

1 Phenological cue use varies with functional traits in North
2 American woody plant communities

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4 November 13, 2023

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10 **Research questions**

- 11 1. Do phenological cue-trait relationships change across transects? Populations?
12 2. How do budburst cues relate to functional traits in temperate woody species?
13 3. How do shrub and tree species differ in their cue-trait relationships?

14 **Materials and Methods**

15 These plots and tables are using the model output from the model with a dummy variable for transect
16 (east = 1) and an interaction between transect and latitude. Latitude is included as a continuous
17 variable, but based on the prior predictive checks, I decided to z-scored it. 90% UI given.

18 **Results**

- 19 1. Our study = one of the first to combine trait data with data of phenological cue response for the
20 same individuals and across species distributions.
- 21 (a) Our data includes plant communities in eastern and western deciduous forests of North
22 America
- 23 (b) Samples collected from multiple populations—modelling approach that accounts for varia-
24 tion across populations and transects
- 25 (c) Joint modelling approach = use sp-level estimates for traits to understand phenological cue
26 responses and budburst timing
- 27 (d) Includes woody tree and shrub species = different growth strategies—and presumably suites
28 of traits
- 29 (a) kjskfj
- 30 2. Found only two of our five traits were related to budburst phenology

- 31 (a) Of the 5 commonly measured traits we measured—only height and DBH correlated with
32 budburst cues
- 33 (b) Height and DBH: short trees had stronger forcing responses (0.1, UI: 0.0, 0.3 for height and
34 0.1, UI: 0.0, 0.2, Fig. 4 a and g), but weaker responses to photoperiod (-0.8, UI: -0.3, -0.1
35 for height and -0.1, UI: -0.2, 0.0, Fig. 4 c and i)
- 36 (c) Other three traits, LMA, SSD, C:N = no relationship to chilling, forcing, or photoperiod
37 (Fig. 4)—posterior centred around zero
- 38 (d) 3 traits lack of trait effect on cues = exemplified by the nonexistent effect on phenology—
39 estimate of our $\beta_{\text{Trait} \times \text{Cue}}$ parameter is fully informed by prior not the data (Fig. 3)
- 40 (a) ksdjfkdj

Figures

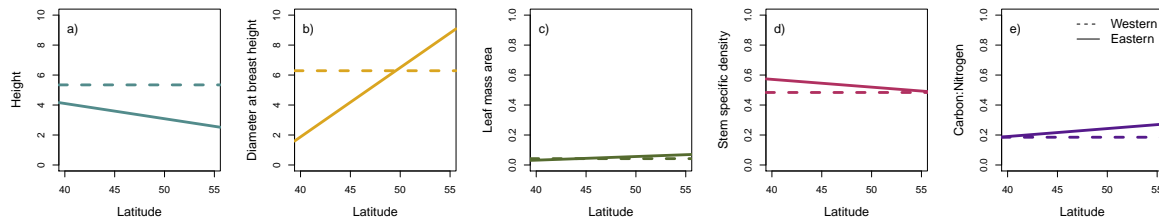


Figure 1: We only found biogeographic differences for four of our functional traits, with the direction of the relationship varying across traits. Both height a. height and b. diameter at base height showed strong interactions between latitude and trait values, while c. leaf mass area has the weakest response, and d. stem specific density, and e. carbon:nitrogen moderate interactive effects.

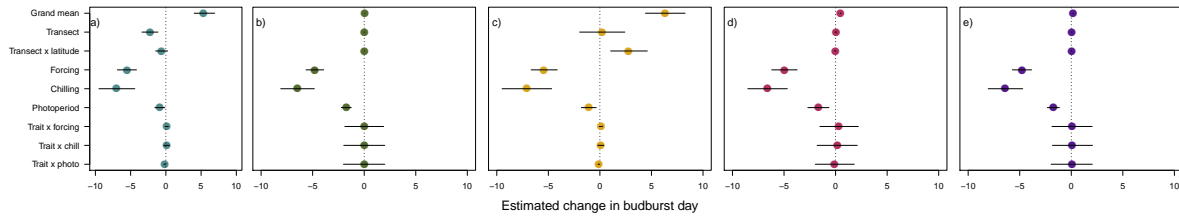


Figure 2: Estimated trait variation and cue responses to chilling, forcing, and photoperiod on budburst timing for 47 species, modelled for five traits: a. height, b. diameter at breast height, c. leaf mass area, d. stem specific density, and e. carbon:nitrogen. Of our five traits, only two appear to relate to budburst cues, despite these three cues being important drivers of budburst timing. Lines represent 50% uncertainty intervals.

