Field-Mapping forest structure and fine-scale spatial distribution in Sabah, Malaysia

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As part of the Stability of Altered Forest Ecosystems (SAFE) Project in Sabah (Malaysian Borneo), we used a laser technology to study structure and fine-scale spatial distribution of trees in twice-logged and fragmented forest.

In two forest blocks B and E, altogether 32 plots (each 25x25 m) placed in fragments of different sizes (1 to 100 ha) were measured. Positions (x,y,z-coordinates) of all live and standing dead woody plants with dbh ≥ 1 cm were recorded using the laser Field-Map technology (IFER) whose principles we present. Light conditions were analysed using hemispherical photographs (fish-eye lens).

Field-Map technology:

= hardware

Laser rangefinder

Impulse 200
(Laser Technology Inc., USA)

Measures distances and vertical angles (may be also used to measure height).

Hardware Specifications:

Weight:	2.2 lbs (1 kg)
Size:	6 x 2.5 x 5 in. (15.2 x 6.4 x 12.7 cm)
Power Supply:	(2) AA batteries (20 hours of use)
Measurement Range:	reflective target 1880 ft. (575 m)
Accuracy (Typical):	0.1 - 0.2 ft. (3 - 5 cm)
Accuracy (Max):	0.5 ft. (15 cm)
Range Resolution:	0.01 ft. (0.01 m)
Inclination Limits:	+/- 90 deg.
Inclination Accuracy:	+/- 0.1 deg.
Temperature:	- 22 to + 140 F (-30 to + 60 °C)
Environmental:	Waterproof to IP 67 and NEMA 6

Modification:
Laser rangefinder with a diameter scope...

...can be used to remotely measure stem and branch diameters.

+ Electronic compass

MapStar Compass II
(Laser Technology Inc., USA)

Measures horizontal angles.

Hardware Specifications:

Weight:	1.25 lbs (570 g)
Size:	12 x 2 x 1 in. (31 x 5 x 2.5 cm)
Sensor Type:	Magneto-Resistive
Construction:	Extruded aluminum
Power Supply:	(2) AA batteries (Up to 8 hours of use)
Data Output:	RS232 Serial
Format:	NMEA 0183
Azimuth Accuracy:	+/- 0.3 deg.
Azimuth Resolution:	0.01 deg.
Temperature:	-22 to 122 F (-30 to 50 °C)
Environmental:	IP 54 and NEMA 3

or

Laser rangefinder combined with an electronic compass

TruPulse
(Laser Technology Inc., USA)

Measures distances, horizontal and vertical angles (may be also used to measure height).

Hardware Specifications:

	TruPulse 200/360°	TruPulse 360° R
Weight:	220 g (0.49 lbs)	385 g (0.85 lbs)
Size:	12x5x9 cm (5x2x3.5 in)	13x5x11 cm (5.2x2.1x4.5 in)
Power Supply:	(2)AA or (1)CRV3	1 CR 123A
Environmental:	IP54	IP56
Temperature:	-20 to 60 °C (-4 to 140 F)	
Battery Life:	Minimum 8 hours continuous use	
Optics:	7X magnification	

Communication: RS232 Serial port: All Models; Bluetooth: TruPulse 200B, 360B, 360R
Range resolution: 0.1 m
Measurement Range: Max to non-reflective targets:1,000 m (3,280 ft); Max to reflective targets: 2,000 m (6,560 ft)
Inclination Limits: +/- 90deg.
Distance Accuracy: short range/light colored/large target: ± 30 cm (1 ft); long range/dark/small target: ± 0.3 to 1 m (1 to 3 ft)
Inclination Accuracy: +/-0.25 deg.; typical
Azimuth Accuracy: +/-1 deg.
TruPulse compared to Impulse+MapStar: +weight, +size, +Bluetooth, -accuracy, -environmental protection.

