Climate Hazards
Trying to organize results

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June 11, 2024

Contents

1 Historical trends

- *Fagus* is determined mainly by FruitIndex (related to frost damage).
- *Pinus* survival dominates (due to carbon problems which comes from not enough chilling.)
- *Quercus* is determined mainly MaturationIndex (does not mature in time) a little, but mostly it is fine.

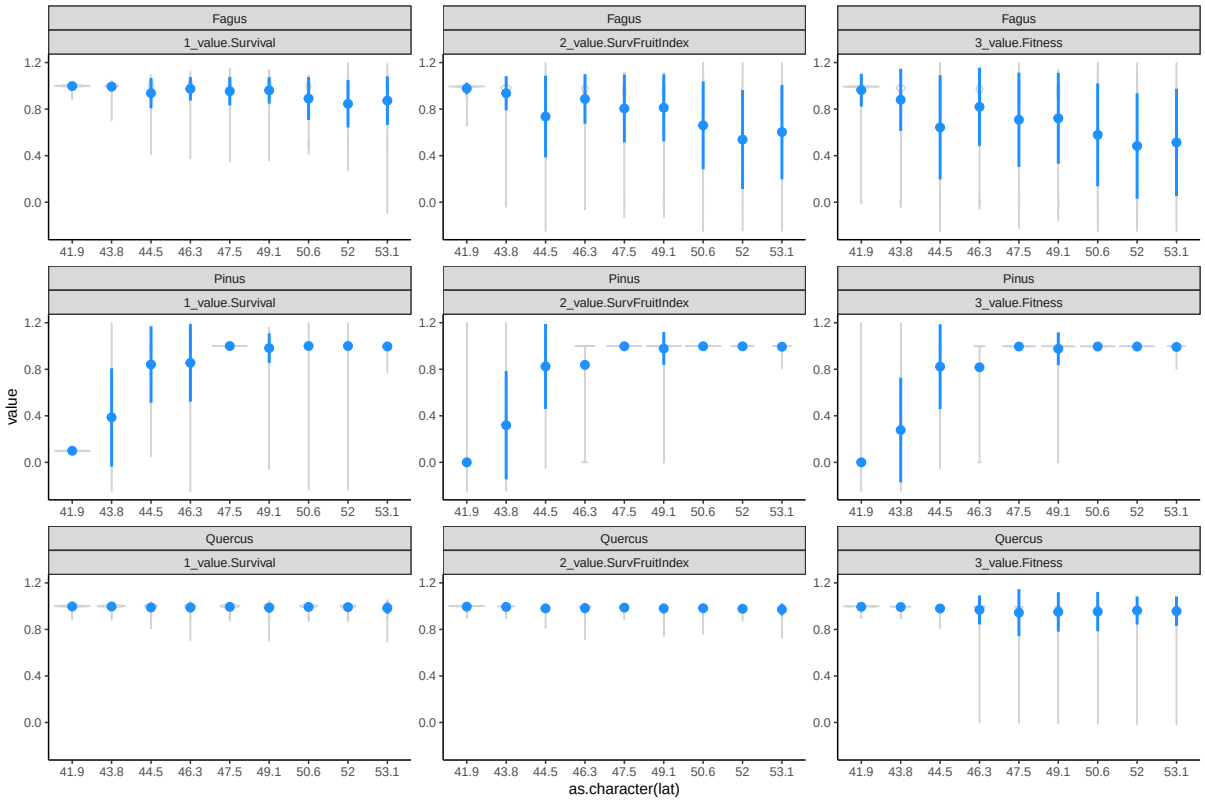

Figure 1: These results build through the multiplicative components of fitness (which are multiplied together): Survival (left), Survival∗FruitIndex (middle) and Fitness, which is Survival∗FruitIndex*MaturationIndex (right). Given high survival and little change between the middle and right panels we can see that *Fagus* is determined mainly by FruitIndex (this makes sense as it is often affected by frost damage, having a low tolerance of low temperatures). We see next the for *Pinus* survival dominates (often it does not meet the chill requirement for leafout and thus has no carbon and low CarbonSurvival so low total Survival) and finally, for *Quercus* it's MaturationIndex (this makes sense as the fruits are quite large and can take a long time to mature—it doesn't always happen according to this model).

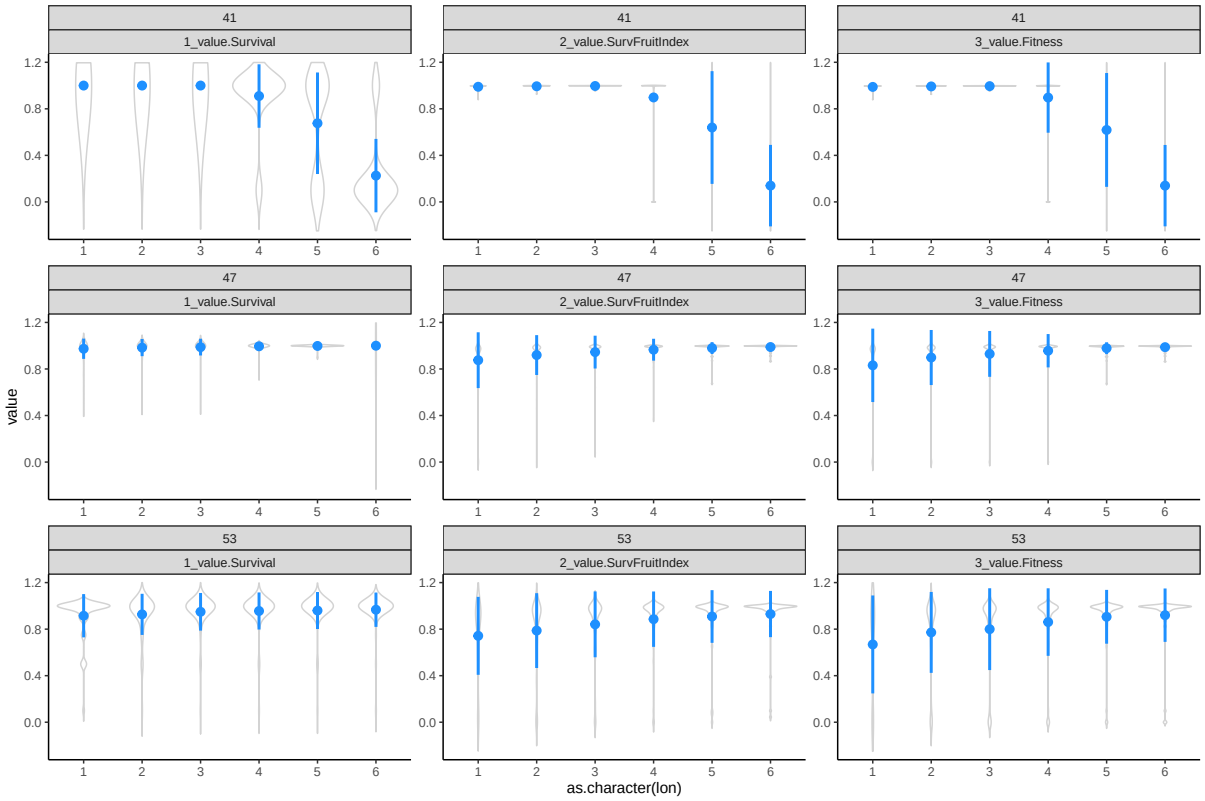

Figure 2: *Fagus* across 0 (1) to +5 (6) mean warming showing three latitudes. In June 2023, we discussed: at low latitudes (see next figure) that there was reduced CarbonSurvival (not enough cold means late dormancy) and thus FruitMaturationDate gets later. While at higher latitudes (see Fig. **??**) there is an increase in the FruitIndex as FruitMaturation is higher.

2 Overview of warming simulation results

2.1 *Fagus* warming results

Next the mean warming simulations. In understanding *Fagus* results (Fig. **??**) we discussed how we could see that at low latitudes (Fig. **??**) that there was reduced CarbonSurvival (not enough cold means late dormancy) and thus FruitMaturationDate gets later. While at higher latitudes (Fig. **??**) there is an increase in the FruitIndex as FruitMaturation is higher.

