Forest Condition Monitoring in Finland – National report

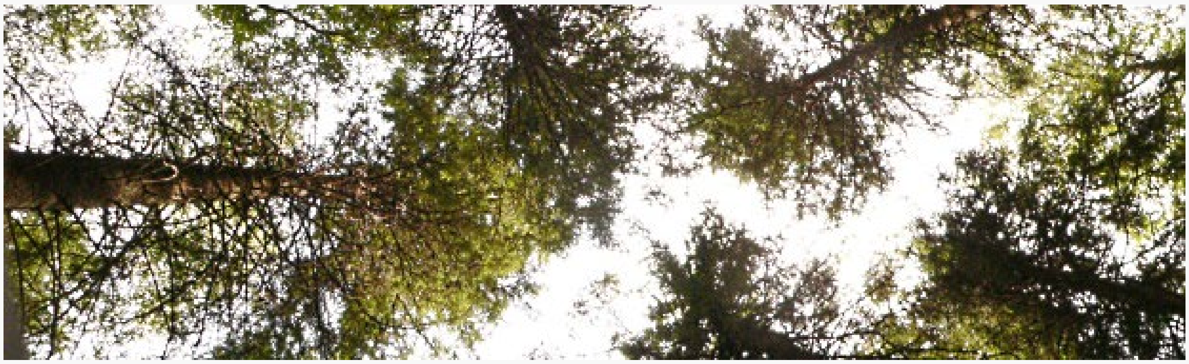


Photo: Liisa Ukonmaanaho

Estimation of canopy cover using planar photography method

By Liisa Ukonmaanaho & Jaakko Heikkinen

Summary

Estimation of forest canopy cover is an important part of forest inventories. We determined canopy cover in 18 Level II plots in August 2010 using digital camera and image analyses technique. Traditional canopy cover varied on Scots pine plots between 32 to 79%, on Norway spruce 30 and 91% and on birch plots 70 to 91%. The effective canopy cover% was less than traditional canopy cover %. In northermost plots the canopy cover was generally less than in southern plots.

Background

Forest canopy cover is an important ecological indicator, that can be used for example to characterize forest microclimate and light environment or to recognize habitants suited for several plant and animal species (e.g. Jennigs et al. 1999, Korhonen & Heikkinen 2009). Canopy cover is also an important ancillary variable in the estimation of leaf area index (LAI) using empirical or physically based vegetation reflectance models (Jasinski 1990, Kuusk and Nilson 2000). In addition, the international definition of a forest is based on canopy cover: at 0.5 ha area potential canopy cover should be at least 10% and potential tree height at least five meters (FAO 2000).

Canopy cover is defined as the proportion of the forest floor covered by the vertical projection of the tree crowns. However, it has been discussed, whether the gaps inside tree crowns should be counted as canopy or not. The traditional definition of canopy cover includes canopy gaps in the cover measurement (=traditional canopy cover). In contrast the term effective canopy cover comprises only the leaves, branches and stems and not the empty spaces between them.

An estimate of the canopy cover can be obtained using e.g. field measurements, statistical models, remotely sensed information or laser scanner data. However, field measurement are the only way to define the true vertical projection of a canopy. Best known field method is the Cajanus tube (Sarvas 1953). However, nowadays canopy cover can be determined reliable and conveniently using digital camera and image analyses techniques.

Results and discussion

The traditional canopy cover was an average 59% on Scots pine stands, 71% on Norway spruce stands and 81% on birch stands (Table 1, pdf). The effective canopy cover was on average 40%, 59% and 63% correspondingly. The traditional canopy cover was on average 30% higher than effective canopy cover in Scots pine, and correspondingly 17% higher in Norway spruce and 22% higher in birch stands. The difference is due to structure of the tree species, obviously in pine stands there are more open gaps between branches and needles compared to spruce and birch stands. The lowest canopy cover % was on the northenmost plots, which are old growth forest with lowest stem volume (Intensive and continuous monitoring...Table 4, pdf).

Material and methods

Photographing

The study was carried out in nine Norway spruce plots, seven Scots pine and two birch plots in August 2010 (Fig 1). Planar photographs were taken using standard digital camera. Digital cameras have considerably higher spatial resolution than traditional AOV (angle of view) instruments (densitometer, moosehorn) and therefore they are suitable for canopy cover measurements. The photos were taken in total 32 points from one of the subplots in each stand. Sixteen of the points were above litterfall collectors which have arranged in a systematic grid (10 x 10 m), other 16 points located in a systematical grid (10 x 10) starting from the south-east corner of the plot, both network covered the subplot area. Average of both network values were used to calculate traditional and effective canopy cover %. The images were taken pointing the camera in a near-vertical, skyward direction at breast height (1.5 m), clear sky in the middlepoint of the photo. It was possible to take photos in varying weather conditions, with the exception of rain, as raindrops in the images disturb analysis. Sunny weather was not an obstacle as long as the sun does not appear directly in the images or result in severe reflections from the canopy.

