Clonal Branching Effects on Biotic Resistance in Coastal Wetlands

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Project Summary

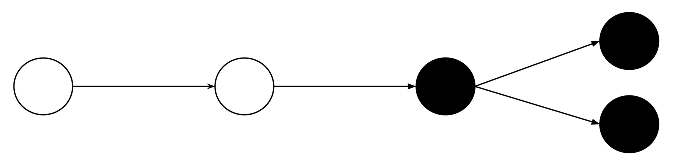
Wetland clonal herbaceous plants explore their space through clonal reproduction, parent ramets creating daughter ramets interconnected underground and able to share nutrient resources. Historically limited by low nutrient conditions, coastal wetlands have seen an influx of nutrients. Limitations removed, wetlands have experienced greater threat from nonnative species. The ability of a native species to branch -- a parent ramet creating two daughter ramets -- and the resulting underground architecture may have great effect on the biotic resistance of these native communities because spatial exploration is an important facet of plant competition. The goals of this project were to create visualization software to examine the architecture of a simulated wetland created by MONDRIAN, and answer the question: If a manager has a choice of species to plant the year after herbicide treatment, would a species with a higher branching rate – all else equal – make it more likely to keep an invader at bay?

Key Terms

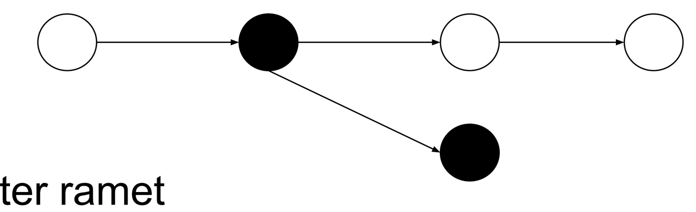
Biotic resistance: The ability of a native wetland plant community to resist invasion by a nonnative species

Ramet: A physiologically distinct organism that is part of a group of genetically identical individuals derived from one progenitor

Terminal branching: A parent ramet that has not yet reproduced creating two daughter ramets



Lateral branching: A parent ramet that has already reproduced creating another daughter ramet



Inter-ramet distance: Distance between parent ramet and daughter ramet

Branching probability: After the parent ramet passes every qualification to produce a daughter ramet on a new branch, this probability is applied as another step

Subsidy: in clonal reproduction, parent ramets are able to subsidize their daughter ramets with nutrients. In the model, a daughter is able to request nutrient subsidies from their parent going five steps back through the chain. This allows a daughter to survive in an more competitive area with lower nutrient intake from the soil by accepting parent nutrient subsidies.

MONDRIAN and Model Setup

MONDRIAN -- Modes Of Nonlinear Dynamics, Resource Interactions, And Nutrient cycling -- is a clonal herbaceous wetland simulator developed by Dr. William Currie and others (Currie et al. 2014). I have used MONDRIAN to examine native coastal wetland biotic resistance based on clonal branching architecture. The model was run with nine different inputs, each with three stochastic runs averaged for the final numeric results evaluated. The model was run with three different natives: *Eleocharis smallii*, *Juncus balticus*, and *Schoenoplectus acutus*. Each native competed alone against the invader: *Phragmites australis*. Each native ran with three branching probabilities: 10%, 17%, and 24%. The invader's branching probability was kept constant at 17%. The nutrient loading conditions for the simulated wetland were kept constant at a medium level, which at base conditions results in the successful establishment of, but not complete domination by, the invader.

