

Supplemental Methods

The hierarchical linear phenology models we fit included response variable (y), which represents day of year of the phenological event (budburst, leafout, or flowering). Predictors were measured air temperature ($temp$) and soil moisture($mois$), which were standardized by subtracting the mean and dividing by the standard deviation. Random effects are species (sp , random slopes and intercepts), and site and year nested within site (random intercepts only); i represents each observation.

$$y_i = \alpha_{sp[i], site[year[i]]} + \beta_{temp_{sp[i]}} + \beta_{mois_{sp[i]}} + \beta_{temp:mois_{sp[i]}} + \epsilon_i \quad (1)$$

$$\alpha_{sp} \sim N(\mu_{sp}, \sigma_{sp}) \quad (2)$$

$$\mu_{site[year]} \sim N(\mu_{siteyr}, \sigma_{siteyr}) \quad (3)$$

$$\mu_{site} \sim N(\mu_{site}, \sigma_{site}) \quad (4)$$

$$\beta_{temp_{sp}} \sim N(\mu_{\beta_{temp}}, \sigma_{\beta_{temp}}) \quad (5)$$

$$\beta_{mois_{sp}} \sim N(\mu_{\beta_{mois}}, \sigma_{\beta_{mois}}) \quad (6)$$

$$\beta_{temp:mois_{sp}} \sim N(\mu_{\beta_{temp:mois}}, \sigma_{\beta_{temp:mois}}) \quad (7)$$

Supplemental Tables

Table S1: **Experimental sites and phenophases included in the ExPhen database.** Experimental sites correspond to the map (Figure S1). We give the study ID, location, source, years of data included, ecosystem, number of species, and phenophases included: budburst (bb), leafout (lo), flowering (fl), fruiting (fr), or senesence (sen) day of year. Note that some sites may have multiple sources; however, we list only one here. * denotes phenophases not included in this paper, because they were measured in fewer than three experiments.

study	location	source	data years	ecosystem	species	phenophases
exp01	Waltham, MA, USA	Hoeppner and Dukes 2012	2009-2011	grassland	44	bb,lo,fl
exp02	Montpelier, France	Morin et al. 2010	2004	temperate deciduous forest	5	fl,fr*
exp03	Duke Forest, NC, USA	Clark et al. 2014	2009-2014	temperate deciduous forest	37	bb,lo
exp04	Harvard Forest, MA, USA	Clark et al. 2014	2009-2012	temperate deciduous forest	29	bb,lo
exp07	Harvard Forest, MA, USA	Pelini et al. 2011	2010-2015	temperate deciduous forest	8	bb,lo,sen*
exp09	Stone Valley Forest, PA, USA	Rollinson and Kaye 2012	2009-2010	temperate deciduous forest	120	lo,fl,fr*,sen*
exp10	Duke Forest, NC, USA	Marchin et al. 2015	2010-2013	temperate deciduous forest	11	bb,fl
exp12	Kessler Farm Field Laboratory, OK, USA	Sherry et al. 2007	2003	grassland	12	fl,fr*

Table S2: **Summaries of budburst, leafout, and flowering models** with centered predictors.

	Average Effects						Species Effects			Site Effects			Site-Year Effects		
	mean	error	25%	75%	5%	95%	mean	error	Ngrp	mean	error	Ngrp	mean	error	Ngrp
BB μ_{α}	97.20	5.10	94.00	100.40	88.60	105.20	16.00	2.40	41	7.3	5	5	9.3	2.4	13
BB μ_{temp}	-7.90	2.10	-9.20	-6.50	-11.30	-4.50	11.40	1.60							
BB μ_{mois}	-1.70	0.60	-2.10	-1.30	-2.80	-0.70	2.70	0.60							
BB $\mu_{temp:mois}$	0.50	0.50	0.20	0.80	-0.40	1.30	1.70	0.70							
LO μ_{α}	129.90	11.00	123.20	136.40	111.90	147.90	12.20	2.10	137	24.3	10.4	5	12.5	4	13
LO μ_{temp}	-10.30	1.40	-11.30	-9.40	-12.70	-7.90	10.30	1.30							
LO μ_{mois}	-0.40	0.90	-1.00	0.20	-2.00	1.00	3.80	1.10							
LO $\mu_{temp:mois}$	0.50	0.70	0.10	1.00	-0.60	1.60	4.60	0.60							
FL μ_{α}	167.00	9.00	161.80	172.00	153.00	180.70	48.20	3.50	124	11.6	10	5	8	4.6	8
FL μ_{temp}	-7.90	1.30	-8.80	-7.10	-10.20	-5.80	6.20	1.20							
FL μ_{mois}	-1.30	0.90	-1.90	-0.70	-2.80	0.20	3.80	1.10							
FL $\mu_{temp:mois}$	-1.10	0.70	-1.60	-0.60	-2.30	0.10	2.70	0.90							