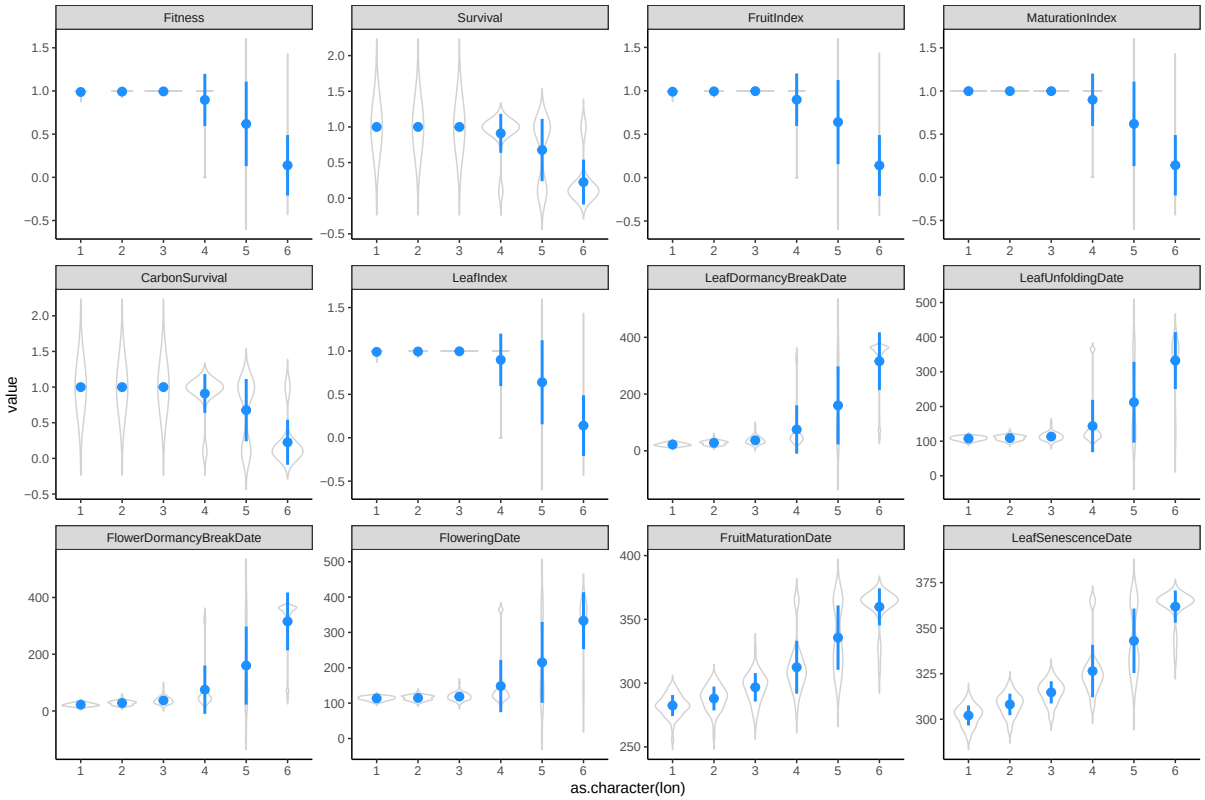

Figure 3: *Fagus* across 0 (1) to +5 (6) mean warming across fitness components at 41°N latitude. Low fitness is driven by low carbonsurvival, which occurs because of late dormancy break date (because leafdormancybreakdate is variable that's the driver; if it were frost, we'd see more constant leafdormancybreakdate and variable in leafindex).

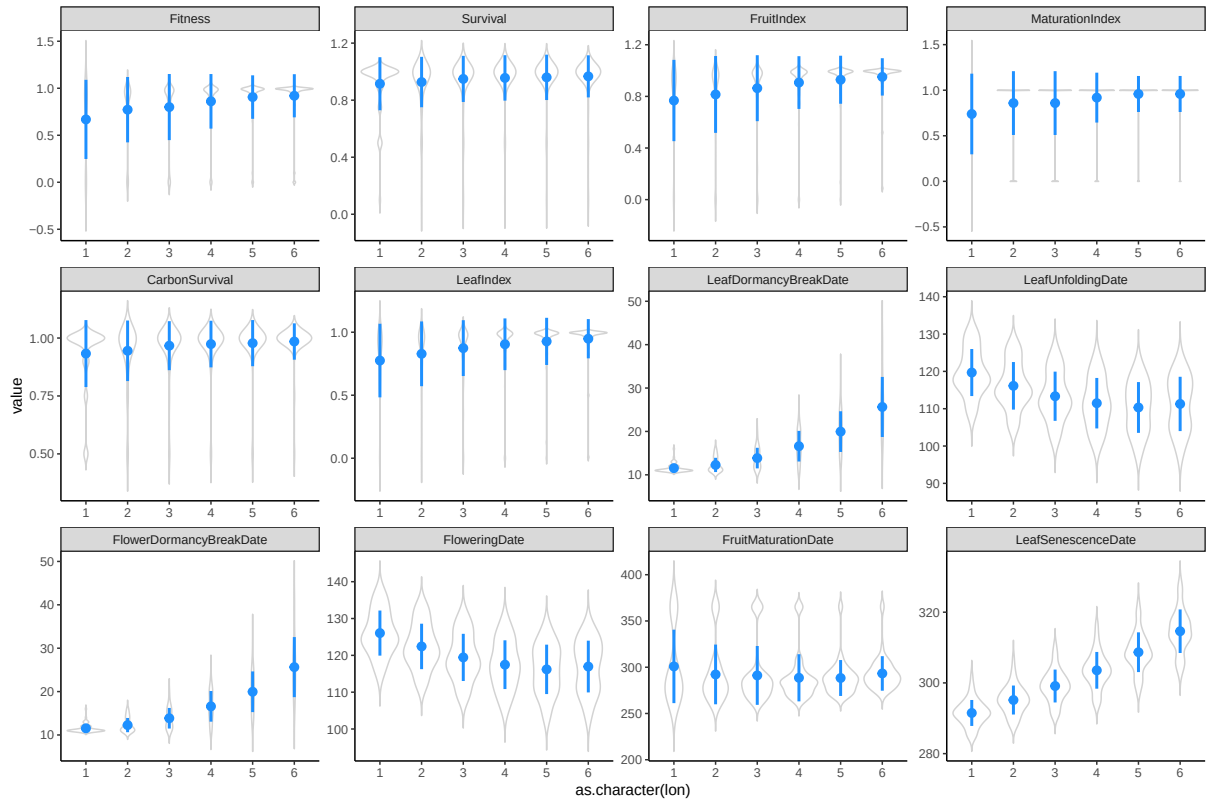

Figure 4: *Fagus* across 0 (1) to +5 (6) mean warming across fitness components at 53°N latitude. Here's warming reduces frost and thus fruitindex goes up (less flowering damage probably) and survival goes up. MatIndex also goes up (likely due to a mix of leafindex going up and there is a direct effect of temperature on MatIndex). Note that the leafdormancybreakdate also gets a little later but leafunfolding does not because the warming is still enough for get earlier leafout (and there is a buffer where early dormancybreakdate does not matter because it's too cold leaf unfolding to start.

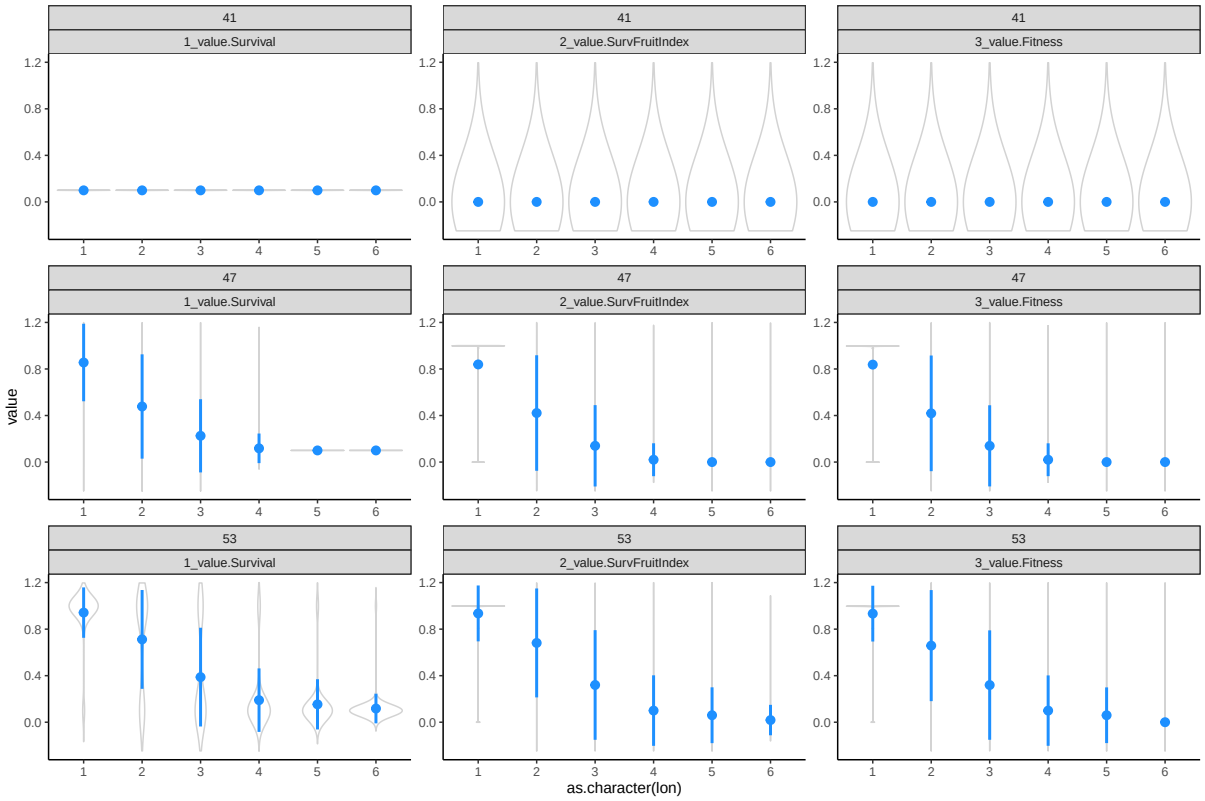

Figure 5: *Pinus* across 0 (1) to +5 (6) mean warming showing three latitudes. There is no survival at low latitudes, while at higher latitudes (see Fig. **??**) warming leads to lower fitness due to low carbon survival (not enough chilling, so late dormancy break).

