Combining forest structure measurements with satellite spectral observations for forest recovery monitoring in burned environments of British Columbia, Canada

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Integrated Remote Sensing Studio

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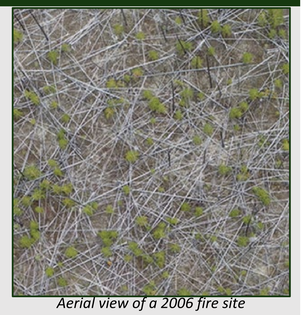
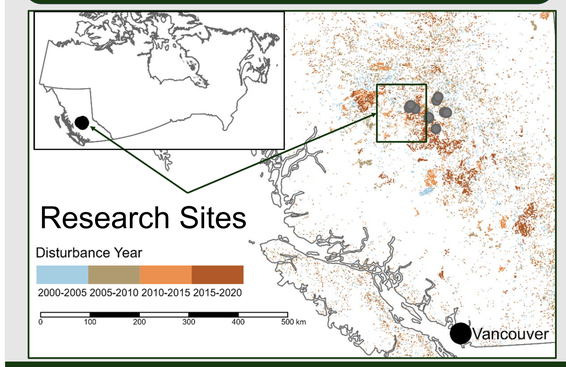
Background and Study Area

- Climate change threatens increased fire, insect, and drought severity[1]
- 20% of interior British Columbia (BC) experienced a disturbance in the last 20 years[2]
- Forests are important part of BC economy - timber harvesting alone are 5% of BC GDP[3]

Question: Can early forest structure be quantified from satellites?



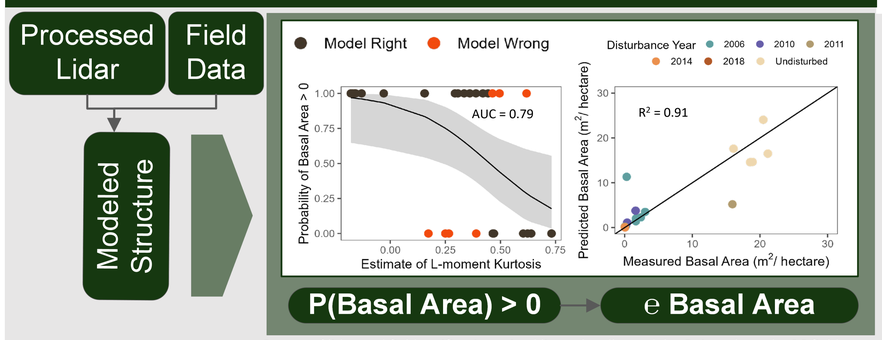
Aerial view of a 2006 fire site



- We used a space-for-time study with 10 1-hectare study areas that burned with high severity fire between 2003–2017
- Study sites burned in 2003 (1 site), 2006 (3 sites), 2010 (1 site), 2011 (site), 2015 (1 site), and 2017 (3 sites)

Location of research sites in interior BC. Colors denote satellite detected disturbances over the last 20 years. Data source[2]

RPA Lidar Models for Basal Area

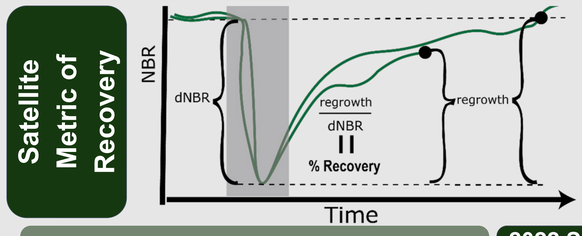


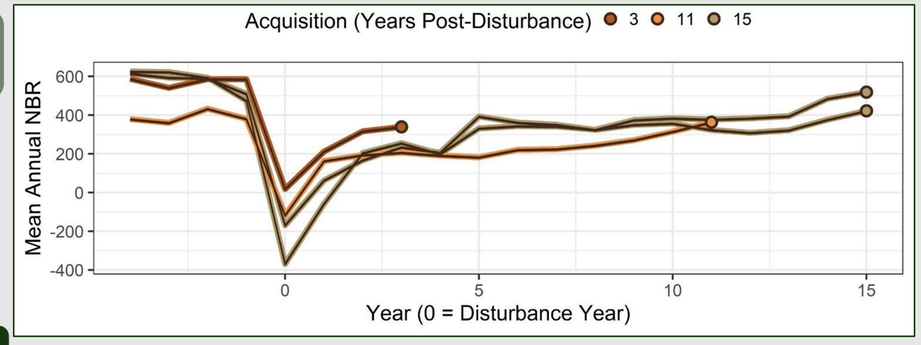
Output of lidar and field verification mixed linear hurdle models. Points show the 26 field verification plots. In the first panel, the grey area is the 95% confidence of the logistic regression. AUC = Area under curve. In the second panel, the black line is the 1:1 line.

