REPORT ON VALERI ESTONIAN CAMPAIGN

2003

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1. Location and description of the test area

This Valeri test site is located in the forest of Järvselja, in the eastern part of Estonia. It corresponds to a 10 km x 10 km square, centered at the geographical coordinates 58°15'N - 27°28'E, corresponding more or less to the POLDER pixel in this area. The location of the test site is shown in the following maps (figure 1). At the south-east and north-east extremities, some bogs and mires (peatland) are found. The whole "pixel" is thus rather heterogeneous at first sight.

In 2003, as in 2001 and 2002, a 3x3 km sub-area inside the 10x10 km region was chosen for the LAI-campaign. This area is mostly covered by a sub-boreal mixed forest of different age, including both conifers (Scots pine and Norway spruce) and deciduous (birch, aspen, alder). Agricultural fields are almost missing on the 3x3km region, however, a few unmanaged open areas are found.

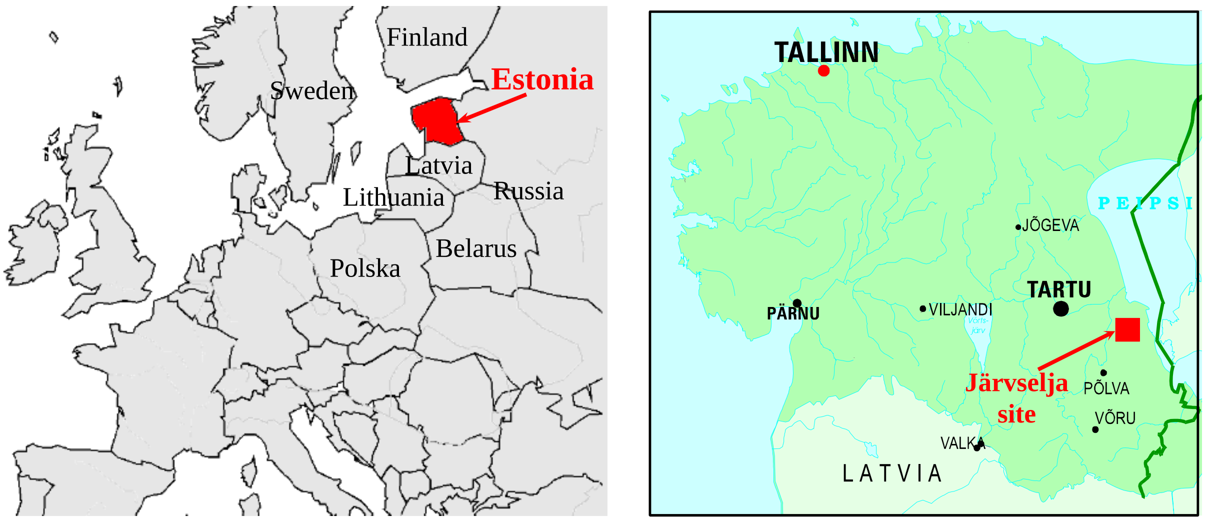

Figure 1: Localisation of the Järvselja Estonian site

2. Sampling protocol and measurement plots selection.

According to the forest management system in Estonia, the region is divided into more or less homogeneous forest parcels – stands. In 2003, many of the measured plots were essentially the same as measured in 2001 and 2002. So, for these stands there is a possibility to estimate possible changes of gap fraction from year to year and get an idea about the measurement uncertainty. In 2003, altogether 36 sample plots were chosen for ground measurements. In addition, measurements were conducted on a cross-shaped regular grid that was marked in 2002. Here, only the sample plots located sufficiently far from stand borders were chosen. This way, additional 22 sample plots were measured.

As a rule, the centre of a plot (CP) to carry out LAI-2000 measurements and to take the hemispheric photos was selected at least 50m from the stand border(s) in a homogeneous area and marked by yellow tape on the nearest tree. The CP was located by a GPS measurement. The GPS-coordinates of the CPs of measured stands are given in the ‘sum03.xls’ file. These data are given in LAMBERT-EST projection (Lambert Conformal Conic 2 parallel) described in table 1.

Table 1: Description of Lambert-Est-92 projection characteristics.

