New Sensor Technologies for Forest Data Collection

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Abstract:

Jon. S. Wilson in the Preface to his "Sensor Technology Handbook" writes "The first decade of the 21st century has been labelled by some as the "Sensor Decade". With a dramatic increase in sensor R&D over the past 15 years sensors are poised on the brink of a revolution similar to that experienced in microcomputers in the 1980's. …. Tremendous advances have been made in sensor technology and many more are on the horizon."

New sensor technologies are improving our ability to determine with greater precision, such things as, what do we have in the seedling-to-customer forestry supply chain, where is it located, how is it changing with time, who is producing it, and what are the impacts of altering its form.

While the introduction of sensor technologies into operations may involve additional costs, resulting benefits may include lower overall operating costs, greater management efficiency, increased safety, improved and more consistent products, and reduced negative environmental and ecological impacts.

This paper will provide a brief overview of sensor technologies that are relevant to the forest industry and describe some international research efforts in this area.

Acoustic Technology for Forestry Applications – Latest Practical Developments

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Abstract:

Assessment of the quality of raw wood materials has become a crucial issue in the operational value chain as forestry and the wood processing industry are under increasing economic pressure to maximize the value of harvested trees. Substantial efforts have been devoted toward developing robust non-destructive evaluation (NDE) technologies capable of predicting the intrinsic wood properties of individual trees and stems and assessing forest value.

Acoustic technology, among others, has been successfully implemented and widely used as a non-destructive technique for assessing the mechanical quality of various wood products (structural lumber, veneer, poles, pulp logs, decay detection, etc.), sample dimensions (whole trees, logs, veneer sheets, etc.), and species based on stiffness. Research has shown that a range of wood and fibre properties can be predicted even in standing trees suggesting that this technology can be used through the entire operational value chain, from timberlands through processing to finished wood products.

Forest harvesting worldwide has become increasingly mechanized during the last few decades, providing a platform for innovative measurement systems which could lead to improved log segregation based on a wider range of wood properties. Real-time “while harvesting” wood quality evaluation is an appealing opportunity and there is a growing interest in incorporating such technologies for measuring internal stem features into a harvester head. Research evaluating hypothetical working procedures for real time measurement of acoustic velocity suggested good operational feasibility. The HITMAN PH330, a processor head integrated sonic tool for stiffness testing is in its final stages of development and operational evaluation.

Determining Radiata Pine Tree Value and Log Product Yields Using Terrestrial LiDAR and Optimal Bucking in South Australia

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Glen Murphy: Forest Engineering, Resources and Management Department, Oregon State University, Corvallis, Oregon
Jan Rombouts: ForestrySA, Mt. Gambier, Australia

Abstract:

Eighteen plots in three radiata pine stands of different tree sizes were scanned using terrestrial Lidar systems. Tree locations were automatically detected using commercially available software. Stem profiles were measured using three methods: (1) from Lidar scans, (2) by the harvester and (3) manually after felling. Stems were optimally bucked based on log specifications and prices for Australian log markets. Tree values and log product yields were estimated for the terrestrial Lidar derived data and compared with estimates based on the harvester and manual stem profiles. Plot preparation and tree characteristics affected the accuracy of automated stem detection and stem profile measurements. Suggestions for future research are provided.

Multiple-use Forest Management: Multiple-use Remote Sensing

Nicholas C. Coops (University of British Columbia) and Darius S. Culvenor (CSIRO)

Abstract:

Current and future sustainable forest management requires the forest resource to be managed for a variety of values, including wood products, water yield, biodiversity, bio-fuels and carbon. As a result, management decisions increasingly require quantitative information to balance these often competing societal demands.
Sensor technologies, such as satellite remote sensing, have already provided significant solutions to these challenges, however it is anticipated that in the next decade tree, plot and stand scale sensing capabilities will fundamentally advance forest measurement and monitoring.

Improved spectral sensing, ground-based sensor networks and online data sharing are some of the major developments that are changing the way in which remotely sensed information is acquired, integrated and accessed. This presentation provides an overview of some of these key developments, how they are serving multiple applications, and the role for remote sensing as a major provider of information to the forest management community in the future.

First Operational LiDAR Based Site Quality Survey of South Australian Radiata Pine Plantations

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Abstract:

Site Quality (site productivity) information underpins many aspects of radiata pine plantation management in South Australia. Site Quality surveys have been conducted for close to 60 years using the same plot based and ocular assessments. Since the criterion of Site quality is stand volume at reference age, site quality assessment is in essence a problem of assessing the spatial variation in stand volume at a sub-hectare resolution. Trials examining the use of airborne LiDAR for Site Quality assessment commenced in 2002 and led to the decision in late 2007 to take LiDAR based Site Quality assessment into operational use. The design of the survey involved decisions about project area, LiDAR data collection parameters and field sampling. In December 2008 LiDAR data were acquired for plantations aged between eight and ten, comprising 34 sites scattered across an area of 6,000 km^2 with an effective area of interest of 7,246 ha. LiDAR data were captured at high altitude (2550m) and at relatively low point densities (0.3 pulses m^{-2}). Field data for model calibration and validation were scheduled to be collected in April 2009 (1999 and 2000 plantations) and April 2010 (2001 plantation). Plot locations were selected based on the distribution of the principal LiDAR predictor variable, with a minimum of five plots per site. LiDAR predictive models for stand volume were fitted to LiDAR and field data. Assessed based on independent validation data, the preferred model produced a prediction RMSE of 13.6 m^3 ha^{-1} (9.2%) and was unbiased. Transition from conventional to LiDAR based methods required some retraining of technical staff but otherwise went remarkably smoothly. The new method required substantially less field work than the conventional method.

