Project Overview: The effects of false spring events on sapling buds

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Project Overview:

For my dissertation, I will be evaluating the effects of climate change — specifically late spring freezing events — on temperate forests. Late spring freezing events, known as false springs, are predicted to increased in intensity as climate change progresses [1, 2] . It is anticipated that budburst dates will initiate earlier in the spring, however last freeze dates will remain the same [3] . This could result in large scale consequences for temperate and boreal tree species, especially species found in regions more at risk of false spring events. The main objective of this experiment is to evaluate the interspecific variation in frost-tolerance. I closely monitored the phenology from budburst to leafout of 45 individuals across three species at the bud level. Once the majority of the buds had bursted on an individual but before the buds reached leafout, I placed the sapling in a growth chamber at -3°C for 24 hours to induce a false spring event. I then observed the individual until every bud leafed out or died. Frost tolerance is lowest between budburst and leafout [4] . For this reason, I am interested in the rate of leafout, or the duration of vegetative risk, and how false spring events affect this rate. I will also assess the percentage of buds that bursted by comparing individuals across treatment.

Overall Project Aim:

The overall objective for this project is to build a functioning model for my future experiment plans. My ultimate goal is to have 8-12 species included in the model and to somehow add another level of hierarchy at the bud level. The full experimental model I wish to build would have the duration of vegetative risk as the response variable with treatment, range limits, and wood anatomy as predictors. However, for this semester project, I only have three species and no information on wood anatomy. I will look at just treatment as a predictor (β_1) for now and duration of vegetative risk (y) as the response variable (Equation 1).

$$y = \beta_0 + \beta_1 * x_1[sp] \tag{1}$$

For my subsetted data, I have approximately 650 observations across three species. Each species has 7-8 individuals per treatment group and each individual has 3-38 buds. One species, *Sambucus racemosa*, was infested by many pests after the phenology was assessed, however, the pest damage may have affected the duration of vegetative risk. For this reason, *S. racemosa* may be removed from the study. If *S. racemosa* is removed, there are 560 observations.

Current Issues and Response to Feedback:

Originally, I was hoping to look at the effects of freezing on each bud and assess two levels of hierachy: the species level and then the individual level. However, after presenting in front of the class, there was a lot of concern about the bud numbering system. Many classmates suggested I measure the distance of each bud from the terminal bud and use that as another predictor value. I am hoping to somehow look at the varying effects of the freezing temperatures on each bud in relation to budburst time. For example, if an axial bud had initiated budburst before going in the growth chamber but the terminal bud did not, then I would expect different effect sizes of the freezing treatment between these two buds. However, if I am looking at treatment as a predictor than this would be pseudoreplicating. Should I focus on each bud as a unique case and use the freezing date as an indicator for freezing treatement at the bud level? But then I would not include whole individual effects. For now, I think the best way is to do two simpler models asking each of these questions and then reevaluating. The simplest model may be to look at percent budburst as the response variable and then have treatment as the predictor.

Initial Results:

The linear model (percentBB tx) suggests that a freezing treatment results in a lower budburst percentage, however, the coefficient standar error, R-Squared value and residual standard deviation indicate low effect sizes. There is an issue of statistical power across this entire experiment. Attached are a couple of figures looking at the total data breakdown, the differences in duration of vegetative risk across bud number, and percent budburst across the two birch species. I plan on investigating the bud dilemma further, looking at different types of models and potentially adding more species, and also integrating these questions into a bayesian framework.

Feedback Evaluation:

Feedback was helpful, hard to provide feedback on a topic you only learn in 7 minutes! That said I still rank all of my feedback-ers pretty high. (E) - 4 (F) - 5 (G) - 4

Tables and Figures:

Table 1: Data Breakdown for Study.

Species	**Individuals**	**Buds**	**Traits**
BETPAP	14	9-27	DVR, SLA, Chlorophyll, Percent BB
BETPOP	15	8-38	DVR, SLA, Chlorophyll, Percent BB
SAMRAC	16	3-7	DVR, Percent BB
VIBCAS	26	NA	DVR, SLA, Chlorophyll
ACEPEN	15	NA	DVR, SLA, Chlorophyll
PRUPEN	12	NA	DVR, SLA, Chlorophyll