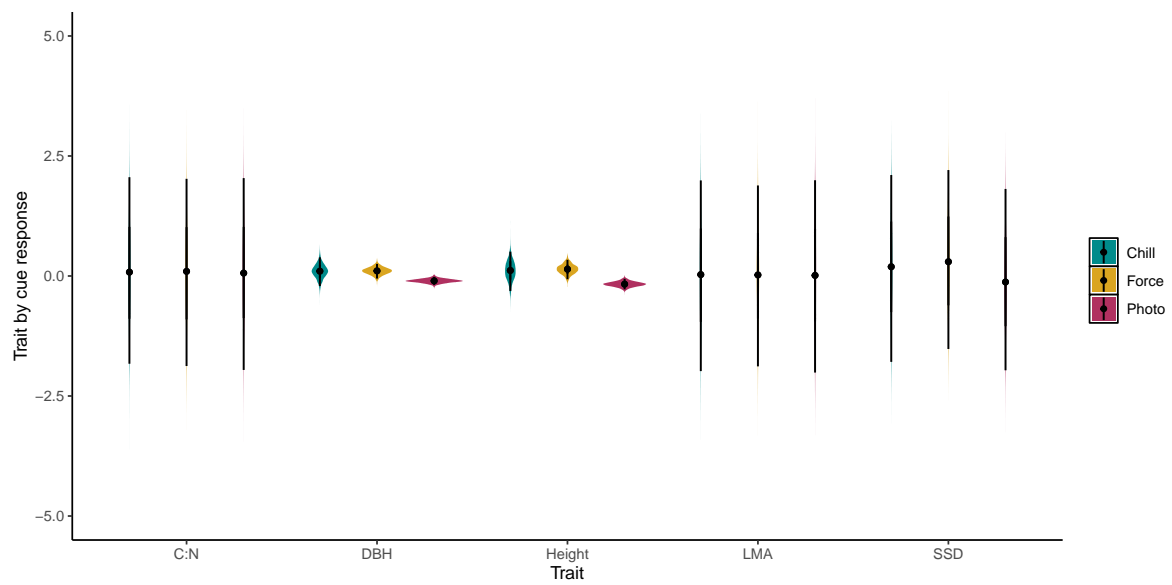


Figure 3: Only some traits were related to budburst phenological cues. For leaf mass area, stem specific density, and the ratio of carbon to nitrogen, traits no effect on budburst timing.