2.2 For our mean results for *Pinus*

... ... it looks like carbon could be the issue again, which is close to 0 (minimum is 0.1 in PhenoFit for C survival) at low latitudes and declines with warming at the higher latitude. Check out dormancybreakdates which show that it must not get enough chilling.

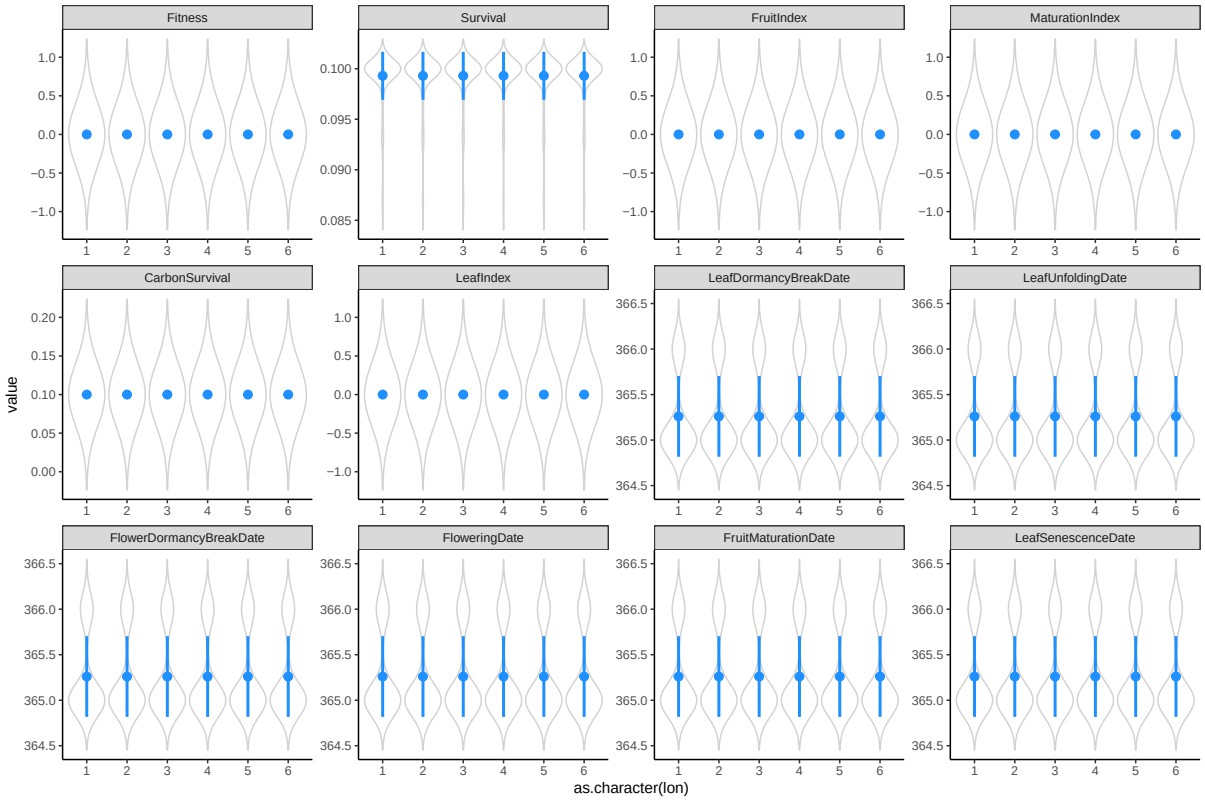

Figure 6: *Pinus* across 0 (1) to +5 (6) mean warming across fitness components at 41°N latitude.

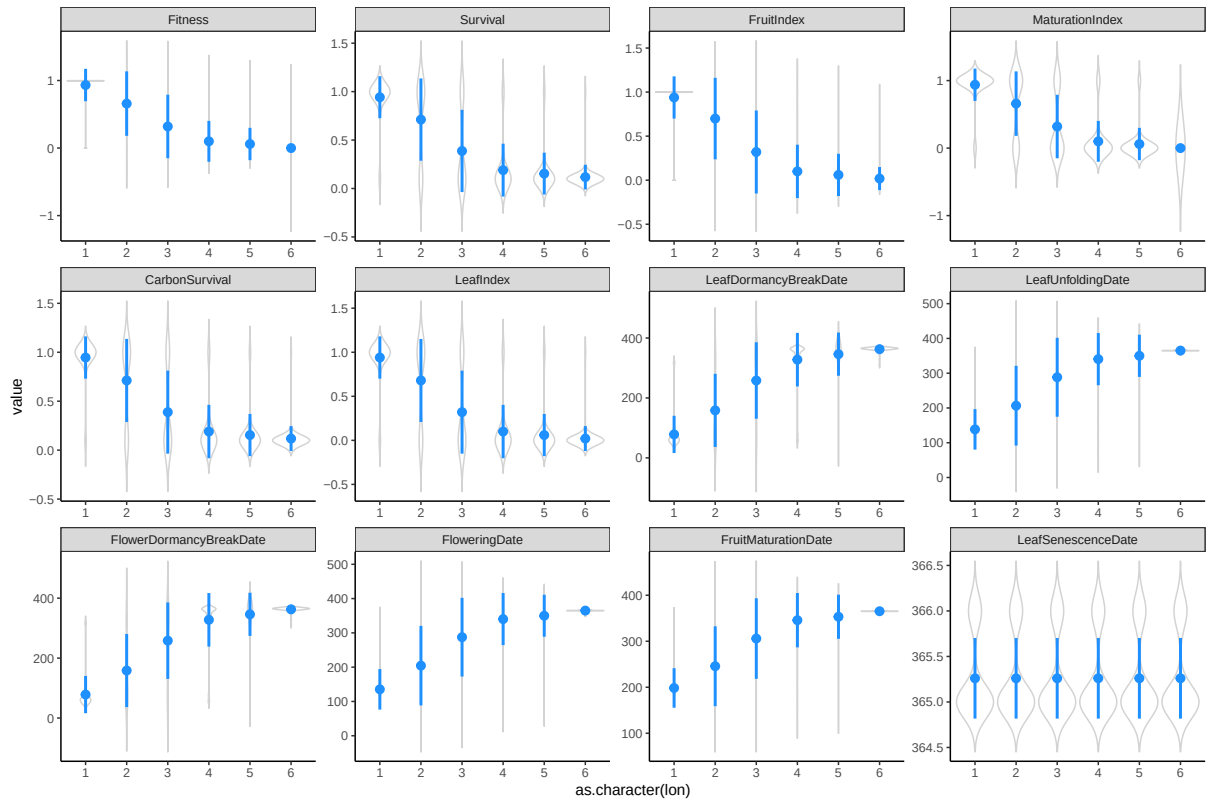

Figure 7: *Pinus* across 0 (1) to +5 (6) mean warming across fitness components at 53°N latitude. See notes in caption of Fig. **??**.

