

# PART 1

## USER'S GUIDE

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## **ForestCalc Inventory**

**ForestCalc Inventory** can be used to compute forest assessment results for a single area or for an area divided into strata. The program works only with metric system units. By using this program you can compute results for five sample plot designs:

- Rectangular plot,
- Circular plot,
- Concentric circular plot,
- Point sampling (relascope),
- Nested rectangular plot.

The program computes all results into a result database. The database contains results by

- tally trees,
- tree classes by tree species by sample plots,
- all trees by sample plots, and
- stratum.

The program can compute all main result variables demanded in a proper forest inventory project, as tree stock by size classes, timber volumes, reliability estimates, biomass and carbon stock. And much more!

This manual, Part I, is called as the **User's guide**. The Manual Part II includes description of the databases and the program parameter files.

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## ABBREVIATIONS

BA	Basal area
d, DBH	Diameter at the breast height (1.3 m)
d0, D0	Diameter of stump, or diameter at the stump height (cm)
d6, D6	Upper diameter at 6 meters height (cm) ( <i>only used in Finland</i> )
F( )	as a function of ..
GIS	Geographical Information Systems
GPS	Global Positioning System
h, Ht	Total tree height (m)
ha	Hectare
Hc	Commercial bole height (m)
lh	Height increment (m)
lr	Increment of radius at 1.3 m (mm)
lr (2x)	Diameter increment (mm)
m	Meter
m3	Cubic meter
MIF	MapInfo Interchange Format
MS	Microsoft
T	length of increment period (years)
US	the United States of America
UTM	Universal Transverse Mercator
v.	Version
V	Total tree volume
WGS-84	World Geodetic System 1984

Depending on country, and harvesting system, there are different names for timber assortments. In this manual the terminology is as follows:

Log = Bole

Pulp wood = Pole wood

Other use timber = Fuel wood part of a stem

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## 1. Installation

**ForestCalc Inventory** runs under Windows 2000, Windows XP or Windows Vista.

### Notice.

Execute **ForestCalc Inventory.msi**. This is the full installation package, and the same file works also as uninstaller. Select drive and folder.

### Windows-settings:

- System decimal symbol must be dot (.)
- System list separator **can not** be dot
- The screen resolution must be at least 1024 x 768.

Before first time running ForestCalc Inventory, ensure that you do the following things:

- 1) Copy **ForestCalcLicence.dat** to the program folder (if not delivered in the setup package);
- 2) Start the program, and if needed, change language (*Asetukset, Vaihda kieli*);
- 3) Set your default data folder = working directory (*Asetukset / Settings*).

### ForestCalc Inventory localized settings:

See more about the parameter files **TreeparalInventory.mdb** and **ForestPara.mdb** in the Manual Part II

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## 2. Using the software

### 2.1. Localization

ForestCalc Inventory can be localized into any conditions where the metric system is in use. All data – parameters, input data, and result data – are saved into MS Access2000 format files. These files can be read or edited using a database management software.

The program is a stand-alone application. However, the database management application (MS Access 2000 or newer) is needed to edit the parameter files in order to localize the program. The following parameters can be adjusted in **TreeparInventory.mdb**:

- Data entry validation rules;
- Tree species information: codes (text), names (local and botanical), species group code, volume model number, bole volume model number (optional), bole volume form factor (optional), biomass conversion factor (optional), charcoal conversion factor (optional);
- Tree species grouping (max. 20 groups);
- Taper curve parameters (*Newnham's* variable-form taper function, or *Sharma & Oderwald* taper function) (optional);
- Tree volume functions (3 function groups:  $f(d)$ ,  $f(d,h)$ ,  $f(d,h,upper\ d)$ ) for each species;
- Bole volume functions (optional);
- Biomass functions (optional);
- Biomass and carbon conversation factors;
- Tree height functions (*Näslund*, *Polynomic* and *Michailoff*);
- Local currency unit;
- Log timber, Pulpwood/Pole and Fuelwood prices by species or/and by species groups. Prices can be entered by cubic meter *or/and* by stem;
- Timber dimensions (Log/Bole and pulpwood/pole. Used only with taper functions) ;
- Timber tables (Optional). Log and pulp/pole percentage tables in text files, as a matrix of tree diameters and heights;
- Default increment period (past increment), if diameter increment is measured;
- User-defined diameter classes in the result tables;

.. and parameters in **ForestPara.mdb**:

- Metadata: list of *Provinces*, *Districts*, *Sub districts* (codes, names, areas);
- Coordinate zones;
- Aggregated data measured/estimated at a plot (0 – 10 aggregated variables, for example *Vegetation type*, *Land use*, *Soil type*, ..) ;
- Aggregated data measured/estimated of sample trees (0 – 5 aggregated variables, for example *Timber use class*, *Tree quality class*, *Health class*, ..);
- Subplot variables for seedlings/regeneration (diameter classes, height classes).

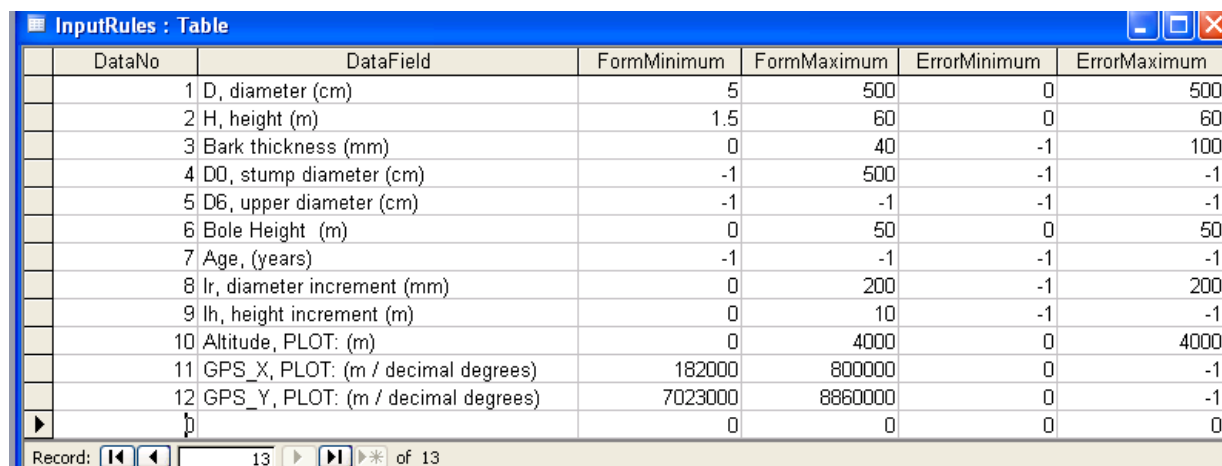
For more details about the program parameters and the parameter files, see Manual Part II.

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The program supplier can edit and add new language versions. All words and phrases used in **ForestCalc Inventory** are written into a text file, which is then compiled into the final exe file. Currently, **ForestCalc Inventory** is available in English, Finnish, Swedish, German, Bahasa Indonesia, Spanish and Portuguese, and if requested also in Russian.

## 2.2. Data validation rules

Data validation rules for data entry can be set into the file *TreeparaInventory.mdb*, table *InputRules*. **ForestCalc Inventory** reads the content of this table when it starts.



DataNo	DataField	FormMinimum	FormMaximum	ErrorMinimum	ErrorMaximum
1	D, diameter (cm)	5	500	0	500
2	H, height (m)	1.5	60	0	60
3	Bark thickness (mm)	0	40	-1	100
4	DD, stump diameter (cm)	-1	500	-1	-1
5	DG, upper diameter (cm)	-1	-1	-1	-1
6	Bole Height (m)	0	50	0	50
7	Age, (years)	-1	-1	-1	-1
8	lr, diameter increment (mm)	0	200	-1	200
9	lh, height increment (m)	0	10	-1	-1
10	Altitude, PLOT: (m)	0	4000	0	4000
11	GPS_X, PLOT: (m / decimal degrees)	182000	800000	0	-1
12	GPS_Y, PLOT: (m / decimal degrees)	7023000	8860000	0	-1
		0	0	0	0

The order of fields is fixed, so do not change it. You can **only** change the values in the fields *FormMinimum*, *FormMaximum*, *ErrorMinimum* and *ErrorMaximum*. Some explanation:

*FormMinimum* = Minimum limit. If the entered value less than this limit, a **warning** given but data will be written into the database.

*FormMaximum* = Maximum limit. If the entered value is greater than this limit, a **warning** given but data will be written into the database.

*ErrorMinimum* = Minimum limit. If the entered value less than this limit, an **error** message given and data will not be written into the database.

*ErrorMaximum* = Minimum limit. If the entered value greater than this limit, an **error** message given and data will not be written into the database.

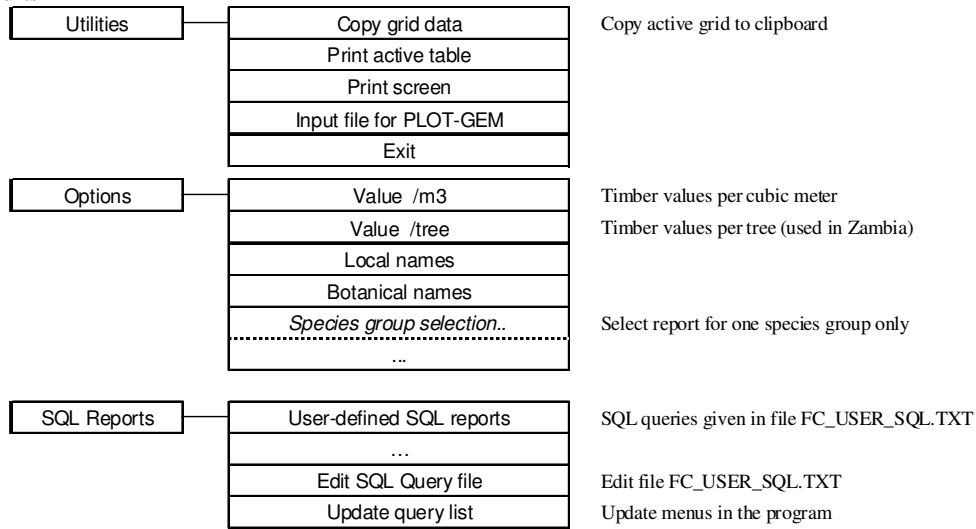
**Notice!** '-1' means that no data checking is carried out.

