Species differences in cue responses in woody plants of North America

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General thoughts

1. "Producing unique temporal niches" — cool, can you expand on this at all? Maybe finally make up some 'control' environmental conditions and plot the species via that (pt 1)
2. Control environment: average conditions perhaps - mean winter chilling, spring temps, 12/12 photoperiod
3. Group results: "cue interactions", "diff across sites", "spp differences"
4. Stronger photoperiod cues Eastern sites - defense agains false spring events?
5. Site by forcing: bc of chilling? Positive at SH - where there was more chilling therefore needing less forcing, but negative at other sites (MP and HF) - less clear
6. move interaction plots to supp
7. Figure changes:
8. fig:siteCues - plot on same fig so cue differences pop
9. muplot in supp
10. Spp plot add a line with the overall estimate mean to each and think of ways to group (along x axis)... maybe by clade and then color by east/west? Or order by pt 1 and color by clade (especially as you have a convincing east/west comparison plot already)?
11. Not sure you need Fig 7-8?
12. overall message: see a lot of spp differences, but not a lot of site level differences - even with the biases introucded by our differences in winter chilling and collection methods

Research questions

1. Are species responses to chilling, forcing and photoperiod cues phylogenetically structured?
2. How do species in deciduous forests across North America to these varying cues?

Results + figures

1. Cue responses and interactions...
   (a) On average, species budburst on the 27.7 day after the start of forcing, but ranged from 13.6 for *Aronia melanocarpa* to 52.1 for *Quercus velutina*
   (b) Species budburst = strongly phylogenetically structured (λ of 0.8 (0.6, 1), root trait value of 12.2 (7.2, 17.4).
   (c) All cues did lead to an advance in budburst date, chilling being strongest and photoperiod weakest
   (d) But strong interactions between cues and between cues and sites.
   (e) Forcing by chilling = strong delaying effect = low chilling offset by high forcing (Fig. S2 a).
2. Sites differed in their their overall budburst dates, but interacted with cues — effects not clearly divided by two transects
   (a) Both populations in eastern transect were more advanced than Smithers, with differing cue responses across sites.
      i. Delaying interaction with chilling and forcing ($b_{forcexsite}$) = earlier bb under high forcing (Fig. S2b), while Harvard Forest had later bb under low forcing (Fig. S2b)
      ii. St. Hippolyte = strongest response to high chilling, while Harvard forest had a slight delay with high chilling (Fig. S2c)
      iii. All eastern spp bb earlier with longer photoperiod, no real trend with short photoperiod (Fig. S2)
   (b) The relative relationship of western populations did not follow expectations...
      i. Forcing had a divergent effect on Manning bb — later bb under low forcing, advanced with high forcing (Fig. S2b)
      ii. Low chilling = slight advance in bb, but high chilling later bb — counter our expectations (Fig. S2c)
      iii. Manning park later than Smithers under longer photoperiods, but earlier under shorter photoperiod conditions (Fig. S2d)
3. Species differences....
   (a) Individual species show more distinct differences in their timing of bb.
      i. Across all species, relative importance of cue = varied = unique temporal niches (Fig. 3)
      ii. But fail to find strong parallels in gradients of bb with cue responses (Fig. 4 and Fig. Fig. 5)
      iii. Species level differences (intercept) explain considerable portion of bb (Fig. 4)
      iv. Only found weak gradients in chilling and forcing with later bb (Fig. 5)
   (b) Species differences are not due to plant architecture — shrubs and trees = very similar responses overall (Fig. 2)
      i. While some understory species, e.g. *Cornus stolonifera* fit predicted profile — weak chilling and forcing cues—- others don't — e.g. *Menziesia ferruginea* = strong responses all 3 cues (Fig. 3.
      ii. Tree species = no strong trends, but e.g. *Quercus velutina* = stronger chilling and photoperiod cues as predicted, and *Fagus grandifolia* = strongest photoperiod response but others like *Prunus pensylvanica*
      iii. But some surprising spp responses, e.g. *Symphoricarpos alba* had the strongest chilling response have consistently weak cue responses (Fig. 3.

