REPORT ON VALERI ESTONIAN CAMPAIGN

3-8 JULY, 2000

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A] Localisation and description of the test area

This Valeri test site is located in the so-called forest of Järvselja, in the eastern par 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).

This area is mostly covered by a boreal mixed forest, including both conifers (different kinds of pines and spruces) and deciduous (birch, aspen, alder). Some agricultural fields and unmanaged open areas are also found. At the south-east and north-east extremities, some bogs and mires (peatland) are taking place. The whole "pixel" is thus very heterogeneous at first sight.

Figure 1: Localisation of the Järvselja Estonian site

B] Sampling protocol and measurement plots selection.

The area sampling is based on a non-supervised classification out of a Landsat image acquired on 10.07.99. A posteriori interpretation achieved by the Estonian team with data base and field observation led to the extraction of sixteen dominant classes (cf. figure 2). In each of these classes, several candidates are selected in relation with existent ancillary data in the forestry data base (species fractional distribution, age, understorey description, height and width of trunks, management practices…), and also taking into account the accessibility of the parcels. These candidates are also chosen so that they are spread all over the area to maximize the spatial sampling of the field data collection.

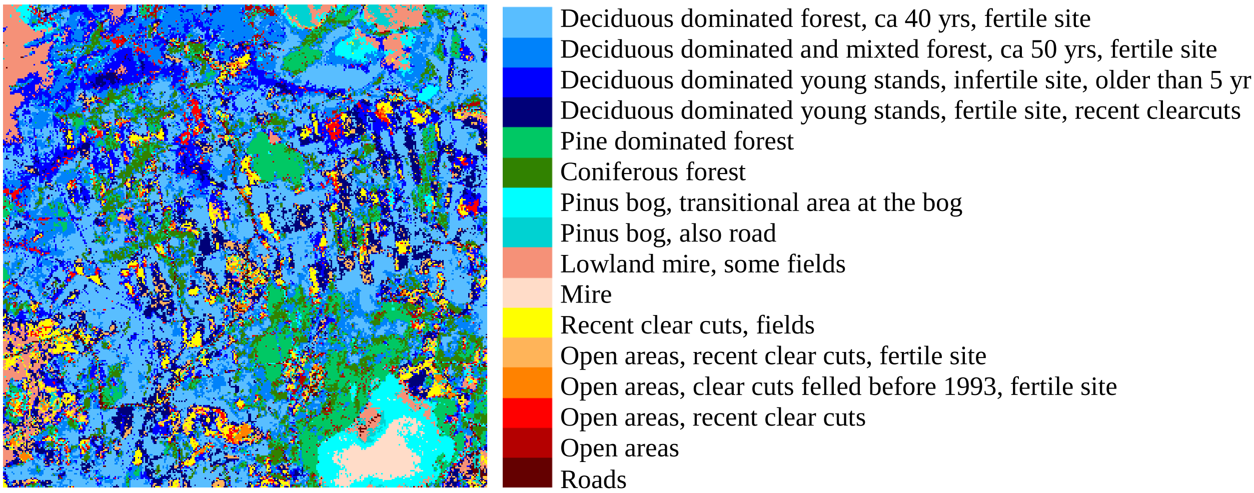


Figure 2: Classification of the Järvselja site from Landsat, 10.07.1999.

The center of the plot (CP) is selected as close as possible to the center of the parcel, in an homogeneous area. This CP is then located by a GPS measurement.
All the GPS positions are given in the "Position.txt" file. Most of them (42 plots) have been post-processed with differential data provided by Tartu fix station, and are marked in the file with a 1 in column "dif". This allow a precision of about one meter for the corrected positions, and about 10 meters for the others. These data are georeferenced in LAMBERT-EST projection (Lambert Conformal Conic 2 parallel) described in table 1.

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

Table 1: Description of Lambert-Est projection characteristics.

C] Protocol of measurement in a given plot, and abbreviations used in this document.

The same LAI measurement protocol is drawn for almost each forest plot.
A first record is made at the center of the plot (CP). Then, five records are made in each geographic direction, in the fixed sequence N-E-S-W, each record being separated by 2m. It will be called the 5R mode. Sometimes, due to specific measuring conditions, explained at each given plot in this document, this number can change: it will be noted xR, where x is the number of records per direction.
One record consists of a measurement below the understorey (at the ground level) plus one at the shoulder level (mode G+S). In that case, if nothing is added as a commentary, the total number of measurements for the plot is 42. When there is no real understorey, or for open areas (no tree), only one measurement is made at the ground level (mode G).
The sensor was partly screened with the 180° mask, and always oriented with the sun in the back of the experimentalist.

When not specified, the reference measurement (above canopy) was acquired in an automatic procedure (each 15s) by a LAImeter displayed in an open area close to the measured plots. The LAImeters have been intercalibrated and the given files provide operational data, which means intercalibrated and mixed below/above canopy records. One point to notice is that the A/B sequence is not regularly shaped.
In some specific cases, like in agricultural fields for instance, both above and below canopy measurements were acquired by the same LAImeter; this information will always be given in this document, with the abbreviation 1S.
Note: a parcel named C1 in this document has not been measured with the LAImeter, but has been recorded as a close to 0 LAI, and GPS position was noted. This can be an additional information to be considered.

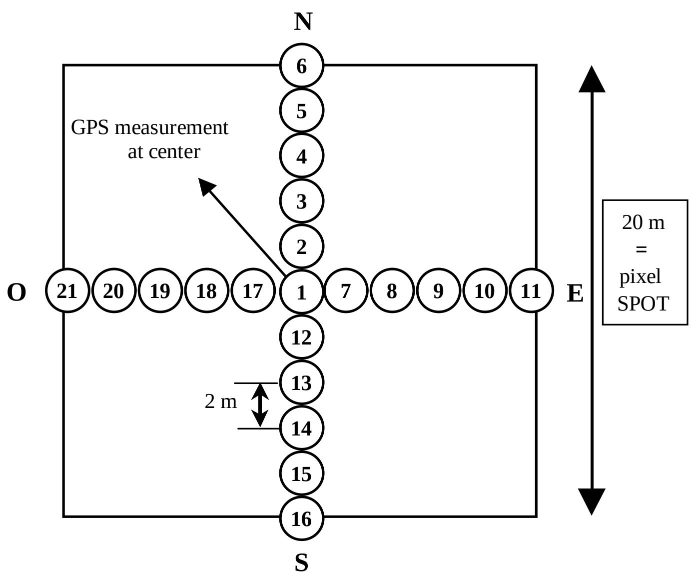


Figure 3: Schematic representation of plot measurement protocol

D] Raw Data: file names and format (directory RawData0)

Each file name is in the following format: PPPSS(x).txt, where PPP is the parcel number as given in the forestry data base (Kvartile) and SS the stand number in the parcel, as given in the data base too. x is eventually a letter if several files exist for the same plot.
These files are in simple text format, and have a recognizable header for the Licor Lai2000 data processing software (C2000.exe). Both below and above canopy measurements are placed in these files, sorted by time of acquirement as demanded by the C2000 software. Times are always given in UT.

