What factors influence whether trees have higher or lower growth rates after the death of their nearest neighbor tree?

Context matters: Natural tree mortality can lead to neighbor growth release or suppression

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What is the effect on nearby trees in a natural, unmanaged forest when a dominant tree dies? If a tree was a competitor to its neighbors, its death opens up resources and the neighbors' growth rates should increase. If a tree was a facilitator, its death may lead to a slower growth rate for surviving neighbors. The authors investigate whether tree mortality leads to growth release or suppression in nearest neighbor trees using a 40-year data set from permanent plots on Mt. Rainier.

Did growth response differ for trees with live and dead neighbors?

- Growth was greater than expected for trees with dead neighbors, while growth of trees with live neighbors did not differ from expectations for all trees pooled. However, growth release or suppression depended on the growth situation of the focal tree.
- Dead trees were 7.9% more likely to have a dead neighbor than healthy trees, but there was little mortality clustering. The likelihood of a tree dying was not related to whether the neighbor tree was the same species.

Did tree size impact growth response after neighbor mortality and how can this inform management?

- Small trees tended to have suppressed growth after neighbor death, while large trees tended to have increased growth. Additionally, growth release was greater when the dead neighbor was a large tree than when it was a small tree.
- Growth suppression that small trees experience when a large neighbor dies, suggests there are facilitative interactions where large trees benefit their small neighbors. Managing stands to retain large trees as neighbors will benefit the next generation of establishing trees.

Was growth response related to whether the dead neighbor was the same species?

- In general, when a conspecific neighbor died the focal tree did not experience growth release or suppression. However, when a heterospecific neighbor died the focal tree generally experienced growth release.
- Improved understanding of trees facilitating growth for conspecific and heterospecific neighbors will improve the ability to determine where management actions will best support a desired outcome and help identify the most appropriate action to take.

Did species characteristics, such as shade tolerance, impact growth response?

- Trees that are less shade tolerant will show a greater response to canopy gaps and will have greater growth release after a neighbor dies.

- If the aim is to foster tree growth through selective thinning, it may be necessary to remove a group of trees, rather than individuals, for the remaining trees to have observable growth release.

What considerations should be kept in mind related to tree growth and neighbor interactions?

- Trees in 12 of 15 study stands showed growth release following neighbor death. In these stands, growth release was negatively correlated with elevation and tree density, and positively correlated with diameter at breast height. In subsequent model testing, a measure of aridity was also important.
- Stands with a variety of tree ages support a diversity of tree interactions, which is important when managing for old growth characteristics or reducing fire severity risk.

Research Approach/Methods

- The researchers sampled in 15 1-hectare plots on Mt. Rainier that were established as permanent plots in 1977 with forest stands that range from 150 to 1200 years old.
- They used data collected at ~5-year intervals including tree diameter at breast height (dbh, at 1.37 m), tree health category, tree species, and ingrowth of new trees. The researchers used associated plant species to rank the stands from least to most warm and dry.
- They plotted the exact location of each tree > 5cm dbh and calculated the distances between all trees in each plot, which they used to identify each tree's nearest neighbor.
- The authors created a growth model for each tree using previous dbh and compared the model-derived expected growth with actual growth for all trees with live nearest neighbors in 2017. For all trees with dead nearest neighbors, the authors compared the expected growth with the actual growth for the first sampling period after neighbor death.
- They used the growth comparisons to determine whether growth release or growth suppression occurred after nearest neighbor death, determined whether tree size influenced tree growth effects, and determined whether trees with a conspecific nearest neighbor were less likely to die.
- Finally, they calculated whether trees in a specific stand tended to show growth release or suppression and then analyzed that trend in relation to the stand's rank as a more or less warm and dry habitat.

Keywords *Abies*, competition, facilitation, growth release, Mt. Ranier, permanent plot, primary forest, *Pseudostuga*, suppression, thinning, tree mortality