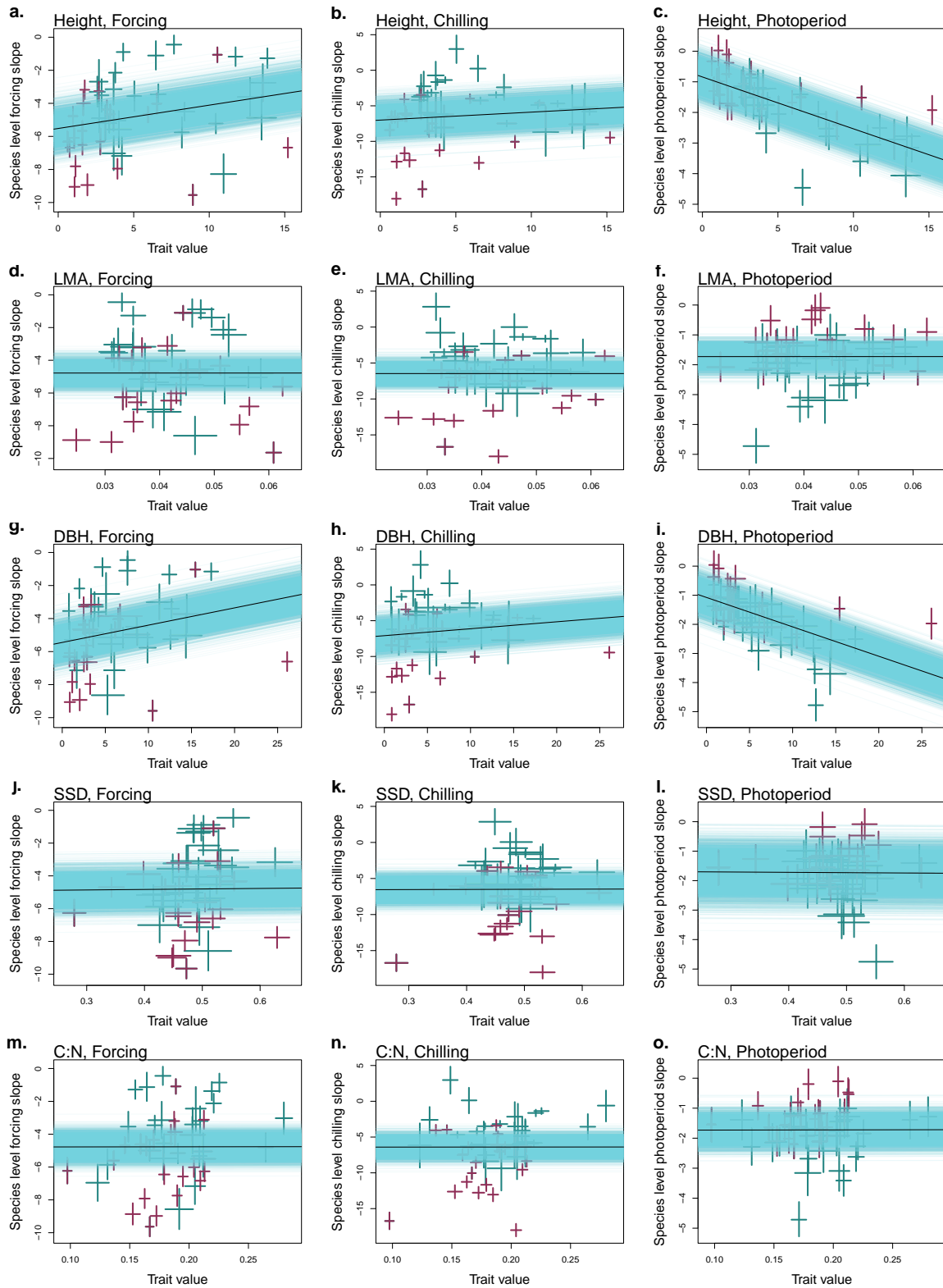


Figure 4: Relationship between species traits and cue responses, for height (a-c), leaf mass area (d-f), diameter at breast height (g-i), stem specific density (j-l), and the carbon to nitrogen ratio (m-o). Point colours representing different species groups, tree species are depicted in maroon and shrub species in teal.



Figure 5: We found budburst estimates differed between our full model (intercept plus cues, depicted as triangles for high cues and circles for low cues), versus the intercepts only model (without cues, shown as squares). Species are ordered in increasing budburst dates for both the eastern (a and c) and western (b and d) populations, spanning from early budbursting shrubs, in red, to late budbursting trees, in blue.

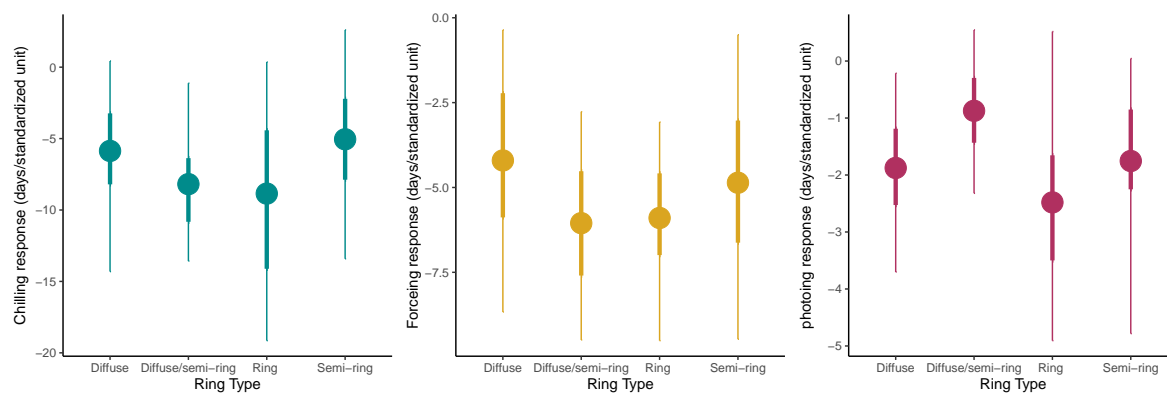


Figure 6: Despite differing in their wood structures and growth strategies, we did not find this trait to correlate with differences in cue responses across species.

