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Supporting Information: Weak evidence of provenance effects in spring phenology across Europe and North America

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1 Additional Methods

We had to exclude several studies that reported spring events on a quantitative scale. This was because (1) such studies usually only assessed where on the scale the spring event of a tree fell onto on the same days across different years (e.g. Robson et al., 2013; Vander et al., 2015; Santini et al., 2014; Schueler & Liesebach, 2004), and (2) scales are not always consistent across different studies (Chmura & Rozkowski 2002; Dhont et al., 2010; Wang et al., 2022). Such factors made it impossible to convert the quantitative scale to DOY.

We additionally excluded several studies because we could not pinpoint their location, or because they focused on non-native species or elevational trends. We excluded studies that did not provide the exact latitude and longitude of the common garden (Bongarten, 1978) or the provenances (Hall et al., 2007; Soolanayakanahally et al., 2013), or they did not link the latitude and longitude of each provenance to the DOY of spring events (Deans & Harvey, 1996). We also left out studies in which woody plants from North American provenances were planted in common gardens in Europe (Cannell et al., 1987; Lavadinovic et al., 2013) because we wanted to test continental variations. Finally, as we are focused on latitudinal trends we excluded studies that examined only provenance altitude (Vitasse et al., 2009; Vitasse et al., 2010; Li et al., 1997; Alberto et al., 2011; Acevedo-Rodríguez et al., 2006).

Table 1: This table includes all publications that met search criteria for this meta-analysis. Some studies had more than one gardens and two studies shared the same garden (D)

No.	**Publication**	**Continent**	**Garden ID**	**Species**	**Species Type**	**Spring Event Definition**	**Fall Event**	**Fall Event Definition**
1	Hamann et al., 1998	North America	A	*Alnus rubra*	Angiosperm	Bud burst	Yes	Leaf abscission
2	Rehfeldt, 1994	North America	B	*Picea engelmannii*	Gymnosperm	Bud burst	Yes	Leaf cessation
3	Bower Aitken, 2008	North America	C	*Pinus albicaulis*	Gymnosperm	Leaf flush	No	n.a.
4	McKown et al., 2013	North America	D	*Populus trichocarpa*	Angiosperm	Bud burst Leaf flush	Yes	Bud set
5	Mimura Aitken 2007	North America	D	*Picea sitchensis*	Gymnosperm	Bud burst	Yes	Bud set
6	Kuser, 1980	North America	E	*Tsuga heterophylla*	Gymnosperm	Bud burst	Yes	Bud set
7	Farmer, 1993	North America	F	*Populus balsamifera*	Angiosperm	Bud burst	No	n.a.
8	Hannerz et al., 1999	North America	G	*Tsuga heterophylla*	Gymnosperm	Bud burst	No	n.a.
9	White et al., 1979	North America	H	*Pseudotsuga menziesii*	Gymnosperm	Bud burst	No	n.a.
10	Guo et al., 2021	North America	I	*Picea mariana*	Gymnosperm	Bud burst	No	n.a.
11	Dixit et al., 2020	North America	J	*Pinus ponderosa*	Gymnosperm	Bud burst	No	n.a.
12	Hawkins Dhar 2012	North America	K/L/M	*Betula papyrifera*	Angiosperm	Bud burst	No	n.a.
13	Rosique-Esplugas, 2021	Europe	Q*	*Fraxinus excelsior*	Angiosperm	Leaf flush	Yes	Leaf senescence
14	Petkova et al., 2017	Europe	R*	*Fagus sylvatica*	Angiosperm	Bud burst	Yes	Leaf senescence
15	Sogaard et al., 2008	Europe	S*	*Picea abies*	Gymnosperm	Bud burst	No	n.a.
16	Gömöry Paule 2011	Europe	T*	*Fagus sylvatica*	Angiosperm	Bud burst	No	n.a.
17	Alberto et al., 2011	Europe	U*/V*	*Quercus petraea*	Angiosperm	Bud burst	No	n.a.

Table 2: Model summary of the relationship between spring event day of year (DOY)and provenance latitude (lat_prov), fitted by different species within a garden (species_garden). European gardens and species are denoted by an asterisk(*).

