

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

3 Deirdre Loughnan¹, Faith A M Jones¹, and E M Wolkovich¹

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5 ¹ Department of Forest and Conservation, Faculty of Forestry, University of British Columbia, 2424
6 Main Mall Vancouver, BC Canada V6T 1Z4.

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8 Corresponding Author: Deirdre Loughnan deirdre.loughnan@ubc.ca
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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 2. Most traits = some degree of latitudinal variation and an interactive effect with transect.
 - 30 (a) Found moderate to strong interaction between latitude and transect—but effects differed
31 by trait

- 32 (b) Both height and ssd = smaller trait values at higher latitudes (-0.6, UI: -1.3,0.1 for height,
33 0, UI: -0.1,0 for SSD)
- 34 (c) DBH = strongest response—2.8, UI: 1.3,4.3—largest diameters occurred in our more North-
35 ern populations
- 36 (d) C:N also increased with latitude—but relatively weak (0, UI: 0.0,0)
- 37 (e) Only LMA = no effect (0, UI: 0.0,0)
- 38 (f) Fig. 1
- 39 3. Found only two of our five traits were related to budburst phenology
- 40 (a) Only height and DBH correlated with budburst cues—responses were consistent across the
41 two traits
- 42 (b) Height and DBH: short trees had stronger forcing responses (0.1, UI: 0.0, 0.3 for height and
43 0.1, UI: 0.0, 0.2, Fig. 4 a and g)
- 44 (c) But weaker responses to photoperiod (-0.8, UI: -0.3, -0.1 for height and -0.1, UI: -0.2, 0.0,
45 Fig. 4 c and i)
- 46 4. Other three traits = no relationship to chilling, forcing, or photoperiod cues
- 47 (a) LMA, SSD, C:N = no relationship—posterior centred around zero (Fig. 4)
- 48 (b) our estimates of the betaTraitxCue parameters for these traits = fully informed by prior
49 not the data (Fig. 3)
- 50 (c) Also no correlation between between ring porosity of wood with our three cues—based on
51 spp means using posterior estimates 6.
- 52 5. By including trait effects—find traits can inform spp phenology
- 53 (a) Estimates bb using our model parameters show clear differences in bb timing between tree
54 and shrub spp 5
- 55 (b) Shrub spp were estimated to bb earlier—especially under stronger cues—tree spp were later
- 56 (c) But effects vary across traits = unique effects on cue responses—estimated order of spp bb
57 order differs between the two models

Figures

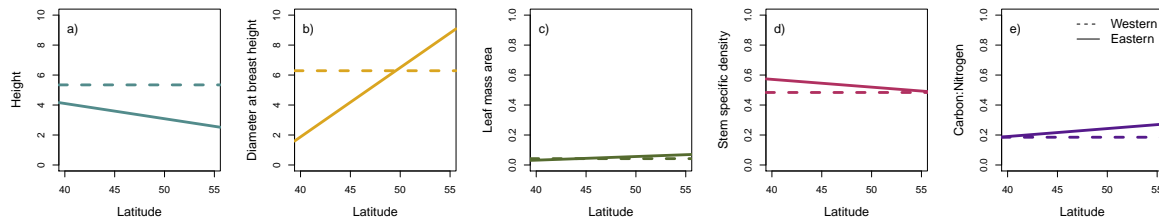


Figure 1: We only found biogeographic differences for four of our functional traits, with the direction of the relationship varying across traits. Both height a. height and b. diameter at base height showed strong interactions between latitude and trait values, while c. leaf mass area has the weakest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

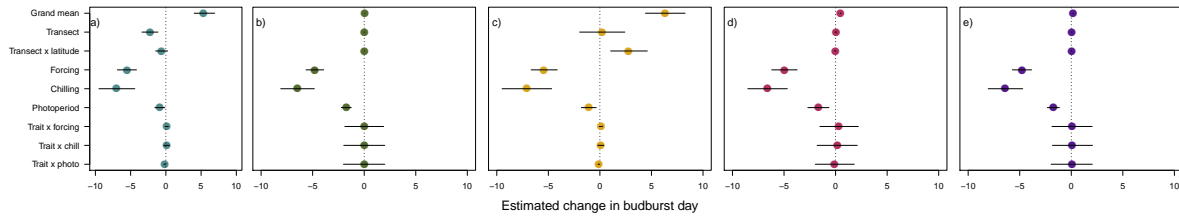


Figure 2: Estimated trait variation and cue responses to chilling, forcing, and photoperiod on budburst timing for 47 species, modelled for five traits: a. height, b. leaf mass area, c. diameter at breast height, d. stem specific density, and e. carbon:nitrogen. Of our five traits, only two appear to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