E] LAI2000 Data Processing

Shoulder and ground levels processing are performed separately.

1] Preprocessing

A preprocessing is first performed in order to select the above measurements being the closest to the below ones (directory RawData).

2] Intercalibration of the instruments

Four LAI2000 instruments were available for the measurements. When separate above/below data acquisition were performed, the same couple of instruments were always used by the same operators: V3/TARTU on one hand, and V1/CESBIO on the other hand. Six above measurements have been simultaneously acquired with the four instruments in an open area, to be compared as a reference for each instrument for a given incoming flux. Couple of instruments having been working together (above and below the canopy) are then intercalibrated on this basis, as shown on the figure 4.

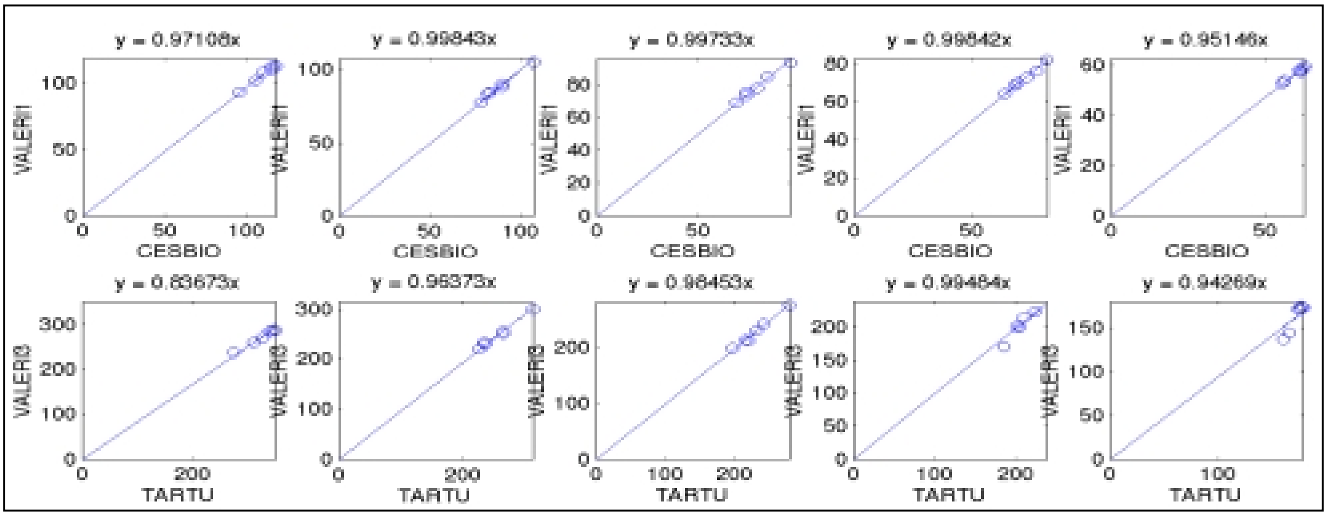


Figure 4: Intercalibration of the LAI2000 instruments for the five rings (from left to right: 7°, 23°, 38°, 53°, 68°). Calibration coefficients applied to the instruments are given above each graph.

3] Computation of LAI

- The LAI2000 instrument measures the fraction of diffuse incident radiation (or transmittance $T(\theta_v)$) that passes through a plant canopy for a given view zenith angle (θ_v), assuming that the foliage is azimuthally randomly oriented. $T(\theta_v)$ is the ratio between the below-canopy and the above-canopy measurement.
- The LAI2000 computations are based on four assumptions :
  - Black foliage (under 490nm)
  - Foliage elements are small compared to the area of view of each ring detector
  - Foliage is azimuthally randomly oriented.

Although no real canopy conforms exactly to these assumptions, the model still works.

- Errors can be observed when below measurement is higher than the above one, when no bare soil is observed. They can be due to :
  - An operator mis-manipulation : for example the operator is not back to the sun
  - Some clouds are passing through the sky where the above measurement is achieved, and no cloud is present where the operator proceeds the below measurement.

These measurements have been normally removed from the whole data set.

When processing, the mean gap fraction per field is computed for each ring. If the decreasing of gap fraction with increasing view angle is not verified, the file is also removed.

a)LAI2000 computations :

The gap fraction in the direction θ_v , $T(\theta_v)$, can be expressed as an exponential function of the path length $S(\theta_v)$, the foliage density μ (m^2 foliage canopy per m^3 canopy) and the fraction of foliage projected towards the direction θ_v , $G(\theta_v)$:

$$\boxed{T(\theta_v) = \frac{below(\theta_v)}{above(\theta_v)} = \exp(-G(\theta_v)\mu S(\theta_v)) \Rightarrow K(\theta_v) = G(\theta_v)\mu = -\frac{\ln T(\theta_v)}{S(\theta_v)}} \qquad \text{Eq 1}$$

$K(\theta_v)$ is the average number of contacts per unit length of path that a probe would make through the canopy at zenith angle θ_v (Welles and Norman,1991).

Foliage density computation :

It is given by : $\mu = -2\int_0^{\pi/2} \frac{\ln(T(\theta_v))}{S(\theta_v)} \sin(\theta_v) d\theta_v$

In an homogeneous canopy, foliage density is related to LAI and canopy height z . The optical path length is also related to z and θ_v :

$$\begin{cases} LAI = \mu z \\ S(\theta_v) = z/\cos(\theta_v) \end{cases} \qquad \text{Eq 2}$$

Substituing this equation in Eq 1 yields :

$$LAI = -2\int \ln(T(\theta_v)) \cos\theta_v \sin\theta_v d\theta_v \qquad \text{Eq 3}$$

As measurements give $T(\theta_v)$ in only five view zenith angles, the leaf area index is computed as following:

$$\boxed{LAI = 2\sum_{i=1}^{5} \frac{\ln(T(\theta_{v_i}))}{S(\theta_{v_i})} W_i} \qquad \text{Eq 4}$$

where, for each detector ring centered at θ_{v_i} , of length l_i , the weight W_i is $W_i = \sin\theta_{v_i} l_i$ and the path length is $S(\theta_{v_i}) = 1/\cos\theta_{v_i}$. Table 2 shows θ_{v_i} , W_i and $S(\theta_{v_i})$ values.

