Fjernanalysebasert skogregistrering i Finland

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Lasse Turunen, Annukka Pesonen and Aki Suvanto: Remote-sensing-based forest inventory in Finland

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In Finland, remote-sensing-based forest inventory has established its position in stand level forest inventory during the last two years. Remote-sensing-based forest inventory is a new way to obtain accurate enough information from large forest areas cost effectively.

In remote-sensing-based forest inventory, lidar, aerial photos and local sample plots from forests are used to construct forest variables. Results of remote sensing forest inventory are used by forest companies and public forest organizations in forest planning and -operations. This new kind of stand-wise forest inventory provides new opportunities to forest organizations and their co-operating organizations, data system providers and remote sensing data providers to do better business together.

Key words: Forest inventory, remote sensing

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In Finland, remote-sensing-based forest inventory has established its position in stand level forest inventory during the last two years. Blom is carrying out remote-sensing-based forest inventories in all Nordic countries. In addition, due to huge processing capacity and customers´ interest in remote-sensing-based forest inventory, Blom has expanded its forest interpretation activity to Spain, Canada and Czech Republic. Remote-sensing-based forest inventory is based on local sample plots, lidar data and aerial photographs. When these data sets are combined in an advanced forest interpretation process, a range of useful forest characterizations are produced as the outcome.

In addition to locally conducted remote-sensing-based forest inventory projects, The National Forest Inventory (NFI) provides new data on stand level every 5–10 years in Finland. NFI provides information on the national and municipality level and it is commonly used in decision making at the national level. The accuracy of NFI data is not sufficient in stand level forest planning or at the operational level. Therefore, other methods, such as remote-sensing-based forest inventories, are needed to fulfill the information needs of operational forest use.

In 2012 there were about 12 Finnish government funded remote sensing forest inventory areas

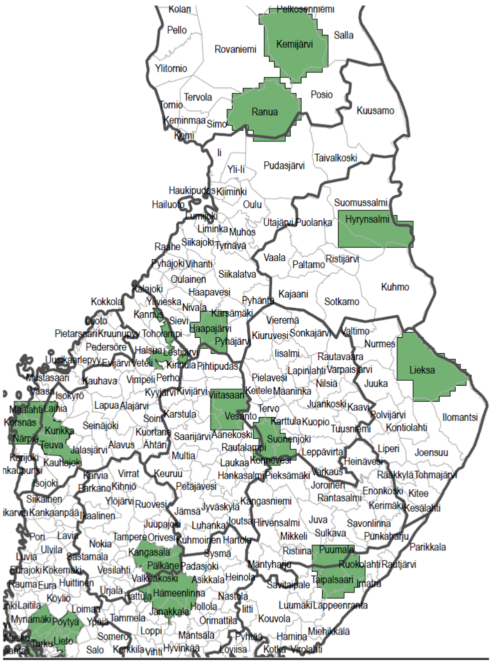

Figure 1. The forest inventory areas are shown in green. The size of the inventory areas is 50 000–400 000 hectares. In year 2012 there were about 12 Finnish government´s funded remote sensing forest inventory areas. (Map Juho Heikkilä, Finnish Forestry Center)

Most of remote-sensing-based forest inventory projects are funded by the Finnish government. In Finland, the organization responsible for stand level forest inventories is The Finnish Forest Center, established at the beginning of 2012. In addition to the remote-sensing-based forest inventory projects ordered by Finnish Forest Center, large forest owners or companies order remote-sensing-based forest inventories of their forest areas. Actually, in 2007 forest companies were the first organizations which ordered remote-sensing-based forest inventories. The inventory data collected in companies' forest inventory projects are used in forest planning or operational actions, for example.

Why use remote-sensing-based forest inventory?

Cost reduction is the main reason for using remote sensing based forest inventories in Finland. When "old traditional stand-wise field inventory" is compared to remote-sensing-based forest inventory, this new technology proves to cost less than half the cost of data collection using old stand-wise field inventory. The final cost efficiency of using remote-sensing-based forest inventory data depends on how the customers' data systems are built to utilize the data, and how educated and motivated their employees are to use the new possibilities for the data.

One relevant issue is the ability of remote-sensing-based forest inventory to capture data over large forest areas in a short time window. Remote-sensing-based forest inventory data are homogeneous compared to stand-wise field inventory because there is minimal human influence.

