Mechanisms of bark beetle-caused mortality following variable density thinning and prescribed fire treatments in a central Sierra mixed-conifer forest

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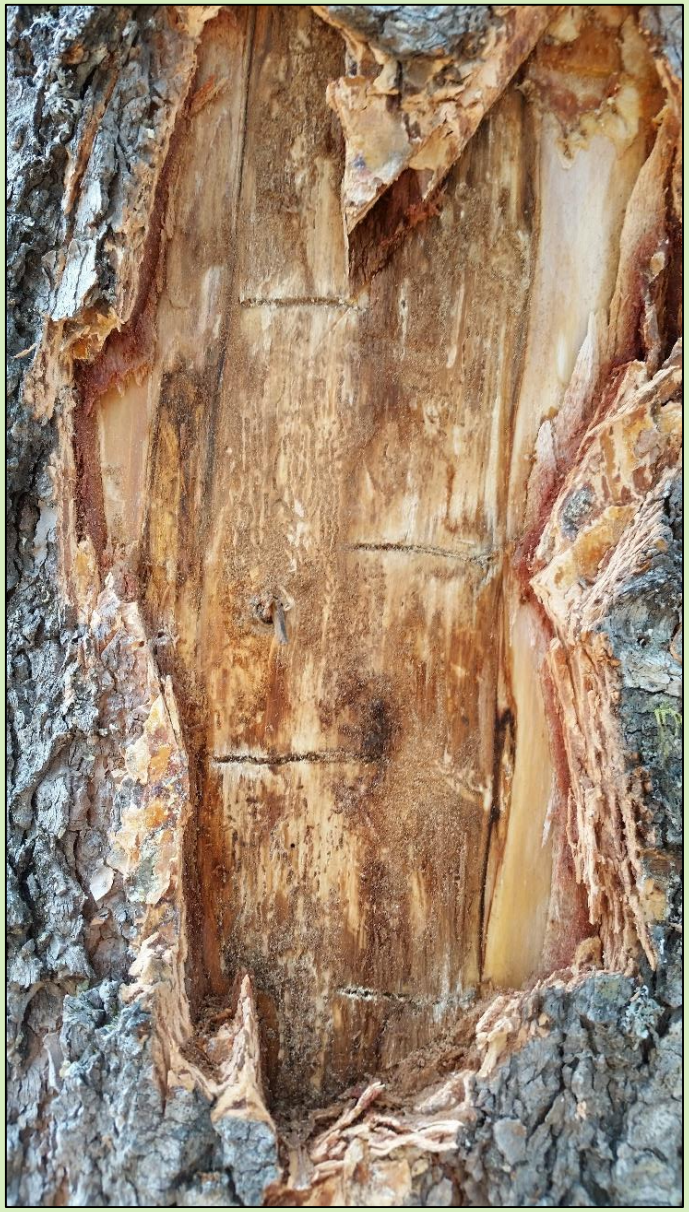
Jeffrey Kane, Humboldt State University, Arcata, CA 95521

Eric Knapp, United States Forest Service – PSW, Redding, CA 96002

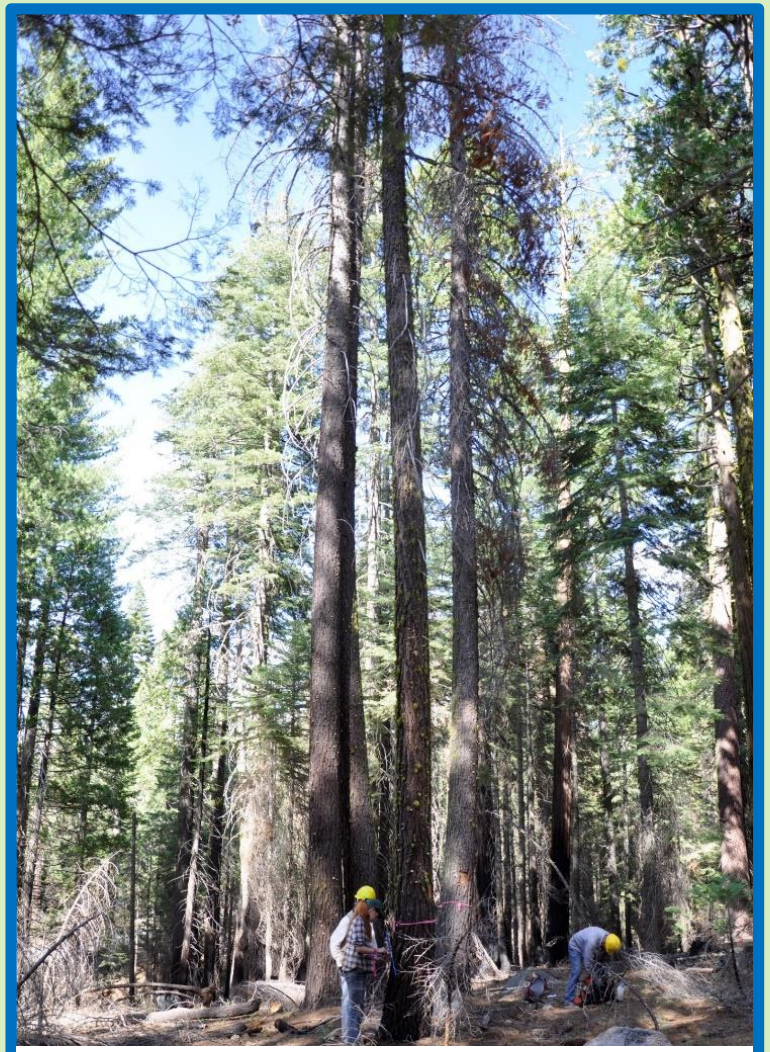
Drought and Bark Beetles

- Important agent of mortality
- Destructive during drought
- Uncertain forest succession



Current Options

- **Fire suppression**
- Alleviate stress
- Lack complexity



Fire suppressed

Current Options

- Fire suppression
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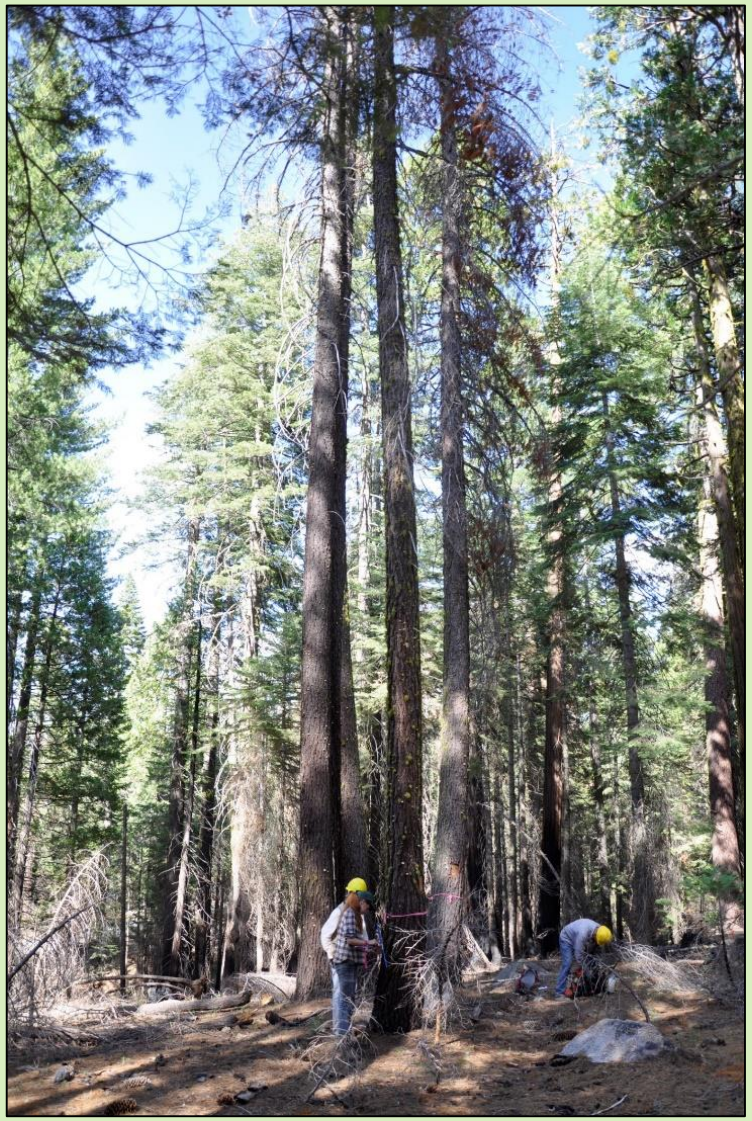
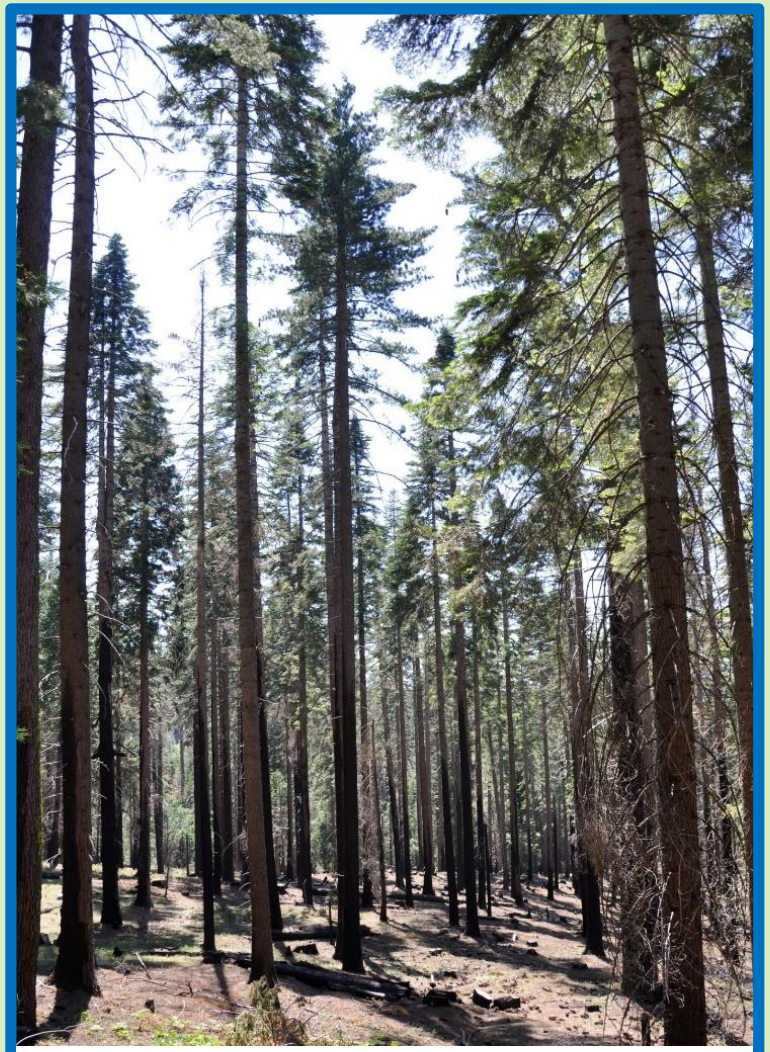




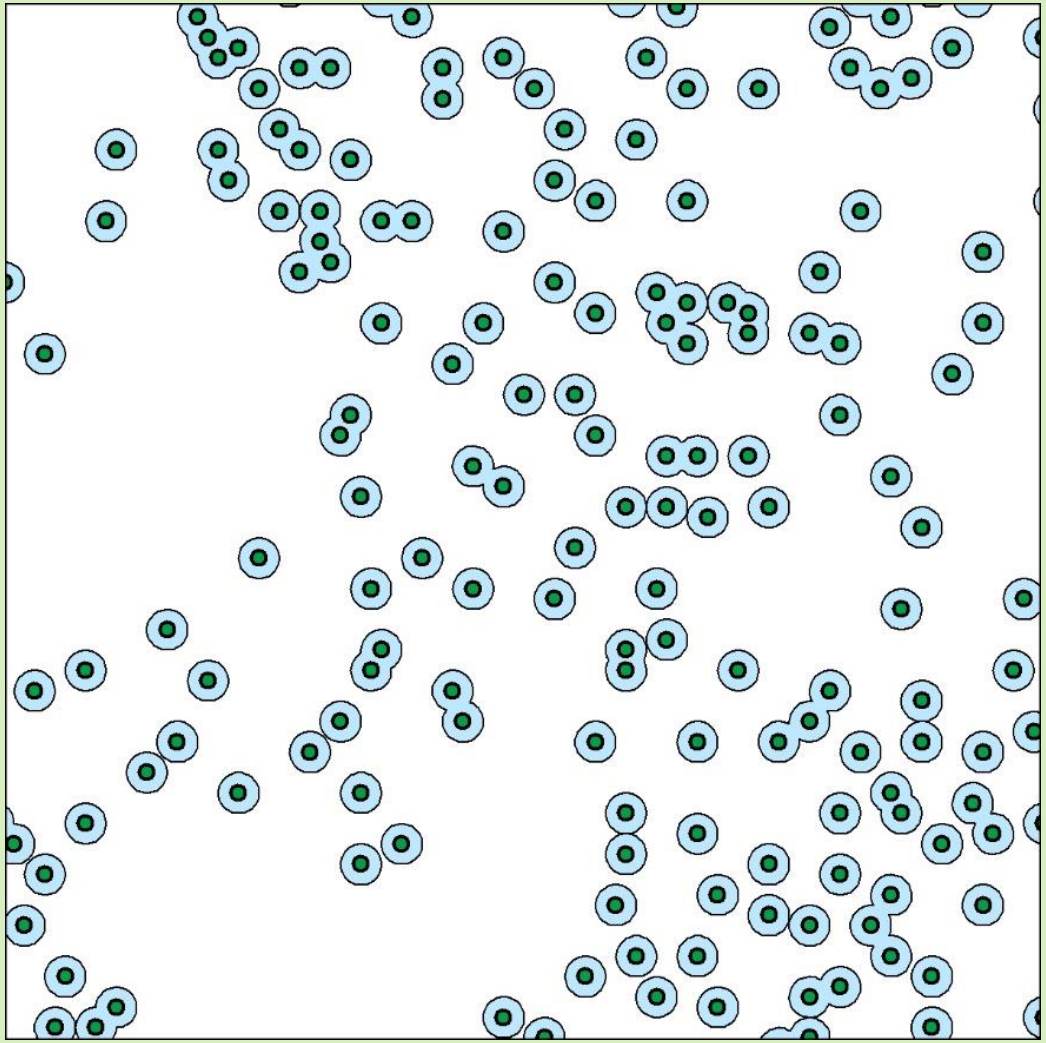
Conventional thinning

Variable Density Thinning

Individual trees

Clumps of trees

Openings/gaps



Variable Density Thinning

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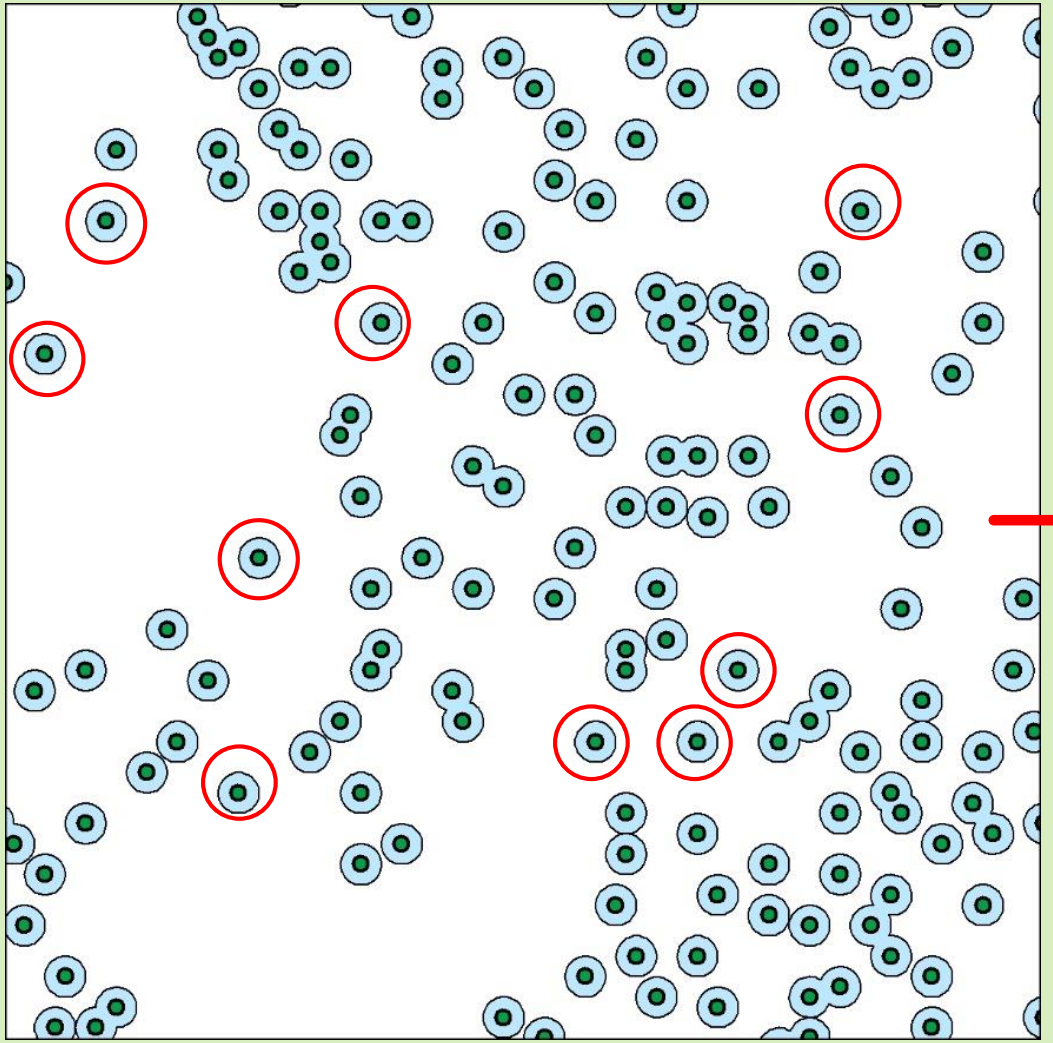

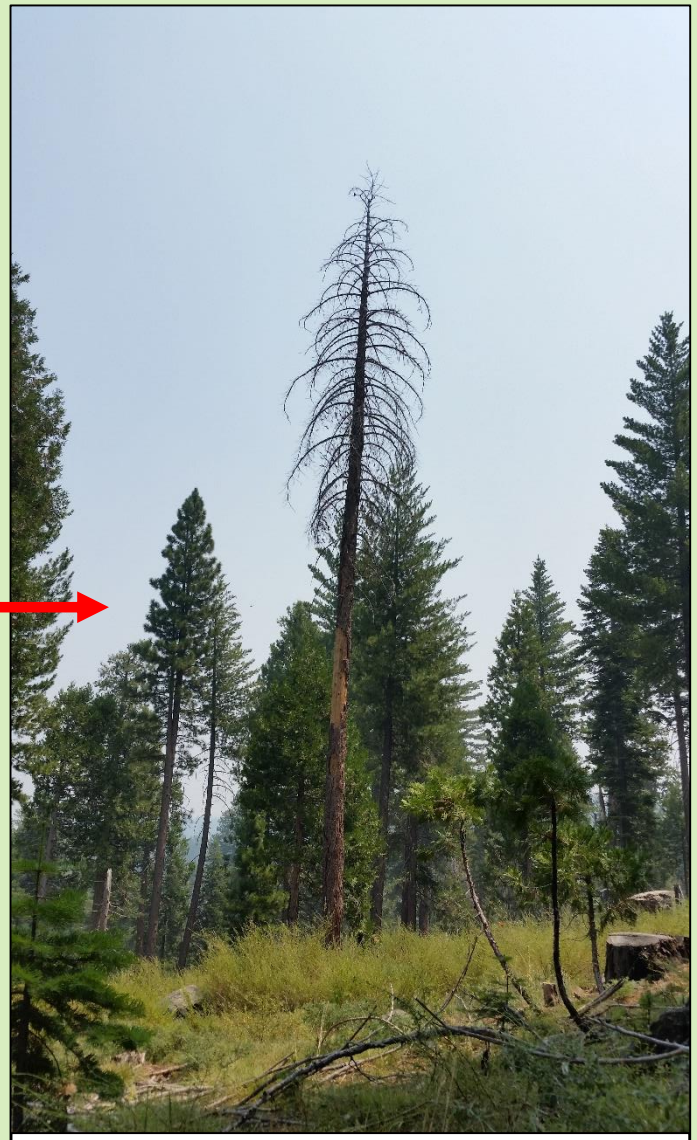

Individual trees

Variable Density Thinning

Individual trees

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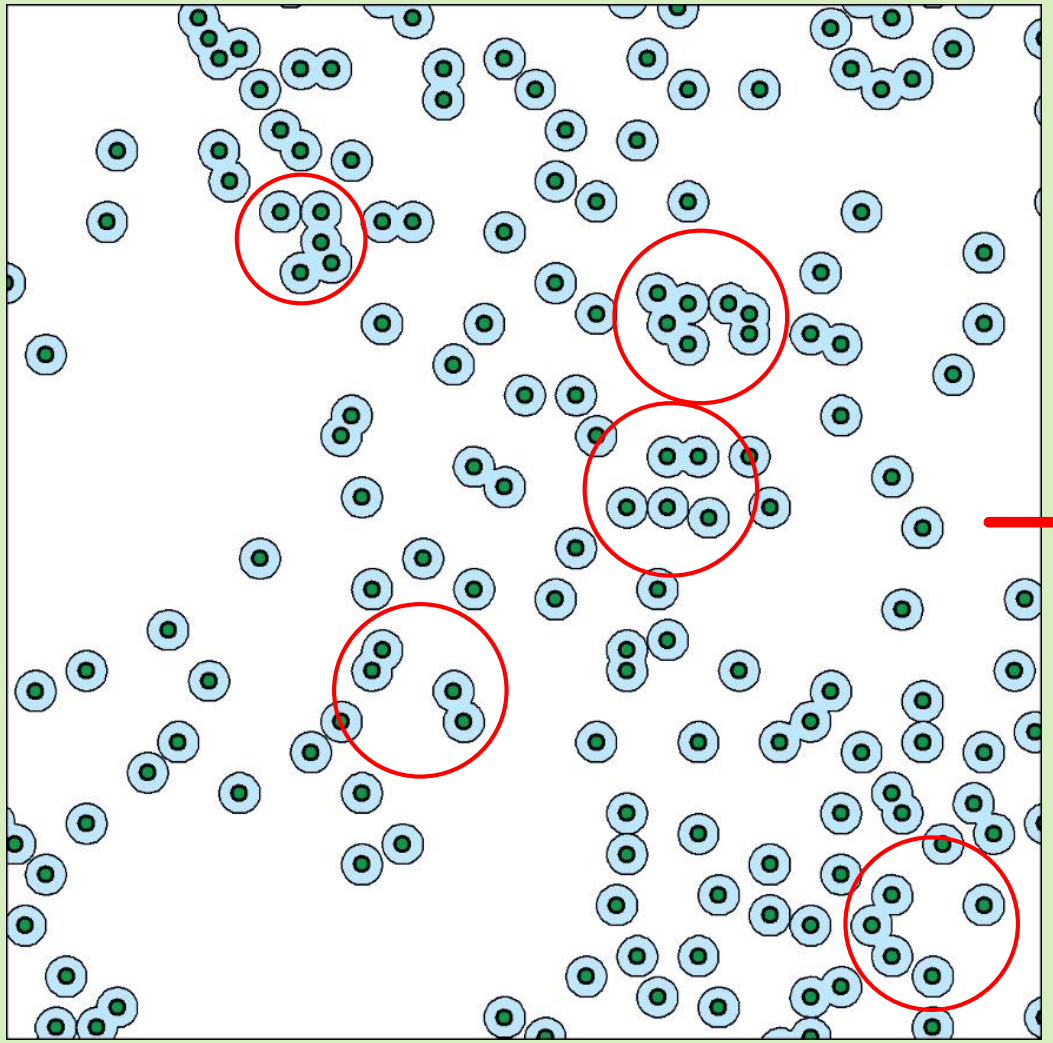