θ_{v_i}	W_i	$S(\theta_{v_i})$
7°	0.034	1.008
23°	0.104	1.087
38°	0.160	1.270
53°	0.218	1.662
68°	0.494	2.670

Table 2 : Parameter value for the LAI computation

Average Leaf Inclination Angle :

Lang (1986) considers a canopy in which all the leaves are oriented at zenith angle θ_l with a random azimuth distribution. The average leaf inclination angle is expressed by a 5th order polynomial of the average slope $\overline{dG(\theta_v)/d\theta_v}$:

$$\theta_l = \sum_{i=1}^{5} a_i x^i, \quad x = \overline{dG(\theta_v)/d\theta_v} \qquad \text{Eq 5}$$

The polynomial coefficients a_i are :

$$\begin{cases} a_0 = 56.81964 & a_3 = -158.6914 \\ a_1 = 46.84833 & a_4 = 522.0626 \\ a_2 = -64.62133 & a_5 = 1008.149 \end{cases}$$

$G(\theta_{v_i})$ is computed by dividing the contact frequency by the leaf area index, for the five view zenith angles. A straight line is fit to the five $G(\theta_{v_i})$ values, and the slope of that line is used to compute θ_l from equation 5. Because of the slope is important at extreme angles, θ_l is less accurately estimated for these values. The LAI2000 forces θ_l to be between 0° and 90°.

Diffuse non interceptance :

It is the probability that the diffuse radiation penetrating the canopy to a particular location :

$$\tau = \frac{\int_0^{\pi/2} \Gamma(\theta_v) T(\theta_v) \sin\theta_v \cos\theta_v d\theta_v}{\int_0^{\pi/2} \Gamma(\theta_v) \sin\theta_v \cos\theta_v d\theta_v}$$

The LAI2000 computes τ , assuming an isotropic diffuse radiation meaning that $\Gamma(\theta_v) = 1$. As for leaf area index, τ is estimated using the five transmittance measurements.

$$\tau = \sum T(\theta_{v_i}) W_i' \text{, where } \begin{cases} W_1 = 0.066 & W_4 = 0.249 \\ W_2 = 0.189 & W_5 = 0.249 \\ W_3 = 0.247 \end{cases}$$

b)Model inversion for leaf area index and average leaf angle estimation:

In this part of the processing, we assume an ellipsoïdal leaf inclination angle distribution ($\zeta(\theta_l, \theta_v)$, Campbell 1986), which induces all possibilities (from planophyll to erectophyll leaves). The monodirectional gap fraction can be expressed as an exponential law of the LAI and ζ :

$$K(\theta_v) = \exp(-LAI.\zeta(\theta_l, \theta_v))$$

LAI and average leaf inclination angle are initialized to the values computed by LAI2000 computation. The gap fraction for the five LAI2000 view angles is then computed with those values and compared to the measured gap fraction. While the error between the estimation and the measure is too high, *LAI* and mean leaf inclination angle values are modified using the simplex optimization method. The cost function corresponds to the relative root mean square error (*RRMSE*) between the measured transmittance in the five view angles and the modelled one, with a constraint on *LAI* (if *LAI* higher than 9, the cost function is drastically increasing) and *ALA* (between 0° and 90°).

c)Look-up table

A look-up table containing 50000 elements is built using the same model as in §b, considering uniform distributions of *LAI* (between 0 and 8) and *ALA* (between 0° and 90°). Each LUT element corresponds to one (*LAI*, *ALA*) value and the corresponding gap fraction in the five rings. The *RRMSE* between the measured transmittance in the five view angles and each LUT element is computed. We then select the 25 elements with the lowest *RRMSE* and take the median value.

d) Nilson's NAI retrieval algorithm

This algorithm is based on the theoretical gap fraction formula given in (Nilson, 1999). It makes use of the measured gap fraction angular distribution, such as by the LAI-2000 instrument at view angles 7.5, 22.5, 37.5, 52.5, 67.5º, respectively.

There is a theoretical scheme how to simulate the gap fraction angular distribution when sufficient stand data has been measured (or somehow estimated). It can be followed from the ValeriLAI.xls Excel file, but the main points are:

- Trees in the stand are divided into different species and size classes. For each class a separate column is given. Column name refers to the species name in Estonian and its storey. Some species codes: KU – spruce, MA – pine, KS – birch, HB – aspen, SA - ash, LM – black alder, LV – grey alder, PN – lime.
- Number 2 in the name (KU2 – second storey spruce) refers to the second storey. In some cases there could be a special storey for regeneration (Kujk- spruce regeneration).
- For each class there is a great number of variables to be given. Crown form can be either an ellipsoid of rotation (logical variable = TRUE) or cone in the upper part and cylinder in the lower part (FALSE)
- In addition, there is a special column (average), which characterises the stand as a whole (total or average for all classes). Just this column is later used for the analysis and LAI retrieval.

With the input data, for each class some auxiliary geometrical parameters as functions of the view angle are calculated below in the Excel file:

S – crown projection area on a horizontal plane (the program uses a small subprogram function 'Pind' written in Visual Basic);

a1 – average transmission through a single crown;

c – a specific coefficient (see Nilson, 1999);

aTHETA – average gap fraction for this particular tree class; at this stage the tree trunks have not been considered.

Next come some means how to simulate the effect of the tree trunks on the gap fraction. The shape of trunk is simulated by means of rather high order polynomial (coefficients a0…a6, h0, d0, p, q, are used for that, z = 1.5m is the height of observation). Then S1tyvi (Visual Basic module Tyvi1) and S2tyvi (module Tyvi2) are the trunk projection areas that are situated outside and inside of the crown projection region, respectively. Resulting estimates of gap fraction where the effect of tree trunks has also been considered is given in ‘binom_labipaistvus tyvega’ and in ‘ainult tyvedega labipaistvus’ stands for the gap fraction if only tree trunks were the shadowing elements in the stand.

Next the measured gap fraction data, column LAI-2000 together with the estimate of the diffuse radiation penetration coefficient aD are presented. Then the estimate of the gap fraction ‘LAI-2000 foliage’ comes where the simulated effect of the tree trunks has been eliminated. In the following columns on rows 142-148 the estimates of the Leaf of Needle Area Index, (NAI or LAI) are calculated. It is done for each view angle (K143…K148), and average LAI estimates over all view angles are given at positions K150, K151 and M149. These estimates differ from each other how the average LAI is calculated. K150 corresponds to the case when the LAI estimate is calculated for each view angle and then simply averaged, in M150 a similar LAI estimate is given, however different view angles are weighted with the weights proportional to the cos(theta)*sin(theta). In position K151 the LAI estimate is given as an integral over the all view angles. (NAI estimate is always given on a half of total area basis).

Thus, the estimated value of the LAI should correspond just to leaf (needle) area with the contribution of branches and trunks eliminated.

The view angle 82.5º not used in the LAI-2000 instrument is included in the algorithm, however, its results should be ignored. At present, I have fitted the gap fractions for the view angle 82.5º to give more or less the same LAI estimate as for the other view angles.

In positions B150..B155 the estimates of the gap fraction for the ground vegetation are given, by simply dividing the measured ground level gap fraction with the gap fraction at the breast height level. In position E156, the estimate of the LAI of ground vegetation with the more or less ‘ordinary’ LAI-2000 method is given.

