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PRESENTATION BRIEF

TITLE : Precision Forestry, A New Approach For Forestry Management

"Precision forestry" is relatively a new term that has recently becoming more well-known especially to the European and North American foresters. However, there is no universally-accepted definition of precision forestry yet. Generally, precision forestry applies a site-specific management concept. It uses the latest technology sensing and analytical tools to collect highly accurate measurements, activities and processes of forested landscapes that are critical in making smart, sustainable management decisions that support site-specific and environment concerns. Advent of technologies such as hyperspectral remote sensing, high-resolution remote sensing, mobile GIS mapping using GPS, LIDAR, PDA's, laser range finder, Silvascan-2, PEGGER-GIS render precision forestry approach a reality for sustainable forest management. However, grasping and integrating these technologies is not yet a straightforward undertaking. This paper discusses the possible application for forestry operations and how it benefits sustainable forestry management.

Precision Forestry – A New Concept for Forestry Application

By

Dr. Alias Mohd Sood

"Precision forestry" is relatively a new term that has recently becoming more well-known to the European and North American foresters. However, there is no universally-accepted definition of precision forestry yet. Generally, precision forestry applies a site-specific management concept. It uses the latest technology sensing and analytical tools to collect highly accurate measurements, activities and processes of forested landscapes that are critical in making smart, sustainable management decisions that support site-specific, and environment concerns. But what is the potential of these technologies, and the special challenges for precision forestry particularly in Malaysia? This paper discusses the possible application for forestry operations and how it benefits sustainable forestry management.

1.0 Introduction

The need for precision forestry is no longer an option in managing forest and producing forest products. Driven by both the ever increasing scrutiny over protection of forest resources and the economic need to use forest products to the fullest, professional foresters now demand quality detailed information about forests they manage and products they produce.

According to Dyck (2003), the term "precision forestry" may vary with foresters of different disciplines. To forest geneticist it may probably means precisely matching the genetics of a tree species to the site to maximize growth. Whereas, to an industrial forester it might means precisely managing a forest to match what a market needs. But, to a forest conservationist it probably means being able to precisely manage a forest to optimize environmental benefits. Since precision forestry can be applied to various disciplines of forest, Taylor et.al 2000 proposed the general field of precision forestry be separated into three main categories:

1. using geospatial-information to assist forest management and planning,
2. site-specific silvicultural operations, and
3. coordinated harvesting, product evaluation, and transportation systems.

Precision technology concept, similarly Precision Agriculture became more applicable upon availability of high spatial satellite imagery and Global Positioning System (GPS). Precision Agriculture has shown to be successful in many places and in Malaysia it has been carried out in Kedah and Sabah for various crops precise management such as rice, oil palm and banana. According to Robert et. al (1994), precision agricultural started with site-specific crop management concept which is information and technology based agricultural management system to identify, analyze, and manage site-soil spatial and temporal variability within fields for optimum profitability, sustainability, and protection of the environment. Thompson and Schmoldt (2003), expanded the idea and outlined the concept of precision agriculture as to;

(1) make precise measurements and continuously monitor field and plant condition through sensors and instruments,

(2) organize large volumes of data with spatially referenced databases,

(3) analyze and interpret information using decision support systems that make economically favorable choices.

Precision Forestry follows similar concept but because of the difference in business nature it needs modification. To institutionalize the concept, a Precision Forestry Cooperative (PFC) was set-up at the Washington University to develop tools and processes that increase the precision of forest data to support better decisions about forests, their services and products, through a collaborative effort with private landowners, public agencies, manufacturers and harvesters

According to Bare (2003), precision forestry employs high technology sensing and analytical tools to support site-specific, economic, environmental, and sustainable decision-making for the forest sector. It provides highly repeatable measurements, actions and processes to grow and harvest trees, as well as to protect and enhance riparian areas, wildlife habitats, esthetics and other environmental resources. It provides valuable information and linkages between resource managers, the environmental community, manufacturers and public policy. It links the practice of sustainable forestry and conversion facilities to produce the best economic returns in an ecologically and socially acceptable manner.