## 2.3. Menu system

<i>Form</i>	<i>Main menu</i>	<i>Sub-menus</i>	<i>Explanation</i>
<b>Main</b>	Settings	Set current working directory.. Dimensions and prices.. Settings.. Volume equation test Plot recoding utility Change language Exit	Set default data folder Set timber prices More settings Test program for volume equations Recoding of plots or strata IDs Exit program
	About program..		
<b>Inventory</b>	Utilities	New district (region) file	Create new databases
		Copy grid data	Copy active grid to clipboard
		Print screen	
		All plot locations to file	Export plot coordinates and attribute data to GIS
		Conversion: v 3.x -> v 4.x	
		Combine input files	Combine 2 input data files
		Update strata values from geodatabase	<i>(valid only in Zambia)</i>
		Change plot number	
		Check data	Check a database
	Exit	Exit subprogram	
Plot database	New	Enter new sample plot	
	Retrieve	View / Edit plot data	
	Delete	Delete one sample plot	
	Metadata	Edit metadata	
	Areas of strata	Strata codes, names and areas	
	Transect line data		
Compute	All plot in the area	Computing of results with regression modeling	
	All plot in the area (no modeling)	Computing of results without modeling	
	* Continue interrupted calculation		
	* Results by strata - updating	Fast recomputing, when stratum data has been edited	
	Compute biodiversity indeces	Biodiversity indeces by plots	
	Compute biomass <i>(by tree components)</i>	Biomass calculations for tally trees into the result database	
Height model	Compute biomass and C-stock	Biomass and carbon calculations for trees, plots, and strata	
	Median (Veltheim)	<i>(Valid only in Finland)</i>	
	Median (Database)	Fit height curve via median tree (D,H)	
	Sample trees (Näslund)	Single tree height curves	
	Sample trees (Polynomic)	solved using regression analysis	
Options	Sample trees (Michailoff)	by plot	
	General	Default price group	
	...	<i>(optional price groups)</i>	
	Volume equation and tables	Equations is computing (Default)	
	Bucking (Finland)	Laasasaho's taper curves in computing (Valid only in Finland)	



**Inventory results**



**2.4. Starting**

Start the program by clicking at the shortcut **ForestCalc Inventory**. If the program has been set to work using different parameters by provinces, you have to select the province first.



**Figure 1.** Select province: this message pops up if the program has been set up to use different parameters by different regions (see more in Manual II, and database *TreeParaInventory.mdb*, table *ProgramForestparaFileDefinition*).

If needed, set up your language (*Settings, Change language*) (*Asetukset, Vaihda kieli*). Set also your default data folder for data (*Settings, Set working directory*). Notice that you can define an unique data folder for each province.

Check all settings (menu command *Settings*) and set appropriate timber prices (*Dimensions and prices*) as applicable.

## 2.5. Region file

Sample plot data are stored into a file identified by a region number. One database can contain information about several strata, but in one database all sample plots must have a unique plot ID. To start entering data for a new area, you must first create new database for input and result data using command **Utilities, New region file** and giving your region number (*long integer*, maximum value is 2147483647). Actually, the program makes copies of two blank database files for your data. For instance, if you gave region number as 131, the program copies two files into the current data folder, as follows:

```
Model_InputData.mdb -> FC_DataInput_131.mdb      (file for the input data)
Model_ResultData.mdb -> FC_DataResult_131.mdb    (file for the results)
```

If same region number already exists in your data folder, the command is not executed and the program gives a warning.

## 2.6. Data entry

Enter your new plot data by selecting **Database, New**. Next, give your region number and plot ID code (as number or text). If the plot ID code already exists or the region number does not have a database yet, the program gives a warning. If your entry is accepted, you get a new tab form. At each form, fill or accept first your plot type and variable list. If your plot is a permanent sample plot (PSP), you can put a tag on it. Next click at **SAVE**-button. Then fill in forms *General data*, *Sample trees* and *Seedling information*, as necessary.

**\*\*\* NOTICE! Press SAVE button on every form! \*\*\***

**\*\*\* NOTICE! Each plot should have a unique PLOT ID. If you enter inventory data from various sources or if you combine two databases together, this rule should be taken into account! \*\*\***

The **data validity checking** bases on the predefined minimum and maximum limits, which can be set into the parameter file **TreeparalInventory.mdb**, table *InputRules*. Read more about the rules in the chapter 2.2.

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**Figure 2.** An example of the *Variables* form.

The following variables can be potentially recorded at a sample plot (*General data* form):

- + Plot ID (text)
- Stratum ID (text)
- + Weight factor (default=1)
- + Plot dimensions, or Relascope factor
- Subplot dimensions
- + Date (Day, Month, Year)
- Measurer (text)
- Altitude (in meters above sea level)
- Slope (in degrees or percentage)
- GPS X coordinate (m or decimal degrees)
- GPS Y coordinate (m or decimal degrees)
- An image file name or image URL address
- Other information. Additional text.
- 0–10 aggregated variables defined in **Forestpara.mdb**, table *Plot\_INVENTORY\_SELECTION*
- \*\*Direction along a transect line to the plot (optional)
- \*\*Distance along a transect line from previous plot (optional)
- \*\*Total distance along the transect line (optional).

+ *obligatory data*

The program does not compute any kind of slope corrections for the plot sizes. These corrections should always been carried out in the field.

In case of a stratified sampling, the plot data can be entered without giving a stratum code. However, stratum codes can be given later, since there is a practical tool to enter stratum ID for each plot: execute **Plot recoding program** at the main **ForestCalc Inventory** window.

**Figure 3.** General data form

At a concentric or nested plot, trees are selected and tallied following rules based on tree diameter limits. For example, at a concentric circular plot, trees less or equal to DBH 10 cm can be measured applying plot radius of 3 meters, and all bigger trees within a plot with radius of 6 meters.

The following variables can be potentially recorded at a sample trees (*Tree characteristics* form):

- Tree number
- + Species code (text)
- Tree class code
- + DBH Diameter at the breast height (cm)
- D0 Diameter of stump (cm) (written into the field 'Diameter' in grid)
- H Total tree height (m)
- Bark Bark thickness, total of two sides (mm)
- D6 Upper diameter at 6 meters height (cm). *Valid only in Finland.*
- Hc Commercial bole height (m)
- Age Tree's age (years)
- Ir (2x) Diameter increment (mm, during default period)
- Ih Height increment (m, during default period)
- Tree's location at the plot
- 0 – 5 aggregated variables defined in **Forestpara.mdb**, *Tree\_INVENTORY\_SELECTION*

Separate sample trees can be selected for different type of measurements. In the other words, height can be measured for example of every sample tree, but age and increment are measured from every second sample tree. Computing of volume increment is possible in the program, when (at least) diameter increment has been detected.

**Tree class codes** are the following (*Optional*):

- 0 = other use (no log/bole and pulp/pole volumes computed)
- 1 = log/bole timber. DEFAULT VALUE
- 2 = pulp/pole wood (no log/bole volume computed)
- 3 = marked log/bole timber (to be removed in thinning)
- 4 = marked pulp/pole wood (to be removed in thinning)
- 5 = stump
- 6 = dead tree (no log and pulp/pole volumes computed, no increment computed)
- 7 = branch

Tree class codes are fixed in **ForestCalc Inventory** and you cannot edit them. If the tree class coding has no meaning for you, do not select them at *Variables* form. This program can also compute results for living trees and dead trees separately, total standing stock and removal (based on stump diameters), and for each tree class. For instance in case of an illegal logging, you can measure stump diameters and standing sample trees to determine how much timber was cut illegally.

Branches can be recorded separately using a special tree class code (7). Otherwise they are treated as trees. Branches are typical for trees growing on African *miombo* lands. Commercial (log/bole) volume for a branch is computed only if the bole height is recorded. Branches are not counted into the total number of stems and into the total basal area. A practical method to record branches is to give them a decimal value as **Tree number**. An example: the main stem gets number 3, the first branch gets 3.1, and so on.

The user may measure locations of trees on the plot. There are two alternative methods:

- X- and Y-coordinates are measured. Usually, a plot's origin is at the lower left corner (south-west), or in the middle of the plot.
- Azimuth and distance are measured from plot's center point, which is the origin.

### **Instructions**

- All trees are measured as sample trees and enumerated individually (so it is **not** possible to enter the number of trees per diameter class).
  - Obligatory fields in the plot form are *Plot code*, *Plot size* or *Relascope factor*, *Weight factor* and *Date*.
  - Obligatory fields in the tree form are *Species* and *Diameter* (or *Total height*). However, the program can compute missing diameters (based on a transverse height curve) if there are enough diameter and height measurements on a plot.
  - The plot has always a weight factor, which is plot's relative weight in a stratum. The default value is one, **zero is not allowed!**
  - In case of a stratified sampling design, the area of each stratum must be given.
  - A plot's aggregated variables may include information about forest and soil types. These are defined in the parameter file **Forestpara.mdb** (see manual, Part II).
  - In case of a missing or blank variable, leave this column blank or just type zero (0).  
An exception: *Tree class code 0* means 'other use tree' (log and pulp wood volumes not computed).
-

**Concentric**

2

Width      D

4 m      20 cm

10 m      9999 cm

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**Seedling information**

3 m

Figure 4. Concentric/Nested plot information.

Variables      General data      **Tree characteristics**

Number	Species	D1.3 (cm)	H (m)
1	BLU	22	10
1	MRT	29	14
1	BNS	67	20
1	MRT	62	20
1	THT	24	12
1	MRT	45	17
1	BLU	28	11
1	KPS	73	18
1	PTT	47	14
1	MRT	20	12
1	NYT	26	10
1	MDG	21	8
1	JBN	22	8
1	ARG	27	12
1	JBN	20	5
1	GRG	22	11
1	JBN	24	7
...	...	...	...

F5      Delete row  
F6      Insert row  
F7      Add rows to table

Figure 5. The sample tree form. Measured variables are set earlier at the form *Variables*.







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**\*\*\* NOTICE! Each plot should have a unique PLOT ID. If you enter inventory data from various sources and you combine two databases, this should be taken into account! \*\*\***

When combining two databases, follow these steps:

- 1) Copy input databases into your data folder.
- 2) Run data validity checking for both databases to be combined. Correct all critical errors.
- 3) In order to avoid overlapping with plot ID codes, run **Plot recoding program**, if necessary
- 4) Click menu command *Utilities, Combine input files*. The program asks first the IDs of databases to be combined, then the new number for the output.
- 5) Check the consistency of your stratum codes, if necessary. Check also the areas of strata.

## 2.9. Computing of missing tree heights

Basically, the program uses always a measured height for a tree if the value exists. Only the missing heights are computed using a height curve. The height curve is always computed by tree species. It is computed by plot, by strata or for whole inventory area (see **Settings**).

There are four possible height calculation methods in the program.

