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)? - Not sure you need Fig 7-8?

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?

0.1 Results + figures

1. General findings...
   (a) Species budburst was strongly phylogenetically structured (with a λ of
   (b) While all cues did lead to an advance in budburst date, there were strong interactions between cues and between cues and sites.
   (c) Forcing and chilling cues produced a strong delaying effect, with low chilling being offset by high forcing conditions(Fig. **??** a).
   (d) Similar delaying interactions occur between forcing and St.Hippolyte ($b_{forcexsite3}$), forcing and Harvard forest ($b_{forcexsite4}$), and for the chilling by St. Hippolyte ($b_{chillxsite3}$) and chilling by Harvard forest interactions ($b_{chillxsite4}$).
   (e) As illustrated in Fig. **??** b and c), sites experienced unique cue responses, with St. Hippolyte having earlier budburst than out western sites, with high forcing leading to earlier budburst. Harvard Forest, however, had later budburst than our Smithers site at low forcing, but a greater response to high forcing, resulting in earlier budburst. Finally, the response in Manning park was surprising, with earlier budburst at low forcing, but delayed budburst under high forcing conditions.
   (f) At each site, low amounts of chilling lead to advances in budburst dates, with the strongest response occurring at St. Hippolyte, which also advanced their budburst at high chilling. However, chilling at both Harvard forest and Manning park had delayed budburst relative to the response of species in Smithers. Suggesting that latitudinal differences might be imporant in shaping chilling cue responses.
   (g) The interaction between photoperiod and our eastern sites in contrast, support a moderate advancing effect, with longer photoperiods at our eastern sites causing budburst dates to advance more, while short photoperiods had a negligible response. A similar but weaker trend was also found for Harvard Forest. But Manning park exhibited the opposite and stronger responses, with low and high chilling converging, with short photoperiod cues leading to earlier budburst than the response of species at Smithers and long photoperiods causing species to have slightly delayed budburst. (Fig. **??** d).
   (h) While there are some differences across cue responses across sites, they are weak when site effects are accounted for (Fig. 1)
   (i) We also did not observe differences across different plant architectures, with both shrubs and trees having very similar cue responses (Fig. 2)
2. Individual species show more distinct trends
   (a) Across all our focal species, cue responses were strongest for chilling and forcing compared to photoperiod, but species varied in the relative importance of each cue, producing unique temporal niches (**??**)
   (b) We do not find strong evidence of generalizable trends in species cue responses across the transects or between tree and shrub species.
   (c) While some understory species, such as *Cornus stolonifera* had both weak chilling and forcing cues, others like *Menziesia ferruginea* exhibit strong responses to all three cues (Fig. **??**.
   (d) Tree species similarly to not show strong trends, with *(*Quercus velutina) having stronger chilling and forcing cues as well as photoperiod as we would predict, but other trees like *Prunus pensylvanica* having consistently weak cue responses (Fig. **??**.
   (e) Our model estimates do support previously identified trends in cue uses, with *Fagus grandifolia* having the strongest photoperiod response, but surprisingly the shrub *Symphoricarpos alba* had the strongest chilling response).

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	12.31	3.09	6.28	12.31	18.40	9887.59	1.00
Lambda	0.78	0.12	0.48	0.81	0.95	7760.47	1.00
Forcing	-8.81	0.72	-10.23	-8.80	-7.38	9931.87	1.00
Photoperiod	-3.45	0.41	-4.25	-3.45	-2.63	8418.40	1.00
Chilling	-15.17	1.27	-17.71	-15.16	-12.66	5282.13	1.00
Manning Park	1.90	0.35	1.22	1.90	2.60	13833.47	1.00
Harvard Forest	-4.15	1.06	-6.26	-4.14	-2.12	1330.94	1.00
St. Hippolyte	-7.13	0.99	-9.10	-7.13	-5.23	1329.89	1.00
Forcing x photoperiod	-0.19	0.65	-1.43	-0.19	1.11	12000.48	1.00
Forcing x chilling	8.66	0.86	7.00	8.65	10.39	7759.42	1.00
Photoperiod x chilling	-0.75	0.90	-2.55	-0.75	1.01	6849.85	1.00
Forcing x Manning Park	-1.78	0.77	-3.27	-1.78	-0.25	11224.65	1.00
Photoperiod x Manning Park	0.54	0.78	-0.99	0.54	2.04	9557.53	1.00
Chilling x Manning Park	-0.23	1.63	-3.51	-0.20	2.94	5942.76	1.00
Forcing x Harvard Forest	3.54	1.14	1.31	3.52	5.82	3930.17	1.00
Photoperiod x Harvard Forest	-2.22	0.87	-3.91	-2.23	-0.50	8263.34	1.00
Chilling x Harvard Forest	7.08	2.11	2.80	7.14	11.06	2838.67	1.00
Forcing x St. Hippolyte	4.86	1.15	2.59	4.86	7.14	4048.10	1.00
Photoperiod x St. Hippolyte	-2.36	0.85	-4.02	-2.37	-0.69	7814.44	1.00
Chilling x St. Hippolyte	6.21	1.72	2.76	6.24	9.57	3335.24	1.00

