Crown Damage in FATES

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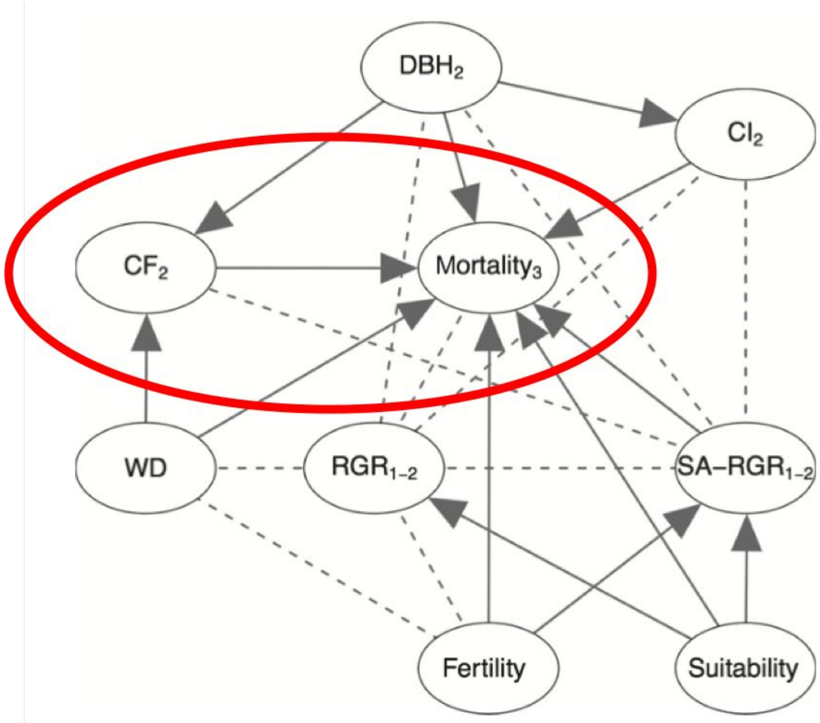
Crown damage is a significant predictor of death



- Identifying cause of death in forest census data is challenging.
- But damage has consistently been linked to increased rates of mortality.

Arellano *et al.* New Phytologist (2019)

Is crown damage worth representing?

- If trees will ultimately die (or recover) from damage, is it worth the computational cost of tracking that damage versus modelling final mortality rates?

- **Do lags between environmental drivers and mortality matter for forest dynamics?**

  Some trees might survive years before death with significantly reduced crowns. This could alter growth rates and biomass estimates.

- **Does cumulative damage matter for final mortality rates?**

  Crown damage facilitates interactions between different drivers of mortality.

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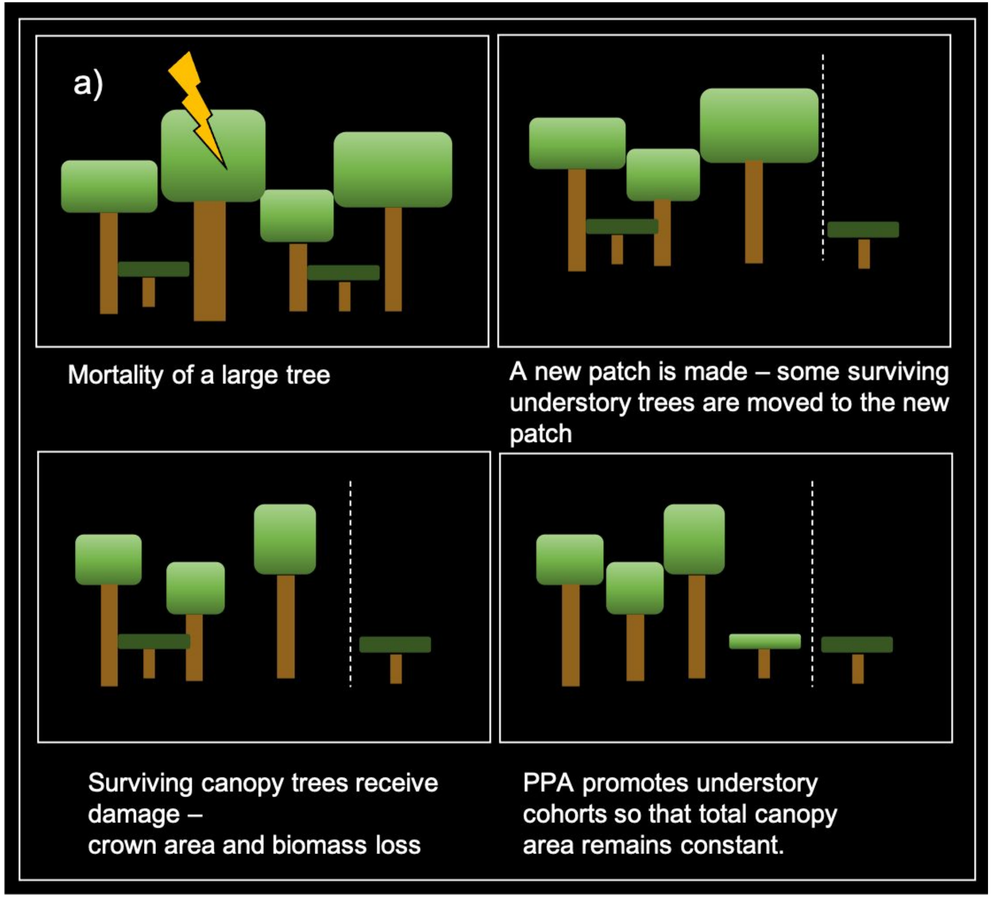
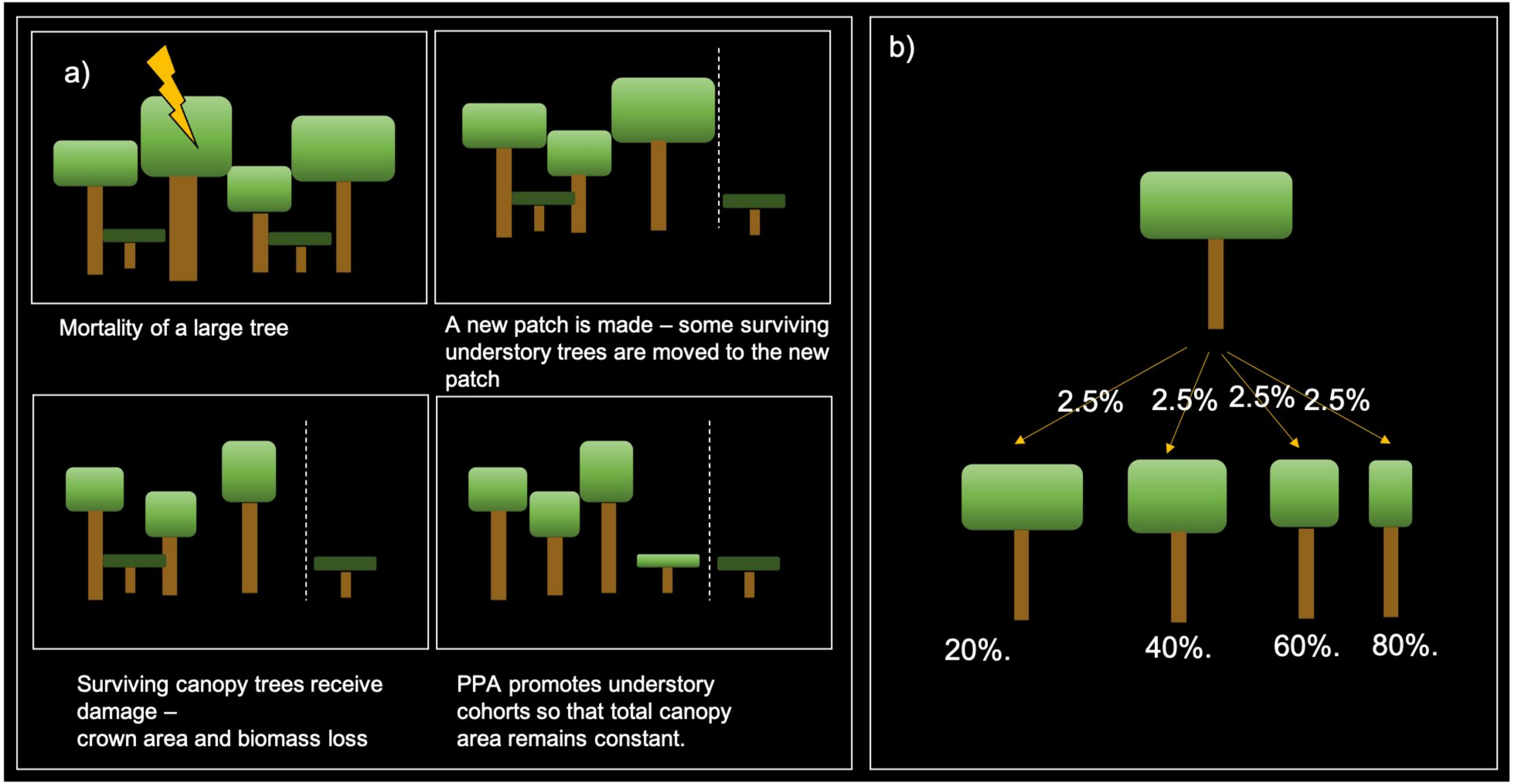
Damage is associated with canopy mortality