- 1) Height curves are not computed: all tree heights are measured in the field (e.g. in Indonesian 100% forest inventory version). This method is valid when you run '*Computing without modeling*'.
- 2) Median (Veltheim). **The first tree with height data** at each plot (of each species) is treated as the median tree of the species. The height curve is computed using formula of Veltheim (in Mäkelä & Salminen 1991). **This method is valid only in the Finnish software version.**  
The curve is calibrated through the true diameter-height data-point of the median tree. For species having no median tree data, the height curve is computed without calibration.
- 3) Median (Database). **The first tree with height data** at each plot (by species) represents the median tree of that species. The height curve is computed using the model given for that particular species in the parameter file **TreeparalInventory.mdb**, table *HeightCurveForInventory*. There can be only one predictor variable: diameter. The curve is calibrated to go through the median diameter-height data-point. For species having no median tree data, the height is computed without calibration.
- 4) Sample trees (**Default**), Regression method. The height curve is computed using two-parameter regression model for each species by plot separately. If there are not enough height sample trees on the plot, then 100 first sample trees of that species are used to compute the model. Models forms are Näslund, Michailoff (Schumacher) and Polynomic.  
A missing tree diameter (DBH=0,  $h > 1.3$  m) is computed from the (reverse) height equation.

The program can correct "illogical height curves": For instance, Näslund model a-parameter may not be negative or Michailoff model a-parameter may not be positive. An illogical curve may

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emerge if the observations (d,h) are as follows: (24,26),(25,23),(26,22). So, the bigger trees (at DBH) are shorter. In this case, uncorrected models may give unrealistic heights for small diameter trees: even more than 1000 meters!

## 2.10. Computing of results

The results are always computed for all plots in the database at a time. First, the program asks for the region number. Second, the program asks whether computing is executed for one single area or by strata. In case of a single area, the program asks you to give the size of the area (in hectares). In case of a stratified sampling, the program uses stratum areas, as entered already. When the processing is completed, you can go to view the results. The computing creates a log file (text file) in the database folder. The log file name is of the form **Info\_Areanumber.log**.

The program computes results for each tree, each tree species at the plot, tree classes at the plot, all trees at the plot, for strata and for the total inventory area. The results are written into the result database. Actually there are more results in the result database as the program can show you! The order in computing is the following: first the program computes all model parameters by species per plot (e.g. height curve parameters), then tree level results, next plot level results and finally stratum level results. The program uses always the measured observations, only the missing values are computed by the help of models.

The regression models are computed only for those variables, which were selected (at the form *Variables*). The computing of missing height was explained in previous chapter. For other variables, the regression models can be computed when there are minimum of 3 observations. This minimum limit can be changed in the program main menu (*Settings*). If a certain species has not enough (at least the minimum number of) observations to compute a model (e.g. age model), then the regression model is computed by collecting more observations first from so-called corresponding (substitution) species list, which rules is read from the database **TreeparalInventory.mdb** (table *TreeSpecies*, field *CspeciesList*). The program collects observations (of corresponding species) as long as there are enough observations for regression. If the number of observations is insufficient at a plot, then the program picks up first 100 trees of that particular species from the data.

### Example 1.

Corresponding list for spruce (code 2) is the following: **1,3,\***

If there are not enough sample trees among spruces at the plot to compute a regression model for age, all pine trees (species code 1) are selected for modelling;

if the number of trees is not yet enough, then all birches will be chosen (species code 3);

if the number of trees is not yet enough, then all (age) sample trees at the plot are chosen.

### Example 2.

If this list for some species is left blank, then all species are equal (same as **\*\*) and there is no priority set to select certain species first**

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The expansion factor (number of trees per hectare) and basal area (per hectare) are computed for each tree. At a relascope sample plot, basal area of each tally tree is equal to the relascope factor, and the number of trees per hectare is computed using the following formula:

$$n_i = 4/\text{PI} * \text{BAf} / d_i^2 = 1.27323 * \text{BAf} / d_i^2$$

where  $n_i$  = trees/ha,  $\text{BAf}$  = relascope factor,  $d$  = diameter (m)

The expansion factor for a rectangular and circular plot is calculated by dividing 1 hectare (10000 m<sup>2</sup>) by the sample plot area. To adjust the plot size at per-hectare, tree basal area is multiplied by the expansion factor and summed up for all trees at the plot. At a concentric/nested plot, plot area of each tree depends on the tree's diameter according to the given rule.

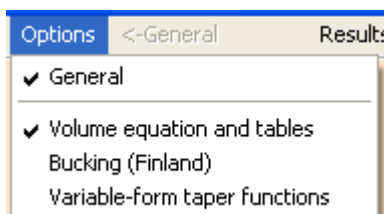
If any diameter increments have been measured, volume of each tally tree  $T$  years ago can be computed (default 5 years back from measuring time). First, the program computes diameter under bark, but if the bark thickness has not been measured, a default bark thickness is assumed to be 10 % of the diameter (at 2 sides).

Second, diameter increment (=2 x radius growth,  $T$  years) is subtracted from the diameter under bark, and the result gives the diameter under bark  $T$  years ago. Third, this diameter is transformed to diameter above bark by assuming that bark's thickness in relation to the diameter is constant. Next, the tree height  $T$  years ago is calculated by subtracting the height increment from the current tree height. If height increments have not been measured, the program estimates the tree height in the past with the help of a height curve.

To calculate **the total tree volumes**, you can select one of the following methods:

- 1) volume equations (**default**), or
- 2) Laasasenaho's taper curves (valid only in the Finnish program version),
- 3) Newnham's variable-form taper functions, or
- 4) Sharma & Oderwald dimensionally compatible taper functions.

About these models, read more later in this document.



**Figure 8.** Selection of the timber group (dimensions and prices) and volume calculation method.

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### **Total stem and timber volumes: Volume equation and tables**

The total stem volume is computed applying the volume equation written into the parameter file by species. If DBH and total tree height are known (or computed using height model), the program uses two-parameter model  $Vol=F(DBH,h)$ . If only the DBH is known, the program uses one-parameter model  $Vol=F(DBH)$ . If the increment data are measured, the program can also compute timber volumes T years ago.

There are basically 3 different methods to compute timber volumes for each tree, depending on the information entered into the parameter file **TreeparalInventory.mdb**, table *TreeSpecies*, field *TimberTableFileName*.

1) If the field *TimberTableFileName* contains a name of a text file name, then

Log and pulp wood are computed multiplying total volume with **log and pulp wood percentages**, which are read from given text file (see the parameter file **TreeparalInventory.mdb**, table *TreeSpecies* in Manual Part II). *This method is valid only in Finland.*

2) If the field *TimberTableFileName* contains an *integer number* referring to the table *BoleVolumeModels*, then

Log/Bole volume is computed using bole volume equation, which is a function of DBH and commercial tree height,  $VolBole=F(DBH,Hc)$ . In this case, pulp/pole volume is not computed.

3) If the field *TimberTableFileName* contains a bole form factor (*decimal number, e.g. 0.8*), then

Log/Bole volume is computed using a form factor [ $VolBole=F(\text{factor},DBH,Hc)$ ]. In this case, pulp/pole volume is not computed.

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**Timber volumes: Taper curves**

The stem volumes can also be computed using a taper curve of Laasasenaho (1982), Newnham (1988, 1992) or Sharma & Oderwald (2001). Hence, the log/bole and pulp part are computed applying the selected taper equation and predefined timber dimensions (from the parameter file). If the increment measurements are available, the program can compute timber volumes T years ago.

---

**Stem value**

The stem value is computed multiplying timber volume by unit prices (log, pulp, top) and totaling the figures.

**Annual volume increment**

The mean annual volume increment and value increment are calculated by subtracting volume (or value) T years ago from the current volume, and the residual is divided by the length of the growing period (T).

**Results for stratum (volume) (see e.g. Freese, 1962)**

Here is the description of methods used to compute the statistical information by forest strata.

**Mean** of the stratum.

$$\bar{X}$$

The mean of sample plot volumes, weighted by proportional of each sample plot area in the stratum

**The standard deviation ( $s_x$ )** is the basic measure of plot-to-plot variability.

$$\sqrt{\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n - 1}}$$

---

where  $n$  = number of sample plots

The **standard error (SE)** in sampling without replacement is computed as

$$SE = \sqrt{\frac{s_x^2}{n} \left(1 - \frac{n}{N}\right)}$$

If  $n/N < 0.05$ , ForestCalc Inventory ignores the finite population correction and uses the shortened form as follows

$$SE = \sqrt{\frac{s_x^2}{n}} = \frac{s_x}{\sqrt{n}}$$

where  $s_x^2$  = variance between plot volumes  
 $n$  = number of sample plots in stratum

**Coefficient of variation (CV).**

$$CV = \frac{s_x}{\bar{X}}$$

Usually presented as percents, then multiplied by 100.

**Results for inventory area (volume)**

The **mean** of the stratified sample is computed by:

$$\bar{X}_{ST} = \frac{\sum_{h=1}^L N_h * \bar{X}_h}{N},$$

where  $L$  = The number of strata  
 $N_h$  = The size of stratum  $h$  ( $h = 1, 2, \dots, L$ ) in ha  
 $N$  = The total size of the area in hectares  $(N = \sum_{h=1}^L N_h)$

The standard deviation (SD) is computed as follows:

$$SD_{ST} = \sqrt{\frac{1}{W^2} \sum_{h=1}^L W_h^2 s_h^2}$$

The stratified **standard error (SE<sub>ST</sub>)** of the mean volume (per hectare) is computed as follows:

$$SE_{ST} = \sqrt{\frac{1}{W^2} \sum_{h=1}^L \left[ \frac{N_h^2 s_h^2}{n_h^2} \left(1 - \frac{n_h}{W_h}\right) \right]}$$

If the sampling fraction in the strata is less than 0.05, then ForestCalc Inventory uses the shortened form as follows:

$$SE_{ST} = \sqrt{\frac{1}{W^2} \sum_{h=1}^L \left[ \frac{W_h^2 Var_h}{n_h^2} \right]}$$

where  $Var_h$  = variance in stratum h  
 $n_h$  = number of plots in stratum h  
 $W_h$  = area (ha) in stratum h  
 $W$  = total size of the area in hectares

**95% confidence interval** for (cubic meter) volume per hectare:

$$\bar{X}_{ST} \pm t_{0.05, n-1} * SE_{ST}$$

where  $t$  = Student t-table value,  
 $n - 1$  = degrees of freedom.

### Relative efficiency (RE)

The effects of stratification and stratified estimation on precision are assessed using relative efficiency, where  $RE > 1$  indicates a beneficial effect. This is defined for (total timber volume) as

$$RE = \frac{Var(\bar{y}_{SRS})}{Var(\bar{y}_{ST})}$$

Where variance based on simple random sampling (SRS) is divided by the estimate of variance based on stratified sampling.<sup>1</sup>

### Two Phase Sampling analysis

Assume a linear regression,  $y = a + bx$  ( $y$  refers to 2<sup>nd</sup> phase data, field data,  $x$  to 1<sup>st</sup> phase data). The program can compute the optimum number to second-phase sampling units ( $m$ ) for strata (when  $r^2$  runs from 0.2 to 0.9) for a given accuracy level for total timber volume per hectare, applying formula by Cochran (1977)<sup>2</sup>:

$$Var_{\bar{y}} \approx s_y^2 \left( \frac{(1-r^2)}{m} + \frac{r^2}{n} \right)$$

Where

$Var_{\bar{y}}$  = variance of the mean;

$r$  = coefficient of correlation between  $x$  and  $y$ ; (0.2 - 0.9).