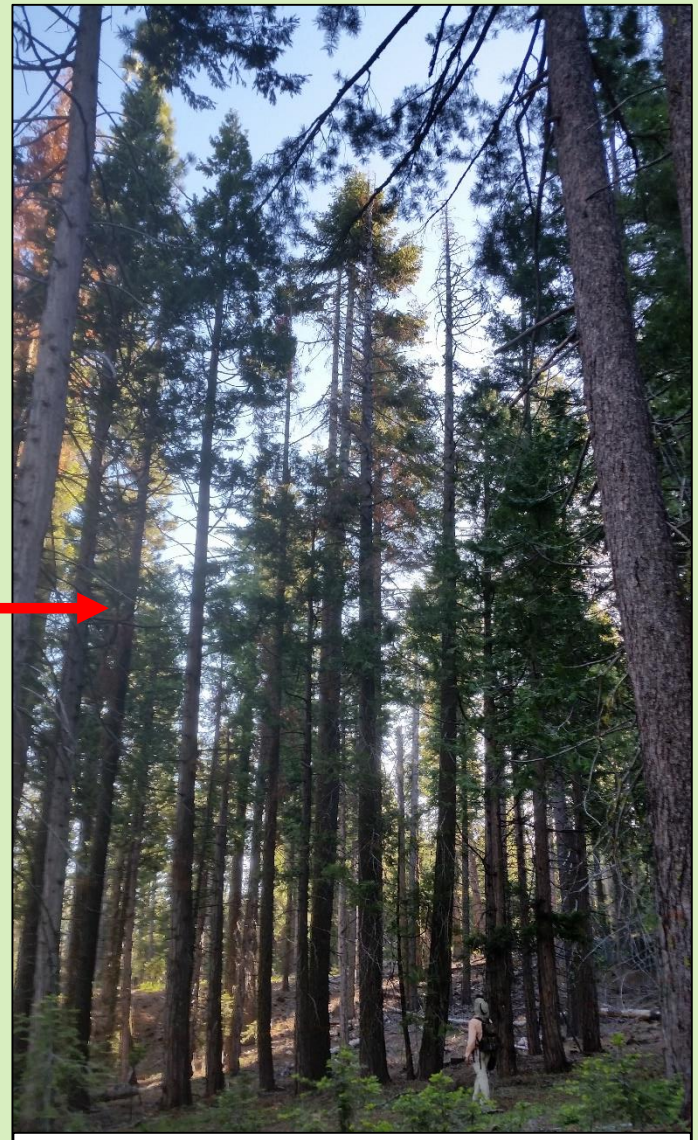

Clumps of trees

Variable Density Thinning

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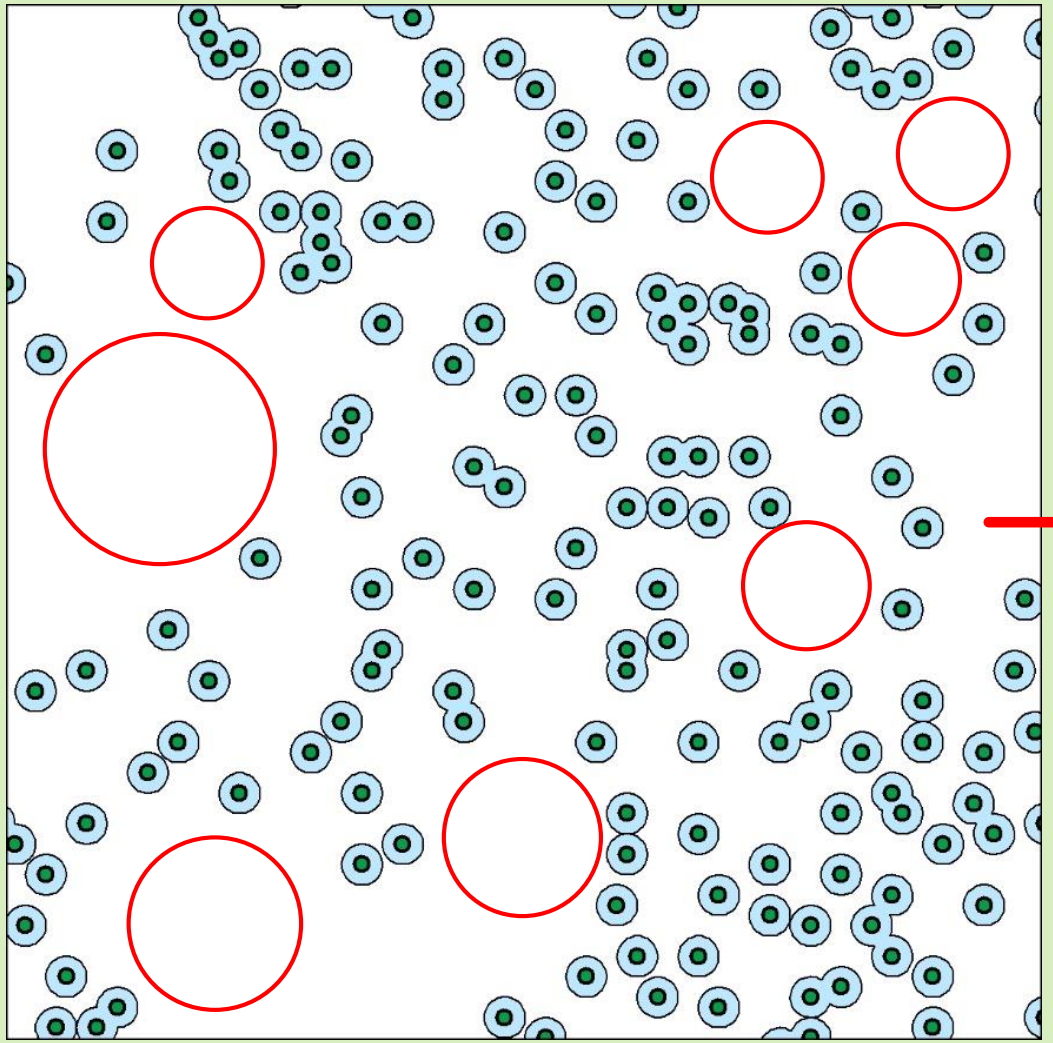
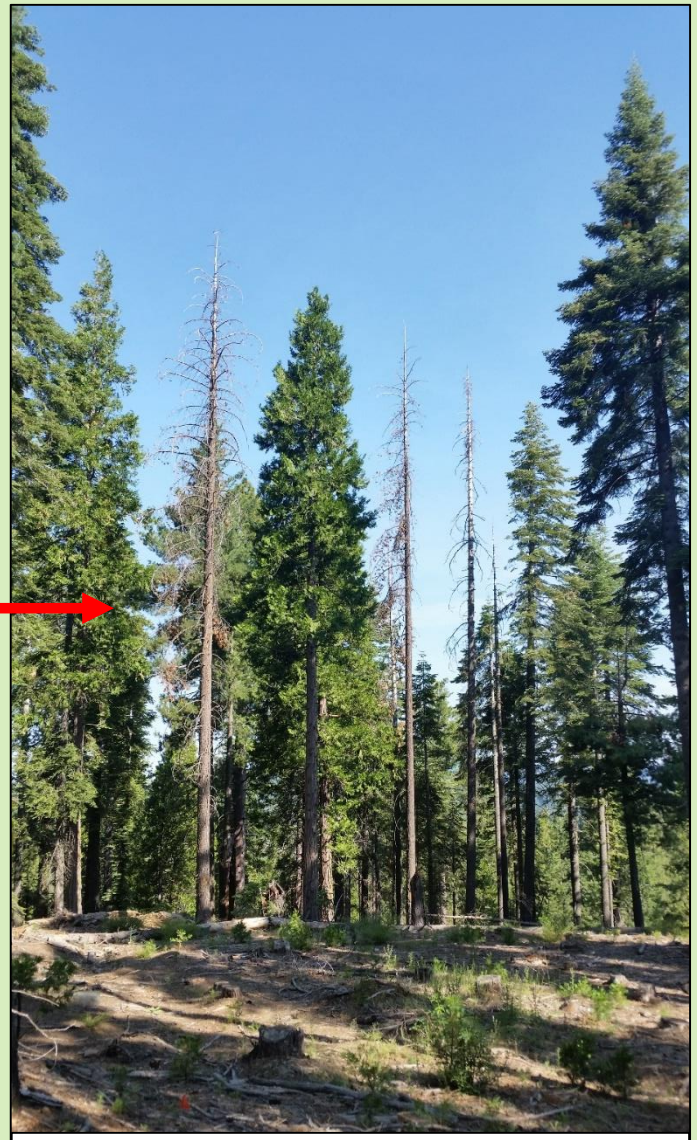




Openings

Variable Density Thinning

Unknowns

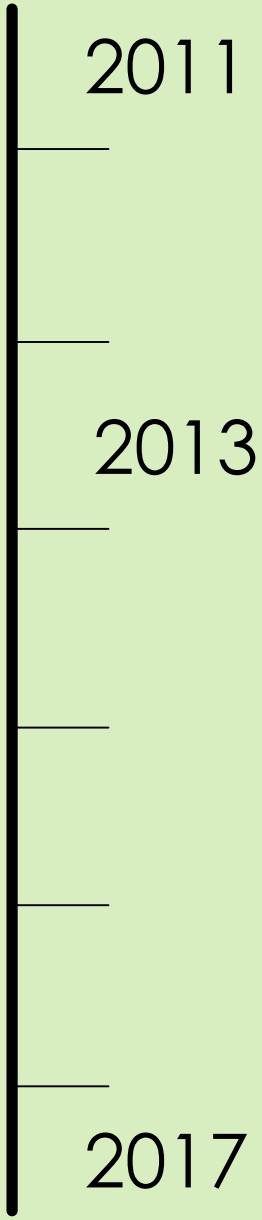
VDT & compounding disturbances

VDT & even-spaced thinning

Variable density thinning

Even thinning

Stanislaus-Tuolumne Experimental Forest



Stanislaus-Tuolumne Experimental Forest

2011

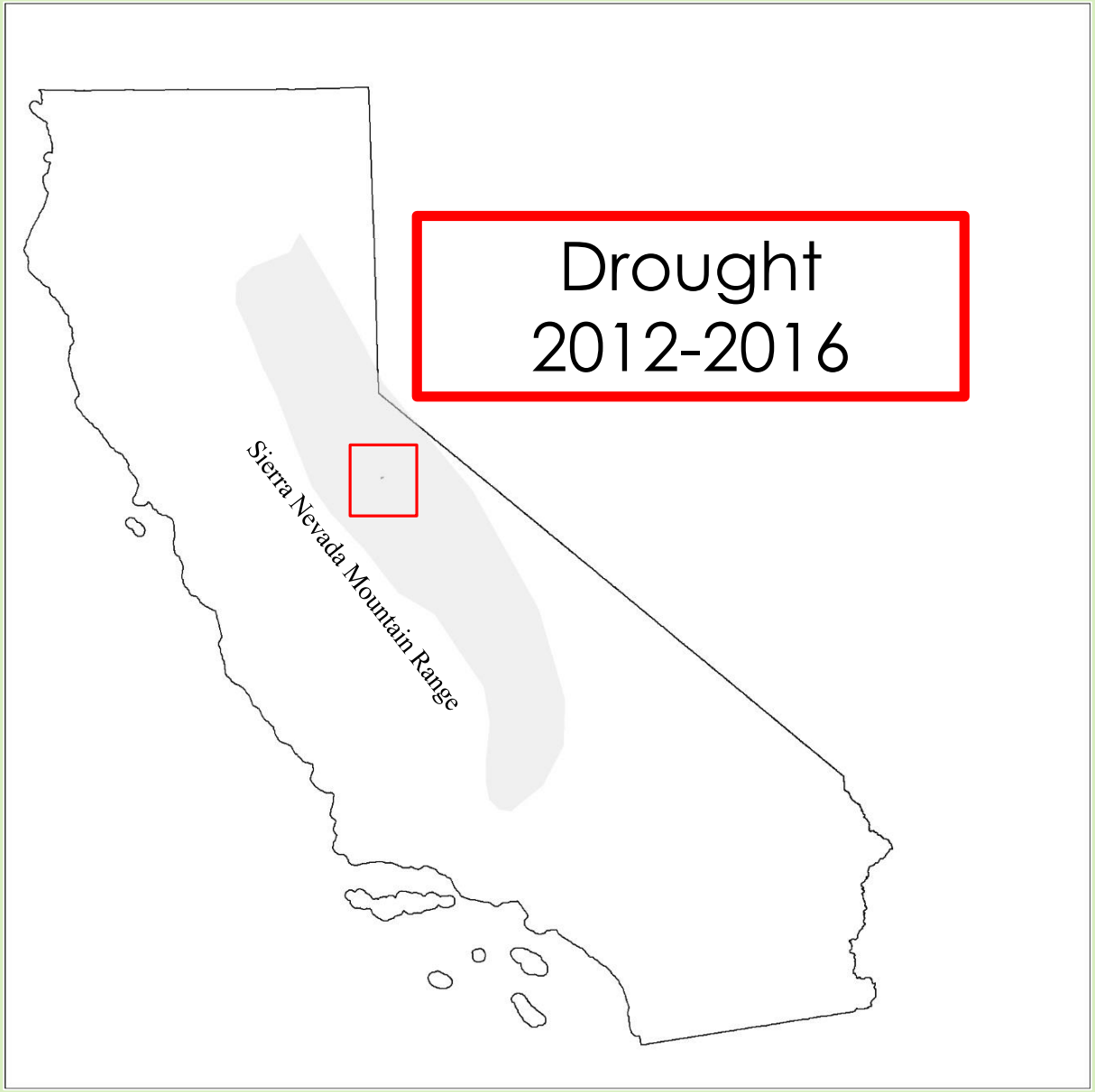
2013

2017

3 thinning treatments

Unthinned
Even thin
Variable density thin

Stanislaus-Tuolumne Experimental Forest



2011

2013

2017

<u>3 thinning treatments</u>

Unthinned
Even thin
Variable density thin

Stanislaus-Tuolumne Experimental Forest

2011

3 thinning treatments

Unthinned
Even thin
Variable density thin

2013

2 burning treatments

Unthinned + Burn
Even thin + Burn
Variable density thin + Burn

2017

Stanislaus-Tuolumne Experimental Forest

2011 **3 thinning treatments**

Unthinned
Even thin
Variable density thin

2013 **2 burning treatments**

Unthinned + Burn
Even thin + Burn
Variable density thin + Burn

2017 Data collection

Research Questions

Does variable density thinning effectively maintain drought **resistance** in live white fir and sugar pine over time?

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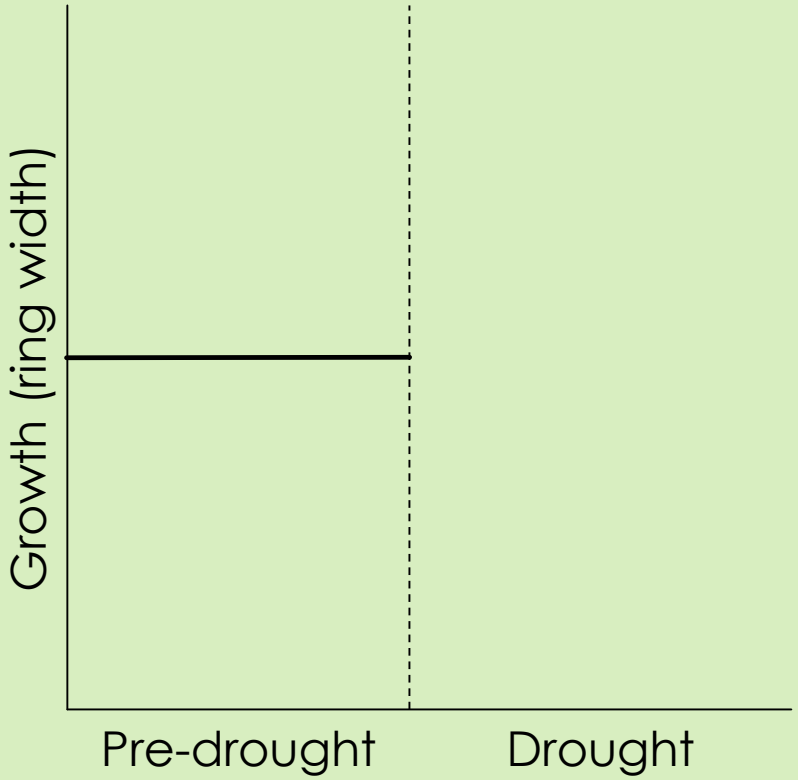
Does variable density thinning effectively maintain drought **resistance** in live white fir and sugar pine over time?

Growth (ring width)



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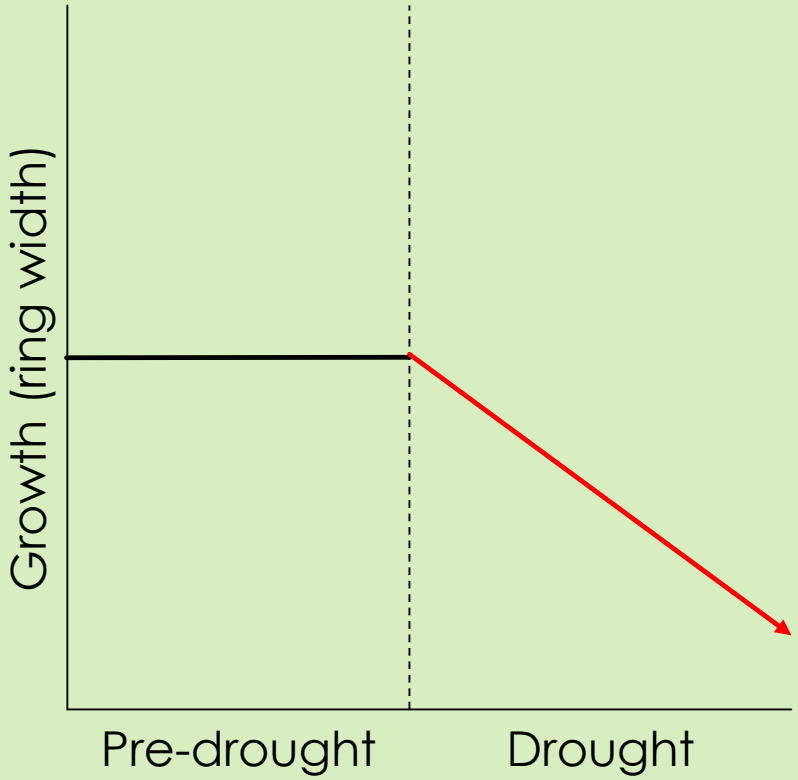

Lacks resistance

Drought < Pre-drought

Drought / Pre-drought **<1**

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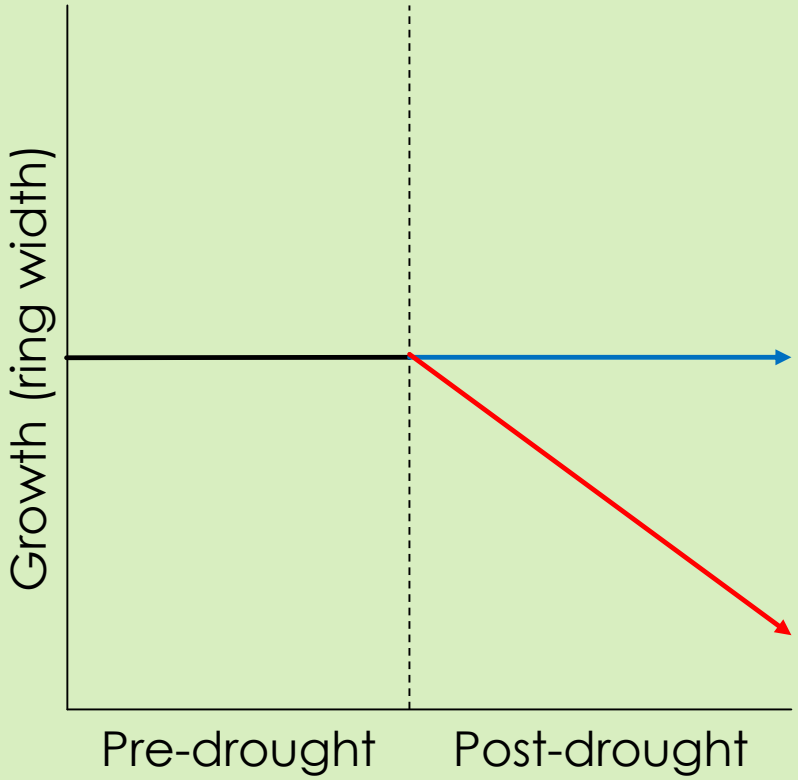