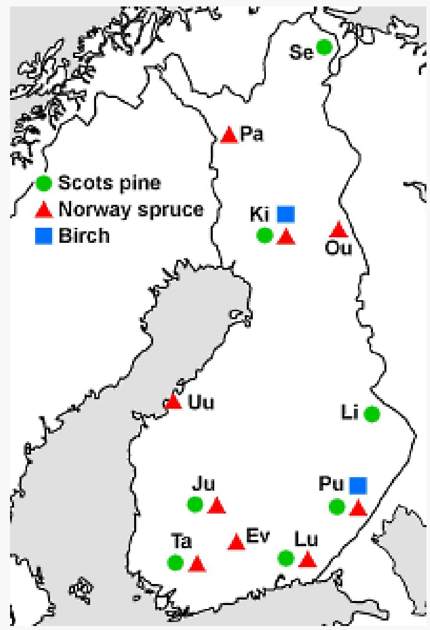
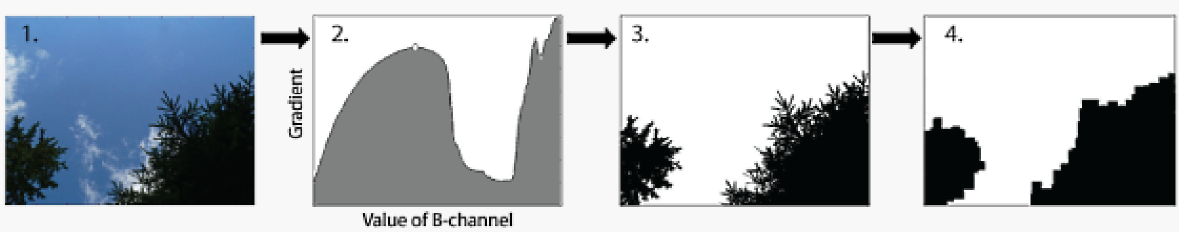


Figure 1. Location of study sites.

Image processing

Main steps of the canopy image analysis is shown in the flow-chart below. Image processing was done using Matlab numerical computing environment (MathWorks Inc. 2008).



1. Original RGB image.
2. Blue component of RGB images is thresholded according to the method proposed by Nobis and Hunziker (2005). The method is based on edge detection. Basically, the idea is to find the value of the blue channel that gives the greatest contrast between the canopy and the sky.
3. Thresholded image. The percentage of black and white pixels in the binary image is calculated -> effective canopy cover.
4. Gaps inside the tree crowns are painted over using morphological dilation and erosion operations -> traditional canopy cover.

The steps of image processing is described in detail in study by Korhonen & Heikkinen (2009). Matlab-script used in canopy image analysis and can be obtained from Matlab file exchange (Heikkinen and Korhonen 2009).

The average cover of images represents the canopy cover of the plot.

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Table 1. Average traditional and effective canopy cover (%) and sd (±) on the plots. The plots are arranged in the table to correspond to the south north gradient through the Finland.

Tree species		Plot	Canopy cover %			
			Traditional		Effective	
			mean	sd	mean	sd
Scots pine	1	Sevettijärvi	32	±22.6	24	±31.1
	6	Kivalo	60	±5.9	39	±7.5
	20	Lieksa	56	±6.8	39	±9.6
	16	Punkaharju	69	±4.0	44	±6.6
	10	Juupajoki	62	±3.4	42	±5.9
	34	Luumäki	51	±9.1	34	±12.9
	13	Tammela	80	±4.0	59	±3.9
Norway spruce	3	Pallasjärvi	30	±22.1	26	±27.6
	5	Kivalo	58	±13.0	50	±15.9
	21	Oulanka	54	±14.6	42	±18.9
	23	Uusikaarlepyy	91	±2.8	73	±2.9
	17	Punkaharju	88	±3.0	76	±3.8
	11	Juupajoki	67	±7.0	55	±9.4
	19	Evo	89	±4.6	74	±5.3
	35	Luumäki	79	±5.8	69	±7.6
	12	Tammela	82	±8.2	70	±9.8
Birch	32	Kivalo	70	±4.6	49	±6.4
	33	Punkaharju	91	±3.2	77	±3.3

Table 4. The basic stand characteristics of ICP Level II plots (measured during 2009–2010).

Plot nr.	Name	Main species	Stems ha^{-1}	Stem volume $m^3\ ha^{-1}$	Basal area $m^2\ ha^{-1}$	Arithmetic mean height m	Mean diameter cm weighted with basal area	Thinning year during 1995-2010	Stand age	Cajanderian forest type*
1	Sevettijärvi	Pine	350	82	14	11	28		210	UVET
3	Pallasjärvi	Spruce	1107	82	15	10	16		150	HMT
5	Kivalo	Spruce	1648	153	25	11	16	2006	80	HMT
6	Kivalo	Pine	1748	197	27	14	15	2008	65	EMT
10	Juupajoki	Pine	378	240	22	23	28		90	VT
11	Juupajoki	Spruce	852	419	38	21	26	2006	90	OMT
12	Tammela	Spruce	663	360	33	22	26		70	MT
13	Tammela	Pine	619	306	29	22	25		70	VT
16	Punkaharju	Pine	741	362	32	24	24	2005	90	VT
17	Punkaharju	Spruce	370	435	34	28	35	**2010	80	OMT
19	Evo	Spruce	1258	711	58	20	32		180	OMT
20	Lieksa	Pine	371	260	25	21	33		140	EVT
21	Oulanka	Spruce	1197	145	21	9	24		180	HMT
23	Uusikaarlepyy	Spruce	848	443	39	23	26	2006	65	OMT
32	Kivalo	Birch	867	130	18	15	18		55	HMT
33	Punkaharju	Birch	1037	169	18	19	16		25	OMT
34	Luumäki	Pine	625	103	14	14	19		60	CT
35	Luumäki	Spruce	678	284	28	19	27		75	MT

*Cajander, A.K. 1949.
**only dead trees removed