LAPINJÄRVI FOREST TERRESTRIAL LASER SCANNING DATA

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LICENCING, CREDITS AND CONTACT DETAILS

For crediting the use data or any publications deriving from it, in printed or electronic format, the following article based on this data should be referred. It is open access, and provides also some additional details of the data.

Pitkänen, T.P., Raumonen, P. and Kangas, A. (2019). Measuring stem diameters with TLS in boreal forests by complementary fitting procedure. *ISPRS Journal of Photogrammetry and Remote Sensing* 147, 294-306. https://doi.org/10.1016/j.isprsjprs.2018.11.027

For any further questions or requests related to the data, you may contact Timo P. Pitkänen by e-mail timo.p.pitkanen@luke.fi.

GENERAL DATA DESCRIPTION

This terrestrial laser scanning (TLS) data consists of 18 scanned and field measured forest plots from Lapinjärvi, Finland (60.7°N, 26.1°E), which belongs to southern boreal forest zone. All the plots are within a few kilometres distance from each other but the study area, however, is a designated research which includes a wide variety of management regimes and forest types.

Scanning was made using Leica P40 scanner, selecting 3.1 mm point spacing at 10 m distance from the scanner. Each plot was scanned using five stations: one in the middle and four additional stations at about 9 m distance in all the cardinal directions (N, E, S, W). Due to nearby obstacles and practical limitations, however, actual stations were allowed to deviate max. 1 m from their intended locations. Scanning was always made in dry conditions, temperatures varying between +17 and +24 °C and wind speeds between 1.6 and 6.5 m/s as recorded by the nearby weather station around the scanning time.

Separate scans have been registered together using black-and-white target boards. One target was always set exactly in the middle of the plot to be used to indicate the plot centre, and additional targets were placed within and around the plot as needed. Beyond 9 m radius, some of the targets were attached on tree trunks, which can potentially disturb automatized analyses outside of this range. Co-registration errors range between 1 and 3 mm depending on the plot.

Points are stored using a local coordinate system, having the origin (0, 0, 0) on ground level in the middle of the plot. Directions are determined by compass measurements i.e. zero angle pointing approximately towards the magnetic north. These angles are consistent with field measured trees but if the point cloud is combined with external geographical data, correction for magnetic declination (roughly +9 degrees) and other potential deviations are needed.

Plot centre coordinates in ETRS-TM35FIN system (EPSG:3067) as well as local coordinates of the five stations can be found from the attached plot data file. Z coordinates of the stations are normally about 1.5 m above the ground due to setting the scanner on a tripod.

Field observations and measurements include both plot and tree variables. All the plots were located on productive non-drained forest land, and measured variables are presented in details later in this document. Tree measurements were performed shortly before TLS scanning with following restrictions:

- Trees having breast height diameter (d1.3) of less than 45 mm, were measured only if they were included in an angle count plot (Bitterlich plot) with relascope factor of 1.5
- Trees having d1.3 between 45 and 94 mm were measured up to 9.00 m distance
- Trees having d1.3 between 95 and 299 mm were measured up to 15.00 m distance
- Trees having d1.3 at least 300 mm were measured up to 20.00 m distance

For all the measured trees, tree species and quality classification were observed, and distance, angle, d1.3 and tree height were measured. Additional measurements, as described below, were performed for tally trees which had d1.3 of at least 45 mm and were included in an angle count plot with relascope factor of 1.5. Some variables had also further specifications in terms of the conditions when they were measured. Variables which had not been measured are denoted as "---". Field measurements are the original values stored during the fieldwork, and may contain some unintentional errors.

From practical point of view, co-registered TLS data was initially planned to be used within 9.00 m radius, and no attention was given if trees outside of this range were scanned properly. In addition, the applied scanning scheme was relatively inflexible relying principally on fixed station locations and, therefore, occlusion effects may hinder proper detection of some trees.

POINT DATA

Point data is distributed in .laz, i.e. compressed las format (version 1.2); coordinates are stored using four decimals (scale factor 0.0001) and zero offset, and intensity is scaled to be a 16-bit integer. Scan numbers (1 = centre, 2 = north, 3 = east, 4 = south and 5 = west from the centre) are saved as UserData records. Exact local coordinates of all the stations can be found from the plot data file. Size of a single dataset varies generally between 400 and 700 MB per plot, depending on the selected version.
Point data is distributed as two different versions:

- **Co-registered point cloud data** which is restricted to **12.5 metres horizontal radius** and decimated to contain, at most, only one randomly selected point per scan within a 5 x 5 x 5 mm cube. Due to decimation in a scan-wise manner, those parts of the co-registered cloud which have been visible from several scanning stations are likely to have higher point density. This data is intended to be used for detecting complete tree shapes within the 9.00 radius (plus additional 3.5 m to include major parts of branches), and allows for separation of single scans. The achieved co-registration accuracy should be sufficient for most applications but, however, wind effects may be visible as disjoint shapes in the upper parts of the trees. No filtering or cleaning has been made at the cloud edge to e.g. remove branches of trees standing outside of the clipping radius.

- **Single scan data from the centre of the plot** without any decimation or clipping to a certain radius. Theoretically, given the applied scanner settings and specifications provided by Leica, points' maximum range is 120 m from the scanner. This data can be used for single-scan evaluations and it has a range extending well beyond the measured trees, if not occluded by closer trees or other obstacles.

In case there is a need for other formats or getting co-registered data without any initial decimation, please contact us for further details.

PLOT AND TREE MEASUREMENT DATA

Additional plot properties (TLS_plot_data.csv) and tree measurements (TLS_tree_data.csv) are available in csv format (semi-colon as field separator, comma as decimal delimiter). Data details and description of the variables are specified below.