There are three kinds of examples given in the Excel file:

1. Stands with recently measured sets of forest inventory parameters made on special sample plots, and additional measurements of crown and canopy closure with the ‘strange instrument’ (such as 162-7, 160-4, 182-6, 131-2, 107-13, 162-4, 164-4, 186-7, 186-8, 301-7, 288-2, 279-5). Some species-specific regressions are used to calculate the values of lacking parameters (including regressions to calculate the initial estimates of LAI).
2. Stands with measured crown and canopy closure, inventory data taken from the old forestry database (based on measurements and estimates on 1993/1994) (such as 226-9, 230-13, 229-19, 240-17, 188-7, 237-4, 242-7).
3. Some stands (especially the pine stands on bog, such as 92-3, 302-3) where the stand data do not exist in the database, the used stand data and canopy closure are nothing more but just guesses.

e) Results.

- **Comparison between the different methods**

Figure 5 shows the comparison between LAI2000 computation and the two other methods for each (above,below) acquisition. For leaf area index, a quite good fitting is observed between the LAI2000 and the LUT, although some points are overestimated. These points correspond neither to particular fields nor to problems linked to *ALA* estimation. The model inversion performs worse with high dispersion around the 1:1 line. This is mainly due to the optimization technique (local minimum) since the initial guess of the solution was given by the LAI2000. For the average leaf inclination angle, high discrepancies are observed both for LUT and SAIL, as compared to LAI2000. As stated earlier, *ALA* computation is not accurate for LAI2000 and thus, for extreme *ALA* values, discrepancies are increasing. LUT and LAI2000 results per field (average *LAI* and *ALA* computed with average gap fraction over all measurements acquired in a field) are very consistent in terms of *LAI*. Results on *ALA* are also improved (figure 6). Considering those results, we have decided to keep LUT method for the compuattion of *LAI* and *ALA*.

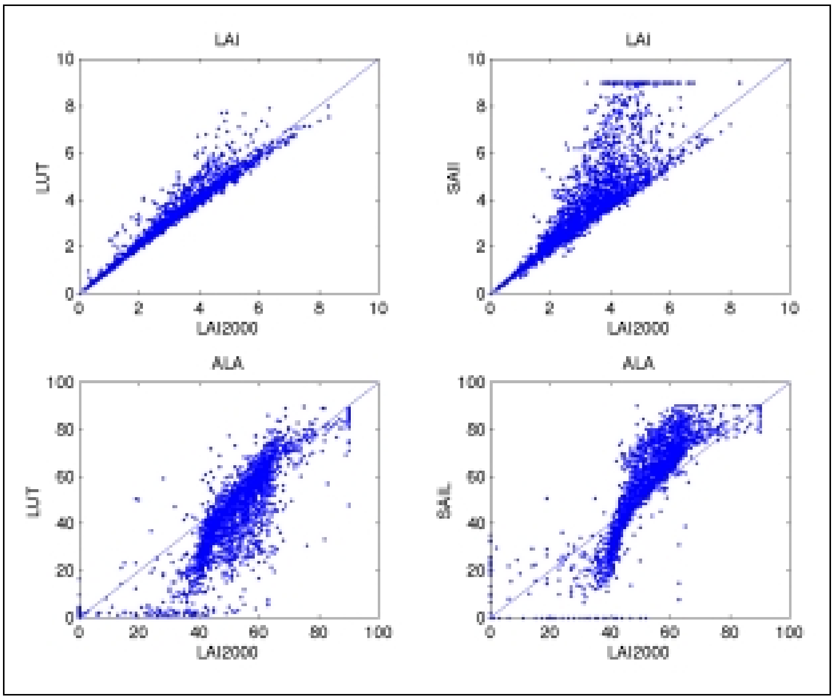


Figure 5: Comparison of LUT and model inversion methods with LAI2000 for the computation of the leaf area index and average leaf angle. Each point of measurement is considered.

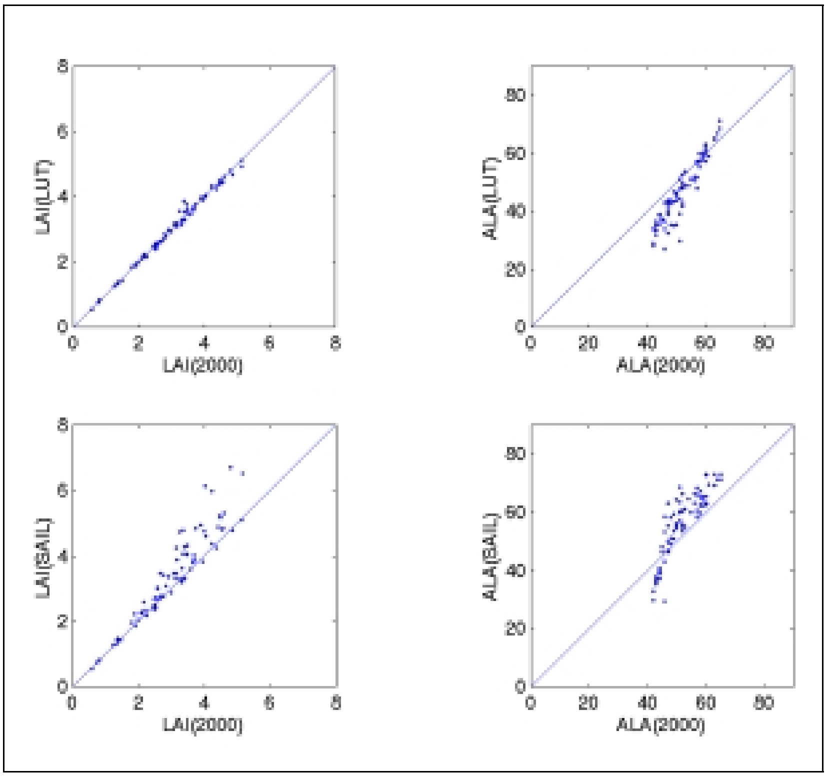


Figure 6: Comparison of LUT and model inversion with LAI2000 for the computation of the leaf area index and average leaf angle. Points correspond to an average value computed for each field, using average gap fraction values.

Figures 7 and 8 show the comparison of these three first computation methods with that of Nilson. Several differences are observed, probably due to the account for mutual shadowing of needles in a shoot, for instance, in Nilson's algorithm, where species-specific kappa coefficients are used for the clumping on a shoot level (0.6 for spruce, 0.56 for pine, 0.8 for all deciduous). It seems that these values could be essential to compare. It has also be noticed by Tiit Nilson that his ground layer vegetation LAIs are systematically lower than that of other methods, due to different algorithms applied for the tree layer and the ground layer. To comment all this, a deeper study should be performed, taking all the informations concerning each method in account.

