0.3305	0.3646	0.3996	0.4355
34								0.2608	0.2958	0.3319	0.3690	0.4071	0.4462	0.4862
36									0.3282	0.3682	0.4092	0.4515	0.4948	0.5391

Table 17. Pine plantation: The phytomass of twigs (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.0003	0.0001												
4		0.0007	0.0004	0.0003										
6		0.0021	0.0013	0.0008	0.0006									
8			0.0028	0.0019	0.0014	0.0011	0.0009							
10			0.0053	0.0036	0.0026	0.0020	0.0017	0.0014						
12			0.0087	0.0059	0.0044	0.0034	0.0028	0.0023	0.0020					
14				0.0091	0.0068	0.0053	0.0044	0.0036	0.0031	0.0027				
16				0.0133	0.0099	0.0078	0.0063	0.0053	0.0045	0.0040	0.0035			
18					0.0138	0.0108	0.0088	0.0073	0.0063	0.0054	0.0049	0.0043		
20					0.0185	0.0145	0.0118	0.0099	0.0085	0.0073	0.0065	0.0058	0.0052	
22						0.0190	0.0154	0.0129	0.0111	0.0096	0.0085	0.0076	0.0068	
24						0.0242	0.0196	0.0165	0.0141	0.0123	0.0109	0.0096	0.0087	
26							0.0247	0.0206	0.0176	0.0154	0.0136	0.0121	0.0110	0.0099
28							0.0304	0.0254	0.0217	0.0189	0.0168	0.0149	0.0134	0.0122
30							0.0368	0.0309	0.0264	0.0230	0.0203	0.0181	0.0163	0.0148
32								0.0370	0.0316	0.0275	0.0243	0.0217	0.0196	0.0177
34								0.0438	0.0375	0.0326	0.0288	0.0257	0.0232	0.0210
36									0.0440	0.0383	0.0338	0.0302	0.0272	0.0247
							Stocking – 0.7							
2	0.0003	0.0001												
4		0.0007	0.0004	0.0003										
6		0.0023	0.0013	0.0009	0.0007									
8			0.0030	0.0020	0.0016	0.0012	0.0010							
10			0.0057	0.0039	0.0029	0.0022	0.0018	0.0015						
12			0.0094	0.0065	0.0048	0.0038	0.0030	0.0026	0.0022					
14				0.0099	0.0073	0.0058	0.0047	0.0039	0.0034	0.0030				
16				0.0145	0.0106	0.0084	0.0068	0.0057	0.0049	0.0043	0.0037			
18					0.0149	0.0117	0.0095	0.0080	0.0068	0.0059	0.0053	0.0046		
20					0.0200	0.0157	0.0128	0.0107	0.0092	0.0080	0.0071	0.0063	0.0057	
22						0.0205	0.0167	0.0139	0.0120	0.0104	0.0092	0.0082	0.0074	
24						0.0262	0.0213	0.0178	0.0153	0.0133	0.0118	0.0105	0.0095	
26							0.0266	0.0223	0.0191	0.0167	0.0147	0.0132	0.0119	0.0108
28							0.0328	0.0275	0.0236	0.0205	0.0181	0.0161	0.0146	0.0133
30							0.0399	0.0333	0.0286	0.0249	0.0219	0.0196	0.0176	0.0161
32								0.0400	0.0342	0.0298	0.0263	0.0235	0.0212	0.0192
34								0.0475	0.0406	0.0354	0.0311	0.0279	0.0250	0.0228
36									0.0477	0.0415	0.0366	0.0326	0.0295	0.0268

Table 18. Pine plantation: The phytomass of needles (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.0002	0.0001												
4		0.0005	0.0003	0.0002										
6		0.0015	0.0009	0.0006	0.0004									
8			0.0020	0.0013	0.0010	0.0008	0.0006							
10			0.0037	0.0025	0.0018	0.0014	0.0012	0.0009						
12			0.0061	0.0041	0.0031	0.0024	0.0019	0.0016	0.0014					
14				0.0064	0.0047	0.0037	0.0030	0.0025	0.0021	0.0018				
16				0.0093	0.0069	0.0054	0.0043	0.0036	0.0031	0.0027	0.0024			
18					0.0096	0.0075	0.0061	0.0050	0.0043	0.0037	0.0033	0.0029		
20					0.0129	0.0101	0.0082	0.0068	0.0058	0.0050	0.0044	0.0039	0.0035	
22						0.0132	0.0107	0.0089	0.0076	0.0066	0.0058	0.0051	0.0046	
24						0.0168	0.0136	0.0114	0.0097	0.0084	0.0074	0.0065	0.0058	
26							0.0171	0.0142	0.0121	0.0105	0.0092	0.0082	0.0074	0.0066
28							0.0210	0.0175	0.0149	0.0129	0.0114	0.0101	0.0090	0.0082
30							0.0255	0.0213	0.0181	0.0157	0.0138	0.0123	0.0110	0.0099
32								0.0255	0.0217	0.0188	0.0166	0.0147	0.0132	0.0119
34								0.0303	0.0258	0.0223	0.0196	0.0174	0.0157	0.0141
36									0.0303	0.0262	0.0230	0.0205	0.0184	0.0166
							Stocking – 0.7							
2	0.0002	0.0001												
4		0.0005	0.0003	0.0002										
6		0.0016	0.0009	0.0006	0.0005									
8			0.0021	0.0014	0.0011	0.0008	0.0007							
10			0.0040	0.0027	0.0020	0.0015	0.0012	0.0010						
12			0.0066	0.0045	0.0033	0.0026	0.0021	0.0018	0.0015					
14				0.0069	0.0051	0.0040	0.0032	0.0027	0.0023	0.0020				
16				0.0101	0.0074	0.0058	0.0047	0.0039	0.0034	0.0029	0.0025			
18					0.0104	0.0081	0.0066	0.0055	0.0046	0.0040	0.0036	0.0031		
20					0.0139	0.0109	0.0088	0.0074	0.0063	0.0054	0.0048	0.0043	0.0038	
22						0.0142	0.0115	0.0096	0.0082	0.0071	0.0062	0.0055	0.0050	
24						0.0182	0.0147	0.0123	0.0105	0.0091	0.0080	0.0071	0.0064	
26							0.0184	0.0154	0.0131	0.0114	0.0100	0.0089	0.0080	0.0072
28							0.0227	0.0190	0.0162	0.0140	0.0123	0.0109	0.0098	0.0089
30							0.0276	0.0230	0.0196	0.0170	0.0149	0.0133	0.0119	0.0108
32								0.0276	0.0235	0.0204	0.0179	0.0159	0.0143	0.0129
34								0.0328	0.0279	0.0242	0.0212	0.0189	0.0169	0.0153
36									0.0328	0.0284	0.0249	0.0221	0.0199	0.0180

