Estimating Leaf area index as an indicator of ecosystem services and management functions using remote sensing techniques

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Introduction

Forest ecosystems deliver a huge number of viable goods and services that are increasingly valued by people (1,2). A wide range of processes of ecological, political, economic, social and cultural services provided by forests. The ecological services that forests provided are water regimes regulation by cut off rainfall, preservation of soil quality, the preventing soil erosion, regulating climate, protection habitats for other species and conserving biodiversity (3). Forests serving economies services and are the basis of many industries such as timber, processed wood and paper, rubber, and fruits. They also include some products such as fuel and fodder, game, fruits, building materials, medicines and herbs which is vital for rural agricultural communities. Another services is scenic and landscape services that is important for ecotourism (3).

Ranking the importance of forest services is really difficult. In fact there is no universally accepted common metric that can be applied in such calculation. Thought, economist and others mentioned that economic metrics would be a good way to measure the value of each services and compare them with each other. Recently the economic value of some forest service's has been estimated at the global level by Costanza et al. (1997). They estimated the annual economic value for forest service's as below (4):

Service	Value (1994 US$ ha^{-1} yr^{-1})
Nutrient cycling	361
Climate regulation	141
Raw materials	138
Erosion control	96
Waste treatment	87
Recreation	66
Food production	43
Genetic resources	16
Soil formation	10
Water supply	3
Disturbance regulation	2
Water regulation	2
Biological control	2
Cultural	2
Total value ($ ha^{-1} yr^{-1})	**969**

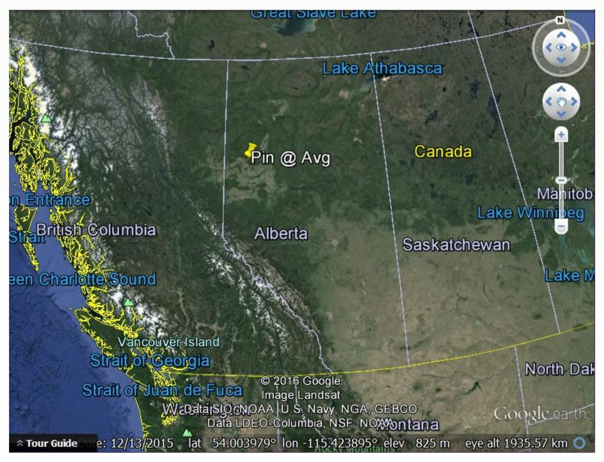
To increase the production of ecosystem services such as carbon storage, scenic landscapes ,wildlife habitat and diversity, watershed services while decreasing nuisance feature such as leaf litter and sidewalk cracking in a forest area an active management is essentially needed (5). Forests provides several benefits that can improve the quality of environment and human health such as air and water quality improvement and reductions in ultraviolet radiation (6,7,8). Proper assessment of forest benefits depended on quantifying forest structure accurately. Forest structure futures (e.g., number of trees, species composition, tree size, health, tree location) are the basic information to calculate the total leaf are, leaf and tree biomass and assessing ecosystem services related to forest functions. Measuring forest structure on every tree is the most precise way for assessing forest structure (9).

Objectives

The purpose of this study is to develop methods for quantifying the function and structure of boreal forest using Lidar, Licor, Vegnet and hemispherical photos datasets.

Material and Methods

The study area in this project is located in northwestern Alberta, Canada (56.74◦ N, -118.35◦ W). at the Peace River Environmental Monitoring Super Site (PR-EMSS) which consist on an old-growth stand of Trembling Aspen (*Populus tremuloides*). Our study area covers ca. 1-hectare of the PR-EMSS.



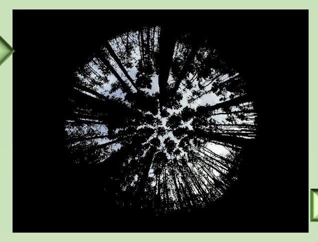
In this project we map 46 trees in a plot study of aspen species representing about 70% of canopy cover in deciduous boreal forest in EMEND site Alberta (10), using Lidar, Vegnet, Licor and hemispherical photos data.