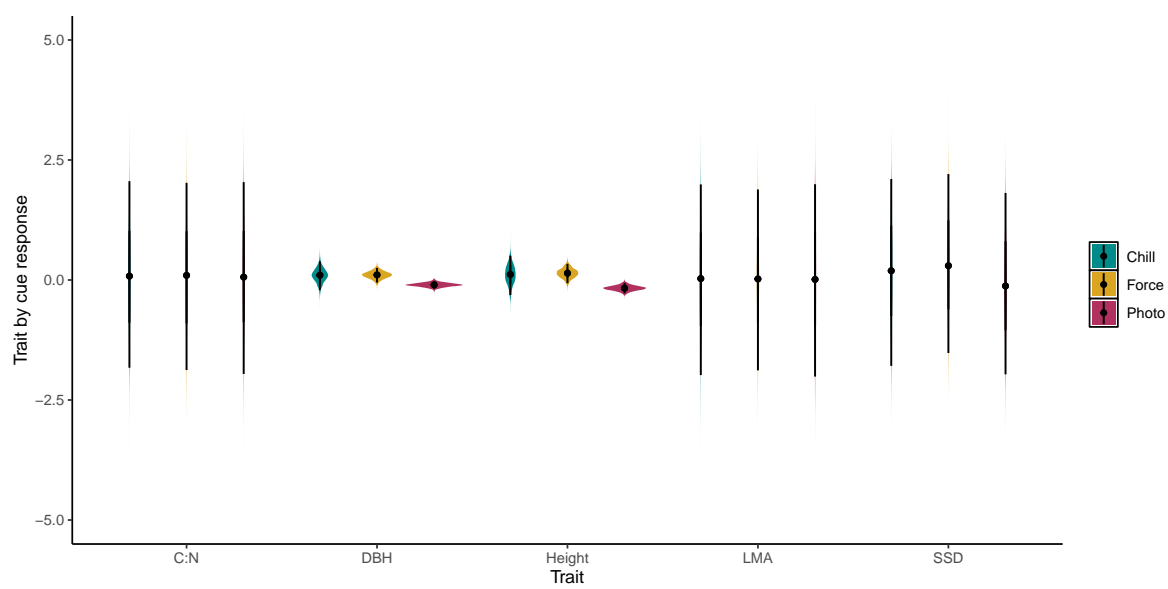


Figure 3: Only some traits were related to budburst phenological cues. For leaf mass area, stem specific density, and the ratio of carbon to nitrogen, traits no effect on budburst timing.