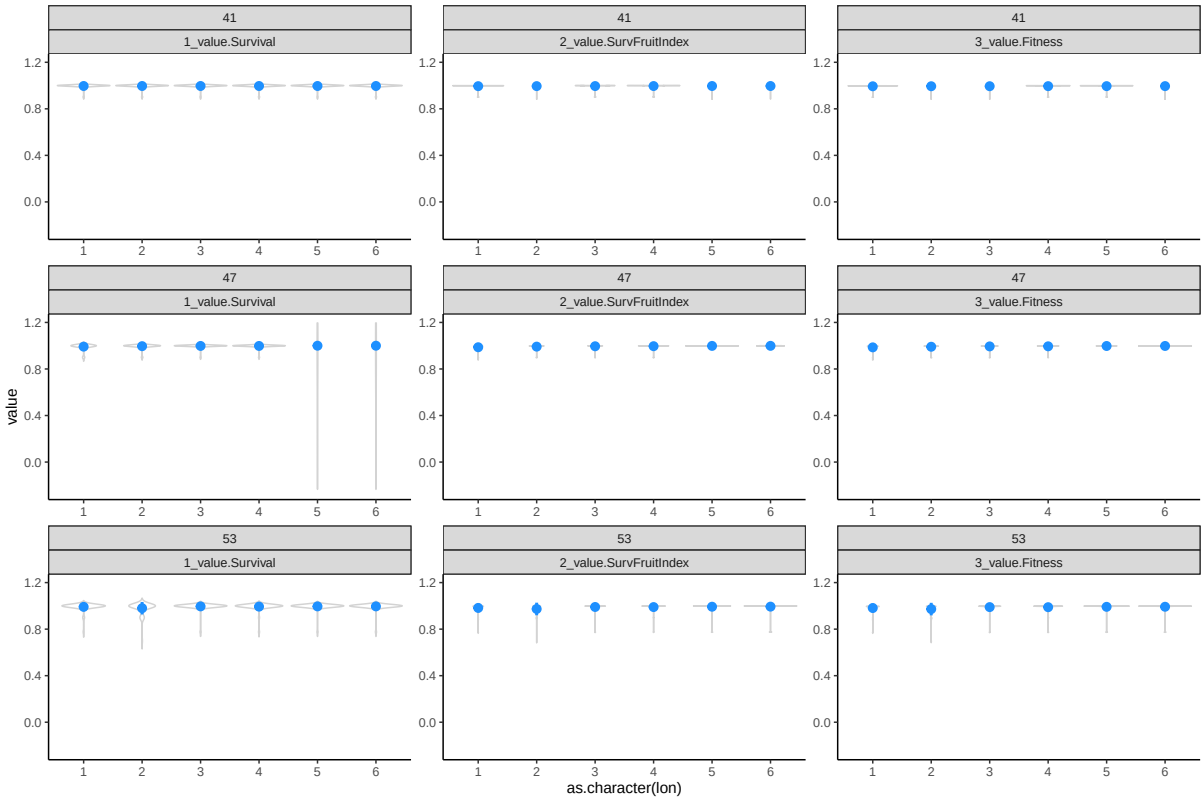

Figure 8: *Quercus* across 0 (1) to +5 (6) mean warming showing three latitudes.

2.3 For the mean results for *Quercus* it is doing very well!

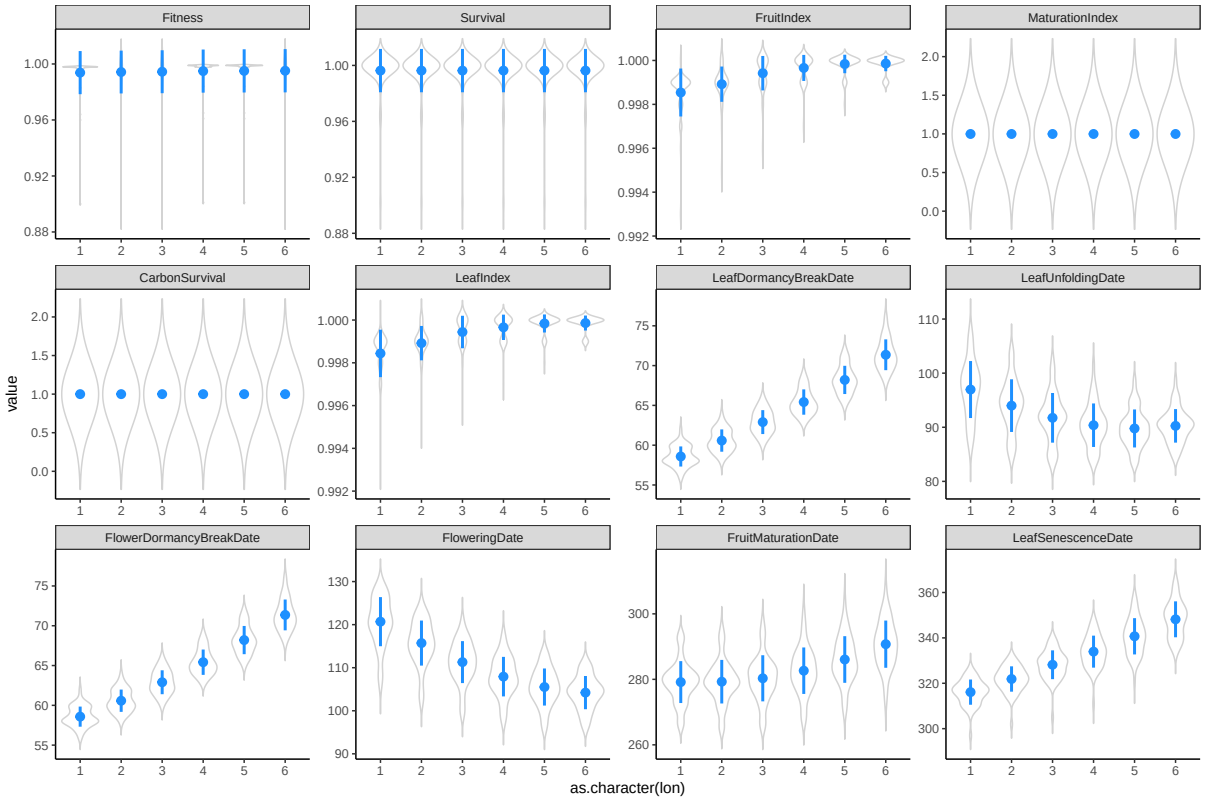

Figure 9: *Quercus* across 0 (1) to +5 (6) mean warming across fitness components at 41°N latitude.

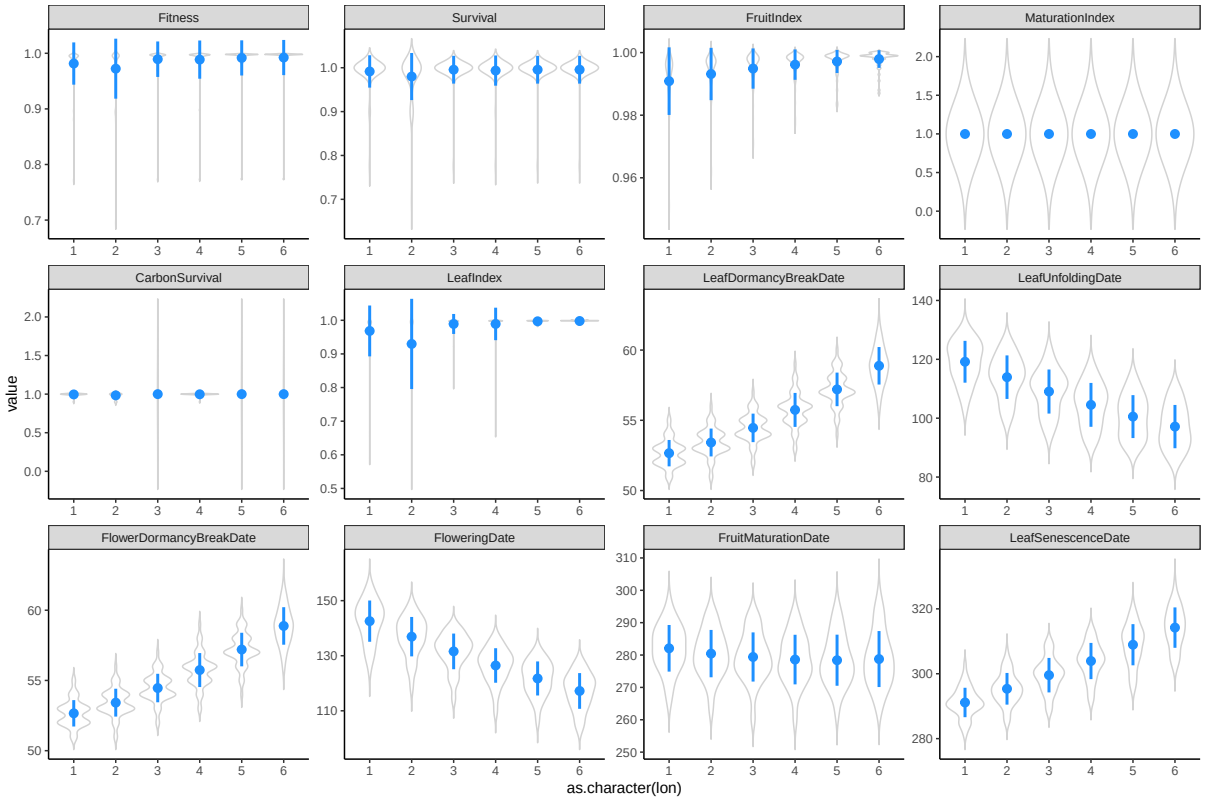

Figure 10: *Quercus* across 0 (1) to +5 (6) mean warming across fitness components at 53°N latitude.