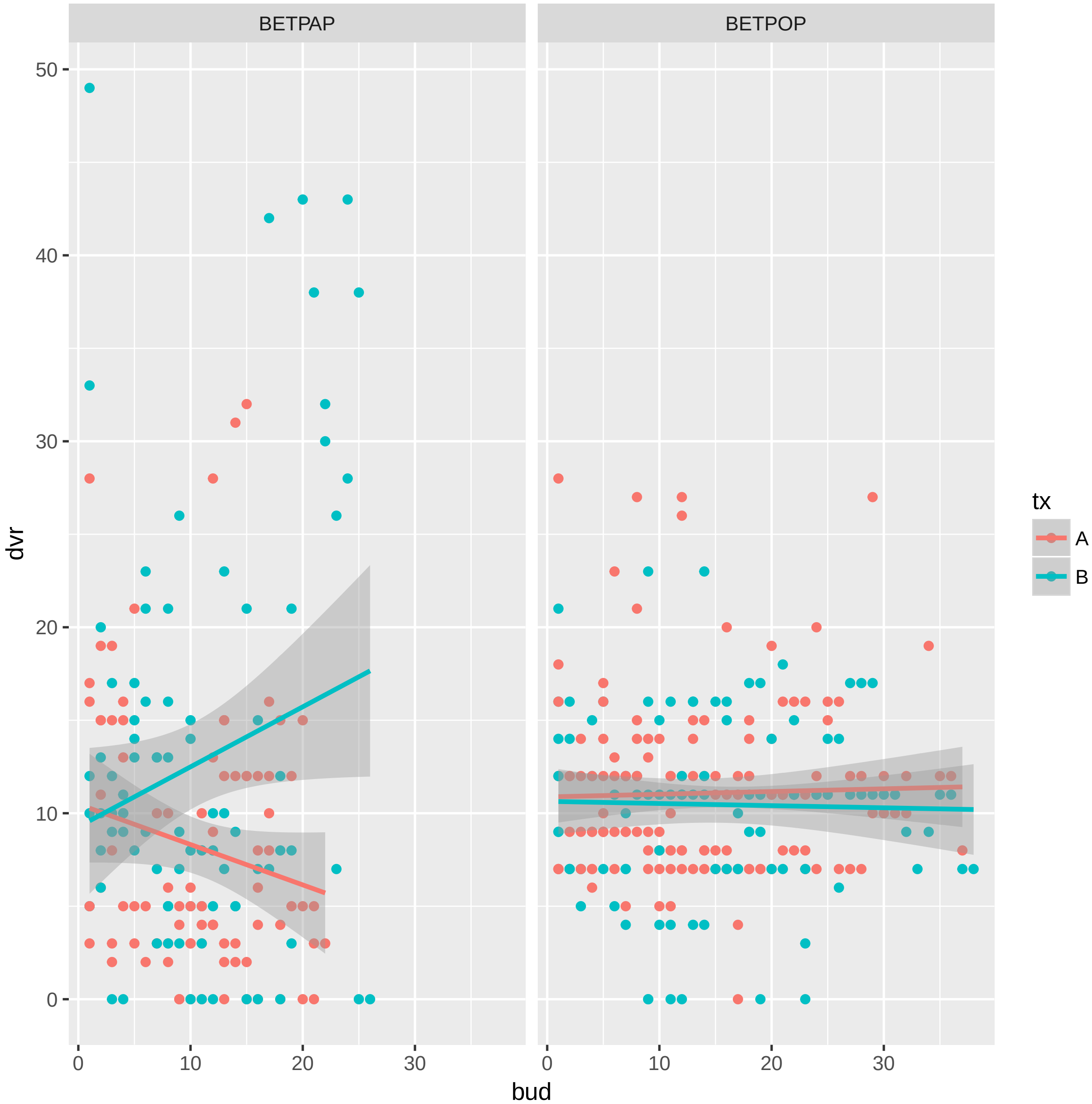

Figure 1: Duration of Vegetative Risk by bud number across the two betula species. As bud number increases, the further away from the terminal bud. The treatment effect on BETPAP appears to be much greater than on BETPOP from a first glance.

lm(formula = perc.bb tx + species, data = percent) coef.est coef.se (Intercept) 74.20 5.29 txB -4.15 6.04 speciesBETPOP 2.13 6.04 — n = 29, k = 3 residual sd = 16.24, R-Squared = 0.02