Table 19. Pine plantation: The phytomass of branches (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking - 1.0							
2	0.0001	0.0000												
4		0.0004	0.0003	0.0002										
6		0.0014	0.0008	0.0005	0.0004									
8			0.0020	0.0013	0.0010	0.0008	0.0007							
10			0.0041	0.0028	0.0020	0.0016	0.0013	0.0012						
12			0.0073	0.0050	0.0037	0.0029	0.0024	0.0020	0.0017					
14				0.0081	0.0060	0.0047	0.0039	0.0033	0.0028	0.0024				
16				0.0125	0.0093	0.0073	0.0060	0.0050	0.0043	0.0038	0.0034			
18					0.0136	0.0107	0.0087	0.0074	0.0063	0.0055	0.0049	0.0044		
20					0.0192	0.0150	0.0123	0.0104	0.0089	0.0078	0.0070	0.0063	0.0056	
22						0.0205	0.0168	0.0141	0.0121	0.0106	0.0094	0.0085	0.0077	
24						0.0273	0.0222	0.0187	0.0161	0.0141	0.0125	0.0113	0.0102	
26							0.0289	0.0242	0.0209	0.0183	0.0163	0.0146	0.0132	0.0121
28							0.0368	0.0310	0.0266	0.0232	0.0207	0.0185	0.0168	0.0154
30							0.0462	0.0387	0.0333	0.0291	0.0258	0.0232	0.0211	0.0193
32								0.0479	0.0412	0.0360	0.0319	0.0286	0.0260	0.0238
34								0.0584	0.0502	0.0439	0.0390	0.0349	0.0317	0.0290
36									0.0606	0.0529	0.0469	0.0421	0.0382	0.0349
							Stocking - 0.7							
2	0.0001	0.0000												
4		0.0005	0.0003	0.0002										
6		0.0017	0.0010	0.0007	0.0005									
8			0.0025	0.0017	0.0012	0.0010	0.0008							
10			0.0051	0.0034	0.0025	0.0020	0.0016	0.0014						
12			0.0091	0.0062	0.0046	0.0036	0.0029	0.0025	0.0021					
14				0.0102	0.0075	0.0059	0.0048	0.0041	0.0035	0.0031				
16				0.0158	0.0116	0.0091	0.0075	0.0063	0.0054	0.0048	0.0043			
18					0.0171	0.0134	0.0110	0.0092	0.0080	0.0070	0.0062	0.0056		
20					0.0242	0.0189	0.0155	0.0130	0.0112	0.0098	0.0087	0.0078	0.0072	
22						0.0259	0.0212	0.0178	0.0153	0.0134	0.0119	0.0107	0.0097	
24						0.0345	0.0281	0.0237	0.0203	0.0178	0.0158	0.0142	0.0129	
26							0.0366	0.0308	0.0264	0.0232	0.0206	0.0185	0.0168	0.0153
28							0.0468	0.0393	0.0338	0.0295	0.0262	0.0235	0.0214	0.0195
30							0.0587	0.0493	0.0424	0.0371	0.0329	0.0295	0.0268	0.0245
32								0.0610	0.0524	0.0458	0.0406	0.0365	0.0331	0.0303
34								0.0746	0.0640	0.0560	0.0496	0.0446	0.0404	0.0369
36									0.0774	0.0676	0.0600	0.0538	0.0488	0.0446

Table 20. Pine plantation: The phytomass of trees (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.0005	0.0005												
4		0.0025	0.0024	0.0027										
6		0.0065	0.0059	0.0061	0.0069									
8			0.0112	0.0114	0.0127	0.0143	0.0162							
10			0.0190	0.0189	0.0203	0.0225	0.0253	0.0284						
12			0.0294	0.0284	0.0301	0.0329	0.0366	0.0409	0.0455					
14				0.0404	0.0419	0.0456	0.0503	0.0558	0.0616	0.0680				
16				0.0552	0.0565	0.0605	0.0661	0.0729	0.0804	0.0886	0.0973			
18					0.0736	0.0780	0.0845	0.0926	0.1017	0.1116	0.1223	0.1333		
20					0.0935	0.0980	0.1055	0.1149	0.1257	0.1375	0.1503	0.1636	0.1773	
22						0.1208	0.1291	0.1398	0.1523	0.1661	0.1810	0.1966	0.2131	
24						0.1466	0.1552	0.1674	0.1817	0.1975	0.2147	0.2329	0.2519	
26							0.1847	0.1977	0.2138	0.2318	0.2513	0.2721	0.2940	0.3167
28							0.2168	0.2312	0.2488	0.2688	0.2909	0.3143	0.3390	0.3650
30							0.2523	0.2674	0.2867	0.3089	0.3333	0.3596	0.3874	0.4165
32								0.3069	0.3277	0.3519	0.3790	0.4079	0.4388	0.4712
34								0.3495	0.3718	0.3981	0.4276	0.4594	0.4936	0.5293
36									0.4191	0.4473	0.4791	0.5141	0.5514	0.5906
							Stocking – 0.7							
2	0.0005	0.0005												
4		0.0026	0.0024	0.0027										
6		0.0069	0.0061	0.0063	0.0071									
8			0.0118	0.0119	0.0130	0.0145	0.0164							
10			0.0203	0.0197	0.0210	0.0230	0.0256	0.0287						
12			0.0317	0.0300	0.0312	0.0338	0.0373	0.0416	0.0460					
14				0.0430	0.0438	0.0471	0.0514	0.0568	0.0625	0.0689				
16				0.0593	0.0593	0.0627	0.0680	0.0745	0.0818	0.0898	0.0983			
18					0.0779	0.0813	0.0873	0.0949	0.1037	0.1134	0.1239	0.1347		
20					0.0995	0.1027	0.1093	0.1181	0.1285	0.1399	0.1524	0.1655	0.1792	
22						0.1272	0.1343	0.1442	0.1561	0.1694	0.1839	0.1992	0.2155	
24						0.1552	0.1622	0.1733	0.1867	0.2019	0.2186	0.2364	0.2552	
26							0.1937	0.2055	0.2203	0.2376	0.2564	0.2767	0.2982	0.3205
28							0.2285	0.2410	0.2573	0.2762	0.2973	0.3201	0.3444	0.3698
30							0.2669	0.2797	0.2973	0.3182	0.3415	0.3669	0.3940	0.4226
32								0.3221	0.3407	0.3633	0.3890	0.4170	0.4470	0.4787
34								0.3682	0.3877	0.4121	0.4398	0.4706	0.5035	0.5384
36									0.4384	0.4642	0.4941	0.5274	0.5635	0.6017