Maintain resistance

Drought = Pre-drought

Drought / Pre-drought **=1**

Lacks resistance

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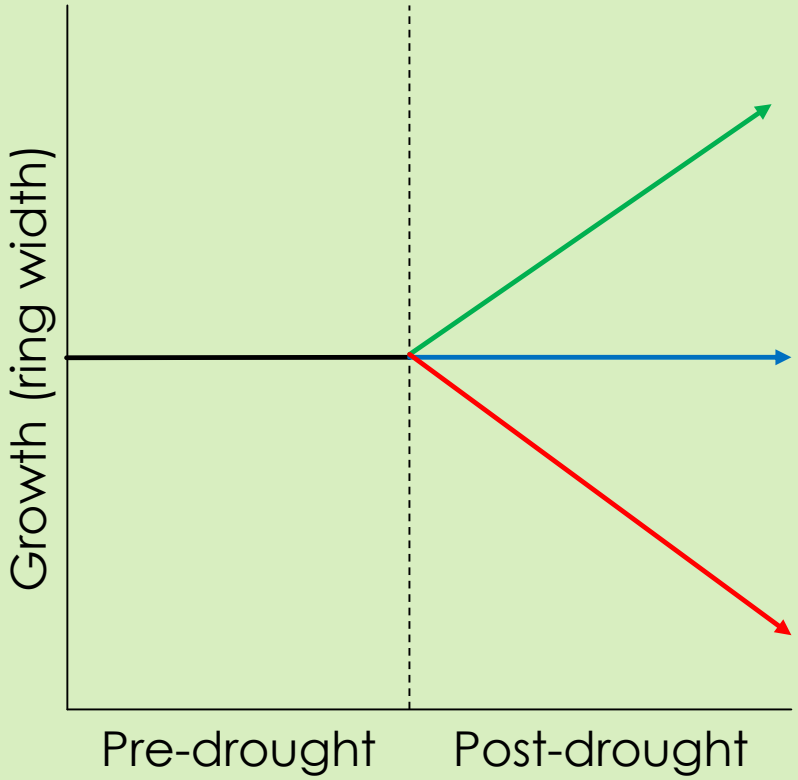

Enhance resistance

Drought > Pre-drought

Drought / Pre-drought **>1**

Maintain resistance

Drought = Pre-drought

Drought / Pre-drought **=1**

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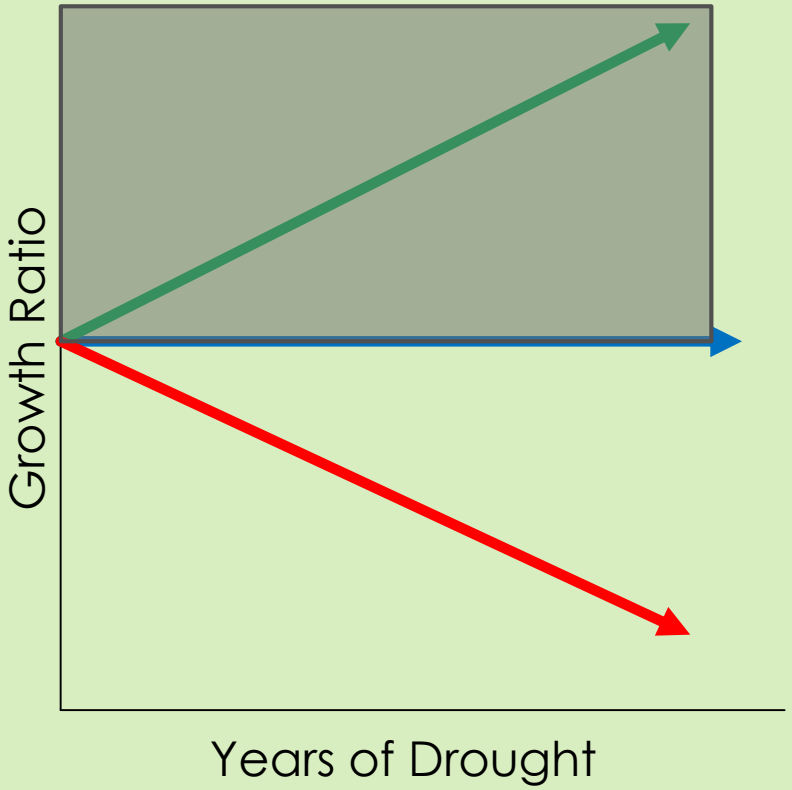
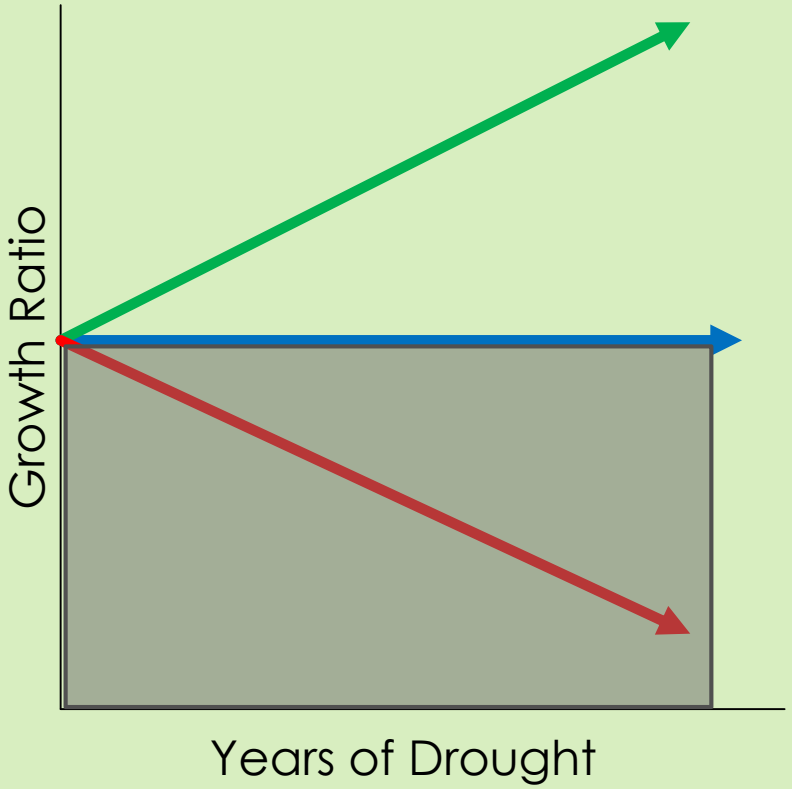


≥ 1 Maintain/enhance resistance
Variable density thinning
Variable density thinning + burn
Even thinning
Even thinning + burn

Research Questions

Does variable density thinning effectively maintain drought **resistance** in live white fir and sugar pine over time?

Growth (ring width)

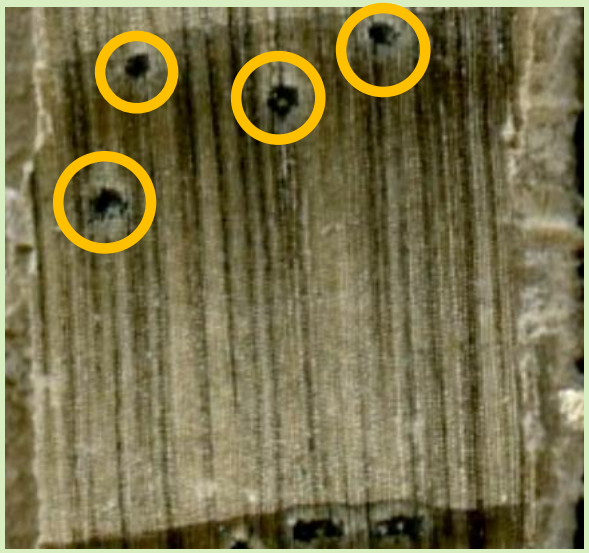


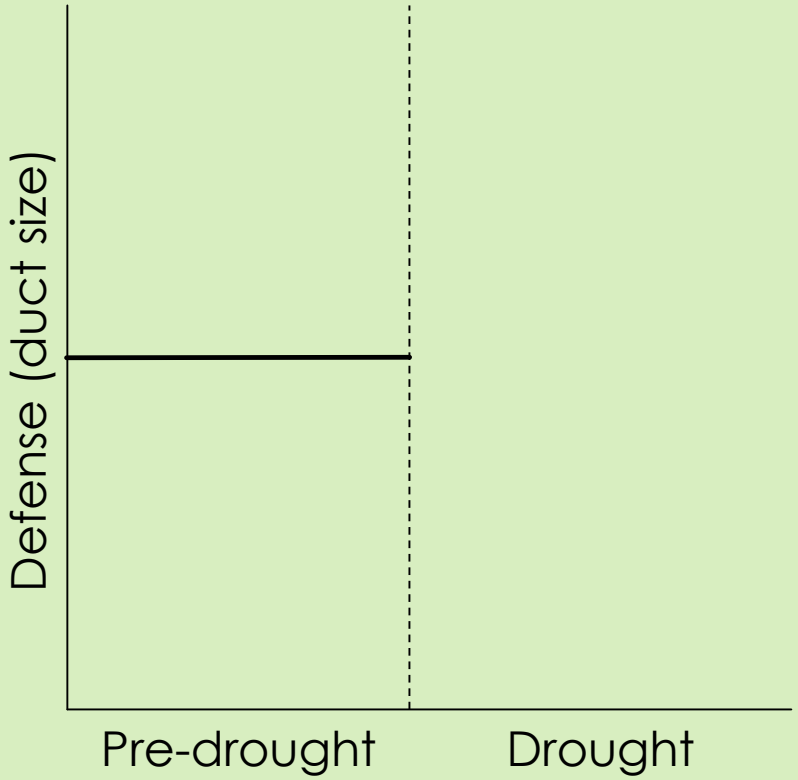
<1 Lacks resistance
Unthinned
Unthinned + burn

Research Questions

Does variable density thinning effectively maintain **defense characteristics** in live sugar pine over time?

Defense (duct size)





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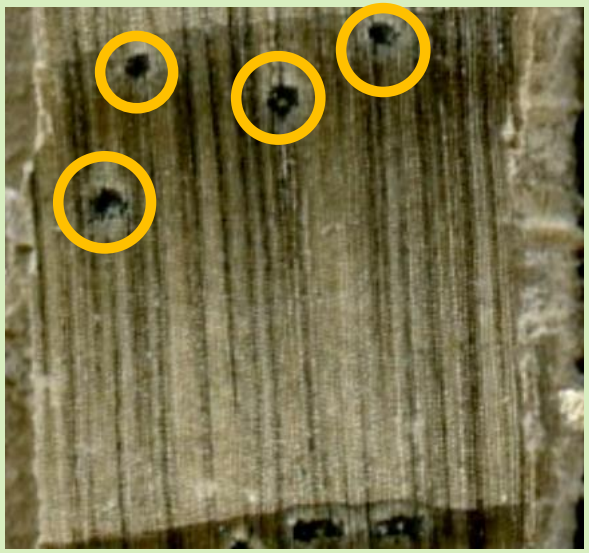

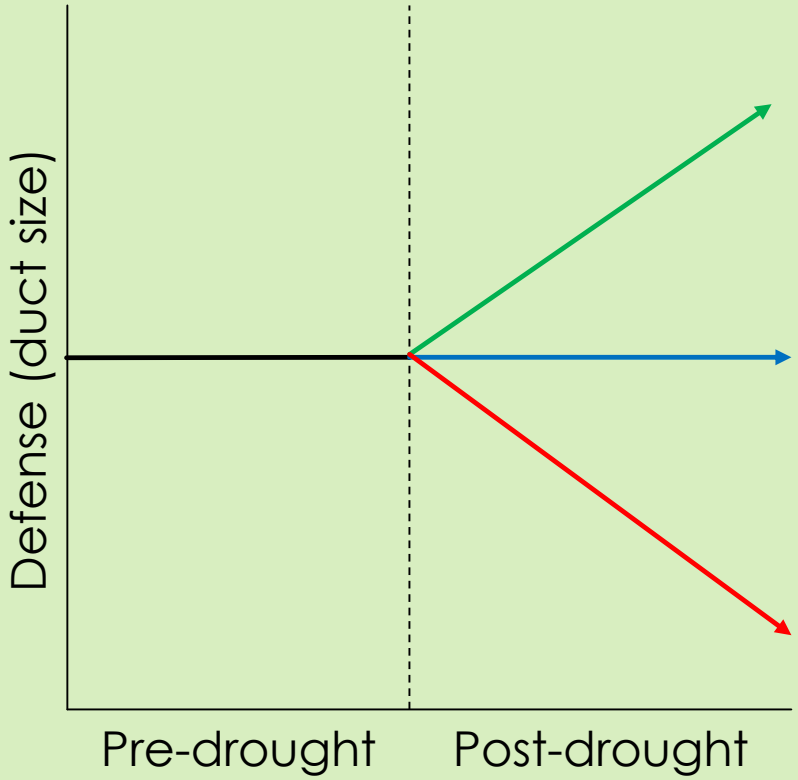

Enhance resistance

Drought > Pre-drought

Drought / Pre-drought **>1**

Maintain resistance

Drought = Pre-drought

Drought / Pre-drought **=1**

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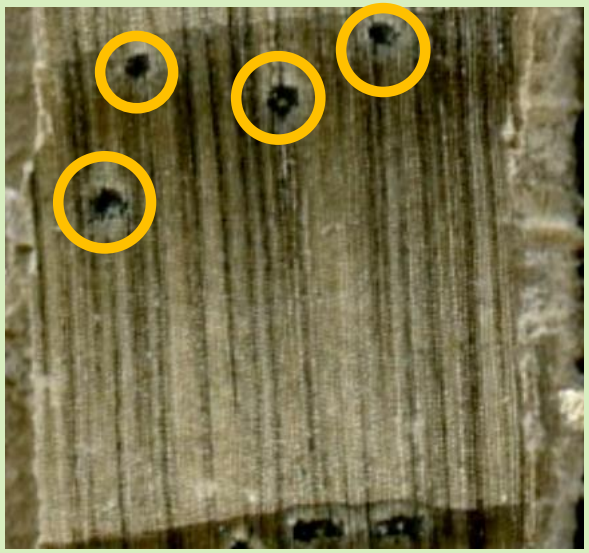

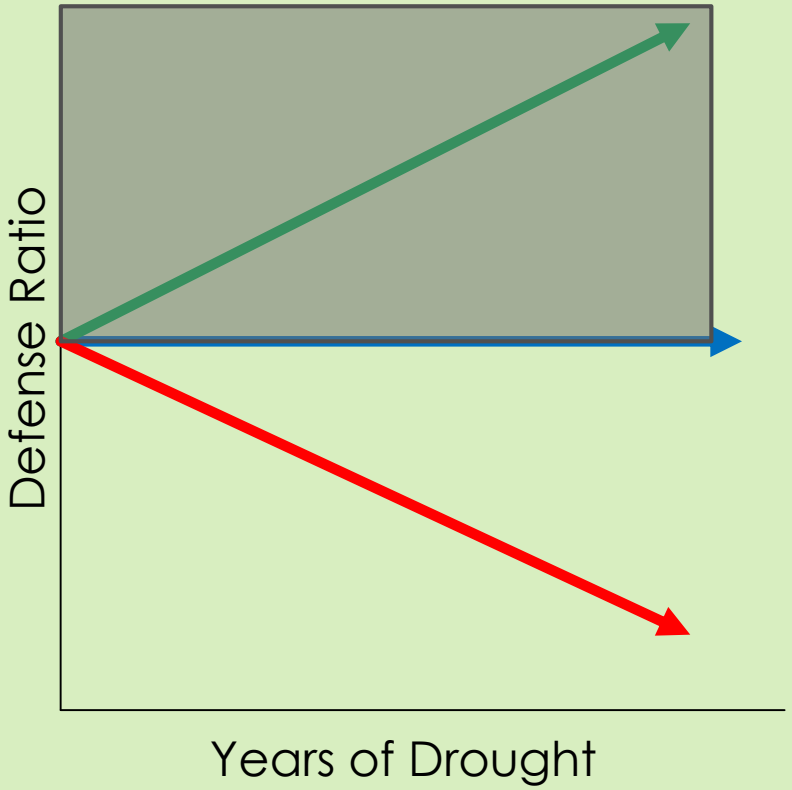

≥ 1 Maintain/enhance resistance
Variable density thinning
Variable density thinning + burn
Even thinning
Even thinning + burn

Research Questions

Does variable density thinning effectively maintain **defense characteristics** in live sugar pine over time?

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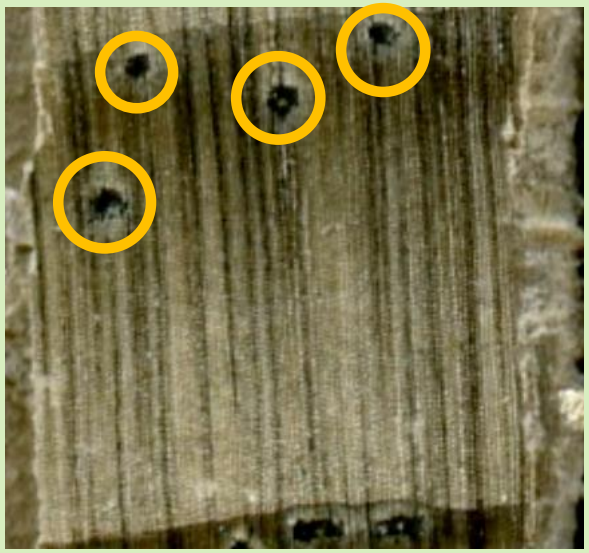
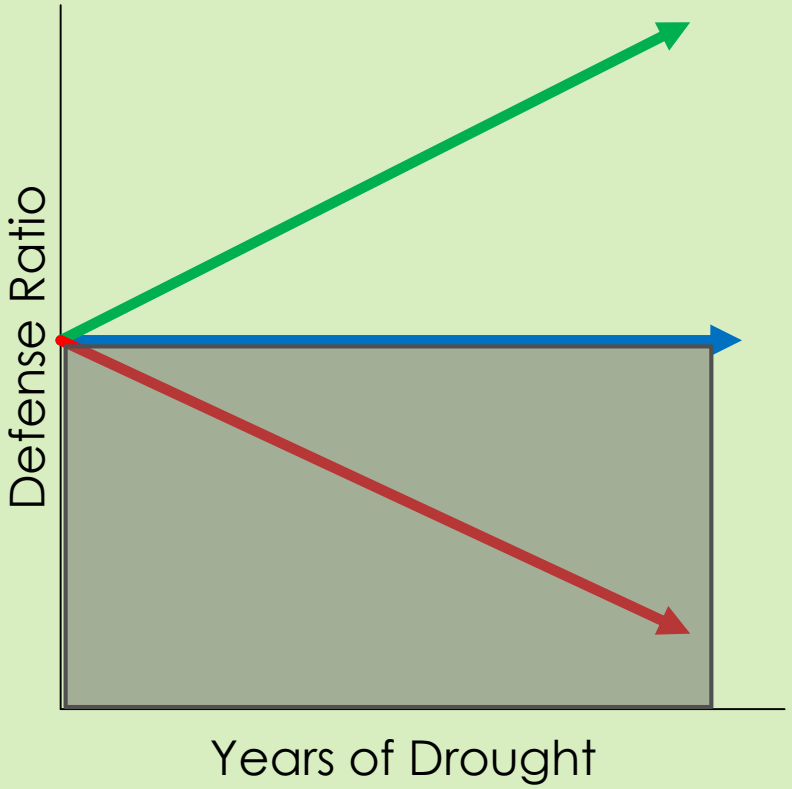




<1 Lacks resistance
Unthinned
Unthinned + burn

Research Questions

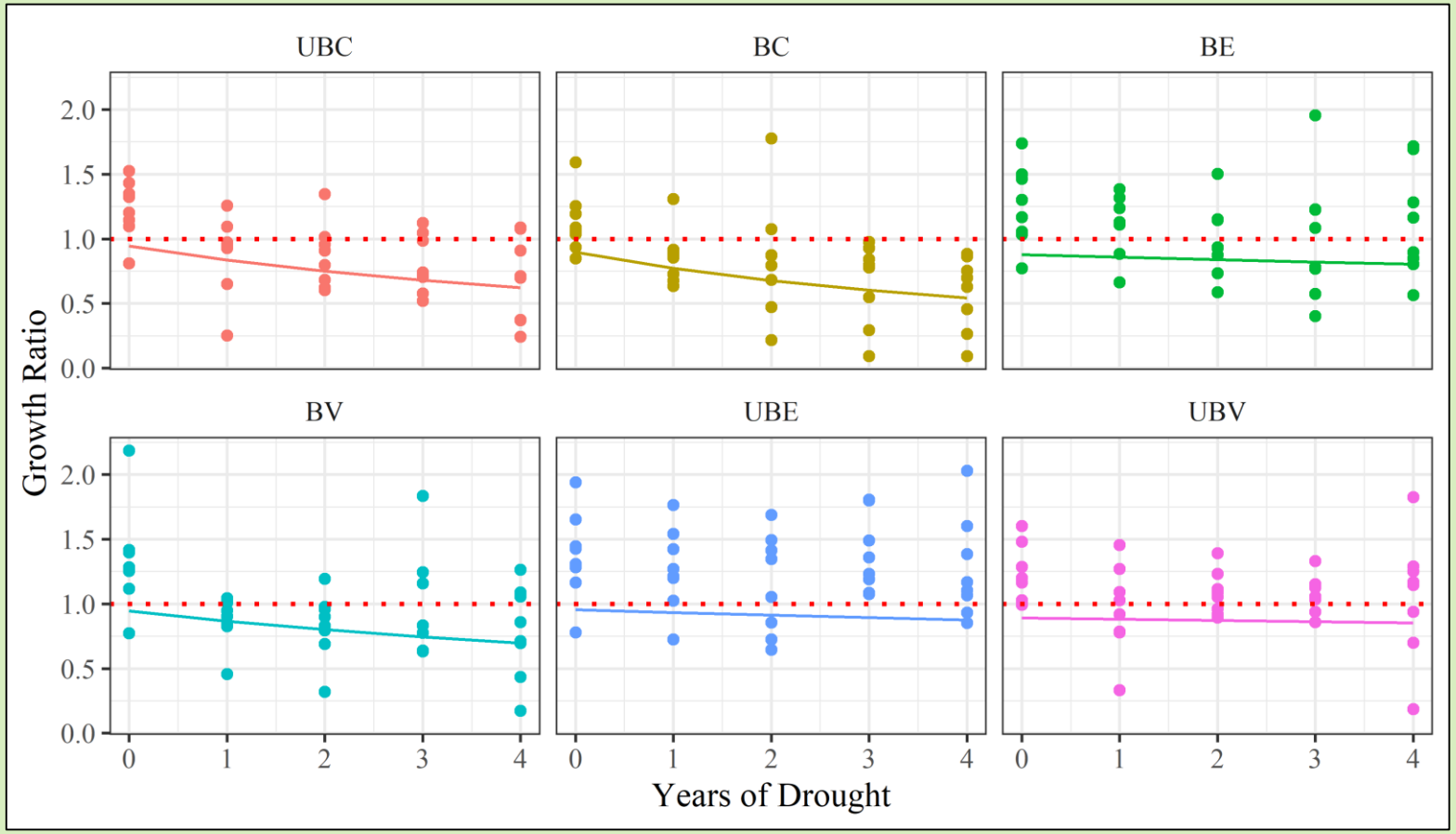
Are resistant characteristics **different** between trees that died from bark beetle-caused mortality and trees that survived?