Percentage of Total NPP from Natives

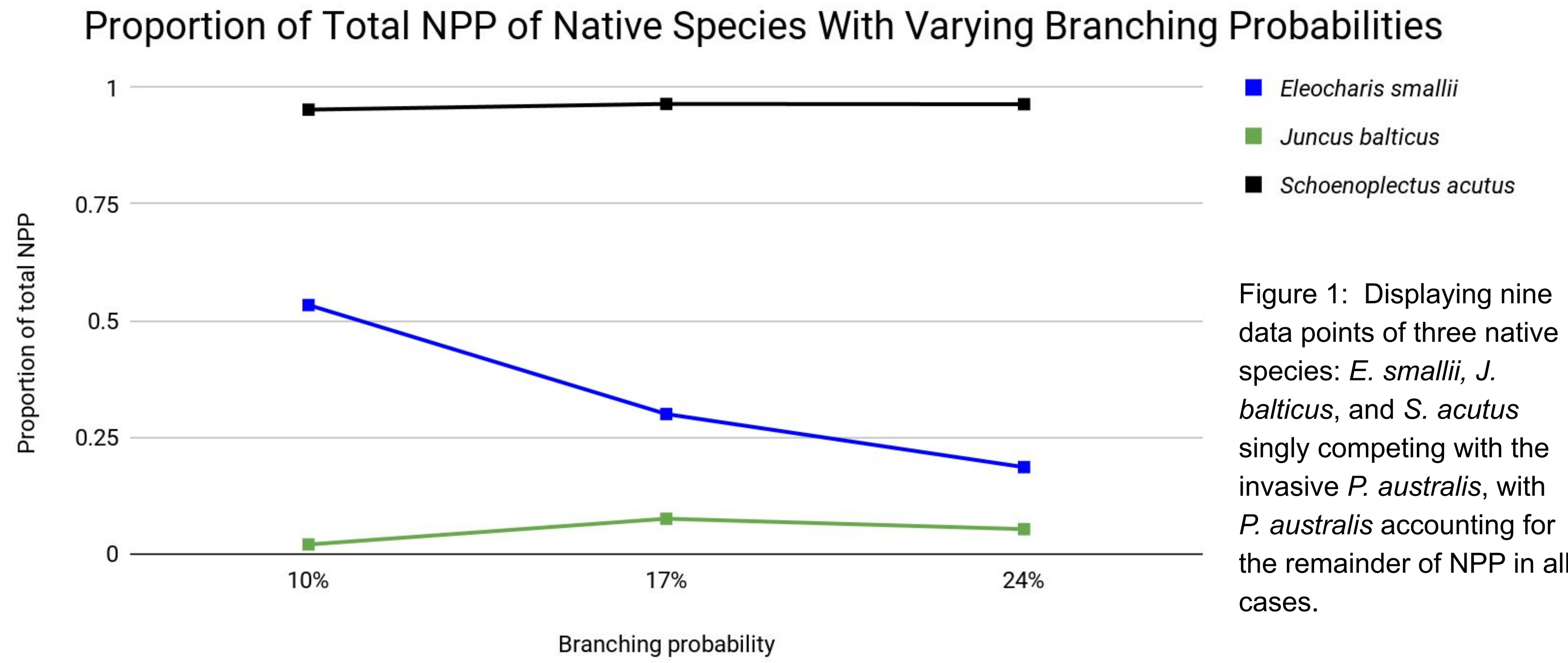