Table 21. Pine plantation: Ratio of tree phytomass and stem volume (t/m^3).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.87	0.50												
4		0.52	0.45	0.43										
6		0.61	0.50	0.44	0.42									
8			0.54	0.47	0.44	0.43	0.42							
10			0.59	0.50	0.46	0.44	0.43	0.43						
12			0.64	0.53	0.48	0.45	0.44	0.43	0.43					
14				0.56	0.49	0.46	0.45	0.44	0.44	0.44				
16				0.59	0.52	0.48	0.46	0.45	0.44	0.44	0.44			
18					0.54	0.49	0.47	0.45	0.45	0.44	0.44	0.44		
20					0.56	0.51	0.48	0.46	0.45	0.45	0.45	0.45	0.45	
22						0.52	0.49	0.47	0.46	0.45	0.45	0.45	0.45	
24						0.54	0.50	0.48	0.46	0.46	0.45	0.45	0.45	
26							0.51	0.48	0.47	0.46	0.46	0.45	0.45	0.46
28							0.52	0.49	0.48	0.47	0.46	0.46	0.46	0.46
30							0.53	0.50	0.48	0.47	0.46	0.46	0.46	0.46
32								0.51	0.49	0.48	0.47	0.46	0.46	0.46
34								0.52	0.50	0.48	0.47	0.47	0.46	0.46
36									0.50	0.49	0.48	0.47	0.47	0.47
							Stocking – 0.7							
2	0.87	0.50												
4		0.54	0.45	0.43										
6		0.64	0.51	0.45	0.43									
8			0.57	0.49	0.45	0.43	0.43							
10			0.63	0.52	0.47	0.45	0.44	0.43						
12			0.69	0.56	0.50	0.46	0.45	0.44	0.44					
14				0.60	0.52	0.48	0.46	0.45	0.44	0.44				
16				0.64	0.54	0.49	0.47	0.46	0.45	0.45	0.45			
18					0.57	0.51	0.48	0.46	0.45	0.45	0.45	0.45		
20					0.59	0.53	0.49	0.47	0.46	0.46	0.45	0.45	0.45	
22						0.55	0.51	0.48	0.47	0.46	0.46	0.46	0.46	
24						0.57	0.52	0.49	0.48	0.47	0.46	0.46	0.46	
26							0.53	0.50	0.48	0.47	0.47	0.46	0.46	0.46
28							0.55	0.51	0.49	0.48	0.47	0.47	0.46	0.46
30							0.56	0.52	0.50	0.48	0.48	0.47	0.47	0.47
32								0.54	0.51	0.49	0.48	0.47	0.47	0.47
34								0.55	0.52	0.50	0.49	0.48	0.47	0.47
36									0.53	0.51	0.49	0.48	0.48	0.47

(B) The phytomass parameters of trees for part of stands removed by thinning

Table 22. Pine plantation: The phytomass of twigs (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0003	0.0001												
4		0.0009	0.0004	0.0003										
6		0.0026	0.0014	0.0009	0.0006									
8			0.0031	0.0020	0.0015	0.0011	0.0009							
10			0.0060	0.0039	0.0027	0.0021	0.0016	0.0013						
12			0.0101	0.0066	0.0046	0.0035	0.0028	0.0022	0.0019					
14				0.0101	0.0072	0.0055	0.0043	0.0035	0.0029	0.0025				
16				0.0149	0.0106	0.0080	0.0063	0.0051	0.0043	0.0037	0.0032			
18					0.0148	0.0111	0.0088	0.0072	0.0060	0.0052	0.0044	0.0039		
20					0.0200	0.0151	0.0120	0.0097	0.0082	0.0069	0.0060	0.0053	0.0046	
22						0.0199	0.0156	0.0128	0.0107	0.0091	0.0079	0.0069	0.0061	
24						0.0255	0.0201	0.0164	0.0137	0.0117	0.0102	0.0089	0.0079	
26							0.0253	0.0206	0.0172	0.0147	0.0127	0.0112	0.0100	0.0089
28							0.0313	0.0255	0.0214	0.0182	0.0157	0.0138	0.0123	0.0110
30							0.0381	0.0311	0.0259	0.0221	0.0192	0.0168	0.0150	0.0134
32								0.0374	0.0313	0.0266	0.0230	0.0202	0.0179	0.0161
34								0.0445	0.0372	0.0317	0.0274	0.0240	0.0214	0.0192
36									0.0438	0.0374	0.0324	0.0284	0.0252	0.0225

Table 23. Pine plantation: The phytomass of needles (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0002	0.0001												
4		0.0006	0.0003	0.0002										
6		0.0018	0.0010	0.0006	0.0004									
8			0.0022	0.0014	0.0010	0.0008	0.0006							
10			0.0042	0.0027	0.0019	0.0014	0.0011	0.0009						
12			0.0071	0.0046	0.0032	0.0024	0.0019	0.0015	0.0013					
14				0.0071	0.0050	0.0038	0.0030	0.0024	0.0020	0.0017				
16				0.0104	0.0074	0.0055	0.0043	0.0035	0.0029	0.0025	0.0022			
18					0.0103	0.0077	0.0061	0.0049	0.0041	0.0035	0.0030	0.0026		
20					0.0139	0.0105	0.0083	0.0067	0.0056	0.0047	0.0041	0.0036	0.0031	
22						0.0138	0.0108	0.0088	0.0073	0.0062	0.0054	0.0047	0.0041	
24						0.0177	0.0139	0.0113	0.0094	0.0080	0.0069	0.0060	0.0053	
26							0.0175	0.0142	0.0118	0.0101	0.0086	0.0076	0.0067	0.0059
28							0.0217	0.0176	0.0147	0.0124	0.0107	0.0093	0.0083	0.0074
30							0.0264	0.0215	0.0178	0.0151	0.0131	0.0114	0.0101	0.0090
32								0.0258	0.0215	0.0182	0.0157	0.0137	0.0121	0.0108
34								0.0307	0.0256	0.0217	0.0187	0.0163	0.0144	0.0129
36									0.0301	0.0256	0.0221	0.0193	0.0170	0.0151

Table 24. Pine plantation: The phytomass of branches (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0002	0.0000												
4		0.0005	0.0003	0.0002										
6		0.0020	0.0010	0.0007	0.0005									
8			0.0026	0.0016	0.0012	0.0008	0.0007							
10			0.0054	0.0034	0.0024	0.0018	0.0014	0.0012						
12			0.0097	0.0061	0.0043	0.0033	0.0026	0.0021	0.0017					
14				0.0102	0.0072	0.0053	0.0042	0.0034	0.0028	0.0025				
16				0.0158	0.0110	0.0083	0.0065	0.0053	0.0044	0.0038	0.0033			
18					0.0162	0.0122	0.0096	0.0078	0.0065	0.0056	0.0048	0.0043		
20					0.0230	0.0172	0.0135	0.0110	0.0092	0.0078	0.0068	0.0060	0.0053	
22						0.0235	0.0185	0.0150	0.0126	0.0107	0.0093	0.0082	0.0073	
24						0.0313	0.0246	0.0200	0.0167	0.0142	0.0123	0.0108	0.0097	
26							0.0320	0.0260	0.0217	0.0185	0.0160	0.0141	0.0125	0.0113
28							0.0409	0.0332	0.0277	0.0236	0.0205	0.0180	0.0160	0.0144
30							0.0514	0.0417	0.0348	0.0296	0.0256	0.0225	0.0201	0.0180
32								0.0516	0.0430	0.0366	0.0317	0.0279	0.0247	0.0222
34								0.0631	0.0526	0.0448	0.0388	0.0340	0.0302	0.0271
36									0.0635	0.0540	0.0468	0.0410	0.0365	0.0327