Images

RANK 1

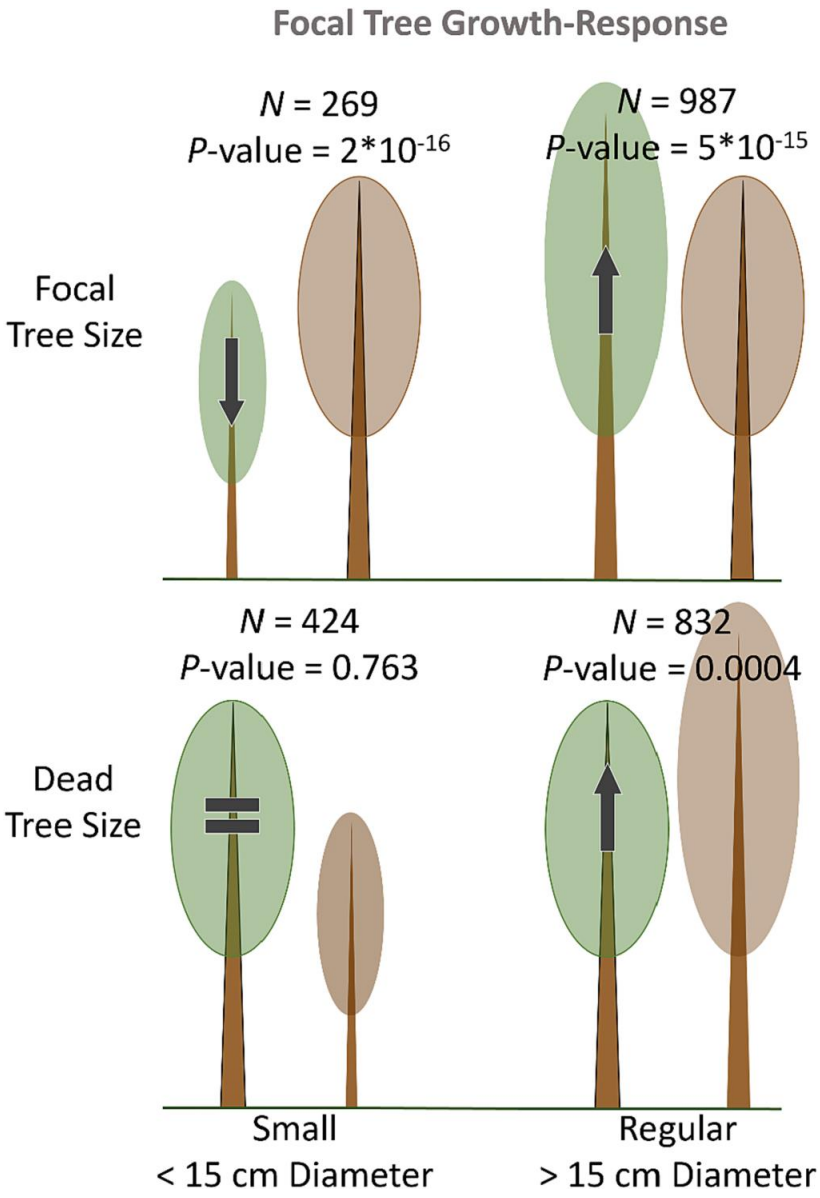

Fig. 2 in Chin et al. (2023). Growth-response to mortality depends on both the size of the focal tree and the dead neighbor. While mature focal trees generally experienced growth release following the natural mortality of their nearest neighbor, there was no impact on their growth if the lost neighbor was smaller than 15 cm in “diameter. In contrast, small focal trees experienced growth suppression following neighbor death, suggesting a loss of facilitative interactions that formally supported their growth. In this figure, small trees are shown as small, regular trees are shown as large, and ‘all-trees-pooled’ is indicated by medium-sized trees with distinct borders. To account for family-wise error, *p*-values should be considered significant below the Bonferroni corrected α of 0.013.