$n$  = number of first phase sampling units (assumed 100000 satellite image pixels).

<sup>1</sup> See more at <http://www.fao.org/forestry/26364/en/>

<sup>2</sup> See Kangas & Maltamo (2006), page 242.



## 2.11. Regression models

### (1) Height

There are 3 different types of height models for the regression method (Table 1). The models are written into **TreeParalInventory.mdb**, table *HeightModel*.

**Table 1.** Height models

Name	Equation	Linearized equation	Y' (Lin. form predicted variable)
Näslund	$h = 1.3 + \frac{d^2}{(a+bd)^2}$	$a + b \times d$	$\frac{d}{\sqrt{h-1.3}}$
Polynomial	$h = 1.3 + a \times d + b \times d^2$	$a + b \times d$	$\frac{h-1.3}{d}$
Michailoff/ Schumacher	$h = 1.3 + ae^{-\frac{b}{d}} = 1.3 + e^B \times e^{\frac{A}{d}}$	$A + B \times d$	$d \times \ln(h-1.3)$

### (2) Bark thickness (mm)

$$b = a_2 + b_2d$$

### (3) Stump height diameter (cm)

$$d_0 = a_3 + b_3d$$

### (4) Upper diameter (d6) (cm)

$$d_6 = a_4 + b_4d$$

### (5) Bole height (m)

$$h_c = a_5 + b_5d$$

### (6) Age (years)

$$t = a_6 + b_6d$$

### (7) Radius increment (mm)

$$i_r = a_7 + b_7d$$

### (8) Height increment (m)

$$i_h = a_8 + b_8d$$

All equations have the same predictor variable  $d$  (the tree diameter at the breast height, cm). All equations are solved by species. If there are not enough (default=3) sample trees of that species, the program uses so-called corresponding species list to collect sufficient number of observations (see the previous chapter).

Linearization causes bias to the result, so the **height model correction factor** needs to be computed as follows: total sum of true heights of sample trees is divided by the sum of heights of sample trees computed using height model.



1,5,5 ! This is the conversion rule 2

!\*\*\*\*\*

! Conversion of Trees with decimals in TreeID code into branches

! For example: TreeID=9 -> stem, TreeID=9.1 -> branch

!

! Values are YES / NO

DecimalConversion = YES

If in the field *TreeClassVariable\_Index\_1* (1<sup>st</sup> variable) there is the value of '4' (conversion rule 1) or '5' (conversion rule 2), the program will use the internal tree class code 5 (= a dead tree).

Because DecimalConversion = YES, the program converts all trees carrying *TreeNumber* with decimals into the class 7 (branches).

**WARNING!** The file **FC\_TreeConversion.txt** may not have right conversion parameters for your forest inventory project. If you want to apply this conversion technique, please test it first!

## 2.13. Biomass calculations

**ForestCalc Inventory** can compute tree biomass and carbon (C) stock results. Biomass and C-stock calculation can be executed only after a successful computing of inventory results. The most simple way to compute tree biomass and carbon stock is to use same default parameters for all tree species. The second option is to compute the results by using parameters by species (see table *TreeSpecies* in the parameter file). See **Settings** to set your default values.

**AG**= above ground, **BG**= below ground

**StemBiomass** (tons) = WoodDensity x StemVolume /1000

**Biomass\_AG** = BEF x StemBiomass

**Biomass\_BG** = RootShootRatio x Biomass\_AG

**Total Biomass** = Biomass\_AG + Biomass\_BG

**Carbon\_AG** (tons) = CarbonFactor x Biomass\_AG

**Carbon\_BG** = CarbonFactor x Biomass\_BG

**Total Carbon** = Carbon\_AG + Carbon\_BG

Alternatively, you can use equations by species for computing stem biomass and/or below-ground tree biomass:

**StemBiomass** (tons) = **F(d,h,WoodDensity,StemVolume)**  
**Biomass\_BG** = **F(Biomass\_AG)**

If you compute results using parameters by species, the program uses the biomass equations if these exist (see more in the next chapter). If species-specific equations do not exist, the program computes biomasses with the help of wood density factor and root/shoot ratio.

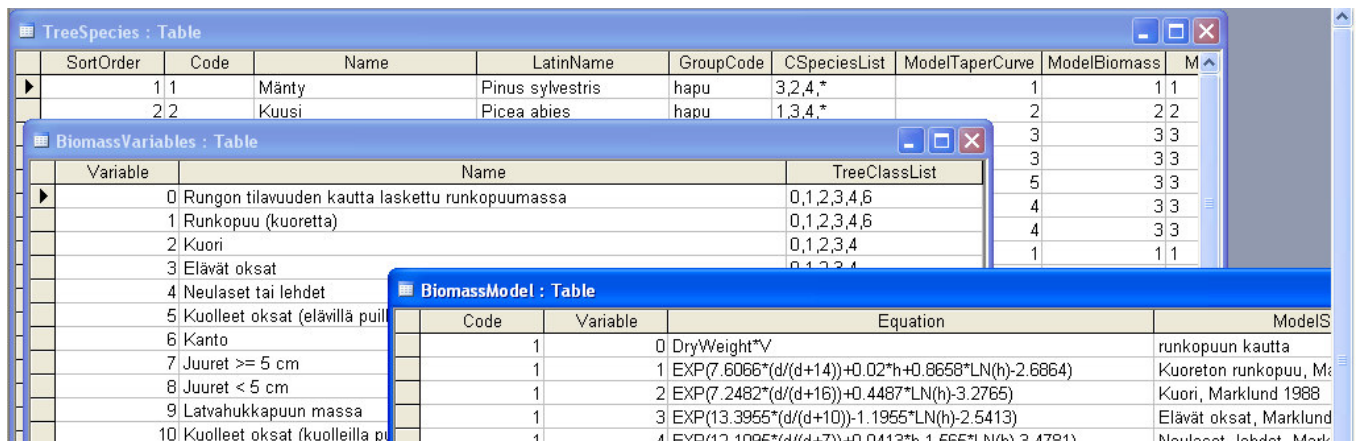
The biomass/carbon calculation by tree class goes as follows:

- live tree (TreeClass codes 0 – 4): stem, AG, BG;
- dead tree (TreeClass = 5): stem, 90% AG, BG;
- stump (TreeClass = 6): stem=0, AG=0, BG;
- branch (TreeClass = 7): stem, AG, BG=0.

**Biomass by tree components**

**ForestCalc Inventory** uses special equation tables for computing biomass components of trees. In the file **TreeparalInventory.mdb**, the biomass variable names are defined in the table **BiomassVariables**, and the equations are given in the table **BiomassModel**. The species are linked into the equations (TreeSpecies.ModelBiomass -> BiomassModel.Code). The 'variable' number refers to the object, so there can be a different model for each tree part (e.g. stem, leaves, needles, living branches, dead branches, roots, etc.).

Biomass calculation can be executed only after a successful computing of inventory results. The biomass results are written into the result database, the table name is **NumTreeBiomass**. The results are written for each tally tree, the unit is per hectare.



**Figure 9.** Biomass models in the parameter database.

The following variables are available when writing the biomass equations (read more about writing rules and variable naming from the **Manual 2**): diameter, total tree height, dry weight factor, 2 user-defined conversion factors by species, total stem volume, log part volume, pulp (pole) part volume and top waste volume.

## 2.14. Results

After computing the results, you can look at the result tables with command *Results*. Results can be shown by strata, species groups, species and tree classes. The results can also be viewed for living trees (*TreeClass* codes 0 – 4), dead trees (*TreeClass* = 5) or branches only (*TreeClass* = 7).

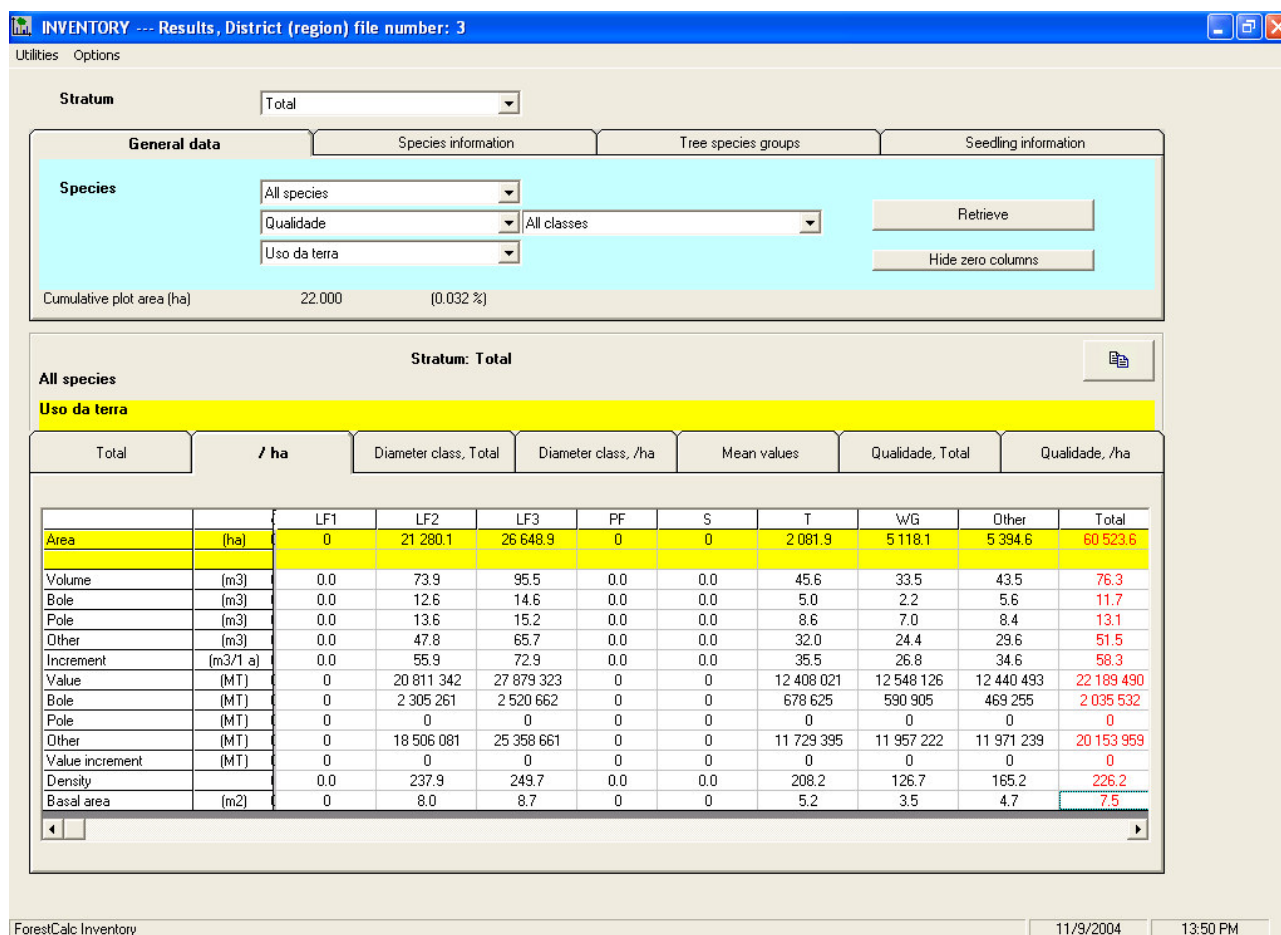


Figure 10. Result window

The **diameter limits** can be changed through the main menu (**Settings**). The lower limit of each diameter class is given at a list and the separator mark is a semicolon.