2.0 Why need precision forestry?

Managing forests in today's ever more educated and environment-concerned public makes it into an increasingly complex and demanding challenge to forest managers. Decisions are made in an atmosphere of often conflicting values with considerable uncertainty. This demands professional forester to acquire more knowledge related to environment and ecology especially at site level information. This call for precision forestry application providing reliable, fast and accurate information.

One the main reasons that forestry is complicated which demands for greater precision is the enormous complexity of trees. After decades of research, we still fail to understand some of the fundamental principles of tree growth and wood. We can grow big trees within short period of time, but we don't fully understand the linkages between growing trees and creating high value wood (Dyck, 2003). Ideally, we would like to know just how variable the quality is in the stand, both within and between trees.

The reforestation and afforestation projects such as Enrichment Planting and Forest Plantation have focused on the log market and the tree market. Consequently, we've either strived to grow volume per hectare or volume per stem. Other than branch size and straightness, there has been relatively little focus on wood quality. Moreover, the success testimony of the Enrichment Planting project is yet unpersuasive. Consequently, technical aspect of the project is currently under revision to further reduce mortality and increase the growth. Hence, it's timely for forest scientist to acquire precise information so as to better understand the species/genetic + soil + gap + geology + slope + elevation + rainfall + micro-climate + others factors associations. Precision tools synergizing technologies and data at site level and analyses carried out can derive new and useful information to understand these associations.

Maps are among the most important forest management tools. The GIS maps are basically originated from scale 1: 50 000 acquired in digital format from the Survey and Mapping Department Malaysia (JUPEM). For forest planning or at macro level, this scale is sufficient but for forest operational we need maps at 1 ; 5,000 while the tree location maps require scale at 1:1,500. Errors and inaccuracy often occur when the basic scale map was enlarged to operational scale and this often lead to unsatisfactory result to the foresters. Thus accuracy of the basic maps needs to be enhanced and this is where precision technologies are pertinent.

3.0 Benefits of precision forestry to forestry applications

Satellite remote sensing technology although has been for three decades has not been very operational especially for industrial forestry. However, most recent advances of this technology have shown potentials. High spatial resolution imagery such as Quickbird (0.6m resolution) and IKONOS (1.0m resolution) provide better forest boundary identification with less remote sensing processes. Meanwhile, airborne hyperspectral imagery depicted promising results for assessing disease infestation and nutrient deficiencies in production forest (Dyck, 2003). According to Kamaruzaman (2005), hyperspectral imagery can also identify Tropical tree species (this is unprecedented for Remote Sensing technology); besides precisely estimating the tree volume and mapping precisely tree location. He tested the potential of airborne hyperspectral imagery at Kelantan, Peninsular Malaysia and information gathered will be useful for site-specific management.

Applying temporal hyperspectral imageries say, before logging and after logging can precisely determine the stock of the area and it's residual after logging. Hence, loggers can estimates their financial more accurate while forest managers can locate accurately areas to be rehabilitated. Road planning will also be better planned avoiding as many potential next-crop trees as possible. Furthermore, tree location map can be generated directly from hyperspectral imagery, thus eradicating the tedious and time-consuming task of the conventional method. If this technology succeeds, it has high potential to supersede the traditional Pre and Post Felling inventories as well as tree location mapping which currently are very time-consuming operations.

The Global Positioning System (GPS) is being used in an ever-increasing array of applications for managing forests and our natural resources. In America, GPS are attached on mobile forest harvesting machines. Data collected from GPS and additional external sensors can improve forest engineering design and management decisions based on machine performance data as a function of terrain and timber stand variables (Taylor et.al. 2001). Applications employing GPS capabilities are being developed for use in site preparation, planting, and managing intensive culture plantations. Forest road and skid trails were precisely mapped through GPS for better supervision. Developments in GPS technology and precision forestry readily adapted to problems in forest operations, particularly in intensive forest production systems. Global Positioning System (GPS) mapping offers accurate information on the ground as well as on the map.