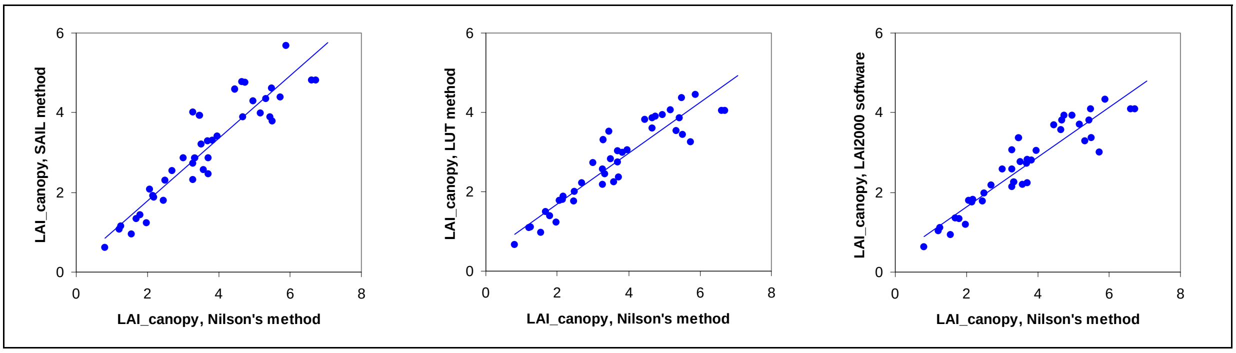


Figure 7: Comparison of LUT, SAIL inversion, and LAI2000 computations with canopy LAI estimated with Nilson's algorithm.

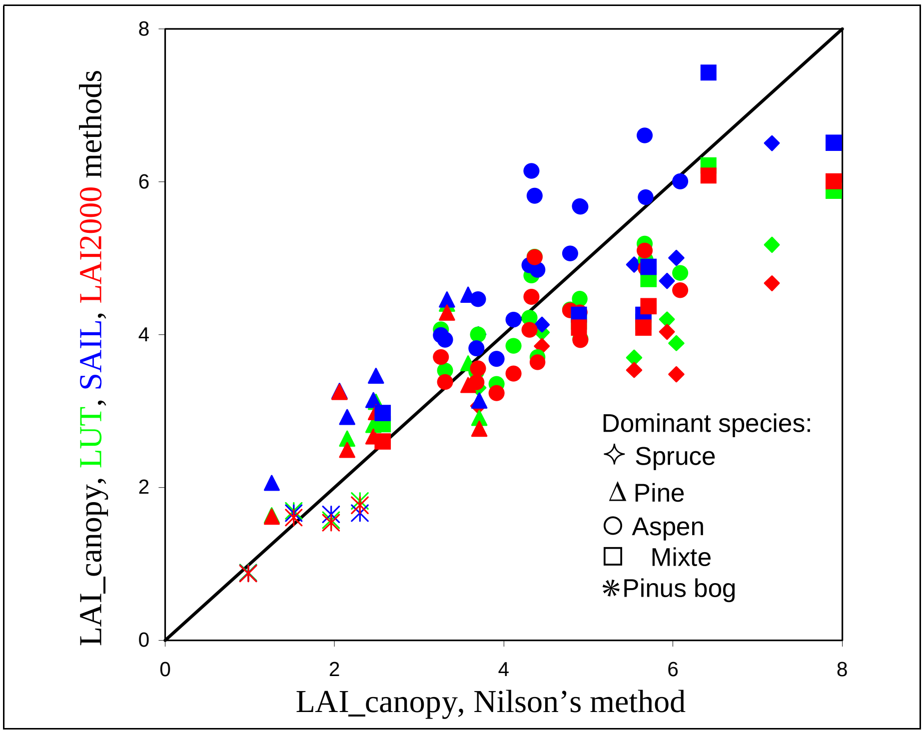


Figure 8: Comparison of LUT, SAIL inversion, and LAI2000 computations with canopy LAI estimated with Nilson's algorithm, for different kind of tree species.

- **Comparison of ground/shoulder LAI measurements**

As stated in §A, for many fields (table 2), two measurements were performed at the same point: one at ground level (taking into account understorey) and one at shoulder level (above the understorey). Figure 7 shows good coherence between the two levels, with higher *LAI* for ground level measurements.

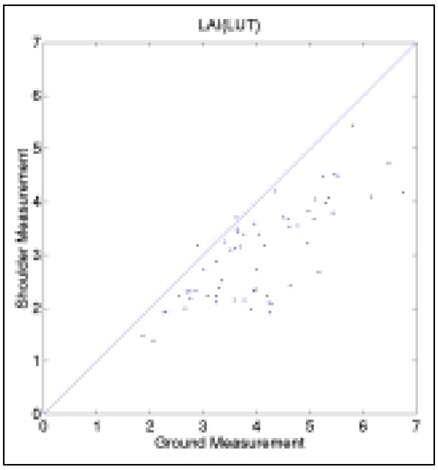


Figure 7: Comparison of *LAI* measurements performed at ground level and at shoulder level

f) File names and format

- **POSITIONS.TXT**

Contains the name of the field, easting and northing coordinates of the central point of data acquisition, indication of postprocessing (dif=1) or no (dif=0), measurement protocol, and number of picture available.

- **GroundTartuLAI.txt** and **ShoulderTartuLAI.txt**

Measurements performed at ground level (GroundTartuLAI.txt) and shoulder level (ShoulderTartuLAI.txt).

Column 1: Field Name
Column 2: Instrument Number
Column 3: Day of measurement
Column 4: Number of plot (N)
Column 5: East Lambert Coordinate
Column 6: North Lambert Coordinate
Column 7: Plot Number
Column 8: Gap Fraction for ring 1 (7°)
Column 9: Gap Fraction for ring 2 (23°)
Column 10: Gap Fraction for ring 3 (38°)
Column 11: Gap Fraction for ring 4 (53°)
Column 12: Gap Fraction for ring 5 (68°)
Column 13: Mean LAI (LAI2000 Computation)
Column 14: Mean LAI (LUT Computation)
Column 15: Mean LAI (SAIL Computation)

Column 16: Mean ALA (LAI2000 Computation)
Column 17: Mean ALA (LUT Computation)
Column 18: Mean ALA (SAIL Computation)

- **valeriLAI.xls**

Computations performed by Tiit Nilson. Each page corresponds to one measurement plot and contains all the data available for the stand, variables used in the algorithm, and gap fraction and LAI estimations

N	Number of trees per m^2
H	Height of tree, m
h1	Length of crown, m
h2	Length of the conical part (if cone+cylinder), m
R	Crown radius, m
DBH	Breast-height diameter, dm
LAI	Leaf (needle) area index - an initial guess
BAI	Branch area index
c	Tree distribution pattern parameter
kappa	Shoot-level clumping index
CRCL	Crown closure
CANCL	Canopy closure
D/m	Relative variance of the tree number distribution, uses function Dm written in Visual Basic
Nsigma	
sigma	
n	
ntais	
BAIcoef	Ratio of needle and branch area

Table 3: list of stand variables

In Estonia the site types are classified according to the type of ground vegetation. There is a lot of different site types. As the name of the type, usually the dominating herb species is given. Some examples occurring in our table:
ND - Aegopodium podagraria (goutwort, goutweed)
AN - Filipendula (dropwort)
MS - Vaccinium myrtillus (blueberry)
JK - Oxalis (wood-sorrel)
PH - Vaccinium vitis-idaea (red whortleberry, cowberry)
TR - Carex (sedge)
KR - Polytrichum

Some of the names describe the type of peatland
SS - Transitional bog
MDS - Lowland mire
KS - Drained peatland
Some of the types are given a mixtures of two dominants
AJMS - Oxalis - Vaccinium myrtillus
JPH - Oxalis - Vaccinium vitis-idaea
Then they like to specify the drained site types by adding K at the first position of the name
KAN - drained Filipendula

KMDS - drained lowland mire
KKMS - drained Polytrichum - Vaccinium myrtillus

Site index is from 1 to 5, 1 is for a rich site and 5 for poor site. Sometimes they use 1A for a very rich site and 5A for extremely poor site.