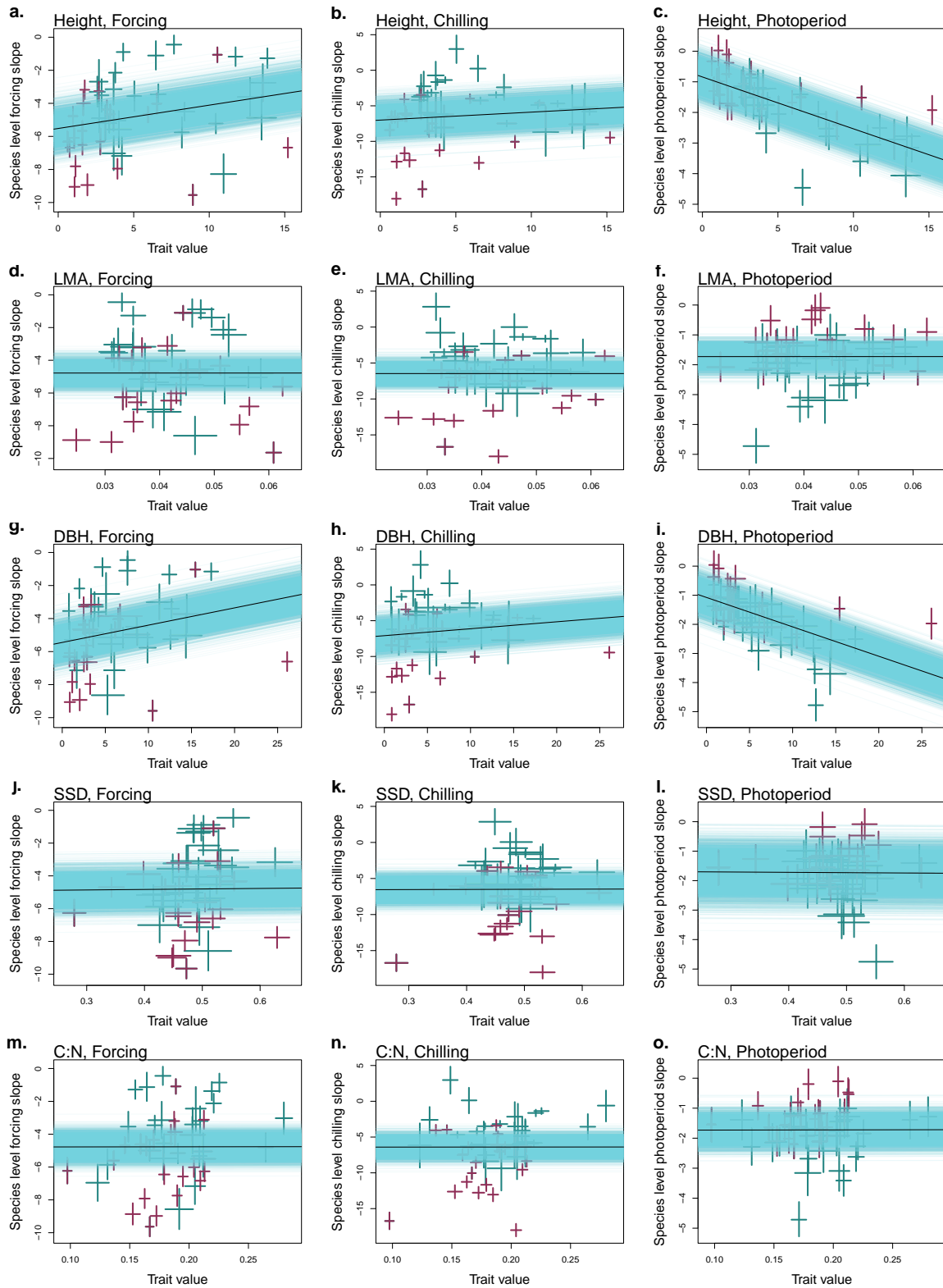


Figure 4: Relationship between species traits and cue responses, for height (a-c), leaf mass area (d-f), diameter at breast height (g-i), stem specific density (j-l), and the carbon to nitrogen ratio (m-o). Point colours representing different species groups, tree species are depicted in maroon and shrub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



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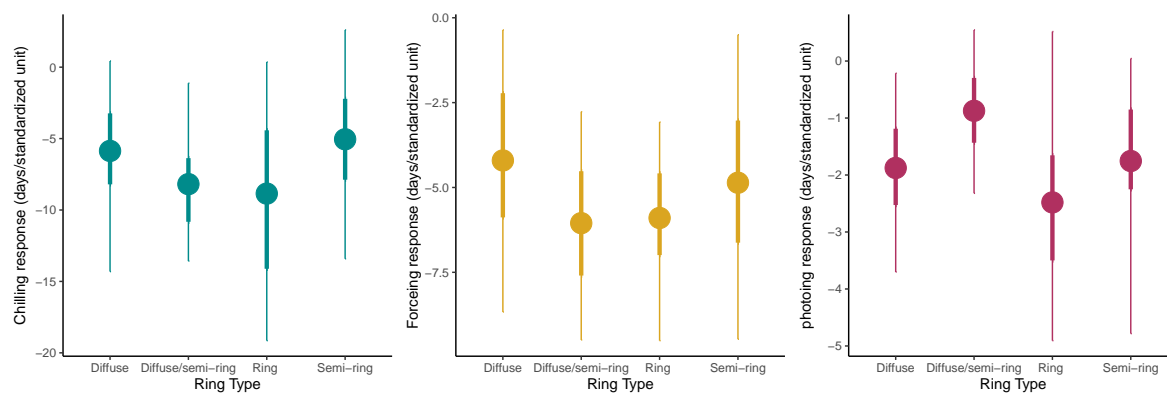


Figure 6: Despite differing in their wood structures and growth strategies, we did not find this trait to correlate with differences in cue responses across species.

59 **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 |