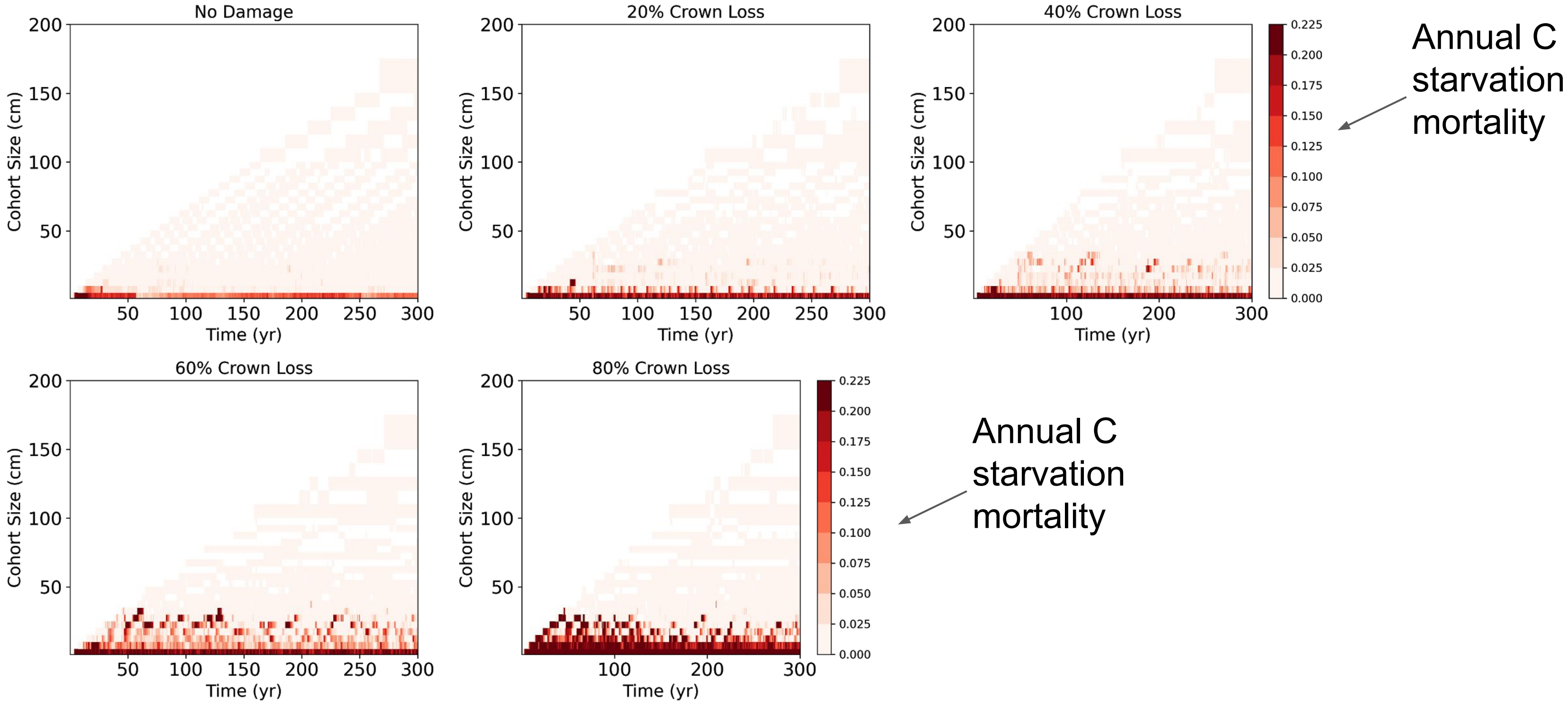


A defined fraction of trees are damaged annually

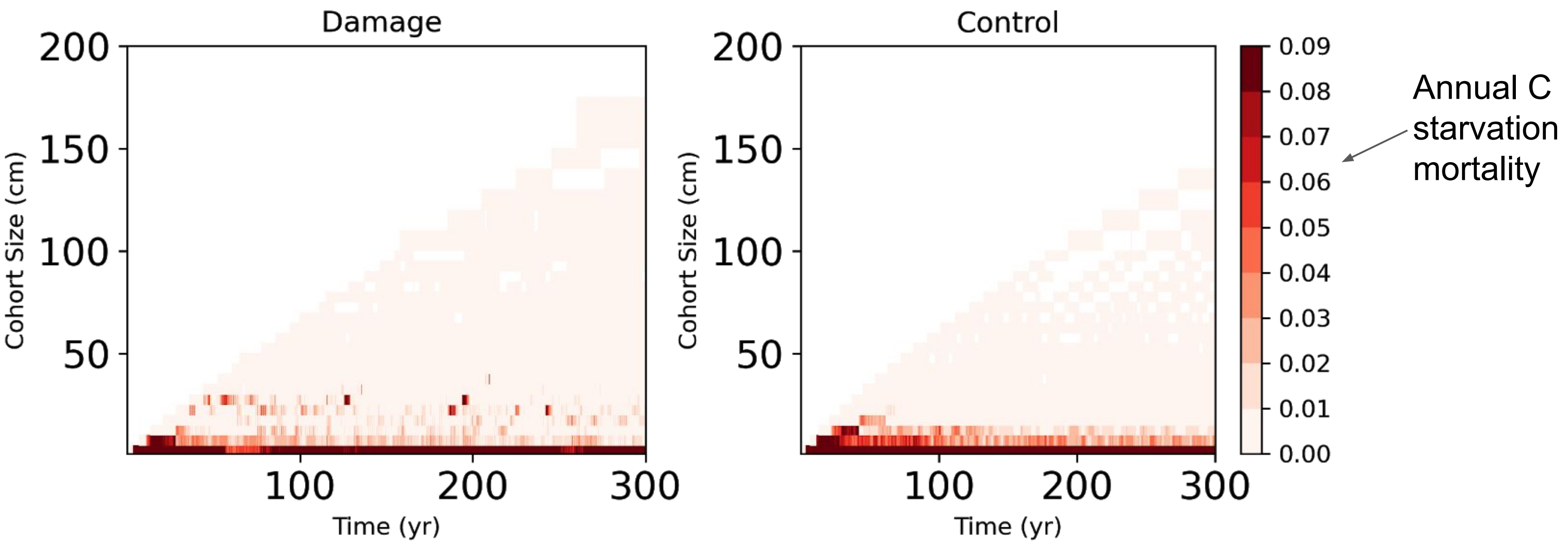


Do damaged trees have higher mortality rates?

Carbon starvation increases in higher damage classes - but mostly in small sizes



Carbon starvation increases overall compared with the control - but only in small sizes



- Large damaged trees in the field do not die of C starvation?