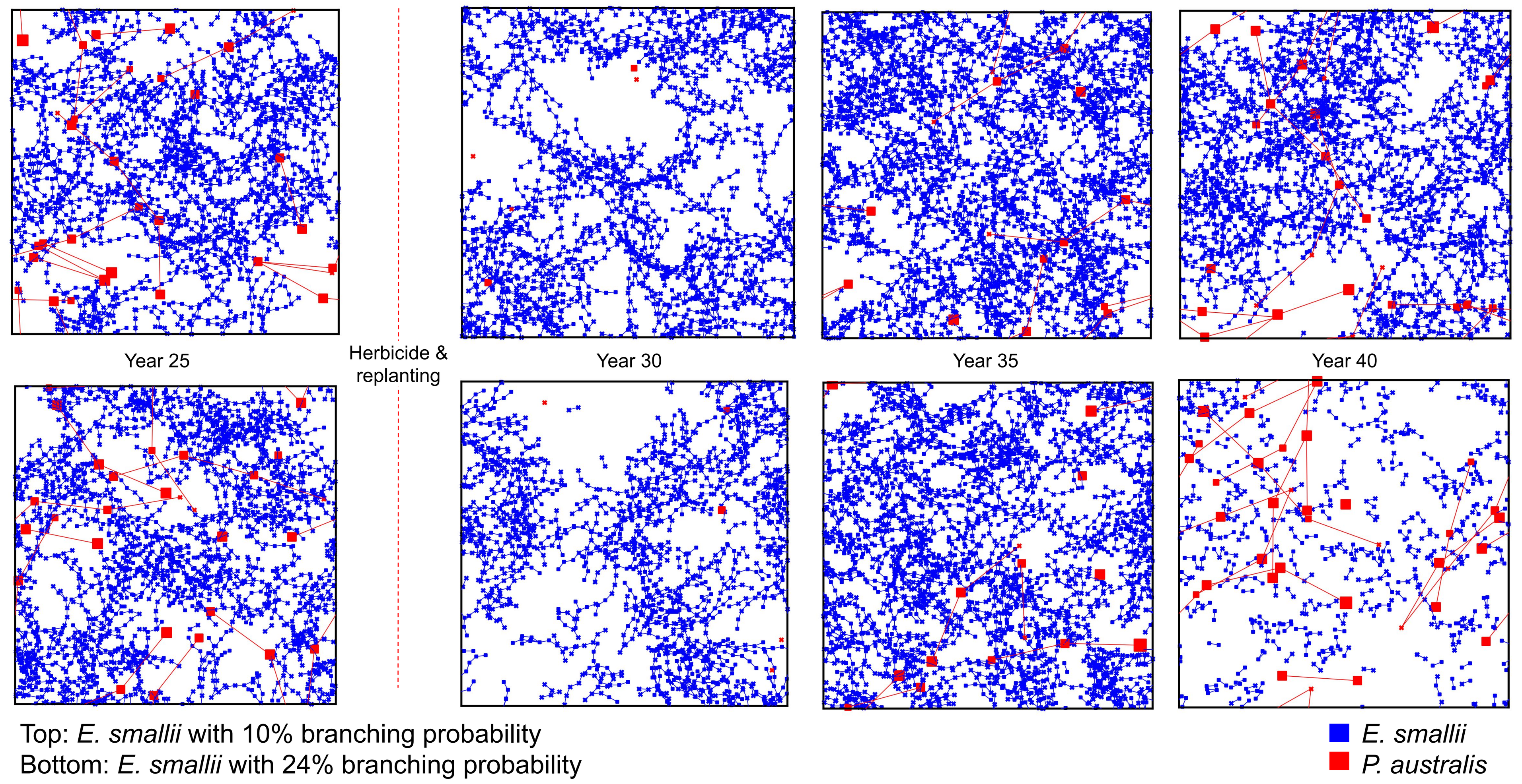


