PRECISION FORESTRY AND ITS TOOLS

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Abstract
The public demands on environment are changed by history what constantly requires modification management of environment. Nowdays, modern technologies allow to keep abreast of increasing requirements of population. The present article provides a survey of precision forestry and its tools, and next it reviews recent progress in forest management. The article is intended to present some of the principles that govern the gathering of data useful for not only forestry.

Key words

Precision forestry, tools of precision forestry, data of precision forestry

1 INTRODUCTION

Forests in the World and Europe are great variety and diversity which is caused by different climate, terrain, age and growth condition. The result of these conditions is miscellaneous biodiversity of stands (tree species) and consequent divergence of wood quality features. Forest resources mainly wood are important for wood processing industry. All forest owners and wood industries would like to obtain roundwood with the best quality, adequate dimension and quantity. Not only demands of wood production, but also increasing economical and environmental public demands require new access solution as well as new technologies, which new and precision data offer us. The detailed data which are collected, analyzed and stored are used for successful management. Profitable management is the result of right planning, organization and control of all forest operations. These claims are reached by implementation of precision forestry.

Precision forestry is new direction for better forest management. Management principle of precision forestry was based on precision agriculture. Precision agriculture is an information-based, decision making agricultural system desingned to improve the agricultural process by precisely managing each step to ensure maximum agricultural production and continued sustainability of the natural resourses (RASHER 2001). Precision agriculture can be defined as managing crop inputs, such as fertilizer, herbicide, etc. on a site-specific basis to reduce waste, increase profits, and maintain the quality of the environment (TAYLOR et al 2002). It uses set of tools, which have been successfully introduced whole World and now they have been used in precision forestry.

Precision forestry is focused on information and supports economical, environmental and sustainable decision by using high technology sensing and analytical tools. It provides highly repeatable measurements, actions and processes to initiate, cultivate, and harvest trees, as well as to protect enhance riparian zone, wildlife habitat, and other environmental resources. It provides valuable information and linkages among resource managers, the environmental community, manufactures and public policy (DYCK 2001). Precision forestry is defined by TAYLOR et al

(2002), as planning and conducting site-specific forest management activities and operations to improve wood product quality and utilization, reduce waste, and increase profits, and maintain the quality of the environment.

Definition of "precision technologies" is: Instrumentation, mechanization, and information technologies that measure, record, process analyze, manage, or actuate multi-source data of high spatial or temporal resolution to enable information based management practice or to support scientific discovery (SCHMOLDT, THOMSON 2001).

2 TOOLS OF PRECISION FORESTRY

2.1 Airborne and satellite remote sensing technology as LIDAR (Light Detection and Ranging) and IFSAR (Interferometric Synthetic Aperture Radar)

These technologies have significant advantage because they are capable of collecting highly detailed data quickly from large and in varying conditions area at repeated time intervals. LIDAR offers us many different data products as digital elevation model grid, contours, raw point data and intensity image. From data of IFSAR we are able to obtain almost similar products like from LIDAR however Orthorectified Radar Imagery (ORRI) is very significant data product of IFSAR. These products are used in Hydrology Modeling, Flood Risk Assessment, Land Use and Land Cover Mapping, Earth Crust Deformation Monitoring, Riparian Studies and Forestry Mapping.

Mainly, LIDAR has important meaning in precision forestry because of accuracy and other advantages. This technology can be used as airborne laser scanning and terrestrial laser scanning. Nowadays, it is one of the most used and researched new technology in the world by which we have reached valuable and useful information of Forestry Management and other branches as Shoreline and Beach Volume Changes, Flood Risk Analysis, Water-Flow Issues, Habitat Mapping, Subsidence Issues, Riparian Studies, Emergency Response, Transportation Mapping, Telecommunication Planning and Urban Development.

Other airborne and satellite remote sensing technologies offer us to aqcuire data from high spatial resolution images, multi-spectral and hyperspectral images. In general, the remote sensing technologies are fast, accurate and cost-effective sources of data.

2.2 GPS (Global Positioning System)

They are highly accurate satellite based radio navigation systems which provide us three dimensional positioning (elevation z and ground coordinates x, y) and time information. This system gathers position data single objectives. Object mapping utilizes both qualitative and quantitative data collection techniques in order to create a database containing the spatial location and attributable information of the objects. Better accurancy can be achieved by differential GPS (KHALI 2001). GPS is American componemt of GNSS (Global Navigation Satelitte System) where Russian GLONASS belongs to, too. In the future there will be GALILEO, which has been developed by Euroupe.