- Representation of damage in FATES simulations is not capturing processes that lead to C starvation in the field?

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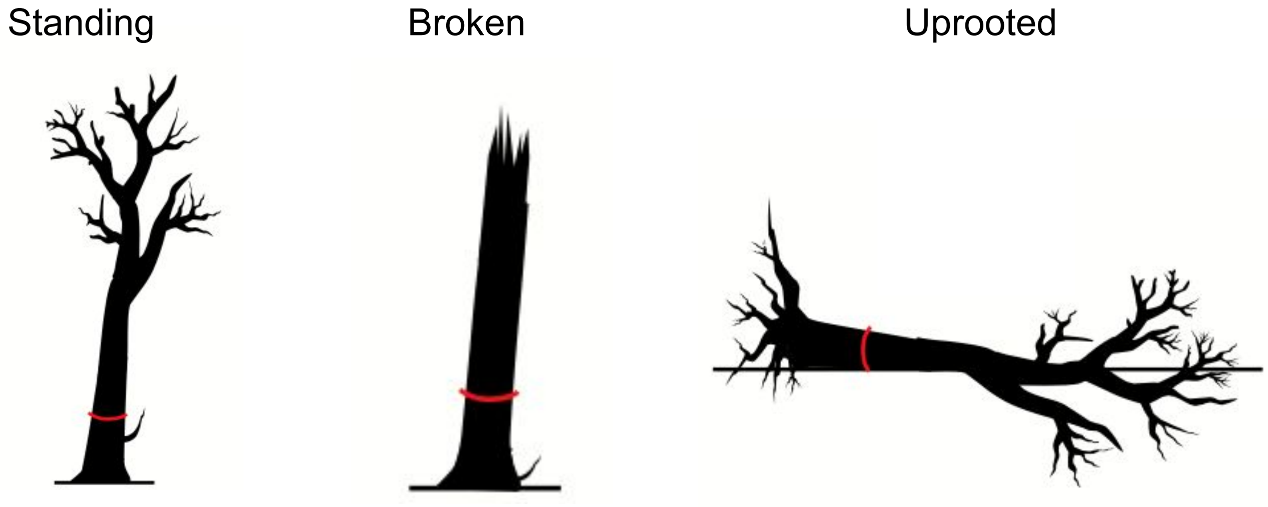
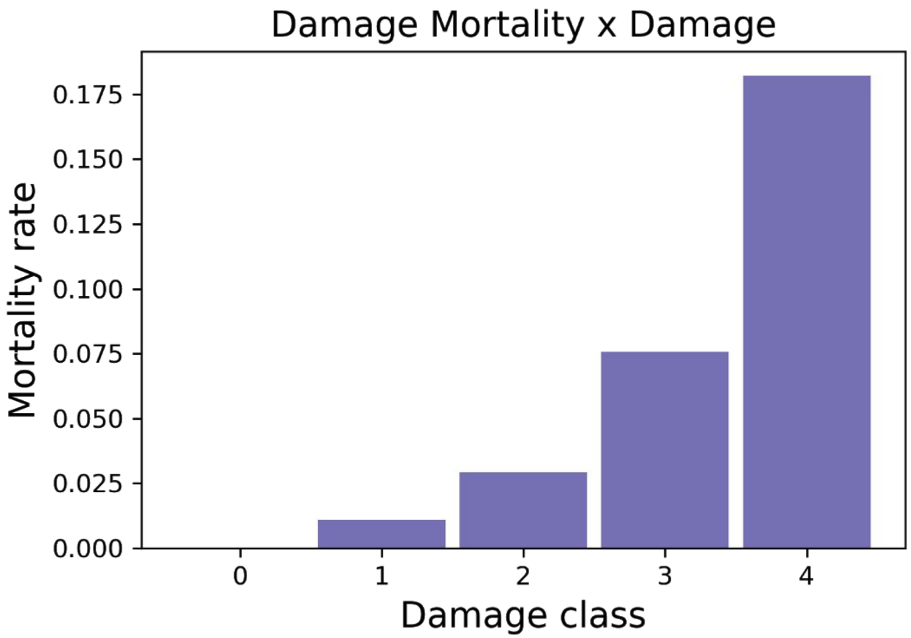
- In mortality surveys across six tropical forests, trees that had crown damage and then died were equally likely to die standing, broken or uprooted.