Key words: site productivity, survey, LiDAR, prediction model, radiata pine

Crown Scale Extraction of Inventory and Health Attributes of a *Pinus Radiata* Plantation Using LiDAR and Digital Camera Data

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Abstract:

We aim to develop an operational data flow framework that processes, classifies and analyses high spatial resolution, Airborne Laser Scanner (lidar) and airborne digital camera CIR data for meaningful canopy inventory and health attributes. Recommended procedures derived from this project will be designed for integration into current resource assessment and planning systems and manageable by specialist Foresters. Results from a multi-focus, 5,000 ha study site located in the Green Hills S.F., a *Pinus radiata* plantation in southern New South Wales will be presented.

Numerous crown delineation techniques using fine spatial resolution imagery now exist. We evaluated three commercial Object-Based Image Analysis software packages and concluded that customisation of Definiens Developer presented the best potential for our aim of a robust semi-automated hierarchical segmentation process that would compliment the existing spatial database of compartments and plantations used by Forests NSW. We have successfully extracted attributes from both healthy and dead/dying crowns using lidar derived crown segmentation, height thresholding and variation in the camera spectral data. Reliable mechanisms for ensuring accurate image co-registration are essential for this process.

The demonstrated cost-effectiveness and multi-functionality (e.g. stand volume and aboveground biomass estimates; canopy health assessment; weed mapping) through fusion of this airborne technology will result in a paradigm shift in the approach taken by plantation managers for resource assessment and hence their strategic and tactical planning.

Evaluation of Remotely Sensed Indices for Assessing Vegetation Fire Severity in Victoria, Australia, using Landsat TM and SPOT 4/5 Satellites

Authors: Haywood, A. and Sparks, T

Abstract:

This study compared vegetation fire severity analyses from time series Landsat5 Thematic Mapper and SPOT 4/5 four band multispectral imagery using a range of indices against ground survey information. The analyses included pre and post comparisons of single bands, band ratios, vegetation indices and linear transformations.

The indices were evaluated by examining the correlation between each remotely sensed severity index and over 700 field based Severity Index (SI) observations augmented with patches derived from aerial photography analysis. An approach using a relative differenced normalised burn ratio (rdNBR) index based on the Landsat system and a ratio of vegetation indices for SPOT data was selected to create a Victorian state-wide fire severity map for the February 2009 wildfires. This approach addressed the need to identify and quantify fire effects over large areas, at times involving many fires.

In contrast to individual case studies, the ability to compare results was emphasised along with the capacity to aggregate information across broad regions and over time (fire seasons). This is important when mapping historic fires where precise field based fire severity data may not be available to aid classification. Results show the spatial heterogeneity of fires and how fire interacts with vegetation and topography. Some of the practical issues associated with mapping large areas are also discussed (scene selection, ortho-rectification, haze effects image processing, image mosaicing, burn perimeter identification, and raster to vector conversion).

Monitoring Grizzly Bear Habitat Disturbance and Phenology using Spaceborn and Ground-based Optical Remote Sensing Technologies in Western Alberta, Canada.

Bater, C.W.[1], Coops, N.C.[2], Wulder, M.A.[3], Hilker, T.[4], and Stenhouse, G.[5]

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Abstract:

Globally, large carnivores are becoming increasingly endangered, with attempts to assess the rate and extent of decline often hampered by limited data and large habitat ranges. In western Alberta, Canada, grizzly bear (*Ursus arctos* L.) populations are under pressure from a range of natural and anthropogenic causes, leading to a need for information on habitat status, abundance, and usage. A critical component of the program is to develop the ability to monitor landscape disturbance and food production with both high spatial and temporal resolution over large areas. To this end, two ongoing remote sensing-based initiatives are described. The first involves the fusion of MODIS and Landsat data to create synthetic image products in support of change detection with an 8 day return interval and 30 m spatial resolution. The second involves the deployment of a network of ground-based digital cameras to monitor vegetation green-up and senescence in forest plots on a daily basis. These images will be used to better understand phenological signals derived from spaceborne sensors such as MODIS and the fused synthetic-Landsat image products. Ultimately, developing spatially explicit, high temporal- and spatial-resolution models of vegetation disturbance and phenology will provide us with information that will lead towards a better understanding of when and why grizzly bears use specific portions of their home ranges.

Keywords: Grizzly bear, habitat, remote sensing, disturbance, phenology, Landsat, MODIS.

Improvement of Low Level Bark Beetle Damage Estimates with Adaptive Cluster Sampling.