In remote-sensing-based forest inventory, the forest attributes produced are, for example: volume, basal area, dominant height, stem number, and median height and diameter. This new technology doesn´t produce all forest attributes, such as tree species information, as reliably as the old application. Remote-sensing-based forest inventory nevertheless provides data sets which stand-wise field inventory doesn´t provide. These include tree lists or accurate diameter distributions, which can be produced using remote-sensing-based methods without theoretical diameter distributions. The accuracy of remote-sensing-based forest inventory is as good for total tree characteristics as the traditional stand-wise field inventory, and actually in most of the cases remote-sensing-based forest inventory is more accurate than traditional methods.

In Europe, Blom is the largest company conducting remote sensing data acquisition. In forest inventory projects, source data are captured usually in the summer when leafing is full (from the beginning of June to the end of August). In National Land Surveys (NLS), lidar data are captured in the spring time in the «leaf off» season. These lidar data are also used in forest inventory projects. NLS lidar data are principally collected for detecting the ground surface, but the forest interpretation requirements are still taken into account as well as possible. Generally, the flight and scanning specifications of NLS lidar data differ from the usual specifications in forest interpretation and this method is therefore not ideal for forest interpretation. In recent years, cooperation between the Finnish National Land Survey and Finnish Forest Center has increased in order to reduce data capture costs.

In forest interpretation projects, vector data sets are the final outputs used in forest decision making. The forest attributes can be calculated, for example, for a regular grid cell network of 16 m * 16 m or microstands generated using automatic segmentation, in which homogenous pieces of forest are delineated based on the height and tree species variation. Forest characteristics are usually delivered as attribute tables for three main tree species.

All raster data sets come as by-products of forest interpretation data capture or processing. Starting in the 1980´s, CIR orthophotos have been the most commonly used forest raster data sets. In 2009, laser rasters were initially delivered to forest customers in Finland. Soon after that the first forest companies discovered the benefits of laser rasters. Canopy Height Model (CHM) and Digital Terrain Model (DTM) are the most used laser rasters. CHM is used together with orthophotos in forest planning in stand delineation and determination of treatment units. DTM is used in harvest planning and ditch cleaning planning.

In Finland, all major forest companies have advanced GIS systems which can exploit re-

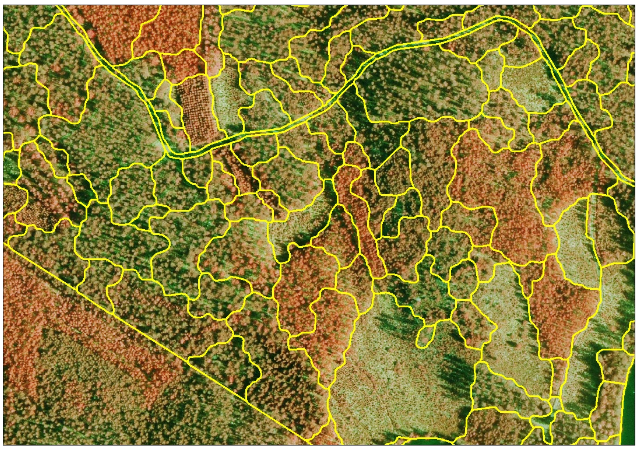

Figure 2. Blom´s generated microstands presented on top of CIR orthophotos. Microstands are homogenius pieces of forest which can be used as forestry treatment units.

	Value
	Microstand_results
	106958
(Actions)	
(Derived)	
Area	0.14144132265
CUTTING	2
DBW_DECID	30.71
DBW_PINE	31.06
DBW_SPRUCE	23.19
DBW_TOT	27.78
DEV_CLASS	04
FERT	3
G_DECID	10.99
G_PINE	11.57
G_SPRUCE	15.28
G_TOT	37.83
HBW_DECID	22.7
HBW_PINE	23.53
HBW_SPRUCE	19.36
HBW_TOT	21.61
HDOM	25.73
Id	106958
LASER_DENS	90.6666902472347
LASER_H	23.8631738730945
MAIN_TS	2
N_DECID	373
N_PINE	175
N_SPRUCE	763
N_TOT	1311
SAP_TREAT	NULL
T_DECID	92
T_PINE	93
T_SPRUCE	91
T_TOT	92
V_DECID	104.25
V_PINE	125.18
V_SPRUCE	141.15
V_TOT	370.57