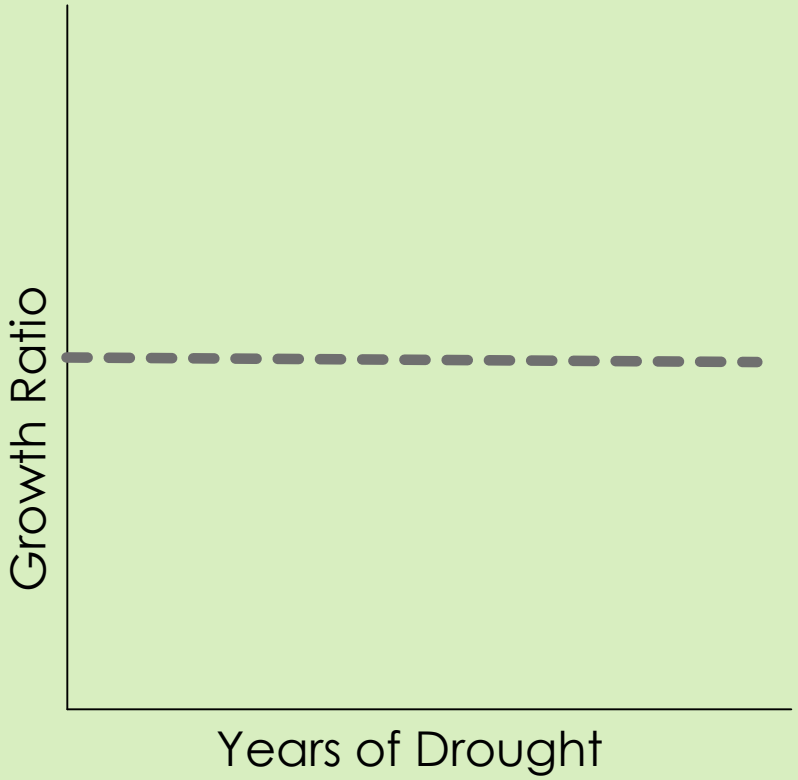
Trees that exhibit drought resistance and greater defense are also trees that avoid bark beetle-caused mortality

Methods

1. Paired live-dead white fir and sugar pine
2. Extracted and cross-dated cores
3. Measured growth and defense
4. Compared effects of treatments on resistance (GLMM)
5. Compared resistant characteristics between live and dead trees (Mann-Whitney test)

Does variable density thinning effectively maintain drought **resistance** in live white fir over time?





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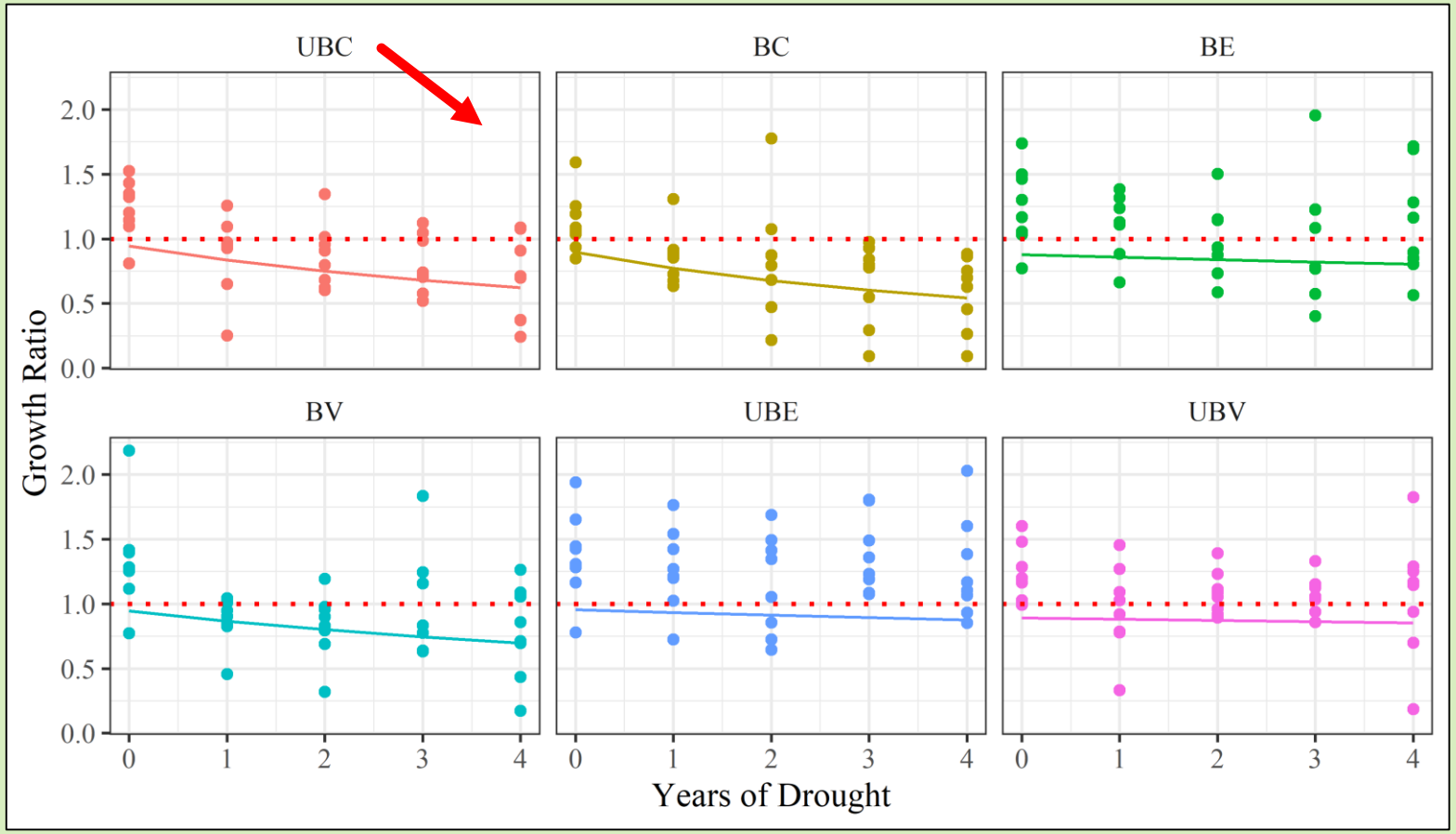

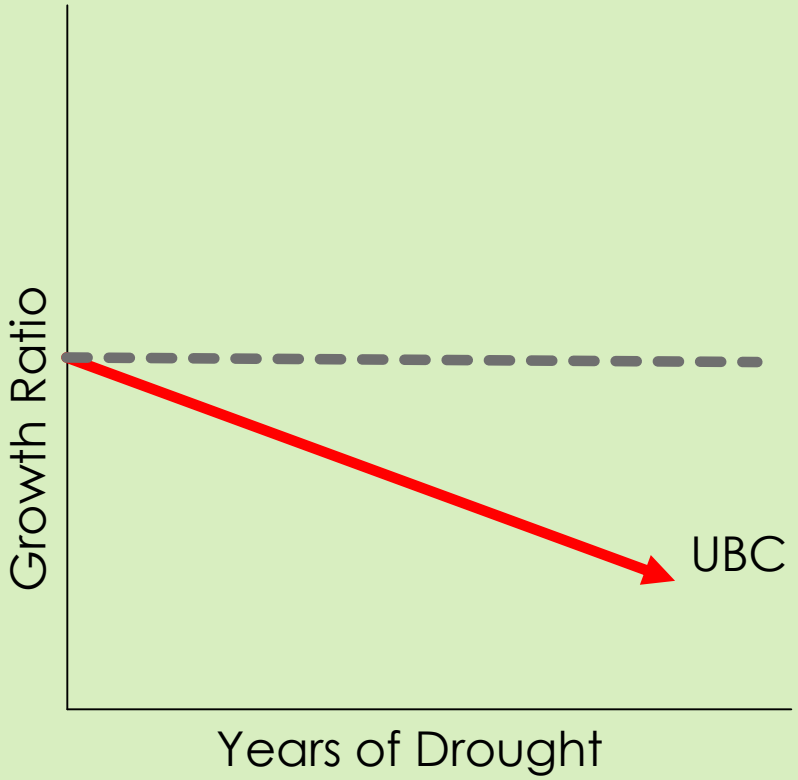

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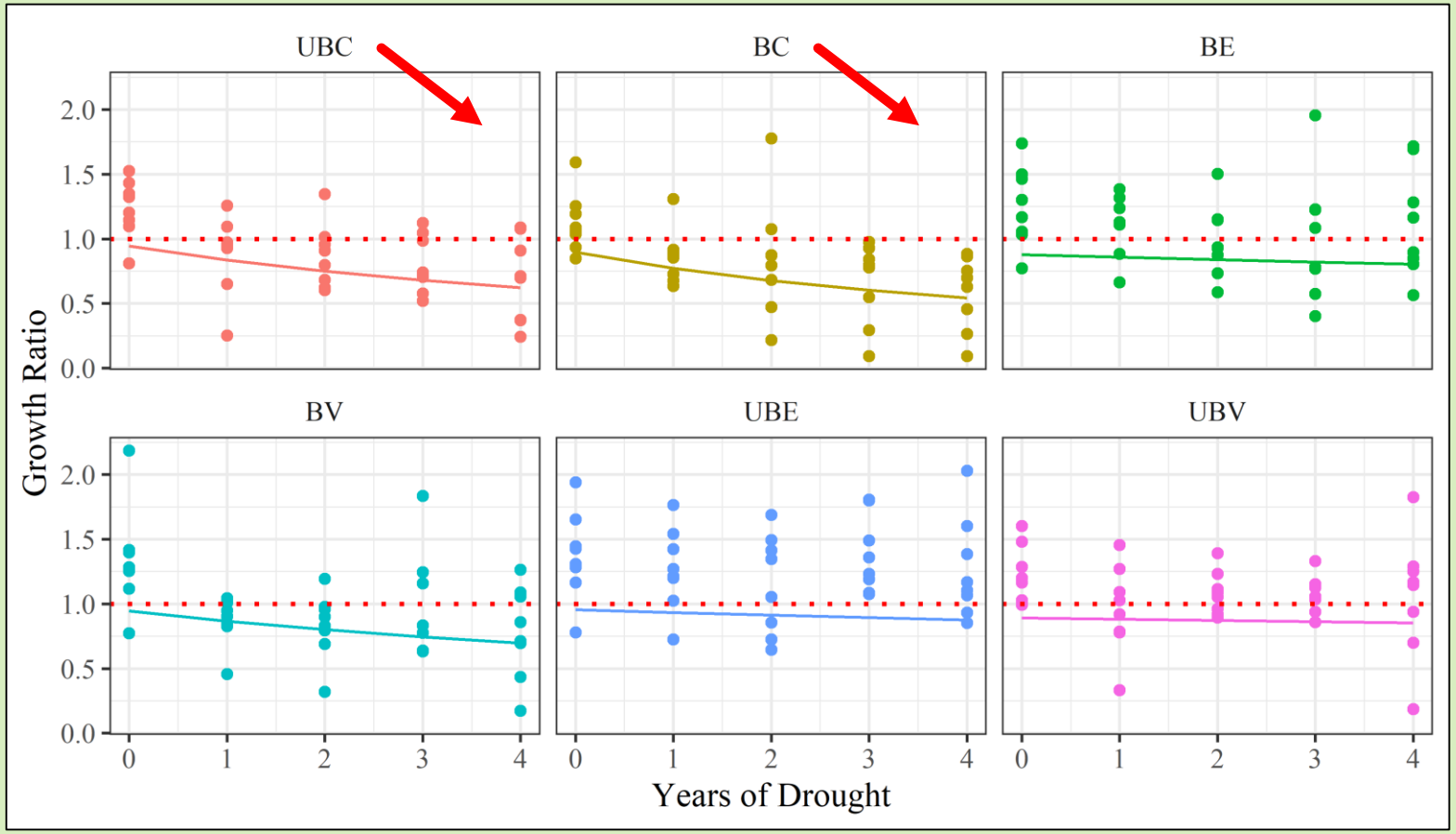

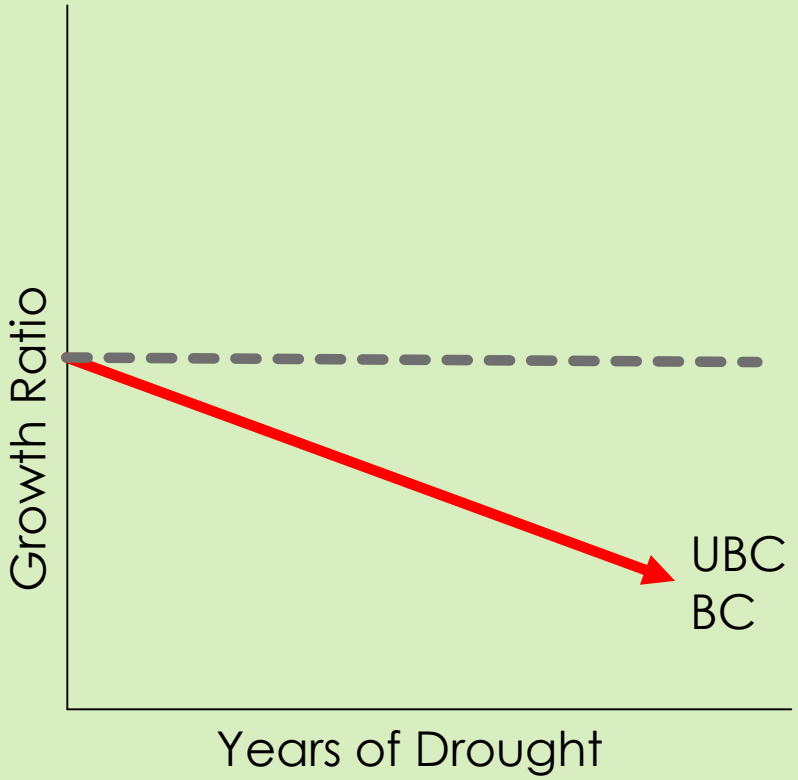

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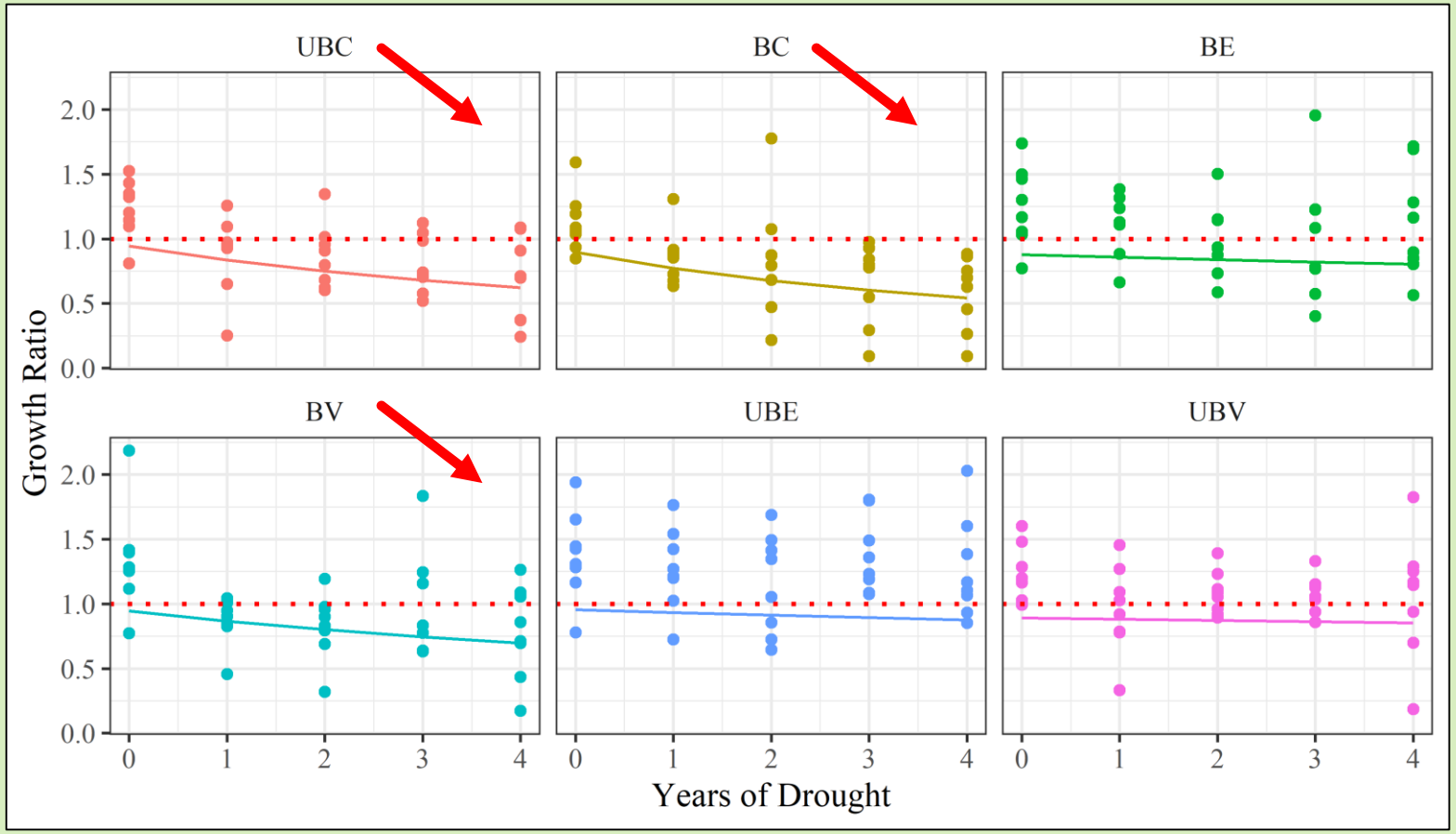

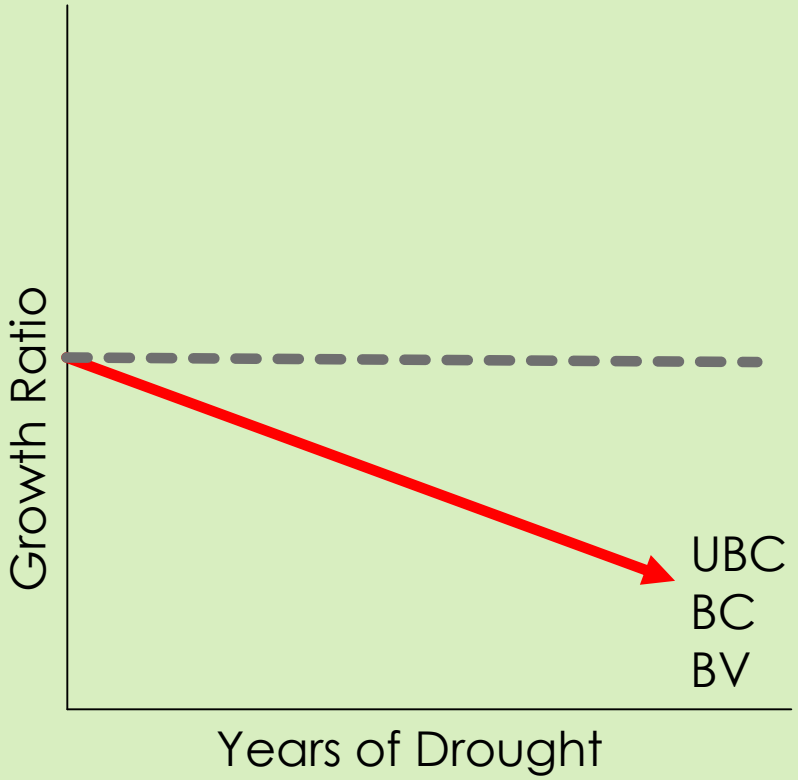

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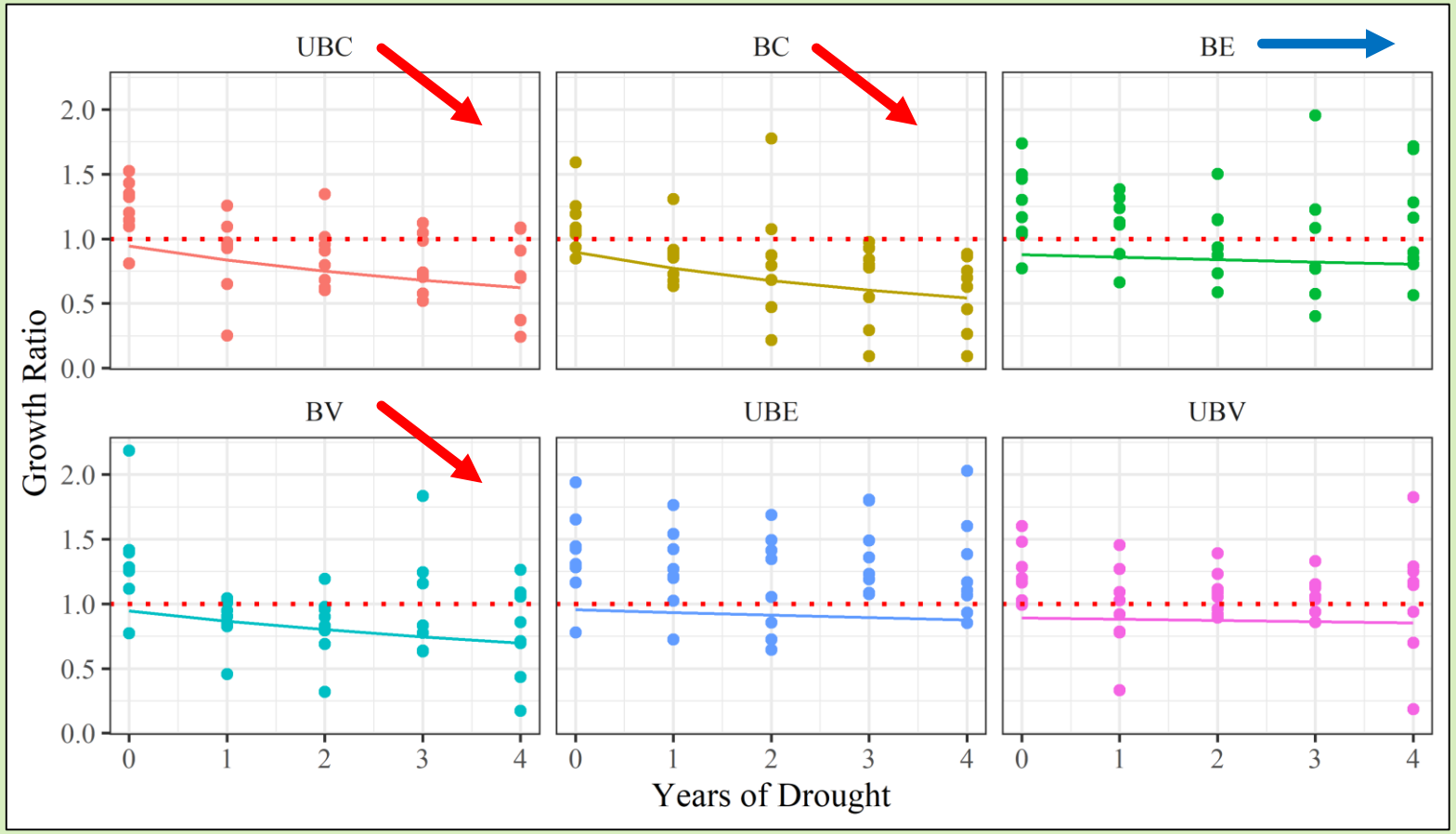

