Woody plant phenological responses are strongly associated with key functional traits

Deirdre Loughnan[1], Faith A M Jones[1], Geoffrey Legault[1], Mira Garner[2], Darwin Sodhi[3], Daniel Buonaiuto[4], Catherine Chamberlain[5], Ignacio Morales Castilla [6], Ailene Ettinger[7], and E M Wolkovich[1]

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

[2] Arnold Arboretum of Harvard University, 1300 Centre Street, Boston, Massachusetts, USA;

[3] Organismic & Evolutionary Biology, Harvard University, 26 Oxford Street, Cambridge, Massachusetts, USA;

[4] XXXX

[5] XXXX

[6] Edificio Ciencias, Campus Universitario 28805 Alcalá de Henares, Madrid, Spain

[7] XXXX

Corresponding Author: Deirdre Loughnan deirdre.loughnan@ubc.ca

1 Summary

Key Words: Budburst phenology, functional traits, Trees, climate chagne

2 Introduction

3 Methods

4 Results

1. Functional traits did influence the timing of budburst date in response to forcing, chilling, and photoperiod cues
2. Trait effects varied with species and trait values
3. In modeling the effects of traits on cue responses we found: references Fig. 1
   (a) unique responses in height to forcing, a smaller advance in budburst with increasing forcing when height effects were included
   (b) increasing chilling & photoperiod lead to a stronger advance in budburst when height's effects were incldued
   (c) the trait effect of SLA resulted in weaker responses to increased forcing and chilling cues, but stronger responses with longer photoperiods.
   (d) For both log10 seed mass and LNC the trait effect was consistent across all three cues
   (e) the advance in budburst dates with increasing cues were stronger when the effect of log10 seed mass was accounted for
   (f) in contrast, the the advance when the effects of LNC were included was smaller as cues increased
4. Triats varied in whether responses in cue slopes followed the predicted gradients in trait values: referencing Fig. 2
   (a) taller species and species with larger seeds had stronger cue responses to chilling (-0.5 m per standardized chilling, , 90% uncertainty interval interval: -1, -0.1) and (-1.1 mg per standardized chilling, -2.8, 0.7, respectively) and photoperiod (-0.3 m per standardized photoperiod, -0.6, 0 for height and -0.6 mg per standardized photoperiod, -1.6, 0.4 for seed mass)
   (b) but taller species had weaker responses with forcing (0.2 m per standardized forcing, -0.1, 0.5), while large seeded species had stronger cue responses to forcing (-0.3 mg per standardized forcing, -1.4, 0.8), as we predicted
   (c) Species with large trait values of both leaf traits, SLA and LNC, had weaker cue responses to forcing and chilling ((0.2 mm^2/mg per standardized forcing, -0.1, 0.4), (0.3 mm^2/mg per standardized chilling, -0.1, 0.7) for SLA and (0.5 mg/g per standardized forcing, 0.1, 0.9) and (0.7 mg/g per standardized, 0.2, 1.2) for LNC)
   (d) but species with large SLA had stronger responses to photoperiod cues (-0.2 mm^2/mg per standardized photoperiod, -0.4, 0), while large LNC speices had weaker photoperiod cue responses (0.3 mg/g per standardized photoperiod, 0, 0.7)
5. Our trait model includes partial pooling across studies, allowing us to better partition the variance caused by study level differences: reference Fig. 3

(a) allows us to better account for differences in tree age, timing of sampling, local adaptation, or human error

(b) see a lot of variation in height data, which is our most commonly measured trait with measurements from 22 studies

