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Warming shortens flowering seasons of tundra plant communities

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Supplementary information for: Warming shortens flowering seasons of tundra plant communities

Supplementary Table S1. Information on the Arctic and alpine sites included in the synthesis. The column: 'Type of data' indicates if sites had phenology data from long-term **monitoring** plots, **warming** experiments, or **both** types of data. 'Species' and 'Years' indicate the total number of species and years of data from each site. The elevations given below are site averages, since some sites collected data at different elevations.

Site	Latitude	Longitude	Elev. (m)	Mean sum. Temp (C)	Data type	Species	Years
Adventalen, Svalbard	78° 9'N	16° 6'E	50	4.0	monitoring	12	4
Alexandra Fiord, Canada	78° 53'N	75° 55'W	20	4.7	both	6	19
Atqasuk, USA	70° 27'N	157° 24'W	22	5.4	both	16	11
Utqiāgvik, USA	71° 18'N	156° 40'W	5	2.8	both	28	15
Daring Lake, Canada	64° 52'N	111° 35'W	430	10.1	both	7	18
Endalen, Svalbard	78° 13'N	15° 39'E	100	9.9	both	6	4
Bogong, Australia	36° 53'S	147° 18'E	1750	4.9	both	15	6
Faroe Islands	62° 04'N	6° 57'W	600	10.3	both	2	4
Finse, Norway	60° 36'N	7° 31'E	1475	9.3	both	4	4
Foscagno Pass, Italy	46° 28'N	10° 16'E	2485	5.5	monitoring	36	8
Healy, USA	63° 52'N	149° 15'W	115	11.9	both	6	5
Qikiqtaruk, Canada	69° 34'N	139° 4'W	42	6.3	monitoring	3	14
Jakabshorn, Switzerland	46° 46'N	9° 50' E	2398	8.0	warming	23	1
Kangerlussuaq, Greenland	67° 6'N	50° 19'W	288	6.8	both	10	12
Latnjajaure, Sweden	68° 20'N	18° 30'E	1000	8.5	both	144	10
Niwot Ridge, USA	40° 6'N	105° 24'W	3500	5.8	warming	18	2
Nuuk, Greenland	64° 7'N	51° 21'W	5	8.6	monitoring	3	4
Stillberg, Switzerland	46° 46'N	9° 52'E	2180	7.7	monitoring	4	3
Tanquary Fiord, Canada	81° 24'N	76° 52'W	4	4.1	monitoring	2	20
Toolik Lake, USA	68° 38'N	149° 38'W	720	9.3	both	17	13
Val Bercla, Switzerland	46° 28'N	9° 34'E	2490	6.1	warming	11	2
White Mountains, USA	37° 30'N	118° 10'W	3400	9.3	warming	2	1
Zackenberg, Greenland	74° 30'N	20° 34'W	40	3.7	monitoring	6	16

Supplementary Table 2. List of the plant species with phenological data used in analyses, followed by the functional group, phenological niche (mean day of year of flowering over all years of measurements at that site), and the summer time window that yearly temperatures were averaged over for each species at each site. For species that were only included in the analyses of experimental warming data, the ‘summer temp.’ is listed as ‘Experiment’ to indicate that we used the difference in flowering dates between experimentally warmed and control plots as our response variable. The flowering dates for the Southern hemisphere alpine site, Bogong, were adjusted by 210 days to match that of the Northern hemisphere growing season.

Site	Species	Functional group	Phenological niche (DOY)	Summer temp.