Names of tree species:
column n KU - spruce (Norway spruce, Picea abies)
column o MA - pine (Scots pine, Pinus sylvestris)
column p KS - birch (Betula pendula, Betula verrucosa)
column q HB - aspen (Populus tremula)
column r LM - (black) alder (Alnus)

Number in the record means the contribution of that species in the total composition. It is defined so that the total should be 10. Sometimes a + sign is present. This means that less than 1 (10%) of that species is present.

- **summary.xls**

Compilation performed by Tiit Nilson of all the LAI estimated by the four different methods for each plot, and corresponding comparison graphs.

g) References.

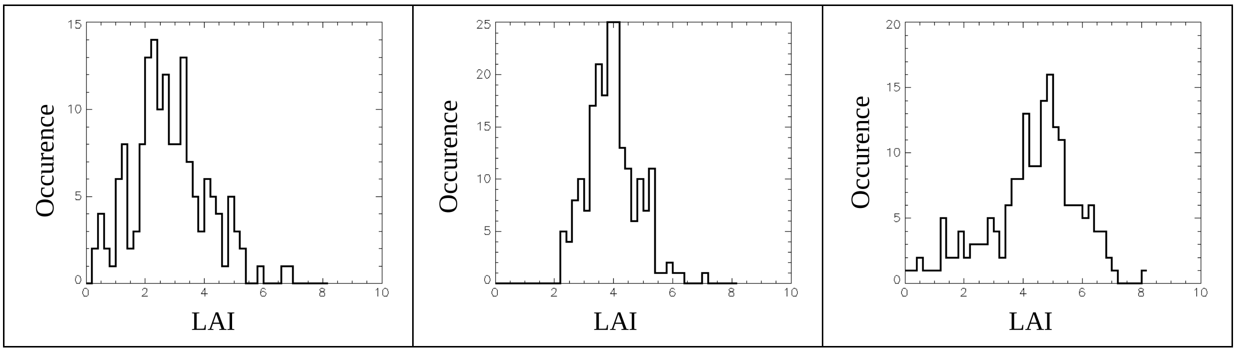
Campbell G., 1986. *Extinction coefficients for radiation in plant canopies calculated using an ellipsoidal inclination angle distribution.* Agricultural and Forest Meteorology, 36:317-321.

Lang A.R.G., 1986. *Leaf area and average leaf angle from direct transmission of sunlight*. Aust. J. Bot. 34:349-355.

Nilson, T. 1999. *Inversion of gap frequency data in forest stands*. Agric. For. Meteorol., 98-99:437-448.

Welles J.M. and Norman J.M., 1991. *Instrument for indirect measurement of canopy architecture.* Agronomy Journal 83:818-825.

F] LAI quantitative distribution in the site



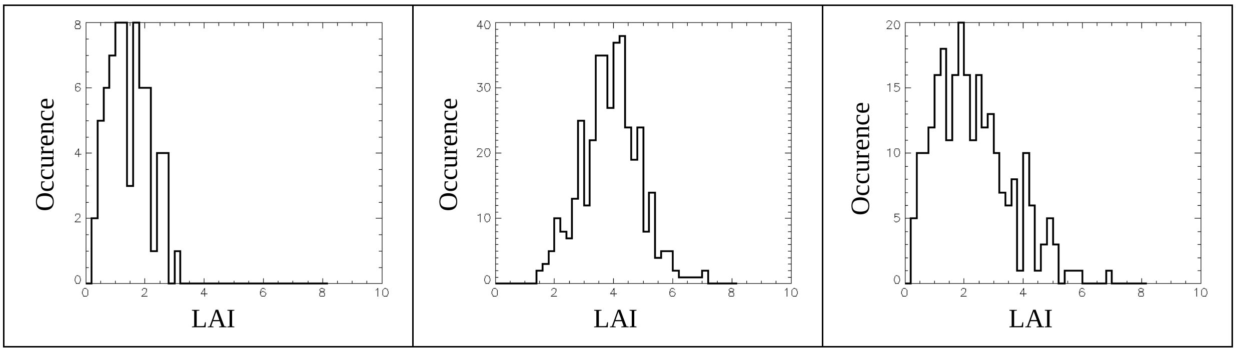


Figure 8: Histograms of the LAI distribution per dominant class in the stand.

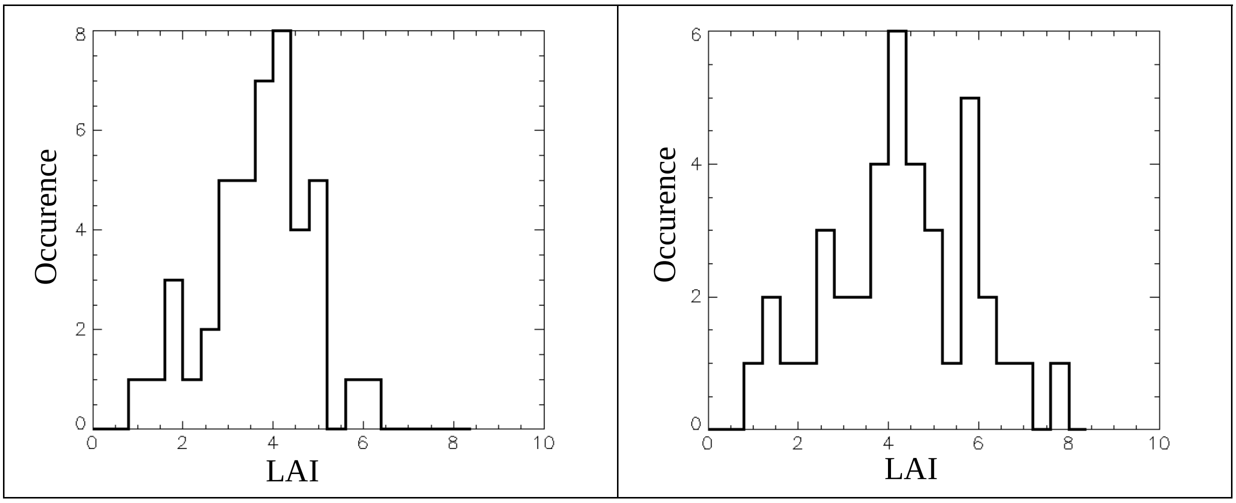


Figure 9: Histograms of the total LAI estimation values over the site a) computed with LUT method and b) computed with Nilson's algorithm.