+ Rugged laptop

E100 - NotePAC
(Kontron, Germany)

with Field-Map software v. 10
(the Institute of Forest Ecosystem Research, Ltd. (IFER), Jílové u Prahy, Czech Republic)

Hardware Specifications:

Weight:	1,400 g
Size:	28x18.4x3.2 cm
Power supply:	Li-ion battery, 5,200mAh (5 hours) External Li-ion battery, 10,000mAh (14 hours)
Temperature range:	-20°C to +60°C (operating option)
Resistance:	dust and water splashing IP 54
Processor:	Intel® A110 Processor 800MHz, Pentium-M Core
Memory:	512 MB, 1GB DDR-II RAM
Display:	8,4" TFT SVGA - light sensor, Ultra-Bright sunlight-readable, touch screen: resistive
Communication:	USB, HSDPA/EVDO, (UMTS), WLAN, BlueTooth, integrated GPS

+ Czech person

Hardware Specifications:

Weight:	78,000 g
Height:	177 cm
Power supply:	rice and noodles
Battery Life:	Up to 11 hours continuous use
Temperature:	-40 to 50 °C
Communication:	Czech, poor English, no Malay

+ software

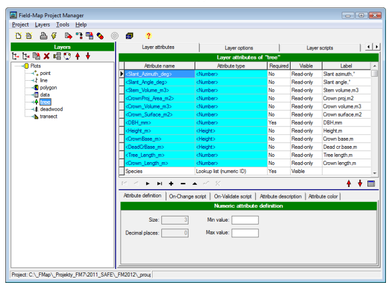
Field-Map software v. 10

(the Institute of Forest Ecosystem Research, Ltd. (IFER), Jílové u Prahy, Czech Republic)

Field-Map Project Manager & Field-Map Data Collector

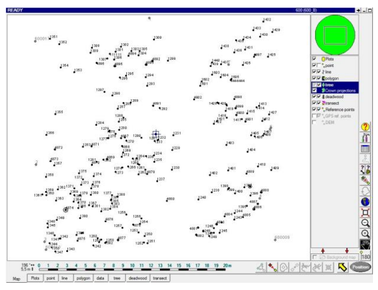
Project structure definition

Field-Map Project Manager defines a database structure of a Field-Map Project. Data types include points, lines, polygons, transects, etc.

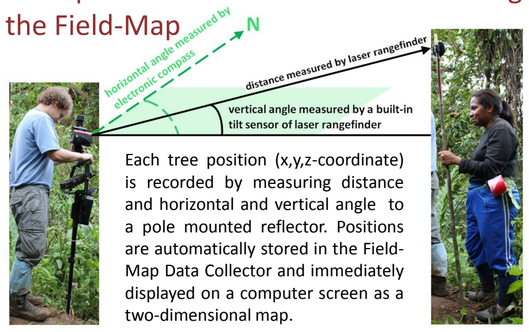


Field data collection

Field-Map Data Collector uses the Field-Map Project to collect data from laser rangefinder, electronic compass, GPS, electronic calliper, etc.



Principles of field data collection using the Field-Map



Each tree position (x,y,z-coordinate) is recorded by measuring distance and horizontal and vertical angle to a pole mounted reflector. Positions are automatically stored in the Field-Map Data Collector and immediately displayed on a computer screen as a two-dimensional map.

Basic features of Data Collector: Tree layer - map and basic data form

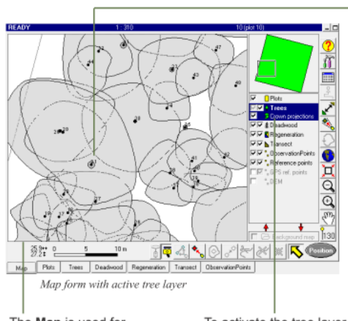
Field-Map Data Collector maintains an active relation between the map and the attribute table. Selecting an entity in the map also selects the appropriate record in attribute table and vice versa.

The **List** of measured trees is used for selecting trees.