Supplemental Figures

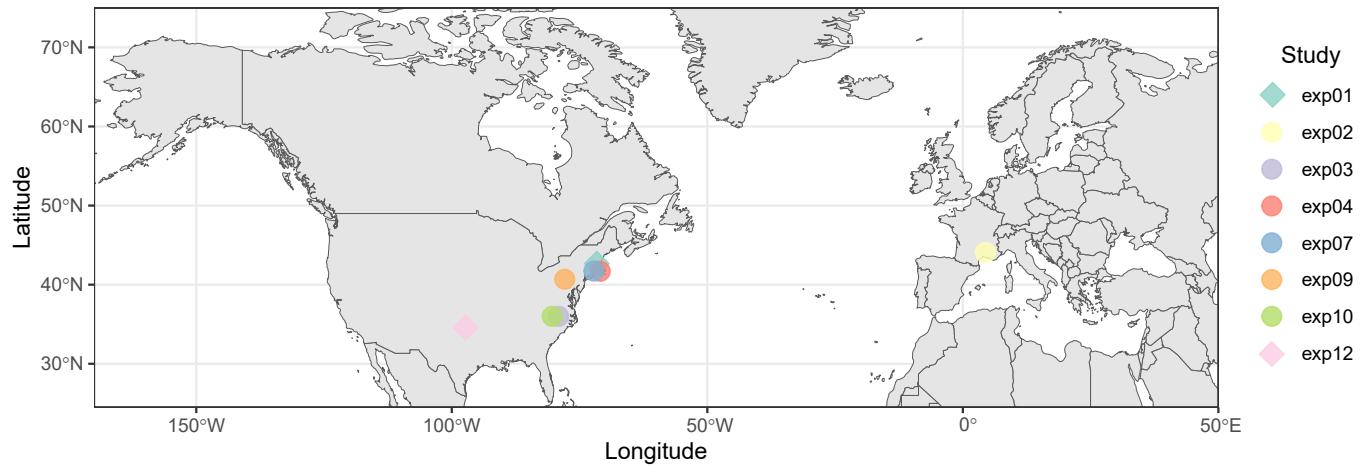


Figure S1: **Map of locations of experiments** included in this meta-analysis. Circles represent experimental studies in forest ecosystems; diamonds are those in grasslands. See Table S1 for study details.