Adventdalen	<i>Alopecurus magellanicus</i>	Graminoid	194	June-July
Adventdalen	<i>Cardamine bellidifolia</i>	Forb	186	June-July
Adventdalen	<i>Cassiope tetragona</i>	Evergreen shrub	187	June-July
Adventdalen	<i>Cerastium arcticum</i>	Forb	199	June-July
Adventdalen	<i>Dryas octopetala</i>	Evergreen shrub	192	June-July
Adventdalen	<i>Luzula confusa</i>	Graminoid	186	June-July
Adventdalen	<i>Oxyria digyna</i>	Forb	186	June-July
Adventdalen	<i>Pedicularis hirsuta</i>	Forb	190	June-July
Adventdalen	<i>Polygonum viviparum</i>	Forb	205	June-July
Adventdalen	<i>Salix polaris</i>	Deciduous shrub	181	June
Adventdalen	<i>Saxifraga oppositifolia</i>	Forb	178	June
Adventdalen	<i>Stellaria crassipes</i>	Forb	200	June-July
Alexandra Fiord	<i>Cassiope tetragona</i>	Evergreen shrub	183	June-July
Alexandra Fiord	<i>Dryas integrifolia</i>	Evergreen shrub	186	June-July
Alexandra Fiord	<i>Luzula arctica</i>	Graminoid	186	June-July
Alexandra Fiord	<i>Oxyria digyna</i>	Forb	183	June
Alexandra Fiord	<i>Papaver radicatum</i>	Forb	192	June-July
Alexandra Fiord	<i>Salix arctica</i>	Deciduous shrub	180	June
Atqasuk	<i>Carex aquatilis</i>	Graminoid	186	June-July
Atqasuk	<i>Carex bigelowii</i>	Graminoid	176	June
Atqasuk	<i>Cassiope tetragona</i>	Evergreen shrub	175	June
Atqasuk	<i>Diapensia lapponica</i>	Forb	175	June
Atqasuk	<i>Dupontia fisheri</i>	Graminoid	200	June-July
Atqasuk	<i>Eriophorum russeolum</i>	Graminoid	178	June
Atqasuk	<i>Eriophorum triste</i>	Graminoid	177	June
Atqasuk	<i>Hieracium alpinum</i>	Forb	181	June
Atqasuk	<i>Ledum palustre</i>	Evergreen shrub	182	June
Atqasuk	<i>Luzula arctica</i>	Graminoid	170	June
Atqasuk	<i>Luzula confusa</i>	Graminoid	180	June
Atqasuk	<i>Pedicularis sudetica</i>	Forb	192	June-July
Atqasuk	<i>Polygonum bistorta</i>	Forb	188	June-July
Atqasuk	<i>Polygonum viviparum</i>	Forb	201	June-July
Atqasuk	<i>Salix phlebophylla</i>	Deciduous shrub	175	June
Atqasuk	<i>Vaccinium vitis-idaea</i>	Evergreen shrub	189	June-July

Utqiāgvik	<i>Arctagrostis latifolia</i>	Graminoid	213	June-July
Utqiāgvik	<i>Cardamine pratensis</i>	Forb	223	June-August
Utqiāgvik	<i>Carex aquatilis</i>	Graminoid	204	June-July
Utqiāgvik	<i>Carex subspathacea</i>	Graminoid	206	June-July
Utqiāgvik	<i>Cassiope tetragona</i>	Evergreen shrub	188	June-July
Utqiāgvik	<i>Cochlearia officinalis</i>	Forb	195	June-July
Utqiāgvik	<i>Draba alpina</i>	Forb	178	June
Utqiāgvik	<i>Draba lactea</i>	Forb	191	June-July
Utqiāgvik	<i>Dupontia fisheri</i>	Graminoid	215	June-July
Utqiāgvik	<i>Eriophorum russeolum</i>	Graminoid	199	June-July
Utqiāgvik	<i>Eriophorum triste</i>	Graminoid	205	June-July
Utqiāgvik	<i>Hierochloe pauciflora</i>	Graminoid	203	June-July
Utqiāgvik	<i>Juncus biglumis</i>	Graminoid	200	June-July
