Growth response of massive giant sequoia to a disturbance severity gradient

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Concepts: Fuel treatments, growth release, mixed severity disturbance regime, competition

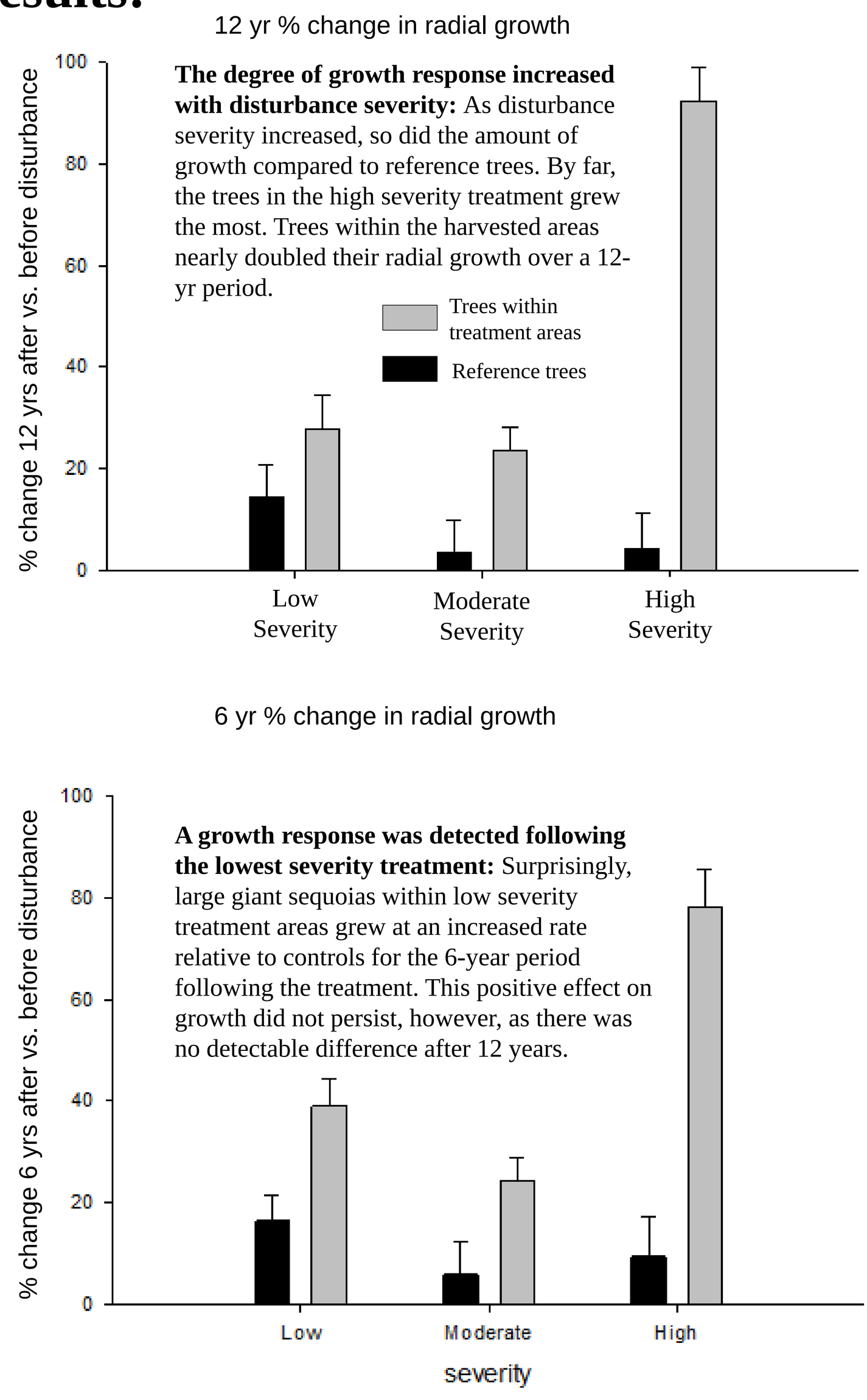
Study objective: Measure the growth response of large giant sequoias following past mechanical disturbances occurring across a wide range of severities. Understand the role of a mixed severity disturbance regime in influencing radial growth of giant sequoia in order to help design resilience-building treatments.

Types of disturbances: The **low severity** treatment removed shrubs and small trees (<4 meters tall) adjacent to large giant sequoias (competition removed only in the understory). The **moderate severity** treatment was a commercial harvest that created distinct canopy gaps adjacent to large giant sequoias (i.e. competition removed on one side of trees). The **high severity** treatment removed canopy trees surrounding individual large giant sequoias (i.e. competition removed on all sides of trees).

Field work: At each site, trees were cored to enough depth to collect growth rings during at least the 12 year periods prior to and after the disturbances. Reference trees adjacent to the disturbed areas were also cored using the same method. There was no evidence of recent disturbance in these reference sites.