Datum	ETRS-89(GRS-80)
1st Standard Parallel	58°00’N
2nd Standard Parallel	59°20’N
Central Meridian	24°00’00’’E
Coordinates of Origin	57°31’03.19415’’N , 24°00’E
False northing	6375 000 m
False easting	500 000 m

Two series of measurements were conducted, a ‘midsummer’ series with full green leaves, and a ‘winter’ series, where the deciduous trees were leafless. In fact, the midsummer series was performed in two parts: one from 7 to 11 July 2003, and another from 12 to 13 August 2003. The winter series was carried out from 8 to 11 November 2003.

During the summer series, altogether 58 plots were measured while during the winter series - 25 plots.

3. Protocol of measurement on a plot

The same LAI measurement protocol has been kept for each forest plot and it was the same as in 2002. Measurements were made at 4m, 8m and 12m distances from the centre of the plot (CP) in each geographic direction, in the fixed sequence N-S-E-W. At each point, 4 records were made. In total, on a sample plot 3x4x4 = 48 LAI-2000 readings were taken.

One record consisted of a measurement below the ground vegetation (at the ground level) plus one at the breast-height level (1.3 m). So, on each plot 48 readings were taken at the ground level and 48 at the breast-height level. The sensor was partly screened with the 180° mask to avoid the influence of the operator, and was always oriented with the sun in the back of the operator.

The reference measurements (above canopy) were acquired in an automatic procedure (each 30s) by a LAImeter displayed in an open area close to the measured plots. The reference sensor in the open was oriented away from the sun direction, and was also operated with the180° mask. The LAImeters were regularly intercalibrated (4-6 times a day) in an open place, and the calibration coefficients were taken into account when calculating the gap fractions.

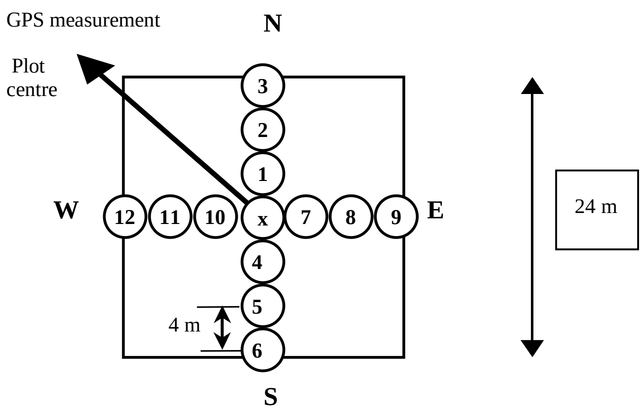

Figure 2: Schematic representation of plot measurement protocol

A part of measurements was conducted on the sample plots corresponding to some of the plots from so-called ‘large cross’ of year 2001. The centre of the 3x3 km region served as the centre of the cross. Measurement points located at each 50m, i.e. at 50m, 100m, 150m, 200m, 250m, 300m, 350m, 400m, 450m and 500m from the centre to N, S, E, and W directions. The previously marked plots were found and the measurements performed on the same plots. No new GPS coordinates were measured in 2003. This year the measurement protocol at the points of the large cross were exactly the same as of the other sample plots, i.e. 48 measurements according to the scheme on Fig. 2 were taken at the ground level and 48 at the breast height level.

Each stand has a code number according to the forestry database. The code number consists of two parts: large compartment number and smaller parcel number. Such as number 225_05 means that the large compartment number is 225 and stand number 5. With these numbers, the stands can be uniquely identified, and the forestry data extracted from the respective forestry database. Also, stand borders as digital vector files can be identified with the similar number (e.g. 22505) and the respective borderlines superimposed on georeferenced raster images (see Fig. 3). However, in 2001 new forestry measurements were made, new stand border vectors created and borderline vector file numbering was introduced. There is not much change in the borderlines compared with the previous borders, but differences in some details do exist. In the summary data file, for all stand measured, the stand IDs according to the old and new (2001) numeration are given.

Location of the sample plots for the measurements during the summer campaign can also be seen on the SPOT image of the region (see Fig. 3).

In addition to the LAI-2000 measurements, digital hemispheric photos of the upper and lower hemispheres were taken at 3x4 =12 points on each sample plot by the Nikon Coolpix 4500 digital camera, supplied with the Nikon FC-E8 Fisheye Converter lens.
To document the site and give an impression about the stand and ground vegetation together, on each plot a hemispheric photo and a photo with the standard lens were taken in the horizontal direction. The latter photos are included into the ‘Image gallery’ of the LAI campaign in 2003.