Utqiāgvik	<i>Luzula arctica</i>	Graminoid	185	June-July
Utqiāgvik	<i>Luzula confusa</i>	Graminoid	194	June-July
Utqiāgvik	<i>Papaver hultenii</i>	Forb	197	June-July
Utqiāgvik	<i>Pedicularis langsdorffii</i>	Forb	177	June
Utqiāgvik	<i>Poa arctica</i>	Graminoid	212	June-July
Utqiāgvik	<i>Potentilla hyparctica</i>	Forb	188	June-July
Utqiāgvik	<i>Ranunculus nivalis</i>	Forb	184	June-July
Utqiāgvik	<i>Salix rotundifolia</i>	Deciduous shrub	178	June
Utqiāgvik	<i>Saxifraga cernua</i>	Forb	219	June-August
Utqiāgvik	<i>Saxifraga foliolosa</i>	Forb	216	June-August
Utqiāgvik	<i>Saxifraga hieraciifolia</i>	Forb	203	June-July
Utqiāgvik	<i>Saxifraga hirculus</i>	Forb	209	June-July
Utqiāgvik	<i>Saxifraga punctata</i>	Forb	194	June-July
Utqiāgvik	<i>Senecio atropurpureus</i>	Forb	207	June-July
Utqiāgvik	<i>Stellaria laeta</i>	Forb	208	June-July
Bogong	<i>Asterolasia trymalioides</i>	Evergreen shrub	177	June
Bogong	<i>Brachyscome decipiens</i>	Forb	188	June-July
Bogong	<i>Carex brevipes</i>	Graminoid	177	June
Bogong	<i>Celmisia pugioniformis</i>	Forb	181	June
Bogong	<i>Erigeron bellidoides</i>	Forb	198	June-July
Bogong	<i>Luzula modesta</i>	Graminoid	184	June-July
Bogong	<i>Oreomyrrhis eriopoda</i>	Forb	172	Experiment
Bogong	<i>Pimelea alpina</i>	Evergreen shrub	171	June
Bogong	<i>Plantago euryphylla</i>	Forb	200	June-July
Bogong	<i>Poa hiemata</i>	Graminiod	212	Experiment
Bogong	<i>Ranunculus victoriensis</i>	Forb	165	June
Bogong	<i>Rytidosperma nudum</i>	Graminoid	214	Experiment
Bogong	<i>Senecio pinnatifolius</i>	Forb	216	Experiment
Endalen	<i>Carex rupestris</i>	Graminoid	173	June
Endalen	<i>Cassiope tetragona</i>	Evergreen shrub	184	June
Endalen	<i>Dryas octopetala</i>	Evergreen shrub	182	June
Endalen	<i>Polygonum viviparum</i>	Forb	190	June-July
Endalen	<i>Salix polaris</i>	Deciduous shrub	174	June
Endalen	<i>Saxifraga oppositifolia</i>	Forb	161	June

Daring Lake	<i>Betula granulosa</i>	Deciduous shrub	170	June
Daring Lake	<i>Carex aquatilis</i>	Graminoid	186	June
Daring Lake	<i>Eriophorum vaginatum</i>	Graminoid	152	May-June
Daring Lake	<i>Ledum decumbens</i>	Evergreen shrub	181	June
Daring Lake	<i>Oxytropis nigrescens</i>	Forb	173	June
Daring Lake	<i>Vaccinium vitis-idaea</i>	Evergreen shrub	187	June
Faroe Islands	<i>Silene acaulis</i>	Forb	170	June
Faroe Islands	<i>Ranunculus acris</i>	Forb	195	June-July
Finse	<i>Leontodon autumnalis</i>	Forb	224	Experiment
Finse	<i>Ranunculus acris</i>	Forb	196	June-July
Finse	<i>Ranunculus glacialis</i>	Forb	204	June-July
Finse	<i>Silene acaulis</i>	Forb	170	Experiment
Foscagno Pass	<i>Agrostis alpina</i>	Graminoid	218	June-August
Foscagno Pass	<i>Antennaria alpina</i>	Forb	196	June-July
Foscagno Pass	<i>Arabis alpina</i>	Forb	211	June-July