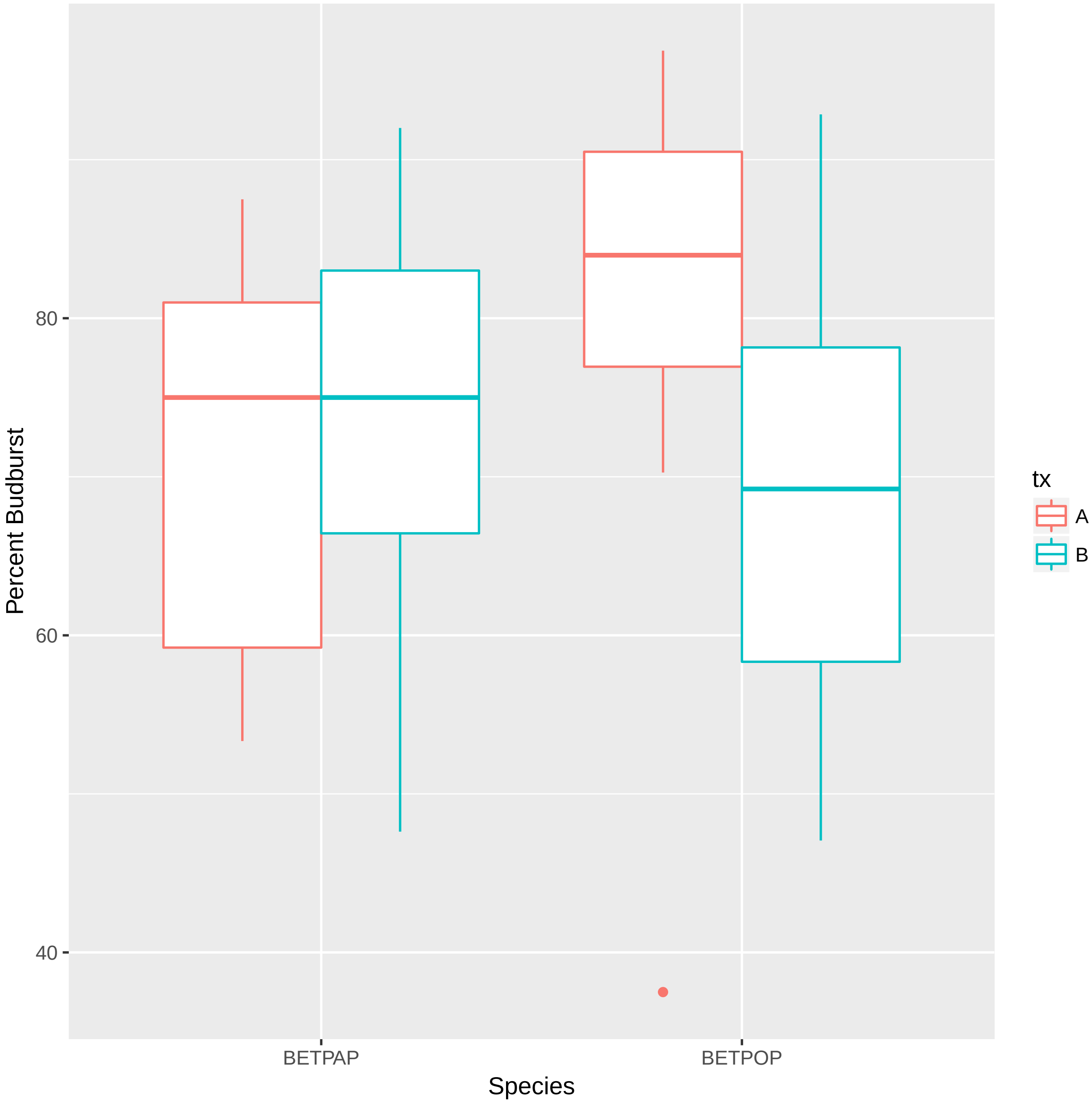

Figure 2: A boxplot looking at the percent budburst of individuals across treatment for each birch species

References

[1] Kodra, E., Steinhaeuser, K., and Ganguly, A. R. Persisting cold extremes under 21st-century warming scenarios. *Geophysical Research Letters* **38**(8), 1–5 (2011).

[2] Allstadt, A. J., Vavrus, S. J., Heglund, P. J., Pidgeon, A. M., Wayne, E., and Radeloff, V. C. Spring plant phenology and false springs in the conterminous U. S. during the 21st century. *Environmental Research Letters (submitted)* **10**(October), 104008 (2015).

[3] Gu, L., Hanson, P. J., Post, W. M., Kaiser, D. P., Yang, B., Nemani, R., Pallardy, S. G., and Meyers, T. The 2007 Eastern US Spring Freeze: Increased Cold Damage in a Warming World. *BioScience* **58**(3), 253 (2008).

[4] Lenz, A., Hoch, G., Körner, C., and Vitasse, Y. Convergence of leaf-out towards minimum risk of freezing damage in temperate trees. *Functional Ecology* **30**, 1–11 (2016).