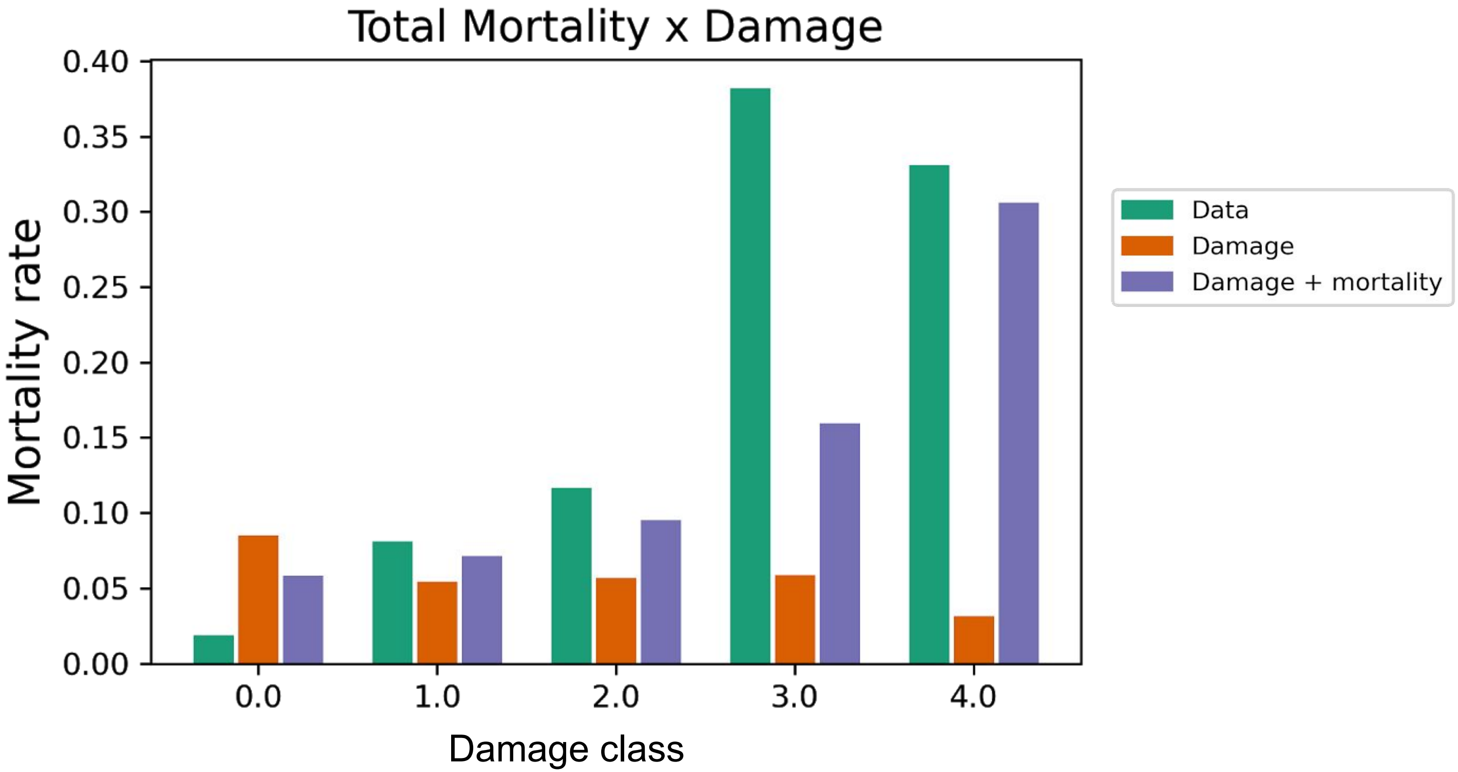


Arellano *et al.* Journal of Vegetation Science (2021)

With an explicit damage mortality term higher damage classes have higher mortality