Foscagno Pass	<i>Avenella flexuosa</i>	Graminoid	218	June-August
Foscagno Pass	<i>Avenula versicolor</i>	Graminoid	214	June-July
Foscagno Pass	<i>Cardamine resedifolia</i>	Forb	190	June-July
Foscagno Pass	<i>Carex curta</i>	Graminoid	180	June
Foscagno Pass	<i>Carex parallela</i>	Graminoid	188	June-July
Foscagno Pass	<i>Carex sempervirens</i>	Graminoid	190	June-July
Foscagno Pass	<i>Cerastium uniflorum</i>	Forb	220	June-August
Foscagno Pass	<i>Doronicum clusii</i>	Forb	215	June-July
Foscagno Pass	<i>Empetrum hermaphroditum</i>	Evergreen shrub	183	June
Foscagno Pass	<i>Euphrasia minima</i>	Forb	202	June-July
Foscagno Pass	<i>Festuca halleri</i>	Graminoid	214	June-July
Foscagno Pass	<i>Geum reptans</i>	Forb	202	June-July
Foscagno Pass	<i>Homogyne alpina</i>	Forb	198	June-July
Foscagno Pass	<i>Juncus trifidus</i>	Graminoid	195	June-July
Foscagno Pass	<i>Loiseleuria procumbens</i>	Evergreen shrub	184	June-July
Foscagno Pass	<i>Leucanthemopsis alpina</i>	Forb	210	June-July
Foscagno Pass	<i>Luzula alpinopilosa</i>	Graminoid	193	June-July
Foscagno Pass	<i>Nardus stricta</i>	Graminoid	208	June-July
Foscagno Pass	<i>Oxyria digyna</i>	Forb	206	June-July
Foscagno Pass	<i>Poa alpina</i>	Graminoid	219	June-August
Foscagno Pass	<i>Poa laxa</i>	Graminoid	226	June-August
Foscagno Pass	<i>Potentilla aurea</i>	Forb	195	June-July
Foscagno Pass	<i>Ranunculus glacialis</i>	Forb	200	June-July
Foscagno Pass	<i>Rhododendron ferrugineum</i>	Evergreen shrub	195	June-July
Foscagno Pass	<i>Salix herbacea</i>	Deciduous shrub	199	June-July
Foscagno Pass	<i>Salix reticulata</i>	Deciduous shrub	192	June-July
Foscagno Pass	<i>Saxifraga bryoides</i>	Forb	223	June-August
Foscagno Pass	<i>Saxifraga oppositifolia</i>	Forb	191	June-July
Foscagno Pass	<i>Sedum alpestre</i>	Forb	205	June-July
Foscagno Pass	<i>Sempervivum montanum</i>	Forb	236	June-August
Foscagno Pass	<i>Senecio carniolicus</i>	Forb	211	June-July
Foscagno Pass	<i>Vaccinium gaultherioides</i>	Deciduous shrub	214	June-July

Foscagno Pass	<i>Veronica alpina</i>	Forb	210	June-July
Healy	<i>Betula nana</i>	Deciduous shrub	160	May-June
Healy	<i>Carex bigelowii</i>	Graminoid	159	May-June
Healy	<i>Rubus chamaemorus</i>	Forb	164	June
Healy	<i>Vaccinium vitis-idaea</i>	Evergreen shrub	171	June
Qikiqtaruk	<i>Dryas integrifolia</i>	Evergreen shrub	187	June-July
Qikiqtaruk	<i>Eriophorum vaginatum</i>	Graminoid	151	May
Qikiqtaruk	<i>Salix arctica</i>	Deciduous shrub	173	June
Jakabshorn	<i>Agrostis rupestris</i>	Graminoid	211	Experiment
Jakabshorn	<i>Antennaria alpina</i>	Forb	202	Experiment
Jakabshorn	<i>Arnica montana</i>	Forb	204	Experiment
Jakabshorn	<i>Campanula barbata</i>	Forb	209	Experiment
Jakabshorn	<i>Carex curvula</i>	Graminoid	179	Experiment