One example of activity towards precision management of forestry application in Malaysia is the Fire Danger Rating System (FDRS) at Sabah Forestry Department (SFD). For ASEAN region, FDRS index can be acquired through the Malaysian Meteorological Services website, but information is only near real-time and is very coarse. Thus, SFD needs substantial amount of local weather stations to relay finer result and at real-time condition. However, Sabah has only few weather stations available throughout the state, and would be insufficient to yield accurate information for fire detection on the site. Eventually, SFD build another 6 electronic weather stations throughout the state to obtain more precise information of FDRS index for each region in Sabah (Phillis 2005).

Traditional ground-based forest inventories give reasonable estimates of tree volumes by species and to some extent external log grades, but as a rule we tend to be less accurate at estimating the true value of stands especially the wood properties. In the absence of reliable technologies, local knowledge and experience becomes extremely important for estimating the inherent wood properties and hence the value of stands and trees. Currently, with Silvascan-2 developed by CSIRO in Australia, fibre properties from an increment core can be measured up to 1,000 times faster than traditional lab-based methods. Meanwhile, in New Zealand, another instrument called Director was developed to determine the average stiffness of lumber produced in logs based on time-of-flight sonics and by inference the value of logs (Dyck, 2003). These technologies enhanced precision forestry for better forest or wood evaluation.

Traditional road proposal was done by laying out a route on a topographical map of the area by the logger. Upon completion, the forest officers will then go to the field to evaluate the proposed road alignment. There's no guarantee that the route was the most environment-friendly or most economical. Now, with a new GIS tools, called PEGGER of ArcView extensions, forest managers can propose the best route for harvesting taking into all the considerations specified by user. Complementing PEGGER, is a companion program ROADVIEW that takes the preliminary route location generated by PEGGER and creates a 3-dimensional model of the road's cuts, fills and running surfaces (Rogers and Schiess, 2001). The accuracy of the systems depends highly on the accuracy of the contours input. Using LIDAR, digital elevation data can be acquired at 10 meters interval as opposed to current 30 meters. These precision technologies can produce information as accurate to the ground.

According to Aruga (2003), implementation of a more efficient and precise forestry operation requires more precise and accurate data on topography and forest conditions. Topography can be measured accurately from by LIDAR. The Japanese Forestry Agency project, developed a survey tool, Formas, consisting of a GPS, an electrical compass, a laser range finder, a digital caliper, and a PDA to precisely measure tree height, diameter, and location and to easily calculate the volume.

As public are more environment-concerned, the forest products international market demands certification that the wood originated from a sustainable-managed forest. This requires tracking the movement of individual logs from stump to mill or at least determine the chain-of custody of group of logs back to the individual stands. Traditional tracking is by paper tagging at each log. Though not in Malaysia yet, bar-coding and radio frequency identification are the dominant technologies for tagging and tracking of forest products. According to Murphy (2003), now, a novel technology, aroma-tagging and an electric-nose forest were introduced at America to track logs from forest through the mill and out of the drying kiln.

Forest inventory, which has to be regularly monitored and repetitively measured is a major indicator of forest resource. Traditional method of inventory is ground inventory which is relatively laborious and time consuming especially if covers large area. According to Andersen et. al. (2003), now with airborne laser scanning of Light Detection and Ranging (LIDAR) technology, forest inventory can be complemented and shown in three-dimensional (3-D) forest structure quantified by measuring vegetation cover of the overstory, understory, shrub, and ground layers. 3-D forest structure information is critical to support a variety of ecosystem management such as habitat assessment, ecological restoration, fire management, and commercial timber harvest. LIDAR can acquire data in night or cloudy weather. In a GIS, LIDAR data can also be displayed in grid format or as contour lines (Faruque, 2003). Although it can measure tree height, however, not proven it can identify tree species, but if fuse with hyperspectral imagery data, they would generate an enormously precise forest inventory result which forest managers would desire to have such data on their screen.