Table 25. Pine plantation: The phytomass of trees (t).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	0.0006	0.0005												
4		0.0027	0.0024	0.0027										
6		0.0074	0.0062	0.0063	0.0070									
8			0.0120	0.0118	0.0129	0.0143	0.0162							
10			0.0208	0.0197	0.0208	0.0227	0.0253	0.0284						
12			0.0328	0.0300	0.0308	0.0333	0.0368	0.0409	0.0454					
14				0.0432	0.0434	0.0463	0.0506	0.0558	0.0615	0.0680				
16				0.0596	0.0587	0.0616	0.0666	0.0731	0.0803	0.0884	0.0970			
18					0.0769	0.0797	0.0854	0.0929	0.1017	0.1115	0.1219	0.1329		
20					0.0983	0.1006	0.1068	0.1154	0.1258	0.1372	0.1498	0.1630	0.1766	
22						0.1244	0.1309	0.1406	0.1525	0.1658	0.1805	0.1959	0.2122	
24						0.1515	0.1579	0.1686	0.1820	0.1972	0.2140	0.2319	0.2509	
26							0.1882	0.1995	0.2143	0.2316	0.2504	0.2710	0.2926	0.3152
28							0.2216	0.2335	0.2497	0.2687	0.2900	0.3130	0.3375	0.3632
30							0.2584	0.2706	0.2879	0.3088	0.3324	0.3580	0.3855	0.4143
32								0.3109	0.3293	0.3519	0.3779	0.4062	0.4364	0.4685
34								0.3546	0.3740	0.3984	0.4265	0.4574	0.4908	0.5262
36									0.4218	0.4478	0.4781	0.5118	0.5483	0.5869

Table 26. Pine plantation: Ratio of tree phytomass and stem volume (t/m^3).

Diameter	Height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
2	1.05	0.50												
4		0.56	0.45	0.43										
6		0.69	0.52	0.45	0.43									
8			0.58	0.48	0.45	0.43	0.42							
10			0.65	0.52	0.47	0.44	0.43	0.43						
12			0.72	0.56	0.49	0.46	0.44	0.43	0.43					
14				0.60	0.51	0.47	0.45	0.44	0.44	0.44				
16				0.64	0.54	0.49	0.46	0.45	0.44	0.44	0.44			
18					0.56	0.50	0.47	0.45	0.45	0.44	0.44	0.44		
20					0.59	0.52	0.48	0.46	0.45	0.45	0.45	0.45	0.45	
22						0.54	0.49	0.47	0.46	0.45	0.45	0.45	0.45	
24						0.55	0.51	0.48	0.46	0.46	0.45	0.45	0.45	
26							0.52	0.49	0.47	0.46	0.45	0.45	0.45	0.45
28							0.53	0.50	0.48	0.47	0.46	0.46	0.45	0.46
30							0.55	0.51	0.48	0.47	0.46	0.46	0.46	0.46
32								0.52	0.49	0.48	0.47	0.46	0.46	0.46
34								0.53	0.50	0.48	0.47	0.46	0.46	0.46
36									0.51	0.49	0.48	0.47	0.46	0.46

Appendix 3

I. The Fresh-Cut State of Phytomass

Table 1. Pine plantation: The phytomass of stem wood (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	8.4	58.0												
4	7.1	36.4	68.3											
6		32.6	57.5	89.1	130.7									
8		31.3	53.0	80.6	116.6	160.6								
10			50.8	76.3	109.1	149.0	195.1							
12				73.2	104.3	141.5	185.5	234.3						
14					100.8	136.4	177.6	224.7	276.8					
16						132.3	172.5	217.3	266.9	321.9				
18							167.5	210.8	259.7	311.5	368.1			
20								206.6	252.9	304.9	358.5	417.3		
22								202.1	248.2	297.1	350.0	407.3	468.7	
24									244.1	291.3	342.5	398.9	456.7	516.0
26									239.1	285.8	337.5	392.4	448.2	505.6
28										282.0	331.8	384.1	439.1	496.2
30											326.0	379.2	435.0	487.1
32											320.8	371.9	424.6	481.4
34											316.2	366.2	419.6	473.0
36												363.1	414.7	466.6
							Stocking – 0.7							
2	5.8	40.7												
4	5.1	25.6	47.8											
6		22.8	40.2	62.4	91.6									
8		21.7	37.2	56.3	81.5	112.2								
10			35.7	53.3	76.2	103.8	136.9							
12				51.3	73.1	99.1	129.5	164.5						
14					70.5	95.5	124.7	157.1	193.6					
16						93.0	120.1	152.5	186.5	224.8				
18							117.3	147.8	182.5	218.5	258.3			
20								144.5	177.4	212.2	252.0	292.7		
22								141.8	173.0	208.8	245.3	284.2	325.5	
24									170.1	203.6	240.4	279.1	319.2	362.9
26									168.3	200.9	236.1	273.1	312.8	353.8
28										198.3	233.8	269.5	308.2	348.9
30											226.9	264.0	301.5	341.6
32											224.8	259.9	299.3	337.6
34											221.3	255.2	292.3	332.5
36												253.4	288.2	326.6

Table 2. Pine plantation: The phytomass of stem bark (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking - 1.0							
2	2.8	12.6												
4	2.2	8.0	12.5											
6		6.9	10.3	14.1	18.7									
8		6.1	9.1	12.2	16.3	20.5								
10			8.2	11.2	14.5	18.3	22.4							
12				10.3	13.5	17.0	20.3	24.1						
14					12.7	15.6	19.0	22.5	26.1					
16						14.8	17.8	21.0	24.4	27.9				
18							17.1	19.7	22.9	26.1	29.2			
20								18.8	21.7	24.8	27.8	30.7		
22								17.8	20.8	23.4	26.1	29.1	31.9	
24									19.9	22.2	24.9	27.6	30.0	32.5
26									18.8	21.4	23.8	26.6	28.7	30.8
28										20.6	23.0	25.0	27.4	29.5
30											22.0	24.0	26.4	28.0
32											20.9	23.3	25.3	27.2
34											20.3	22.4	24.1	26.0
36												21.5	23.3	24.9
							Stocking - 0.7							
2	1.9	8.9												
4	1.5	5.6	8.8											
6		4.8	7.2	9.8	13.1									
8		4.3	6.3	8.7	11.3	14.3								
10			5.9	7.9	10.2	12.6	15.9							
12				7.2	9.3	11.9	14.4	17.2						
14					8.7	11.0	13.2	15.9	18.4					
16						10.3	12.4	14.6	17.2	19.4				
18							11.8	13.9	16.1	18.3	20.6			
20								13.1	15.2	17.2	19.5	21.5		
22								12.7	14.5	16.5	18.4	20.3	22.0	
24									13.9	15.6	17.3	19.5	21.0	22.9
26									13.4	14.9	16.7	18.3	19.9	21.7
28										14.4	16.0	17.7	19.4	20.8
30											15.2	16.7	18.2	19.7
32											14.7	16.2	17.7	19.1
34											13.9	15.7	16.7	18.2
36												15.3	16.3	17.5