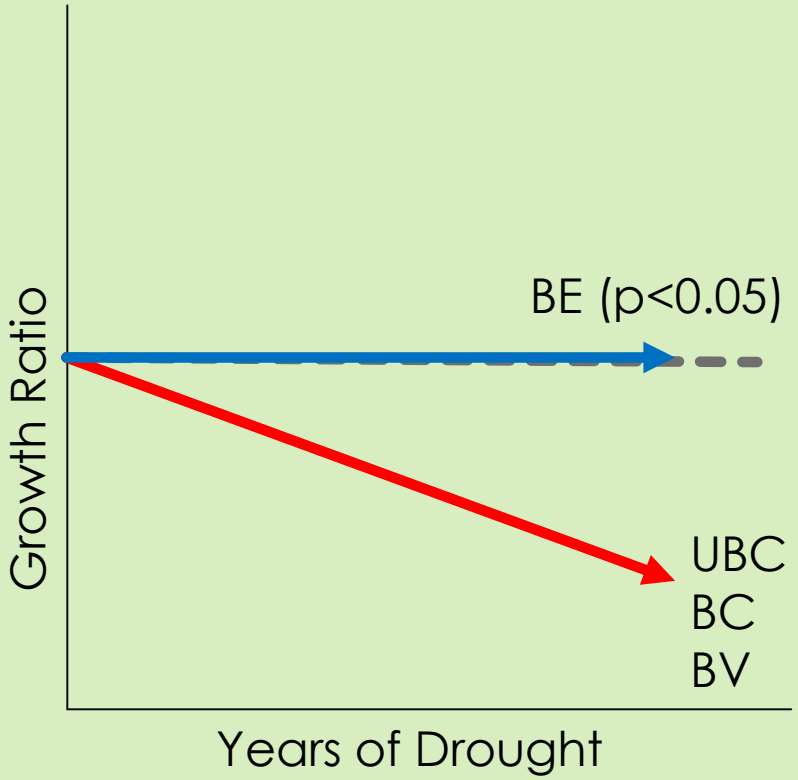

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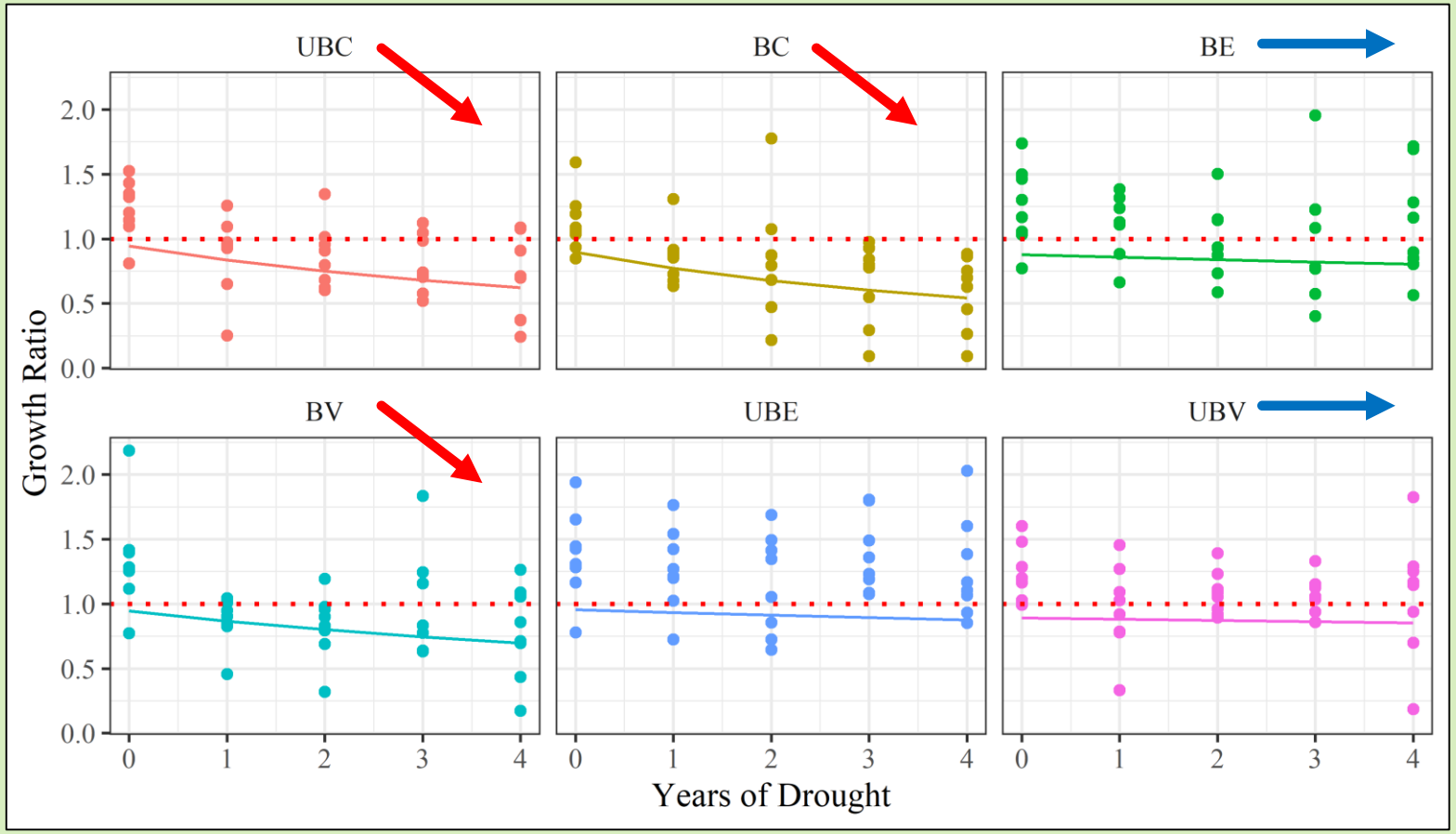

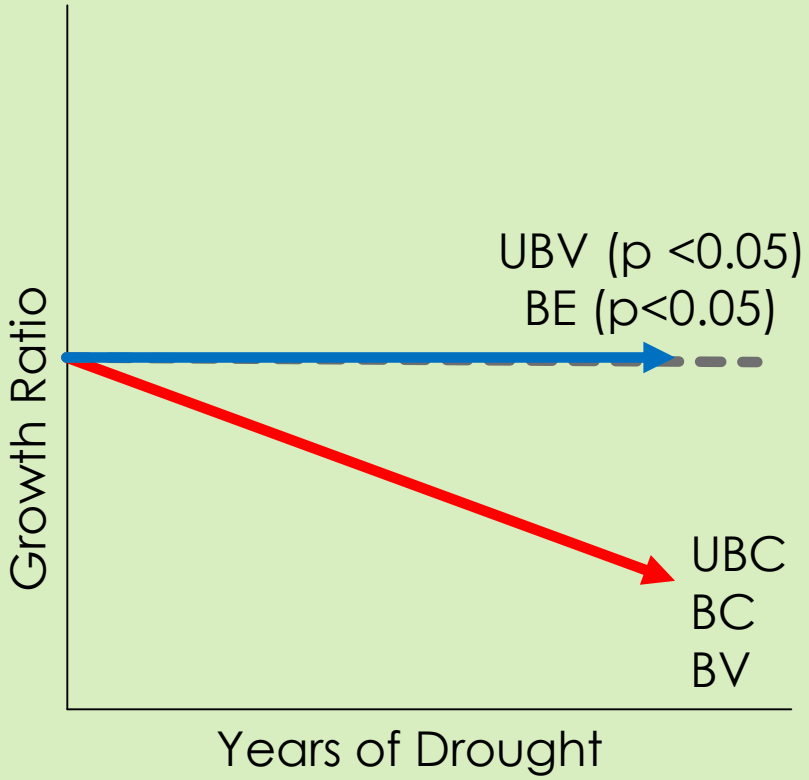

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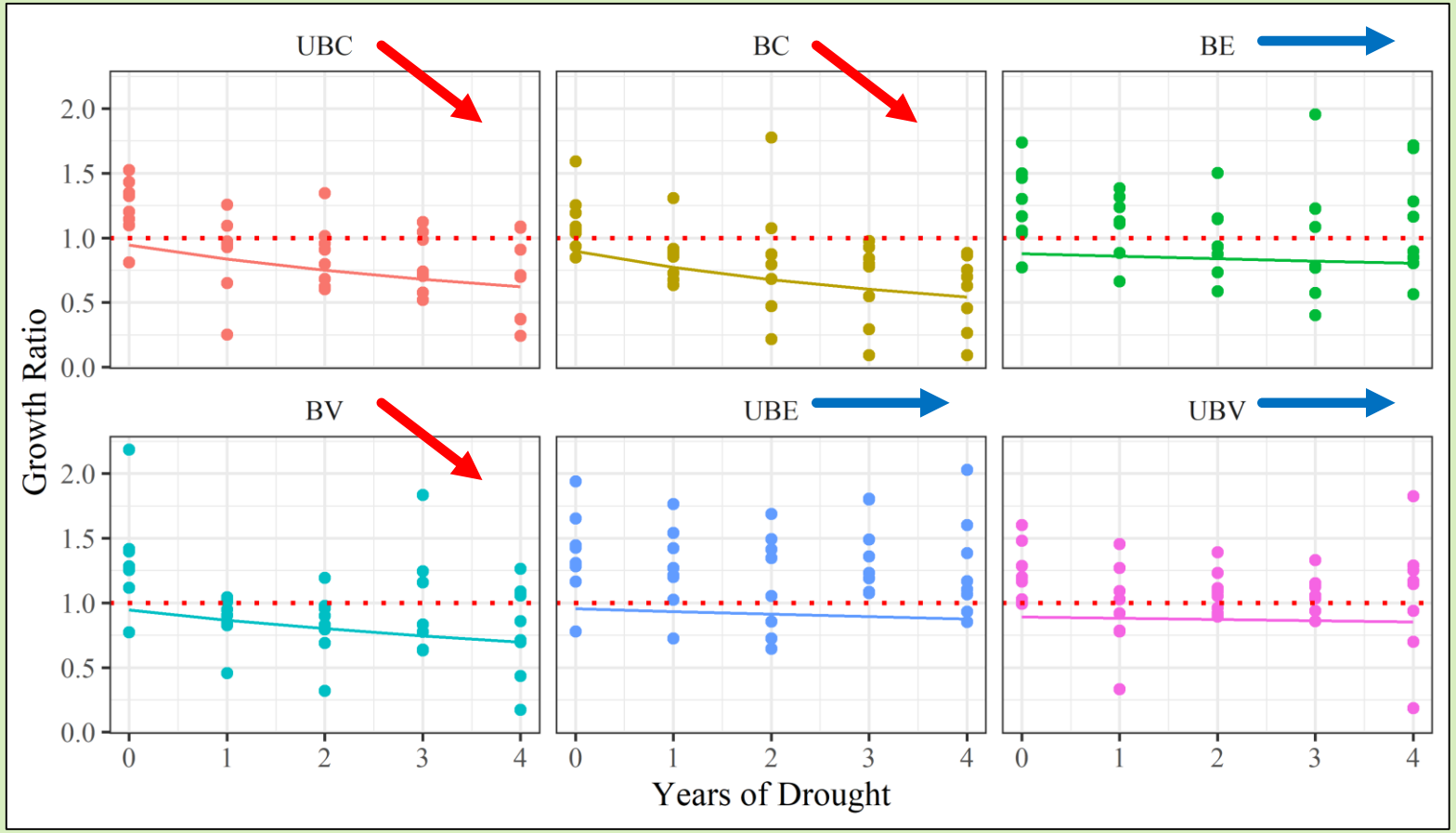

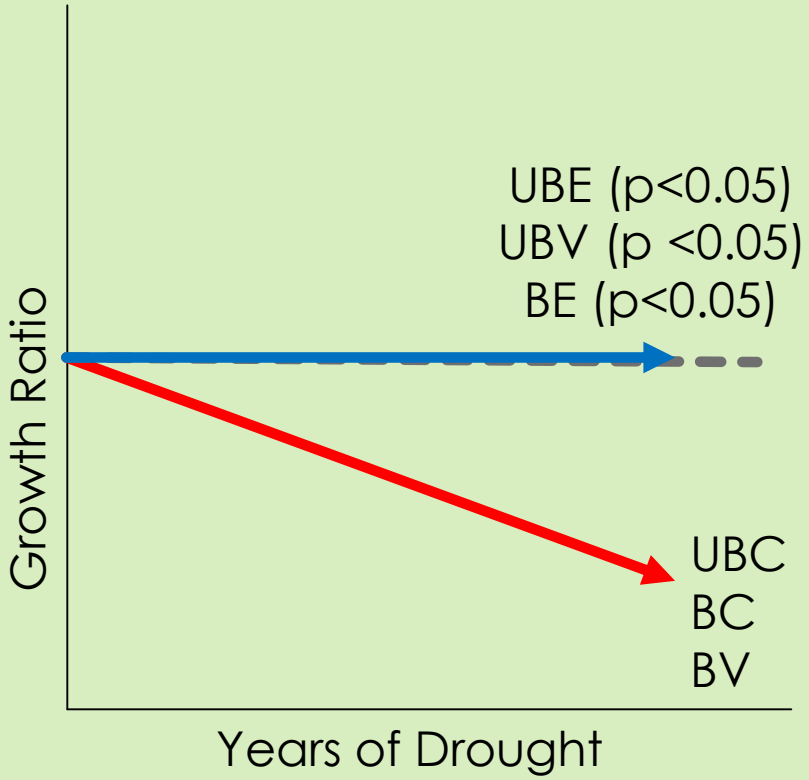

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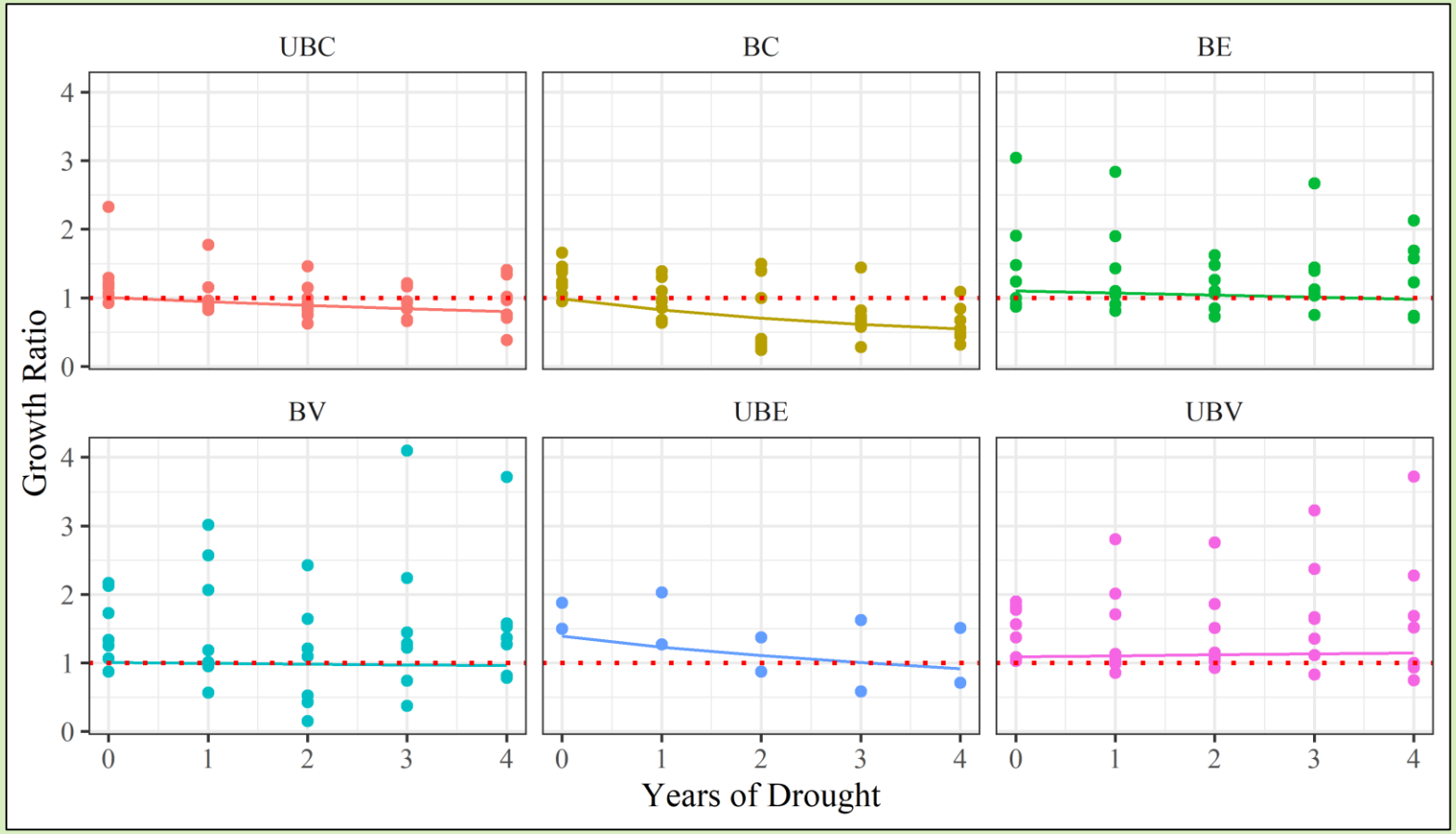