### An example of user-defined diameter limits

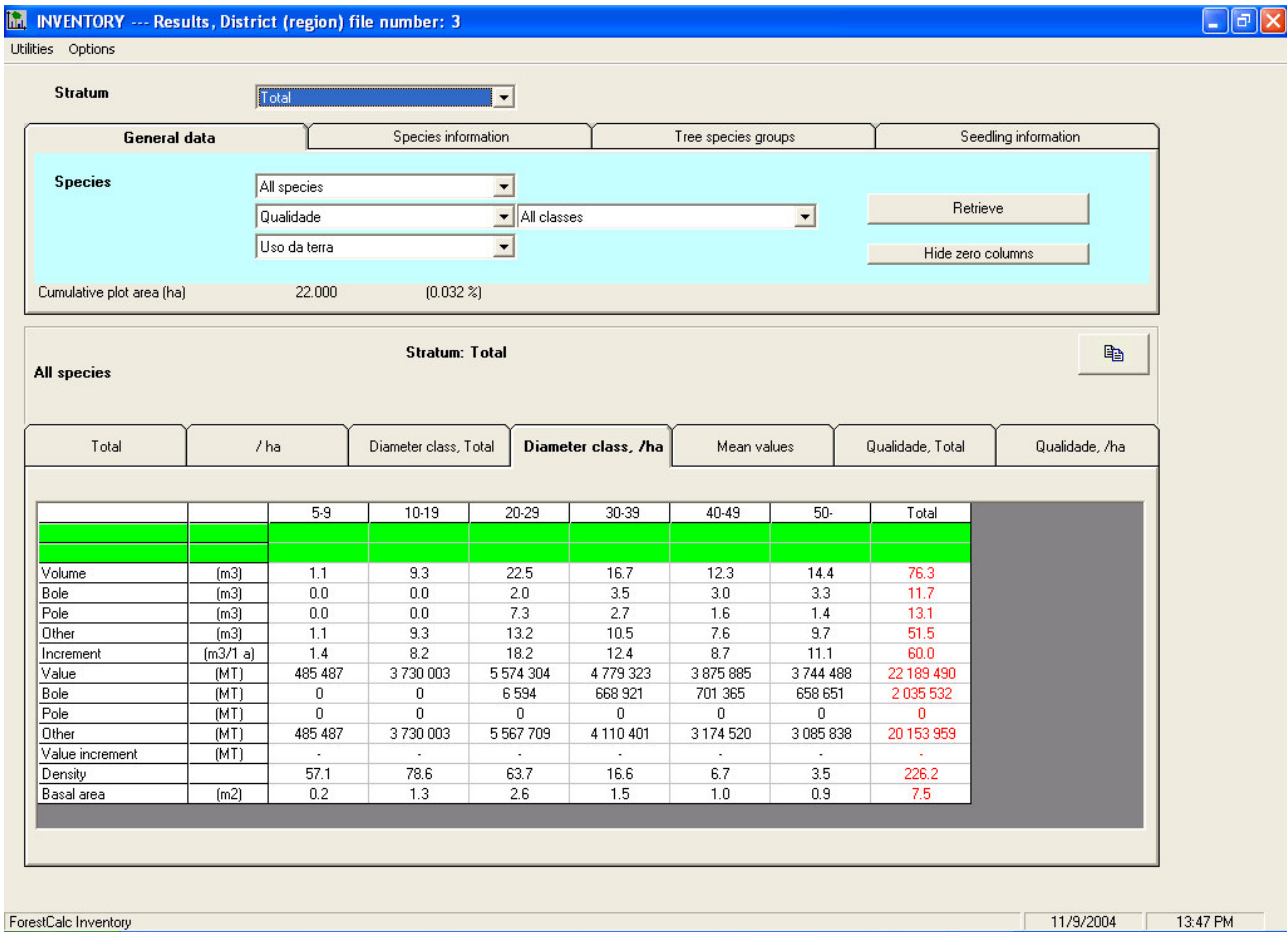
1) if the list is *0;10;20;30;40*

Then the results are shown by diameter classes as follows:  $0 \leq d < 10$ ,  $10 \leq d < 20$ ,  $20 \leq d < 30$ ,  $30 \leq d < 40$ ,  $40 \leq d$

2) if the list is of the form *20;40;50*

Then the results are shown by diameter classes as follows:  $20 \leq d < 40$ ,  $40 \leq d < 50$ ,  $50 \leq d$

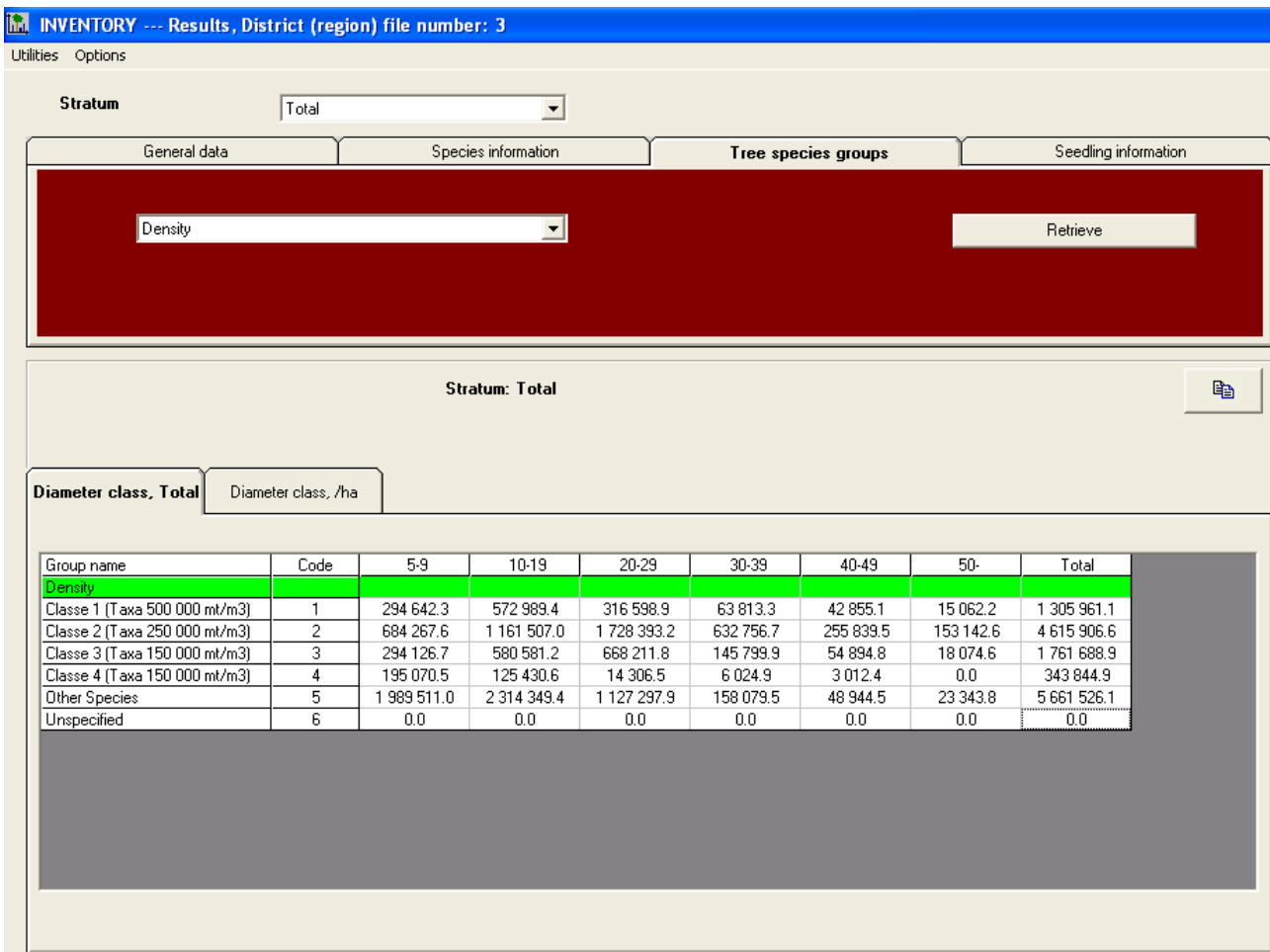
Trees less than 20 cm DBH are not shown.



**Figure 11.** Results by the diameter classes.

You can look at the following results through the program: total timber volume, bole (log) volume, pole (pulp) timber volume, increment (past time), value by timber types, density (trees/hectare), basal area, mean diameter, mean height, biomass (above ground and total) and carbon stock (above ground and total).

**Plot and tree variables** can be changed from the dropdown lists. The aggregated plot variables are read from the parameter file *ForestPara.mdb* (more in Manual II). The result tables can be copied via clipboard to a spreadsheet program, which is a practical tool for creating informative charts to visualize the results.



**Figure 12.** Results by species groups. You can select your variable of interest from the dropdown list.

## 2.15. Calculation of biodiversity indices

A biodiversity index seeks to characterize the diversity of a sample or community by a single number (Magurran 1988). The concept of "species diversity" involves two components: the number of species, or richness, and the distribution of individuals among species, or evenness. Most indices that have been proposed to measure biodiversity try to encompass the two dimensions of the concept: richness and evenness. Many of the differences between indexes lie in the relative weighting that they give to evenness and species richness. With **ForestCalc Inventory**, the following indices can be computed for each sample plot from sample tree data:

1. Species Richness (Species count)
2. Alpha diversity
3. Shannon index
4. McIntosh index
5. Dominance index (= 1 - Simpson Index)
6. Berger-Parker index
7. Evenness
8. Q-Statistic

**Species Richness (S).** The simplest measurement of species diversity is a species count. Simple species counts remain the most popular approach to evaluate species diversity and to compare habitats or species assemblages. While species counts are often an early step in many ecological and community studies, the number of species *per se* provides little insight into the underlying ecological mechanisms that define biodiversity, nor does it encompass evenness.