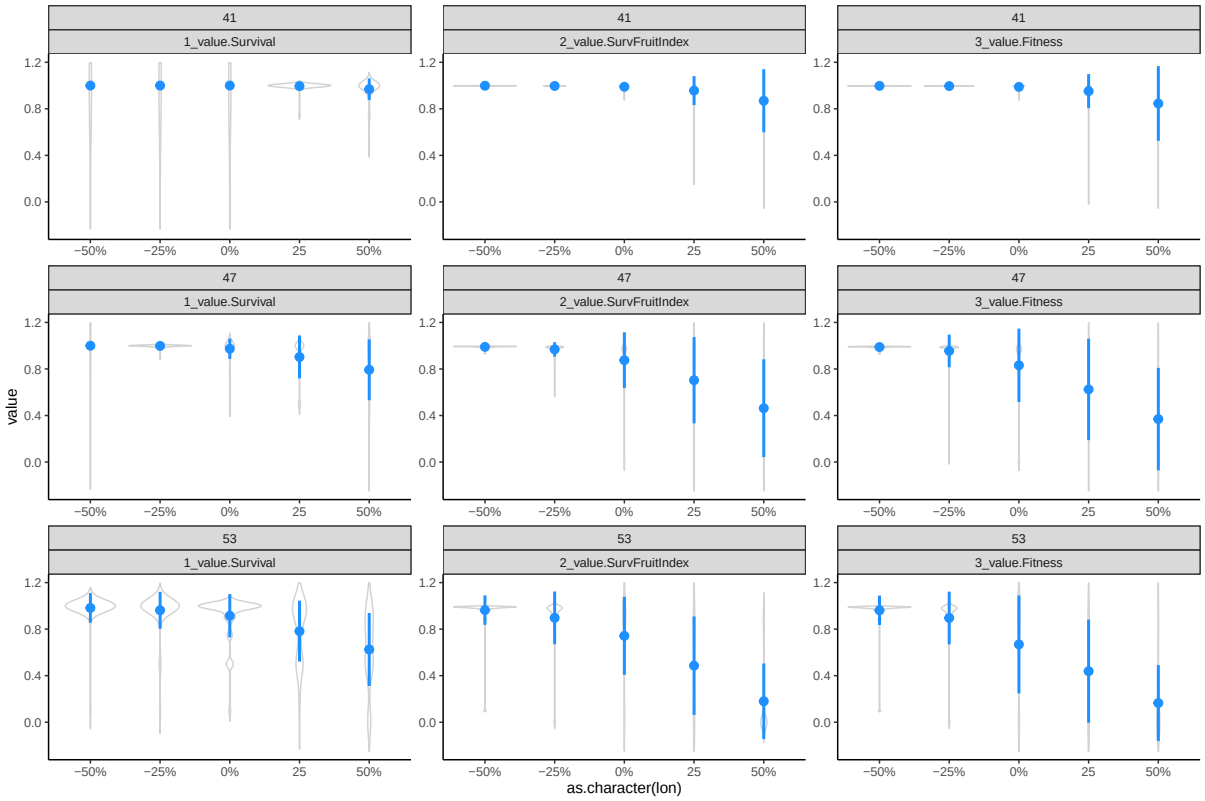

Figure 11: *Fagus* across changing variance showing three latitudes. ...
sd

3 Overview of SD simulation results

- *Fagus* is determined mainly by a combo of damage to leaves and flowers, which increases with increasing variance.
- *Pinus* survival dominates at low latitudes (no carbon survival and variance does not change this), but at highest latitude variance also leads to later leafout (low chill, later dormancy break) and thus lower leafindex (note that Pinus can sustain VERY low temperatures and is unlikely to have frost damage).
- *Quercus* is not changing much but does see some frost losses at higher variance.

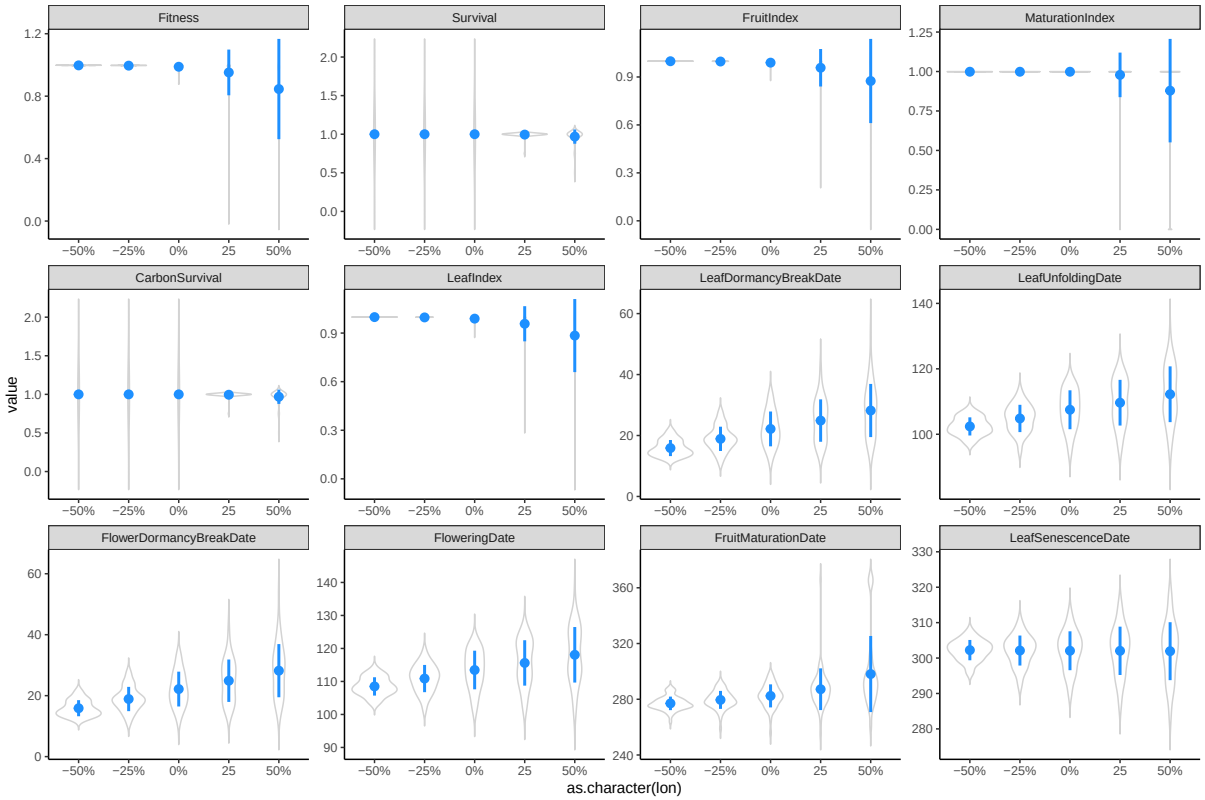

Figure 12: *Fagus* across changing variance across fitness components at 41 latitude. Low fitness is driven by low carbonsurvival, which occurs because of late dormancy break date (because leafdormancybreakdate is variable that's the driver; if it were frost, we'd see more constant leafdormancybreakdate and variable in leafindex).

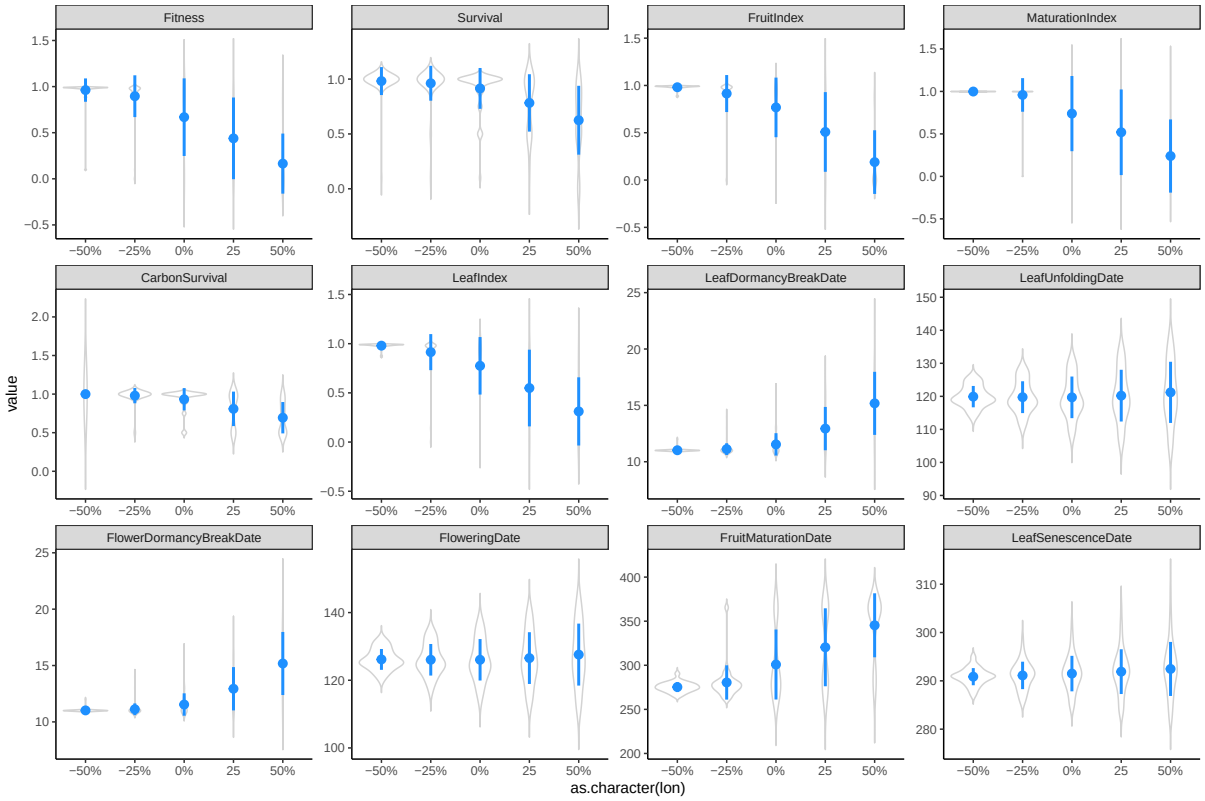

Figure 13: *Fagus* across changing variance across fitness components at 53°N latitude. Here's warming reduces frost and thus fruitindex goes up and survival goes up. Note that the leafdormancybreakdate also gets a little later but leafunfolding does not because the warming is still enough for get earlier leafout (and there is a buffer where early dormancybreakdate does not matter because it's too cold leaf unfolding to start.