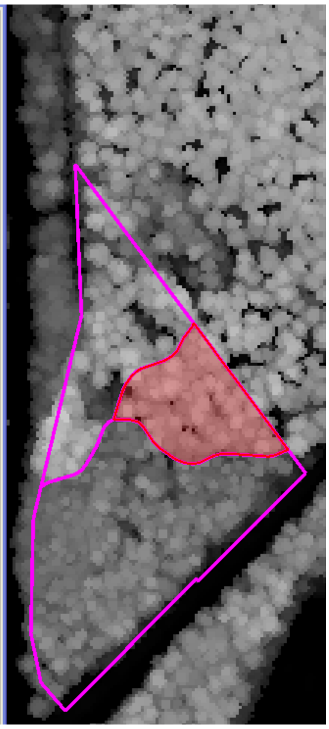

Figure 3. Here Blom´s main forestry attributes are presented. Many forest and laser variables are delivered at microstand level.

mote sensing datasets. Many of Blom´s forest customers are developing their data systems continuously to facilitate more efficient use of remote-sensing-based forest inventory data. A stand level generalization tool is one of the best examples of preparation to use remote sensing data. That kind of tool can nowadays be found in most of the forest costumers' data systems. Blom is co-operating with data system providers to allow the forest inventory data sets to work in customers' data systems as well as possible. Co-operation is useful for both parties, and also for the customer. Every forest interpretation project is unique and requires new development work. To date, Blom has been able to deliver all required forest inventory data sets in the data formats used by the customers' data systems.

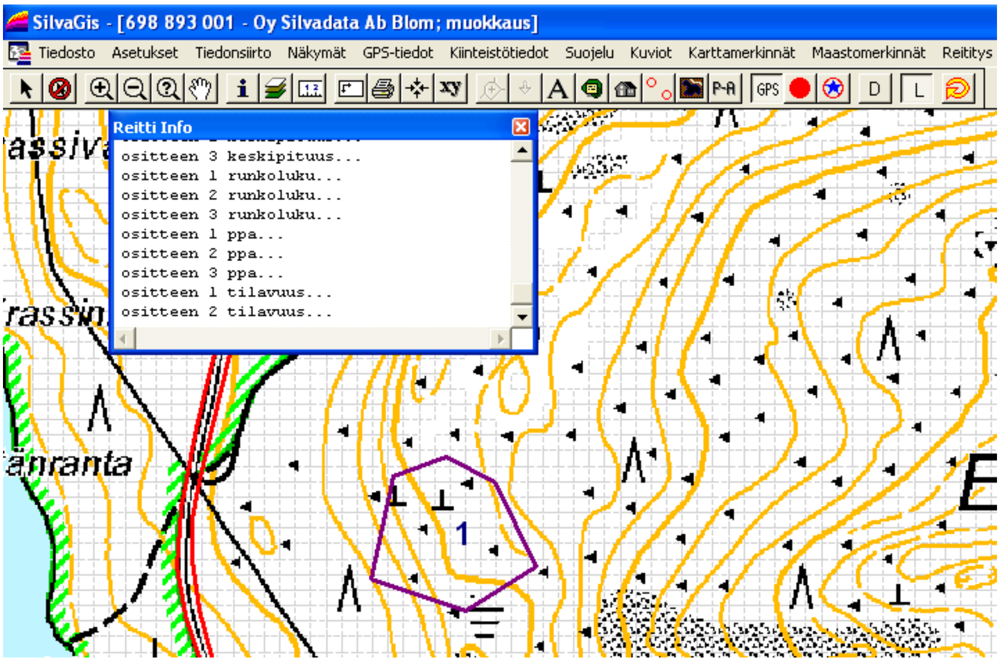

Figure 4 is a screenshot from Silvadata´s forestry data system. SilvaGis stand level generalization tool can calculate forest variables inside a wanted closed vector polygon from a grid cell network.

Future view

Due to the short history of remote-sensing-based forest inventory, this technology is not utilized to the extent that it could be. In the near future, the greatest opportunity is for forest organizations in different countries to utilize more extensively the various remote-sensing-based forest inventory data sets, such as forest interpretation characteristics and lidar rasters. Forest organizations traditionally use old data sets and systems, and changes in working routines often happen very slowly. Luckily, the younger generation, especially, has recognized the benefits of remote-sensing-based forest inventory data sets and the pressure of making a final breakthrough of new inventory technology clearly rests on the shoulder of the younger generation.

The global discourse about biomass and carbon calculations has been active during recent years. This far the discussion has mainly been at a political level and the actual actions are minor. In the future, to involve in biomass and carbon inventories might be an opportunity also for Blom.