Fig. 3. A false-color SPOT4 (xs2, xs3, xs4) image (26 June 2003) of the test site in Järvselja, together with the superimposed stand borders and locations of LAI measurement sample plots in 2003. The 3x3 km test site is inside the black square. A part of the sample plots from the 'large cross' of plots established in 2001 were also used as additional sample plots in 2003. Coniferous forests appear in dark, deciduous forests in green tones, recent clear cuts and open areas in pink and yellowish.

4. Results of LAI-2000 measurements and simulation

The file 'LAI03_1.xls' gives the Excel version of Nilson's algorithm. Each sample plot is analysed on a separate spreadsheet page. Winter measurements are inverted on the same sheet as summer measurements.

The summary data on the stands, on the results of LAI-2000 measurements are of processing the data are given in the file ‘sum03.xls’. In this file, the following information is given:
Stand id, plot centre coordinates (Lambert Est-92) x and y, stand data from forest mensuration carried out in 2001 [age, site index (0 best, 1 very good,…,5 poor) , site type (see the sheet codes_ground_vgt), breast-height diameter (DBH, cm), tree height (m), basal area (m^2/ha), volume (m^3/ha), species composition of the 1st tree layer (in tenths), comments, and information about recent thinning].

The next columns refer to the LAI-2000 measurements and the results of processing the data in summer conditions. First are given the columns with the measured by LAI-2000 gap fraction data for the 5 angular rings, measured at the breast height (1.3 m) and averaged over all 48 readings taken on the plot. The quantity ‘kappa*LAI+BAI’ refers to the effective foliage area index. The canopy leaf area index (LAI_canopy) is derived from the gap fraction data by the Nilson’s (1999) algorithm (column ‘inverted’). In the next column the tree layer LAI as derived from forest inventory data (‘database’) is given, followed by the columns of ‘BAI_inverted’ and ‘BAI_database’, i.e. the estimates of the canopy branch area index from the LAI-2000 measurements and from the forestry database, respectively. In the next 5 columns, the LAI-2000 data for the ground-level measurements are given. The next 5 columns represent the gap fraction in the ground vegetation layer alone, i.e. obtained by dividing the gap fractions at the ground level to those at the breast-height level. LAI_ground is derived from the latter gap fractions by using the standard LAI-2000 algorithm. Finally, LAI_total is calculated as the sum of LAI_canopy and LAI_ground.

Quite similarly, the results of LAI-2000 measurements are presented in the file ‘sum03.xls’ for the winter campaign in the columns starting from column BB onward. Similarly, first are given the LAI-2000 gap fractions for the breast-height level, followed by the estimate of tree layer needle area indices as determined from the forestry database. The next columns represent the branch area indices derived by means of inversion of winter-time gap fraction measurements, and that of derived from the database.

In winter conditions, the readings of the LAI-2000 from the breast height are influenced by the presence of coniferous needles and of the branches and trunks of deciduous trees.

We have also recalculated the LAI estimates for the sample plots from the results of summertime LAI-2000 measurements carried out in 2001 and 2002. In all calculations, the stand data used in the algorithm are now the same and correspond to the stand measurements from 2001. The results have been summarised in the file ‘summary.xls’. One sheet ‘time series’ presents the sequential results of LAI measurements over the period from 2001 (2000) to 2003.

The average LAI of the tree storey and ground vegetation averaged over all measured plots and obtained from the LAI-2000 measurements in summer conditions are summarized in Tables 2, 3 and 4, that of winter conditions in Table 5. Note that the selection of stands for measurements in different years has been somewhat different. A comparison of the branch area index estimates for summer and winter campaigns 2003 are given in Table 6.

Table 2. Summary data of the results of ground measurements and simulation of LAI from the 2001 summer campaign

	LAI tree storey		LAI ground vegetation	LAI total
	LAI-2000, Nilson's algorithm	Forestry database	LAI-2000	LAI-2000
average over sample plots	3.70	3.95	0.70	4.40
average over large cross plots	2.95	3.60	0.95	3.90
average over all plots	3.24	3.71	0.84	4.12

Table 3. Summary data of the results of ground measurements and simulation of LAI from the 2002 summer campaign

	LAI tree storey		LAI ground vegetation	LAI total
	LAI-2000, Nilson's algorithm	Forestry database	LAI-2000	LAI-2000
average over sample plots	3.76	3.47	0.89	4.65
average over large cross plots	3.32	3.64	0.84	4.16
average over all plots	3.54	3.56	0.86	4.40