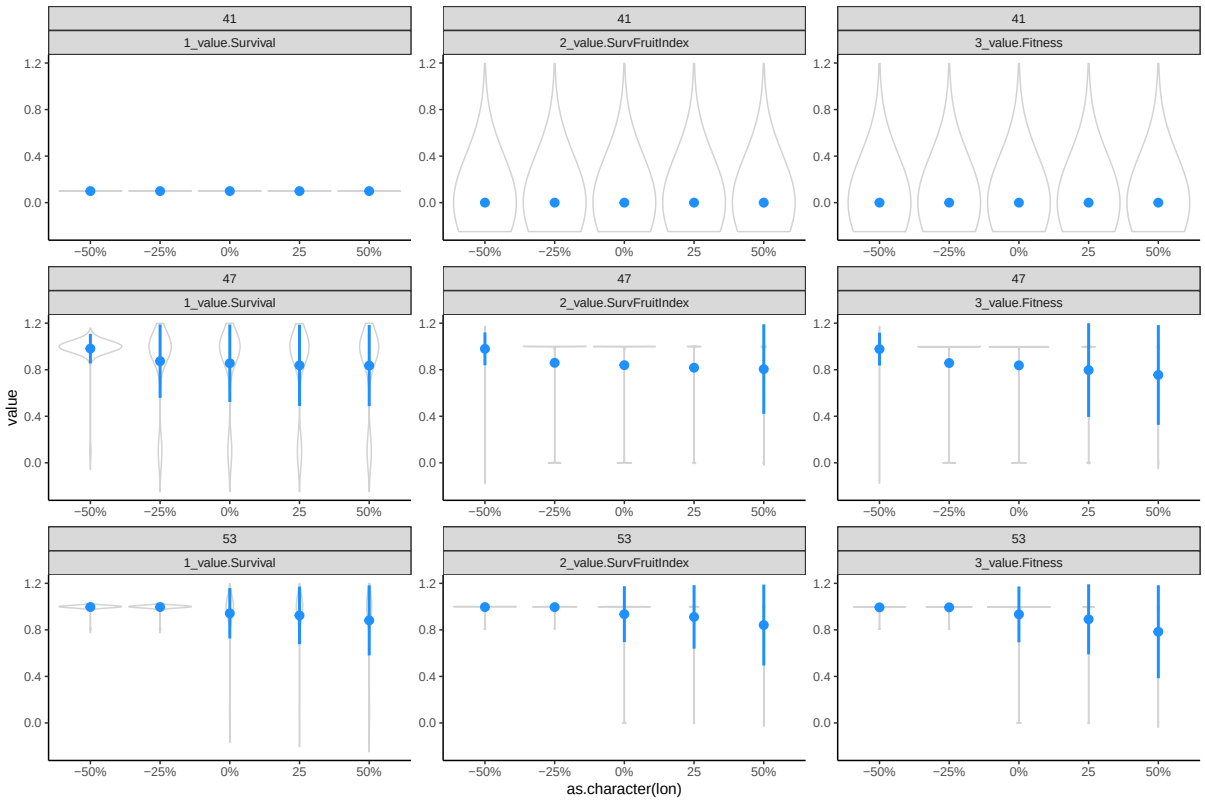

Figure 14: *Pinus* across changing variance showing three latitudes. There is no survival at low latitudes, while at higher latitudes (see Fig. **??**) there is.

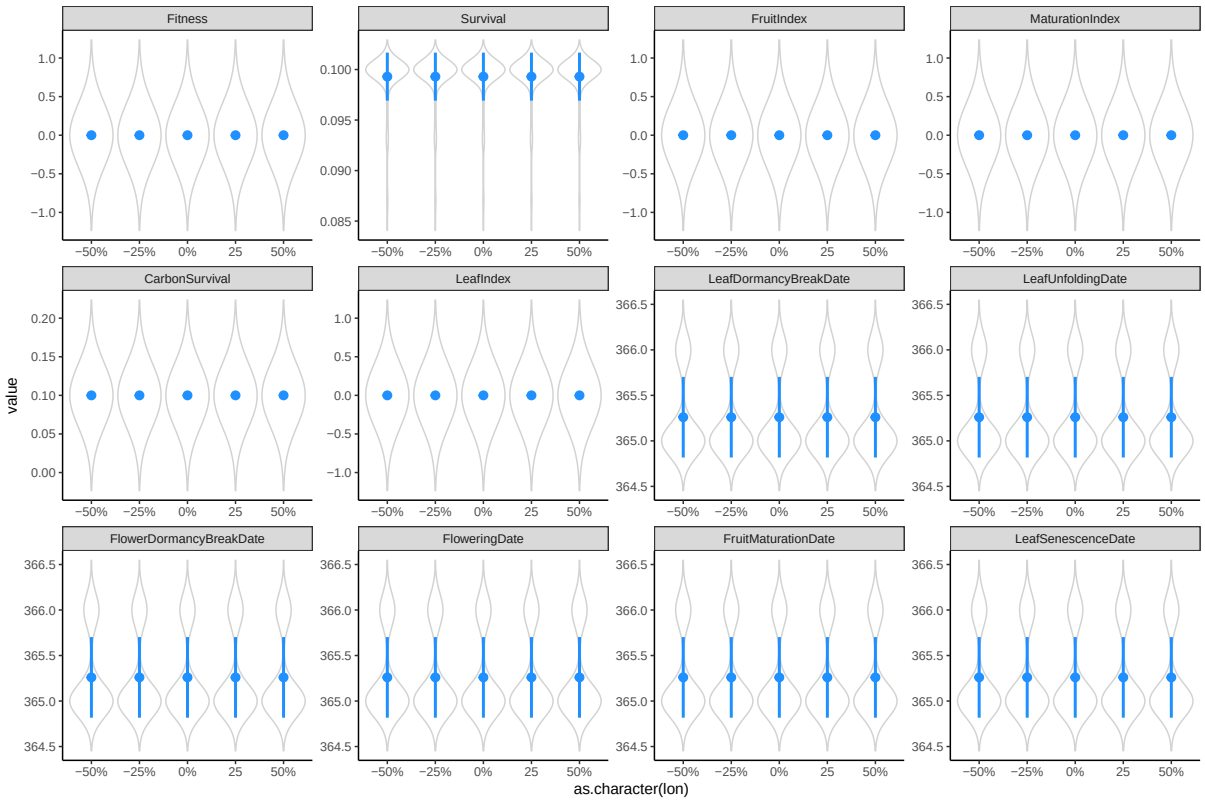

Figure 15: *Pinus* across changing variance across fitness components at 41°N latitude.