Table 3. Pine plantation: The phytomass of stem and bark (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking - 1.0							
2	11.2	70.6												
4	9.3	44.4	80.8											
6		39.5	67.8	103.2	149.4									
8		37.4	62.1	92.8	132.9	181.1								
10			59.0	87.5	123.6	167.3	217.5							
12				83.5	117.8	158.5	205.8	258.4						
14					113.5	152.0	196.6	247.2	302.9					
16						147.1	190.3	238.3	291.3	349.8				
18							184.6	230.5	282.6	337.6	397.3			
20								225.4	274.6	329.7	386.3	448.0		
22								219.9	269.0	320.5	376.1	436.4	500.6	
24									264.0	313.5	367.4	426.5	486.7	548.5
26									257.9	307.2	361.3	419.0	476.9	536.4
28										302.6	354.8	409.1	466.5	525.7
30											348.0	403.2	461.4	515.1
32											341.7	395.2	449.9	508.6
34											336.5	388.6	443.7	499.0
36												384.6	438.0	491.5
							Stocking - 0.7							
2	7.7	49.6												
4	6.6	31.2	56.6											
6		27.6	47.4	72.2	104.7									
8		26.0	43.5	65.0	92.8	126.5								
10			41.6	61.2	86.4	116.4	152.8							
12				58.5	82.4	111.0	143.9	181.7						
14					79.2	106.5	137.9	173.0	212.0					
16						103.3	132.5	167.1	203.7	244.2				
18							129.1	161.7	198.6	236.8	278.9			
20								157.6	192.6	229.4	271.5	314.2		
22								154.5	187.5	225.3	263.7	304.5	347.5	
24									184.0	219.2	257.7	298.6	340.2	385.8
26									181.7	215.8	252.8	291.4	332.7	375.5
28										212.7	249.8	287.2	327.6	369.7
30											242.1	280.7	319.7	361.3
32											239.5	276.1	317.0	356.7
34											235.2	270.9	309.0	350.7
36												268.7	304.5	344.1

Table 4. Pine plantation: The phytomass of twigs (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	5.8	14.8												
4	8.5	19.2	17.5											
6		23.8	21.0	18.3	16.5									
8		28.3	24.6	21.1	18.9	17.3								
10			28.0	23.9	21.2	19.4	17.9							
12				26.6	23.6	21.4	19.8	18.5						
14					25.9	23.4	21.5	20.1	18.9					
16						25.4	23.4	21.8	20.4	19.4				
18							25.1	23.4	22.0	20.7	19.7			
20								25.0	23.4	22.2	21.0	20.0		
22								26.6	24.9	23.5	22.2	21.2	20.3	
24									26.5	24.8	23.5	22.4	21.3	20.3
26									27.8	26.1	24.8	23.7	22.5	21.4
28										27.5	26.1	24.7	23.5	22.5
30											27.2	26.0	24.9	23.5
32											28.4	27.0	25.7	24.6
34											29.6	28.1	26.9	25.6
36												29.4	28.0	26.6
							Stocking – 0.7							
2	4.4	11.2												
4	6.5	14.5	13.2											
6		18.0	15.9	13.8	12.5									
8		21.4	18.6	15.9	14.3	13.1								
10			21.2	18.1	16.0	14.6	13.6							
12				20.1	17.9	16.2	15.0	14.0						
14					19.5	17.8	16.4	15.2	14.3					
16						19.3	17.6	16.6	15.5	14.6				
18							19.0	17.7	16.7	15.7	14.9			
20								18.9	17.8	16.7	16.0	15.2		
22								20.2	18.8	17.9	16.9	16.0	15.2	
24									19.9	18.8	17.9	17.0	16.2	15.5
26									21.2	19.9	18.8	17.8	17.0	16.2
28										21.0	19.9	18.8	17.9	17.1
30											20.5	19.6	18.6	17.8
32											21.6	20.4	19.6	18.7
34											22.4	21.2	20.2	19.5
36												22.2	21.0	20.1

Table 5. Pine plantation: The phytomass of needles (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	3.9	9.8												
4	5.6	12.8	11.6											
6		15.8	14.0	12.2	11.0									
8		18.8	16.4	13.9	12.7	11.5								
10			18.5	15.9	14.2	12.8	11.9							
12				17.6	15.7	14.2	13.1	12.3						
14					17.3	15.5	14.2	13.4	12.6					
16						17.0	15.6	14.4	13.7	12.9				
18							16.8	15.5	14.5	13.8	13.0			
20								16.6	15.6	14.7	14.0	13.2		
22								17.7	16.7	15.7	14.8	14.2	13.5	
24									17.7	16.6	15.8	15.0	14.3	13.4
26									18.7	17.6	16.4	16.0	15.2	14.3
28										18.2	17.4	16.5	15.9	15.2
30											18.2	17.2	16.7	15.4
32											19.0	17.9	17.2	16.3
34											19.6	18.9	17.9	17.1
36												19.5	18.5	17.8
							Stocking – 0.7							
2	2.9	7.4												
4	4.4	9.7	8.7											
6		12.1	10.5	9.3	8.5									
8		14.3	12.5	10.7	9.6	8.8								
10			14.3	12.0	10.7	9.8	9.0							
12				13.5	11.8	10.6	10.0	9.5						
14					13.0	11.9	10.8	10.0	9.5					
16						12.8	11.8	11.1	10.4	9.8				
18							12.6	11.8	11.2	10.5	9.9			
20								12.7	11.8	11.2	10.8	10.0		
22								13.3	12.6	11.9	11.2	10.8	10.1	
24									13.5	12.6	12.0	11.2	10.9	10.4
26									14.2	13.3	12.5	12.0	11.5	11.0
28										14.1	13.4	12.5	11.8	11.3
30											13.8	13.0	12.2	11.8
32											14.3	13.7	13.2	12.5
34											14.7	14.0	13.5	13.2
36												14.6	13.7	13.3