Parameter	**mean**	**sd**	**10%**	**50%**	**90%**
(Intercept)	112.6	5.4	105.8	112.6	119.4
b[lat_prov species_garden:*Alnus_rubra_A]*	-0.7	0.3	-1.1	-0.7	-0.4
b[lat_prov species_garden:*Betula_papyrifera_K]*	1.1	0.4	0.5	1.1	1.6
b[lat_prov species_garden:*Betula_papyrifera_L]*	0.9	0.4	0.4	0.9	1.4
b[lat_prov species_garden:*Betula_papyrifera_M]*	0.8	0.4	0.3	0.8	1.3
b[lat_prov species_garden:*Fagus_sylvatica_R*]*	0.2	0.3	-0.2	0.2	0.7
b[lat_prov species_garden:*Fagus_sylvatica_T*]*	0.2	0.2	-0.1	0.2	0.4
b[lat_prov species_garden:*Fraxinus_excelsior_Q*]*	0.9	0.3	0.4	0.9	1.3
b[lat_prov species_garden:*Picea_abies_S*]*	-0.4	0.5	-1	-0.3	0.2
b[lat_prov species_garden:*Picea_engelmannii_B]*	0	0.2	-0.3	0	0.2
b[lat_prov species_garden:*Picea_mariana_I]*	-0.3	0.5	-0.9	-0.3	0.2
b[lat_prov species_garden:*Picea_sitchensis_D]*	-0.1	0.2	-0.4	-0.1	0.1
b[lat_prov species_garden:*Pinus_albicaulis_C]*	-1.2	0.3	-1.6	-1.2	-0.7
b[lat_prov species_garden:*Pinus_ponderosa_J]*	-0.5	0.7	-1.4	-0.5	0.4
b[lat_prov species_garden:*Populus_balsamifera_F]*	0.2	0.4	-0.3	0.2	0.8
b[lat_prov species_garden:*Populus_trichocarpa_D]*	0.7	0.2	0.5	0.7	1
b[lat_prov species_garden:*Pseudotsuga_menziesii_H]*	0.6	0.3	0.2	0.6	1
b[lat_prov species_garden:*Quercus_petraea_U*]*	-0.1	0.7	-1	-0.1	0.8
b[lat_prov species_garden:*Quercus_petraea_V*]*	-0.1	0.7	-1	-0.1	0.7
b[lat_prov species_garden:*Tsuga_heterophylla_E]*	-0.8	0.3	-1.2	-0.8	-0.4
b[lat_prov species_garden:*Tsuga_heterophylla_G]*	0.6	0.5	0	0.6	1.3
sigma	5.1	0.1	4.9	5.1	5.3
Sigma[species_garden:(Intercept),(Intercept)]	1604.9	600.8	957.6	1491.2	2411.2
Sigma[species_garden:lat_prov,(Intercept)]	-23	10.3	-36.6	-21.2	-11.7
Sigma[species_garden:lat_prov,lat_prov]	0.5	0.2	0.3	0.5	0.8

Table 3: Model summary of the relationship between spring event day of year (DOY)and provenance MAT (MAT_prov), fitted by different species within a garden (species_garden). European gardens and species are denoted by an asterisk(*).

