ESTIMATION OF FOREST LITTER-BED FUEL LOAD USING AIRBORNE LIDAR DATA

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Accurate description of forest litter-bed fuel load has its significance in assessing potential fire hazards and assisting in fuel hazard-reduction burns to reduce fire risks to the community and environment. In this study, Light Detection and Ranging (LiDAR) data was used to estimate litter-bed fuel load.

RESEARCH QUESTIONS

- Can airborne LiDAR - derived canopy profile be used to estimate litter-bed fuel load?
- How forest litter-bed fuel load is related to forest type, fire disturbances and other environmental factors (e.g. weather and topography)?

STUDY AREA AND SAMPLES

The study area is located at Upper Yarra Reservoir National Park. Litter fuel load were collected at forty-one sampling sites sized 0.5 m * 0.5 m at six plots in order to have various terrain features and fire histories using a stratified sampling method.

METHODS

A predictive mode of forest litter-bed fuel load is developed using airborne LiDAR indices (Table 1).

Stratification of forest structure

The vertical profile of the forest structures in the study area tends to follow a bimodal distribution (Fig.1); the 1st component of the model represents the density distribution of LiDAR points across vertical profile of understorey shrubs; the 2nd component of the model plots the density distribution of LiDAR points in overstorey vegetation. The stratification of the forest vegetation between overstorey and understorey were then carried out by identifying the 2nd derivative of the bimodal distribution function.

The stratified LiDAR indices (Table 1), and LiDAR-derived canopy density (*CD*), aspect (*A*), elevation (*E*), and slope (*S*) were then used to develop predictive models to estimate litter-bed fuel load (*FL*).

Model development and error assessment

The model assumptions were assessed through Cook's distance plot, histogram of residuals and the normal probability plot. Akaike information criterion was carried out for model selection as well as restricting overfitting problems. Finally, preferred model predicted values of litter-bed fuel load were then compared with the observed fuel load for a further assessment of accuracy of the prediction.

Table 1. LiDAR derived indices of height and intensity.

LiDAR Indices		Maximum	Minimum	Mean	Median	Standard Deviation	Percentile 99th	Percentile 9^{5th} -	Percentile 1st
Height Indices (H)	*Overstorey vegetation(C)*	H_{maxC}	H_{minC}	H_{meanC}	$H_{medianC}$	H_{StdC}	$H_{99^{th}prctileC}$	$H_{95^{th}prctileC} - H_{5^{th}prctileC}$	$H_{1^{st}prctileC}$
	Understorey shrubs (S)	H_{maxS}	H_{minS}	H_{meanS}	$H_{medianS}$	H_{StdS}	$H_{99^{th}prctileS}$	$H_{95^{th}prctileS} - H_{5^{th}prctileS}$	$H_{1^{st}prctileS}$
	Lower vegetation(L)	H_{maxL}	H_{minL}	H_{meanL}	$H_{medianL}$	H_{StdL}	$H_{99^{th}prctileL}$	$H_{95^{th}prctileL} - H_{5^{th}prctileL}$	$H_{1^{st}prctileL}$
Intensity Indices (I)		I_{max}	I_{min}	I_{mean}	I_{median}	I_{Std}	$I_{99^{th}prctile}$	$I_{95^{th}prctile} - I_{5^{th}prctile}$	$I_{1^{st}prctile}$

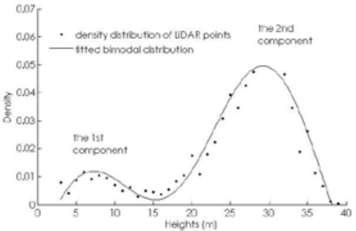

Fig.1. Plot 1 density distribution of LiDAR points.

RESULTS AND DISCUSSION

$$FL=-107.53-0.22*H_{meanS}+3.92*\log(H_{maxC})-8.2367*\log(H_{meanC})-0.15*\log(A)-0.03*H_{medianS}*H_{StdS}-27.79*\log(H_{medianC})*\log(E)+8.95*\log(H_{StdC})*\log(E) \quad (1)$$

The established model (eq.1) predicted *FL* with a prediction error of 44 g/m² (Fig.2). It explains 63% of the variation in litter-bed fuel load of the dataset. Fig.3a shows the fire history of the study area sized 800 ha. Airborne LiDAR – derived stratified height indices and topography were used to map spatial variation in *FL* across this area (Fig.3b).

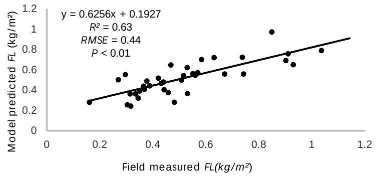

Fig.2. Scattergram of fitted values against field observed values.

CONCLUSION

- The predictive models provide spatially accurate information for making regional decisions for forest fuel management.
- The LiDAR - derived stratification for characterizing forest vegetation, is of interest for land cover classification, habitat mapping, and forest ecosystem and wildlife management.

END USERS STATEMENT

Understanding bushfire fuel is fundamental to understanding fire behaviour and risk to life, property and the natural environment from bushfires. Quantitative measures of fuel loads and arrangement have always been a limiting factor in predicting fire behaviour and the effect of fire on values. Most methods are limited to point locations. This research provides spatially continuous indices of fuel across the landscape, which is useful for analyzing not only fuel loads, but the variation of fuel across a given area. This is very useful for fire behaviour analysis, risk planning and fuel reduction burn planning. The objectiveness of using LIDAR will also reduce any error or bias introduce by semi-qualitative methods currently used. This project also has links with the National Bushfire Fuel Classification project being headed by AFAC, an initiative in which many agencies across Australia are involved.
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Fig.3a. Upper Yarra Reservoir fire history and Nearmap imagery(27 April 2011).

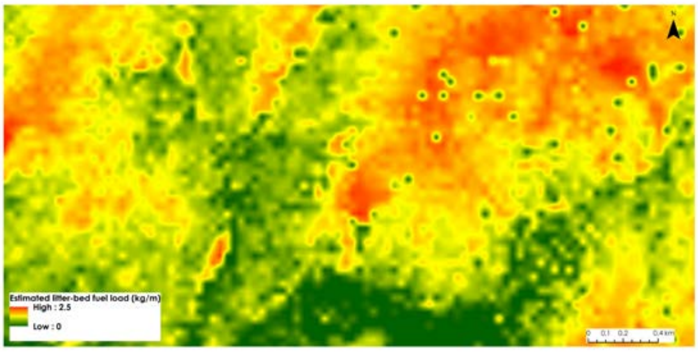

Fig.3b. LiDAR - derived litter-bed fuel load (kg/m²).

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