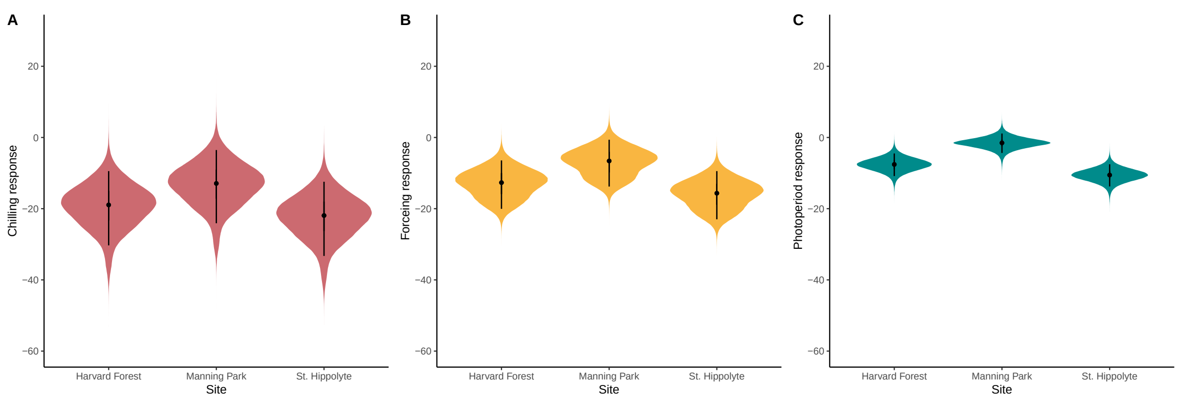

Figure 1: Posterior distributions of estimated cue responses with site level effects for individual sites, depicting a) chilling, b) forcing, and c) photoperiod cue responses. Black circles represent the median cue response, while the thinner black line the 90% quantile interval. The coloured distribution 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.

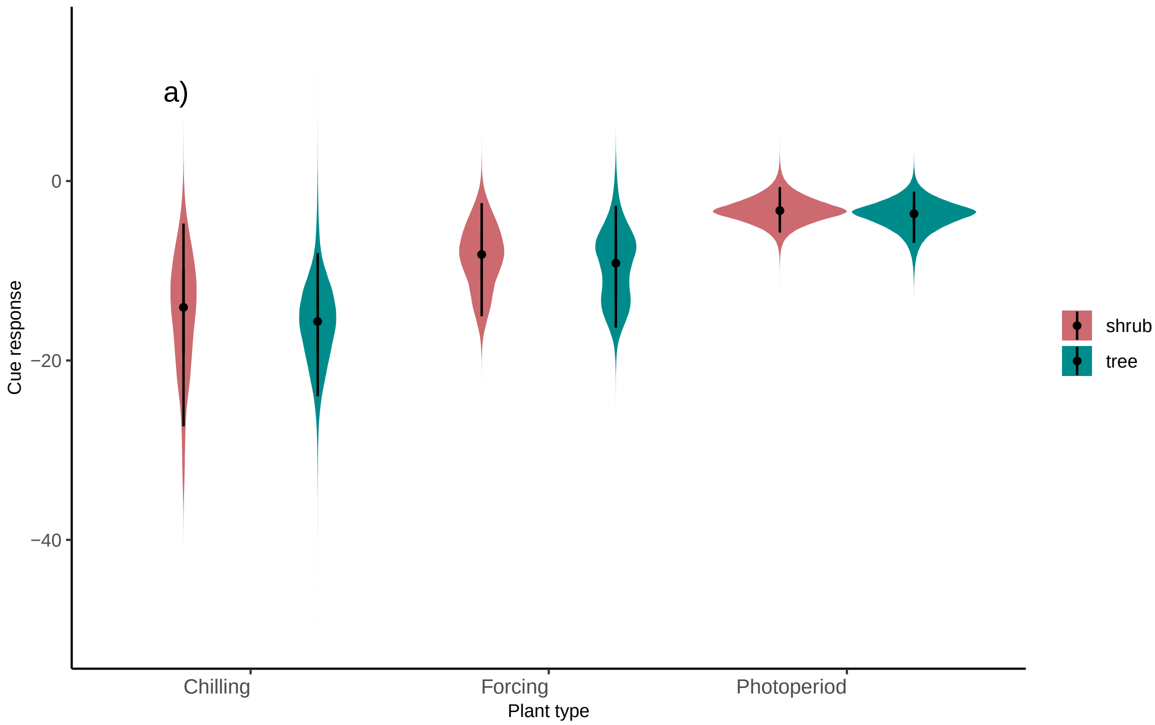

Figure 2: Comparisons of posterior distributions for cues estimates between shrub and tree species. Black circles represent the median cue response, while the thinner black line the 90% quantile interval. The coloured distribution is the the posterior density of the posteriors of the cue responses for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