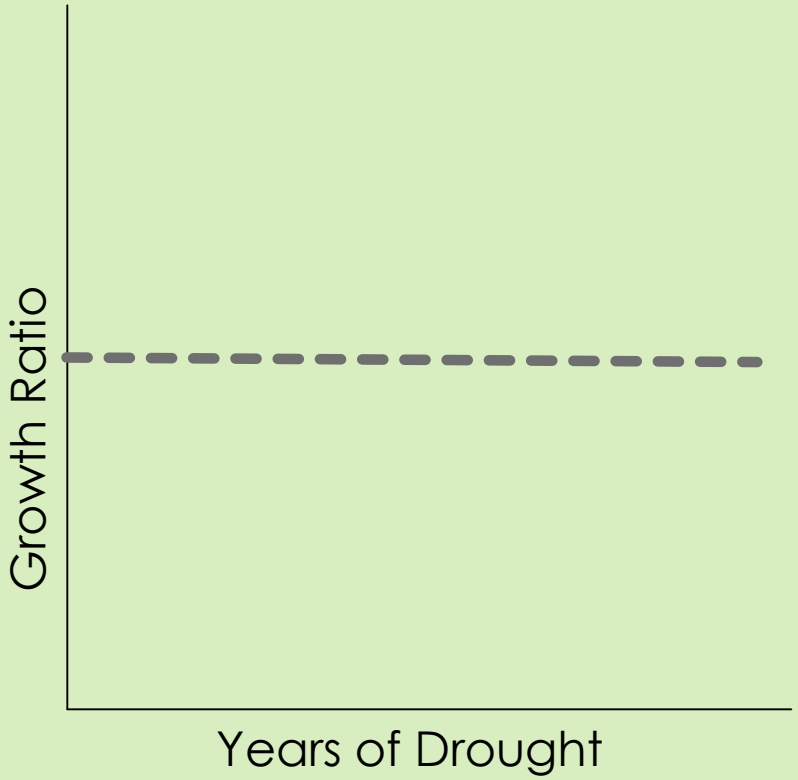

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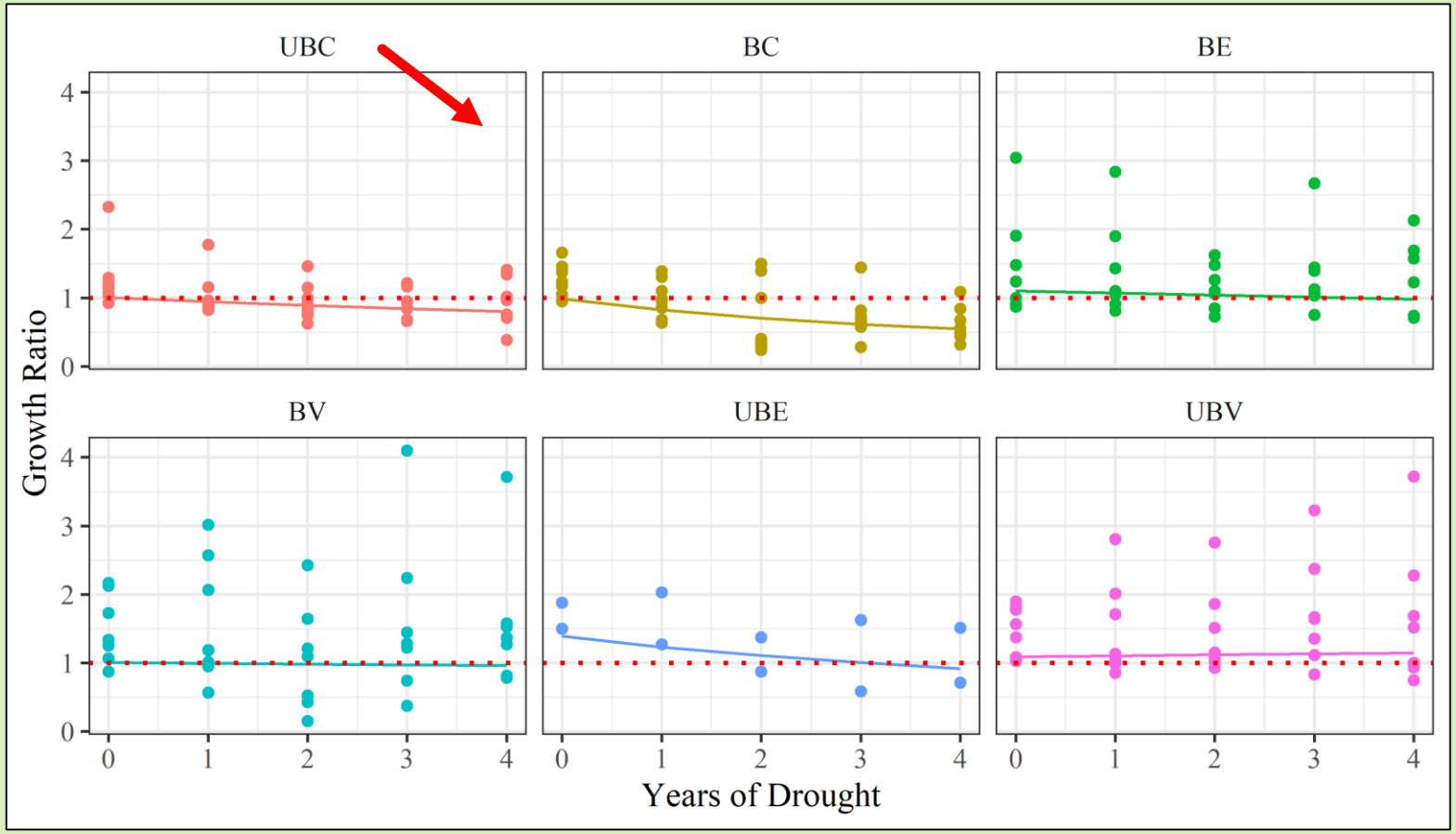

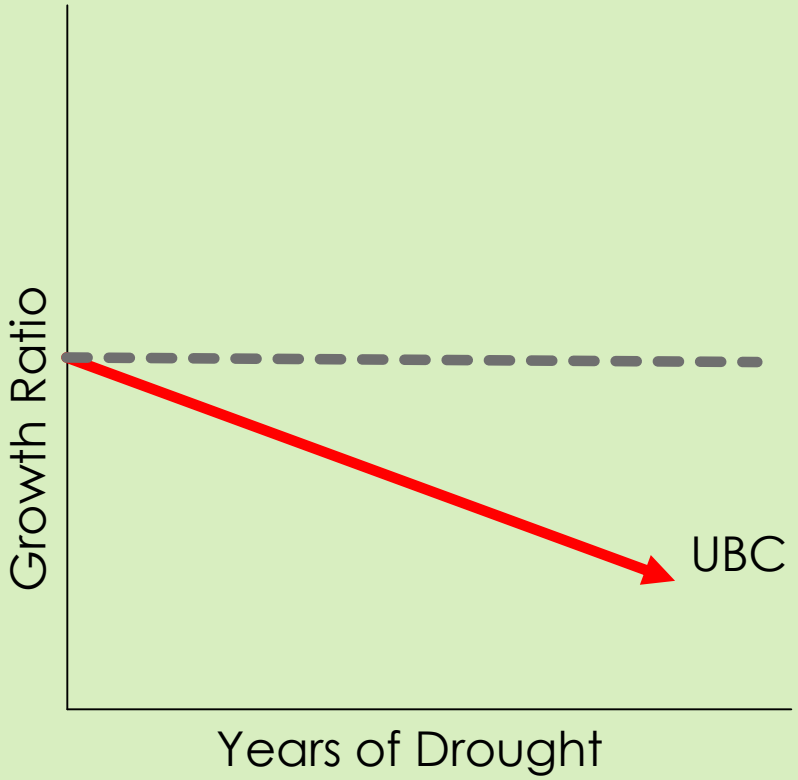

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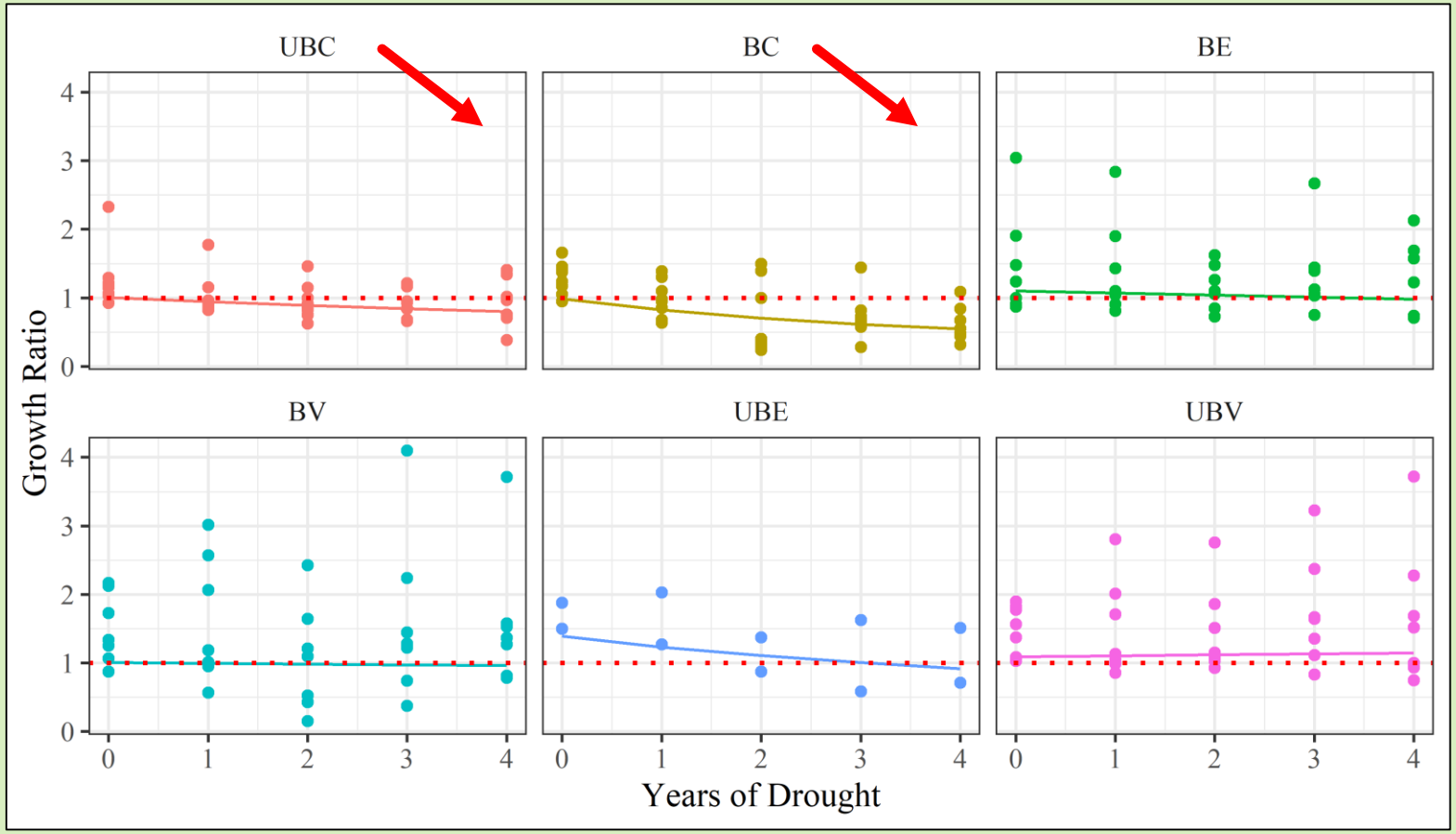

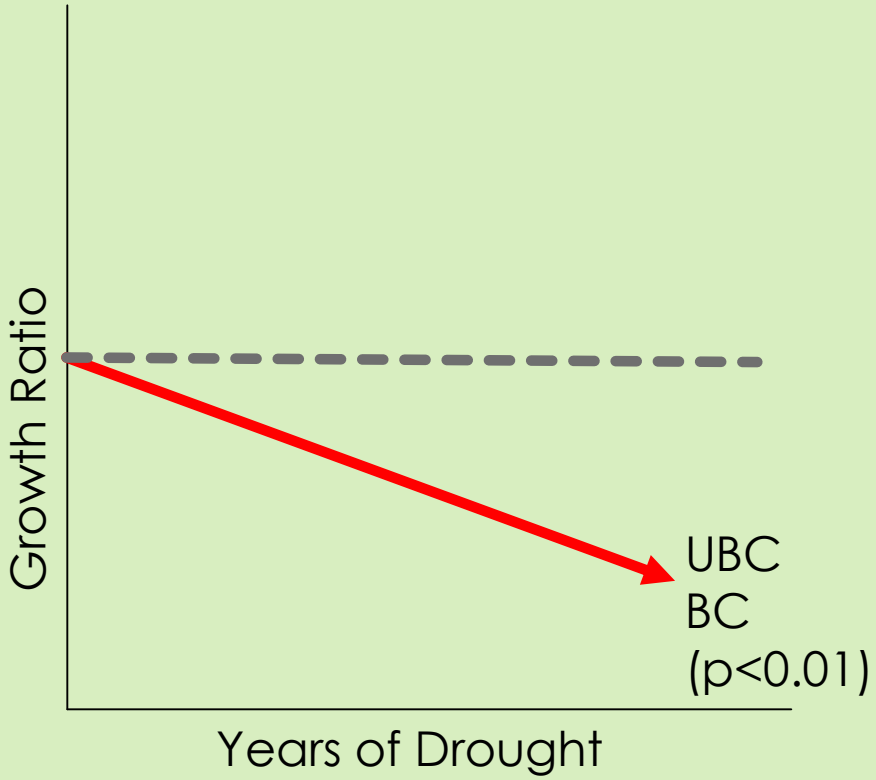

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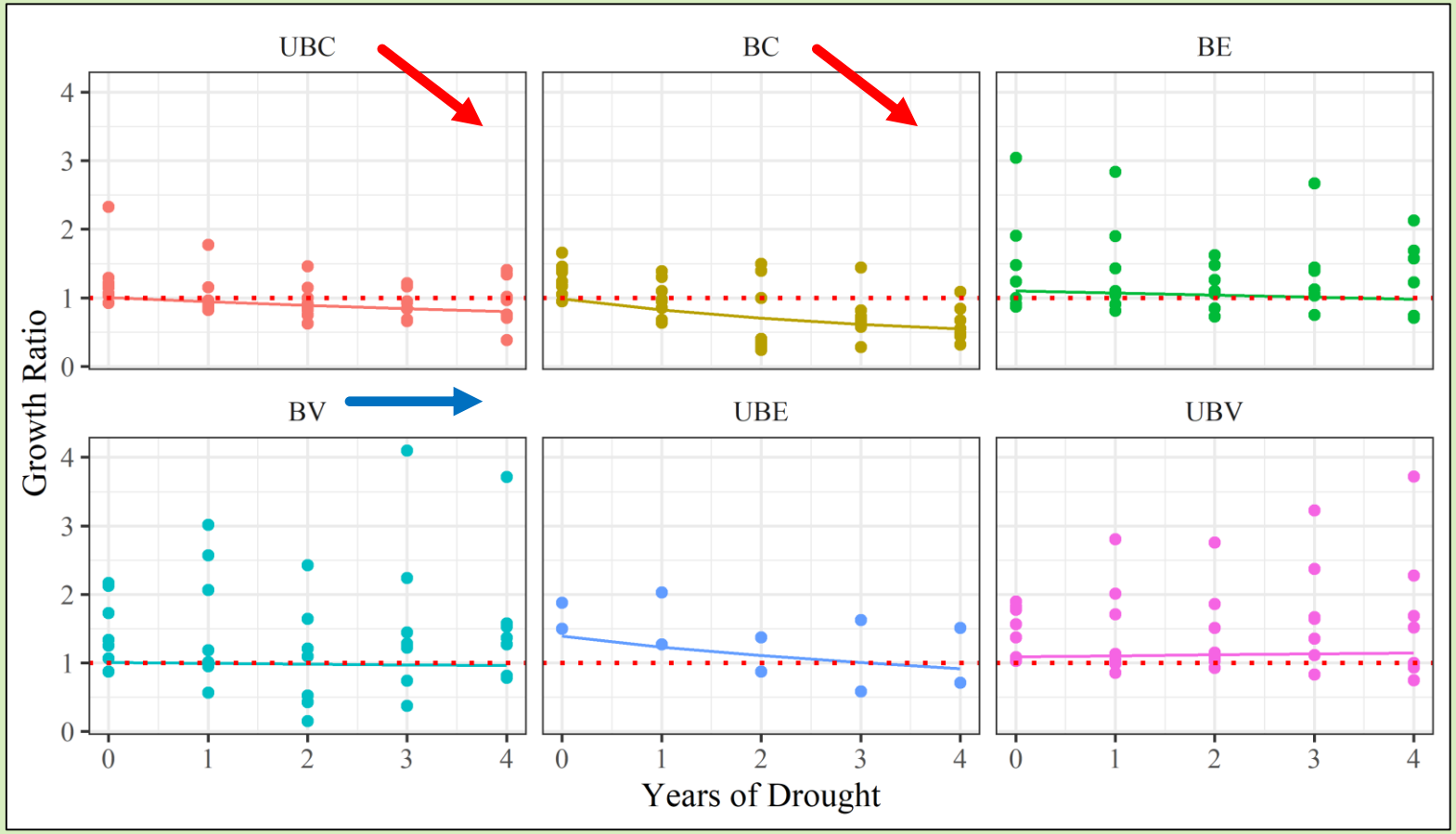