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Abstract:

The mountain pine beetle (*Dendroctonus ponderosae* Hopk.) is an aggressive pest of lodegpole pine (*Pinus contorta* Dougl. var. *latifolia* (Englem.)) trees in western Canada and the United States. In Canada, infestations with a range of severities have increased from 164,000 ha in 1999 to over 14 million ha in 2008. Typically, infestations initiate on one or two trees in a forest stand and when provided with suitable conditions rapidly expand to large areas. To inform forest managers and aid mitigation activities, methods are required to obtain accurate, spatially explicit information on low levels of attack prior to infestation expansion. Adaptive cluster sampling is a grid-based region growing approach that locates clusters on the landscape to provide estimates that describe the population of interest. An adaptive cluster sampling approach was applied to very high spatial resolution (0.20 m) digital aerial imagery to locate low levels of mountain pine beetle infestations within a 40 km^2 site in western Canada. Results indicated a mean number of 7.36 infested trees per ha, with a variance of 18.34. In contrast, a non-adaptive approach estimated the mean number of infested trees in the same area to be 61.6 trees per ha with a variance of 41.4. Using a relative efficiency estimator, the adaptive cluster sampling approach was found to be twice as efficient when compared to a non-adaptive approach. This methodology provides a technique to characterize forest insect outbreaks over large areas with sample based estimates.

Key words: Object-based classification; high-spatial resolution digital aerial imagery; forest inventory; large area.

Opportunities of Extended Waveform LiDAR Data Combined With Hyperspectral Data to a Multi-Dimensional Data Cube in Forestry Data Acquisition

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Abstract:

Light distance and ranging (LiDAR) based aerial survey technology and techniques are well established as a proven means to generate highly accurate point cloud data sets. Full waveform LiDAR scanners such as the Riegl LMS-Q560 which capture the complete digitized returning pulse wave enable advanced post flight processing, point cloud creation and classification.

Traditional full waveform post processing procedures create point cloud data sets with more targets per pulse and greater target accuracy than the simpler first/last point online processing scanners, however these point clouds are still only 3-dimensional (x y z) with mathematical classification routines providing a 4^{th} dimension (e.g. ground, vegetation, etc).

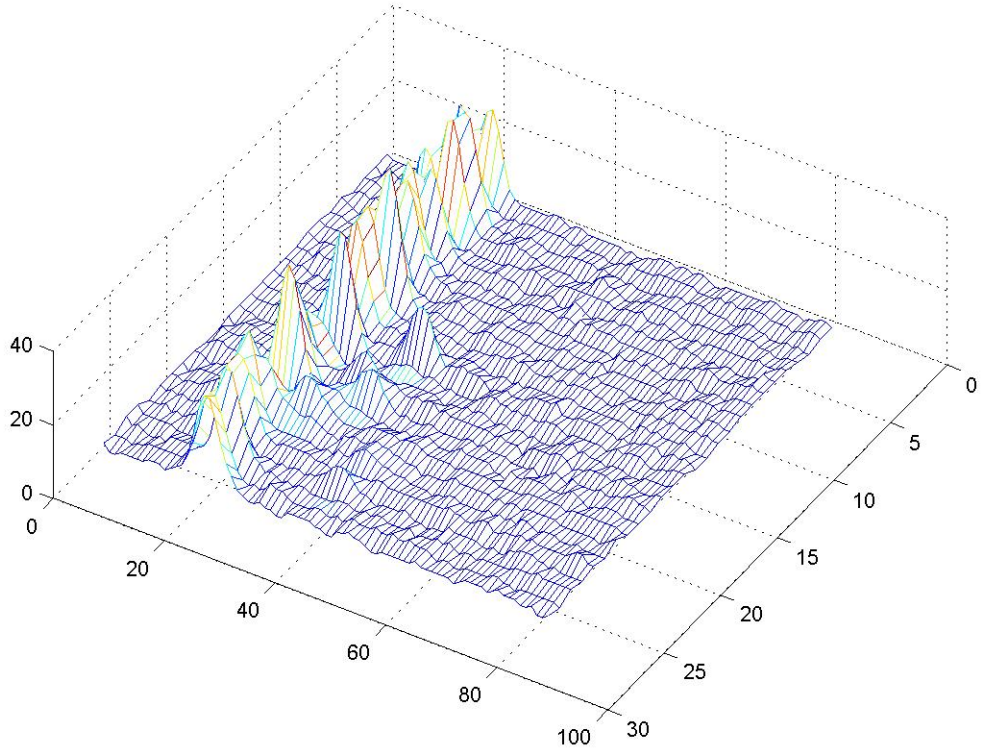
Advanced full waveform analysis techniques such as Gaussian curve fitting, hidden peak detection and extraction; along with derived wave and peak parameters such as expected value, variance, inflection points permit extraction of denser point clouds and refined algorithms to enhance classification accuracy. Such additional data expands the basic 4-dimensional data set into the n^{th} dimension from which classification routines can be adapted and created providing greater accuracy and finer sub-classification methods in itself.

Combining these data with same time collected VNIR high resolute Hyperspectral data (160 channels, Ground Sample Distance between 25 and 40cm) as additional information for the airborne visible points allows further analysis. Before combining the data all hyperspectral data are orthorectified based on the Lidar DTM and atmospheric corrected.

Especially the classification of the canopy relevant Lidar data points can now be based on:
1. The classical approach of echo number, position of the point to other points around etc.
2. The exact waveform details for this point describing the reflection situation as result of for instance the diameter of the branch etc.
3. The hyperspectral information giving details of tree species, health status, stress situation etc.

The solution can't eliminate ground base plot data collection and ground truthing, but is expected to reduce the costs for this further. In the same time it adds additional values to airborne collected data to provide data for multiple forestry relevant issues.
Actual there is a beta phase software solutions supporting this multisensor concept. Further steps are focussed on the development of plot based calibration procedures and the implementation in the operational forestry.