1 Tables and figures

Table 1: Summary output from a phylogenetic mixed-effect model in which species are partially pooled and phylogeny is included on the intercept. The model includes photoperiod, forcing, and site as dummy variables, while the chilling effect is included as continuous chill portions.

	mean	sd	2.5%	50%	97.5%	n_eff	Rhat
Root trait intercept	12.24	3.12	6.22	12.23	18.24	12238.58	1.00
Lambda	0.79	0.12	0.49	0.81	0.95	10387.34	1.00
Forcing	-8.79	0.73	-10.21	-8.80	-7.35	12616.03	1.00
Photoperiod	-3.45	0.42	-4.27	-3.45	-2.64	10309.11	1.00
Chilling	-15.14	1.27	-17.68	-15.13	-12.65	6496.74	1.00
Manning Park	1.90	0.35	1.21	1.90	2.58	16138.58	1.00
Harvard Forest	-4.18	1.05	-6.27	-4.17	-2.18	1641.45	1.00
St. Hippolyte	-7.16	0.99	-9.15	-7.15	-5.24	1632.10	1.00
Forcing x photoperiod	-0.19	0.66	-1.45	-0.19	1.12	13735.69	1.00
Forcing x chilling	8.64	0.87	6.97	8.63	10.39	8764.40	1.00
Photoperiod x chilling	-0.75	0.89	-2.54	-0.74	1.02	7283.02	1.00
Forcing x Manning Park	-1.79	0.77	-3.29	-1.79	-0.28	12317.18	1.00
Photoperiod x Manning Park	0.54	0.80	-1.02	0.55	2.10	10772.65	1.00
Chilling x Manning Park	-0.31	1.64	-3.64	-0.28	2.90	6942.19	1.00
Forcing x Harvard Forest	3.53	1.15	1.28	3.52	5.81	5324.15	1.00
Photoperiod x Harvard Forest	-2.24	0.88	-3.94	-2.24	-0.48	9744.45	1.00
Chilling x Harvard Forest	7.16	2.13	2.89	7.22	11.25	3869.17	1.00
Forcing x St. Hippolyte	4.86	1.15	2.62	4.86	7.11	4853.50	1.00
Photoperiod x St. Hippolyte	-2.36	0.87	-4.05	-2.37	-0.66	9547.88	1.00
Chilling x St. Hippolyte	6.21	1.71	2.77	6.22	9.52	4761.63	1.00

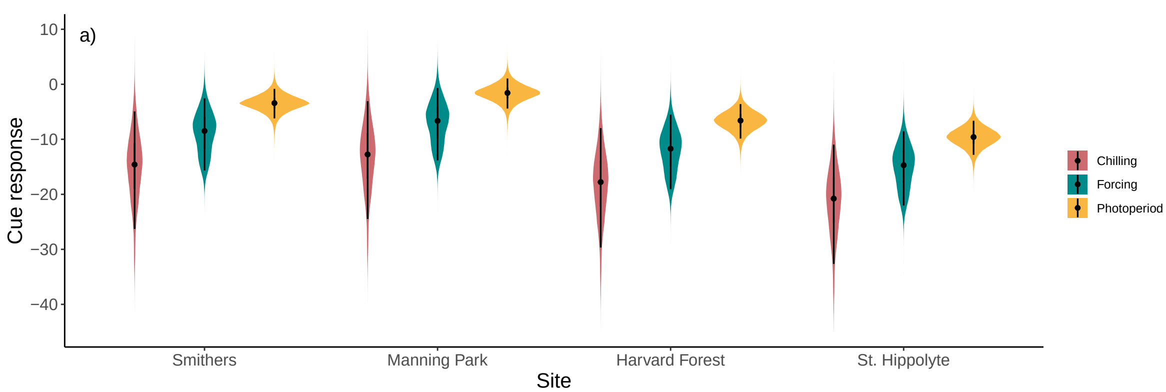

Figure 1: Posterior distributions of estimated cue responses with site level effects for individual sites, depicting a) chilling, b) forcing, and c) photoperiod cue responses. Black circles represent the median cue response, while the thinner black line the 90% quantile interval. The coloured distribution is the the posterior density of the posteriors of the cue responses and site level responses for all species at a given site. The y-axis spans the entire range of the data.