The equipment on the GPS basis, sometimes called GPS/GIS, is effective in data collection in forested areas, e.g. also in forest stand description (forest taxation), in forest detail object location and attribute collection in forestry thematic mapping (TUČEK et al. 2002). These systems are used mainly for navigation on the ground and under canopy but LIDAR and IFSAR remote sensing technologies are equipped with GPS for obtaining accurancy coordinate system of flying. This time there is effort to equip the new forest (wheeled skidder, track skidder) and agriculture technologies by GPS, because of their navigation and monitor. GPS builds connection among map, image or digital database and real, physical location on the Earth surface. A possibility of using such equipment for tracing and navigation (from the map, plan or image to real conditions) is its another important attribute (TUČEK et al. 2002).

2.3 Real-time process control scanners

Tools of precision forestry which belong to here, propose information in real-time. They have hardware and software device which can be used either directly in the forestry fieldwork (combination by GPS) or in the wood processing industry (sawmill).

- ***RFID*** (Radio Frequency Identification) – it is focused on identifying trees and timber via wireless means and on sensing properties of the tree/timber during the identification process. RFID is a tag on tree that can gather a wide variety of information about trees and wood in-situ and real-time (WILSON et al. 2001).
- ***UDD*** (Ultrasound decay detectors) – it is used to detect decay in trees. It measures ultrasound signal time of flight from the transmitter to the receiver across the diameter of a tree (LEININGER et al. 2001).
- ***Automated Log Grading System*** – Computed tomography uses x-rays to produce high-resolution cross-sectional images of the internal structure of log (RAYNER et al. 2001). The result is a defect map from the computed tomography data.

2.4 GIS (Geographic Information System)

GIS is a spatial information system that comprises four basic elements of computer hardware, computer software, data and user. By capturing, storing, checking, manipulating and analyzing the terrain information concerned with spatial and geographic distribution, it can export all kinds of data and graphs, and provide a series of assistant facilities and plan for the decision maker (LI et al. 2000).

It is a requirement to transfer and keep spatial data related to forestry in a standard computer format preferably in a GIS environment. GIS is an integrated resource data base system that has the capability to store, edit and process digital data; and that supports development planning and analysis (KHALI 2001). GIS is an abbreviation of geographic information system, which deals with collection, storage, retrieval, management of data, conversion, analysis, modeling and display spatial data.

This system can accommodate large amounts of data. GIS treats with variety data types as maps, images, digital products, GPS, text data and tabular data which are received from multiple sources. There is possible to create large databases from gaining and measuring data which are joined with vector and raster formats. These outputs provide us specific images and maps as Digital Elevation Models (DEMs), Digital Terrain Models (DTMs), Topographic Line Maps (TLMs), Contours, Shaded Relief, Slope & Aspect and Thematic Maps. The outputs are results of some analysis as Image analysis, Distance analysis, Spatial analysis, Geostatisticals analysis, Surface analysis, ect.

GIS as software has very significant meaning among other tools. This software can be integrated into handheld computers using for fieldwork and information are obtain directly outside. GIS has one important advantage, there is possible to create network of GIS, what allows quick access to data and information.

2.5 Decision support systems

They are specific software, which have been developed for solving specific problems and offer forecast and factually information. Advantage of decision support systems is that it can be joined with GIS by which we can improve results. At present, there have been some decision support systems which deal with suggesting road networks (PEGGER), forest operation planning, forest inventory and others. All of them are based on algorithms by which the solution and forecast is reached, and next vizualizated.

Among decision support systems could be file growth simulator softwares which are implemented in forestry and ecology. In Slovakia there has been developed the growth simulator with name SYBILA which provides the advantage of an individual tree modeling approach. The model is able to predict forest development under the consideration of a wide range of input parameters. The growth simulator has already been successfully applied for the simulation of the impact of climate change and differently type of forest calamity on the development of Slovak forests (FABRIKA et al. 2008). This model can be implemented into current forestry practice as a tool for decision support. Also, the other European countries have some famous growth simulator softwares as SILVA, MOSES, FOREST, STAND PROGNOSIS MODEL, BWIM and CORKFITS. These softwares are very accurate and they have been always improved.