Table 4. Summary data of the results of ground measurements and simulation of LAI from the 2003 summer campaign

	LAI tree storey		LAI ground vegetation	LAI total
	LAI-2000, Nilson's algorithm	Forestry database	LAI-2000	LAI-2000
average over sample plots	3.57	3.67	0.80	4.37
average over large cross plots	3.71	3.34	0.81	4.52
average over all plots	3.62	3.54	0.80	4.43

Table 5. Summary data of the results of ground measurements and simulation of the tree-layer needle area index (NAI), branch area index (BAI) and ground-layer vegetation leaf area index (LAI) from the 2003 winter campaign

	LAI & BAI, tree storey		LAI ground vegetation	LAI total
	BAI, Nilson's algorithm, from LAI-2000	NAI, Forestry database	LAI-2000	LAI-2000

average over sample plots	0.29	1.57	0.32	1.89
average over large cross plots	0.68	1.17	0.24	1.41
average over all plots	0.41	1.45	0.29	1.75

Table 6. Comparison of branch area index (BAI) estimates from the LAI-2000 measurements of the summer and winter campaigns and estimated from the database

	BAI, tree storey		
	BAI, Nilson's algorithm, from summer LAI-2000	**BAI, Nilson's algorithm, from winter LAI-2000**	**BAI, Forestry database summer/winter**
average over sample plots	0.42	0.29	0.42/0.39
average over large cross plots	0.45	0.68	0.41/0.38
average over all plots	0.43	0.41	0.42/0.39

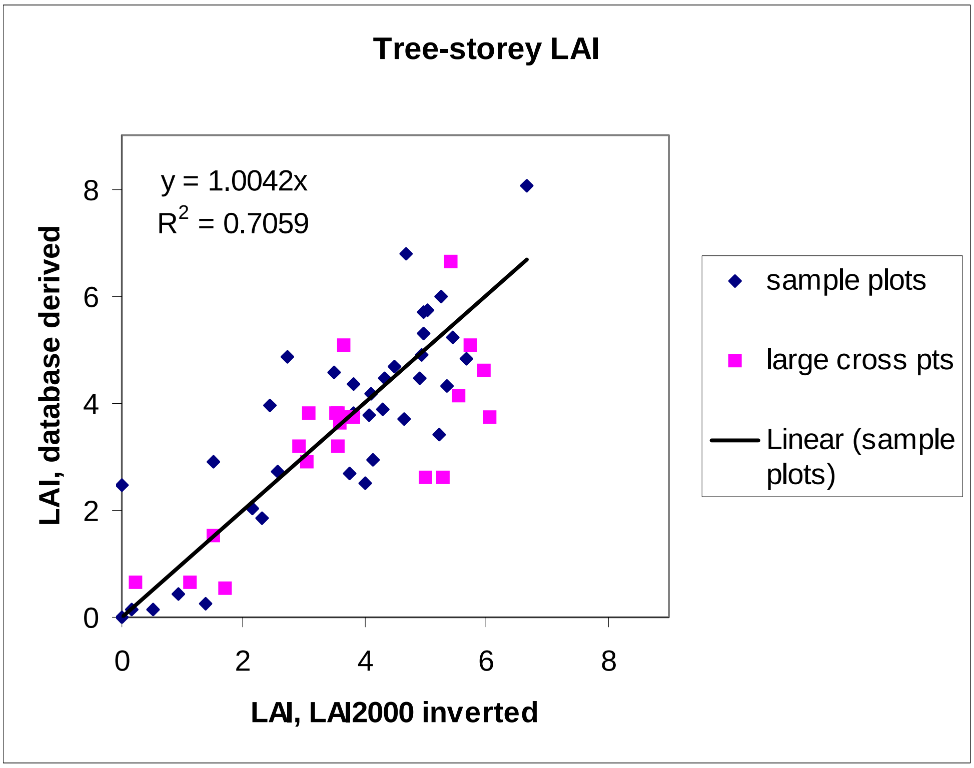

Fig. 4. Relation between the tree-storey LAI determined from the LAI-2000 breast height measurements and derived from the data containing in the forestry database for the main sample plots. Data from summer 2003.