G] Ancillary Data

- Two 1997 forestry maps (scale: 1/20000).
- One 1998 satellite photomap (scale: 1/50000).
- A CD-ROM containing a forestry database + one field map.
- Landsat image (10 July 1999) + unsupervised classification.
- Spot Image (December 1999).
- Spot Image (26 August 2000).
- In-Situ photos.
- GPS (differential and not differential) file.
- Canopy closure measurements in some plots.
- Campaign field notebooks.
- Sunphotometer and direct/diffuse radiation (BF2) measurement files.

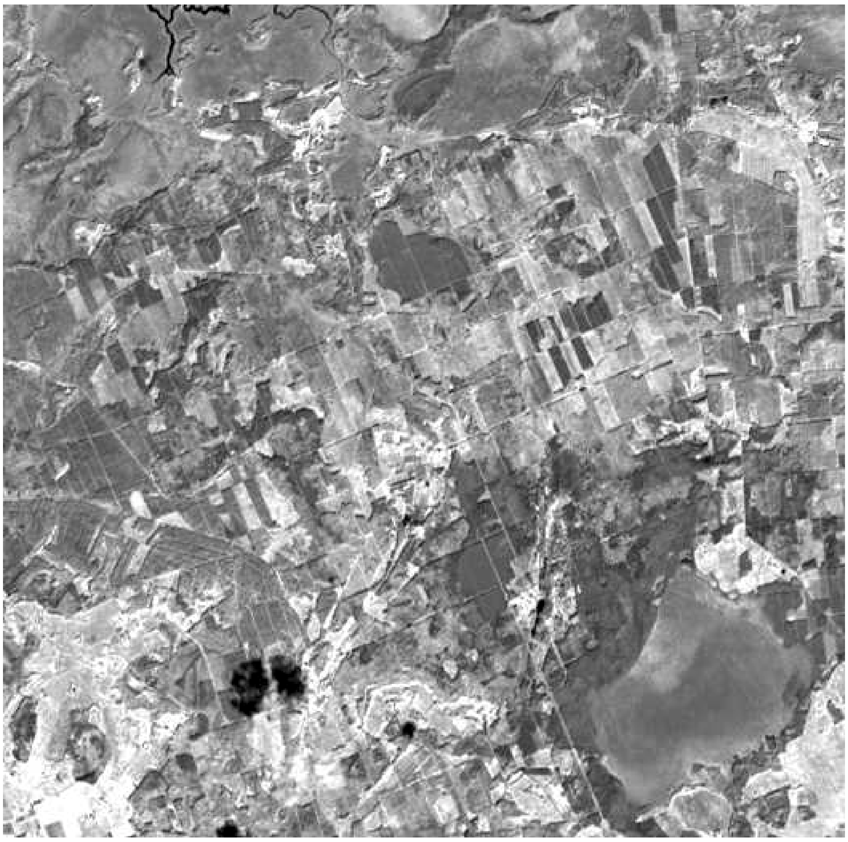


Figure 10: SPOT image (XS3) acquired on the 26th August 2000 over the Järvselja test site.

H] Concluding remarks

- SPOT image was acquired very late due to bad weather.
- Sunphotometer and BF2 measurements were acquired at different date (July 4-5-6 for sunph. and 7 for BF2). No relationships between the two measurements can be derived. Moreover, the SPOT image having been acquired after that week, atmospheric correction can't be performed.
- Due to variable weather, fixing one week seems impossible. Estonian team proposes to take measurements when good conditions are observed during one month for example. Considering understorey growth and satellite image acquisition date, is it reasonable?
- Estonian team suggests taking accommodation at Järvselja (on test site) instead at Tõravere (Tartu observatory).
- Campaign during winter or early spring could be interesting to observe LAI variability during the year.
- Tartu observatory needs a sunphotometer and a LAI2000. This was scheduled in the EU proposal which has not been accepted yet (and seems not to be accepted).
- Marc Leroy suggests reducing the 100km^2 area to 9km^2 as in the MODLAND validation project.

ANNEXE] Field observations

The following table describe the whole data set: field name, instrument used to perform the measurements, day of data acquisition, GPS positioning (if dif=1, GPS post-processing was performed), measurement protocol, number of available pictures and some notes that describe the field.

Field	Instr	Doe	Northing	Easting	Dif	Protocol	Pic	Notes
03529a	V3/Ta	188	6470137.05373	691122.50635	1	5RG	1	Grass Lowland Mire
03529b	V3/Ta	188	6470090.24757	691084.45919	1	5R(G+S)	1	Lowland Mire, Birch Forest, willow undergrowth
03530	V3/Ta	188	6470043.95724	691101.05578	1	5R(G+S)	2	Lowland Mire, Few Birch, Willow
05203	V1/Ce	187	6468418.00000	689207.00000	0	5R(G+S)	1	Clear-cut. Raining a little bit
05303	V1/Ce	187	6468419.00000	689332.00000	0	5RG	1	
05710a	V3/Ta	188	6468377.44630	690798.18582	1	5R(G+S)	1	Thinned young birch forest, many white birch, stems could be problematic
05710b	V3/Ta	188	6468432.99528	690785.09655	1	5R(G+S)	0	Same as 05710a with spruce regeneration (1/3m high)
05710c	V3/Ta	188	6468431.04801	690742.94806	1	5R(G+S)	0	
06334	V3/Ta	187	6469299.86691	695435.19578	1	5R(G+S)	0	Mixed Birch, Pine, and Spruce. Last year thinned 30%
08904	V1/Ce	187	6469057.92265	695699.02130	1	5RG	1	Marsh. Not at the center of the field due to wet land
09203	V3/Ta	187	6469124.09116	696527.37996	1	5R(G+S)	0	Pinus bog, grass layer, ledum palustre, carex
10612	V3/Ta	187	6467171.90073	690671.86564	1	30RG	0	Ground Vegetation, grasses, very young aspen
10713	V3/Ta	187	6466997.09159	690873.02408	1	5R(G+S)	0	Spruce Forest (no grass and herb)
11212	V1/Ce	187	6467576.00000	692669.00000	0	5R(G+S)	1	
13102	V3/Ta	188	6466581.50451	689397.49153	1	5R(G+S)	2	Birch forest (50-60years), Lowland Mire, Frangula alnus undergrowth
13504	V3/Ta	188	6466807.51817	690804.36399	1	5R(G+S)	1	Clear cut, Aspen regrowth
14203	V1/Ce	187	6467166.00000	692842.00000	0	5RG	1	Open Area, Covered sky (storm)
14204a	V1/Ce	187	6466781.00000	692730.00000	0	5R(G+S)	1	Start raining. Droplets
14204b	V1/Ce	187	6466781.00000	692730.00000	0	5R(G+S)	1	Same as 14204a, no rain