42 **Tables**

[1] "/Users/deirdreloughnan/Documents/github/Treetraits/docs"

Table 1: Summary of a joint model for height

	mean	X2.5.	X25.	X50.	X75.	X97.5.
mu_grand	5.35	4.02	4.87	5.33	5.80	6.93
b_tranE	-2.26	-3.39	-2.64	-2.25	-1.88	-1.12
b_tranlat	-0.61	-1.45	-0.90	-0.61	-0.31	0.26
muForceSp	-5.52	-6.88	-5.98	-5.52	-5.06	-4.17
muChillSp	-7.01	-9.50	-7.90	-6.99	-6.11	-4.40
muPhotoSp	-0.84	-1.56	-1.07	-0.83	-0.61	-0.15
muPhenoSp	27.09	24.22	26.03	27.08	28.12	29.92
betaTraitxForce	0.14	-0.07	0.07	0.14	0.21	0.34
betaTraitxChill	0.11	-0.31	-0.02	0.11	0.25	0.51
betaTraitxPhoto	-0.17	-0.28	-0.20	-0.17	-0.13	-0.06
sigma_traity	2.87	2.76	2.83	2.87	2.91	2.99
sigma_sp	4.30	3.48	3.98	4.25	4.59	5.37
sigmaForceSp	2.58	1.98	2.34	2.56	2.81	3.33
sigmaChillSp	4.96	3.76	4.45	4.90	5.38	6.58
sigmaPhotoSp	1.02	0.56	0.87	1.01	1.17	1.54
sigmaPhenoSp	9.79	7.91	9.00	9.73	10.49	12.12
sigmapheno_y	9.50	9.30	9.43	9.50	9.57	9.70

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Table 2: Summary of a joint model for leaf mass area

	mean	X2.5.	X25.	X50.	X75.	X97.5.
mu_grand	0.05	0.05	0.05	0.05	0.05	0.05
b_tranE	0.01	0.01	0.01	0.01	0.02	0.02
b_tranlat	0.01	0.01	0.01	0.01	0.02	0.02
muForceSp	-4.78	-5.64	-5.07	-4.77	-4.50	-3.93
muChillSp	-6.47	-8.10	-7.03	-6.46	-5.92	-4.84
muPhotoSp	-1.73	-2.22	-1.89	-1.72	-1.57	-1.26
muPhenoSp	27.03	24.19	26.07	27.03	27.98	29.86
betaTraitxForce	0.01	-1.88	-0.60	0.02	0.63	1.89
betaTraitxChill	0.02	-1.98	-0.68	0.03	0.72	1.99
betaTraitxPhoto	0.02	-2.01	-0.68	0.01	0.71	2.00
sigma_traity	0.02	0.02	0.02	0.02	0.02	0.02
sigma_sp	0.01	0.01	0.01	0.01	0.01	0.01
sigmaForceSp	2.64	2.02	2.39	2.62	2.86	3.40
sigmaChillSp	4.91	3.74	4.43	4.87	5.32	6.37
sigmaPhotoSp	1.20	0.75	1.03	1.18	1.35	1.72
sigmaPhenoSp	9.74	7.97	9.02	9.66	10.36	12.04
sigmapheno_y	9.50	9.30	9.43	9.50	9.57	9.70