Lab work and analysis: Annual growth increments measured from cores were averaged over both 12- and 6-year growth periods in order to match the pre-suppression era fire interval (~12 years) and half-way point between the interval. I assumed these time ranges to be relevant for managers who use fire history and prescribed fire effects as tools for designing treatment type and frequency. I looked for an interaction between disturbance severity and the difference in growth between trees within treatment areas and those in reference areas. In a preliminary analysis, I also explored the year-to-year growth response following treatments.

Results:



The degree of growth response increased with disturbance severity: As disturbance severity increased, so did the amount of growth compared to reference trees. By far, the trees in the high severity treatment grew the most. Trees within the harvested areas nearly doubled their radial growth over a 12-yr period.

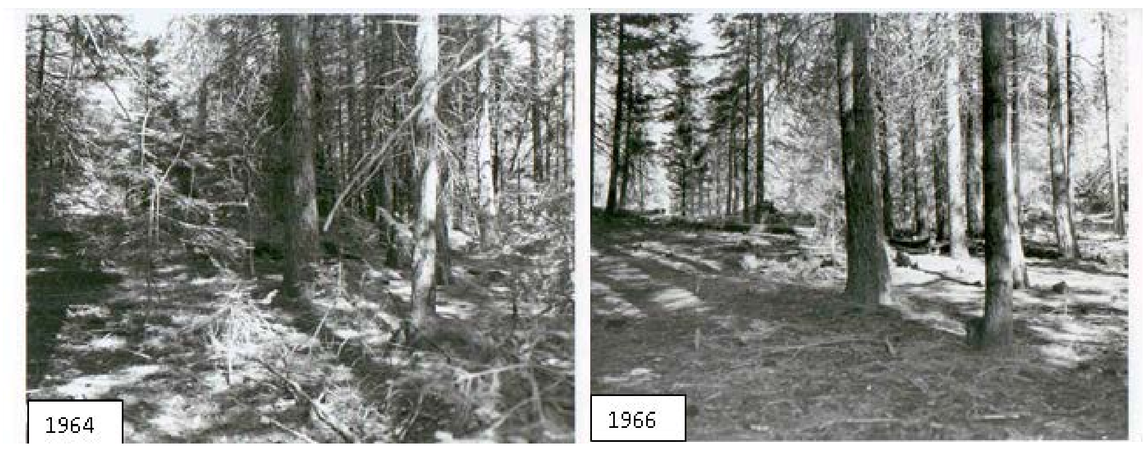
A growth response was detected following the lowest severity treatment: Surprisingly, large giant sequoias within low severity treatment areas grew at an increased rate relative to controls for the 6-year period following the treatment. This positive effect on growth did not persist, however, as there was no detectable difference after 12 years.

Integration:

- The massive giant sequoias in this study responded with marked sensitivity to a wide range of disturbance severities, providing further evidence that large sequoia maintain a very high capacity to respond to their competitive environment.
- The highest severity treatments created a distinctly two-tiered structure and led to a sustained increased growth rate of individual trees. I noted the fall of one tree, which was on the edge of one of the harvested areas.
- The mid-severity treatments (gap creation) had effects that were in between the low- and high-severity treatments, but were closer to the lower-severity treatment effects. Planted giant sequoia were established in some gaps, but survival was highly variable.
- This study demonstrates the role of a mixed-severity disturbance regime in maintaining giant sequoia over its lifespan and the need to incorporate disturbance severity variability into active adaptive management frameworks. Treatments aiming to build resilience in giant sequoia should not be constrained to either very low or high severities, but should consider a range of severities that are monitored and adjusted over time.

Mechanical treatments

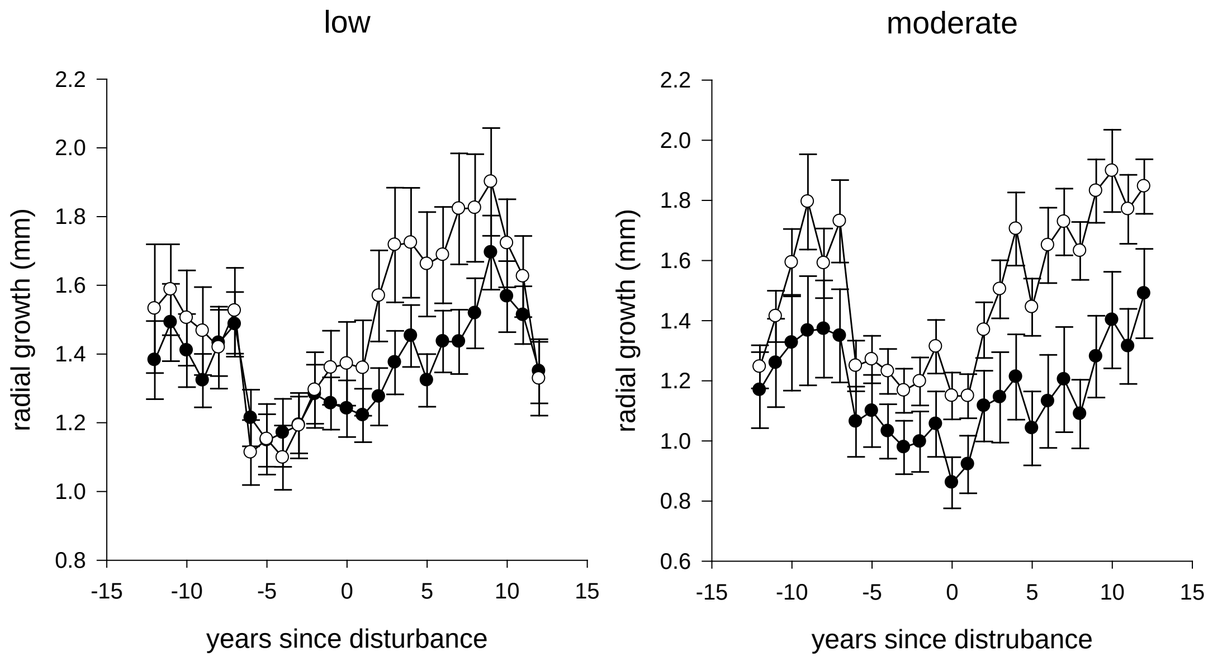
Low severity: trees less than 4m tall were cut and piled by hand in 1964 in the Redwood Mt. Grove. This created a clear understory surrounding large giant sequoias and medium sized conifers. N = 34 treatment trees and 36 reference trees.