15401	V3/Ta	187	-	-	-	5R(G+S)	0	
16004	V3/Ta	185	-	-	-	5R(G+S)	0	
16207	V3/Ta	185	-	-	-	5R(G+S)	0	Changing clouds
16402	V3/Ta	185	-	-	-	5R(G+S)	0	
16404	V3/Ta	185	-	-	-	5R(G+S)	0	
18105	V3/Ta	187	6467365.61217	696784.49181	1	5R(G+S)	0	Clear cut, Birch
18206	V3/Ta	185	-	-	-	5R(G+S)	0	High LAI grass layer
18607	V1/Ce	185	6465477.45921	691239.60343	1	5R(G+S)	1	
18608	V1/Ce	185	6465503.14512	691345.01710	1	5R(G+S)	1	
18807a	V1/Ce	185	6465398.83212	691756.48033	1	5R(G+S)	0	Sun appears at time.
18807b	V1/Ce	185	6465503.21400	691737.26349	1	5R(G+S)	1	Mixed canopy, Spruce, Birch, understorey has changed, sun coming
19310	V3/Ta	186	6465928.23022	695320.40291	1	5RG	1	Clear area
19407	V3/Ta	186	6465975.00000	695470.00000	0	5R(G+S)	1	
19408	V3/Ta	186	-	-	-	5R(G+S)	1	
20210	V1/Ce	185	6464641.39433	691748.14960	1	5R(G+S)	1	
20303	V1/Ce	185	6464853.19857	691865.68746	1	5R(G+S)	1	Clear sky, sun at horizon, excellent conditions!!!
21202	V3/Ta	186	6465831.00000	695460.00000	0	5R(G+S)	1	Dense Undercover, Broken clouds, worst situation!!!
21305	V3/Ta	186	6461688.87517	694226.30793	1	5R(G+S)	1	
22609	V1/Ce	187	6464873.00000	694905.00000	0	5R(G+S)	1	
22615	V1/Ce	187	6464649.00000	695934.00000	0	5R(G+S)	0	Virgin Forest
22713	V1/Ce	187	6464710.00000	695212.00000	0	5R(G+S)	0	
22917	V1/Ce	187	6464776.00000	695835.00000	0	5R(G+S)	1	
23013	V1/Ce	187	6464840.00000	695959.00000	0	5R(G+S)	1	Broken clouds
23704a	V1/Ce	185	6463742.85455	693498.10615	1	8R(G+S)	1	Pinus sylvestrus/ Scots pine Meas. With 2 sensors

23704b	V3/Ta	185	6463742.85455	693498.10615	1	8R(G+S)	1	
24017	V1/Ce	186	-	-	-	5R(G+S)	1	Understorey with big ferns, Canopy not too high
24113	V1/Ce	186	6463955.13107	694749.34164	1	5R(G+S)	1	60% Spruce, 20% Aspen, 20% Birch, ~30m high, wet soil
24207	V1/Ce	186	-	-	-	5R(G+S)	1	Not regular in shape, aspen+rare spruce and birch, not too dense understorey of grass
24306	V1/Ce	186	-	-	-	5R(G+S)	2	Aspen, dense understorey with small bushes
265xx	V1/Ce	187	6462095.00000	691319.00000	0	5RG	1	High clouds, sun at time
26608	V1/Ce	187	6462108.00000	691521.00000	0	5RG	1	Open area
27905	V1/Ce	187	6461856.00000	691361.00000	0	5R(G+S)	1	High clouds, sun at time
28001	V1/Ce	187	6461836.00000	691836.00000	0	5R(G+S)-1	1	High clouds, sun at time
28802	V1/Ce	186	6462310.11917	694596.98071	1	5R(G+S)	1	
29911a	V3/Ta	188	-	-	-	5R(G+S)	0	Spruce Forest, no thinning, almost no herb layer
29911b	V3/Ta	188	-	-	-	5R(G+S)	0	Spruce forest uniformly thinned
29912a	V3/Ta	188	-	-	-	5R(G+S)	1	Spruce forest, moderately and uniformly thinned. Ground layer oxalis not measured due to low leaves (LAI~0.5-10)
29912b	V3/Ta	188	6461185.00000	693649.00000	0	5R(G+S)	1	Spruce Forest (51 years), thinned from below in 1971, 1976, 1980
30107	V1/Ce	186	6461678.00000	694235.00000	0	5R(G+S)	0	
30204	V1/Ce	186	6461398.00000	694516.00000	0	5R(G+S)	1	Partly Bog
30301	V1/Ce	186	6461447.51453	694783.24903	1	5R(G+S)	1	
30904	V1/Ce	186	6461138.00000	694230.00000	0	5R(G+S)	1	
31002	V1/Ce	186	6461309.25083	694634.23506	1	5R(G+S)	1	
32020g	V3/Ta	188	6469801.42081	692159.89828	1	5RG	0	Abandoned agricultural field: sparse grass on sandy soil
32020ja	V1/Ce	187	6470122.00000	691866.00000	0	5R(G+S)	1	

32020	V1/Ce	186	6470185.00000	691787.00000	0	5R(G+S)	1	
A1	V1	188	6465297.28129	692978.47878	1	2(A+5B)	1	Agricultural field (probably oat). First above might be sunlit
A2	V1	188	6465209.33306	692987.50647	1	2(A+5B)	1	Agricultural field (probably rye)
B1	V1	188	6465024.98214	692822.99812	1	5R(G+S)	1	Salix Bush, dense
C2	V1	188	6466568.32144	693231.66105	1	4(A+5B)	1	Clear cut (5 year old) covered by grass
G1	V1	188	6464196.41418	688563.57712	1	4(A+5B)	1	Grassland
G2	V1	188	6463906.11411	688864.77532	1	4(A+5B)	1	Grassland
G3	V1	188	6464988.94215	692897.30138	1	4(A+5B)	1	Grassland
Grslnd	V3/Ta	187	6469191.88396	696069.55743	1	5RG	0	Cultivated sparse grassland
Huu	V1	188	6461588.00000	695537.00000	0	4(A+5B)	2	Center of Huulika peat bog. Sparse and rachitic pines, peat-moss (sphagnum)
O1	V1	188	6463971.75318	688511.47425	1	4(A+5B)	1	Unmaintained grassland
O2	V1	188	6463969.29541	688682.36137	1	4(A+5B)	1	Unmaintained grassland
O3	V1	188	6468738.93340	692425.27884	1	4(A+5B)	1	Open Area, clear cut
C1	-	-	6466507.26126	693108.48107	1	-	1	Clear cut

Table 4: Description of Estonian site measurements