Jakabshorn	<i>Avenella flexuosa</i>	Graminoid	206	Experiment
Jakabshorn	<i>Empetrum nigrum</i>	Evergreen shrub	171	Experiment
Jakabshorn	<i>Euphrasia minima</i>	Forb	210	Experiment
Jakabshorn	<i>Gentiana acaulis</i>	Forb	181	Experiment
Jakabshorn	<i>Helictotrichon versicolor</i>	Graminoid	194	Experiment
Jakabshorn	<i>Hieracium bupleuroides</i>	Forb	201	Experiment
Jakabshorn	<i>Leontodon helveticus</i>	Forb	195	Experiment
Jakabshorn	<i>Leucanthemopsis alpina</i>	Forb	198	Experiment
Jakabshorn	<i>Loiseleuria procumbens</i>	Evergreen shrub	180	Experiment
Jakabshorn	<i>Luzula alpina</i>	Graminoid	208	Experiment
Jakabshorn	<i>Luzula lutea</i>	Graminoid	204	Experiment
Jakabshorn	<i>Nardus stricta</i>	Graminoid	203	Experiment
Jakabshorn	<i>Phyteuma hemisphaerica</i>	Forb	203	Experiment
Jakabshorn	<i>Ranunculus villarsii</i>	Forb	182	Experiment
Jakabshorn	<i>Senecio incanus</i>	Forb	198	Experiment
Jakabshorn	<i>Soldanella alpina</i>	Forb	170	Experiment
Jakabshorn	<i>Vaccinium myrtillus</i>	Deciduous shrub	182	Experiment
Jakabshorn	<i>Vaccinium uliginosum</i>	Deciduous shrub	188	Experiment
Latnjajaure	<i>Agrostis mertensii</i>	Graminoid	190	June-July
Latnjajaure	<i>Alchemilla wichurae</i>	Forb	169	June
Latnjajaure	<i>Andromeda polifolia</i>	Evergreen shrub	177	June
Latnjajaure	<i>Angelica archangelica</i>	Forb	198	June-July
Latnjajaure	<i>Antennaria alpina</i>	Forb	164	June
Latnjajaure	<i>Antennaria dioica</i>	Forb	188	June-July
Latnjajaure	<i>Anthoxanthum alpinum</i>	Graminoid	174	June
Latnjajaure	<i>Arabis alpina</i>	Forb	157	May-June
Latnjajaure	<i>Arctostaphylos alpina</i>	Deciduous shrub	156	May-June
Latnjajaure	<i>Arenaria norvegica</i>	Forb	189	June-July
Latnjajaure	<i>Astragalus alpinus</i>	Forb	169	June
Latnjajaure	<i>Astragalus frigidus</i>	Forb	184	June-July
Latnjajaure	<i>Bartsia alpina</i>	Forb	173	June
Latnjajaure	<i>Betula nana</i>	Deciduous shrub	160	May-June
Latnjajaure	<i>Calamagrostis laponica</i>	Graminoid	195	June-July
Latnjajaure	<i>Calamagrostis stricta</i>	Graminoid	191	June-July

Latnjajaure	<i>Campanula rotundifolia</i>	Forb	211	June-July
Latnjajaure	<i>Campanula uniflora</i>	Forb	182	June
Latnjajaure	<i>Cardamine bellidifolia</i>	Forb	170	June
Latnjajaure	<i>Carex aquatilis</i>	Graminoid	188	June-July
Latnjajaure	<i>Carex atrata</i>	Graminoid	177	June
Latnjajaure	<i>Carex atrofusca</i>	Graminoid	180	June
Latnjajaure	<i>Carex bigelowii</i>	Graminoid	169	June
Latnjajaure	<i>Carex brunnescens</i>	Graminoid	193	June-July
Latnjajaure	<i>Carex capillaris</i>	Graminoid	173	June
Latnjajaure	<i>Carex fuliginosa</i>	Graminoid	154	May-June
Latnjajaure	<i>Carex lachenalii</i>	Graminoid	181	June
Latnjajaure	<i>Carex norvegica</i>	Graminoid	179	June
Latnjajaure	<i>Carex parallelia</i>	Graminoid	174	June