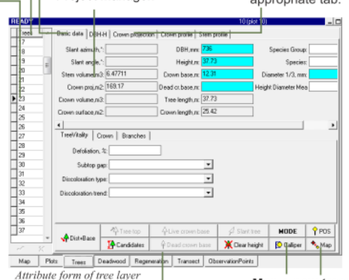
The **Overview field** is useful for showing important attributes for all measured trees.

Descriptive **attributes** of a selected tree are listed in column in the same order they were defined in Field-Map Project Manager.

Special forms for measuring horizontal crown projection, vertical crown profile and stem profile as well as DBH-H relation graph are accessible by clicking on the appropriate tab.



Map form with active tree layer



Attribute form of tree layer

The **Map** is used for viewing the position of measured trees. You can also select trees by clicking on a tree point in the map.

To activate the tree layer, doubleclick on its label in the **Layer list**.

Buttons for tree height and crown parameters measurement. The appearance of this panel changes depending on the selected tree height measuring mode.

Map a new tree button that enables mapping a new tree without switching to the map form.

Buttons for choosing the tree height measuring mode and downloading data from calliper and positioning .

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Basic features of Data Collector: Tree layer - stem profile and DBH-H form

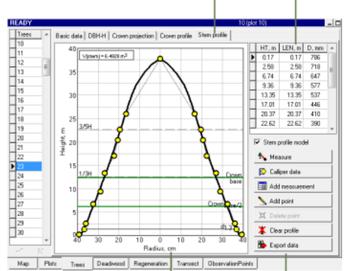
The **List** of measured diameters and heights of measuring is useful for viewing the break points.

For reviewing DBH distribution on the plot use the **DBH class frequency graph**.

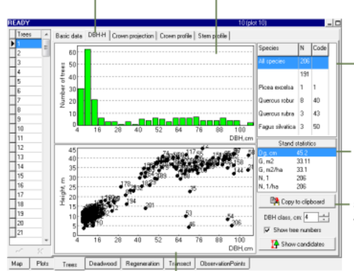
The **Stem profile form** is accesible by clicking on this tab.

DBH-H graphs are accesible by clicking on this tab.

By selecting different items in the **List** of species you display tree statistics for all or for an individual species.



Stem profile form.



DBH-H relation form.

Basic stand characteristics are calculated in the **stand statistics** window.

Buttons and settings for working with the graphs.

The **View** is useful for validating the measured shape and also for pen editing.

The **Control panel** for measuring and editing stem profiles.

DBH-H relation graph is used for a preliminary visualization of DBH and height attributes. Mistakes can be easily discerned. (In case of repeated measurement, previous and new measurement is marked using different color and/or symbol.)

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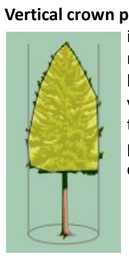
Additional features of Data Collector (not used in SAFE): Measuring horizontal projections and vertical profiles

Horizontal crown projection is measured by obtaining positions of points at the perimeter of the crown projection.

Vertical crown profile is recorded by measuring horizontal and vertical angles to a series of points at the crown profile.

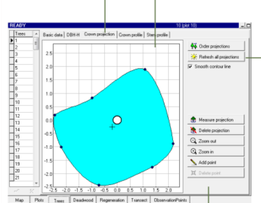


The **Horizontal crown projection** form is accessible by clicking on its tab.

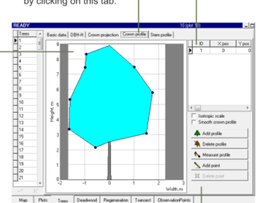
The **View** is useful for validating the measured shape and also for pen editing.

Field-Map allows you to measure several vertical crown profiles for each tree. They are listed in the **list of profiles.**

The **Vertical crown profile** form is accessible by clicking on this tab.



Tree horizontal crown projection form.



Tree vertical crown profile form.

The **Control panel** for measuring and editing horizontal crown projection.