Table 6. Pine plantation: The phytomass of branches (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	3.4	9.0												
4	6.0	13.2	12.2											
6		18.4	16.2	14.2	12.7									
8		23.7	20.4	17.7	15.7	14.4								
10			25.0	21.1	18.9	17.5	16.1							
12				25.0	22.3	20.4	18.9	17.6						
14					25.8	23.4	21.6	20.0	19.0					
16						26.3	24.5	22.9	21.4	20.4				
18							27.4	25.6	24.1	22.6	21.6			
20								28.6	26.9	25.6	24.1	23.2		
22								31.2	29.5	27.7	26.4	25.2	24.4	
24									32.4	30.3	28.7	27.7	26.6	25.5
26									35.1	33.2	31.7	29.9	28.7	27.6
28										36.1	34.2	32.8	30.7	29.5
30											36.7	35.3	33.8	32.3
32											39.3	37.8	35.8	34.8
34											42.2	40.0	38.6	36.8
36												43.1	41.5	39.2
							Stocking – 0.7							
2	2.8	7.5												
4	4.9	11.3	10.5											
6		15.6	14.0	12.0	10.7									
8		20.4	17.4	15.0	13.6	12.5								
10			21.7	18.6	16.4	14.9	14.0							
12				21.8	19.5	17.7	16.4	15.1						
14					22.4	20.5	19.0	17.6	16.5					
16						23.3	21.2	19.9	18.8	17.8				
18							24.1	22.5	21.1	20.3	19.4			
20								24.9	23.7	22.1	21.2	20.4		
22								28.0	25.8	24.8	23.5	22.0	21.4	
24									28.3	27.0	25.7	24.6	23.3	22.6
26									31.5	29.5	28.2	26.6	25.3	24.3
28										32.1	30.6	29.3	27.9	26.9
30											32.6	31.2	29.9	28.6
32											35.5	33.3	32.2	30.9
34											38.0	35.9	34.1	32.8
36												38.6	36.8	35.3

Table 7. Pine plantation: The phytomass of stands (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	18.5	89.4												
4	20.9	70.4	104.6											
6		73.7	98.0	129.6	173.1									
8		79.9	98.9	124.4	161.3	207.0								
10			102.5	124.5	156.7	197.6	245.5							
12				126.1	155.8	193.1	237.8	288.3						
14					156.6	190.9	232.4	280.6	334.5					
16						190.4	230.4	275.6	326.4	383.1				
18							228.8	271.6	321.2	374.0	431.9			
20								270.6	317.1	370.0	424.4	484.4		
22								268.8	315.2	363.9	417.3	475.8	538.5	
24									314.1	360.4	411.9	469.2	527.6	587.4
26									311.7	358.0	409.4	464.9	520.8	578.3
28										356.9	406.4	458.4	513.1	570.4
30											402.9	455.7	511.9	562.8
32											400.0	450.9	502.9	559.7
34											398.3	447.5	500.2	552.9
36												447.2	498.0	548.5
							Stocking – 0.7							
2	13.4	64.5												
4	15.9	52.2	75.8											
6		55.3	71.9	93.5	123.9									
8		60.7	73.4	90.7	116.0	147.8								
10			77.6	91.8	113.5	141.1	175.8							
12				93.8	113.7	139.3	170.3	206.3						
14					114.6	138.9	167.7	200.6	238.0					
16						139.4	165.5	198.1	232.9	271.8				
18							165.8	196.0	230.9	267.6	308.2			
20								195.2	228.1	262.7	303.5	344.6		
22								195.8	225.9	262.0	298.4	337.3	379.0	
24									225.8	258.8	295.4	334.4	374.4	418.8
26									227.4	258.6	293.5	330.0	369.5	410.8
28										258.9	293.8	329.0	367.3	407.9
30											288.5	324.9	361.8	401.7
32											289.3	323.1	362.4	400.1
34											287.9	320.8	356.6	396.7
36												321.9	355.0	392.7

Table 8. Pine plantation: Ratio of stand phytomass to stems volume (t/m^3).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	1.32	1.06												
4	1.83	1.33	1.10											
6		1.58	1.24	1.08	1.00									
8		1.82	1.36	1.15	1.05	0.99								
10			1.49	1.23	1.09	1.02	0.98							
12				1.30	1.14	1.06	1.00	0.97						
14					1.19	1.09	1.03	0.98	0.96					
16						1.12	1.05	1.00	0.97	0.95				
18							1.07	1.02	0.99	0.96	0.94			
20								1.04	1.00	0.97	0.95	0.94		
22								1.06	1.02	0.98	0.96	0.95	0.93	
24									1.03	1.00	0.97	0.95	0.94	0.93
26									1.05	1.01	0.98	0.96	0.95	0.93
28										1.02	0.99	0.97	0.95	0.94
30											1.00	0.98	0.96	0.95
32											1.01	0.99	0.97	0.95
34											1.02	1.00	0.98	0.96
36												1.01	0.98	0.97
							Stocking – 0.7							
2	1.36	1.09												
4	1.98	1.41	1.14											
6		1.69	1.30	1.11	1.02									
8		1.97	1.44	1.20	1.08	1.01								
10			1.61	1.29	1.14	1.05	1.00							
12				1.38	1.19	1.09	1.02	0.99						
14					1.25	1.13	1.05	1.01	0.98					
16						1.17	1.08	1.03	0.99	0.97				
18							1.11	1.05	1.01	0.98	0.96			
20								1.07	1.03	0.99	0.97	0.95		
22								1.10	1.04	1.01	0.98	0.96	0.95	
24									1.06	1.02	0.99	0.97	0.95	0.94
26									1.08	1.04	1.01	0.98	0.96	0.95
28										1.06	1.02	0.99	0.97	0.96
30											1.03	1.00	0.98	0.96
32											1.05	1.01	0.99	0.97
34											1.06	1.03	1.00	0.98
36												1.04	1.01	0.99

II. The Dry State of Phytomass

Table 9. Pine plantation: The phytomass of stem wood (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	3.0	21.4												
4	2.6	14.0	26.8											
6		12.9	23.1	36.5	54.4									
8		12.3	21.6	33.6	49.2	68.3								
10			20.9	32.1	46.5	64.3	85.2							
12				31.2	44.9	61.7	82.0	104.6						
14					43.9	60.0	79.0	101.3	125.8					
16						59.0	77.7	98.7	122.4	148.8				
18							75.7	96.5	119.8	145.3	173.0			
20								95.3	117.6	143.3	169.7	199.1		
22								93.6	116.3	140.3	166.9	195.8	226.8	
24									115.3	138.7	164.3	192.8	222.4	253.1
26									113.4	137.0	162.9	191.1	219.8	249.8
28										135.5	161.1	188.0	216.6	246.3
30											159.1	186.7	215.8	243.2
32											157.4	184.0	211.7	241.9
34											155.9	182.3	210.4	238.8
36												181.3	208.6	236.9
							Stocking – 0.7							
2	2.1	15.2												
4	1.9	9.9	18.8											
6		8.9	16.1	25.5	38.0									
8		8.5	15.1	23.4	34.5	47.9								
10			14.7	22.5	32.5	44.9	59.9							
12				21.7	31.4	43.4	57.2	73.3						
14					30.7	42.2	55.5	70.6	87.8					
16						41.2	53.7	69.1	85.5	104.1				
18							53.2	67.7	84.1	101.8	121.3			
20								66.4	82.6	99.7	119.5	139.5		
22								65.8	81.0	98.6	117.1	136.6	157.4	
24									80.2	96.8	115.4	134.9	155.5	178.0
26									80.2	96.2	113.8	132.8	153.1	174.7
28										95.6	113.6	131.8	151.9	173.3
30											110.7	129.9	149.5	170.5
32											110.2	128.7	149.1	169.6
34											109.1	126.8	146.5	167.8
36												126.4	145.1	165.6