Results

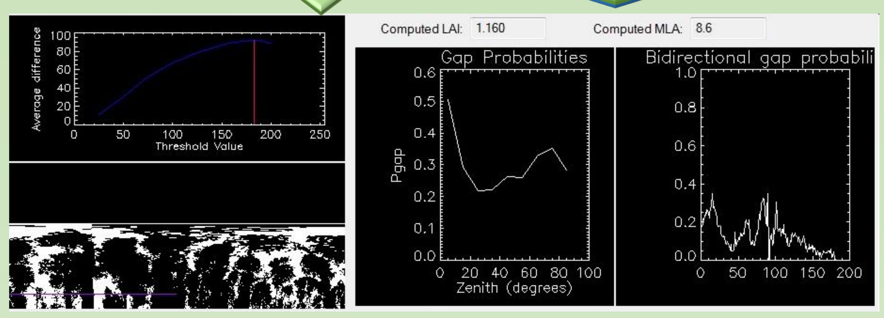
In this study lAI was calculated using different method and devices.

Hemispheric data

Filtering hemiphotos by threshold of 183



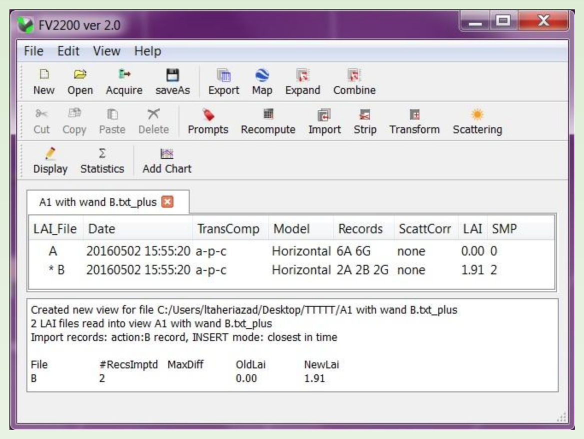
LAI analyzed with BHPA software using Hemispherical photos = 1.16



Licor 2200 C data

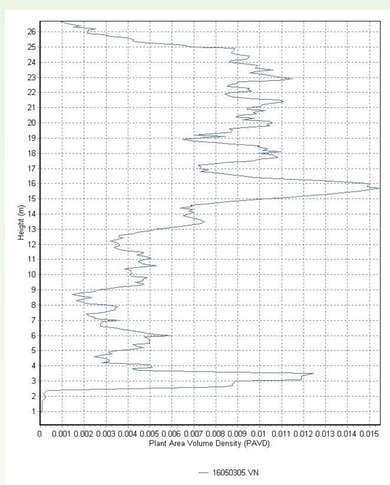
Recording A and B reading by Licor

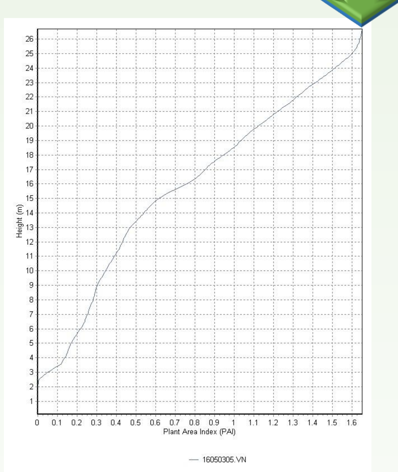
LAI analyzed with FV2200 software =1.91



PAI analyzed with Vegnet software = 1.65

Vegnet Lidar





Discussion and Conclusion

Taugourdeau et al. 2014 demonstrated that LAI is a valuable indicator of management functions and ecosystem services in coffee agro-forestry and they scaled LAI from plant to plot and to the landscape. The study result of Charmetant et al., 2007 and Charbonnier, 2013 showed that LAI is a strong indicator of coffee vigour or of energy and gas exchanges.

At the plot level and for a range of ecosystems, various research studies shown that LAI has affect on microclimate, evapotranspiration, hydrological services, control of erosion, growth and biomass, gross and net primary productivities (11).

