

WOODY VEGETATION LANDSCAPE FEATURE GENERATION FROM MULTISPECTRAL AND LIDAR DATA (A CRCSI 2.07 WOODY ATTRIBUTION PAPER)

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ABSTRACT

There is a need for accurate estimation of Australian woody vegetation parameters. State and Commonwealth land management agencies are mandated to report about forest condition every five years. The CRCSI 2.07 “*Australian woody vegetation landscape feature generation from multi-source airborne and space-borne imaging and ranging data*” aims at producing ready-to-use methods to report forest condition based on remote sensing data. The first efforts have focus on field data techniques and canopy structure characterization using LiDAR data. Results demonstrate canopy profile can be accurately estimated using Weibull probability density functions at 30x30m pixel size. Moreover different field techniques to measure vegetation fractional cover has been tested and compare finding differences up to 15%.

Index Terms— Australian woody vegetation, forest extent, fractional cover, canopy vertical profile.

1. INTRODUCTION

State and Commonwealth land management agencies are mandated to map and report Australian native woody vegetation (NWV) condition i.e. extent, configuration and health (see National State of the Environment 2011 [1]). However, there is a lack of accurate and affordable procedures to characterise the woody vegetation at the regional scale. In Australia forest is defined by ABARES [2] as “an area, incorporating all living and nonliving components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 2 metres and with existing or potential crown cover of overstorey strata equal to or greater than 20 percent”. Consequently, canopy height and cover have to be accurately assessed in order to estimate forest extent. Although single-source data has been used in the past for these purposes (e.g. hyperspectral or LiDAR), data fusion

techniques have been demonstrated as efficient tools for accurate assessment of forest areas. Examples of forest height, vegetation cover, canopy health and species mapping can be found in [3-8].

This paper presents the initial results of the project entitled “Australian woody vegetation landscape feature generation from multi-source airborne and space-borne imaging and ranging data” that commenced in early 2012. The primary project objective is to develop operational techniques and tools to assess data primitives for the characterisation of Australian woody vegetation systems. In the first stage of the project a set of data primitives was selected according to operational forest management, industry and research community needs [9]. Data primitives are a set of fundamental variables describing woody vegetation systems (e.g. canopy height, leaf area index, canopy cover). During the second stage of the project, standard operating procedures will be developed to derive woody vegetation data primitives from optical and LiDAR imagery. Data primitive information layers will be combined into features used to spatially characterise woody vegetation at the landscape level. This paper presents the results of the first stage including the study site selection, field data collection and preliminary data analysis. Finally, the future steps are summarised.

2. STUDY SITES

Three 5 km² sites located in Victoria, Australia were selected for this project. The sites were chosen as being undisturbed ecosystems representative of major Victorian ecosystem types. The first site (36.74S, 144.96E) is located in central Victoria and comprises Box Iron Bark forest dominated by red iron bark (*Eucalyptus tricarpa*), red stringybark (*Eucalyptus macrorhyncha*), red box (*Eucalyptus polyanthemus*), long leaf box (*Eucalyptus gonicalyx*) and grey box (*Eucalyptus microcarpa*). The second site (37.69S, 145.68E) is a Wet Sclerophyll forest representative of the plateaux and slopes of the upper

watershed areas south of the Great Dividing Range. Species composition is characterised by a mature open forest of mountain ash (*Eucalyptus regnans*), Shining Gum (*Eucalyptus nitens*) and Alpine Ash (*Eucalyptus delegatensis*), vegetation is much denser and predominantly consists of two or more canopy layers. The third study site (37.48S, 148.33E) is a Mixed-Species Dry Sclerophyll forest located in east Victoria. The vegetation of this region is dominated by Shrubby Dry Forest and Damp Forest on the upland slopes; Wet Forest ecosystems which are restricted to the higher altitudes; and Grassy Woodland, Grassy Dry Forest and Valley Grassy Forest ecosystems are associated with major river valleys.

