Characterizing Relationships Between Conifer Growth Metrics and Microtopography at SPRUCE

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Intro

- Peatlands contribute to 1/3 of the global terrestrial carbon stock[3]
- Northern boreal peatlands are being disproportionately affected by climate change[7,8]
- Climate change degrades peatlands primarily by causing water table drawdown[9]
- Relationships between water table hydrology, surface microtopography, and vascular plants can determine site-scale variation in carbon storage and efflux[1,6]

Methods

- Terrestrial lidar scans were collected in all SPRUCE plots in spring and summer
- Conifer tree bases were geolocated via Mask R-CNN machine learning model
- SPRUCE tree metrics and microtopography datasets[4] from 2016-2018 were utilized to examine the relationship between conifer growth and microtopography
- A Bayesian Gamma Mixed Effects Model was used to assess the effects microtopography and SPRUCE treatments on conifer DBH

Results

- There is a non-zero positive relationship between conifer DBH and hollow index, temperature treatment, and CO_2 treatment (**Fig. 4**)
- Negative interaction between CO_2 and temperature treatment suggests mediating effect (**Fig. 5, Fig. 7**)
- Under ambient conditions, greater hollow index (more hollow-like) is associated with larger conifer DBH

Discussion/Future Work

- The positive relationship between hollow index and DBH was unexpected and contrasts previous findings[2,5]; This relationship will be assessed with a larger sample size in a future study
- More explicit analysis of microtopography time series needed to understand shifts in microforms
- A larger sample size is needed for a robust analysis of ambient peatland conditions

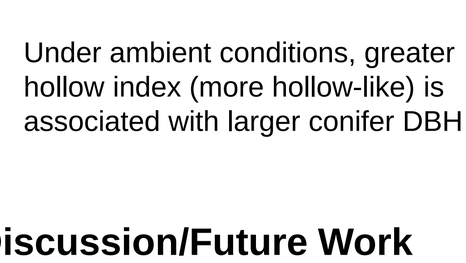

Figure 1: Microtopography and conifers at SPRUCE

Conifer DBH is correlated with microtopography and climate manipulations at SPRUCE

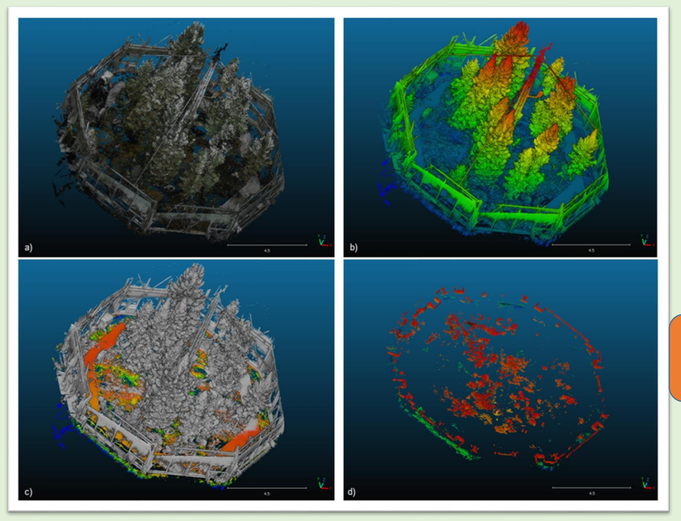

Figure 2: Preprocessing of Lidar data for Mask R-CNN model. **a)** True color plot point cloud **b)** Point cloud filtered by z-value **c)** Filtering point cloud based on z-value **d)** filtered Lidar 'slice' to be rasterized for Mask R-CNN processing