Remote-sensing of LAI can provide direct and indirect LAI data for various of studies that require LAI data. Sainte-Marie et al., 2014 demonstrated that measuring LAI via satellite imagery can provide the LAI data to simulate LAI by models directly . Some processes are indirectly depended on LAI such as canopy light budgets (12,13,14), rainfall interception, evapotranspiration, surface temperature and photosynthesis. It should also allow the up scaling in time and space of ES, provided that they are closely related to LAI (11).

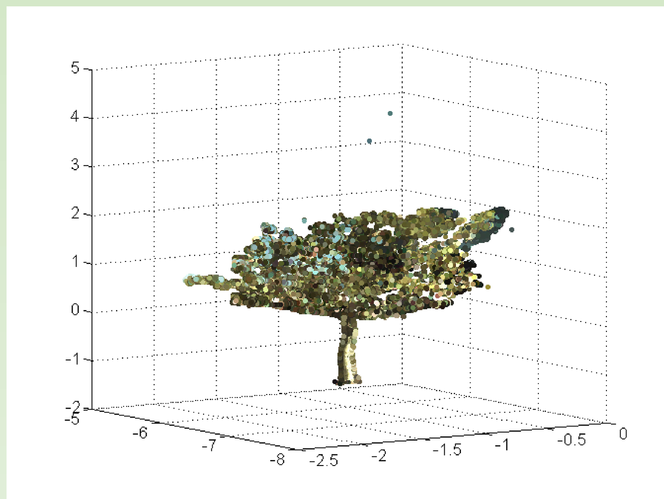
Lidar Results

Ground Lidar data

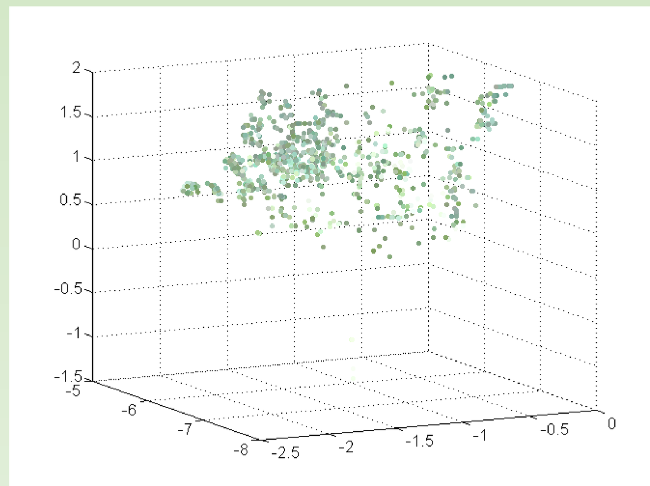
Calculating LAI by separating leaf and wood material in leaf-on and leaf-off season based on RGB from Lidar image.

Extracting PCD from Cyclone software

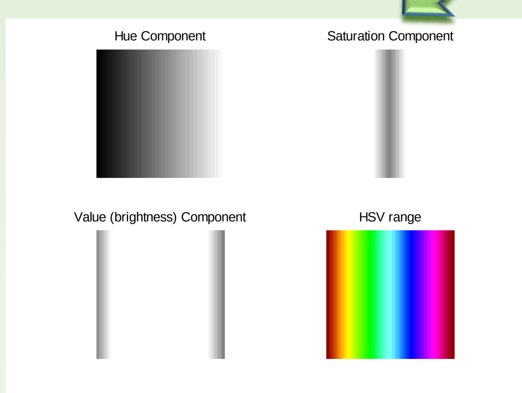
LAI analyzed by Ground Lidar with resolution of 1 mm =2.61



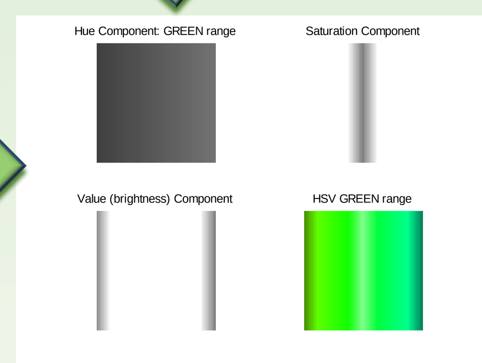
Leaf and wood material



Leaf material



Convert RGB to HSV color



Only green color

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