Keywords: Full Waveform Lidar, Hyperspectral Data, extended processing algorithm, n-dimensional data cube



Picture: Full waveform raw data of 25 Lidar strikes before allocation to the individual data point.

Precision Forestry and Value Chain Management: Challenges and Opportunities for the Australian Forest Industry

Dr. Mauricio Acuna[1,2] and Mr. Martin Strandgard[1,3]
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2 University of Tasmania
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Abstract:

The forest sector worldwide is facing competitive and complex market scenarios and Australia is no exception. Markets demand wood products for very specific end uses and the forest industry supplies those products while trying to maximize profitability. Precision forestry can play an important role in developing new technologies to locate, harvest, transport and process trees with different external and internal characteristics, and to provide better log products that meet customer demands and increase profitability as higher value wood is allocated to higher value markets. In addition, these new technologies and analytical tools help support site-specific, economic, environmental, and sustainable decision-making. Their development and use, however, represent challenges and opportunities that are necessary to understand and be aware of to meet the goals of sustainable forestry in these complex market scenarios.

Likewise, it is necessary to understand that focusing on costs in isolated business units is not enough to be competitive. We must be able to add to and maximize the value and quality of wood products, embracing value chain optimisation networks through new business models that link different units of the value chain in a more holistic and integrated way.

Examples of new sensing, monitoring and optimisation technologies being developed and applied in Australia to reduce costs and improve value along the supply chain are presented. These include the use of onboard dataloggers and communication systems to improve productivity from harvesting equipment, guidelines for better harvester calibration procedures, a truck scheduling system to minimize transportation costs and determine the optimal fleet size, the development of a modelling tool to estimate harvesting productivity and costs, the use of terrestrial Lidar and optimal bucking to estimate log product yields, and near infrared spectroscopy to estimate wood properties.

Keywords: Precision forestry, value chain optimisation, value recovery, sensing technologies

ForValueNet: A Canadian Research Initiative to Link Tree Growth Modelling with Wood Properties, Product Optimization and Decision Support

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Abstract:

ForValueNet is a Canadian research network engaged in a five-year initiative to integrate tree growth modeling with wood properties, wood product optimization, and decision support tools on a national scale. The project focuses on three coniferous species [Jack pine (*Pinus banksiana*); white spruce (*Picea glauca*); and black spruce (*Picea mariana*)] and one broadleaf species [Trembling aspen (*Populus tremuloides*)] that grow throughout the boreal forest of Canada. The presentation will provide a brief overview of the network structure and its major component projects, as well as highlight some of the work completed in the 18 months the network has been in operation. In addition, the opportunities and challenges of conducting this sort of trans-disciplinary research within a national network framework will be discussed.

Keywords: growth models, wood properties

Precision Forestry Development in the Southeast U.S.: Challenges and Opportunities

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Abstract:

The development of precision forestry tools and techniques in the southeast U.S. has been influenced by numerous technological and economic factors. This paper describes the past, present, and future stages of precision forestry in the southeastern U.S. In the early stages of precision forestry development, the research community used GPS and GIS to quantify productivity and environmental impacts from forest operations while a few silvicultural contractors began using GPS and GIS tools to assist with application of fertilizers and herbicides to maximize productivity of southern pine plantations. Further evolution of the technology resulted in the development of GPS-based data collection systems for manual tree planting and herbicide application systems to provide verification of services to the forest landowners. Most recent research and product development has focused on data collection systems for timber harvesting equipment that will collect timber yield data and utilize LiDAR data to help improve site-specific forest management. However, today's economic pressures have led to major shifts in forest land ownership, away from the industrial forest land owner to timber investment management organizations and real estate investment trusts along with the private, non-industrial landowners. This shift in land ownership has probably reduced the demand for precision forestry tools and data gathering systems. We predict that in the future, other global trends, such as producing biomass for fuels and electrical power as well as carbon sequestration and carbon trading, will lead to increased use of precision forestry systems for yield mapping and intensive silvicultural management.

Keywords: precision forestry, GPS, GIS, forest yield mapping, herbicide, fertilizer, bioenergy

Precision Forestry in Sweden – Focus on Customer Needs

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Abstract:

In order to optimize the (wood) value chain there are several possibilities already on the market and in early pre-commercial phases. Saw mills demand more specific logs (quality and dimensions) and pulp and paper industries demand wood with specific characteristics. Both industries also require better delivery precision.
Results from trials with laser scanning of stands indicate forecasts with higher precision compared to methods used today. New harvesting systems like “the Beast” and harwarder have been studied and compared with traditional harvesters and forwarders.
ETT is a three-year research project that will investigate the scope for achieving greater energy efficiency and reduced haulage costs by increasing the payload of timber haulage vehicles by "One more pile".

Mobile broad-band enables efficient flow of information. Efficient transport operations are to great extent a matter of efficient management and sharing of information. SDC, an information hub owned by the Swedish Forest Industry, plays an important role concerning information flow and standardization issues.

To manage the wood flow a number of decision support systems (DSS) based on optimization are in use and more are being developed. FlowOpt has been used for some years to analyze and optimize the wood flow on at strategic-tactical level. RuttOpt is a DSS system for routing of logging trucks. SPORRE is a project for optimizing the forwarder’s work on a harvesting site. DSS integrating harvesting and transportation will also be discussed.

Keywords: Value chain, decision support system, optimization, delivery precision.