- Validated Remotely Piloted Aircraft (RPA) lidar estimates of basal area with 26 circular forest structure plots (each 900 m^2)
  - Measured trees with diameter at breast height >4cm
- Used a stepwise regression with 8 uncorrelated (Spearman correlation < 0.7) lidar metrics; models limited to ≤ 5 predictors
- Present parsimonious model for lidar metrics using 2-step model process:
  - P(Basal Area) model incorporates L-moment Kurtosis
  - Estimate of Basal Area incorporates L-moment Kurtosis, L-moment skewness, % of points > mean, the absolute deviation of points from the mean

Compiled Landsat Recovery and RPA Lidar Model Estimates

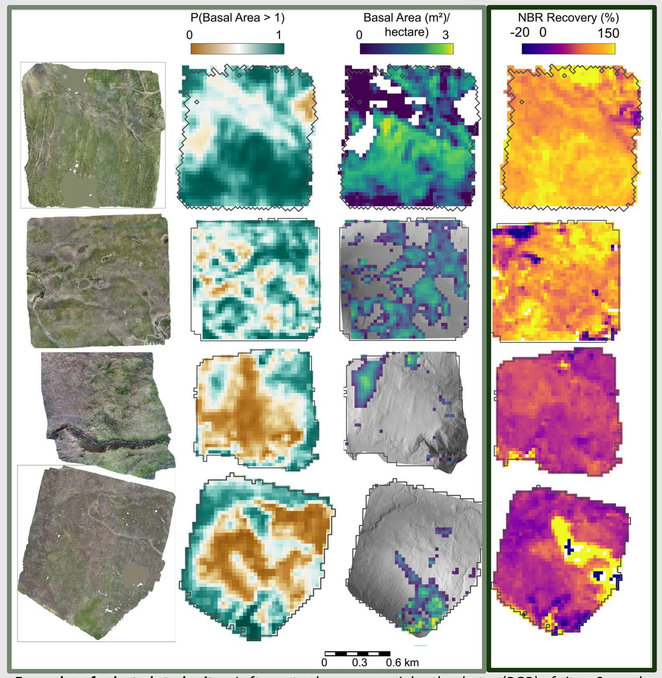
Landsat Satellite Spectra (From Growing Season Best-Available Pixel)





*Examples of Average dNBR for **select study sites (see center plot)** ordered by time since disturbance. Acquisition year is 2021. Fire years are 2017 (or 3 years post disturbance), 2010 , and 2006.*

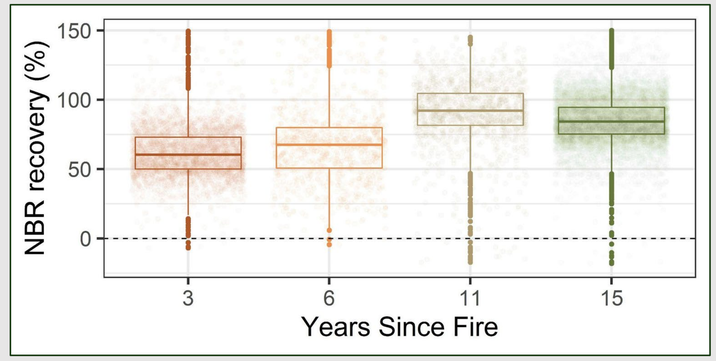
Examples of 2022 Lidar Models | **2022 Satellite Data**



***Examples of selected study sites**. Left-most column are aerial orthophotos (RGB) of sites. Second column shows output of the first model step (the probability of a measurable basal area). Third column are the lidar estimates basal area and the fourth column is the NBR % recovery for each Landsat pixel. The years since fire is noted to the right.*

- Study sites showed structural and spectral differences from lidar and satellites
- All sites had low basal area measurements. Recent burns (<6 yrs) had little to *no* field measured or lidar estimated basal area.

Key Findings



Satellite NBR Recovery % for the years since fire. The bold middle line is the median and the boxes are the interquartile range. Bold points are outliers data points and faded points represent unique pixels

- Recovery of measurable basal area is slow and often not detectable for fire disturbances less than < 6 years old
- RPA lidar can measure early onset of forest structural recovery
- Trends of structural recovery are present in spectral trajectories from Landsat

References

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[2]Hermosilla, T., Wulder, M. A., White, J. C., Coops, N. C., Hobart, G. W., & Campbell, L. B. (2016). Mass data processing of time series Landsat imagery: pixels to data products for forest monitoring. International Journal of Digital Earth, 9(11), 1035-1054.
[3]Beutista, L., (2020). Economic State of the British Columbia Forest Sector. Report for BC Ministry of Forest, Lands, Natural Resource Opertations and Rural Development

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