Explicit damage mortality captures the increase in mortality with crown loss



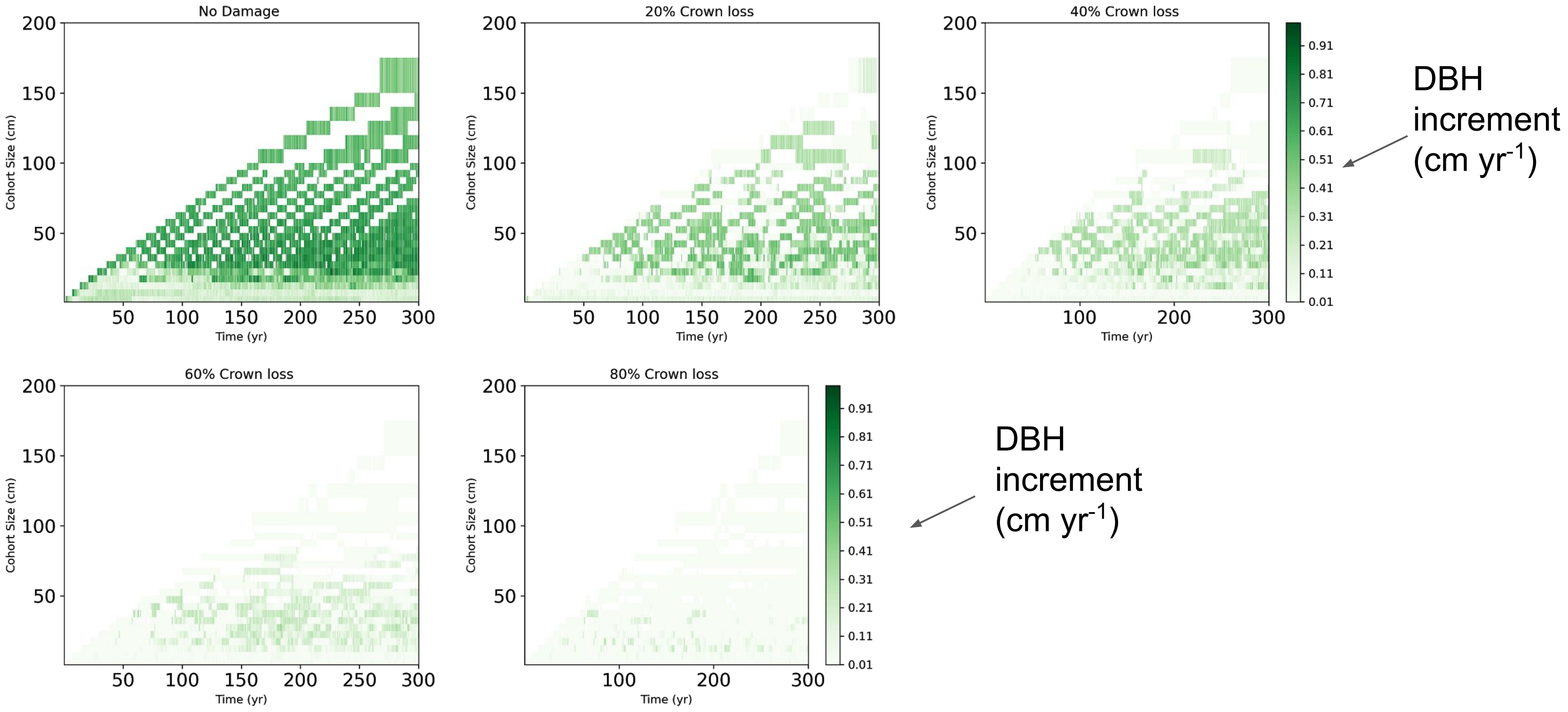
- **Do lags between environmental drivers and mortality matter for forest dynamics?**

  Some trees might survive years before death with significantly reduced crowns. This could alter growth rates and biomass estimates.

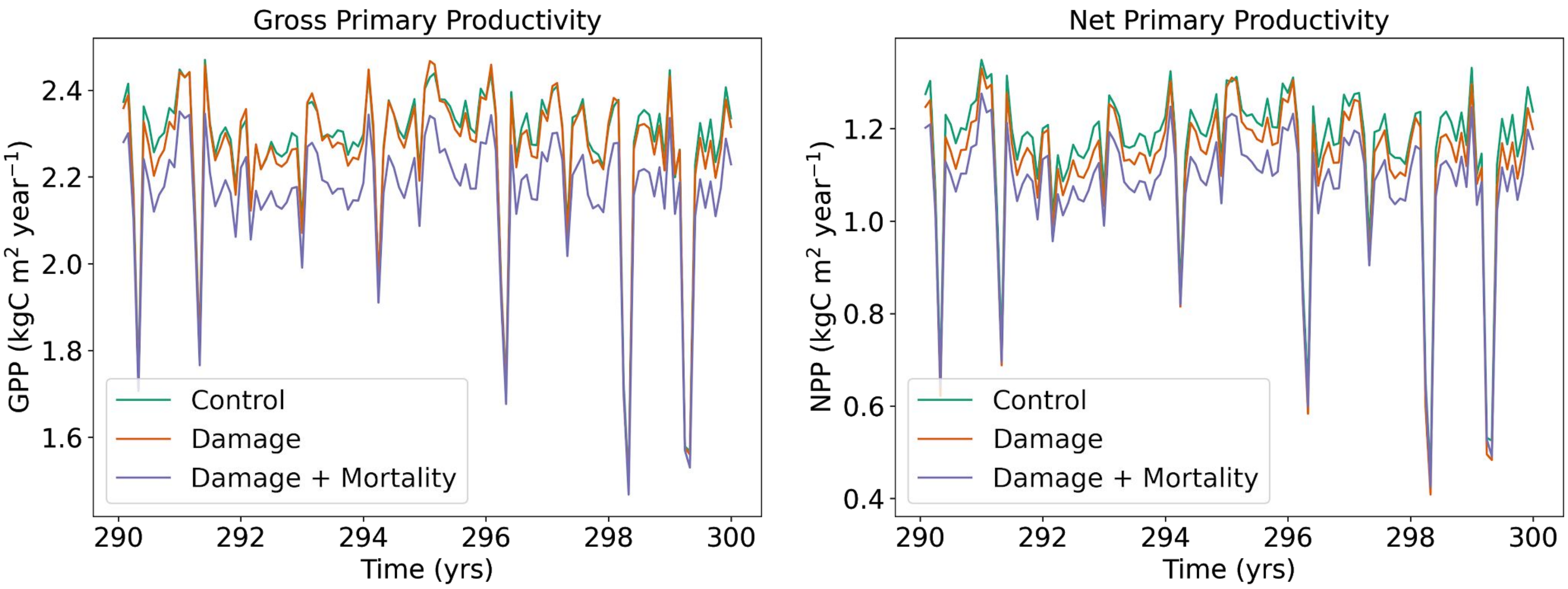
- **Does cumulative damage matter for final mortality rates?**

  Crown damage facilitates interactions between different drivers of mortality.