Assessment of Visitor Use Density to Prevent Degradation of Wilderness

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2 Graduate School of Informatics, Kyoto University
3 Field Science Education and Research Center, Kyoto University

Abstract:

In Japan, more and more people are getting interested in recreation and tourism in mountain areas. Thus, many mountain areas are threatened by numerous visitor-caused impacts, which are sometimes beyond unacceptable limits. The objectives of this study are to suggest appropriate measures to control the number of visitors under the acceptable level of visitor-caused impacts. In this study, we used a Global Positioning System (GPS) receiver to monitor visitor use density of the Kyoto University Forest in Ashiu, where degradation of wilderness is becoming a serious problem. In addition, questionnaire survey to investigate visitors' awareness of and willingness to pay (WTP) for nature conservation was conducted. As a result, we collected GPS tracking data for 223 groups (815 visitors), and 361 responses to the questionnaire. A map of visitor use density was made based on the GPS tracking data, and it successfully showed that the Kamitani and Makuradani valleys were visited by a lot of people, and that the visitor number to these valleys should be controlled under the acceptable level. In the questionnaire, we asked the respondents if they had willingness to pay (WTP) for nature conservation of the forest in Ashiu. As a result, 79% of them had WTP, and the average WTP was 415 yen/visit/person.

Keywords: mountain tourism, visitor use density, GPS, questionnaire, WTP

Assessing Greenhouse Gas Dynamics in Planted Forests: Constraints and Challenges

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Abstract:

Carbon stored and sequestered in planted forests represents both an opportunity and a liability for forest managers. The role of forests in the global carbon cycle and the opportunities for expanding the forest area and changing forest management practices to increase carbon sequestration and mitigate increasing CO_2 from the burning of fossil fuels have been apparent for some time. Recently there have been some very significant estimates of potential carbon sequestration in the Australian landscape that are focussing further policy attention on the opportunities presented by planted forests. However, there are risks for owners and managers of planted forests in policy settings and accounting rules that result in the inclusion of some forests toward emission reduction targets or emissions trading arrangements and the inclusion of forest carbon pools but not wood products in accounting arrangements. There are also potential risks in managing losses due to fire, drought, insect pests and diseases, which could be exacerbated by future climate change.

This paper provides an overview of current policy, management and measurement issues that impact on the assessment of greenhouse gas dynamics in planted forests. Climate change policy and accounting arrangements will drive the focus of research in assessing the dynamics of carbon in planted forests. Key challenges include:

- Growth prediction systems that address uncertainties associated with future climate change;
- Design and implementation of efficient measurement systems for hectare, stand, landscape and estate scale carbon assessment;
- Assessing carbon dynamics in soils, forest floor and woody debris, particularly during the harvest, site preparation and replanting phase;
- Assessing the impacts of non-harvest disturbances such as fire;
- Assessing carbon sequestration rates and dynamics in multi-species and mixed age systems designed for biodiversity conservation objectives;
- Assessing below-ground (in roots) carbon sequestration, particularly in drier regions or heavy clay soil types; and
- Assessing the impacts of planted forest establishment on non-CO_2 greenhouse gas and developing policy arrangements that provide for their incorporation in climate change mitigation arrangements.

Nationally Consistent Carbon Accounting to meet International Policy Requirements

Rob Waterworth

Abstract:

Land sector carbon accounting involves a combination of science and policy. The development of a national carbon accounting system must allow for both the scientific and policy requirements. This presentation will highlight the key policy and reporting requirements that a national carbon accounting system should fulfil. Even when individual countries have similar requirements in terms of reporting and policy guidance, the quantity and quality of existing skills and available data that can be used to produce a carbon accounting system will affect the end design. At present, an array of methods, including remote sensing and forest inventory, are being proposed for application in different countries. The application of one single method or technology is not sufficient to fulfil all the requirements of a national carbon accounting system. A key factor will be to integrate a range of methods and data from a variety of sources to construct spatially and temporally consistent carbon accounting systems. This presentation will also address issues including dealing with current uncertainty in future international frameworks, reporting guidance and guidelines, and key areas of work to develop a national carbon accounting system.

Vegetation Change Detection Using Multi-Temporal Satellite Data in The Horton Plain National Park, Sri Lanka

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[2] Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka
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Abstract:

The Upper Montane Rain Forest and wet patana grasslands in Sri Lanka are characterized as unique vegetation type to this region. Understanding ecosystem patterns and properties is important for effective monitoring of ecosystem change due to land use and climate change. Remote sensing provides the best tools for monitoring ecosystem patterns and processes. This paper investigates the spatio-temporal change analysis of vegetation cover in conjunction with ground-based phytosociological data of the Horton Plain National Park in Sri Lanka. For this study, Landsat images (TM and ETM+) of 1990 and 2002 were used. The data were analysed using image processing programs supported by GIS techniques. The Maximum Likelihood Classification was performed on the data to identify forest cover types in the study area. The Normalized difference Vegetation Index (NDVI) was used to detect areas of vegetation stress and changes. The study revealed that montane grassland communities (patanas) had changed significantly between 1990 and 2002. Further, the results show that canopy dieback in the park had increased during the study period. The monitoring studies based on satellite data and geographic information systems provide an early warning system for vegetation stresses and spatial change.