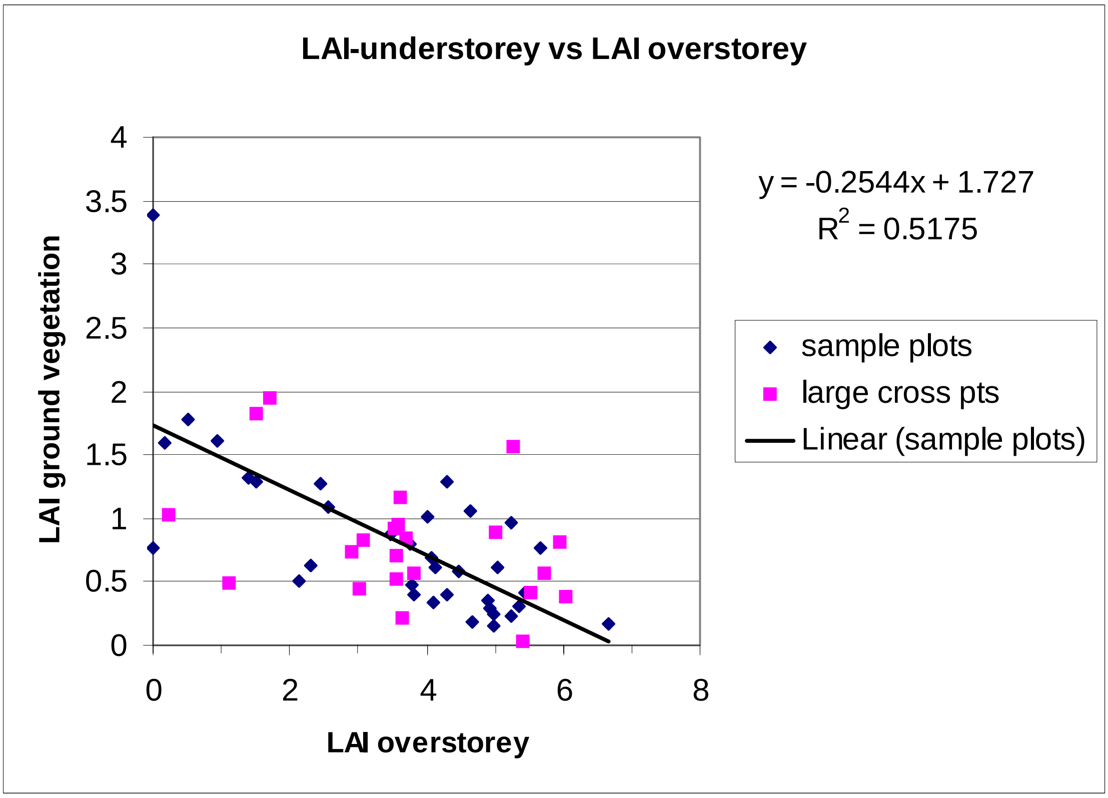

Fig. 5. The relation between the tree layer and ground layer LAI as determined from the LAI-2000 measurements on the main sample plots.

An image of LAI was created with the data containing in the forestry database of year 2001 over the study area (Fig. 6). The LAI-image is given for the 3x3 km region with some buffer area around it. For each stand, first an estimate of the leaf area per tree (m^2) was created by using the species-specific regression equations of the leaf (needle) mass (kg) of trees against the tree height and breast-height-diameter, and by converting the leaf mass to area by a species-specific values of LWA (leaf weight per area, m^2/kg). Then the leaf area per tree was multiplied by the stem number (m^{-2}), and summed over all species according to the documented species composition. If applicable, the procedure was used for the 1st and 2nd tree storey separately and then summed. In fact the procedure was the same as applied in the file 'LAI03_1.xls' to form the initial guess of the tree layer LAI.