**Alpha** is calculated by first estimating  $x$  from the iterative solution of

$$\frac{S}{N} = \frac{1-x}{x} (-\ln(1-x))$$

where  $S$  = the number of species in the sample and  $N$  = the number of individuals in the sample, and then calculating Alpha from

$$\alpha = \frac{N(1-x)}{x}$$

**The Shannon or Shannon-Weaver (Weiner) Index** is calculated as

$$H' = - \sum p_i \ln p_i$$

where  $p_i$  is the proportion of individuals in the  $i^{\text{th}}$  species. Shannon's Index measures the average count per individual of samples taken from a population of species.

**The McIntosh index** is calculated as

$$M = (\sum n_i^2)^{0.5}$$

Where  $n_i$  is the number of individuals in the  $i^{\text{th}}$  species in the sample.

**Simpson's (dominance) Index** is calculated as

$$D = \sum \left( \frac{n_i(n_i - 1)}{N(N - 1)} \right)$$

where  $n_i$  is the number of individuals in the  $i^{\text{th}}$  species. Simpson's Index encompasses the richness (total number of species) and evenness (number of individuals per species of a given population). The higher  $D$ , the lower the diversity.

**The Berger-Parker Index** is calculated as

$$d = \frac{N_{\max}}{N}$$

where  $N_{\max}$  = the number of individuals in the most abundant species. Like Simpson's index, higher  $d$  means lower diversity, so the reciprocal is often used.

**Evenness** is a measure of how similar the abundances of different species are. When there are similar proportions of all species then evenness is one, but when the abundances are very dissimilar (some rare

---



and some common species) then the value increases. One type of evenness index is derived from the Shannon-Weaver index:

$$E = H / \ln(S)$$

where  $S$  = number of species in the sample,

$H$  = Shannon-Weaver index.

**Q-Statistic (Q)** is a diversity index presented by Kempton and Taylor (1976). The index is based on the slope of cumulative species curve in the mid-range of abundances.  $Q$  is less sensitive to the commonest species in the sample, than e.g. Simpson's index. Mathematical presentation is as follows:

$$Q = S/2 \ln(R_2/R_1)$$

Where

$S$  = number of species in the sample,

$R_1$  = lower quartile of the species abundance distribution,

$R_2$  = upper quartile of the species abundance distribution.

---

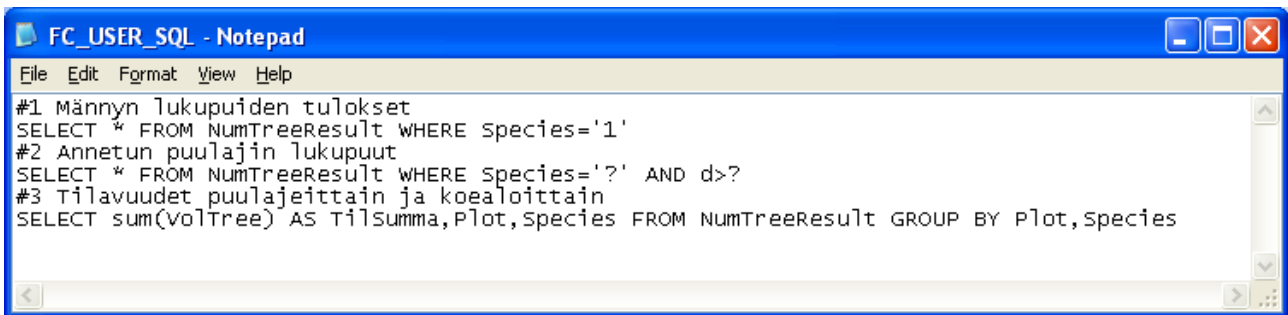
## 2.16. User-defined SQL Queries

User-defined SQL Queries can be written into the file FC\_USER\_SQL.TXT and then used through the program. FC\_USER\_SQL is a text file which can be edited with a text editor. Maximum of 10 SQL queries can be set. There syntax is as follows:

**#number Query\_Title**

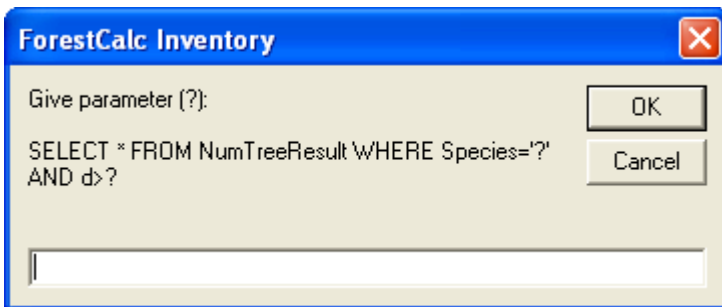
Notice! There must be the space mark between **number** and **Query\_Title**

A SQL query can retrieve data only from the result database.

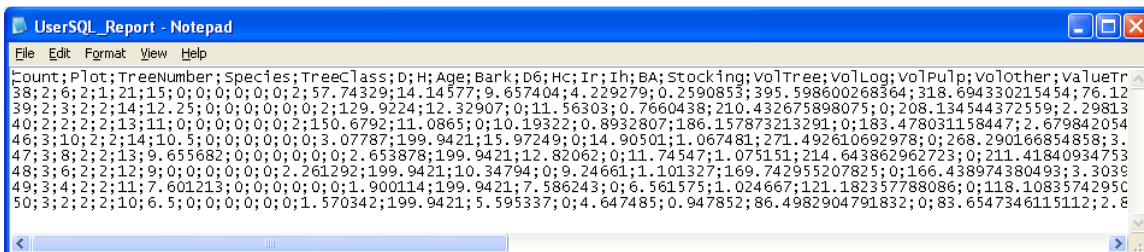


```
FC_USER_SQL - Notepad
File Edit Format View Help
#1 Männyn lukupuiden tulokset
SELECT * FROM NumTreeResult WHERE species='1'
#2 Annetun puulajin lukupuut
SELECT * FROM NumTreeResult WHERE species='?' AND d>?
#3 Tilavuudet puulajeittain ja koealoittain
SELECT sum(volTree) AS Tilsumma,Plot,Species FROM NumTreeResult GROUP BY Plot,Species
```

If there is a question mark in the sentence, then the program halts and there pops up an input box asking the value of the parameter. This will be repeated as many times as there a question mark.



Result of a query is written into a text file and opened in NotePad. The separator mark is semicolon. This data is easy to copy via the clipboard into a spreadsheet program for further analysis (Ctrl+A, Ctrl+C).

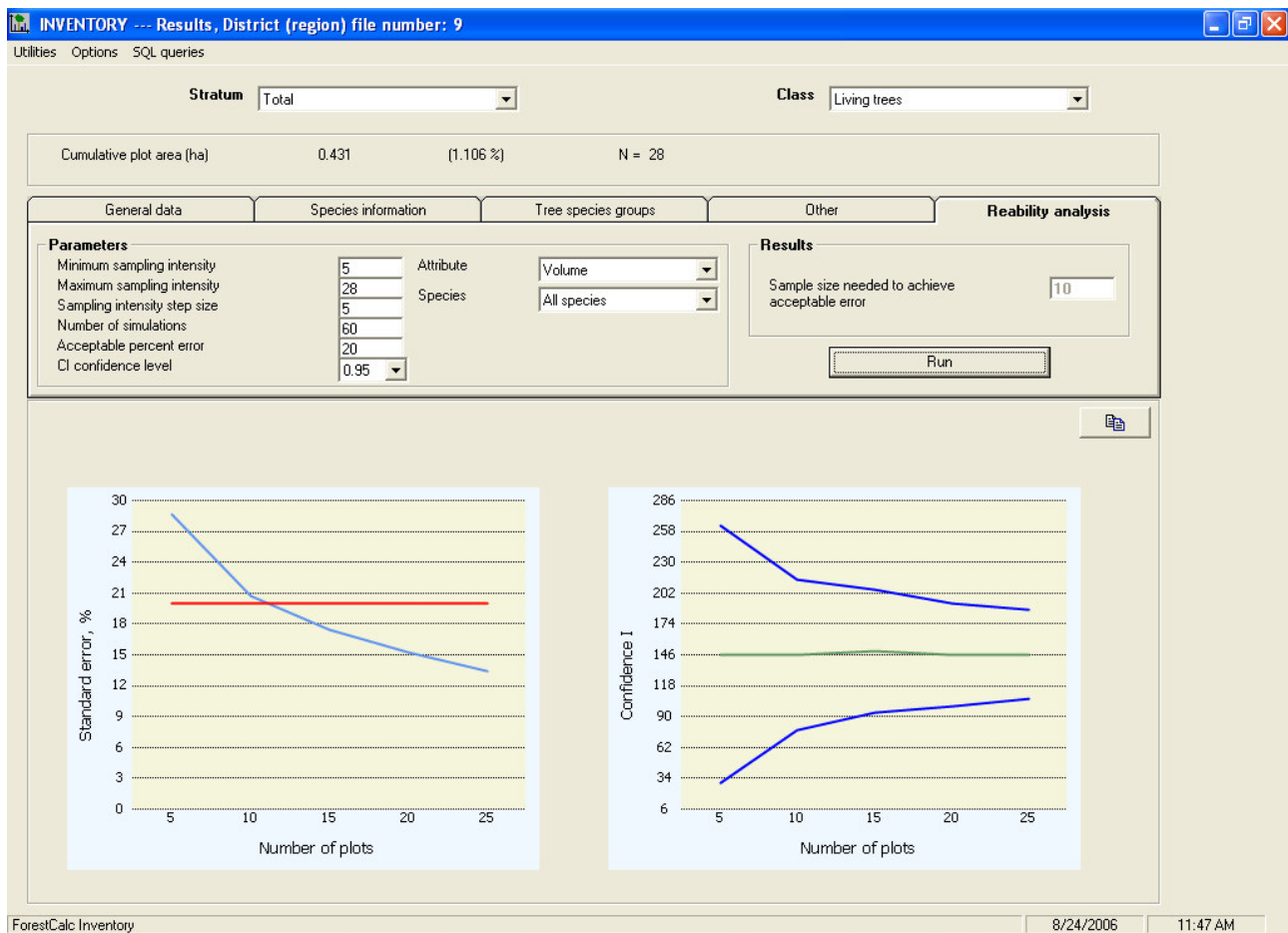


```
UserSQL_Report - Notepad
File Edit Format View Help
Count;Plot;TreeNumber;Species;TreeClass;D;H;Age;Bark;D6;Hc;Ir;Ih;BA;Stocking;volTree;volLog;volPulp;volOther;valueTr
38;2;6;2;1;21;15;0;0;0;0;0;0;2;57.74329;14.14577;9.657404;4.229279;0.2590853;395.598600268364;318.694330215454;76.12
39;2;3;2;2;14;12.25;0;0;0;0;0;0;2;129.9224;12.32907;0;11.56303;0.7660438;210.432675898075;0;208.134544372559;2.29813
40;2;2;2;2;13;11;0;0;0;0;0;0;2;150.6792;11.0865;0;10.19322;0.8932807;186.157873213291;0;183.478031158447;2.679842054
46;3;10;2;2;14;10.5;0;0;0;0;0;0;3;07787;199.9421;15.97249;0;14.90501;1.067481;271.492610692978;0;268.290166854858;3.
47;3;8;2;2;13;9.655682;0;0;0;0;0;0;2.653878;199.9421;12.82062;0;11.74547;1.075151;214.643862962723;0;211.41840934753
48;3;6;2;2;12;9;0;0;0;0;0;0;2.261292;199.9421;10.34794;0;9.24661;1.101327;169.742955207825;0;166.438974380493;3.3039
49;3;4;2;2;11;7.601213;0;0;0;0;0;0;1.900114;199.9421;7.586243;0;6.561575;1.024667;121.182357788086;0;118.1083574295C
50;3;2;2;2;10;6.5;0;0;0;0;0;0;1.570342;199.9421;5.595337;0;4.647485;0.947852;86.4982904791832;0;83.6547346115112;2.8
```