Keywords: Landsat, NDVI, Horton Plains, vegetation change, tree mortality

Forest Carbon Assessment in Papua New Guinea

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Abstract:

An overview of forest carbon assessment activities in Papua New Guinea (PNG) undertaken as part of Australian Centre for International Agricultural Research (ACIAR) project FST/2004/061 will be presented. PNG has become the focus of the climate change mitigation initiative Reduced Emissions from Deforestation and Degradation (REDD), but much technical work is required before the mechanism can become operational.

Results from the first national forest carbon assessment will be presented based on analysis of Permanent Sample Plots (PSP). The integration of PSP data with GeoSAR X-Band (VV, 9.7GHz), and P-Band, (HH, 0.35GHZ) interferometric data for wall to wall forest carbon mapping will be discussed. 15 years of PSP census also allow a determination of carbon dynamics; sequestration rates in primary and secondary forest, and influences such as selective-logging and El Niño climatic influences.

A methodology for community carbon assessment will be introduced, and an application to the Sogi project area near Madang will be presented. The methodology integrates ASTER optical data and stratified random point sampling for wall to wall carbon mapping at local scales. The methodology is the basis of a simple spreadsheet that is being used by communities in PNG. Species-specific individual-tree models are being developed from PSP data to examine the influence of community forest use (small-scale forestry and extraction of construction materials) on the local forest carbon dynamic.

Work on national and community forest carbon assessment will be placed in the context of the PNG United Nations REDD road map.

Keywords: Biomass, Sequestration, Forest dynamics, Selective-logging, REDD,

Assessing the Dynamics of Non-CO2 Greenhouse Gas Exchange in Australian Forests and Woodlands

Stephen Livesley, The University of Melbourne

Abstract:

Forest soils provide important ecosystem services; they are the largest terrestrial store of carbon and the largest terrestrial sink for methane (CH_4). In comparison, agricultural systems are the largest source for both nitrous oxide (N_2O) and CH_4. Planting new forests within the Australian agricultural landscape may improve their net greenhouse gas (GHG) balance in more ways than just carbon sequestration. We have measured soil-atmosphere exchange of CO_2, N_2O and CH_4 in several forest systems throughout Australia: temperate eucalypt woodlands and forests, *Pinus radiata*, *Eucalyptus globulus*, Savanna woodland. We have often measured GHG exchange in adjacent agricultural systems at the same time.

Near Albany, south-west Western Australia, we measured GHG exchange using an automated trace gas measurement system between October 2005 and June 2006. Mean N_2O emission in the pasture was 26.6 µg N m^{-2} h^{-1}, significantly greater than that in the native and managed forests (< 2.0 µg N m^{-2} h^{-1}). N_2O emission from pasture soil increased after rainfall events (up to 100 µg N m^{-2} h^{-1}) and correlated with the increase in soil water into winter, whereas no N_2O emission response to rainfall or soil water content was detected in the forest systems.

Forest soils were a constant CH_4 sink, up to -20 µg C m^{-2} h^{-1} in the native woodland, whereas pasture soil was an occasional CH_4 source, but a weak CH_4 sink overall (-3 µg C m^{-2} h^{-1}). There were no strong correlations ($R < 0.4$) between CH_4 flux and soil moisture or temperature. Soil CO_2 emissions (35 to 55 mg C m^{-2} h^{-1}) correlated with soil water content ($R > 0.5$) in all but the *E. globulus* plantation. Soil N_2O emissions from improved pastures can be considerable and comparable to intensively managed, irrigated and fertilized dairy pastures. In all land-uses, soil N_2O emissions exceeded soil CH_4 uptake on a carbon dioxide equivalent basis. Overall, afforestation of improved pastures decreases soil N_2O emissions and increases soil CH_4 uptake.

Carbon Assessment and Monitoring of Plantation Forests in Western Australia.

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Abstract:

Methods for the assessment and monitoring of carbon sequestration in planted forests managed by the Forest Products Commission of Western Australia will be discussed. The FPC has been very active in this area, commencing destructive sampling research and carbon inventory in 1998. Carbon inventory has, to date, relied on ground-based direct measurements. Calibration of models to forecast carbon sequestration from field measurement data will be discussed.

Examples will be presented for alternative forest management regimes involving: block and belt planting arrangements; mallee and tree-form species; harvest and non-harvest forests. The models include the *FullCAM* carbon accounting model and an in-house model (*FarmWood*).

The merits of using remote sensing technologies to supplement or replace direct measurement data in the carbon assessment processes described will be discussed. For example, above-ground biomass could be monitored from aerial- or satellite-based measurements, or root biomass inferred from Ground-Penetrating Radar.

Key words: direct measurements, remote sensing, carbon

Integrating Existing Data Across Multiple Scales to Obtain Within Stand Structural Information

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Presented at the IUFRO conference on ""Meeting Multiple Demands for Forest Information: New Technologies in Forest Data Gathering", Mt. Gambier, Australia, August 17 to 20, 2009

Abstract:

Forest information over a landscape at a single point in time often includes: i) Forest Cover information represented as polygons, and displayed and stored in a Geographic Information System (GIS) layer as a forest cover map; ii) remoted sensed imagery represented as pixels, and stored and displayed as images; iii) ground plot data for trees, representing small circular or square land areas, and stored and displayed as measures at point; iv) ground plot data for small trees and other vegetation, representing smaller circular or square land areas. For many forest management problems, these data sets at different scales must be combined to provide the particular information needed and/or to forecast this information forward in time. Variable-space nearest neighbour imputation methods provide a method to link these data together for a variety of purposes. In this paper, I present a number of applications of nearest neighbour methods using forest inventory data to obtain within stand structural information, including tree-lists, withini stand variation, regeneration, and preliminary work for non-timber forest products. Challenges in making these linkages are also presented.

