Short term gap dynamics of the Canadian mixedwood boreal forests using multi-temporal lidar data

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1. Background

- Gap dynamics of boreal ecosystem is not well understood.
- Spatially explicit characterization of the dynamic processes of structure and function of the canopy canopies with multi-temporal lidar data spatial analysis has the potential to advance our knowledge on canopy gap dynamics.

2. Questions

- How can lidar help in delineating recent canopy gaps of boreal forests?
- How are the gap processes, like random new gap, gap expansion, gap closure from the side and gap closure from below, occurring in these forests?
- Are the older stands maintaining equilibrium with regard to the structure compared to the younger stands in the boreal forest?

3. Study site

- 6 km² of the Conservation zone (Fig.1) in the Training and Research Forest of Lake Duparquet, Quebec (latitude 48.5 N).
- Largely mixed wood boreal forest with trembling aspen (Populus), white birch (Betula), white and black spruces (Picea), jack pine (Pinus).

4. Data

- Optimally constructed and co-registered 0.25 m resolution Canopy height models (CHMs) or vegetation surfaces of the medium density discrete lidar data acquired in June, 1998 and August, 2003 (a sample window in Fig. 2).
- Reconstructed mixed initiation maps.
- Independent assessment of both lidar datasets for maximum tree height with ground measurements showed r² of 0.88 and 0.86 respectively.

5. Defining canopy gap on lidar vegetation surface

Gaps are individual objects of contiguous binary grid cells determined by a gap indicator function (1) that has a minimum size of 5m² represented by atleast 3 lidar vegetation returns. For a given grid cell at (x,y) on the CHM, G 1998 and 2003, a gap indicator function is:

\[ G(x,y) = \begin{cases} 1 & \text{if } CHM(x,y) < a \\ 0 & \text{otherwise} \end{cases} \]  

6. Field verification and accuracy

- Number of gaps and gap length measured along 8 transects of 960 m length on ground in September 2004.
- DGPS and compass were used to cruise and Vector III to measure the distance.
- The percentage number of gaps and the proportion of the total gap length along the transects matched between the lidar derived and ground measured were compared.

7. Mapping gap dynamic characteristics

Using the definitions describe above, various combinations on gaps objects of 1998 and 2003 is applied to map different gap events, gap expansions, random new gaps, laterally closing gaps and regenerating gaps.

8. Results

**Accuracy assessment**

- Comparison of 29 field measured gaps with lidar derived gaps showed a good agreement.
- Overall, the number of matched gaps is 96.5% and matched gap length is 75.0%.

**Gap characterisation**

- Gap size distributions varied significantly in both years (Kolmogorov-Smirnov test, p<0.01), but both followed log normal distribution.
- The total area under gaps decreased as the annual rate of gap closure (1.25%) in twice that of the new gap openings (0.66%).
- These forests consistently maintain an open area of about 23%.
- Of the existing gaps in 1998, 49% of them closed mostly due to regeneration, 21.3% expanded and 19.7% partially closed and opened by 2003.
- The estimated turnover times are 1-48 and 80 years respectively for new gap opening and closures.

9. Conclusions and Prospects

- The study of this large contiguous area confirms that gap disturbances do determine the structure and processes of the mixedwood boreal forest.
- Lidar is an excellent tool for delineating gaps formed by single to multiple tree falls even in a complex canopy structure.
- Multi-temporal lidar data analysis helped in rapidly acquiring their short-term dynamics a new dimension to the current understanding of the role of canopy gap disturbances.
- With a potential to extend to a long-term combining lidar and photogrammetry, we should be able to improve our knowledge of role of gaps in successional dynamics, especially in maintaining mixedwood.
- This new insight will also have direct implications where natural disturbance is used as a template for management practices.

Selected References


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