(c) Seed mass comes from five studies and is least variable

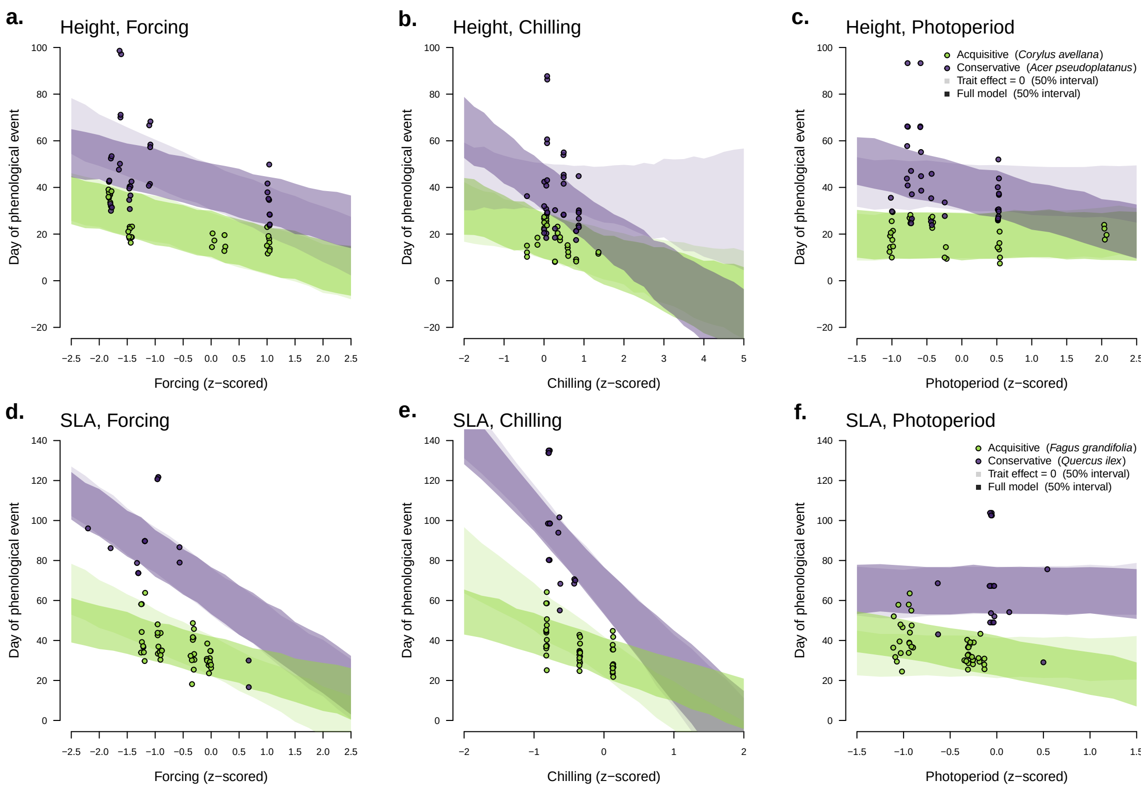

Figure 1: Comparisons of estimated cue responses of a species with an trait value associated with acquisitive growth strategies, shown in green, or conservative growth strategies, shown in purple. Points represent the raw budburst data for each respective species. Dark bands represent the 50% uncertainty interval for the posterior cue estimates for the full model, while opaque bands represent the 50% uncertainty interval interval for the posterior cue estimates with a trait effect of zero.

5 Discussion

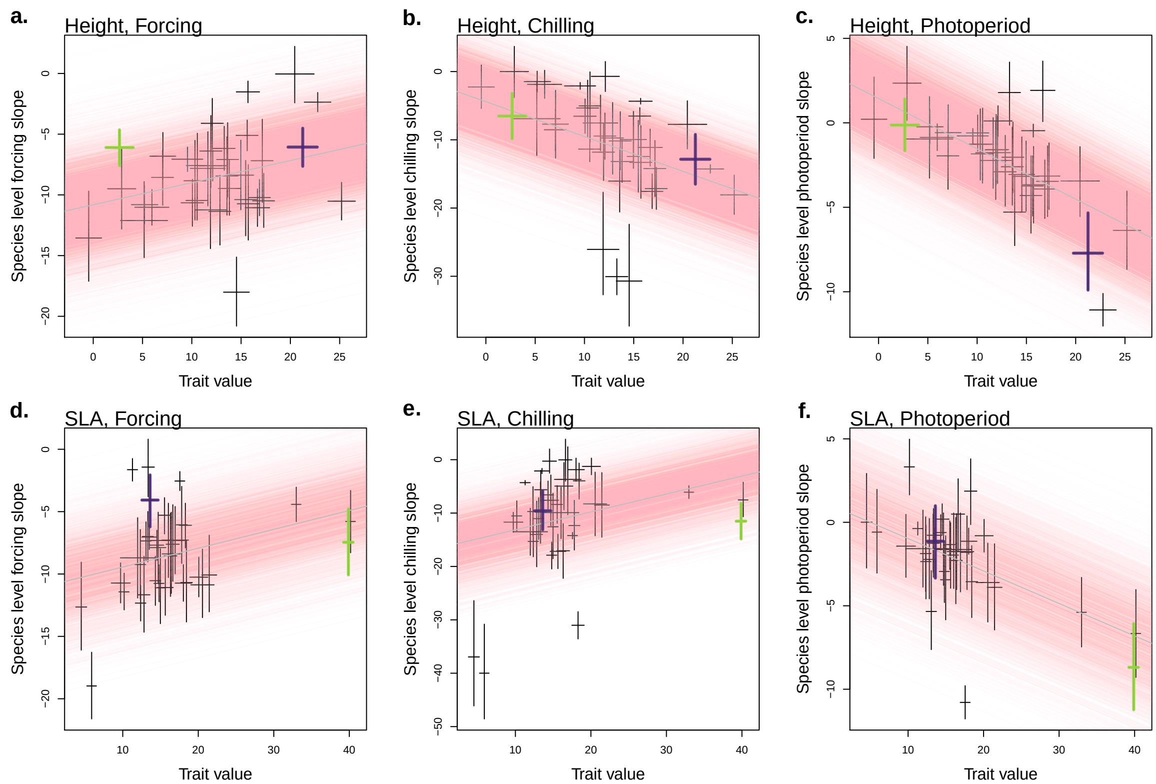

Figure 2: Estimated trait values for height (a-c) and SLA (d-f) traits, correlated against species level cue responses to forcing (a & d), chilling (b & e), and photoperiod cues (c & f). Parameters were estimated using our joint trait-phenology model, with the grey line depicting the mean linear relationship between estimated trait effects and the slope of the cue response. The pink shading represents the distribution of the posterior estimates. The species depicted in Fig 1 are highlighted in each panel, with the acquisitive species shown in green, and the conservative species, shown in purple.