Table 10. Pine plantation: The phytomass of stem bark (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	1.5	6.1												
4	1.0	3.6	5.6											
6		3.1	4.3	6.1	7.9									
8		2.8	3.8	5.3	6.9	8.9								
10			3.6	4.6	6.3	7.9	9.8							
12				4.5	5.8	7.3	8.9	10.9						
14					5.4	6.8	8.4	10.2	11.9					
16						6.5	7.8	9.6	11.3	13.0				
18							7.7	9.0	10.9	12.4	14.3			
20								8.7	10.1	12.1	13.8	15.5		
22								8.7	9.9	11.5	13.1	15.0	16.6	
24									9.7	11.4	12.8	14.5	16.2	17.7
26									9.4	10.7	12.4	13.9	15.6	17.2
28										10.4	12.0	13.7	15.1	16.8
30											11.7	13.2	14.9	16.5
32											11.4	13.1	14.6	16.1
34											11.3	12.8	14.4	15.8
36												12.6	14.1	15.4
							Stocking – 0.7							
2	1.0	4.3												
4	0.8	2.5	3.9											
6		2.2	3.1	4.2	5.6									
8		1.8	2.6	3.6	4.9	6.1								
10			2.5	3.3	4.3	5.6	6.8							
12				3.1	3.9	5.2	6.3	7.5						
14					3.7	4.7	5.9	7.1	8.3					
16						4.7	5.6	6.5	7.9	9.2				
18							5.5	6.4	7.5	8.6	9.9			
20								6.1	7.2	8.3	9.7	10.7		
22								5.9	6.9	8.0	9.3	10.3	11.5	
24									6.6	7.9	9.0	10.2	11.2	12.5
26									6.6	7.6	8.4	9.7	11.0	12.0
28										7.3	8.6	9.6	10.7	11.9
30											8.2	9.2	10.4	11.5
32											8.1	9.2	10.2	11.2
34											7.9	9.0	10.0	11.0
36												8.9	9.6	10.8

Table 11. Pine plantation: The phytomass of stem and bark (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	4.5	27.5												
4	3.6	17.6	32.4											
6		16.0	27.4	42.6	62.3									
8		15.1	25.4	38.9	56.1	77.2								
10			24.5	36.7	52.8	72.2	95.0							
12				35.7	50.7	69.0	90.9	115.5						
14					49.3	66.8	87.4	111.5	137.7					
16						65.5	85.5	108.3	133.7	161.8				
18							83.4	105.5	130.7	157.7	187.3			
20								104.0	127.7	155.4	183.5	214.6		
22								102.3	126.2	151.8	180.0	210.8	243.4	
24									125.0	150.1	177.1	207.3	238.6	270.8
26									122.8	147.7	175.3	205.0	235.4	267.0
28										145.9	173.1	201.7	231.7	263.1
30											170.8	199.9	230.7	259.7
32											168.8	197.1	226.3	258.0
34											167.2	195.1	224.8	254.6
36												193.9	222.7	252.3
							Stocking – 0.7							
2	3.1	19.5												
4	2.7	12.4	22.7											
6		11.1	19.2	29.7	43.6									
8		10.3	17.7	27.0	39.4	54.0								
10			17.2	25.8	36.8	50.5	66.7							
12				24.8	35.3	48.6	63.5	80.8						
14					34.4	46.9	61.4	77.7	96.1					
16						45.9	59.3	75.6	93.4	113.3				
18							58.7	74.1	91.6	110.4	131.2			
20								72.5	89.8	108.0	129.2	150.2		
22								71.7	87.9	106.6	126.4	146.9	168.9	
24									86.8	104.7	124.4	145.1	166.7	190.5
26									86.8	103.8	122.2	142.5	164.1	186.7
28										102.9	122.2	141.4	162.6	185.2
30											118.9	139.1	159.9	182.0
32											118.3	137.9	159.3	180.8
34											117.0	135.8	156.5	178.8
36												135.3	154.7	176.4

Table 12. Pine plantation: The phytomass of twigs (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	2.4	5.9												
4	3.4	7.8	7.0											
6		9.7	8.6	7.5	6.8									
8		11.6	10.0	8.6	7.7	7.0								
10			11.5	10.0	8.6	8.0	7.4							
12				10.9	9.9	8.8	8.2	7.6						
14					10.6	9.6	8.8	8.3	7.8					
16						10.6	9.6	8.9	8.6	7.9				
18							10.3	9.7	9.3	8.7	8.3			
20								10.4	9.7	9.3	8.7	8.5		
22								11.2	10.5	9.8	9.3	8.9	8.6	
24									11.2	10.2	10.0	9.4	9.1	8.5
26									11.8	11.1	10.5	10.0	9.5	9.2
28										11.7	10.9	10.6	10.0	9.6
30											11.6	11.1	10.6	10.0
32											12.1	11.6	10.8	10.5
34											12.7	11.9	11.5	11.0
36												12.4	11.9	11.4
							Stocking – 0.7							
2	1.6	4.6												
4	2.6	5.9	5.5											
6		7.3	6.5	5.6	5.0									
8		8.8	7.4	6.6	5.9	5.5								
10			8.6	7.4	6.6	5.9	5.6							
12				8.3	7.2	6.6	6.1	5.8						
14					8.0	7.2	6.8	6.2	5.8					
16						8.0	7.2	7.0	6.5	6.1				
18							7.7	7.2	6.9	6.6	6.3			
20								7.9	7.4	7.0	6.6	6.3		
22								8.4	7.8	7.4	7.0	6.6	6.4	
24									8.3	7.9	7.2	7.2	6.7	6.6
26									8.9	8.3	7.9	7.6	7.2	6.8
28										8.8	8.4	7.7	7.4	7.0
30											8.6	8.2	7.9	7.5
32											9.1	8.7	8.4	8.1
34											9.4	9.1	8.3	8.3
36												9.4	9.0	8.7

Table 13. Pine plantation: The phytomass of needles (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	1.7	4.1												
4	2.3	5.5	4.8											
6		6.8	6.0	5.3	4.8									
8		8.1	7.0	5.9	5.4	4.8								
10			8.0	7.0	6.0	5.5	5.1							
12				7.5	6.9	6.0	5.6	5.2						
14					7.3	6.6	6.0	5.7	5.3					
16						7.4	6.5	6.0	5.9	5.3				
18							7.0	6.6	6.3	5.9	5.6			
20								7.0	6.6	6.3	5.9	5.7		
22								7.6	7.2	6.6	6.2	6.0	5.7	
24									7.6	6.8	6.8	6.3	6.1	5.5
26									8.1	7.6	7.0	6.8	6.4	6.1
28										7.8	7.3	7.1	6.7	6.5
30											7.8	7.3	7.1	6.5
32											8.1	7.7	7.1	6.8
34											8.4	7.9	7.6	7.3
36												8.1	7.7	7.5
							Stocking – 0.7							
2	1.1	3.2												
4	1.8	4.1	3.8											
6		5.1	4.5	3.9	3.5									
8		6.2	5.2	4.6	4.1	3.9								
10			6.0	5.1	4.6	4.1	3.8							
12				5.8	4.9	4.5	4.2	4.0						
14					5.5	4.9	4.6	4.2	3.9					
16						5.5	4.9	4.9	4.5	4.2				
18							5.2	4.9	4.7	4.5	4.3			
20								5.4	5.0	4.8	4.5	4.2		
22								5.6	5.3	5.0	4.7	4.4	4.2	
24									5.7	5.4	4.8	4.8	4.5	4.4
26									6.0	5.6	5.3	5.2	4.9	4.6
28										5.9	5.7	5.0	4.8	4.5
30											5.8	5.4	5.1	4.9
32											6.0	5.8	5.6	5.4
34											6.1	6.0	5.4	5.5
36												6.1	5.8	5.7