The **Buttons** for changing the appearance of horizontal crown projection in a "Map" form.

The **Control panel** for measuring and editing a vertical crown profile.

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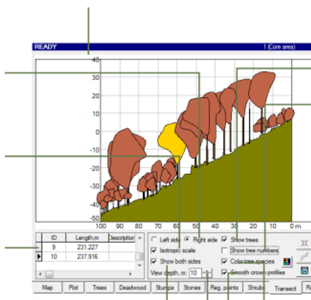
Additional features of Data Collector (not used in SAFE): Tree layer - transect

The **Transect view** is used for the visualization of vertical crown profiles. It is very useful for showing the vertical structure of the forest.

The side view can be changed using the **radio buttons**.

For displaying transect in **isotropic scale**, tag this check box.

Several transects can be measured on one plot. Select the one you want to display in the **List of measured transects**.



Transect form

Trees can be shown on the transect by tagging **Show trees** check box.

Tree ID can be shown on the transect by tagging **Show tree numbers** check box.

The **Delete point** button is used for deleting any of the measured points on the transect.

The line of the transect can be extended by selecting the **Stretch line** button.

You can export transect to Windows Metafile or Enhanced Metafile format by clicking the Export picture button.

For **Showing both sides** of the transect tag this check box.

For highlighting trees species tag Color tree species check box.

The depth of the view is defined in the **View depth** edit box.

Smooth crown profiles by tagging this check box.

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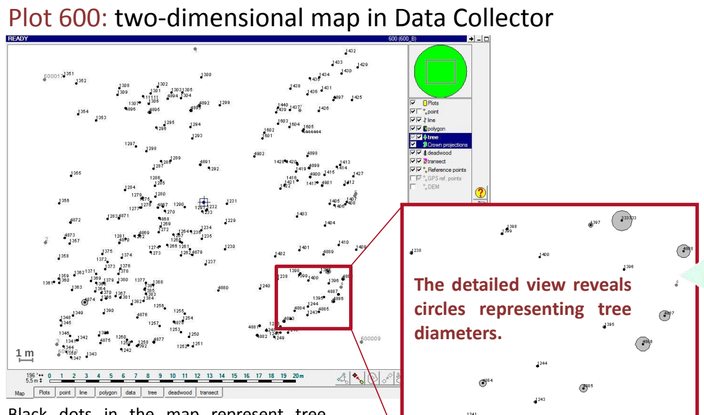
Output examples from Field-Mapping the SAFE Project

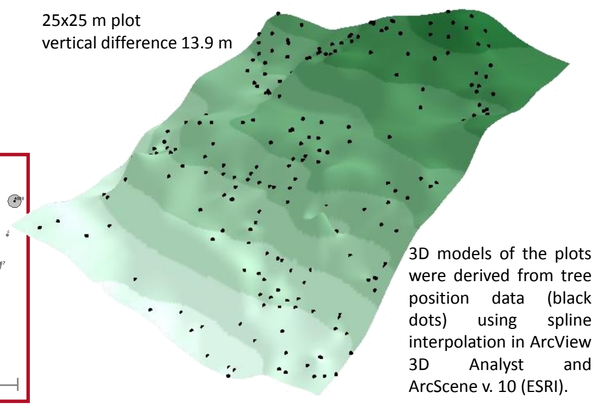
Plot 600: two-dimensional map in Data Collector



Black dots in the map represent tree positions within the 25x25 m plot.

