Dead Trees are Good Trees
Towards the Estimation of Tree Structural Class in Northwest Coastal Forests Using Lidar Remote Sensing

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Dead Trees and Structural Diversity

• The presence of dead trees increases canopy patchiness.
• A partially open canopy aids in the maintenance of understorey vegetation and canopy sub-layers.
• Structural diversity increases habitat and microclimate variety.
Dead Trees and Biodiversity

Percentage of forest dwelling vertebrate species in Clayoquot Sound using different forest components for breeding (after Clayoquot Sound Scientific Panel, 1995).
The Objective

Our goal was to estimate the percentage of dead trees found in forest plots using lidar remote sensing.
Study Area

Cayoquot Sound, Vancouver Island, British Columbia, Canada
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Quickbird true-colour composite (bands 321) of the study area.
Methods

Field Program: Estimating Wildlife Tree Class

- Established 22 forest plots. **Two outliers were excluded.**
- Pole/sapling (n=5), young forest (n=3) and old forest (n=12).
- WT class was estimated for all trees, snags and stumps with a DBH greater than 10 cm.
Methods

Lidar Data

• Lidar Survey Parameters
  – TRSI Mark II discrete return sensor
  – Two returns per laser pulse
  – Mean footprint diameter = 0.4 m
  – Optimal posting distance = 1.5 m
  – 4 x 7 km area flown over Clayoquot Sound

• Height Variables Extracted Included
  – 5, 10, 15.... 95 percentiles
  – Means, maximums, standard deviations, coefficients of variation
Results

Lognormal probability density functions were fit to distributions of dead trees in each plot.

- **Pole/Sapling**: 7% Dead
  - μ = mean of \( \log(x) \) or scale parameter
  - σ = standard deviation of \( \log(x) \) or shape parameter
  - \( \mu = 0.11, \sigma = 0.41 \)

- **Young Forest**: 14% Dead
  - \( \mu = 0.18, \sigma = 0.47 \)

- **Old Forest**: 15% Dead
  - \( \mu = 0.45, \sigma = 0.57 \)

- **Old Forest**: 23% Dead
  - \( \mu = 0.46, \sigma = 0.77 \)

- **% Live (WT classes 1-2)**
- **% Dead (WT classes 3+)**
Results

The best predictor of dead trees in each plot was the lognormal $\mu$ (scale) parameter.
Results

The best predictor of $\mu$ was the coefficient of variation of the lidar vegetation returns.

$r^2 = 0.75$, $r = 0.87$

RMSE = 0.070

$p < 0.001$
The heights of the lidar-derived 20th percentiles were also good predictors of $\mu$. 

Results

$r^2 = 0.69$, $r = -0.83$
RMSE = 0.079
$p < 0.001$
Results

Generally, the lowest lidar height percentiles were good predictors of $\mu$. 
Discussion

- There is a direct linkage between tree mortality and stand structure.
  - Young forests tend to have few dead trees and very dense canopies.
  - Old forests have heterogeneous canopies, with gaps where trees have died.
  - Gaps increased the penetration depth of lidar returns into the forest canopy, resulting in decreased heights of the lower height percentiles.
Discussion

As forest stands increase in age, the percentage of dead trees and canopy gaps increase, allowing lidar returns to penetrate further into the canopy.
Summary

- Dead trees, both standing and fallen, are a critical component of old growth stands in Clayoquot Sound.
- Lognormal probability density functions were fit to WT class data.
- Predicted the values of the proxies using lidar-derived variables.
- The best lidar-derived predictors were the coefficient of variation and, generally, the heights of the lowest lidar percentiles.
- Canopy gaps where dead trees are standing or have fallen result in increased penetration of lidar pulses into the stand.
The End

Questions?

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