Keywords: variable-space nearest neighbour analysis, landscape level analysis, linkages across scales, forest inventory, stand structure, non-timber forest products

LiDAR: Operational Trial to Operational Reality

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Abstract:

The potential for airborne LiDAR to significantly improve a wide range of forest mapping and inventory functions has been widely acknowledged. However, actual use of LiDAR by forestry organisations in Australia and New Zealand has been largely experimental, project-based, or small-scale.

Forestry Tasmania has just completed a major LiDAR Feasibility Trial, aimed at investigating the technical and financial feasibility of applying LiDAR across its entire forest estate. LiDAR data was obtained over a 300 sq km study area of native forest and plantations, and was used to inform a wide range of routine roading, harvesting and other operations over a two-year period. Trial results were overwhelmingly positive, showing that LiDAR results in better, cheaper outcomes, and that its implementation is financially justifiable when it is integrated fully across an organisation, not implemented narrowly on individual tasks.

As a result of the Feasibility Trial, Forestry Tasmania is investing in LiDAR across the majority of its State forest, and will radically change its approaches to inventory, mapping, planning and infrastructure development to capitalise on its benefits.

IUFRO Division 4.01 Conference – Mount Gambier, South Australia
17 – 20 August 2009
Meeting Multiple Demands for Forest Information: New Technologies in Forest Data Gathering.

One Measure of Quality and Disturbance can be used to Improve Estimates of Almost Anything.

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Abstract:

Satellite-based remote sensing platforms have been collecting repeat measurements of the earth's surface at various scales for many decades. More than a dozen composite Landsat-based images (TM and MSS), for example, cover the continent of Australia since the early 1970's. Numerous researchers have used one or more of these data to estimate various forest population parameters, often with significant and useful results when the signal is not saturated. Similarly, Digital Elevation Models (DEMs) and networks of rainfall and temperature recording stations can be used to model climate history on relatively fine scales across continents. Although there is a huge wealth of information included in the temporal sequence of these remotely-sensed images and models, it remains very difficult to exploit this continental-scale data.

The National Carbon Accounting System (NCAS) developed by the Commonwealth Government of Australia to support policy development, especially in relation to global climate change and forests, allows for the integration of information captured through long-term satellite sensing, physiological and empirical modelling, field-based measurements and regional "text" information. Although the amount of spatially referenced data used as input into NCAS is substantial, much of the data is subsequently summarised as an index of Net Primary Productivity (NPP) and years since substantial disturbance. These two parameters are provided over the Australian continent at a sub-hectare resolution and are reasonably robust even though some of the input data is at coarser levels of resolution. After extensive assessment by the IPCC the NCAS is accepted as a reliable tool for estimation of carbon emission and sequestration as well as policy development. In addition, the NCAS framework has also provided free access to a spatial database of integrated site quality and disturbance information at a sub-hectare scale. Individual landowners and researchers can download information on forest type, site productivity, disturbance and long-term climate from publicly-available NCAS databases simply by entering the appropriate latitude and longitude coordinates.

This presentation demonstrates how the use of the site quality and disturbance history is used to improve estimates of forest products (at farm-scale and larger areas) as well as providing estimates of forest structural diversity at stand level, and potentially generating diversity indices at landscape levels. Use of the NCAS data in a multi-phase allows for inventory efficiency improvement of 33% compared to simple random sampling. The approach also allows historical data (e.g. from previous field measurements) to be included in an inventory which would otherwise violate the assumptions of simple or restricted random sampling approaches.

Keywords: Carbon accounting; multi-phase inventory; forest products; forest biodiversity;

Multiple Use of Data Collected from the New Zealand Indigenous Forest Plot Network

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Abstract:

An inventory of New Zealand's natural forest was carried out from 2002-2007 using ground-based Permanent Sample Plots located on a systematic 8 x 8 km grid across the country. These plots are now being remeasured. The prime reason for establishing the network of plots was to provide an unbiased estimate of carbon stocks and to collect data suitable to determine if New Zealand's natural forests are carbon neutral, a source or a sink. Development was motivated by the need to meet New Zealand's reporting requirements under the UNFCCC and the Kyoto Protocol. Although it would have been possible to restrict measurements to those required only to estimate live and dead above-ground carbon, plant biodiversity information were also collected to achieve wider government sector benefits. National Vegetation Survey (NVS) plots that were established 20 or more years earlier and met certain operational criteria were revisited and re-established as part of the sample in order to provide an indication of the likely change in forest biomass and composition since 1990. The indigenous forest total above ground carbon stock has increased significantly since 1990, with the increase occurring in the coarse woody debris pool. The aboveground live biomass and stem volume remained largely unchanged or increased in some species, but declined in several others. Tree species that increased over the period were in forests that would have been recovering from past logging activities while those that declined were considered to be susceptible to possum browsing.