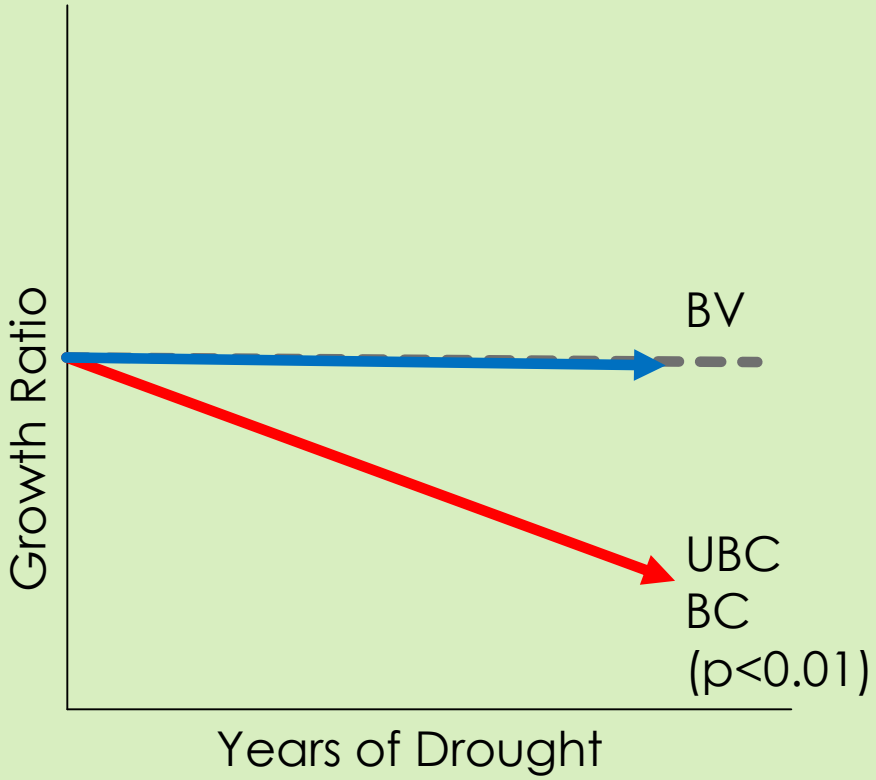

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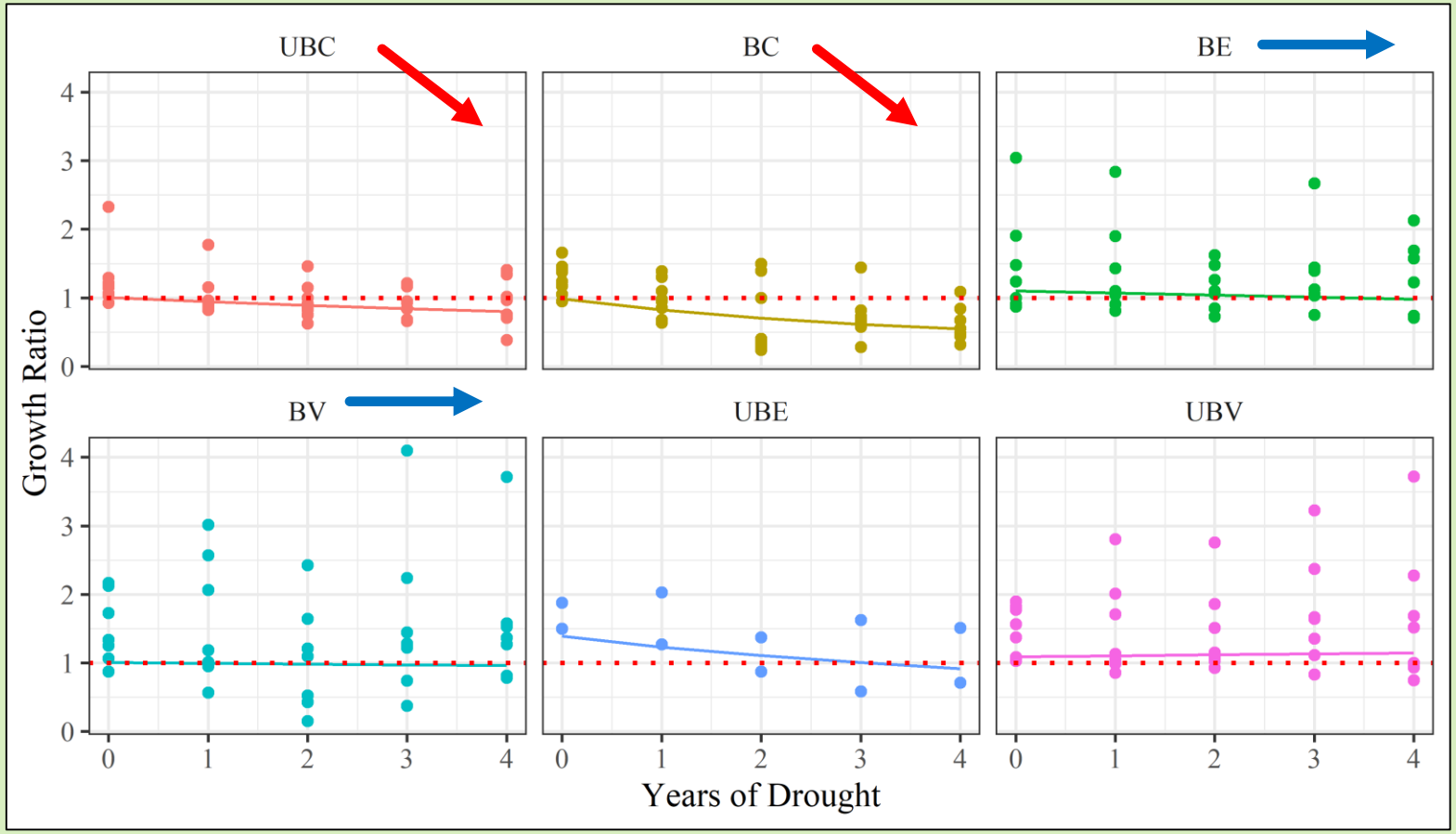
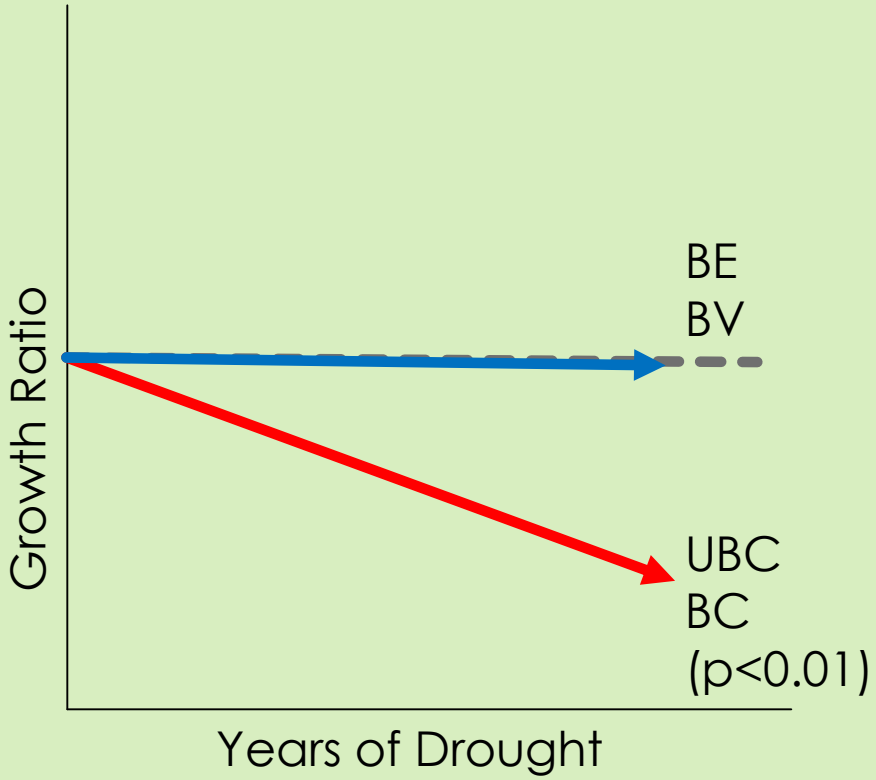
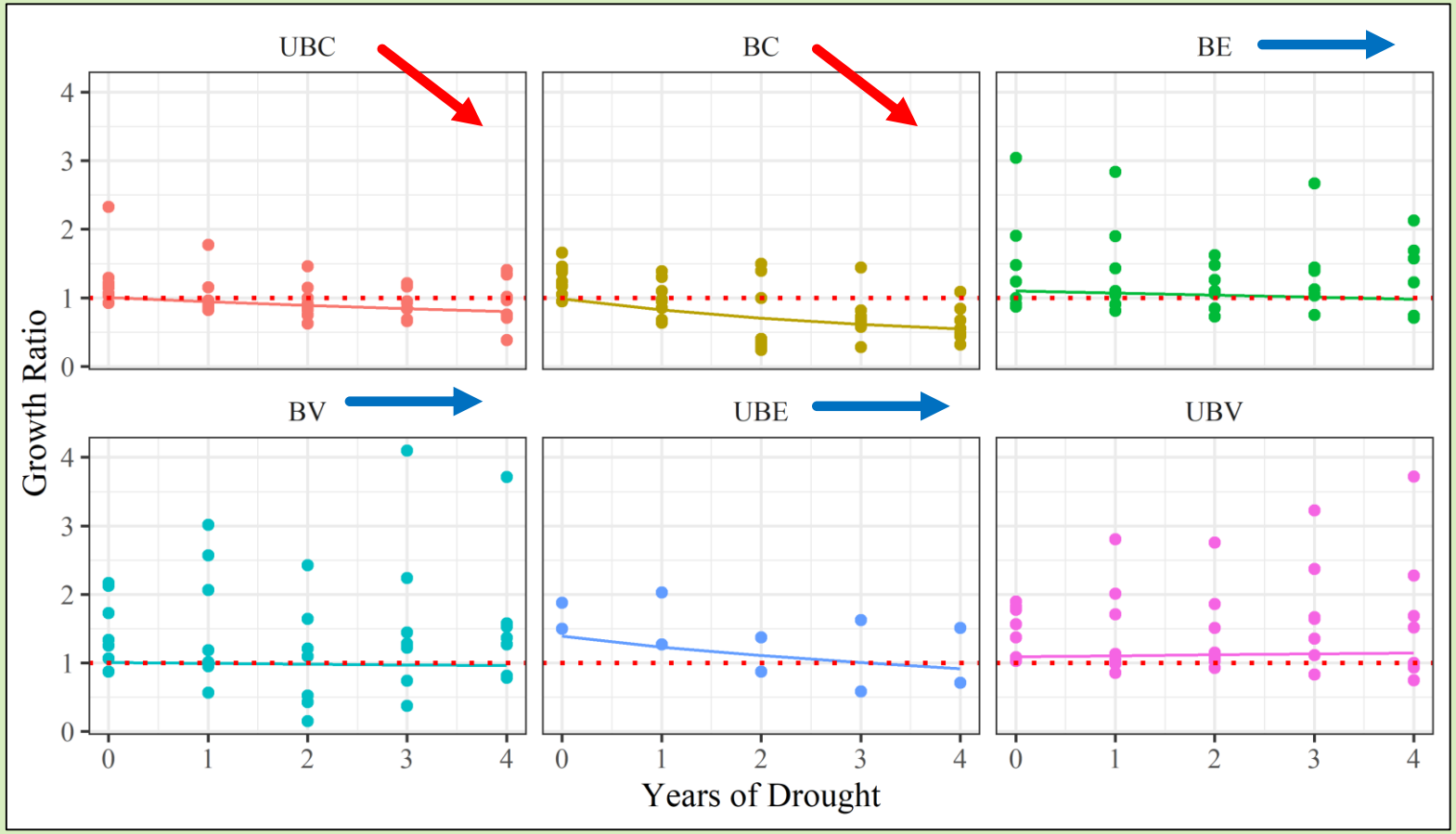
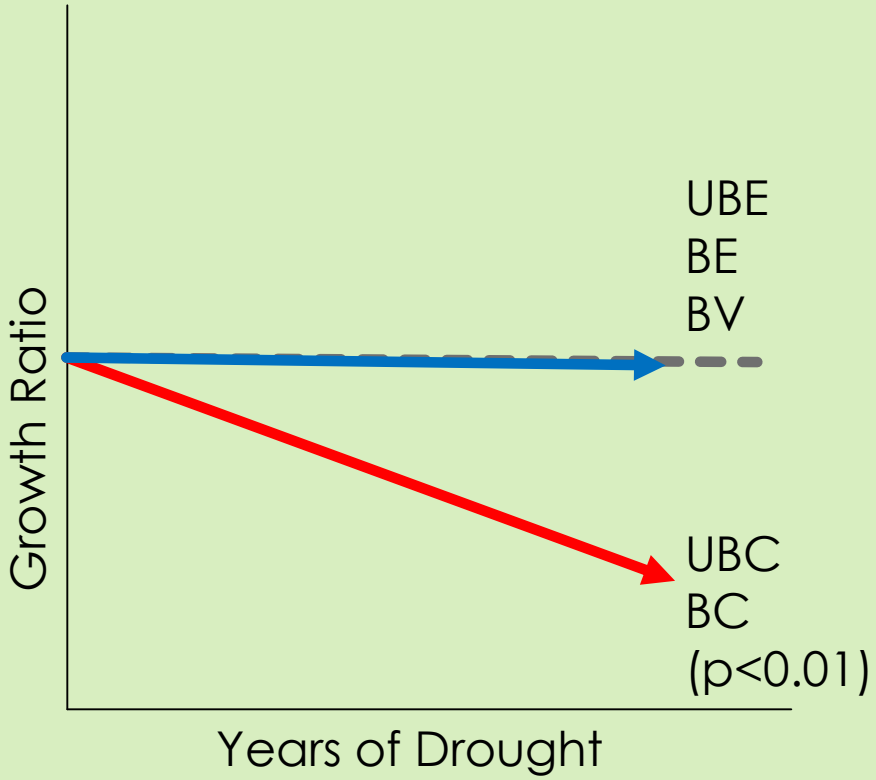




Does variable density thinning effectively maintain drought **resistance** in live sugar pine over time?





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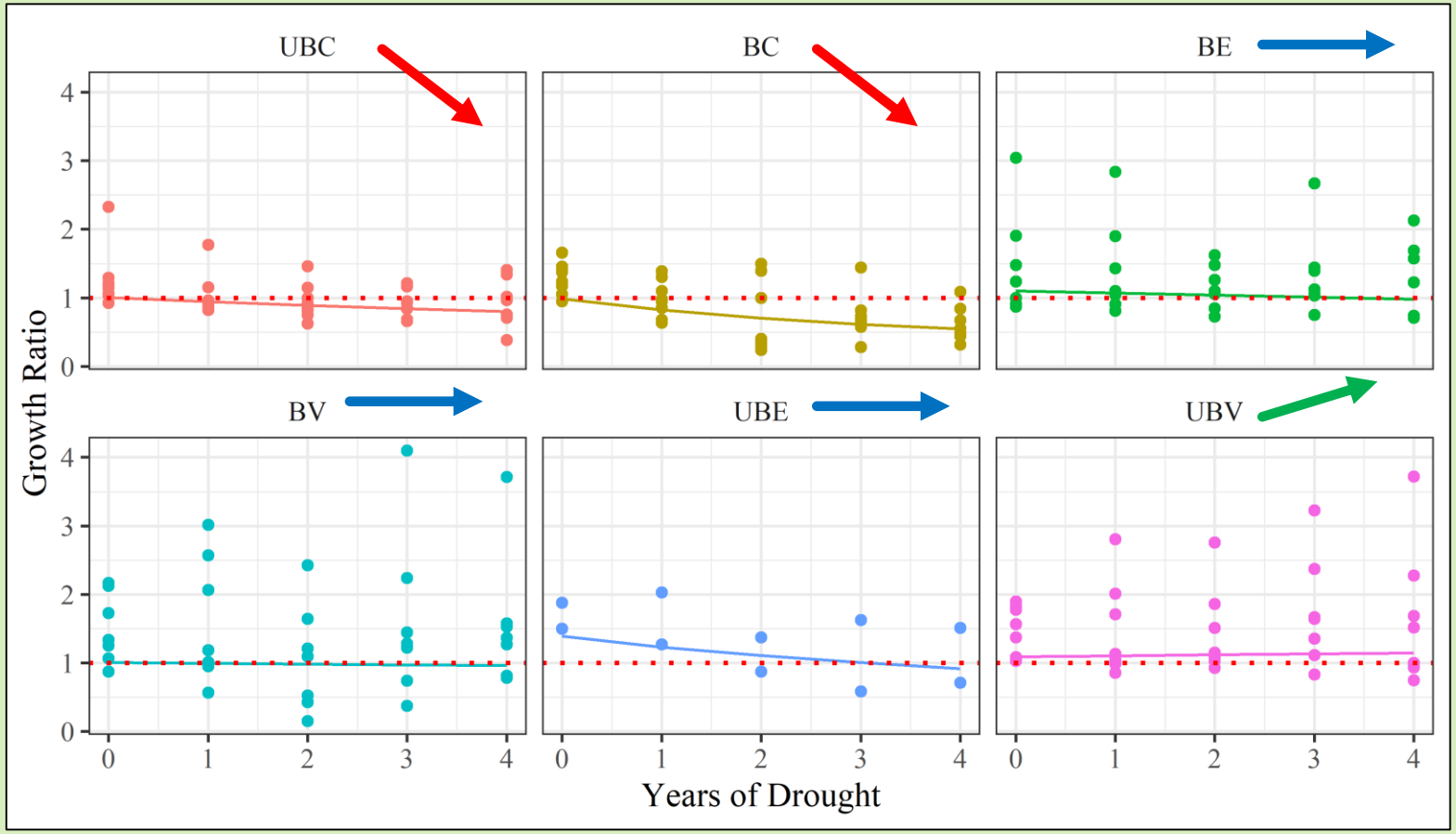
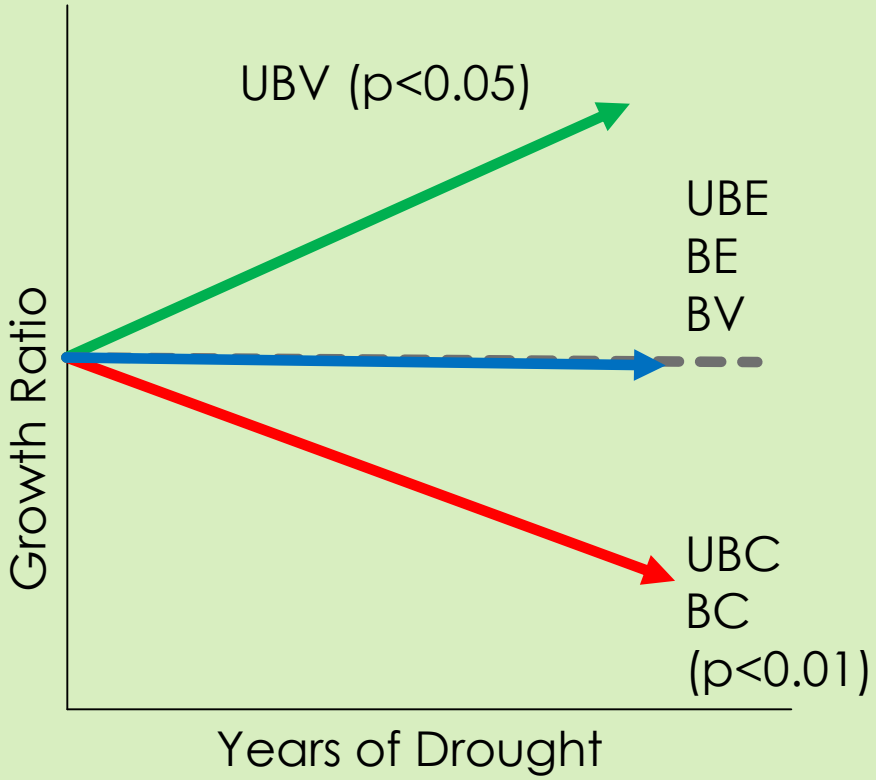
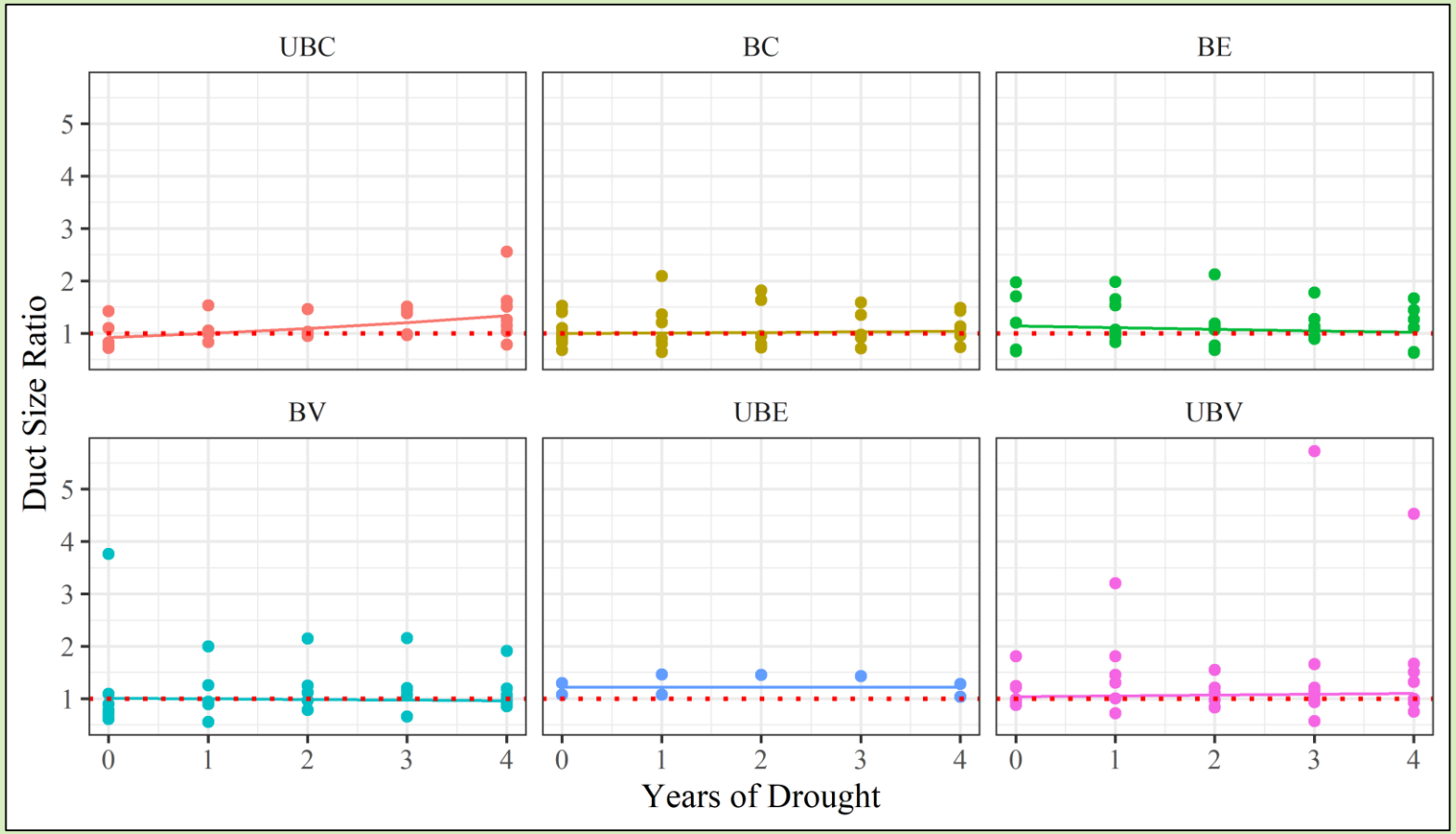
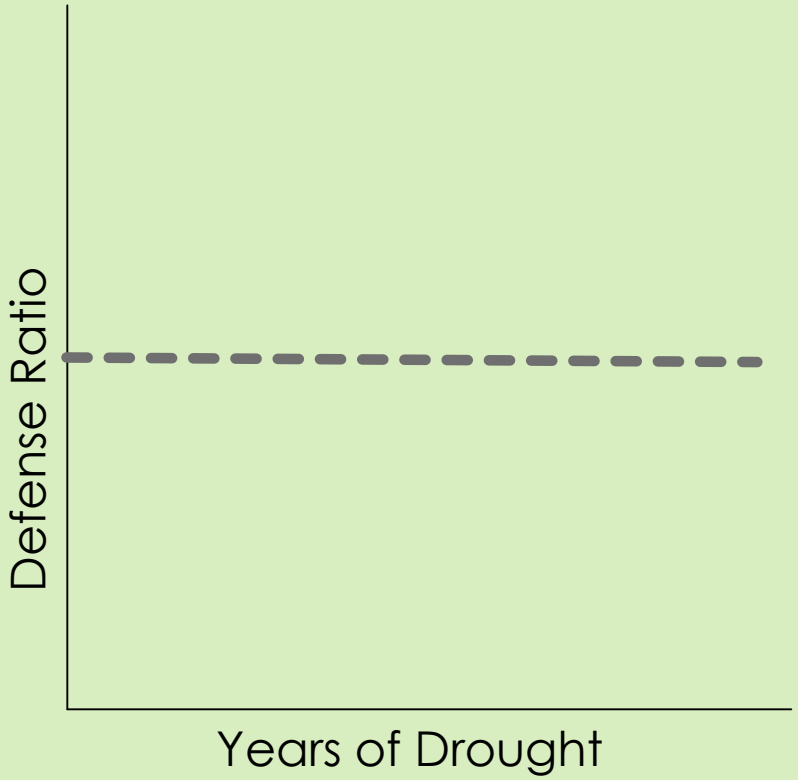


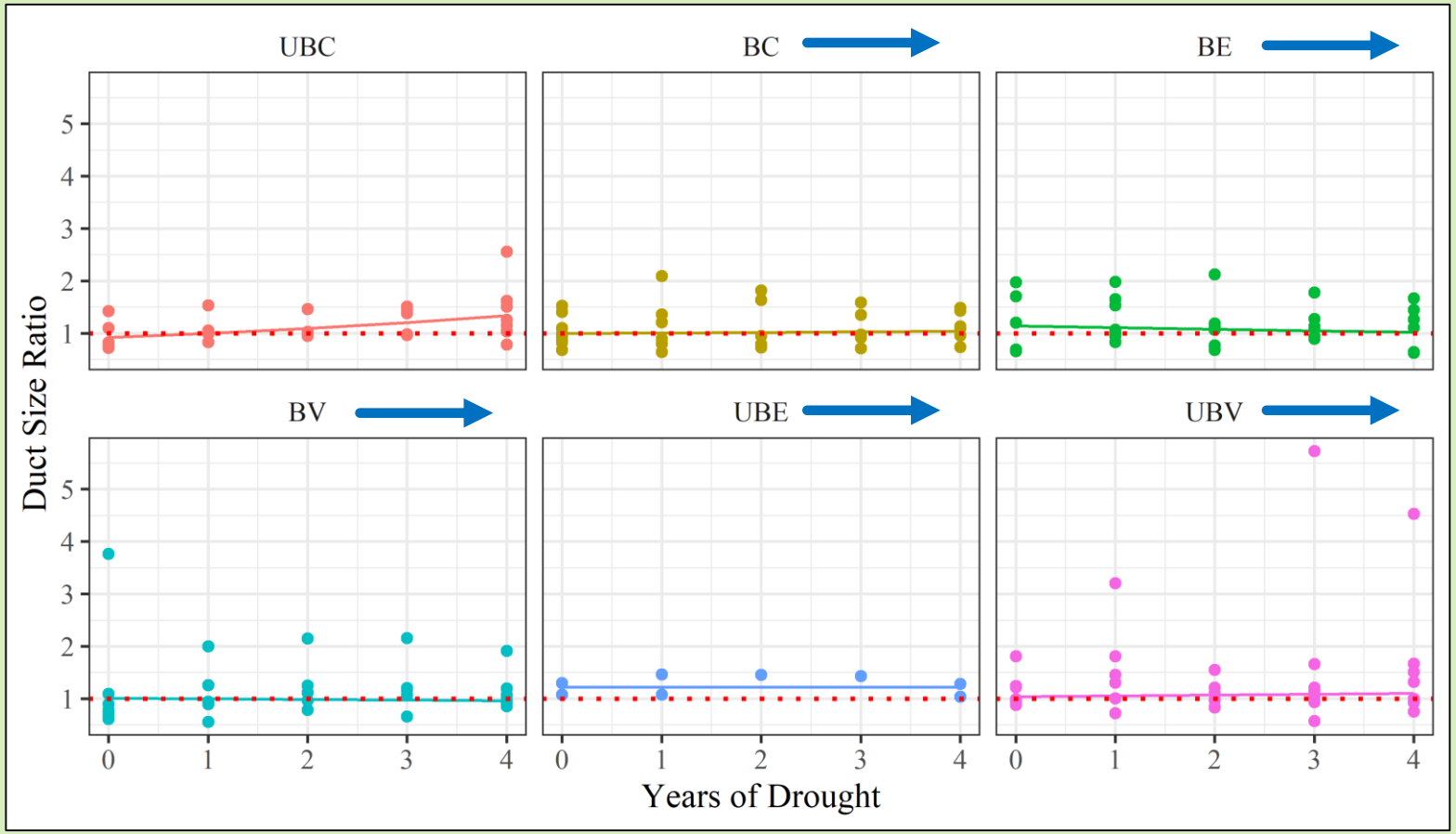


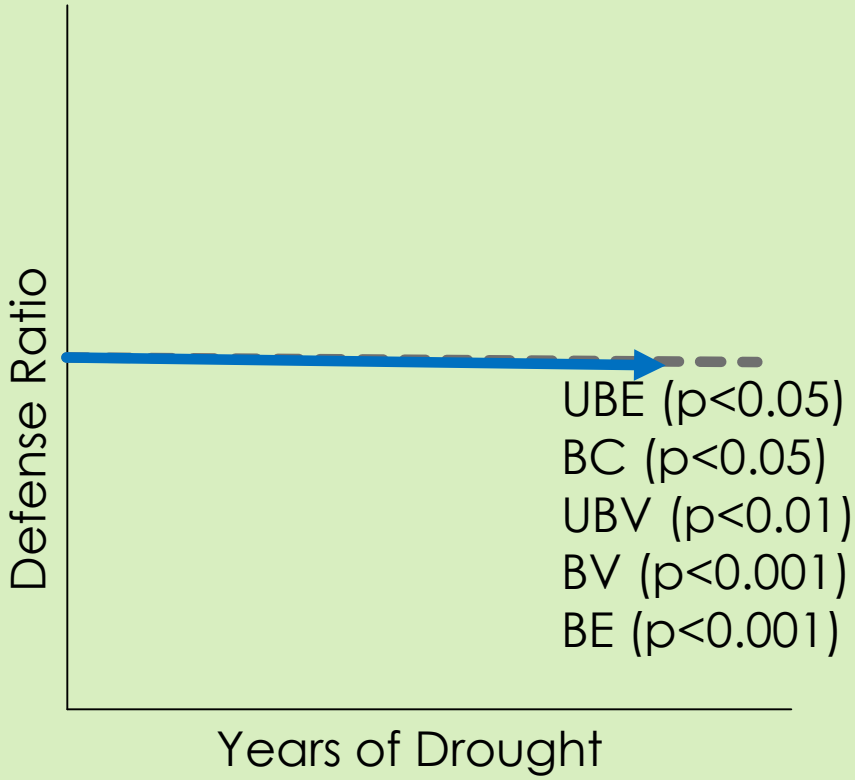
Does variable density thinning effectively maintain **defense characteristics** in live sugar pine over time?