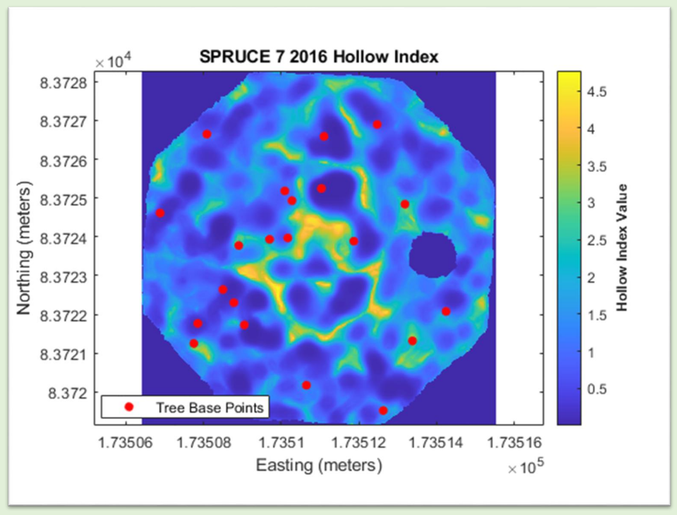

Figure 3: Hollow Index Raster overlaid with tree base points geolocated via Mask R-CNN Machine Learning Model. Hollow Index is a continuous index created from parameters of slope, concavity, and elevation to describe how hollow-like a region is. Higher hollow index = more hollow-like