Table 14. Pine plantation: The phytomass of branches (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	1.3	3.2												
4	2.2	4.8	4.5											
6		6.7	5.9	5.1	4.8									
8		8.6	7.5	6.4	5.7	5.5								
10			9.3	7.8	7.2	6.5	6.2							
12				9.3	8.4	7.7	7.2	6.7						
14					9.9	8.9	8.3	7.7	7.4					
16						10.1	9.4	9.0	8.5	8.3				
18							10.8	10.1	9.5	8.9	8.6			
20								11.4	10.9	10.2	9.8	9.4		
22								12.4	12.0	11.3	10.8	10.5	10.4	
24									13.1	12.3	11.7	11.4	11.3	11.0
26									14.5	13.6	13.1	12.5	12.2	11.7
28										15.0	14.6	13.9	13.2	12.8
30											15.5	15.2	14.5	13.8
32											16.6	16.2	15.4	15.4
34											18.1	17.3	16.7	16.1
36												18.7	18.2	17.2
							Stocking – 0.7							
2	1.0	2.7												
4	1.8	4.0	3.8											
6		5.7	5.1	4.4	3.9									
8		7.4	6.4	5.6	5.0	4.6								
10			7.9	6.8	6.1	5.6	5.2							
12				8.2	7.4	6.6	6.2	5.7						
14					8.5	7.8	7.2	6.8	6.6					
16						9.0	8.3	7.8	7.4	6.9				
18							9.3	8.8	8.3	8.2	7.9			
20								9.9	9.5	9.0	8.5	8.5		
22								11.1	10.4	10.2	9.8	9.2	9.1	
24									11.2	11.1	10.7	10.3	9.7	9.4
26									12.9	12.3	12.0	11.2	10.7	10.4
28										13.2	13.0	12.3	11.8	11.7
30											13.6	13.3	12.9	12.6
32											15.2	14.2	13.7	13.5
34											16.3	15.3	14.8	14.6
36												16.8	16.3	15.7

Table 15. Pine plantation: The phytomass of stands (t/ha).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	7.5	34.8												
4	8.1	27.9	41.7											
6		29.5	39.3	53.0	71.9									
8		31.8	39.9	51.2	67.2	87.5								
10			41.8	51.5	66.0	84.2	106.3							
12				52.5	66.0	82.7	103.7	127.4						
14					66.5	82.3	101.7	124.9	150.4					
16						83.0	101.4	123.3	148.1	175.4				
18							101.2	122.2	146.5	172.5	201.5			
20								122.4	145.2	171.9	199.2	229.7		
22								122.3	145.4	169.7	197.0	227.3	259.5	
24									145.7	169.2	195.6	225.0	256.0	287.3
26									145.4	168.9	195.4	224.3	254.0	284.8
28										168.7	195.0	222.7	251.6	282.4
30											194.1	222.4	252.3	280.0
32											193.5	221.0	248.8	280.2
34											193.7	220.3	249.1	278.0
36												220.7	248.6	277.0
							Stocking – 0.7							
2	5.2	25.4												
4	6.3	20.5	30.3											
6		21.9	28.8	38.0	51.0									
8		23.9	29.3	37.2	48.5	62.5								
10			31.1	37.7	47.5	60.2	75.7							
12				38.8	47.6	59.7	73.9	90.5						
14					48.4	59.6	73.2	88.7	106.6					
16						60.4	72.5	88.3	105.3	124.4				
18							73.2	87.8	104.6	123.1	143.4			
20								87.8	104.3	121.8	142.2	162.9		
22								88.4	103.6	121.8	140.9	160.5	182.2	
24									103.7	121.2	139.9	160.2	180.9	204.3
26									105.7	121.7	139.5	158.9	179.7	201.7
28										122.0	140.9	158.7	179.2	201.4
30											138.3	157.8	177.9	199.5
32											139.5	157.9	178.6	199.7
34											139.4	157.1	176.7	198.9
36												158.2	176.8	197.8

Table 16. Pine plantation: Ratio of stand phytomass to stem volume (t/m^3).

Mean diameter	Mean height (m)													
(cm)	2	4	6	8	10	12	14	16	18	20	22	24	26	28
							Stocking – 1.0							
2	0.53	0.41												
4	0.71	0.53	0.44											
6		0.63	0.50	0.44	0.41									
8		0.72	0.55	0.47	0.44	0.42								
10			0.61	0.51	0.46	0.44	0.42							
12				0.54	0.48	0.45	0.44	0.43						
14					0.51	0.47	0.45	0.44	0.43					
16						0.49	0.46	0.45	0.44	0.44				
18							0.48	0.46	0.45	0.44	0.44			
20								0.47	0.46	0.45	0.45	0.44		
22								0.48	0.47	0.46	0.45	0.45	0.45	
24									0.48	0.47	0.46	0.46	0.46	0.45
26									0.49	0.48	0.47	0.46	0.46	0.46
28										0.48	0.48	0.47	0.47	0.47
30											0.48	0.48	0.47	0.47
32											0.49	0.48	0.48	0.48
34											0.50	0.49	0.49	0.48
36												0.50	0.49	0.49
							Stocking – 0.7							
2	0.53	0.43												
4	0.79	0.55	0.46											
6		0.67	0.52	0.45	0.42									
8		0.78	0.58	0.49	0.45	0.43								
10			0.64	0.53	0.48	0.45	0.43							
12				0.57	0.50	0.47	0.44	0.43						
14					0.53	0.48	0.46	0.45	0.44					
16						0.51	0.47	0.46	0.45	0.44				
18							0.49	0.47	0.46	0.45	0.45			
20								0.48	0.47	0.46	0.45	0.45		
22								0.50	0.48	0.47	0.46	0.46	0.45	
24									0.49	0.48	0.47	0.47	0.46	0.46
26									0.50	0.49	0.48	0.47	0.47	0.47
28										0.50	0.49	0.48	0.47	0.47
30											0.49	0.49	0.48	0.48
32											0.50	0.50	0.49	0.49
34											0.51	0.50	0.49	0.49
36												0.51	0.50	0.50