Precision forestry and all tools provide many advantages to foresters, forest owners and wood processing industries. Information from tools of precision forestry which was collected and analyzed is treated into database. Modern information technologies allow quick and direct communication among single forest operations. This allows reducing costs and increasing yield for forest enterprise and wood processing industry.

There are some disadvantages and problems with tools of precision forestry. One of them is that tools of precision forestry are not standard in all forest enterprises. Individual tools of precision forestry must be necessary combined to obtain more precise information not only quantitative but also the qualitative aspects of the forest resource. The most common combination of tools are GIS, GPS and remote sensing technologies, which offer adequate resources of gaining precision data and additionally accurancy information using for decision. The other tools have narrow range of utilization and they are focused on specific field of forestry management. The next disadvantage is the price of some required data types which are significantly influenced by cost of tools operations and their accessibility. Tools of precision forestry are demanding mainly on hardware and some of them also software. Because of demandingness on hardware, the acquisition costs are increased and tools are not approachable for all forest enterprise at present.

3 DATA AND INFORMATION OF PRECISION FORESTRY

Among character, data, information and knowledge there is tight relationship which is shown by the Figure 1.

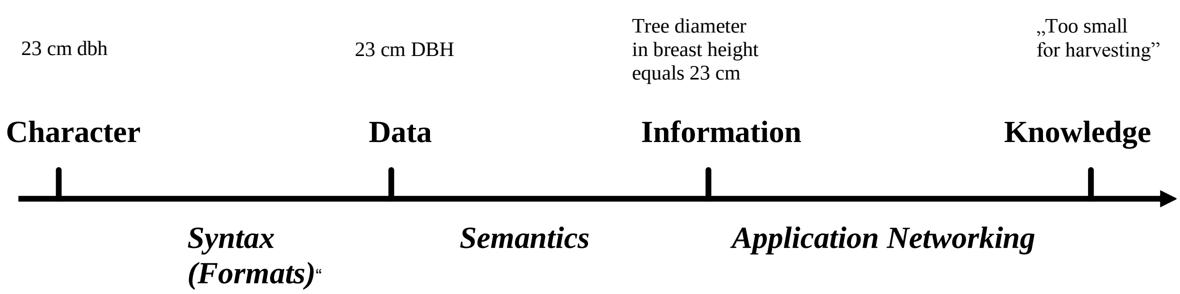

Figure 1 From character to knowledge (KÄTSCH 2006)

Collected data are characters about trees, stand, soil properties, water supply, terrain, forest resources, wildlife habitat, etc.

The main types of data, which are collected and measured to a higher-level resolution are:

- *Trees data:* stem diameter, height, increment, quality of stem and crown, crown density, volume

- *Stand data:* canopy, structure, species of trees, localization of stand, standing volume, health, age, density

All recording data from tools are processed by suitable software and additionally necessary information is gained. Information has been recognized as being of similar importance as the basic production factors in producing enterprises. It plays an important role in planning, implementation and controlling production processes while supporting the management by providing relevant data on how to dispose of all relevant production factors (KÄTSCH 2006). There is some issue of information quality, mainly problems with poor accuracy, low precision, incompleteness and missing relevancy, which can be removed by combination and development of tools of precision forestry. Obtained information from treated data can be used by all forest operations, wood processing industry and environmental protection.

- Information for forest operations is used by selecting the suitable stand, harvesting operation, forwarding, storage and transport wood. Knowledge of information significantly influences planning, organization, control and duration of forestry works.
- For wood processing industry there is important information about wood as dimension, grade, grain, blight disease, stiffness and taper. This information influences production wood products thereby profitability wood industry.
- For environmental protection there is important information mainly about soil as erodibility, disturbance, compaction of soil, and water supply as sedimentation, ditchwater. New information and knowledge have significant function in protecting unusual ecosystem, part of county so aquatic and wildlife habitat.

4 CONCLUSION

Precision forestry and agriculture have three principal parts by which we acquire required results:

1. Make precise measurements and continuously monitor conditions of following area or plants
2. Organize large volumes of data with spatially referenced databases
3. Analyze and interpret that information using decision support systems that make favorable choices (SCHMOLDT, THOMSON 2001).