Table 3: Summary of a joint model for diameter at base height

	mean	X2.5.	X25.	X50.	X75.	X97.5.
mu_grand	6.33	4.42	5.67	6.33	6.99	8.26
b_tranE	0.21	-1.96	-0.55	0.20	0.96	2.42
b_tranlat	2.77	1.04	2.14	2.77	3.39	4.60
muForceSp	-5.45	-6.67	-5.89	-5.46	-5.02	-4.14
muChillSp	-7.09	-9.49	-7.91	-7.10	-6.30	-4.68
muPhotoSp	-1.08	-1.80	-1.31	-1.08	-0.83	-0.36
muPhenoSp	27.08	24.26	26.13	27.10	28.01	29.91
betaTraitxForce	0.10	-0.05	0.06	0.11	0.16	0.25
betaTraitxChill	0.10	-0.21	0.01	0.10	0.19	0.39
betaTraitxPhoto	-0.10	-0.18	-0.13	-0.10	-0.07	-0.02
sigma_traity	5.63	5.41	5.55	5.62	5.71	5.86
sigma_sp	5.81	4.68	5.32	5.75	6.23	7.35
sigmaForceSp	2.60	2.00	2.35	2.58	2.82	3.35
sigmaChillSp	4.96	3.74	4.46	4.90	5.38	6.57
sigmaPhotoSp	1.09	0.64	0.93	1.08	1.24	1.59
sigmaPhenoSp	9.77	7.90	9.02	9.68	10.45	12.04
sigmapheno_y	9.50	9.29	9.43	9.50	9.57	9.71

Table 4: Summary of a joint model for stem specific density

	mean	X2.5.	X25.	X50.	X75.	X97.5.
mu_grand	0.48	0.45	0.47	0.48	0.49	0.52
b_tranE	0.04	-0.04	0.01	0.04	0.06	0.11
b_tranlat	-0.03	-0.09	-0.05	-0.03	-0.01	0.03
muForceSp	-4.95	-6.20	-5.37	-4.95	-4.53	-3.73
muChillSp	-6.59	-8.51	-7.25	-6.59	-5.94	-4.68
muPhotoSp	-1.67	-2.70	-2.04	-1.68	-1.32	-0.65
muPhenoSp	27.04	24.10	26.05	27.04	28.01	30.02
betaTraitxForce	0.31	-1.52	-0.35	0.30	0.96	2.21
betaTraitxChill	0.19	-1.79	-0.45	0.19	0.84	2.10
betaTraitxPhoto	-0.11	-1.96	-0.76	-0.13	0.52	1.81
sigma_traity	0.22	0.21	0.22	0.22	0.22	0.23
sigma_sp	0.07	0.06	0.07	0.07	0.08	0.10
sigmaForceSp	2.62	2.05	2.39	2.59	2.83	3.34
sigmaChillSp	4.92	3.73	4.43	4.87	5.32	6.49
sigmaPhotoSp	1.21	0.77	1.05	1.20	1.35	1.71
sigmaPhenoSp	9.74	7.99	8.99	9.67	10.38	11.94
sigmapheno_y	9.50	9.30	9.42	9.50	9.57	9.71

Table 5: Summary of a joint model for carbon to nitrogen ratio

	mean	X2.5.	X25.	X50.	X75.	X97.5.
mu_grand	0.19	0.17	0.18	0.18	0.19	0.20
b_tranE	0.06	0.04	0.05	0.06	0.06	0.07
b_tranlat	0.03	0.02	0.03	0.03	0.04	0.04
muForceSp	-4.78	-5.71	-5.09	-4.78	-4.47	-3.85
muChillSp	-6.41	-8.06	-6.99	-6.41	-5.87	-4.71
muPhotoSp	-1.74	-2.32	-1.94	-1.73	-1.53	-1.15
muPhenoSp	27.04	24.09	26.03	27.05	28.02	29.94
betaTraitxForce	0.07	-1.88	-0.60	0.10	0.74	2.02
betaTraitxChill	0.07	-1.83	-0.61	0.08	0.75	2.06
betaTraitxPhoto	0.06	-1.96	-0.62	0.06	0.73	2.04
sigma_traity	0.04	0.04	0.04	0.04	0.04	0.04
sigma_sp	0.04	0.03	0.03	0.04	0.04	0.04
sigmaForceSp	2.64	2.04	2.40	2.61	2.85	3.38
sigmaChillSp	4.96	3.76	4.45	4.90	5.37	6.60
sigmaPhotoSp	1.19	0.77	1.02	1.18	1.35	1.71
sigmaPhenoSp	9.72	7.97	8.99	9.63	10.36	11.94
sigmapheno_y	9.51	9.31	9.43	9.51	9.58	9.71