RANK 2

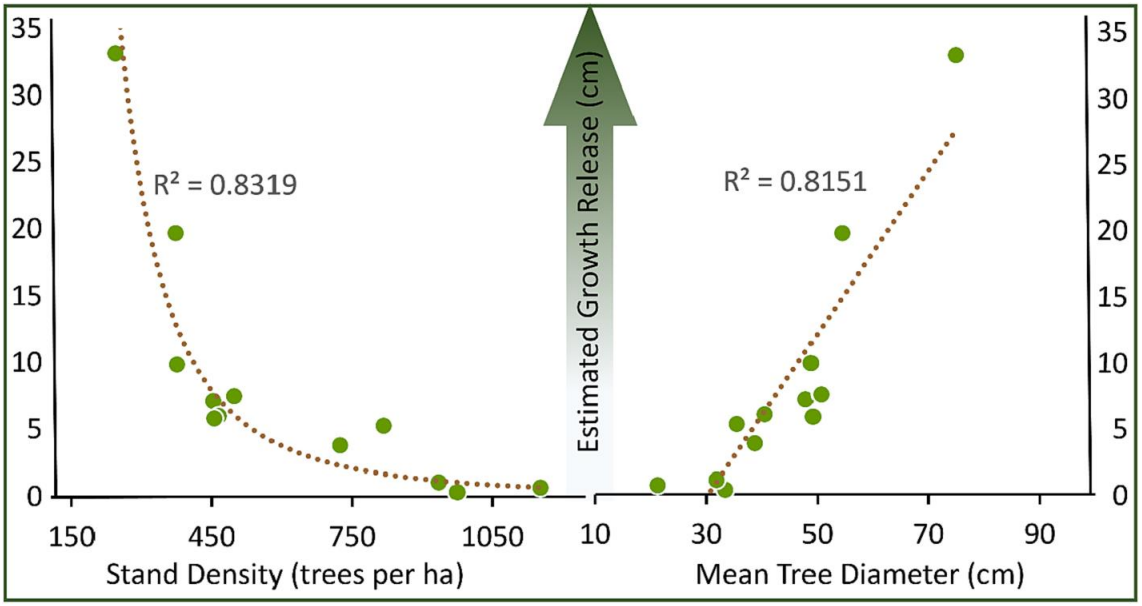

Fig. 3 in Chin et al. (2023). Estimated growth release is strongly correlated with both stand density and tree size. Although stand density and mean tree diameter are closely correlated (*R*2 = 0.8), their relationship to estimated growth release does not take the same form, strongly suggesting that they have independent effects on tree growth response. Scale is excluded from the y-axis because we wish to avoid prediction of growth response from this data, while still exploring its magnitude.

RANK 3

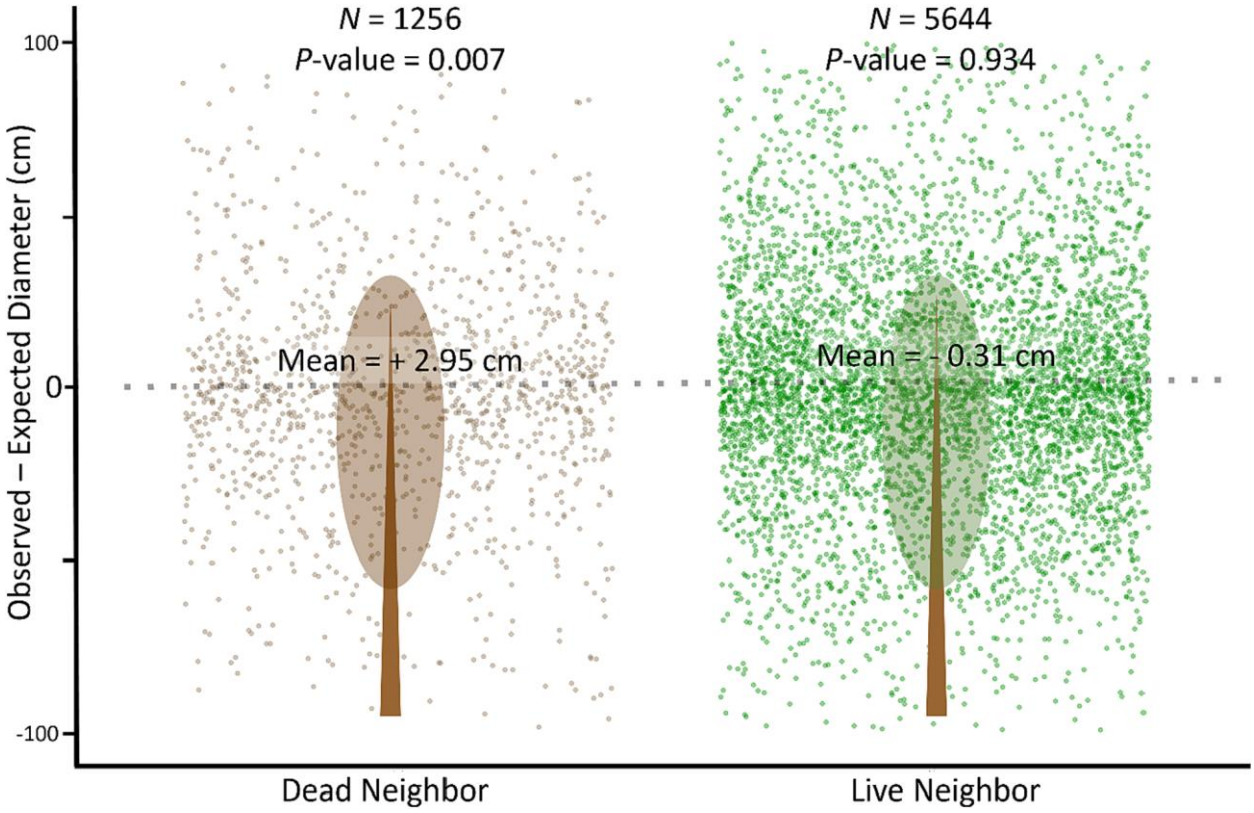

Fig. 1 in Chin et al. (2023). Raw differences between observed dimeter measurements and expected diameter as predicted by individual growth-models. Although our growth models in some cases wildly over or underestimated tree growth, likely due to measurement errors, in aggregate they provide a valuable approximation of the direction of growth response following neighbor death as evidenced by the reasonable means and further validated by the relationships in Fig. 3. To avoid relying on the magnitude of the difference between observed and expected values, we compared these values with a pair-wise rank test (*p*-values shown), only using this difference magnitude in the form of stand-level means (see Fig. 3). To account for family-wise error, *p*-values should be considered significant below the Bonferroni corrected α of 0.025.