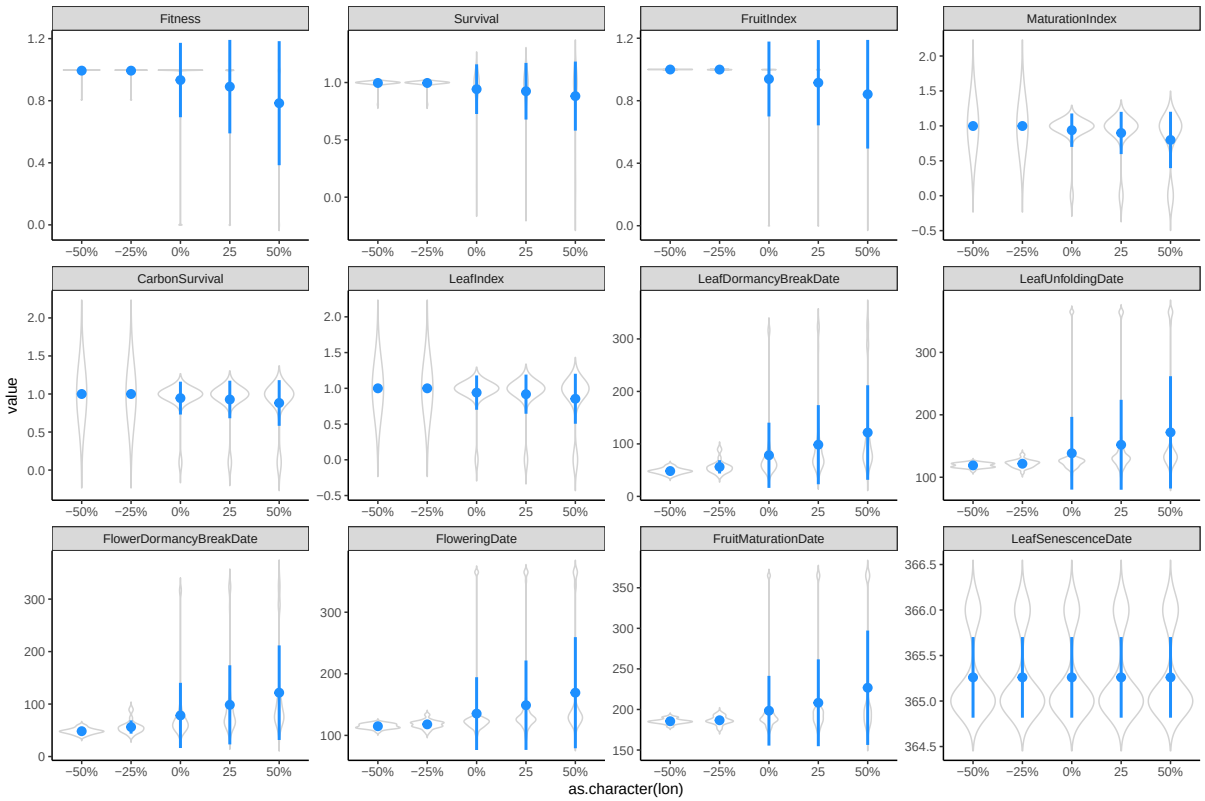

Figure 16: *Pinus* across changing variance across fitness components at 53°N latitude.

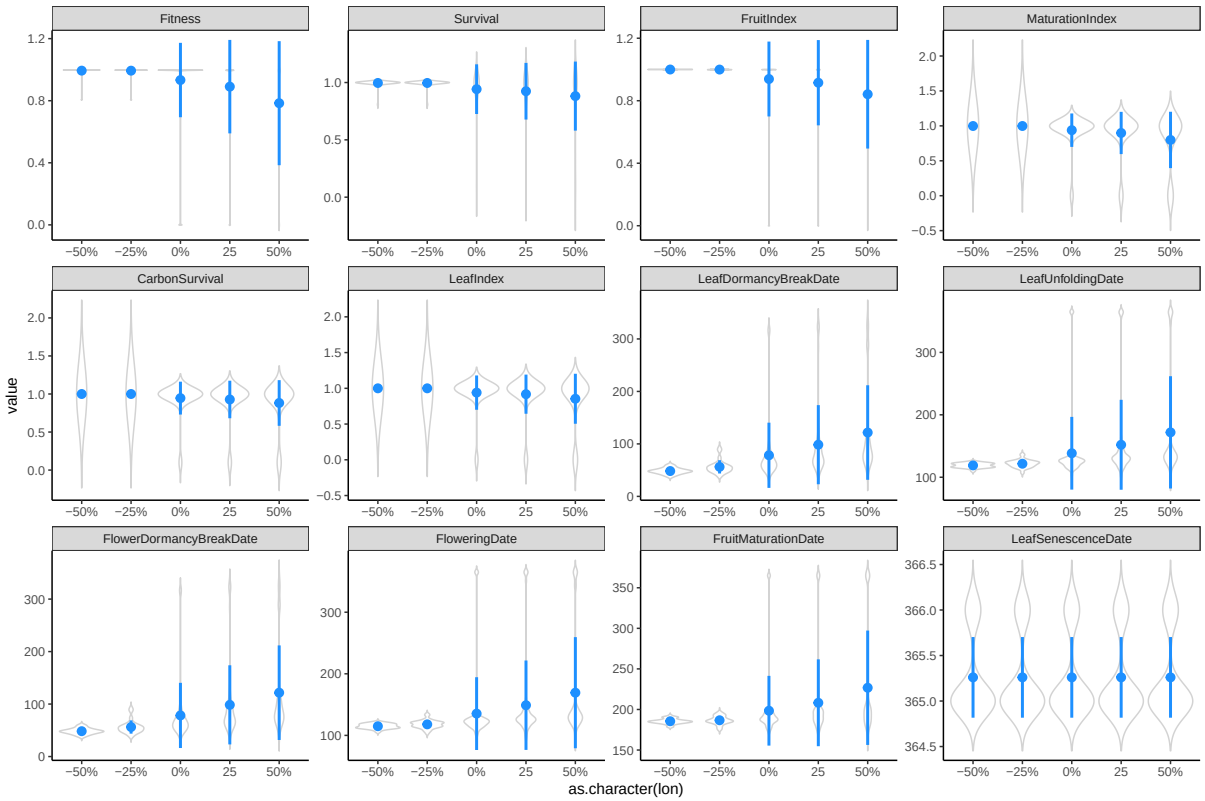

Figure 17: *Pinus* across changing variance across fitness components at 53°N latitude.

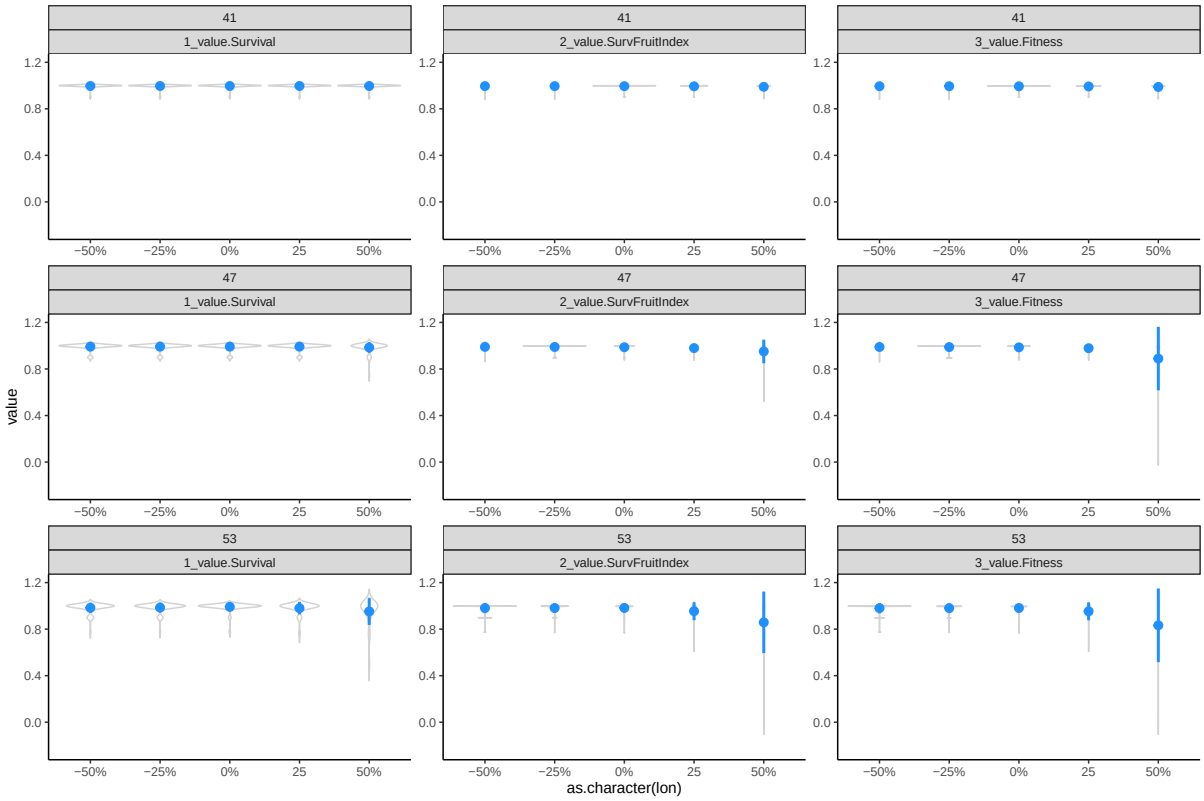

Figure 18: *Quercus* across changing variance showing three latitudes.

For the sd results for *Quercus* ....