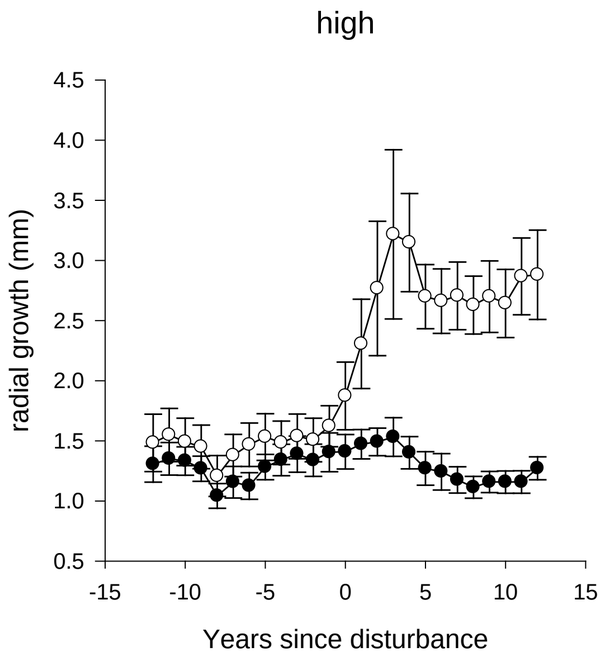


Moderate severity: Distinct canopy gaps ranging in size from 0.01 to 0.3 ha were harvested adjacent to large giant sequoias in the Mt. Home grove in 1993. N = 50 treatment trees and 24 reference trees.

High severity: Non-giant sequoia were removed within tracts from 3 to 17 ha, leaving clumps and isolated giant sequoias. Treatments were done in the mid 1980's in the Lockwood, Bearskin, Little Boulder, Redwood Mt., Starvation, and Black's Mt. Groves. N = 45 treatment trees and 40 reference trees.

Inter-year growth responses





The treatments occurred at year zero on the x-axes. Hollow circles represent averages of trees within treatment areas and the dark circles represent trees in nearby untreated areas. Whiskers are standard errors of the means.

Regeneration effects:

While I did not measure regeneration response in this study, some observations were evident and may be worth exploring further:

- The low severity treatments did not lead to any sequoia seedling establishment. This was also the only treatment not planted.
- Some gaps that were planted following the moderate severity treatment had established sequoia, but patterns were extremely variable within and between gaps
- The high severity treatment by far had the highest densities of young giant sequoia.

Potential areas of future study

- Competitive interactions between large trees and their offspring, as well as effects of future treatments
- Recruitment rates of individuals under different treatment options
- A study is currently underway to measure the age structure of giant sequoia at Whitaker's Forest
- Fire scar size effects on capacity to release following disturbance

For more information on recent giant sequoia research, see:

York, R.A., O'Hara, K.L., and Battles. J.J. 2013. Density effects on giant sequoia (*Sequoiadendron giganteum*) growth through 22 years: Implications for restoration and management. **Western Journal of Applied Forestry**

Fahey, C., York, R.A., and Polowska, T.E. 2012. Arbuscular mycorrhizal colonization of giant sequoia (Sequoiadendron giganteum in response to restoration practices. **Mycologia**

York, R.A., Fuchs, D., Battles, J.J., and Stephens, S.L. 2010. Radial growth responses to gap creation in large, old *Sequioadendron giganteum.* **Applied Vegetation Science**

York, R.A., Battles, J.J., Eschtruth, A.E., and Schurr, F.G. 2011. Giant sequoia (*Sequoiadendron giganteum)* regeneration in experimental canopy gaps. **Restoration Ecology**

O'Hara, K.L., York, R.A., and Heald, R.C. 2008. Effect of pruning severity and timing of treatment on epicormic sprout development in giant sequoia. **Forestry**

York, R.A., Battles, J.J., and Heald, R.C. 2006. Giant sequoia release potential: 20 year results. **Forest Ecology and Management**

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