Definitions of plot data variables:

plot_ID	ID code for each plot
plot_code	Three-digit code describing the forest type of the plot; FIRST NUMBER: tree species dominance 1 = pine dominated stand (>70% of the total tree volume) 2 = spruce dominated stand (>70% of volume) 3 = deciduous tree dominated stand (>70% of volume) 4 = coniferous tree dominated stand, but not belonging to 1 or 2 (>70% of volume) 5 = mixed stand; none of above SECOND NUMBER: basal area 1 = less than 10 m^2/ha 2 = 10 – 20 m^2/ha 3 = 20 – 30 m^2/ha 4 = over 30 m^2/ha

	THIRD NUMBER: mean diameter at breast height (1.3 m) 1 = less than 120 mm 2 = 120 – 250 mm 3 = more than 250 mm
TM35_E	East coordinate according to the ETRS-TM35FIN coordinate system (EPSG:3067)
TM35_N	North coordinate according to the ETRS-TM35FIN coordinate system (EPSG:3067)
fieldmeas_date	Date of field tree measurements (DD.MM.YYYY)
scan_date	Date of TLS scanning (DD.MM.YYYY)
main_site	Main site class; 1 = mineral soil, 2 = spruce mire
fertility	Fertility class, according to the following codes 2 = herb rich heath forest for mineral soil, mesothropic spruce mire for plot k75 3 = mesic forest 4 = sub-xeric forest 5 = xeric forest
structure	Stand structure, according to the following codes 0 = uneven-aged (multi-storied) structure 1 = one-storied structure 2 = two-storied structure
mean_reg_err_m	Mean TLS co-registration error (m)
max_err_m	Maximum TLS single target error in the co-registration (m)
stat1_x (…) stat5_z	X. Y and Z coordinates of the separate TLS scanning stations (1-5) indicated in the local coordinate system

Definitions of tree data variables:

plot_ID	ID code for each plot
fieldtree_ID	Number of the field measured tree. Numbering generally starts from north (zero angle) and continues clockwise throughout the full circle. Deviations to this general scheme are caused by practical issues, i.e. according to easiest measurement order.
fieldtree_spec	Species of the field measured tree, according to the following codes 1 = Scots pine (*Pinus sylvetris*) 2 =Norway spruce (*Picea abies*) 3 = Silver birch (*Betula pendula*) 4 = Downy birch (*Betula pubescens*) 5 = Aspen (*Populus tremula*) 6 = Grey alder (*Alnus incana*) 7 = Common alder (*Alnus glutinosa*) 8 = Rowan (*Sorbus aucuparia*) 9 = Goat willow (*Salix caprea*) 10 = other; none of above
tree_class	Quality classification of the tree, according to the following codes LIVING TREES: 0 = small tree; d1.3 less than 45 mm (for d1.3 definition, see below) 1 = wastewood; d1.3 at least 45 mm but tree is inferior due to decay, or the trunk is divided or curved

	3 = pulpwood; d1.3 is at least 45 mm and quality is sufficient for pulp production but not for timber 7 = timber tree; quality is sufficient for sawtimber use DEAD TREES DUE TO NATURAL LOSS: A = usable standing tree B = usable fallen tree with over 1.3 m tall standing base C = non-usable standing tree STUMPS: F = over 1.3 m tall standing stump
d13_mm	Diameter measured at breast height (1.3 m) in millimetres, measured using Masser Sonar electronic caliper from top of the bark at a perpendicular direction against the line towards the plot center. If there was an obvious stem deformation at 1.3 m level, measurement was made just below the deformed part.
d6_mm	Diameter measured at 6 m height in millimetres, measured using manual caliper from top of the bark at a perpendicular direction against the line towards the plot center. Only measured from specific tally trees which exceed the height of 8 m.
height_dm	Tree height, in decimetres. Only measured from specific tally trees.
age	Age of the tree (years), estimated in the field without boring. Age was estimated from one or few trees which were selected from each of three potential strata (pines, spruces, deciduous trees) if available, and intended to be close to the stratum-specific mean basal area.
dead_cr_base_dm	Height (in decimetres) of dead crown base (i.e. dry branches or their previous places) with minimum branch diameter of 15 mm, intended to be used for timber quality assessment. Code "E" indicates a case when such dry branches do not exist, or they begin at higher height than living crown. Only measured from specific tally trees which are pines, spruces, bitches or aspens belonging to quality class 7.
liv_cr_base_dm	Height (in decimetres) of living continuous crown base (i.e. living branches). Living branches, which are separated by at least two dead branch whorls on top of them, are not counted as the base. Only measured from specific tally trees.
dist_side_cm	Distance to the side of the tree at 1.3 m level, in centimetres
dist_core_cm	Distance to the core of the tree at 1.3 m level, in centimetres
angle_gon	Angle to the tree at 1.3 m level, in gons (full circle = 400 units)
x_coord	X coordinate of the tree (0 = plot centre), calculated from core distance and angle
y_coord	Y coordinate of the tree (0 = plot centre), calculated from core distance and angle

PHOTOGRAPHS

During the TLS scanning, a set of photos was taken from field plots. They may be helpful in perceiving local forest conditions as well as offer reference material for objects which are observed in the point clouds. For each plot, four photos are included. They are taken from the plot centre towards north (N), east (E), south(S) and west (W). Quality of the photos is mostly good, but occasional camera shaking and focusing problems can be observed in part of them. Photos can be downloaded from the link below:

http://www.nic.funet.fi/index/geodata/luke/tls/2016/lapinjarvi/photos/