SPRUCE Gamma Mixed-Effects Model

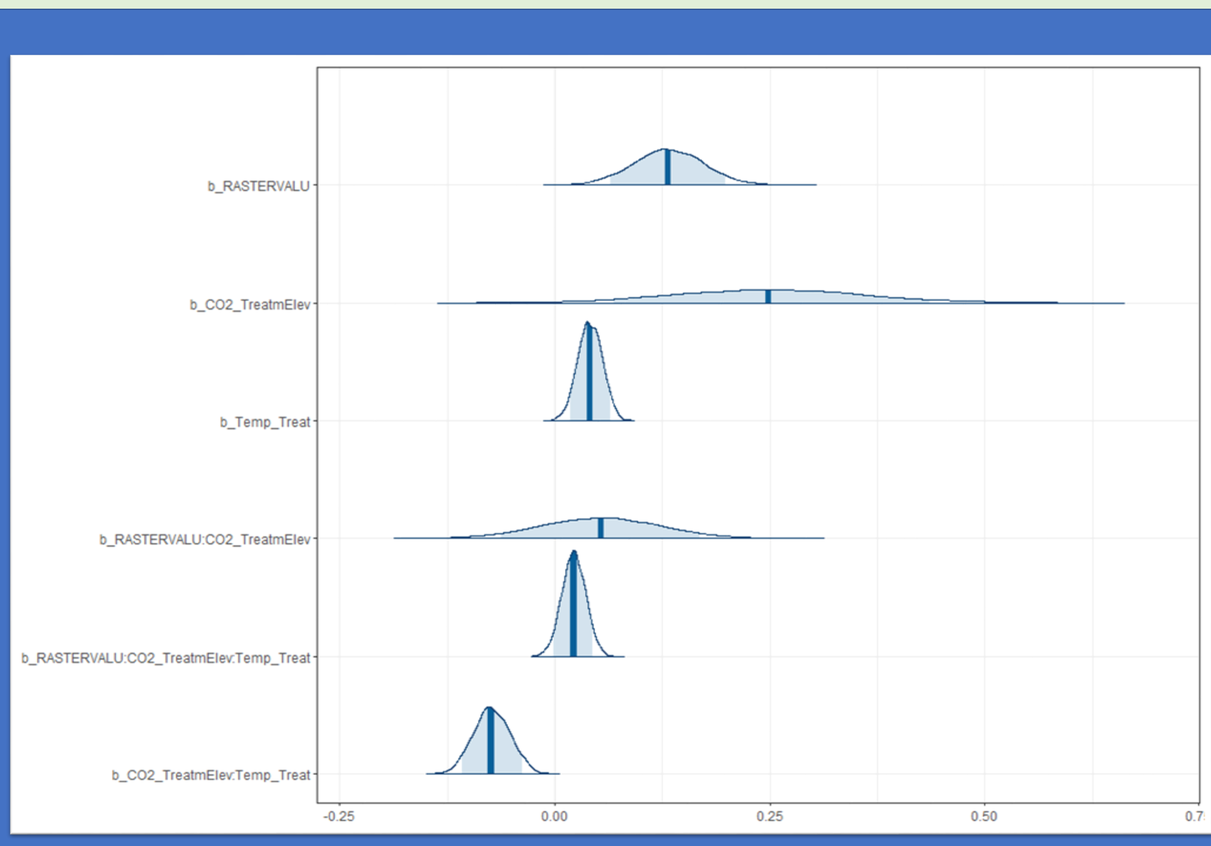

Figure 4: MCMC plot of SPRUCE Gamma Mixed Effects Model illustrating posterior distributions with 95% credible intervals

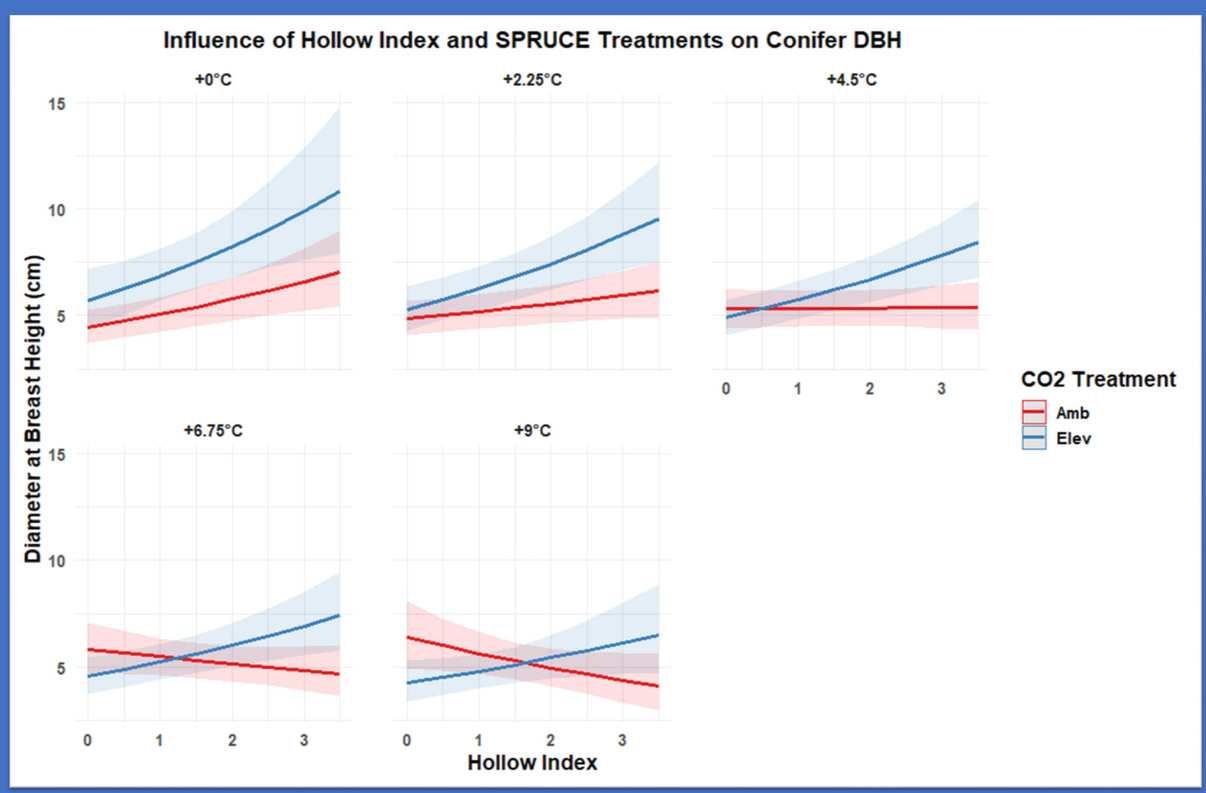

Figure 5: Plot of SPRUCE Gamma Mixed Effects Model. Subplots denote temperature treatment level. Y axes are DBH value, x axes are Hollow Index, trendlines denote ambient and elevated CO_2 treatments