Parameter	**mean**	**sd**	**10%**	**50%**	**90%**
(Intercept)	115.1	5.1	108.7	115	121.7
b[MAT_prov species_garden:*Alnus_rubra_A]*	0.9	0.5	0.2	0.9	1.5
b[MAT_prov species_garden:*Betula_papyrifera_K]*	-3.4	0.7	-4.4	-3.4	-2.5
b[MAT_prov species_garden:*Betula_papyrifera_L]*	-2.1	0.7	-3	-2.1	-1.2
b[MAT_prov species_garden:*Betula_papyrifera_M]*	-1.4	0.7	-2.3	-1.4	-0.5
b[MAT_prov species_garden:*Fagus_sylvatica_R*]*	-0.5	0.7	-1.4	-0.5	0.4
b[MAT_prov species_garden:*Fagus_sylvatica_T*]*	1	0.3	0.6	1	1.5
b[MAT_prov species_garden:*Fraxinus_excelsior_Q*]*	-1.2	0.6	-1.9	-1.2	-0.4
b[MAT_prov species_garden:*Picea_abies_S*]*	1.1	0.9	0	1.1	2.2
b[MAT_prov species_garden:*Picea_engelmannii_B]*	0.1	0.3	-0.4	0.1	0.5
b[MAT_prov species_garden:*Picea_mariana_I]*	0.6	0.6	-0.2	0.6	1.3
b[MAT_prov species_garden:*Picea_sitchensis_D]*	0.3	0.4	-0.2	0.3	0.8
b[MAT_prov species_garden:*Pinus_albicaulis_C]*	2.3	0.7	1.4	2.3	3.2
b[MAT_prov species_garden:*Pinus_ponderosa_J]*	-0.1	0.5	-0.7	-0.1	0.5
b[MAT_prov species_garden:*Populus_balsamifera_F]*	-0.3	0.6	-1	-0.3	0.4
b[MAT_prov species_garden:*Populus_trichocarpa_D]*	-0.6	0.2	-0.9	-0.6	-0.3
b[MAT_prov species_garden:*Pseudotsuga_menziesii_H]*	-0.4	0.3	-0.8	-0.4	0
b[MAT_prov species_garden:*Quercus_petraea_U*]*	-0.5	0.4	-1	-0.5	-0.1
b[MAT_prov species_garden:*Quercus_petraea_V*]*	-0.8	0.4	-1.3	-0.8	-0.4
b[MAT_prov species_garden:*Tsuga_heterophylla_E]*	3.9	0.7	3.1	3.9	4.8
b[MAT_prov species_garden:*Tsuga_heterophylla_G]*	-0.8	1.3	-2.5	-0.8	0.8
sigma	4.9	0.1	4.8	4.9	5.1
Sigma[species_garden:(Intercept),(Intercept)]	537.4	170.4	349.2	508.8	760.8
Sigma[species_garden:MAT_prov,(Intercept)]	-9.7	10	-22.2	-8.7	1.6
Sigma[species_garden:MAT_prov,MAT_prov]	3.4	1.5	1.9	3.2	5.3

Table 4: Model summary of the relationship between fall event day of year (DOY)and provenance latitude (lat_prov), fitted by different species within a garden (species_garden). European gardens and species are denoted by an asterisk (*).

Parameter	**mean**	**sd**	**10%**	**50%**	**90%**
(Intercept)	325.5	35	287.1	318.9	373.9
b[lat_prov species_garden:*Alnus_rubra_A]*	-2.3	0.5	-3	-2.3	-1.6
b[lat_prov species_garden:*Fagus_sylvatica_R*]*	0.2	0.6	-0.5	0.3	1
b[lat_prov species_garden:*Fraxinus_excelsior_Q*]*	-1.2	0.6	-1.9	-1.2	-0.5
b[lat_prov species_garden:*Picea_engelmannii_B]*	-0.1	0.3	-0.5	-0.1	0.3
b[lat_prov species_garden:*Picea_sitchensis_D]*	-5.5	0.3	-5.9	-5.5	-5.2
b[lat_prov species_garden:*Populus_trichocarpa_D]*	-9.5	0.3	-9.9	-9.5	-9.1
b[lat_prov species_garden:*Tsuga_heterophylla_E]*	-3.8	0.4	-4.3	-3.8	-3.3
sigma	8.2	0.3	7.8	8.2	8.6
Sigma[species_garden:(Intercept),(Intercept)]	13147.6	4738.9	7953.6	12418.3	19373.1
Sigma[species_garden:lat_prov,(Intercept)]	-326.3	126.5	-481.1	-309.2	-191.2
Sigma[species_garden:lat_prov,lat_prov]	12.2	8.4	6.5	10.2	19.2

Table 5: Model summary of the relationship between fall event day of year (DOY)and provenance MAT (MAT_prov), fitted by different species within a garden (species_garden). European gardens and species are denoted by an asterisk(*).

Parameter	**mean**	**sd**	**10%**	**50%**	**90%**
(Intercept)	270.3	23.1	238.7	273.6	296.9
b[MAT_prov species_garden:*Alnus_rubra_A]*	2.8	1.1	1.4	2.8	4.3
b[MAT_prov species_garden:*Fagus_sylvatica_R*]*	-0.2	1.6	-2.2	-0.2	1.9
b[MAT_prov species_garden:*Fraxinus_excelsior_Q*]*	1.6	1.3	-0.1	1.6	3.4
b[MAT_prov species_garden:*Picea_engelmannii_B]*	0.3	0.8	-0.7	0.2	1.2
b[MAT_prov species_garden:*Picea_sitchensis_D]*	11.2	0.9	10.1	11.1	12.3
b[MAT_prov species_garden:*Populus_trichocarpa_D]*	10.5	0.5	9.9	10.5	11.2
b[MAT_prov species_garden:*Tsuga_heterophylla_E]*	7.3	0.9	6.2	7.3	8.5
sigma	10.7	0.4	10.2	10.7	11.3
Sigma[species_garden:(Intercept),(Intercept)]	4746.1	2270.5	2455.2	4247.7	7676.8
Sigma[species_garden:MAT_prov,(Intercept)]	-328	177.8	-545.8	-301.2	-150.8
Sigma[species_garden:MAT_prov,MAT_prov]	40.8	28.3	19.4	33.4	68.8