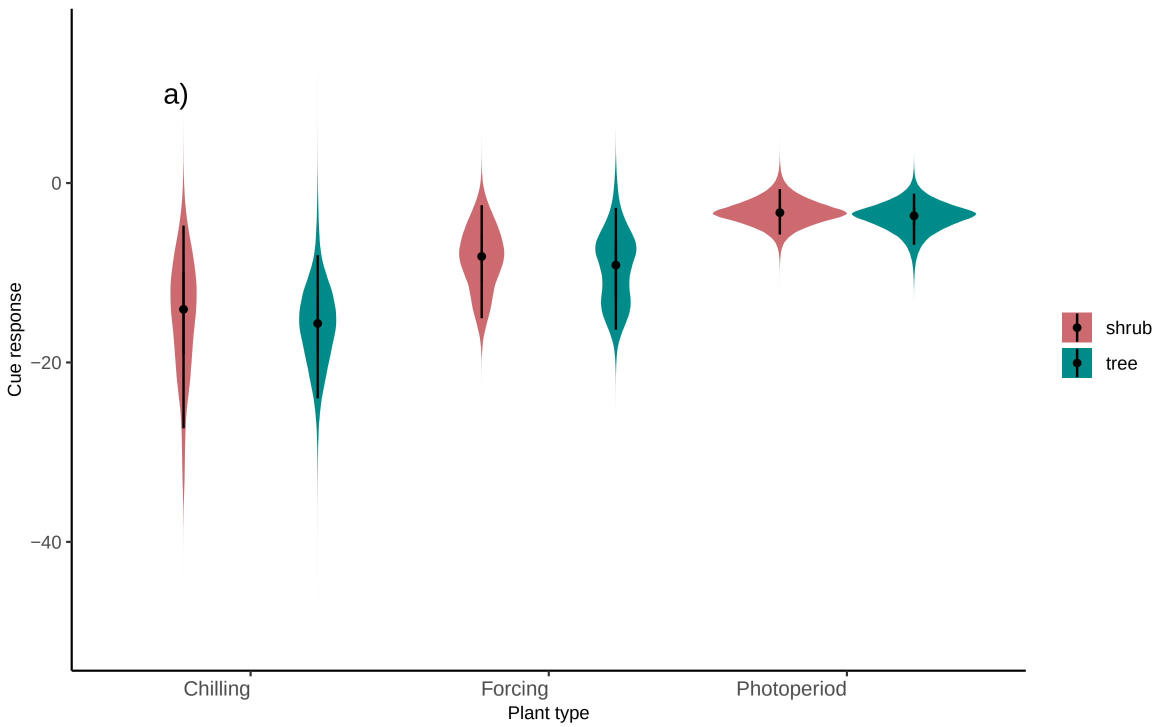

Figure 2: Comparisons of posterior distributions for cues estimates between shrub and tree species. Black circles represent the median cue response, while the thinner black line the 90% quantile interval. The coloured distribution is the the posterior density of the posteriors of the cue responses for all species within a given architectural type. The y-axis spans the entire range of the data.