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Equation:

*DBH ~ Hollow Index * CO_2 Treatment * Temperature Treatment + (1|Year)*

Equation 1: Equation for the SPRUCE Gamma Mixed Effects Model; includes interaction terms between microtopography and SPRUCE treatments and a varying intercept by year

Term	Estimate	Est. Error	95% CI (Lower)	95% CI (Upper)	Rhat	Bulk ESS	Tail ESS
Intercept	1.49	0.09	1.29	1.65	1.00	1146	464
RASTERVALU	0.13	0.04	0.05	0.21	1.00	1573	2271
CO2_TreatmElev	0.24	0.11	0.02	0.46	1.00	1282	1870
Temp_Treat	0.04	0.01	0.01	0.07	1.00	1056	2015
RASTERVALU:CO2_TreatmElev	0.06	0.07	-0.08	0.20	1.00	1212	1871
RASTERVALU:Temp_Treat	-0.03	0.01	-0.05	-0.01	1.00	993	1952
CO2_TreatmElev:Temp_Treat	-0.07	0.02	-0.11	-0.03	1.00	1001	1583
RASTERVALU:CO2_TreatmElev:Temp_Treat	0.02	0.01	-0.01	0.05	1.00	995	1573

Figure 6: Coefficients for the SPRUCE Gamma Mixed Effects Model; nonzero effects include RASTERVALU (hollow index), CO2_TreatmElev, Temp_treat, and CO2_TreatmElev:Temp_Treat

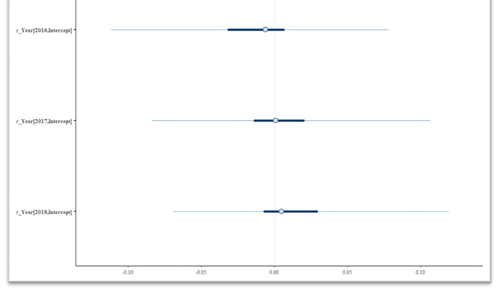

Figure 7: Restructured **Figure 4** plot predictions to illustrate the effect of CO_2 treatments on the DBH~hollow index relationship

Term	Estimate	Est. Error	Q2.5	Q97.5
Pseudo-R2	0.1785956	0.03947669	0.1060543	0.2615569
OOS RMSE	2.035219	***	***	***

Figure 8: Pseudo-R2 with 95% Confidence interval and out-of-sample RMSE for three-fold cross validation

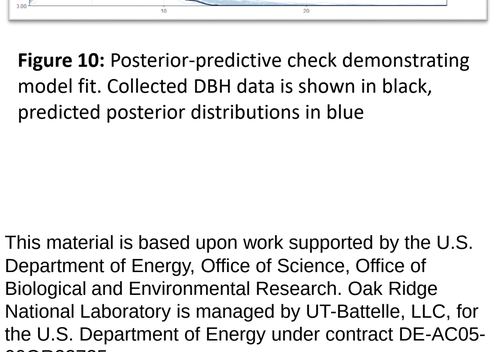

Figure 9: MCMC Plot of variable intercepts by year

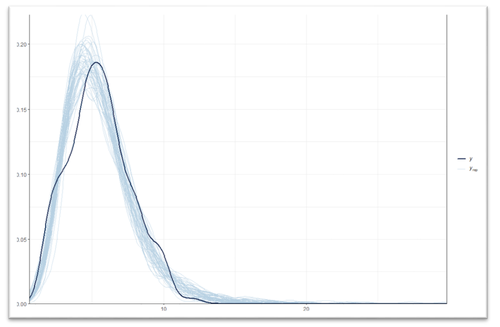

Figure 10: Posterior-predictive check demonstrating model fit. Collected DBH data is shown in black, predicted posterior distributions in blue

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