Forest inventory also include acquiring information on number of trees, diameter, volume and stem condition. Stem mapping is a mean to capture these variables. Stem mapping is useful for relocating a particular tree for remeasurement or spatial analysis. Other precision forestry developments such as Radio Frequency Identification would likely require stem location as an attribute. Obtaining a GPS point at each stem in a stand would be very time intensive. Stem mapping using a tape and compass is quite time consuming and frustrating, especially in thick understory. Sonic devices as well as laser rangefinders have been used with varying levels of success to attempt to speed up the process of stem mapping. According to Clarck (2001), the TMS instrument was developed to enable capturing the distance and azimuth digitally which can then be automatically tied to a coordinate position and individual tree record. This allows the TMS system to rapidly acquire heights and diameters for an entire tree bole. Furthermore, the imaging nature of the collected data allows more intensive variables such as stem form and some defect information to be assessed precisely.

4.0 Precision Forestry Challenges

Introducing precision technologies into forest environments is not easy as it thought and faces challenges. First among those, is changing the foresters' mindsets. Conventional foresters have been quite uneasy when discuss about precision, their common satisfactory expressions is "close enough for forestry". What really meant was that, in forestry you didn't have to be very precise, after all forestry was just cutting down trees and getting them to a sawmill where logs were made into lumber and shipped off to the market; generally a pretty crude business.

However, the business has changed, primarily as logs have become more valuable and environmental issues put the squeeze on operations. Foresters need to quickly react and understand the forest industries concerned about forest and forest products. They want to know where the forest are, how big they are and what's in them. However, they also want to know the "risk" – how healthy are the forests, what's their nutritional status, and are there potential liabilities associated with high value conservation areas, endangered species habitat, or cultural sites that need to be protected. We are reasonably good at valuing forest on a very broad basis, but we're not really good at rapidly determining risk values such as nutritional and health status (Dyck, 2003). This is where we need precision forestry technologies to be adapted in current practice. Precise information renders precise decision making

Another challenge is scale issues. Our measurements must be possible at millimeter range (micro scale such as nitrogen fixation in soil) and also at kilometer range (macro scale such as stand health, stand timber volume). Events occurring over short time period (e.g. stomatal aperture) can be equally important to much longer-period phenomena (e.g. tree diameter growth). Focusing on precision does not imply we can neglect the macro scale. Technology available must able to blend these scales and tallied for better decision making.

Another new challenge is forest tree species identification. Foresters have been traditionally-trained to identify individual trees from the ground, never from the sky. With high spatial remote sensing and hyperspectral remote sensing technologies on the forthcoming, foresters are required to have certain familiarities seeing at trees from the sky. To assist foresters whom mostly without this familiarity, it is necessary to develop the Tropical Tree Canopy Library (TTCL) and the Tropical Tree Spectral Signature library (TTSSL). TTCL will consist of canopy color, shape, structure, tone, texture and other parameters that differs the canopy of each individual species. Whereas, the TTSSL will consist of range of reflectance digital numbers of each band for each species. These libraries will assist the system to accurately identify tree species. These are challenges for remote sensing foresters to accomplish precision forestry.

5.0 Conclusion

Precision technology contributes precise information and advent of technologies such as hypespectral remote sensing, high-resolution remote sensing, mobile GIS mapping using GPS, LIDAR, PDA's, laser range finder, Silvascan-2, PEGGER, and others have make precision forestry approach a reality for sustainable forest management. However, grasping these technologies requires foresters ready to learn and accept new knowledge as well as ready to change fast their conventional working manner. This is the main challenge for foresters in adapting precision forestry.

New precision technologies are being developed that can help us to better evaluate the forest at macro and micro level, enhance our ability to estimates stand volumes, and even measure the properties of individual trees and logs. These tools should lead to greater profitability for environment, social and economic aspect of forest management. Increased profitability can also be achieved by better understanding the precise interactions of genetic, site and sivicultural management to grow more valuable wood or forests. These technologies will potentially submit new information and new knowledge which may need the policy to adapt.

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