

Vegetation ground truth guidelines for validating lidar products

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30-40 circular sample plots with 15m radius (Jensen et al. 2008) are distributed throughout the entire study area. The distribution of the plots should be stratified by vegetation types such as conifer, deciduous, mixed, and meadow. Within each vegetation type, the samples can be further stratified based on canopy density, i.e., dense, medium and sparse (Figure 1). Each plot center should be greater than 20 m away from any man-made objects such as buildings and roads.

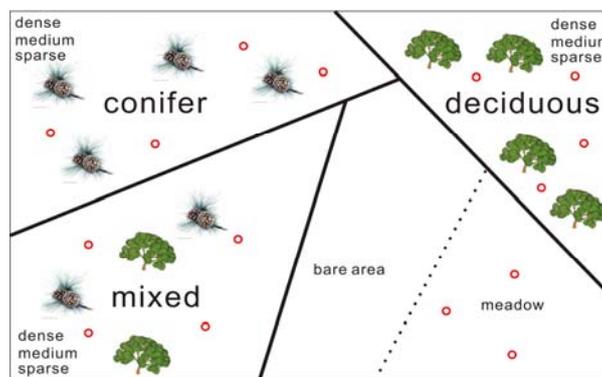


Figure 1: Sampling stratification among different vegetation types

Within each plot, it is recommended to record the following parameters*:

- 1) geographic coordinate of the plot center (P);
- 2) species name (I);
- 3) tree height (I);
- 4) diameter at breast height (DBH) (I);
- 5) crown class (only live trees) (I);
- 6) crown width [**Optional**] (I);
- 7) height to live crown base (only live trees) [**Optional**] (I);
- 8) location of individual tree (sub meter accuracy) [**Optional**] (I);
- 9) total number of trees within each plot (P);
- 10) crown closure (P);
- 11) leaf area index (LAI) (P);

I: represents individual tree level measurement; P: represents plot level measurement.

* For meadows, only species names and average heights are measured.

Details on some parameters are described below:

1) Plot center: the position of each plot center should be accurately located, with differential GPS if possible. GPS positions should be collected in an area with good reception. If the plot center is under canopy, other accurate surveying methods (e.g. laser range finder, total station, or digital compass) should be used together with GPS to locate the plot center. Also, take nice photos to characterize individual species and the plots. *Recommendation:* the photos are taken from north, east, south and west, roughly from the boundary of the plot towards the center; one photo is obtained from approximately breast height (1.3m) looking directly towards the sky (SNAMP 2008).

2) Individual tree: Try to measure all individual trees within a plot whenever possible. Laser ranger finder is recommended to measure the tree heights. For each tree, measure the tree height three times and calculate the average value. DBH can be measured using a tape. The measurement of crown width is optional. Each measured tree within a plot should be georeferenced using GPS laser offsets: combining GPS with the laser rangefinder (with built-in or MapStar compass) for all remote GPS positioning (<http://www.lasertech.com/GIS-GPS-Mapping.aspx>).

3) Crown closure: crown closure is an important structural parameter for quantifying the energy and mass exchange features of terrestrial ecosystem. Spherical Densimeter (with an angle of view of 60°) is recommended for the acquisition of crown closure (Paletto and Tosi 2009). For each plot we mount the instrument on a tripod at five survey points (1.3m height): the first in the center of the plot and other four at 7-m distance from the center in direction of North, South, East and West (Figure 2). In each sample point the operator will execute four measures with convex SD oriented in direction of a different cardinal point. The canopy closure of each plot is the average of the five survey points, each including four cardinal point measures.

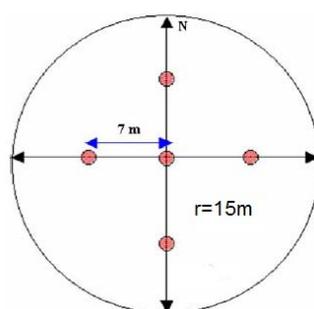


Figure 2. Sampling points of crown closure within each plot (Paletto and Tosi 2009)

4) LAI: LAI is an important vegetation parameter for quantifying the energy and mass exchange characteristics of forest ecosystems such as photosynthesis, respiration, transpiration, carbon and nutrient cycles, and rainfall interception. Some specific requirements for LAI measurement: a) select plots from all representative vegetation

types (i.e., conifer, deciduous, mixed); b) at least 30 plots are needed for the whole study area; c) within each vegetation types, choose plots that are representative to the spatial variability of LAI (i.e. low, medium, and high); d) within each plot, multiple samples are needed to estimate the average LAI within the plot. Figure 3 shows the sampling protocol (Jensen et al. 2008) for LAI measurements within each plot. Brief description is as follows: a 15 m-radius plot are designed and six locations are selected to measure below-canopy radiance. The LAI sensor (e.g. Licor LAI-2000) should be placed 1 m above the ground, which represents the LAI of over-story.

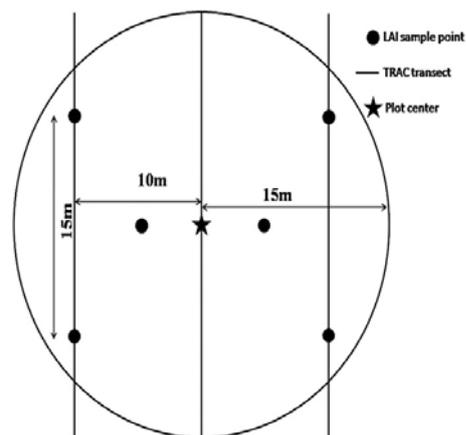


Figure 3. LAI sampling design (Jensen et al. 2008)

Recommended Instruments

GPS: GeoXH, Zephyr antenna, GeoXM or Trimble Recon Controller (anything that supports ArcPad and can accept signal from the laser ranger finder setup). If you use a GeoXM, you also need an adapter for COM port.

<http://66.29.215.14/itemimages/670980-00THMB.jpg>;

Laser ranger finder (e.g. TruPulse™ 200) + electronic compass setup;

LAI-2000 or LAI-2200 for LAI;

Spherical Densimeter for crown closure

(<http://www.cspoutdoors.com/spherden.html>);

Others: tape, digital camera.

Definitions

Crown class (four categories):

D Dominate-Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side

CD Co-dominant-Trees with crowns forming the general level of the crown cover and receiving full light from above, but comparatively little from the sides.

I Intermediate-Trees shorter than those in the two classes above but with crowns either below or extending into the above crown cover receiving little direct light from above and none from the sides.

S Suppressed-Trees with crowns entirely below the general level of the crown cover, receiving no direct light either from above or from the sides.

Tree height: the height of the tree.

Height to live crown base: the height to the lowest, live, vertically continuous crown. The partial canopy should be at least a 30 degree wedge.

Crown width: the average of four perpendicular radii measured from the bole of a tree towards each cardinal direction.

Crown closure: the proportion of sky hemisphere obscured by vegetation when viewed from a single point.

Leaf area index (LAI): defined as the half the total leaf area per unit ground surface area (dimensionless, m^2 / m^2).

REFERENCE

Jensen, J.L.R., Humes, K.S., Vierling, L. A., Hudak, A.T., 2008. Discrete return lidar-based prediction of leaf area index in two conifer forests. *Remote Sensing of the Environment* 112: 3947-3957.

Sierra Nevada Adaptive Management (SNAMP), 2008. Study Plan and Inventory Protocol.

Paletto, A. and Tosi, V., 2009. Forest canopy cover and canopy closure: comparison of assessment techniques. *Eur J Forest Res* 128:265–272.