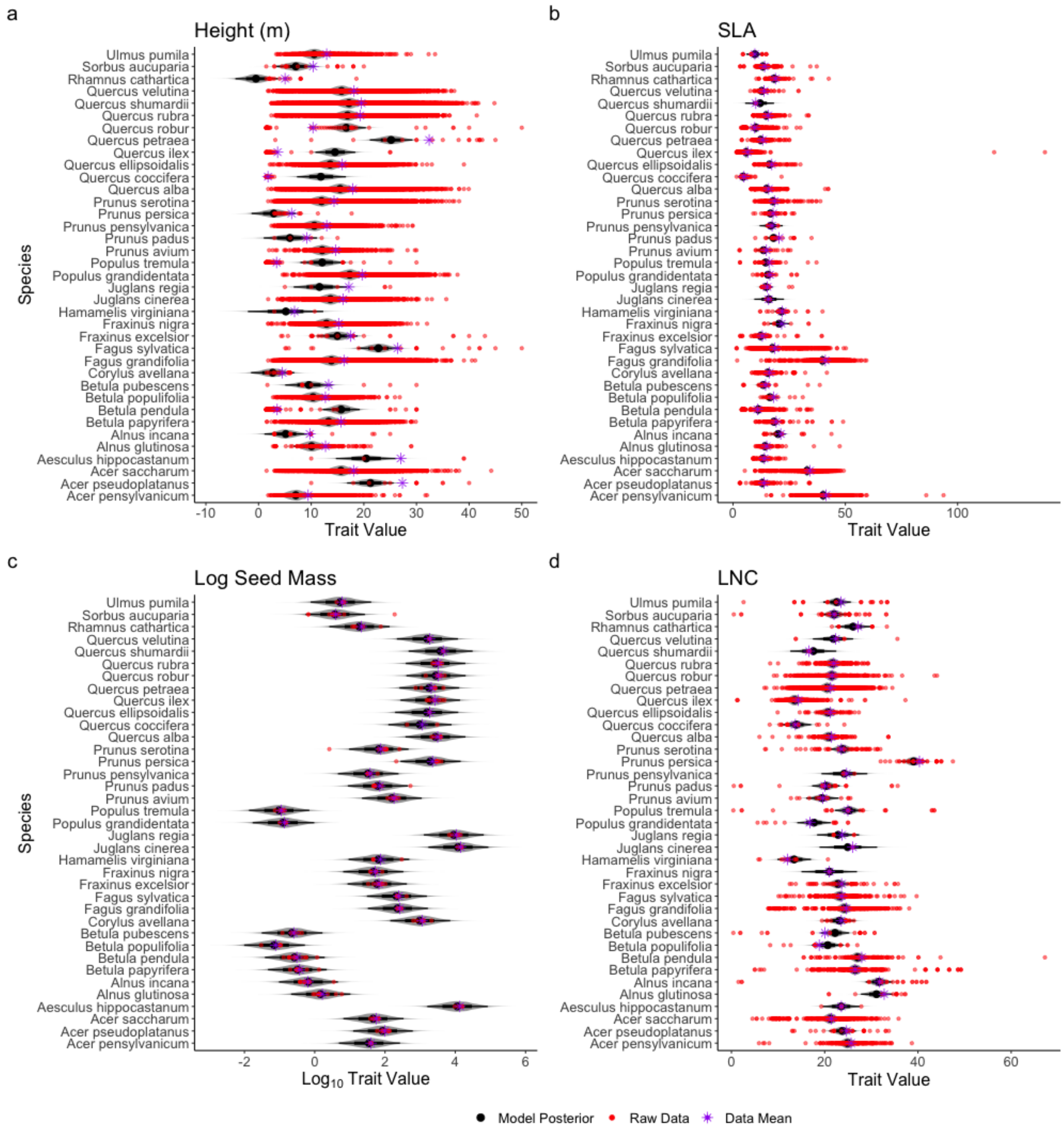

Figure 3: Comparisons of estimated model fits and raw data from joint models of trait effects on budburst phenological cues for 37 species of woody deciduous plants. Four functional traits – a. height, b. SLA, c. seed mass, and d. LNC – were modeled individually, with the calculated trait value being used to jointly model species responses to standardized chilling, forcing, and photoperiod cues. Model posteriors are shown in black, with the thicker line depicting the 66% interval and the thinner black line the 97% interval. Overall species level model posterior distributions were well aligned with the raw data, shown in red, and the speceis level means from the raw data, denoted as a purple stars.