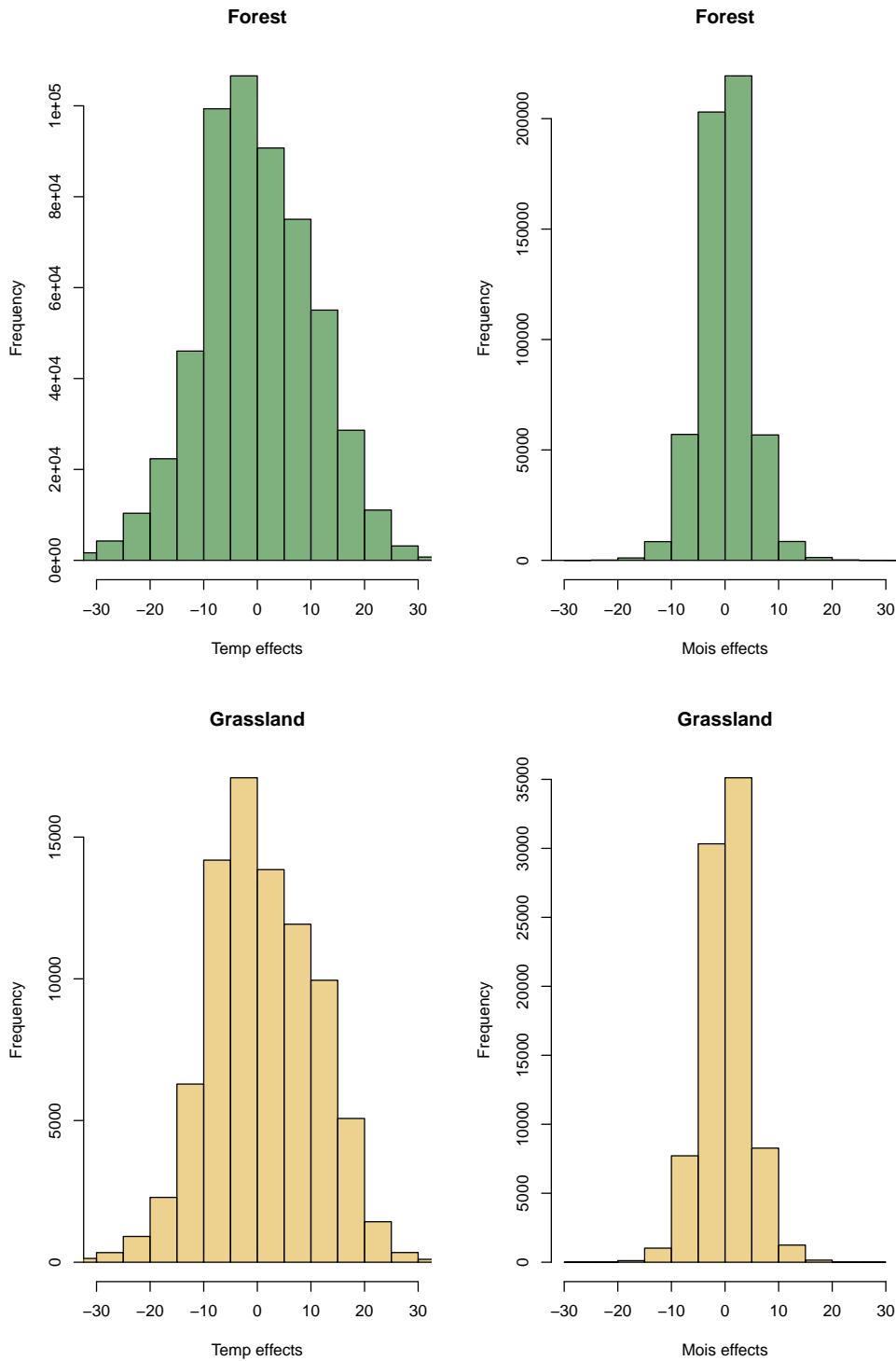


Figure S2: Effects of temperature and soil moisture do not differ strongly across ecosystems (forest vs grassland) for leafout (top) and budburst (bottom) models..

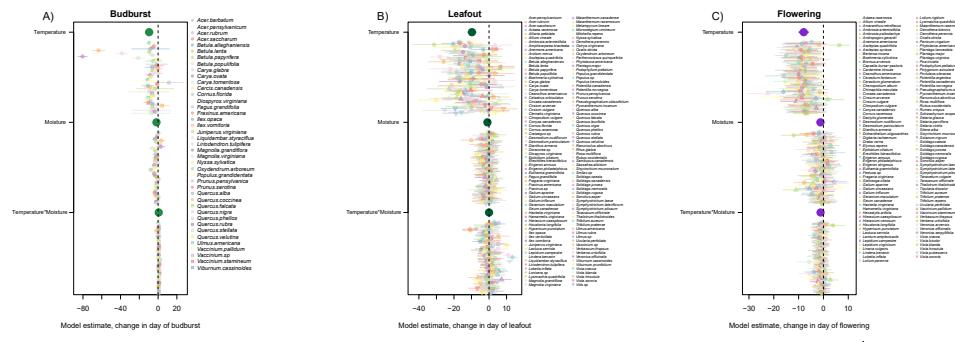


Figure S3: Model coefficients from budburst, leafout, and flowering models (with centered predictors) for all species included in our models.