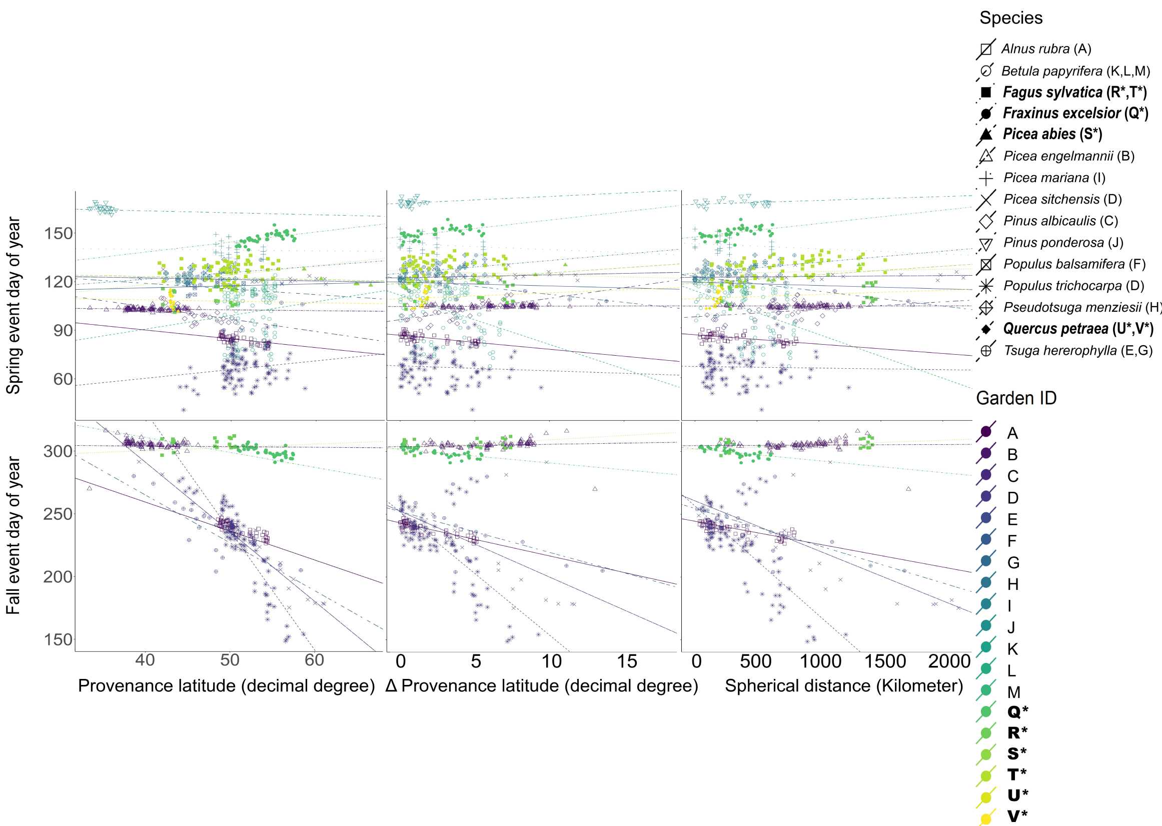

Figure 1: Results were similar across different distance metrics: provenance latitude, difference between provenance and garden latitude, and spherical distance between provenance and garden.