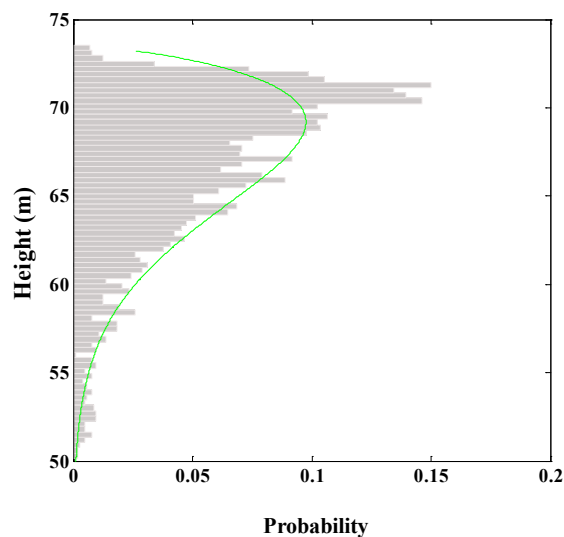
3. AIRBORNE AND FIELD DATA COLLECTION

In April 2012, hyperspectral imagery and LiDAR data was acquired over the three study sites. The airborne campaigns were conducted by Airborne Research Australia (ARA) using the Specim AISA Eagle/Hawk hyperspectral imaging system (Oulu, Finland) positioned on opposite sides of the same airborne platform and a Rigel LMS-Q560 (Horn, Austria) on a second platform. The hyperspectral imagery, with 0.5 m ground spatial resolution, was processed to deliver geo-rectified and calibrated reflectance values. The LiDAR data was delivered in a number of formats including a fully digitised waveform and as a decomposed point cloud. Simultaneous to imagery acquisition, forest inventory data were collected in the field. In each 5 km² study site, 9 randomly located reference plots were established for full characterisation. For each location, coarse woody debris, soil and vegetation inventories were done within a 11 m radius (0.04 ha) circular plot. The height and Diameter at Breast Height (DBH) was measured for all the trees with a DBH >10 cm, further information related to canopy health collected for five trees distributed across the range of tree heights. The foliar cover of the plot area was measured using different sampling designs including low (CI-110) and high resolution hemispherical photography and densitometer readings collected on Statewide Land cover and Trees Study pattern transects (SLATS, [10]). Furthermore, the nine reference plots were scanned using a Terrestrial Laser Scanner (TLS, Trimble CX). Finally leaf samples were collected from the uppermost third of 150 crowns across the three sites. The purpose of leaf sampling collection was to measure leaf spectroscopy and leaf nutrient, pigment and water content. A full description of the leaf sampling procedure can be found in [11].

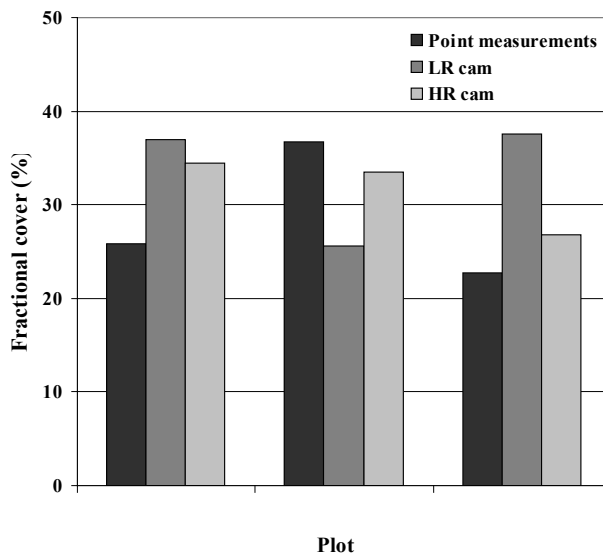
4. DATA ANALYSIS

The efforts of the project team during the first stage were focused on canopy height, vertical profile and foliage estimation using LiDAR and field data. A Gaussian Pulse Fitting method was used to simulate discrete returns from

the waveform LiDAR data provided by ARA [12], the resulting point density was ~17 points/m². Canopy height profiles were derived for each reference plot as well as the fitting of Weibull Probability Density Functions (PDF) to characterise profile [13]. Metrics of height were estimated using the first, first and last and all returns, metrics included maximum height, mean of highest 80%, predominant and the 99th percentile. Full analysis and results can be found in [14].



(a)



(b)

Figure 1. a) A canopy height profile and Weibull probability density function for a 30 x 30 m LiDAR plot captured over a single canopy forest system. b) Comparison of foliage fractional cover measured in the field with 3 different techniques: densitometer discrete point readings, low and high resolution hemispherical cameras (LR and HR respectively).

Foliage cover was estimated using the discrete densitometer readings and hemispherical low and high resolution images acquired in the field. Foliage cover was computed from the densitometer readings as the ratio between non-woody vegetation points to total number of points. Cover estimation from hemispherical imagery was based on a supervised classification to separate vegetation and sky pixels carried out in CAN-EYE software (INRA_Avignon, France). More information about the methodology for foliage cover estimation can be found in [15].

The comparison between canopy cover derived from hemispherical cameras and canopy cover derived from densitometer readings was done using the same sampling pattern and viewing angles.

5. RESULTS

The analysis of different metrics to estimate canopy height demonstrate that using only the first return component derives similar estimates of height when compared with using first-and-last and all returns. Utilising only the first return component reduces data volume by 37%; this would decrease computation time particularly when considering regional LiDAR campaigns (results not shown please refer to [14] for further information). The Weibull PDF proved adequate to describe the canopy vertical profile for non-complex forest structures. An example for a single canopy forest system is presented in Figure 1a. Figure 1b shows a comparison of the values obtained when measuring foliage cover in the field using different techniques and instruments. The comparison of techniques to measure foliage cover in the field demonstrates the need for consistency in the measurement procedure to avoid data inaccuracies.

6. FUTURE DIRECTIONS

In the next stage, the project will focus on the use of data fusion techniques to develop automatised procedures for vegetation landscape feature generation based on both optical and LiDAR information.

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