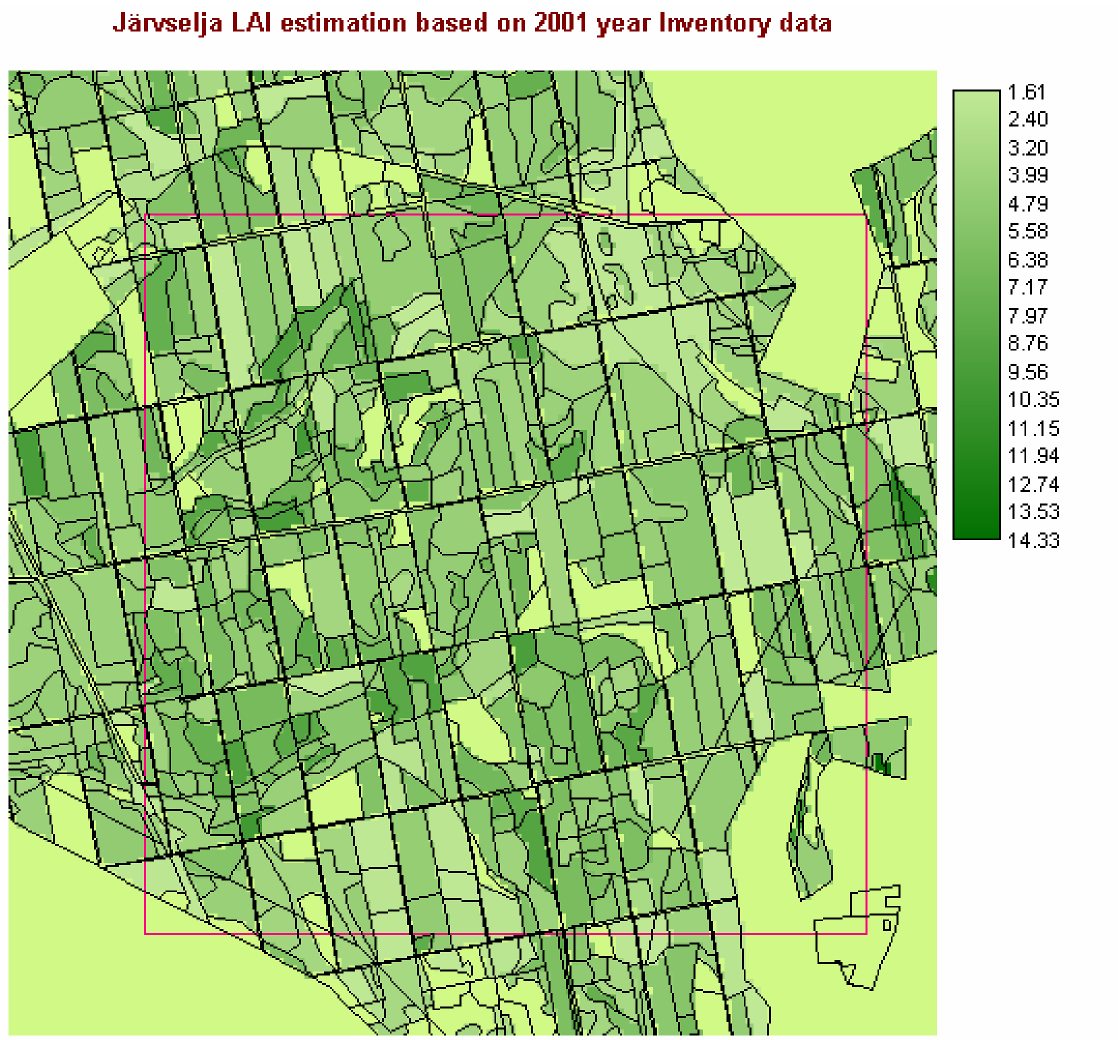

Fig. 6. The image of total LAI (tree storey + ground vegetation) as derived from the data containing in the forestry database. The 3x3 km study region is inside the red square.

To obtain the total LAI with the ground layer vegetation contribution included, the following procedure was applied. It is assumed the overstorey and understorey LAIs are related to each other. A linear regression was derived between the tree-storey and ground vegetation LAIs from the measurements on the sample plots (Fig. 7). This means that in open areas (which are mainly the recent clear cuts, and the ground vegetation has not been recovered in full), the average ground vegetation LAI is approximately 1.6, while the ground vegetation is practically absent when the tree storey LAI reaches the value LAI_tree~7.8. The latter happens typically in dense spruce-dominated forests.

By summing the contributions of the tree-storey LAI and ground vegetation LAI, the total LAI was obtained, and the respective number was assigned to each stand in the region. In cases when no stand information was available (a few meadows or private forest land not surveyed), the tree-layer LAI was supposed to be 0.

With this method, the average LAI value for the 3x3 km region is 4.12 and the standard deviation 1.95. The LAI-image (Fig. 6) gives us the idea of expected variation of the LAI over the study area and gives a possibility to derive a LAI variogram over the region caused by between-stand variation in the LAI.

Problems seem to be with the systematic overestimation of gap fraction at the lowest rings of the LAI-2000 instrument. Most probably this is due to the contribution of scattered radiation by trunks and crowns. Especially, when the measurements are made in the presence of sunshine and with some tree species with rather bright trunks, such as birch.