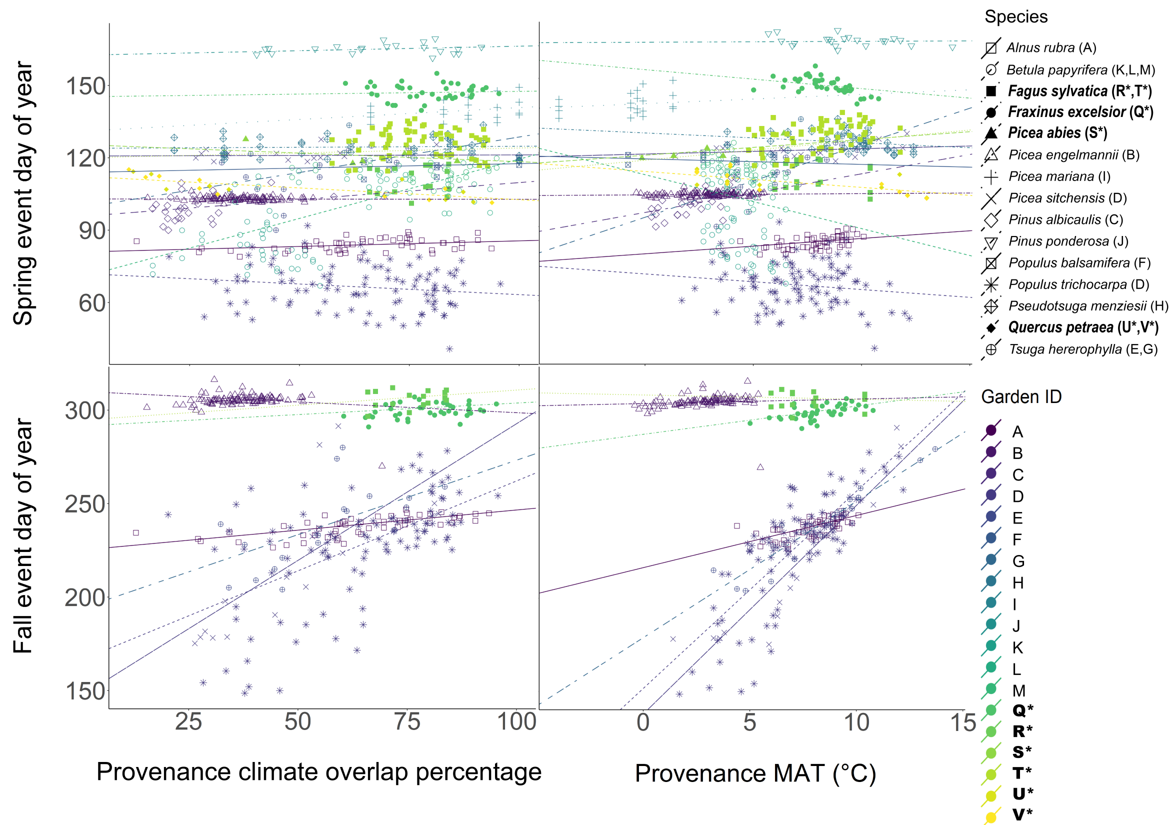

Figure 2: Results from using climate overlap were not qualitatively different than using MAT.

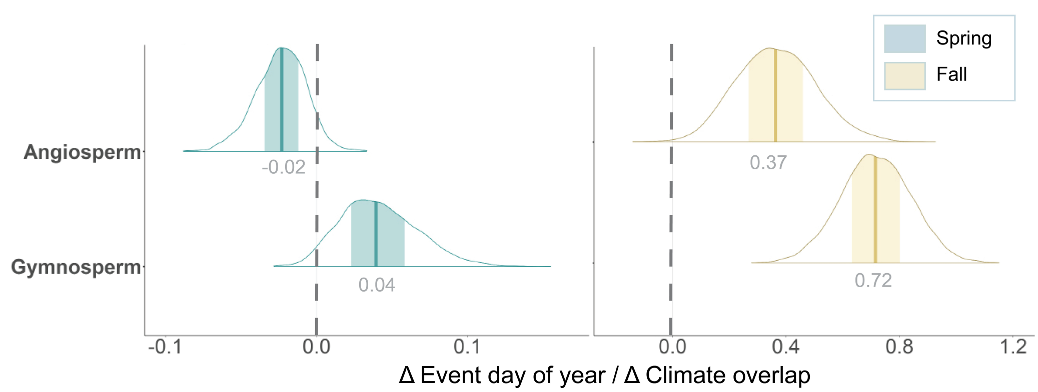

Figure 3: We observed very weak effects of climate overlap on spring events (0.01 [0.02 - 0.03] days per one per cent increase in climate overlap), nearly identical across angiosperms (0.02 [0.00 - 0.05]) and gymnosperms (0.04 [0.00 - 0.09]). Fall events advanced as climate overlap declined, but slightly more strongly for gymnosperms (advancing 0.72 [0.51 - 0.92] days per one per cent decline in climate overlap).