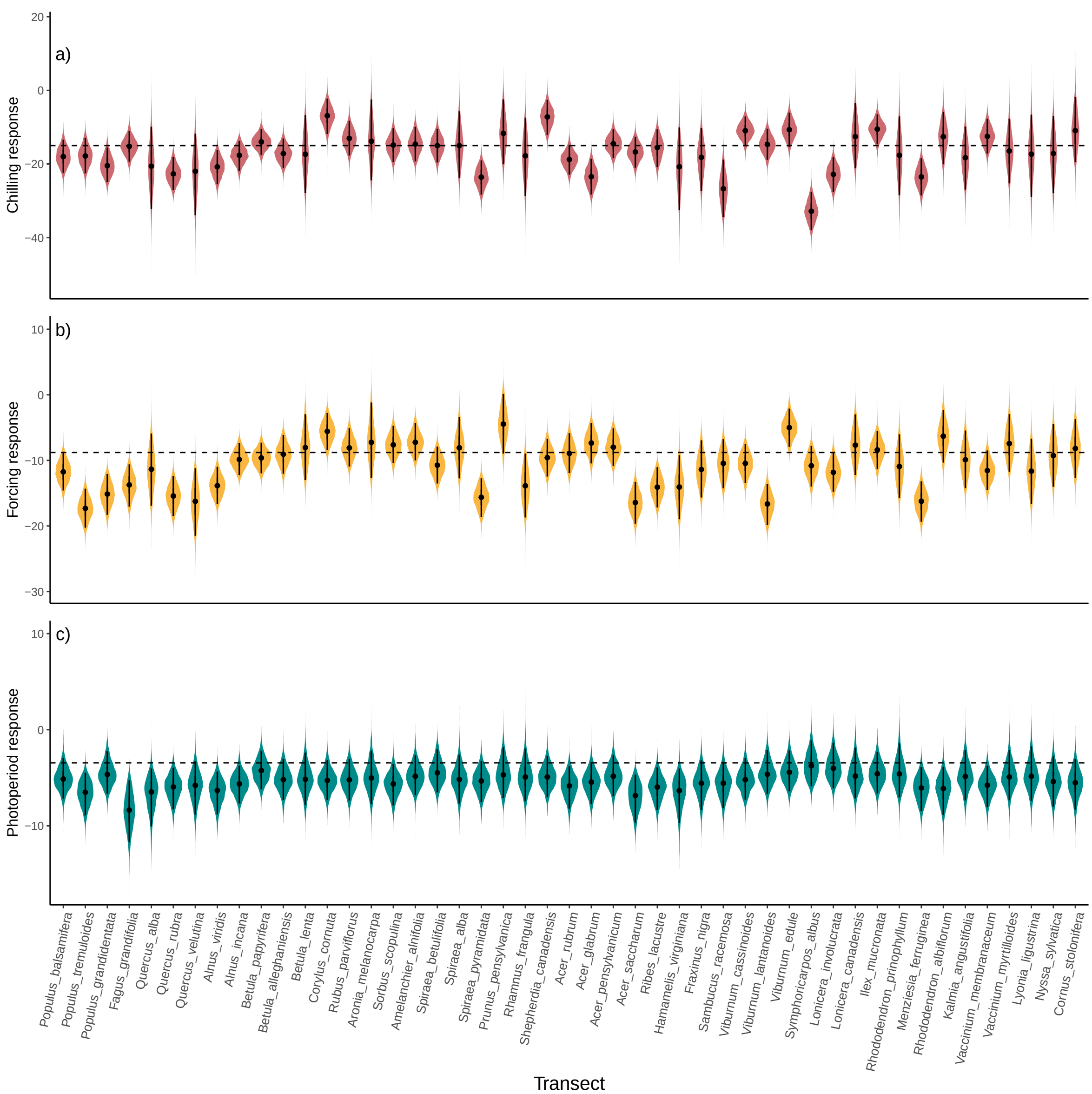

Figure 3: Species differences in cue estimate posterior distributions, comparing species differences across a) chilling, b) forcing, and c) photoperiod cues. The median cue response is illustrated by the black circle, while the 90% quantile interval is illustrated by the black line. The coloured distribution depicts the shape of the posterior density for all samples of a given species.

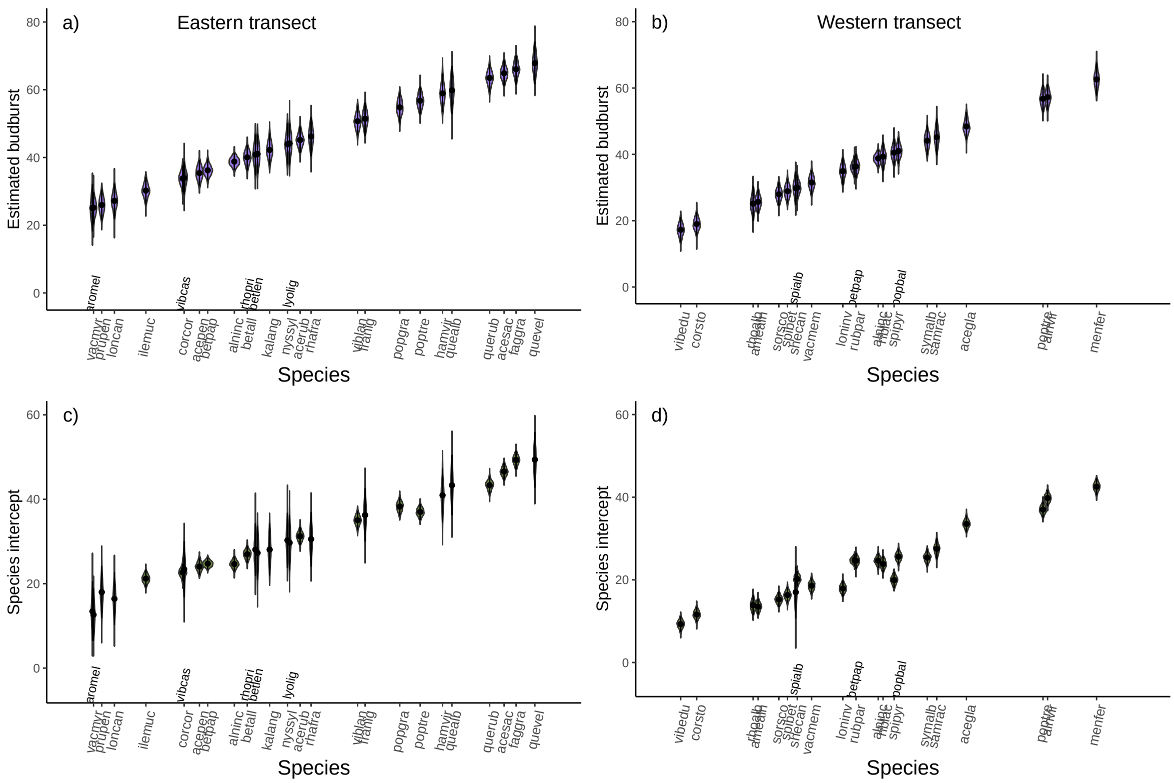

Figure 4: Estimated budburst (a, b) and species intercepts (c, d) ranked by budburst dates for both the eastern (a, c) and western (b, d) transects.