Does variable density thinning effectively maintain **defense characteristics** in live sugar pine over time?





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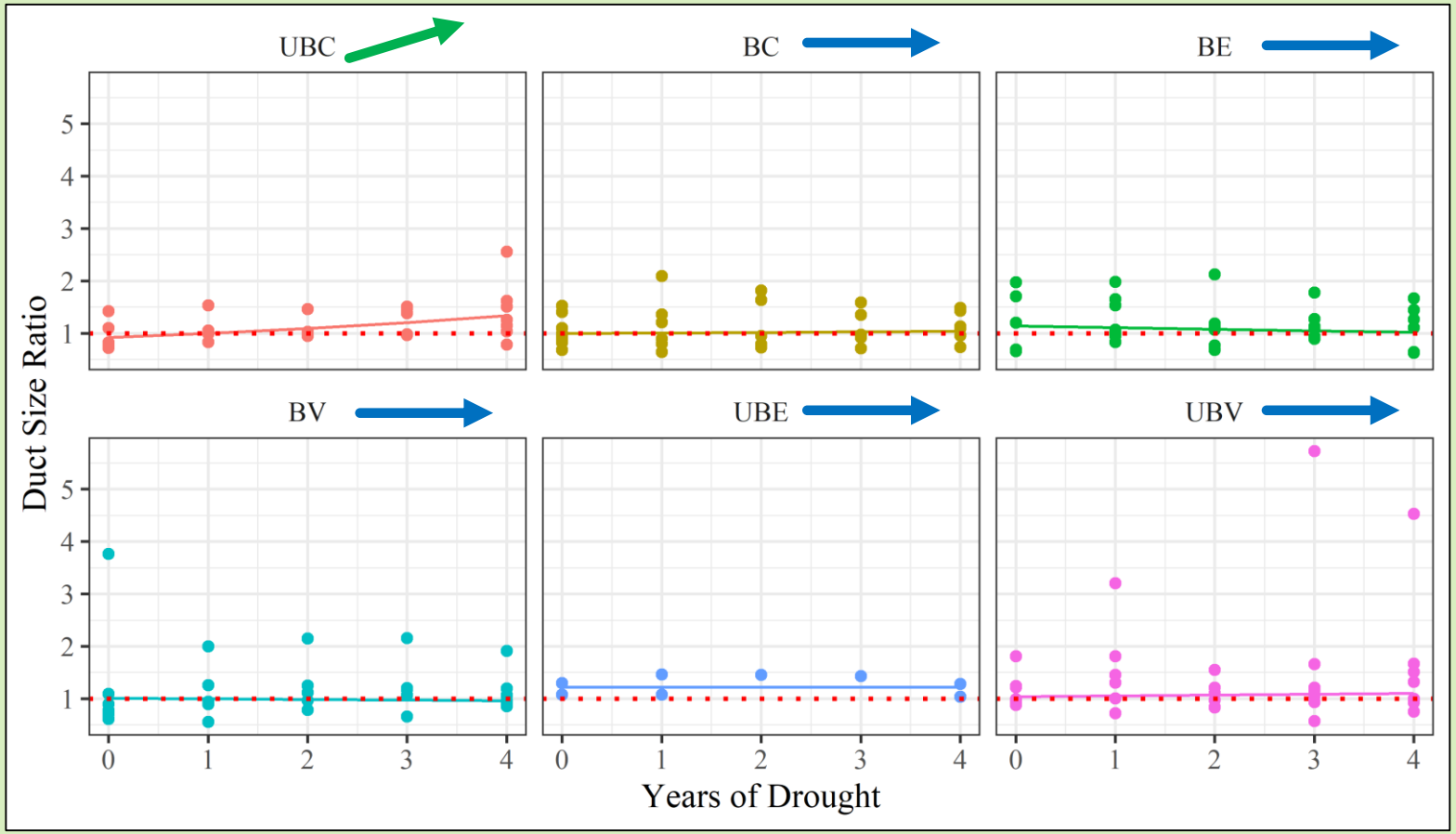
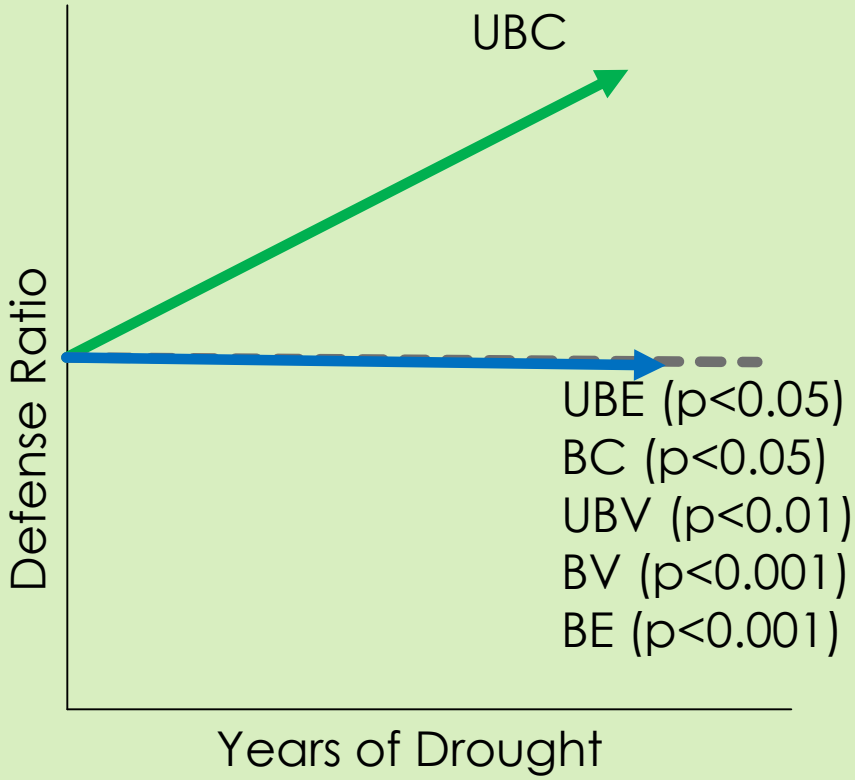
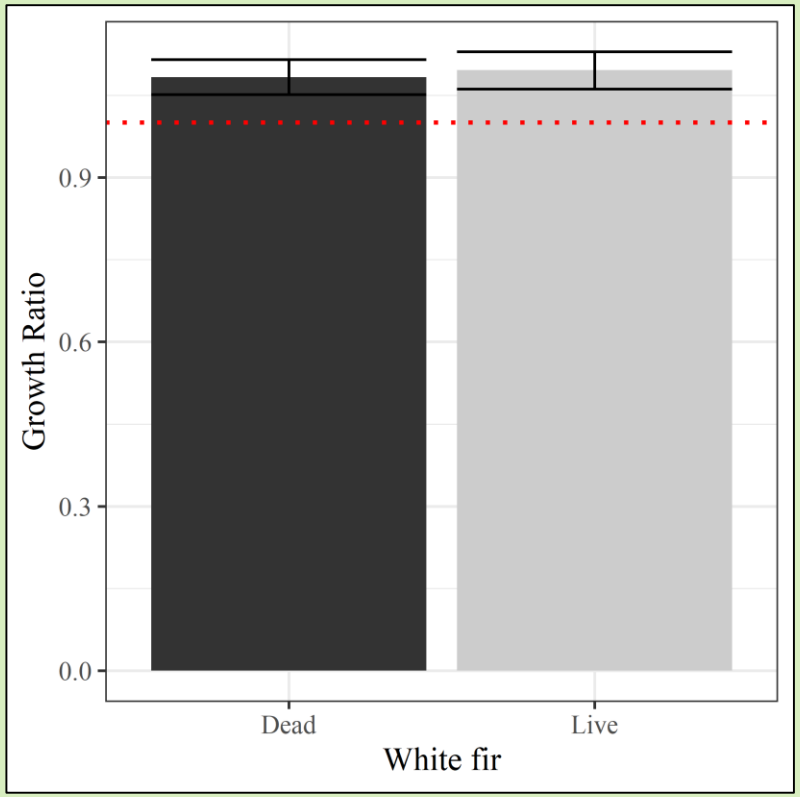
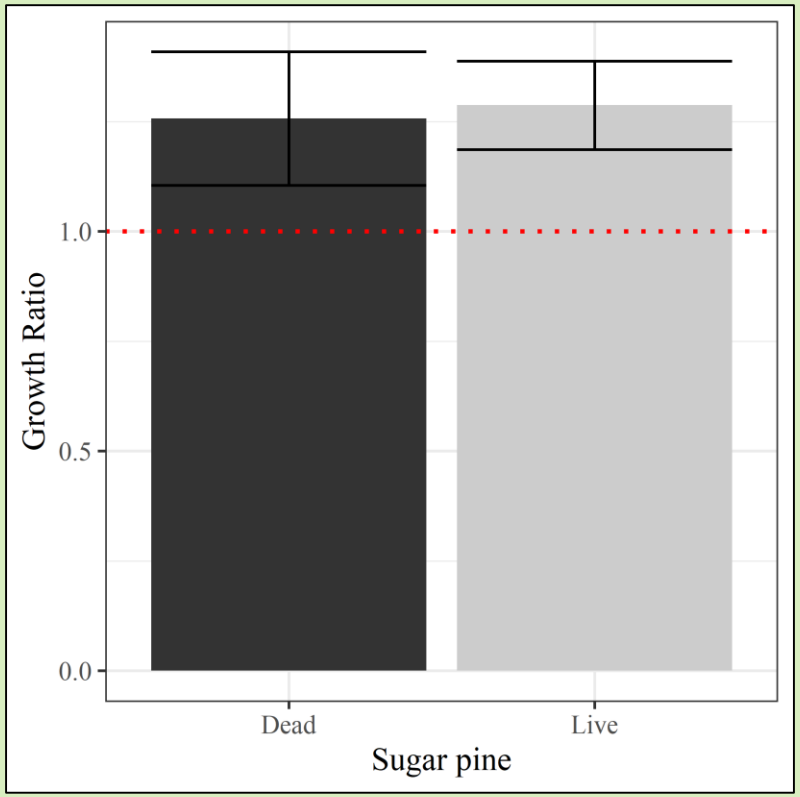
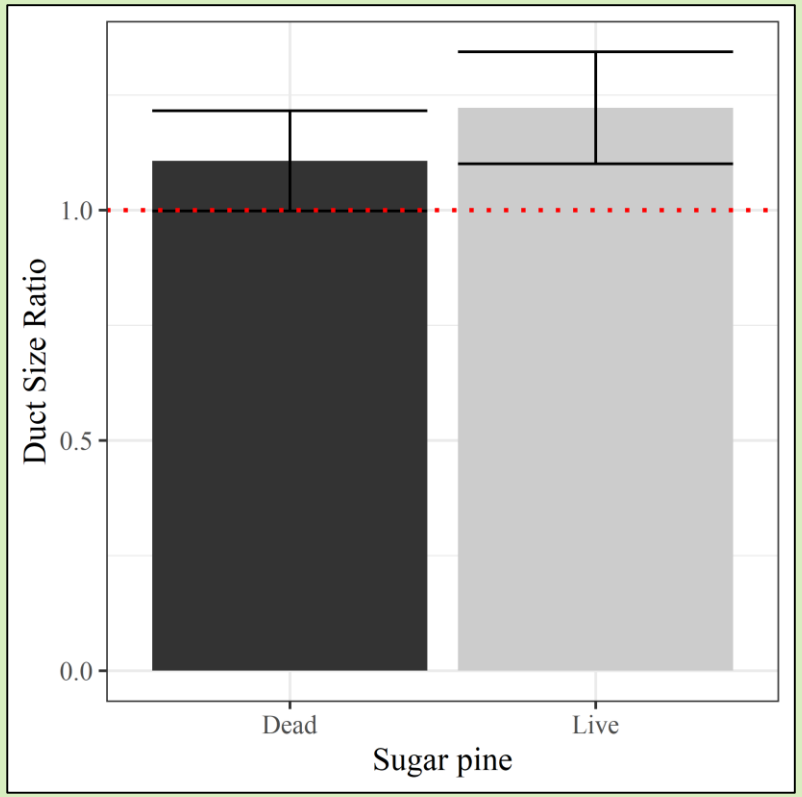




Are resistant characteristics different between live and dead trees?







Conclusions

Does variable density thinning effectively maintain drought **resistance** in white fir over time?

Variable density thinning
can have **neutral effects** on white fir, but **no different** than conventional methods.

Prescribed fire can have short-term adverse affects if unthinned.

Conclusions

Does variable density thinning effectively maintain drought **resistance** in sugar pine?

Variable density thinning can have **neutral to beneficial effects** on sugar pine, suggesting an **improvement** over conventional methods.

Prescribed fire can have short-term adverse affects if unthinned.

Conclusions

Does variable density thinning effectively maintain **<u>defense characteristics</u>** in sugar pine?

Variable density thinning can have **neutral effects** on sugar pine, but **no different** than conventional methods.

Increase in average duct size in control units may be resource trade-off.

Conclusions

Does drought resistance enhance resistance to bark beetle-caused mortality?

It depends…

Growth as a resistance metric

Positive feedbacks

Plot level measurements

Spatial variability metrics

Conclusions

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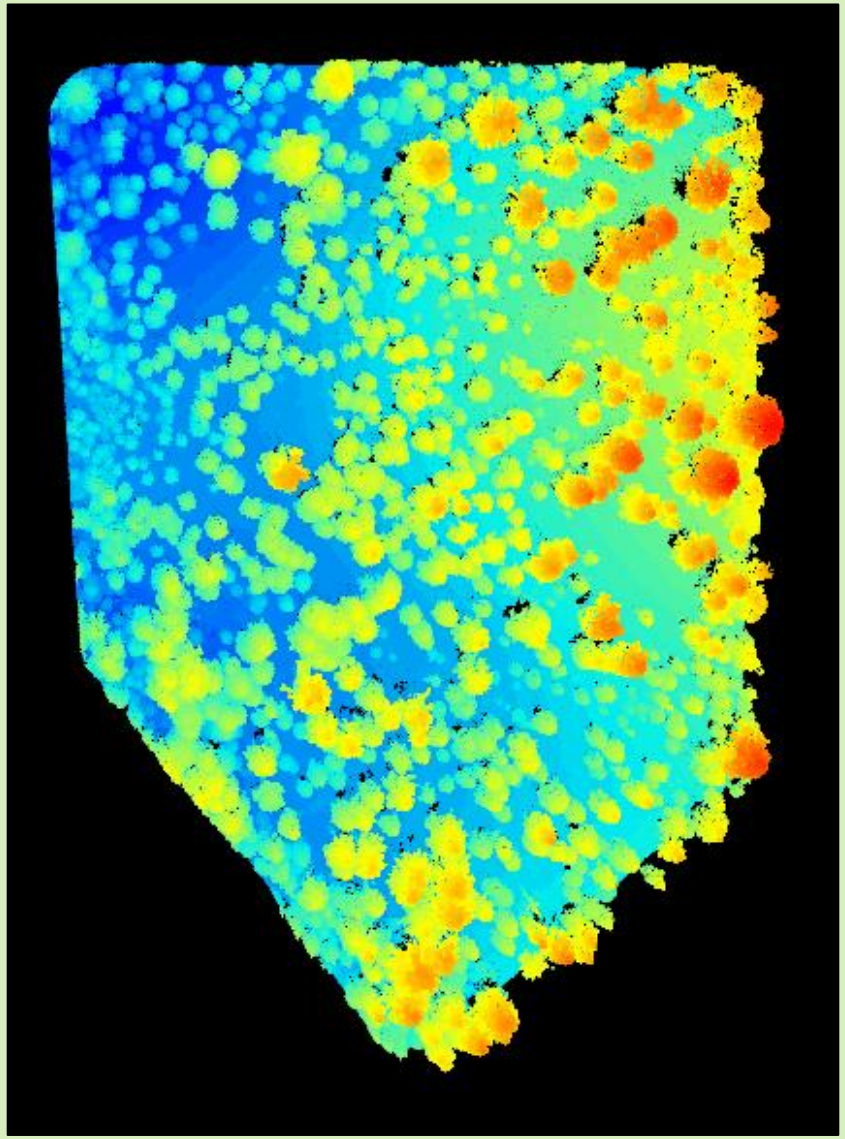
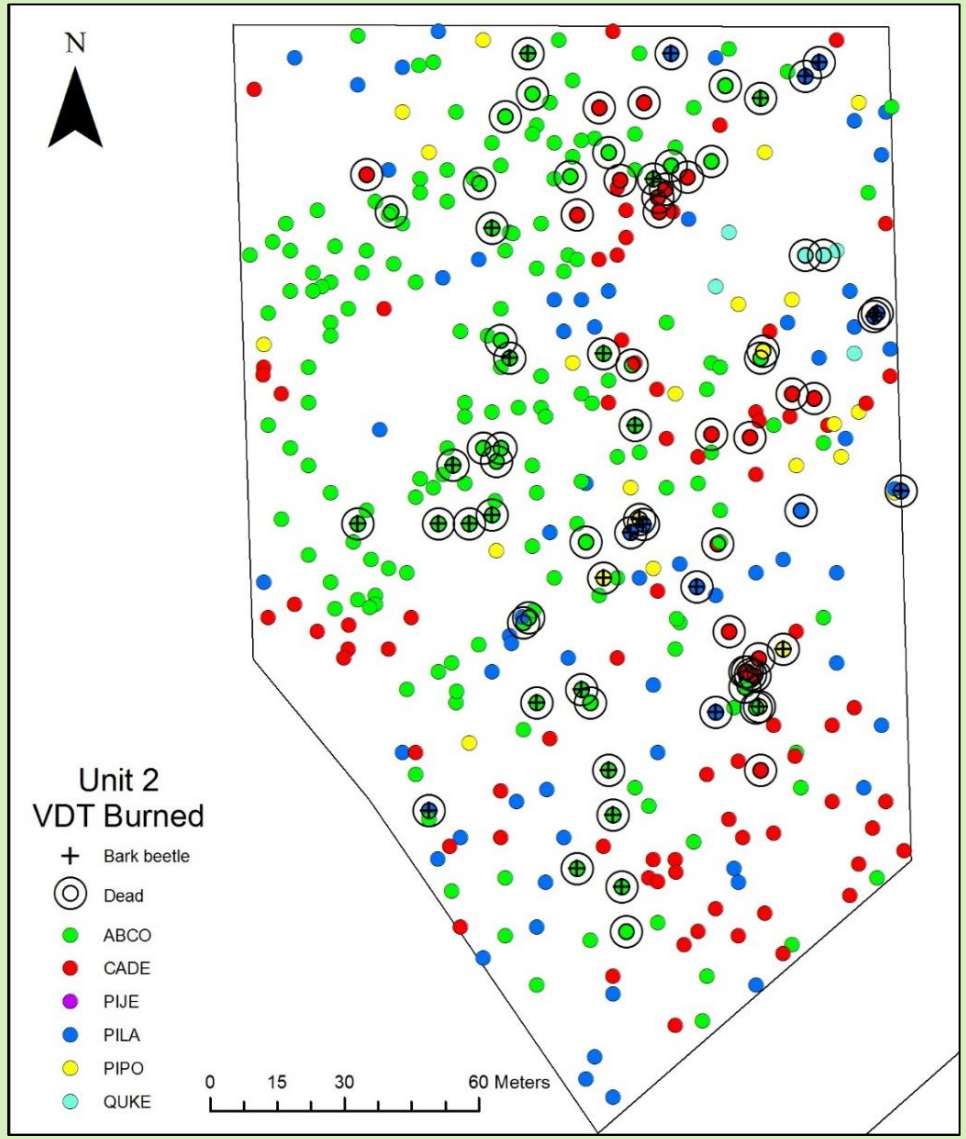
Future Research





- Quantify spatial heterogeneity
- Quantify spatial patterns of mortality
- Which structures promote or inhibit bark beetle resistance?

Acknowledgements

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