## 2.17. Reliability analysis

**ForestCalc Inventory** contains a reliability analysis tool and it can substitute some external programs, such as PLOT-GEM (see the next chapter). This practical tool can be used to determine the sample size set to achieve a desired accuracy for the selected estimate of a mean in a stratum or at the total inventory area. The program uses bootstrap technique in the processing.

The following estimates can be selected for the criteria of analysis: volume (m<sup>3</sup>/ha), density (trees/ha), basal area (m<sup>2</sup>/ha), biomass (tons/ha) or carbon stock (tons/ha). There are three options estimating confidence interval limits: 90%, 95% and 99%. The analysis can be executed for living trees only or for all trees at a time (living+dead). It can be also done for a certain tree species.



**Figure 13.** Reliability analysis.

## 2.18. Two Phase Sampling analysis

Assume a linear regression,  $y=a + bx$  ( $y$  refers to 2<sup>nd</sup> phase field plot data,  $x$  to 1<sup>st</sup> phase Remote Sensing data). Based on existing forest inventory data, the program can compute the optimum number to second-phase sampling units for strata (when  $r^2$  runs from 0.2 to 0.9) for a given accuracy level for total timber volume per hectare, applying formula by Cochran (1977). See more explanations in the chapter 2.10. (*Computing of results*). The results are written into a file *2PhaseSampling.txt* as semicolon delimited text. The file is easy to copy/open to MS Excel (Fig. 14).

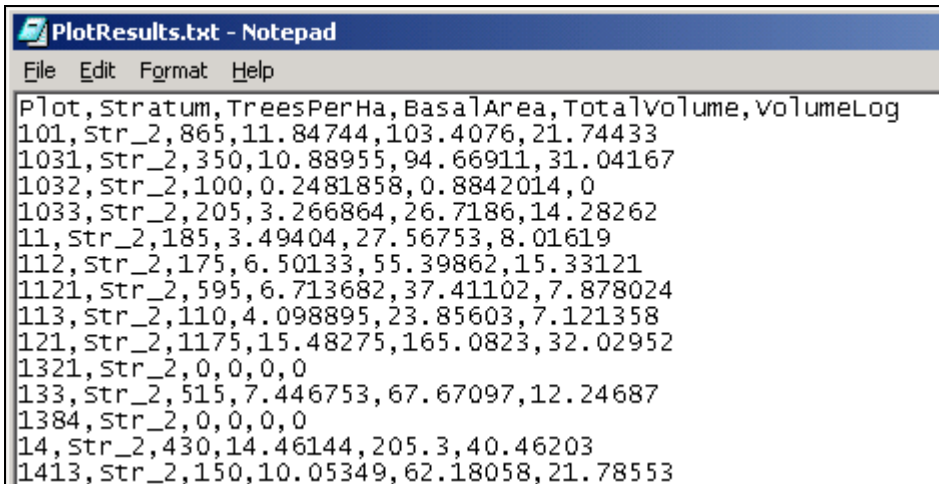
Stratum	N_InvPlots	N of field plots	R2=0.9	R2=0.8	R2=0.7	R2=0.6	R2=0.5	R2=0.4	R2=0.3	R2=0.2
1	9		12	24	36	48	60	72	83	95
2	6		3	6	9	12	15	17	20	23
4	12		2	4	5	7	8	10	11	13
5	20		2	3	4	5	6	7	8	9
6	23		2	4	5	7	9	10	12	14
7	21		2	4	5	7	8	10	11	13
8	19		1	2	3	4	5	6	7	8
9	38		2	4	6	7	9	11	12	14
10	12		2	4	6	8	9	11	13	15
11	19		3	6	8	11	13	16	18	21
12	25		2	4	5	7	8	10	11	13
13	3		1	2	3	3	4	5	6	6
14	10		2	4	5	7	8	10	11	13
15	13		2	3	4	5	6	7	8	9
16	13		2	4	5	7	8	10	11	13
17	22		2	4	5	7	8	10	12	13
18	4		1	2	3	4	5	6	7	8
19	8		4	7	10	13	16	19	22	25
20	11		2	3	4	6	7	8	9	11
21	3		3	6	9	12	15	18	21	24
22	4		1	2	3	4	5	6	7	8
23	5		4	7	11	14	18	21	25	28
Total Area	300		57	109	154	205	250	300	345	396
Acceptable error	10	Percent								

**Figure 14.** Optimum number to second-phase sampling units.

## 2.19. Input file for PLOT-GEM

**PLOT-GEM** is freeware software developed at the US Forest Service, Inventory & Monitoring Institute in Fort Collins, Colorado. **PLOT-GEM** can be used to determine the sample size necessary to achieve a desired accuracy for the estimate of a mean in an individual stratum. **Plot-GEM** generates the percent error using a bootstrap technique. This program and its manual can be downloaded from the Internet.

**ForestCalc Inventory** can write a text file compatible with **PLOT-GEM** data entry structure. First retrieve results to the region of interest. Then run *Utilities, Input file for PLOT-GEM*. The program writes a text file and opens it in Notepad. Each row presents plot result (per hectare basis). In Notepad, select all (Ctrl+A) and copy selection to the clipboard. Paste selection into PLOT-GEM's input form.



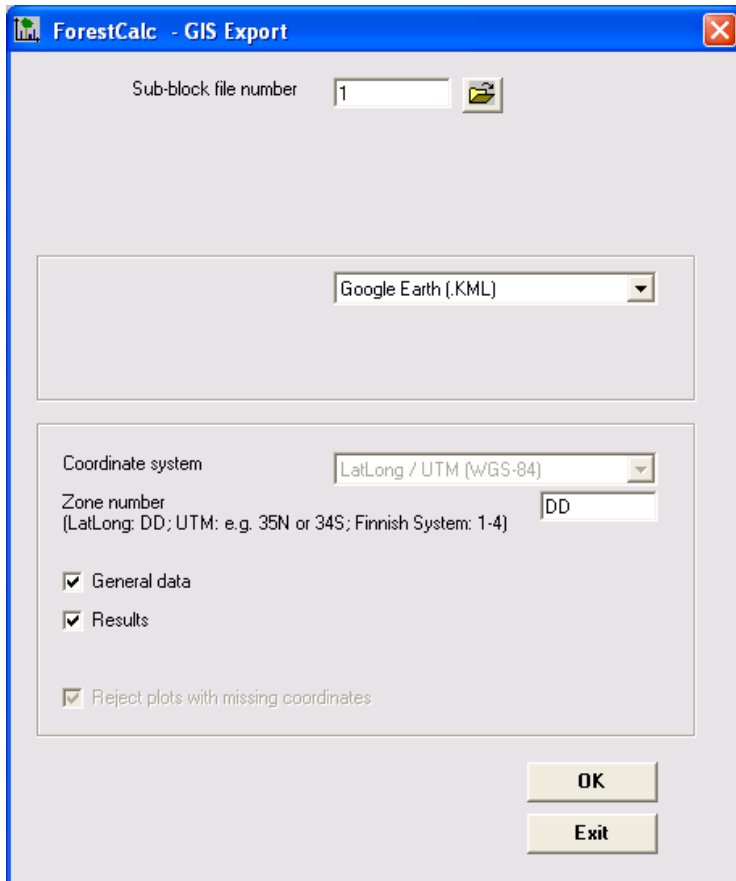
```
PlotResults.txt - Notepad
File Edit Format Help
Plot,Stratum,TreesPerHa,BasalArea,TotalVolume,VolumeLog
101,Str_2,865,11.84744,103.4076,21.74433
1031,Str_2,350,10.88955,94.66911,31.04167
1032,Str_2,100,0.2481858,0.8842014,0
1033,Str_2,205,3.266864,26.7186,14.28262
11,Str_2,185,3.49404,27.56753,8.01619
112,Str_2,175,6.50133,55.39862,15.33121
1121,Str_2,595,6.713682,37.41102,7.878024
113,Str_2,110,4.098895,23.85603,7.121358
121,Str_2,1175,15.48275,165.0823,32.02952
1321,Str_2,0,0,0,0
133,Str_2,515,7.446753,67.67097,12.24687
1384,Str_2,0,0,0,0
14,Str_2,430,14.46144,205.3,40.46203
1413,Str_2,150,10.05349,62.18058,21.78553
```

**Figure 15.** Input data for PLOT-GEM.

At the time of writing this manual, there were some troubles running PLOT-GEM in Windows XP, but no problem with Windows2000.

## 2.20. Inventory plot locations to GIS

All plot coordinates can be exported to GIS by selecting *Utilities, All plot locations to file*. The program opens a new window (Fig. 16).