Plot 600: 3D visualisation in ArcScene

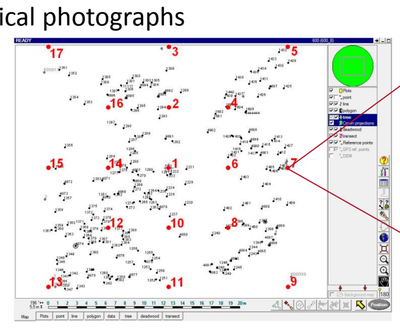
25x25 m plot
vertical difference 13.9 m



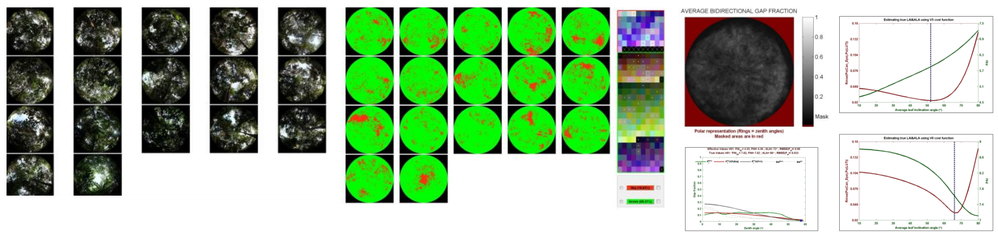
3D models of the plots were derived from tree position data (black dots) using spline interpolation in ArcView 3D Analyst and ArcScene v. 10 (ESRI).

Plot 600: hemispherical photographs

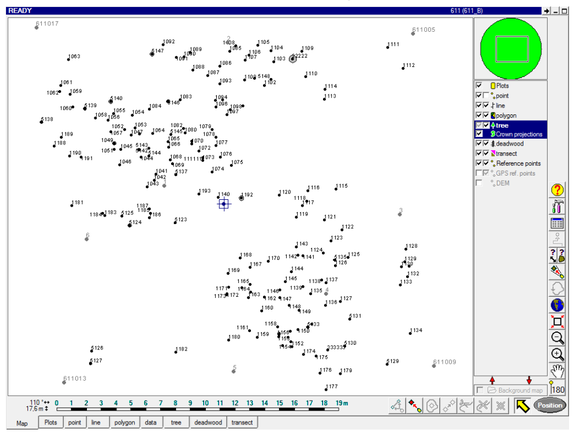
To measure light conditions, hemispherical photographs were taken at 17 points (see right) within each plot at two different heights (0.5 and 2 m) using the Canon EOS 550D camera with Sigma 4.5mm f/2.8 EX DC HSM Circular Fisheye lens. The photos are being analysed (see example outputs below) using CAN-EYE software v. 6.39 (INRA, France).



Hemispherical photo taken at 2 m height.

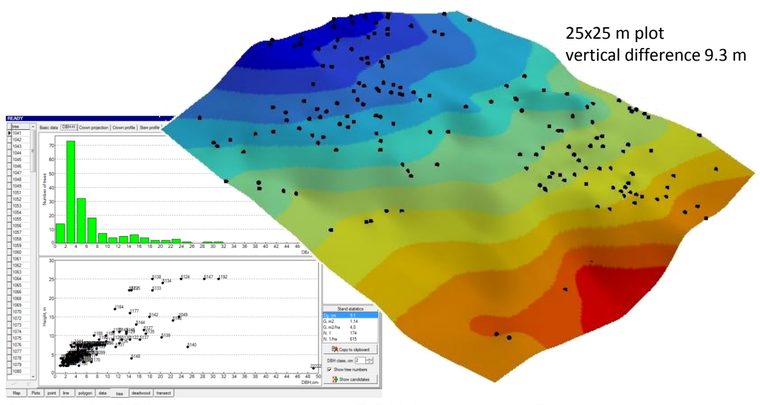


Plot 611: two-dimensional map in Data Collector



Plot 611: 3D visualisation in ArcScene

25x25 m plot
vertical difference 9.3 m



Plot 611: DBH distribution and DBH-H graph in Data Collector

The data (tree positions, DBH, height, species, and light conditions) which were collected by pre-logging Field-Mapping will serve as a baseline for future re-measurements. Repeated Field-Mapping of 25x25 m 'vegetation' plots is planned every year to capture the effect of forest fragmentation on the dynamics of (especially small) trees at the fragment edges and centres.

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