Estimating Wood Volume in Native White Cypress Pine Forests Using Airborne LiDAR and Digital Aerial Photography

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Tony Brown – Resource Officer, Forests NSW Western Region
Marcelo Stabile – PhD candidate, University of Sydney

Forests New South Wales (FNSW) is investigating the potential of both Airborne Laser Scanners (ALS) and Digital Multispectral Aerial Photography (DMAP) as spatial tools for supporting forest resource assessments. In early 2008, remote sensing data was acquired across 240,000 ha of native forest in the predominantly flat Pilliga area near the town of Baradine in northern NSW. The key aim of the project is to derive wood volume estimates for White Cypress Pine stands which primarily dominate these mixed species open forests. Results from the study have demonstrated the capacity to extract both crown level (dominant tree) and stand level attributes that provide current standing volume estimates at a range of management scales.The study has also demonstrated how this remote sensing data integrates with existing yield scheduling programs to model longterm wood flow estimates.

Local Application of Genetic Technologies using a Global Perspective

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Abstract:

The use of genetically improved trees in plantations is an effective way of lifting the productivity and quality of the forest resource. The objective of a tree improvement program is to breed and select genetic material with improved biological characteristics for traits of commercial importance. The STBA uses economic indices to describe the genetic worth of trees in the population. Breeders must work with growers, processors and economists to derive economic objectives and also update parameters over time. STBA and its partners work with multiple species adapted to different environments and production systems, including *Pinus radiata*, *Eucalyptus globulus*, *E. nitens* and other plantation species. A large amount of biological data has been collected on many trees over decades of breeding for these species. This data is collected for a range of purposes for use in tree improvement and associated research. STBA uses its web based DATAPLAN system to manage information, as well as facilitate access by breeders and other industry personnel. The TREEPLAN system has been developed for the genetic analysis of tree breeding data on a species wide or global basis. All performance data collected in hundreds of trials over time is combined in national genetic evaluations using full pedigree. This allows for the objective comparison of trees and genetic material for breeding and deployment. Results are reported on a regional basis, to ensure genotype by environment interactions are accounted for and the best genetics is identified for each situation. The TREEPLAN software is a joint initiative of the tree and livestock industries. This ongoing collaboration allows innovation to be developed with application across multiple plant and animal species. TREEPLAN has global utility, with its recent adoption in Sweden for national evaluations in Scots pine, Norway spruce, Lodgepole pine and Silver birch. Knowledge of genetic and economic merit is important for selection and mate allocation in the breeding program. However, it is also important for decision making in deployment activities of seed and plant production, as well as matching improved genetics to particular environments. Innovative software tools like SEEDPLAN are being used to deliver outputs of the tree improvement programs to industry. MATEPLAN software is also important for managing risk associated with population fitness across generations of breeding. It is important breeders, geneticists and researchers work together with industry to improve the efficiency of tree improvement programs for plantation forestry. The national cooperative provides a framework for facilitating this interaction, ensuring research is aligned with industry needs.

Keywords: tree breeding, genetic improvement, data analysis, economic worth

Bio-Economic Modelling as a Method for Linking Genetics to Plantation Economics

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Abstract:

Correctly set breeding objectives will determine how much improvement in different tree characteristics is needed to maximise profitability of a production system. A bio-economic model provides a framework for simultaneously considering breeding, management, and production decisions. Such a model should result in optimal breeding (and silvicultural) objectives if main goals of a production system are well defined. Historically estimation of economic weights for breeding-objective traits has been based on partial regressions and profit functions relating only to certain parts of the production system. A bio-economic model includes effects of growth rate, branching, form, and wood quality on all production system components and on overall profitability of an integrated production system. However, long rotation cycles in forestry make determination of relative economic values for the breeding objective traits particularly difficult. When modelling complex systems under uncertainty about future production goals, there are necessary trade offs between the complexity of the model and the use of simplifying assumptions.

Key words: tree breeding, wood quality, plantation economics, bio-economic model

Site Specific Genetics

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Abstract:

Bio-economic models, discounted cash flow analysis and risk analysis provide tools for establishing what may be important at the estate level to guide breeding for a species when more than one trait is of importance. These tools need to be easily customisable so that they can be applied to each site to allow the appropriate genetics to be put on that site. A simple case study of *Eucalyptus globulus* grown for wood chip export in the south-west of Western Australia shows the potential of site specific genetics. The descaled genetic values of 156 seedlots for basic density and harvest volume on different site types were calculated using TREEPLAN® breeding values and models of pollination incorporating seed orchard flowering time and distance. Bio-economic information was collected on 20 planting sites and trait site means predicted for reference genotypes using local growth and wood quality models. The seedlot values were then scaled for each site based on the site mean modified to the centre of the genetic values of the available seedlots. A wood chip export bio-economic model was then applied to derive a matrix of the net present value of each seedlot for each site. Linear programming then maximised the value of seedlot allocations to each planting site, resulting in an increase in the average net present value of $250/ha compared to mixing the seedlots and distributing them evenly across the planting sites. Application of this approach to the more complex situation of *Pinus radiata* is not currently possible. The bio-economic models are currently not flexible enough to be applied to the wide variety of sites planted. While much is known about variation in productivity, little is known about how the mean and variance of a number of key traits in the model (branch size, modulus of elasticity and sweep) vary in response to site and silvicultural characteristics. Without that it is not possible to scale the genetic values to each site to avoid, for instance, putting straight genotypes on a site that is already straight. While some work has started on gathering such information from forests, it seems there are still some steps before they can be routinely applied in conjunction with bio-economic models to allow site specific genetics (and silviculture). Integration of such optimisation with operational activities is also a challenge.

Keywords: tree breeding, genetic evaluation, breeding objectives, site variation