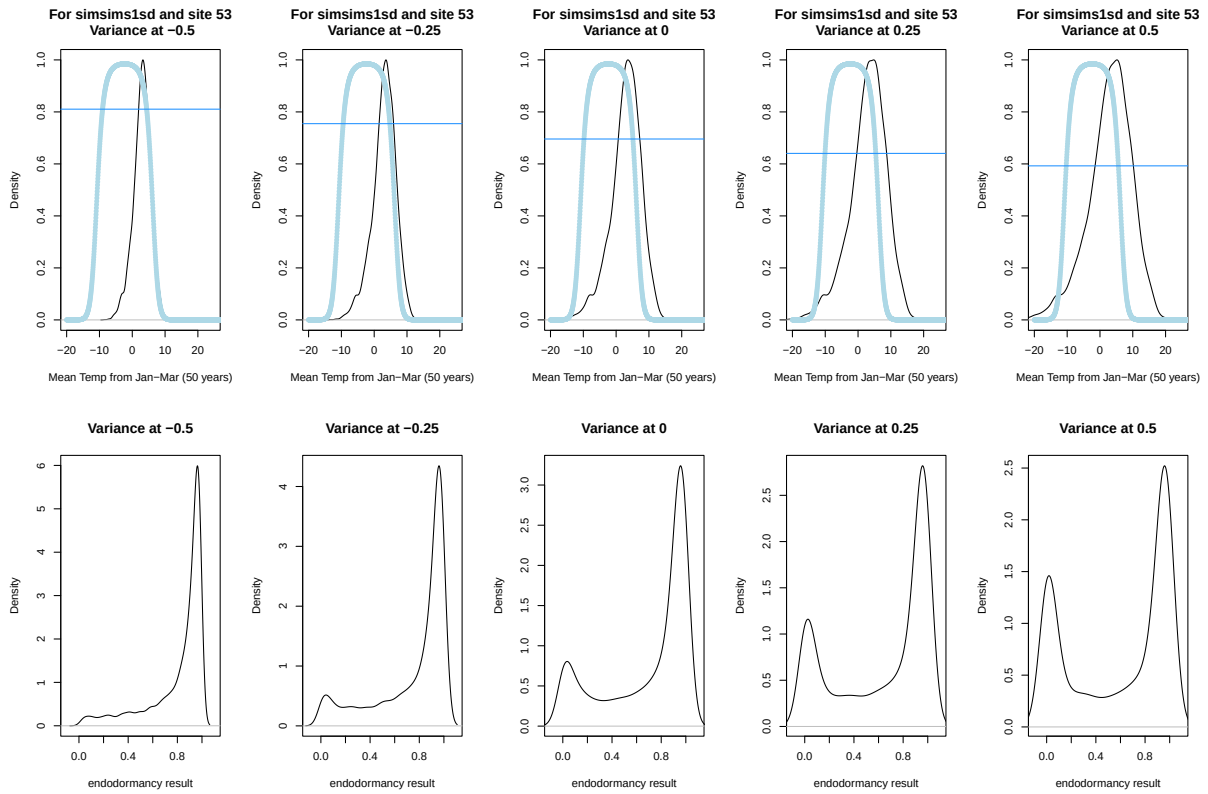

Figure 19: Top: *Pinus* endodormancy curves (same curve, always in light blue) across mean temperatures with changing variance at 53°N latitude. Darker blue horizontal line shows estimated endodormancy. Because of which side the endodormancy curve is on relative to temperature, increasing variance leads to more days falling outside the curve and leading to (bottom) 0 accumulated endodormancy, instead of 1. **Note** that I should change to Oct-Feb temperatures for these figures.

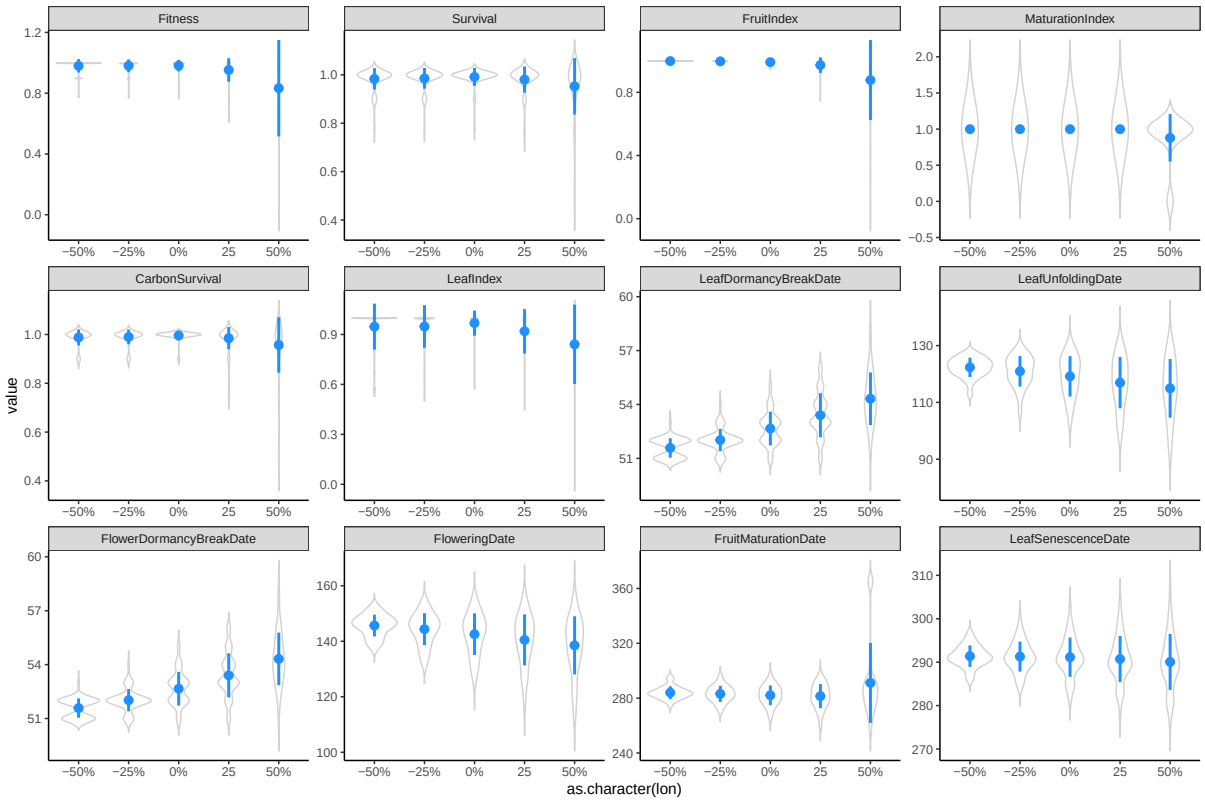

Figure 20: *Quercus* across changing variance across fitness components at 53°N latitude. Small declines in fitness with higher variance come from some frost (lower leafindex)

4 Predictions for SD x mean warming!

Short update from 7 June: When we discussed this, we felt most predictions were vaguely correct to varying degrees. See the section following and review the results to confirm.

Victor and Lizzie made predictions for what we will see in simulations of increased warming crossed with -0.5 and +0.5 increases in variance. Lizzie added the take-home message that goes with each genus *after* the meeting).

- *Quercus*: some positive and negative effects of more variance depending on whether warming is high or low
  - No effects of increased variance at all of higher warming because no more frost damage, but ...
  - At lower levels of warming and increased variance may start to see lower survival due to frost damage.
  - However, we may see that later dormancy date break actually becomes a problem, but probably not as even at southern site the dormancy break date is not too late.
- *Pinus*: Variance and warming compound to lead to greater negative effects.
  - More variance and more warming will lead to even greater issues with dormancy break dates and thus lower carbon survival. Small chance of non-linear responses for warming x variance at northern site.
  - Less variance will not change the negative results of increased warming, and like may even make it worse as possibly the curve moves out of getting much chill at all rapidly.
- *Fagus*: Results depend on latitude, but include variance and warming compounding to greater positive effects.
  - Site 41 N: Increase variance could reduce negative effects of late dormancy somewhat, also less frost with increased warming x increased variance so high warming and high variance could lead to positive effects (more positive than either change alone)
  - Site 53 N: increased variance problems (frost) go away when combined with increased warming (also, it's always easy to reach dormancy accumulation at this site)
  - Added 6 June 2024: Lower variance could increase negative effects of warming at southern site.

We also discussed how important the endodormancy curves are to predictions; because basically warming moves out of low temperatures needed for chilling.

Also, given we're not sure about the endodormancy curves (perhaps especially for Quercus, which has quite a wide endodormancy curve) we should not make predictions specifically about these species, but more generally about responses to shifting mean and variance.

5 Results for SD x mean warming

These results come from work on 6-7 June 2024, while Lizzie was in Montpellier and may not yet be fully and perfectly digested. Also, I was pretty exhausted during this meeting so take them with a grain of salt. Plots are meansdsimallmetricsFSlat41.pdf etc.. See also 'Overview of June 2024 in Montpellier' in the log for a few take home messages from around 4pm on a Friday.

- *Quercus*: some positive and negative effects of more variance depending on whether warming is high or low
  - At site 41: Flowering is earlier for higher variance, but very similar and no earlier mat date. Dormancy break date is later, but does not seem to lead to later flowering, and also does not affect fitness. Basically all fine (lower fitness a TINY bit for lower warming x higher variance). At 53 N: higher variance, lower warming leads to some frost but not much.
- *Pinus*: Variance and warming compound to lead to greater negative effects. Or, as we said on the 7th, "everything is bad."
- *Fagus*
  - Site 41 N: Low variance is better except at high warming where there are issues with late breaking.
  - Site 53 N: Increased variance is constantly worse, but increased warming leads to less frost. Fruit maturation stalls (even though flowering advances) though it appears to have no or low impact on fitness.

6 Some reminders for Lizzie...

- Minimum carbon survival is 0.1.
- Pinus can sustain VERY low temperatures and is unlikely to have frost damage
- Fagus and Quercus have mixed buds (so flower endodormancy should be the same as leaf endodormancy).
- Temperature survival really does not matter. See 7 June 2024 log notes.
- Drought survival should not matter as we do not change the water in the soil (WHC) or the precip.