Figure 1: Displaying nine data points of three native species: *E. smallii*, *J. balticus*, and *S. acutus* singly competing with the invasive *P. australis*, with *P. australis* accounting for the remainder of NPP in all cases.

The results indicate a nonstandard reaction to increased branching probability across native species competing individually with the invader. *E. smallii* responds negatively to increased branching probability, at 10% branching probability accounting for over 50% NPP while at 24% branching probability accounting for less than 25% NPP. *E. smallii* is the smallest native species with the shortest inter-ramet distance, and increased branching may result in ineffective exploration of space.

Alternatively, the larger native species, *J. balticus* and *S. acutus*, respond positively to increased branching probability. This may result from the larger inter-ramet distance allowing them to naturally explore space well, and increased branching rates better their ability to dominate an area quickly, therefore blocking *P. australis* from establishing in these areas.

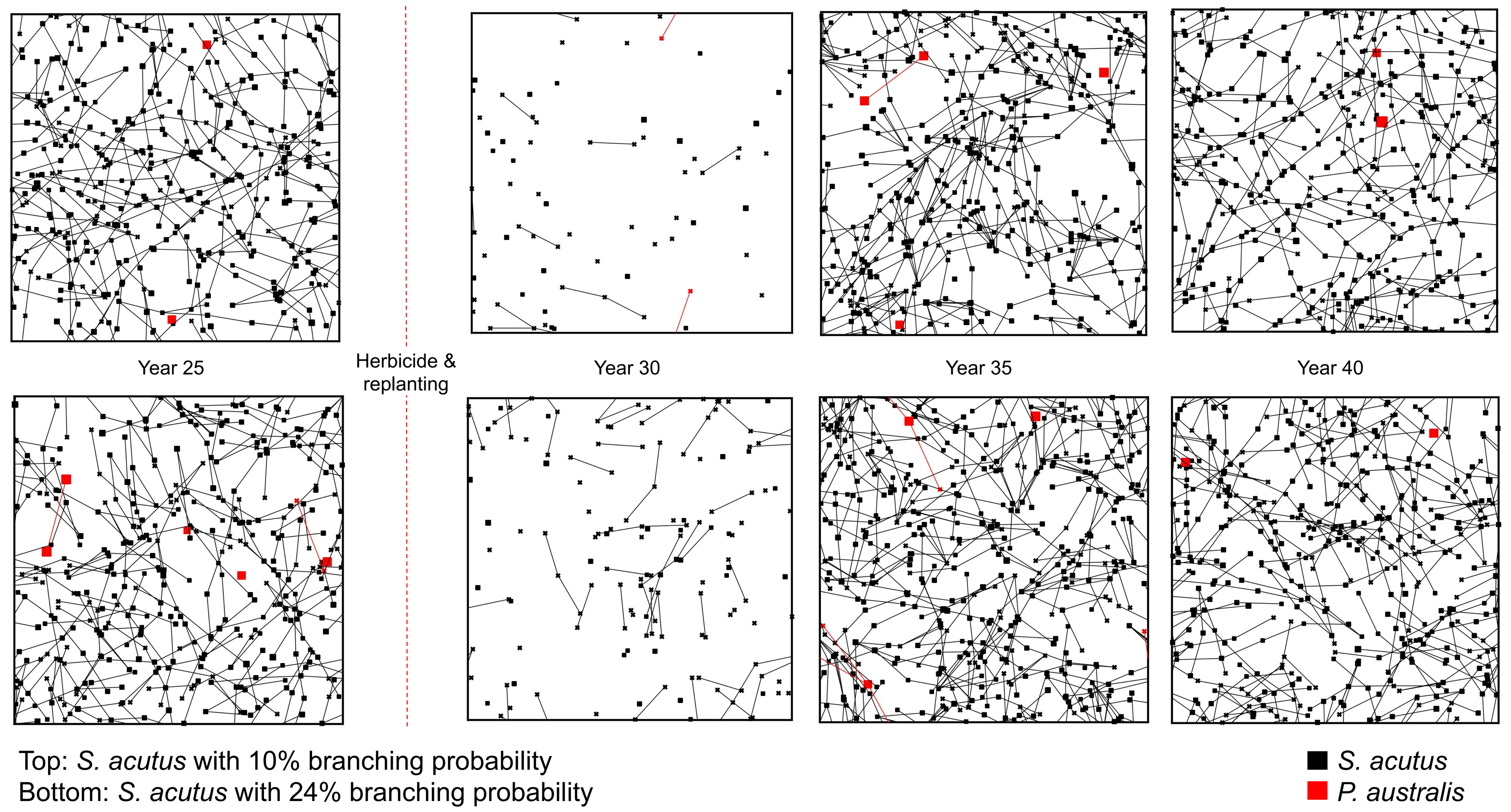
Eleocharis smallii Spatial Analysis



Top: *E. smallii* with 10% branching probability
Bottom: *E. smallii* with 24% branching probability

The visualization of 10% *E. smallii* branching shows stronger competition against *P. australis* as compared with 24% *E. smallii*. My hypothesis which requires further testing with quantitative spatial analysis is *E. smallii* at lower branching rates is able to better explore its available space and thus leave less open gaps for *P. australis* establishment.

Schoenoplectus acutus Spatial Analysis



Top: *S. acutus* with 10% branching probability
Bottom: *S. acutus* with 24% branching probability

The visualization of 10% *S. acutus* branching shows relative sparseness directly after the herbicide treatment, leaving some space available for establishment of *P. australis*. Comparatively, the visualization of 24% *S. acutus* branching shows the branching benefit of quickly capitalizing on nutrient richness in areas it has already colonized, thereby becoming established quicker and better able to resist the invasive *P. australis*.

Conclusion

Adding visualization to this complex model has significantly improved the ability to interpret complex results. Branching probability has shown to not affect all species productivity equally, and requires further quantitative spatial analysis. The model suggests that for native species with larger inter-ramet distances, increased branching provides greater biotic resistance. The model suggests, in contrast, that for native species with smaller inter-ramet distances, increased branching results in lower biotic resistance. These differences center on a species finding the balance of **exploring their available space** and **capitalizing on already colonized areas.** The model suggests managers may increase biotic resistance by encouraging a variety of species with both large inter-ramet distances and high branching frequency, and small inter-ramet distances and lower branching frequency, as these combinations may yield the most effective balance as suggested by MONDRIAN.

References

Currie, William & Goldberg, Deborah & Martina, Jason & Wildova, Radka & Farrer, Emily & Elgersma, KJ. (2014). Emergence of nutrient-cycling feedbacks related to plant size and invasion success in a wetland community–ecosystem model. Ecological Modelling. 282. 69–82. 10.1016/j.ecolmodel.2014.01.010.

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