



Research Brief for Resource Managers

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Interval Squeeze In Action: Modeling Woody Plant Species Survival Under Three Climate Scenarios

Henzler, Julia, Hanna Weise, Neal J. Enright, Susanne Zander, and Britta Tietjen. 2018. A squeeze in the suitable fire interval: simulating the persistence of fire-killed plants in a Mediterranean-type ecosystem under drier conditions. *Ecological Modeling* 389: 41-49. [10.1016/j.ecolmodel.2018.10.010](https://doi.org/10.1016/j.ecolmodel.2018.10.010)

Because of climate change, Mediterranean-type Ecosystems (MTEs) around the world are projected to get drier and hotter, with shorter fire return intervals. But according to the Interval Squeeze Model (Enright 2015 [research brief](#)), these changes will likely harm many endemic MTE plant species. Specifically, the new drought conditions will slow plant growth and maturation rates, prolonging juvenile stages and decreasing viable seed production. The drought-related bad weather will reduce seedling recruitment, as well as increase seedling mortality. Further, the drought related weather will almost certainly shorten the average fire return intervals, just when longer average fire intervals are needed for the drought-stressed populations to persist. The combination of such demographic shifts, post-fire recruitment shifts, and fire interval shifts will likely lead to localized population extinctions.

To test the Interval Squeeze Model concept on real, fire sensitive woody species, these authors created a process-based model of a plant population that could be used for any serotinous, fire-killed species using NetLogo Version 6.0.2. Based on empirical data, they then set appropriate model parameters to approximate the lifecycle of *Banksia hookeriana*, an obligate

Management Implications

- This simple model could be used to project how other fire-killed, serotinous MTE species will respond to local climate change.
- For *B. hookeriana*, drought conditions were projected to increase seedling mortality, slow demography rates, and make seedbank replacement less efficient.
- For *B. hookeriana*, reduced fire intervals were projected to amplify the effects of the drought conditions by squeezing the remaining, drought stressed population, just as the Interval Squeeze Model predicts.

seeding, serotinous, fire killed species from Australia that has co-evolved with an average fire return interval of 13 years.

Starting with a population of 2500 hypothetical, mature, 5-year-old *B. hookeriana* plants in a 100m² area for each simulation, two different sets of simulation experiments were conducted under rainfall conditions of each of three different climate scenarios: current climate, future intermediate emissions (RCP4.5), and future high emissions (RCP8.5). The first experiment simply simulated *B. hookeriana* survival with a fixed, 13 year FRI for up to 200 years. The second experiment was essentially a series of four

experiments incorporating the various Interval Squeeze conditions: 1) demographic shift for up to 50 years; 2) post-fire recruitment shift for up to 50 years; 3) demographic envelope (1 and 2 conditions together) for up to 50 years; and 4) Interval Squeeze (FRIs ranging from 6 to 32 years) to estimate population survival for up to 200 years. There were 30 repetitions for each simulation to account for stochasticity.

The results of the first experiment shows that for current climate conditions and intermediate emissions (RCP4.5) with a steady, 13 year fire return interval, *B. hookeriana* will remain viable and stable. However, given the future high emissions climate scenario (RCP8.5), *B. hookeriana* will rapidly decline and possibly become extinct. This means that increasing drought alone could be enough to eradicate this species, even without a shortened average fire return interval.

In the second experiment, the Interval Squeeze simulation results (Fig.3) showed rapid declines at several demographic stages. Specifically, climate change related increases in drought reduces the number of viable, available seeds (Fig.3a); climate change reduced seedling recruitment (no. seedlings/seed; Fig.3b); climate change reduced the number of adults since last fire (Fig.3c); and the window of survival shrinks, or is “squeezed”, by climate change and reduced fire return intervals (Fig.3d).

Under current, baseline climate conditions (Fig.3d; blue), *B. hookeriana* would likely survive, some reduction in average fire return intervals. However, the combination of shorter fire return intervals and a drying climate together will likely be too much for this species to persist in both the moderate (yellow) and extreme (red) climate change scenarios. These results validate the Interval Squeeze Model concept.

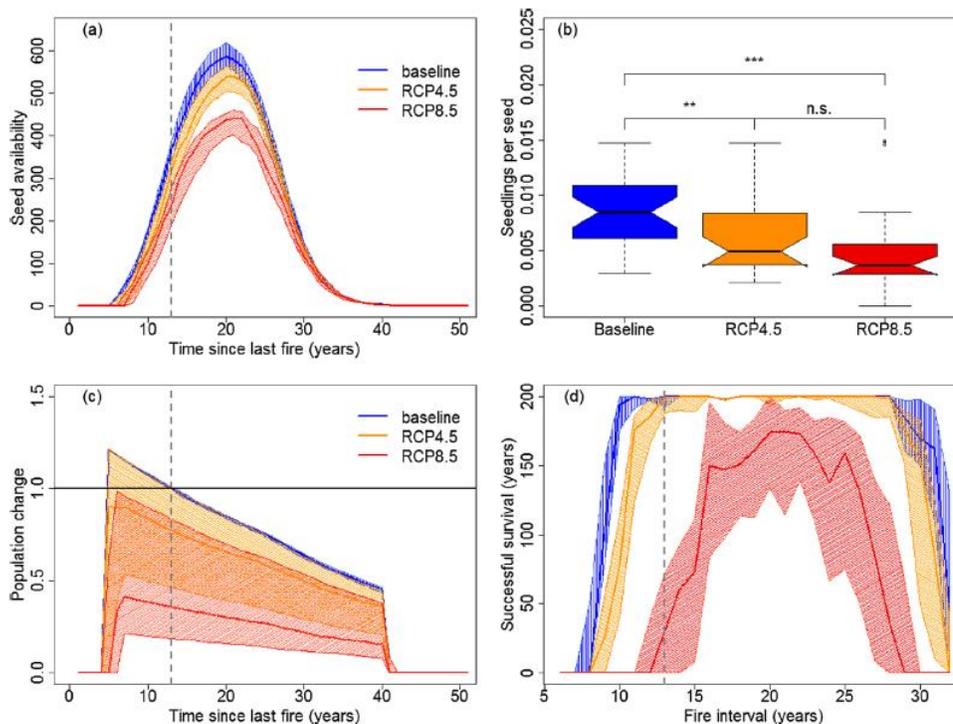


Fig. 3. Simulated components of the Demographic Squeeze Model for *Banksia hookeriana* under present and future climate conditions. a) Demographic shift shown as seed availability per plant over time in the absence of fire, b) post-fire-recruitment shift of plants given as the fraction of seeds that germinated and survived to the 4th year after fire, c) demographic envelope calculated as the relative change in the number of mature shrubs over time in comparison to pre-fire population size, and d) Interval Squeeze as the viable fire interval time window (i.e. of successful self-replacement) for fixed fire intervals ranging from 6 to 32 years. The lines in a), c) and d) show median values and shaded areas the lower and upper quartiles. The dashed grey line indicates the current estimated mean fire interval of 13 years, and the black horizontal line in c) indicates the threshold for self-replacement. Boxes in b) show the median as well as upper and lower quartiles with significant differences between climate scenarios indicated by asterisks (n.s.: not significant $p \geq 0.05$, **: $p < 0.01$, ***: $p < 0.001$). Simulations for each scenario were replicated 30 times.