Assessing the accuracy of GEDI for mapping resilience in the Amazon rainforest along a gradient of disturbance to recovery

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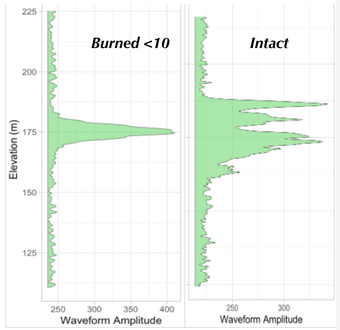
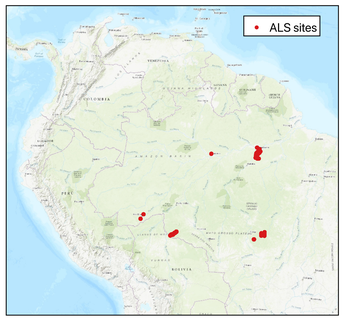
INTRODUCTION

The Amazon, the world's largest continuous tropical forest, is identified as a potential tipping element in the Earth's climate system (Lenton et al., 2008). Understanding the resilience of tropical vegetation, its ability to recover from disturbance, is fundamental to assess future responses to environmental and climatic fluctuations (Lenton et al., 2022). The Global Ecosystem Dynamics Investigation (GEDI) spaceborne LiDAR characterises a new era of large-scale forest height quantification, with capabilities to further understand forest structure, and therefore forest response to perturbation across the entire Amazon.



GEDI waveform: burned vs intact forest



Site map of GEDI/ ALS overlap for this study

RESEARCH AIMS

(A) Evaluate the use of metrics derived from GEDI to understand recovering forest compared to airborne lidar (ALS).

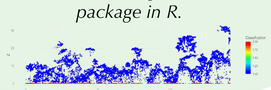
(B) Assess forest structure variation along a gradient of degradation and recovery as a proxy for resilience.

(C) Investigate the potential to classify degraded forest states e.g logged and burned with GEDI data.

METHODOLOGY

1

ALS: *preprocessed (filtered, classified and normalised) data from Permian Global and Sustainable Landscapes Brazil project (dos-Santos et al. 2019), using the LidR package in R.*



2

GEDI: *downloaded 2A, 2B and 4A products within ALS extents using the chewie package. Calculated regression models to summarise relative height (rh) 0 -100 for canopy distribution metrics (slope, variance, intercept) using waveformlidar package (Dwiputra et al 2023).*

3

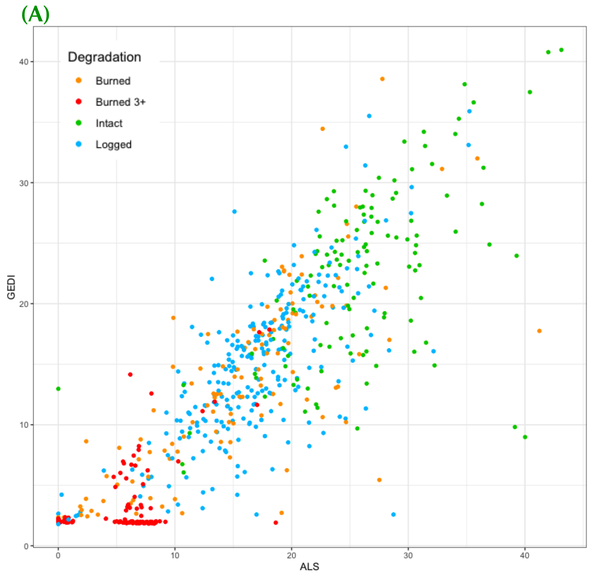
Forest classification: *Obtained secondary forest stand age dataset (Silva Junior et al. 2020), and MAPBIOMAS burn frequency (1985-2023). Stand age was extended to current date. Forest was classified by degradation type and age since disturbance.*

4

Analysis: *Extract ALS relative height and canopy cover metrics within 25 m GEDI footprints. Correlation/ correspondence analysis between ALS and GEDI (Dorado Roda et al. 2021). Principal Component Analysis (PCA) of GEDI metrics/waveform summaries to understand which are most indicative of forest state*

PRELIMINARY RESULTS

(A)

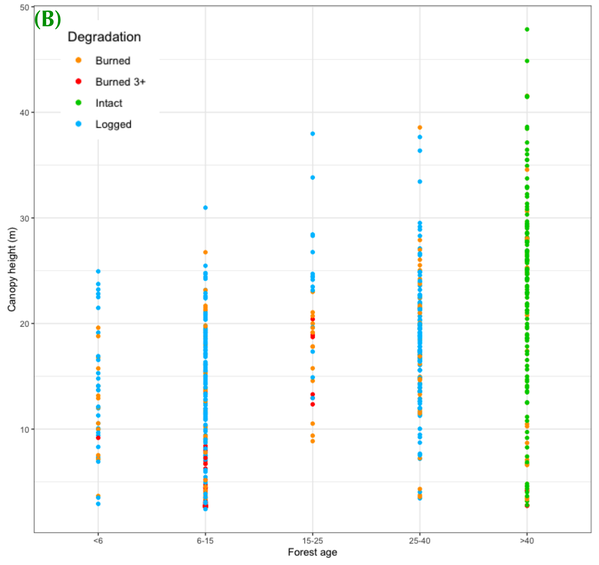


(A) Correspondence between ALS and GEDI rh95. Overall there is a significant positive correlation for all forest conditions. However, the correspondence is lower for intact forest, and particularly forest burned multiple times, supported by a very low Lin's CCC score.