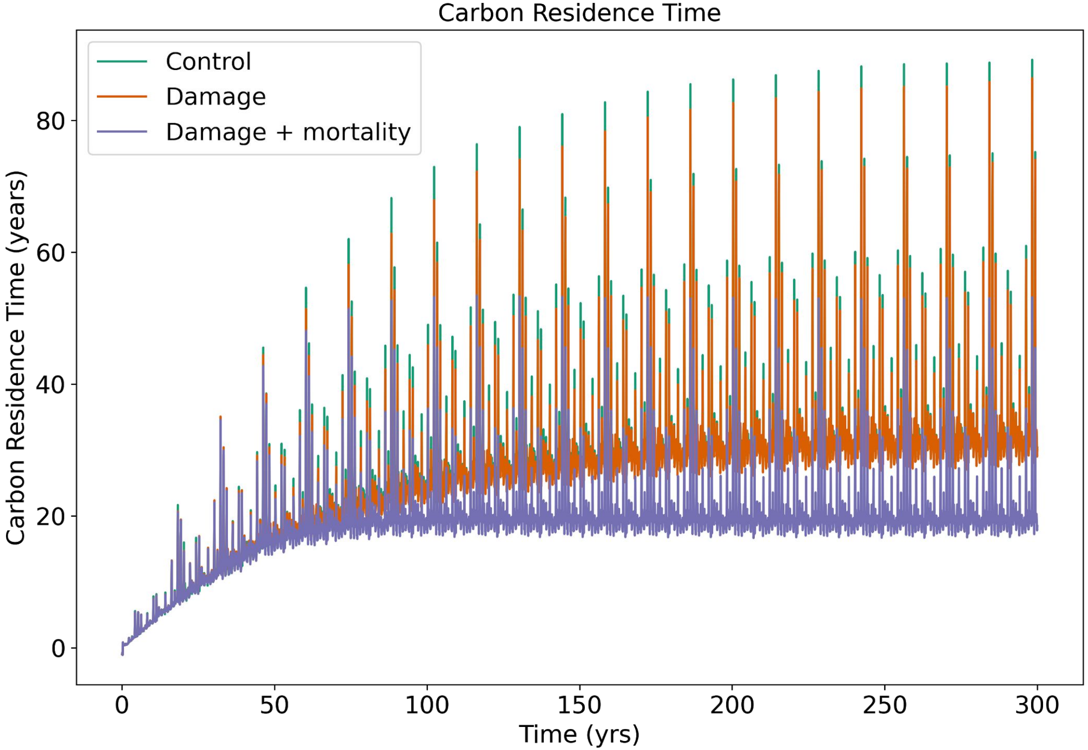
Damaged trees have slower growth rates



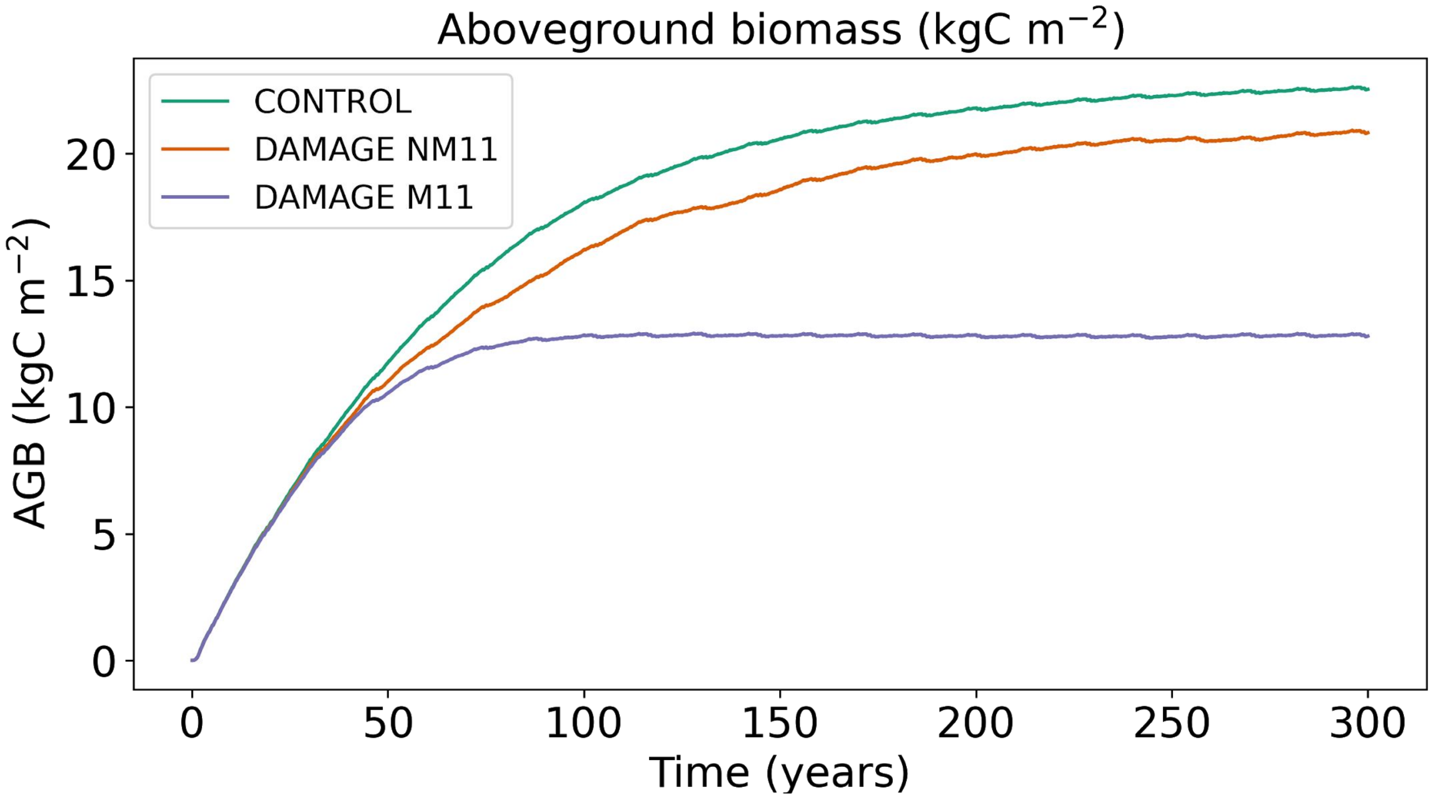
GPP and NPP are reduced at the plot scale



Damage related mortality decreases carbon residence time at the plot scale

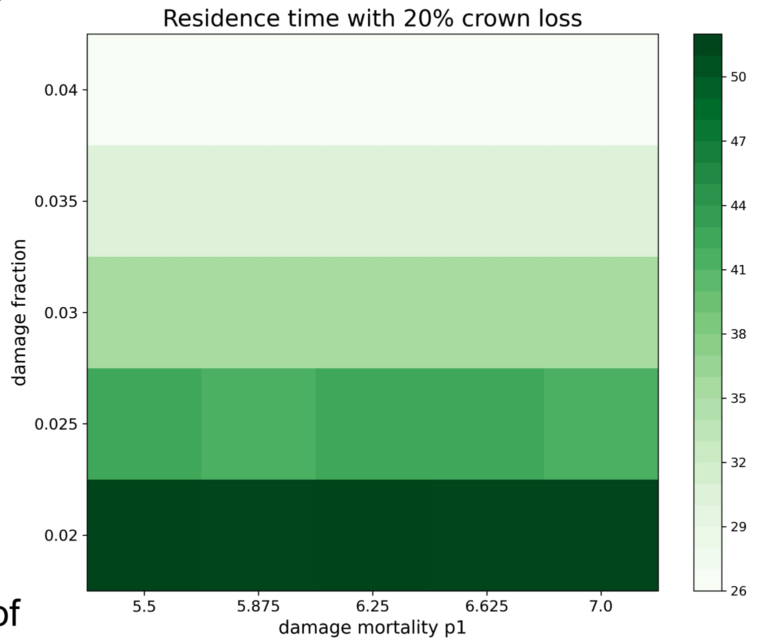


Despite a higher density of canopy trees, AGB is decreased



The lag between damage and mortality is controlled by the fraction of cohorts damaged each year