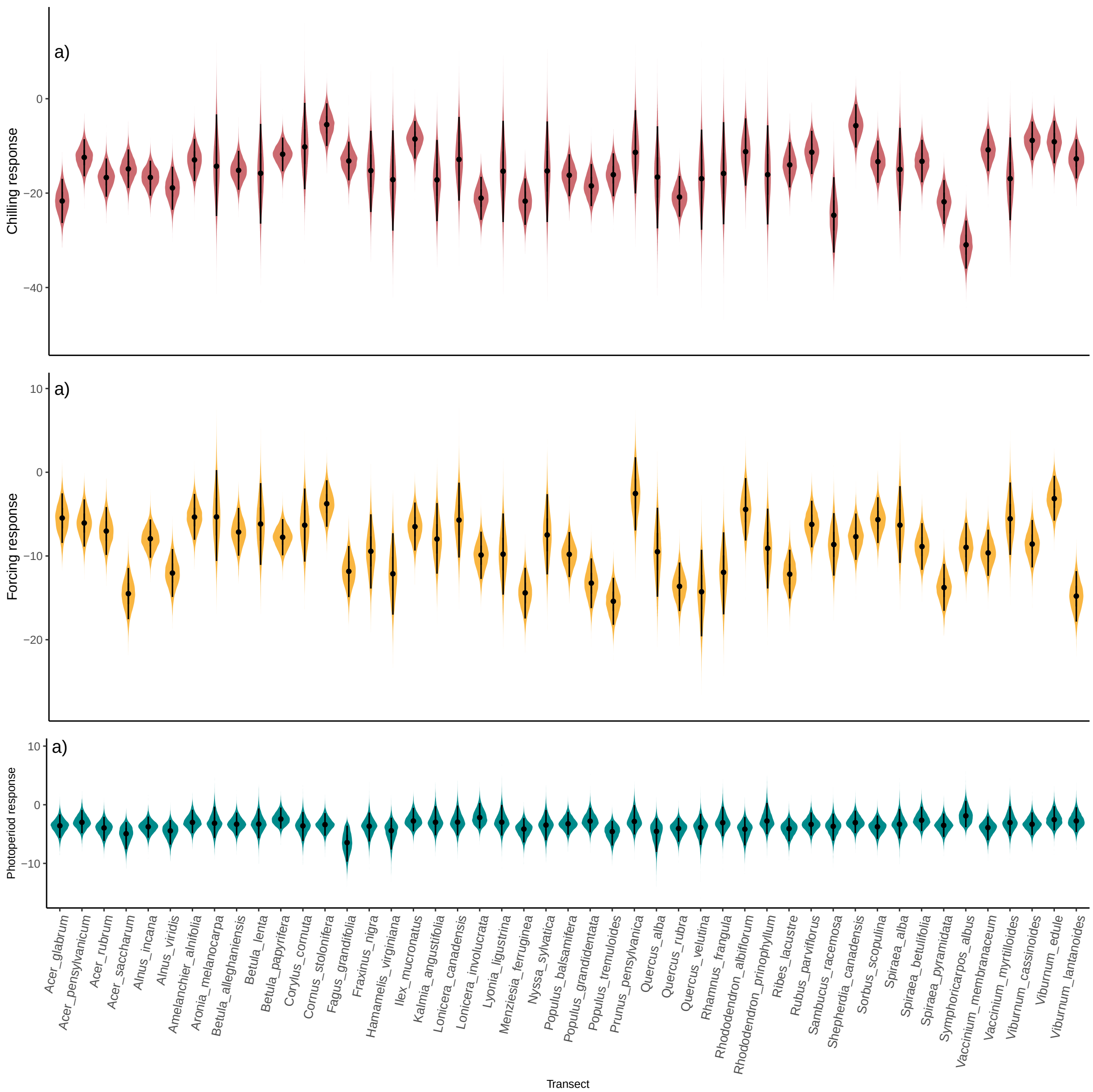

Figure 3: Species differences in cue estimate posterior distributions, comparing species differences across a) chilling, b) forcing, and c) photoperiod cues. The median cue response is illustrated by the black circle, while the 90% quantile interval is illustrated by the black line. The coloured distribution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