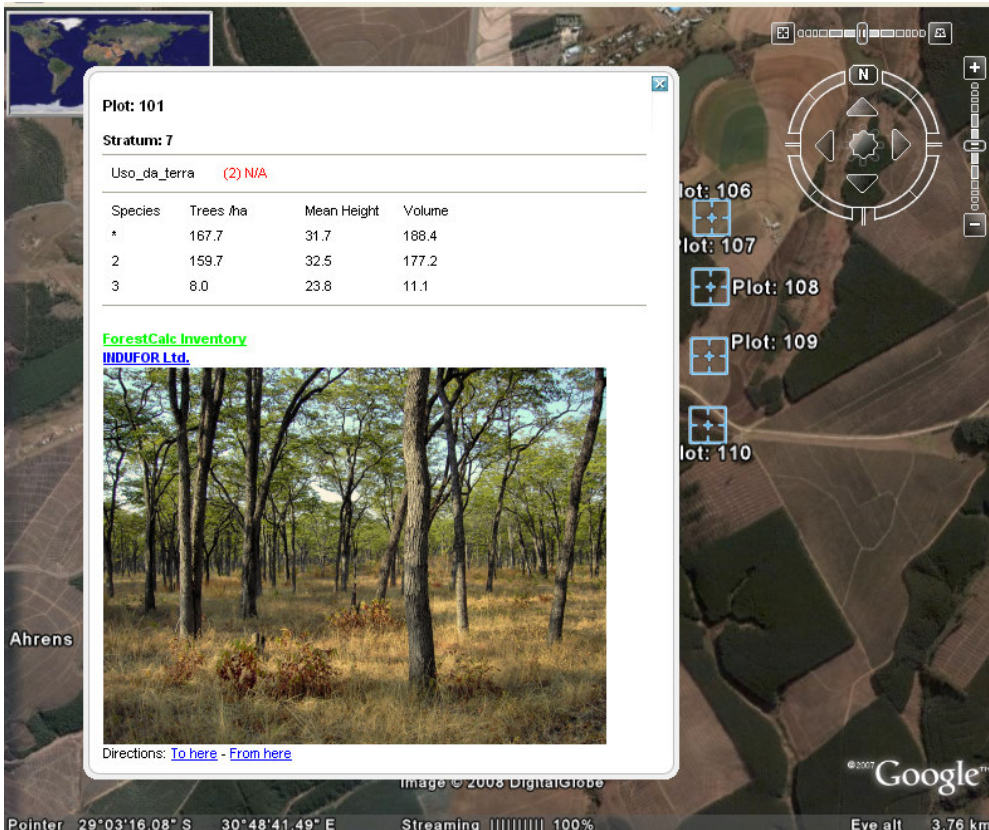
**Figure 16.** GIS export options.

There are three export formats which you can select: MIF/MID, KML and text file. MIF/MID is the interchange format developed by MapInfo® Corporation (Fig. 16). KML was developed to show location data on Google Earth®.

If MIF/MID format output is selected, and if the region number is 100, then the program writes data into files *Area100.mif* and *Area100.mid*, either as point data or as polygon data. The polygon data can show the true plot borders on a map, and MIF/MID can carry coordinate system information too. The input data can be in the UTM (*Universal Transverse Mercator*, with datum WGS-84), in Latitude/Longitude coordinates as decimal degrees (in WGS-84) or in Finnish KKJ-system. If you use the UTM, the program asks the zone number and hemisphere (*S=Southern/N=Northern*). Give it as form of '35N'. An advanced user can modify the MIF-file, if more changes are needed.

Output in KML format creates two output files: one file for point data and another file for polygon data. For region number 100, the name of point file is *Area100\_Points.kml* and for polygon file *Area100\_Polygons.kml*.

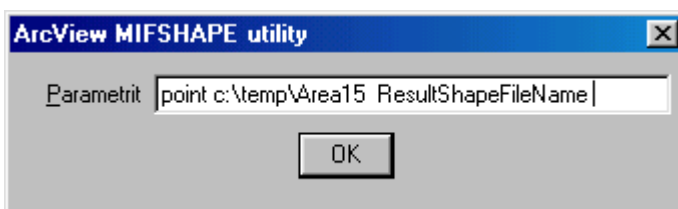
For export in KML format, the user can select whether to embed plot's input data into the point file, or some key results. If an image file exists for a plot, the program writes information about it into the point file too.



**Figure 17.** ForestCalc KML file in Google Earth.

In export in text format, the output file consists of plot location coordinates. Attribute data (General data) contains region number, stratum and plot codes, and the general plot data (such as vegetation type, soil class). The results can be written into a text file either by writing the plot level data into it, or tree level data. The plots without coordinate data (0,0) are not written into the result file.

Mif-format files can be converted to ArcView shape files for instance using ESRI utility program MIFSHAPE (MIF to Shape).



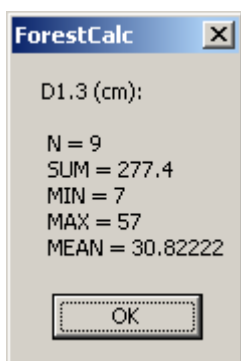
**Figure 18.** Query box in ArcView GIS. Add full path to the input file and to the result file, and no spaces in path names.

## 2.21. Grid data and statistics

The program uses grids (controls) in many part of the program (see e.g. Figure 6). The following keys are valid on these grids:

<F5>	Delete row. Active row is deleted.
<F6>	Add row. A new row is added.
<F7>	Add new blank rows to end of table
<F8>	Add a new row and copy all data from the previous row.
<DELETE>	Delete cell content
<BackSpace>	Delete previous character
<ENTER>	Move cursor into the next cell
Ctrl+C	Copy active cell to the clipboard
Shift+Ins, Ctrl+V	Paste

The user can get statistics from any grid column where there are input data. First, activate the grid (click cursor into it), and then press right mouse button upon the selected column header. If the selected column includes text (characters) in any cell, then the programs computes only the number of cases (**N**).



**Figure 19.** Statistics on selected column.

All grid data can be copied to the clipboard using command *Utilities, Copy table*. This function is practical tool when the grid data needs to be processed for example in MS Excel. The program copies the active (visible) grid to the clipboard.

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### 3. Timber table

All timber dimensions and prices are stored into the parameter file **TreeparalInventory.mdb**, table *TimberTable*. This table can be edited in **ForestCalc Inventory**: click *Settings, Dimensions and prices*.

Source	Name	Type	Species	MinUpperD	MinLenght	MaxLenght	Division	Value	Value/Tree	Rules
Zambia prices	Bole, CLASS 1	1	14,152,171,	10	1	10	1	10800	10800	
Zambia prices	Bole, CLASS 1	1	26,235,236,	10	1	10	1	18000	18000	
Zambia prices	Bole, CLASS 1	1	15,16,17,18	10	1	10	1	1000	9000	
Zambia prices	Bole, CLASS 1	1	112,113,114	10	1	10	1	1000	14400	
Zambia prices	Bole, CLASS 1	1	117,118	10	1	10	1	1000	12240	
Zambia prices	Bole, CLASS 1	1	131,132,133	10	1	10	1	1000	15840	
Zambia prices	Bole, CLASS 2	1	22,42,59,61	10	1	10	1	1000	7200	
Zambia prices	Bole, CLASS 3	1	1,2,4,5,6,8,1	10	1	10	1	1000	7200	
Zambia prices	Bole, CLASS 3 cont.	1	118,129,162	10	1	10	1	1000	7200	
Zambia prices	Bole, CLASS 3 cont.	1	278,281,288	10	1	10	1	1000	7200	
Zambia prices	Bole other species	1	*	10	1	10	1	1000	7200	
Zambia prices	Pole, 25-30	2	*	10	1	10	1	0	900	AND(d>=25,d<30
Zambia prices	Pole, 20-25	2	*	10	1	10	1	0	540	AND(d>=20,d<25
Zambia prices	Pole, 15-20	2	*	10	1	10	1	0	360	AND(d>=15,d<20

**Figure 20.** Timber table.

Data shown with yellow header are required, however field 'Name' is useful fill in too. Timber prices are in the column **Value**, and **the price is given per cubic meter in the local currency unit**. The value of one single stem – if applicable - is given in the field **Value/Tree** (*in use in Zambia*).

The table includes minimum upper diameters that are used only with taper curves, not with volume equations. However, fill also these fields using some default values.

The user can give different unit prices e.g. by organizations, companies or geographical areas (*Source*). The maximum number of different groups (~field "Source") is ten.

### Rules for filling this table

Fill first all data for group 1 so that group's name is written similarly on each row. Give prices of logs/boles (*Type* = 1), then pulp/pole wood prices (*Type* = 2), if applicable. Last, give your price for the other use wood (such as firewood) (*Type* = 0).

If applicable, next fill in data for price group 2, following the rule above.

The same prices (and dimensions) can be given at a time for more than one species: fill in field *Species* as a list of species codes, where the separator mark is a comma (,). Dimensions and prices can also be given by species groups: write first a hash (#) following the species group code, as follows: **#1,#2** (= species groups one and two). Check your species grouping in the parameter file **TreeparalInventory** (TreeSpecies.GroupCode -> TreeSpeciesGroups.Code).

When computing the results, **ForestCalc Inventory** uses the timber table as follows:

The lookup is always executed top to down.

- 1) Check 'Group name' -> If TRUE, stop; otherwise move down
- 2) Check timber type (1=log/bole, 2=pole, 0=other) -> If TRUE, stop; otherwise move down
- 3) Check species code -> If TRUE, stop; otherwise move down
- 4) Check diameter from the rule list -> If TRUE, stop; otherwise move down

If there is no match for certain timber type or species, then that tree part cannot get any monetary value.

### Bucking (valid with taper curves)

The log (bole) dimensions can be given by species or/and by species groups: fill in the minimum upper diameter (over bark), minimum and maximum length and the cutting interval in bucking (*Division*). If interval value is zero, the program uses interval of 0.3 meters. Dimensions for pulpwood can be given in a similar way: fill in the minimum upper diameter (over bark). Pulp log minimum length is always 2 meters in the program. The dimension's for "other use" (class=0) are not used anyway, but the priced of timber is used.

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## 4. About application

### Copyright and liability

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### Background

The program is coded using Visual Basic<sup>TM</sup> Pro 6.0 and Service Pack 6. Database structure is created using MS Access2000<sup>TM</sup>. The program uses freeware RMCHART graphic control for showing results of the reliability analysis. All texts in the program are written into a text file (which is linked into the EXE-file), so that the program can be modified and translated into any new language. At the moment, there are ready versions in English, Finnish, German, Swedish, Bahasa Indonesia, Spanish and Portuguese. *MS Visual Studio Installer* and *Orca* are used to create deployment packages.

The development of the program initiated in October 1997 and ForestCalc 1.0 was released in August 1998. The original **ForestCalc** consisted of the following modules: *Timber analysis, Single tree volume, Tree group volume, Sample plot, Compartment calculation* and (until version 3.x) *Forest inventory*.

The application solely dedicated for forest inventories, **ForestCalc Inventory**, was launched after a consultancy mission to Central Kalimantan (Indonesia), in August 2003. Several experts and users all over Europe, Asia and Africa have given me ideas how to develop this program. Thanks for all!

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All inquiries, comments and feedback regarding **ForestCalc Inventory** are welcome to:

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