Precision forestry tools will help to make future operation more economical and satisfy public and environment demands. This is important for sustainable management of forest and renewable resources. By idea of precision forestry we are able to improve productivity of forest, long-term planning, global and crop inventory, planning of road network (hauling road, skid trail), sustainable utilization of renewable resources and reducing negative environmental consequences.

Integration of precision forestry into Slovak forest management will have important meaning in the future. Quick progress of precision forestry assigns to make technologies and accurate data accessible both forest enterprise and public. Additionally, every deficiency of forest management can be reduced or completely removed. This new direction of “Precision forestry” will bring modernization into Slovak silviculture.

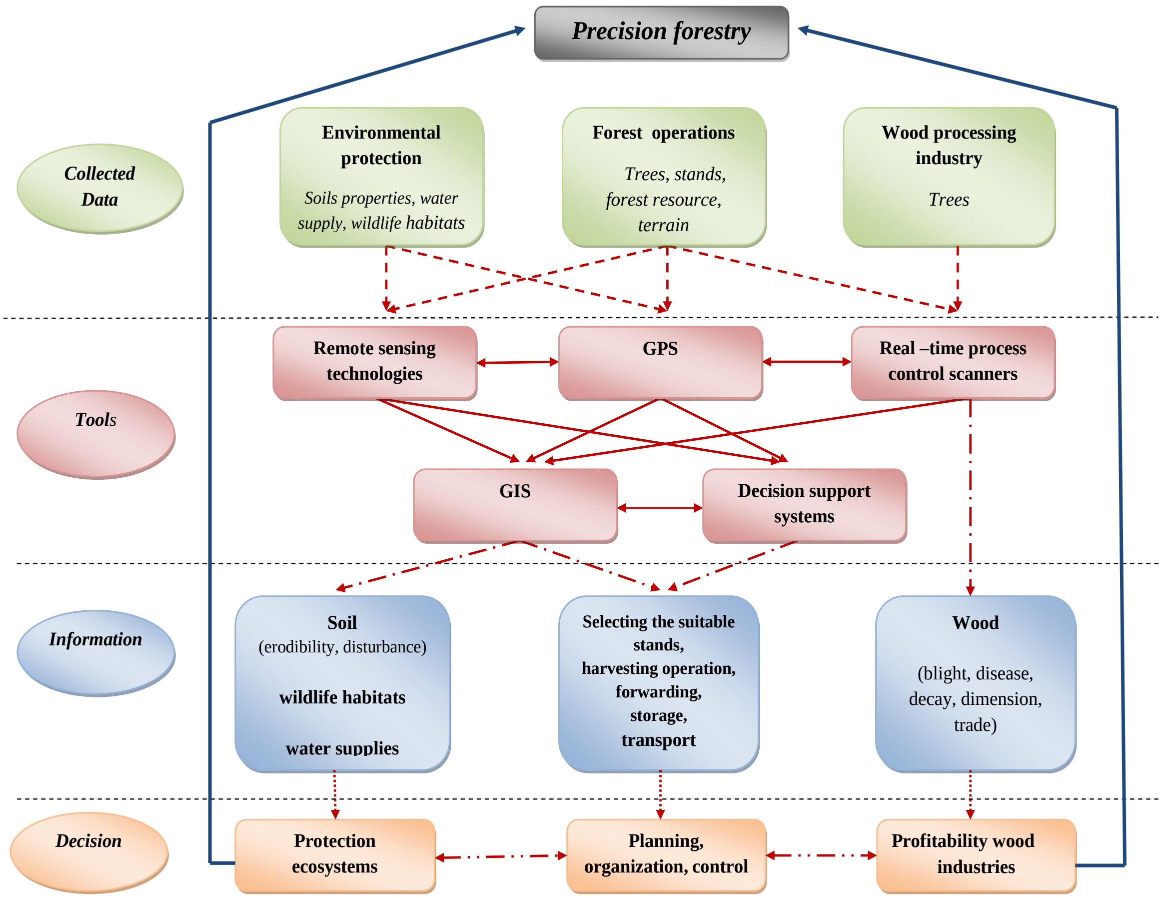

Figure 2 Diagram of Precision forestry

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