Larger fraction of trees damaged



The residence time in each damage class increases as damage fraction decreases

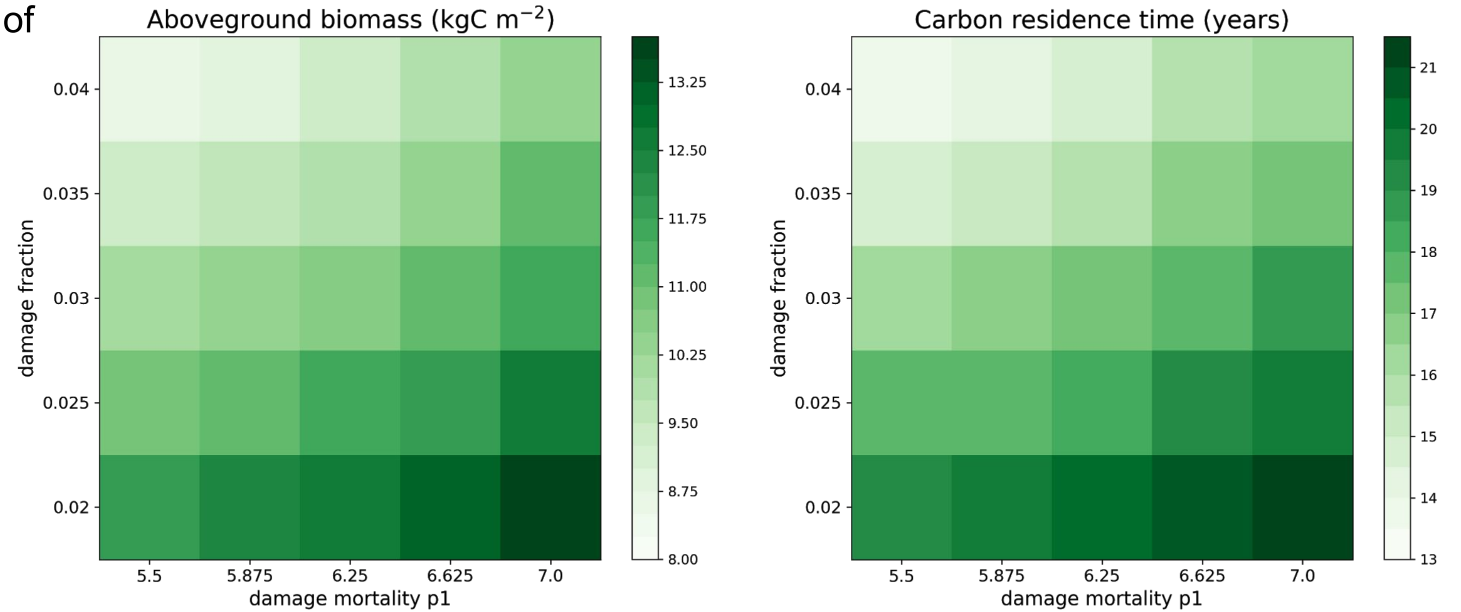
Smaller fraction of trees damaged

Higher damage mortality

Lower damage mortality

The longer trees remain damaged, the higher AGB and C residence time at the plot scale

Larger fraction of trees damaged



Smaller fraction of trees damaged

Higher damage mortality

Lower damage mortality

Conclusions

- Damage module provides new capabilities for hypothesis testing
- Carbon starvation alone does not appear to kill damaged trees
- In the case of an idealised forest the effect of damage on stand structure is mostly due to altered mortality rather than damage itself
- As we add mechanistic drivers of damage we can test the effect of cumulative stress on final mortality

Acknowledgements

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NGEE-Tropics

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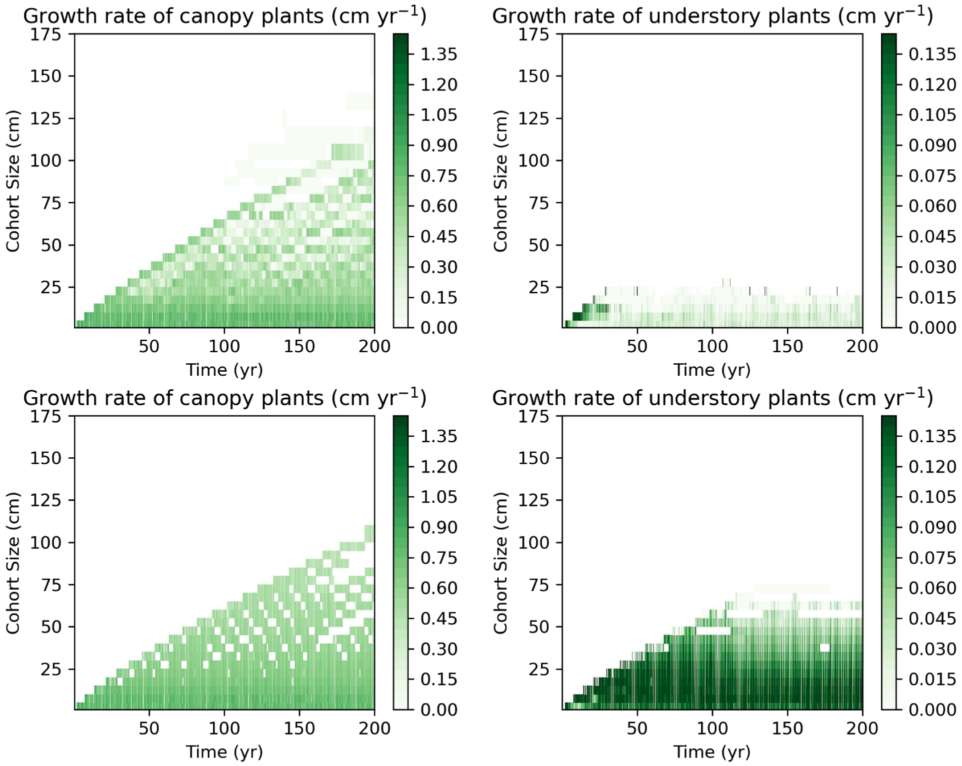
ForestGEO