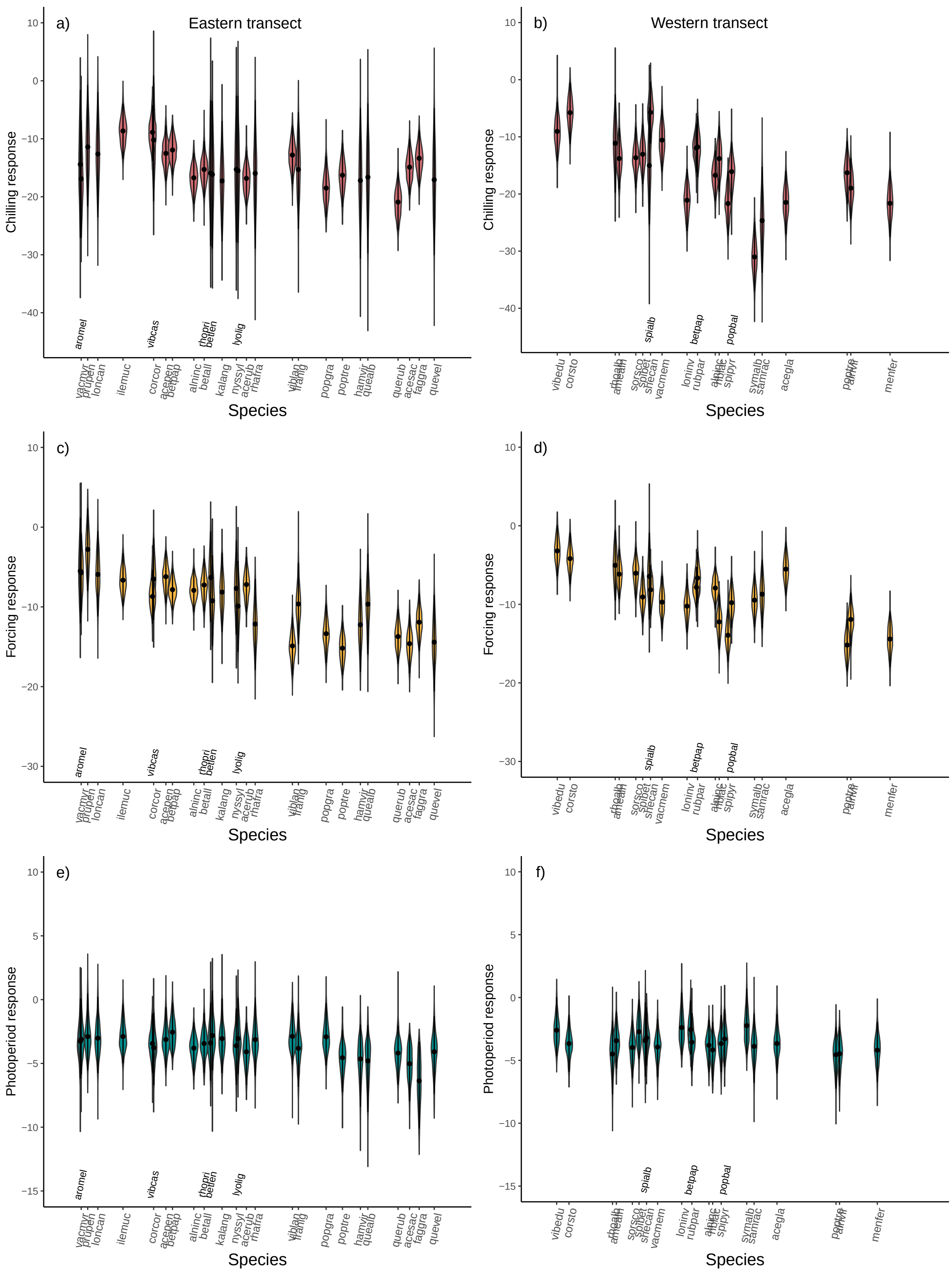

Figure 5: Species' chilling (a,b), forcing (c,d) and photoperiod (e,f) cue responses ranked by estimated budburst dates for both the eastern (a, c, e) and western (b, d, f) transects.