Forest condition	Corresponding metric	Lin's CCC	Pearsons Correlation	RMSE (m)	rRMSE (%)	Bias (m)	rBias (%)
All	zq95 - rh95	0.81	0.87 ***	5.46	33.87	2.36	14.67
Intact	zq95 - rh95	0.55	0.58 ***	7.14	44.27	3.44	21.34
Logged	zq95 - rh95	0.68	0.68 ***	5.03	31.21	2.20	13.62
Burned	zq95 - rh95	0.81	0.88 ***	4.88	30.25	1.99	12.36
Burned 1-3	zq95 - rh95	0.77	0.81 ***	5.35	33.17	2.06	12.80
Burned 4-6	zq95 - rh95	0.12	0.29 ***	4.14	25.70	1.89	11.75

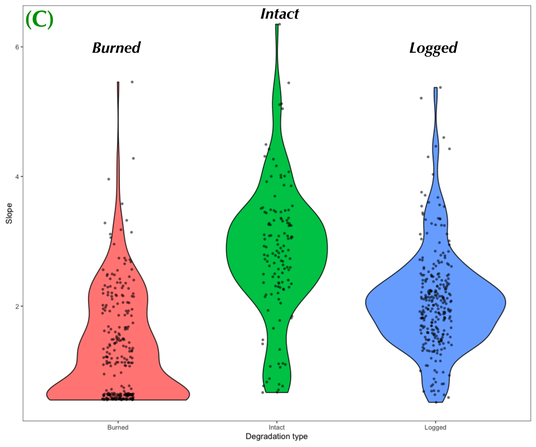
1-3, 4-6 refers to burn frequency *** *all correlations significant to p < 0.001*

(B)



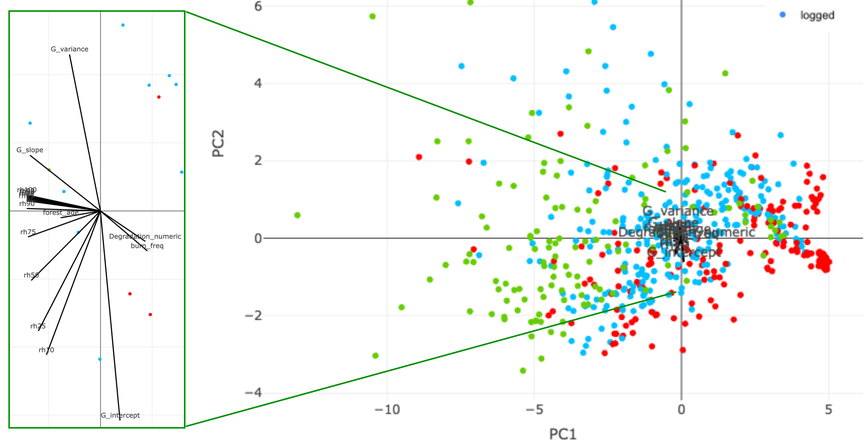
(B) GEDI canopy height by degradation. Generally height increases as forest recovers, whilst more frequent burn scars have a lasting legacy in forest recovery both height and canopy.

(C)



(C) Gradient slope of relative height profile. The summary relative height regressions of the GEDI waveform (slope, variance, intercept) demonstrate differences between intact, logged and burned forest.

(C) PCA analysis of GEDI metrics and forest degradation. The first three PCA's explain 91.8% of the total variance. Overall the relative height metrics demonstrate the highest loading for capturing variation. After subsetting the data by degradation type: waveform summaries of intercept and slope had higher loading.



PRELIMINARY CONCLUSIONS

- GEDI canopy height and cover metrics along a gradient of burned forest are comparable within literature to ALS degraded forest structure study (Vedovato et al. 2024), strengthening confidence in the ability of GEDI to portray structurally degraded forest state.
- The use of GEDI to differentiate between forest state with structural metrics has promise for resilience research, but also has potential to be used to improve carbon estimates by including degraded/ recovering forest, and to inform monitoring for forest management.

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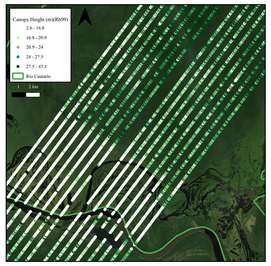
Format of GEDI data in swaths →



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ABSTRACT →