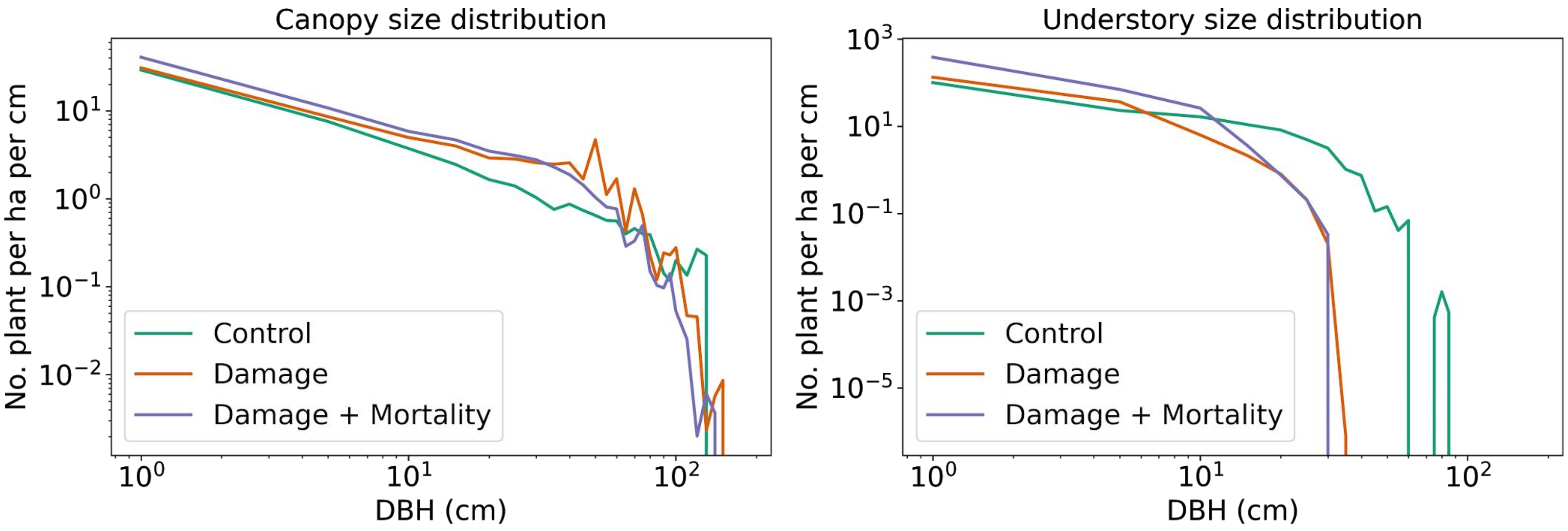
Damaged trees have slower growth rates

Damage + mortality

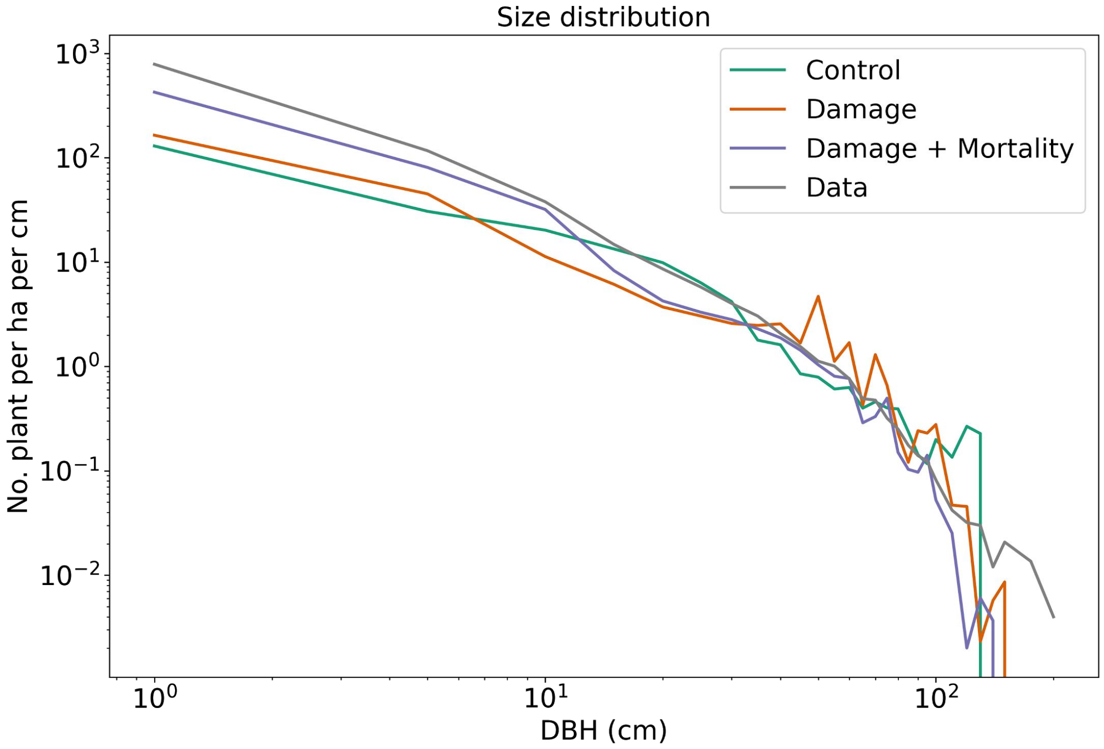
Control



When some trees have smaller crowns the size threshold for being in the canopy is smaller

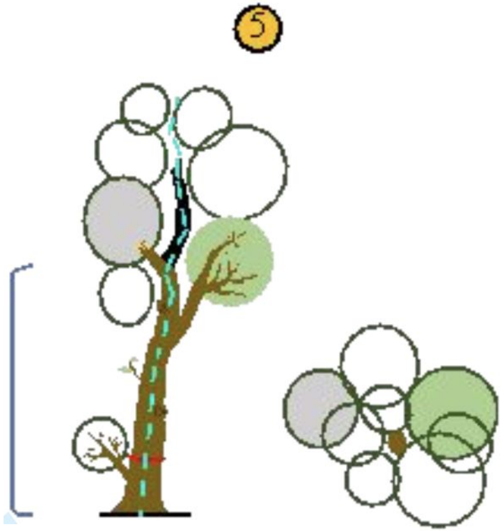


Damage alters size distributions at the plot scale



FATES simulations are compared to field data from BCI

- Estimate percent of main stem that is still alive
- Estimate percent of branches lost from alive portion of main stem
- Compare with allometric target biomass to estimate biomass lost



Arellano *et al.* Journal of Vegetation Science (2021)