Latnjajaure	<i>Carex rariflora</i>	Graminoid	193	June-July
Latnjajaure	<i>Carex rupestris</i>	Graminoid	149	May
Latnjajaure	<i>Carex saxatilis</i>	Graminoid	183	June
Latnjajaure	<i>Carex vaginata</i>	Graminoid	164	June
Latnjajaure	<i>Cassiope tetragona</i>	Evergreen shrub	176	June
Latnjajaure	<i>Castilleja hyperborea</i>	Forb	166	June
Latnjajaure	<i>Cerastium alpinum</i>	Forb	181	June
Latnjajaure	<i>Cerastium arcticum</i>	Forb	178	June
Latnjajaure	<i>Cerastium cerastoides</i>	Forb	195	June-July
Latnjajaure	<i>Cerastium glabratum</i>	Forb	183	June
Latnjajaure	<i>Chamorchis alpina</i>	Forb	186	June-July
Latnjajaure	<i>Coeloglossum viride</i>	Forb	180	June
Latnjajaure	<i>Deschampsia alpina</i>	Graminoid	206	June-July
Latnjajaure	<i>Deschampsia flexuosa</i>	Graminoid	206	June-July
Latnjajaure	<i>Diapensia lapponica</i>	Forb	161	June
Latnjajaure	<i>Draba daurica</i>	Forb	171	June
Latnjajaure	<i>Draba fladnizensis</i>	Forb	163	June
Latnjajaure	<i>Draba lactea</i>	Forb	150	May
Latnjajaure	<i>Draba nivalis</i>	Forb	165	June
Latnjajaure	<i>Dryas octopetala</i>	Evergreen shrub	185	June-July
Latnjajaure	<i>Empetrum hermaphroditum</i>	Evergreen shrub	145	May
Latnjajaure	<i>Epilobium anagallidifolium</i>	Forb	204	June-July
Latnjajaure	<i>Erigeron uniflorus</i>	Forb	173	June
Latnjajaure	<i>Eriophorum scheuchzeri</i>	Graminoid	176	June
Latnjajaure	<i>Eriophorum triste</i>	Graminoid	175	June
Latnjajaure	<i>Eriophorum vaginatum</i>	Graminoid	160	May-June
Latnjajaure	<i>Euphrasia frigida</i>	Forb	193	June-July
Latnjajaure	<i>Festuca ovina</i>	Graminoid	173	June
Latnjajaure	<i>Festuca vivipara</i>	Graminoid	182	June
Latnjajaure	<i>Gentiana nivalis</i>	Forb	182	June
Latnjajaure	<i>Gentianella tenella</i>	Forb	212	June-July
Latnjajaure	<i>Geranium sylvaticum</i>	Forb	193	June-July
Latnjajaure	<i>Gnaphalium norvegicum</i>	Forb	203	June-July
Latnjajaure	<i>Gnaphalium supinum</i>	Forb	194	June-July

Latnjajaure	<i>Hieracium alpinum</i>	Forb	202	June-July
Latnjajaure	<i>Hierochloe alpina</i>	Graminoid	180	June
Latnjajaure	<i>Hierochloe hirta</i> ssp. <i>arctica</i>	Graminoid	192	June-July
Latnjajaure	<i>Juncus biglumis</i>	Graminoid	181	June
Latnjajaure	<i>Juncus trifidus</i>	Graminoid	174	June
Latnjajaure	<i>Juncus triglumis</i>	Graminoid	191	June-July
Latnjajaure	<i>Kobresia myosuroides</i>	Graminoid	175	June
Latnjajaure	<i>Loiseleuria procumbens</i>	Evergreen shrub	168	June
Latnjajaure	<i>Luzula arcuata</i>	Graminoid	169	June
Latnjajaure	<i>Luzula multiflora</i>	Graminoid	166	June
Latnjajaure	<i>Luzula parviflora</i>	Graminoid	180	June
Latnjajaure	<i>Luzula spicata</i>	Graminoid	163	June
Latnjajaure	<i>Luzula sudetica</i>	Graminoid	179	June
Latnjajaure	<i>Luzula wahlenbergii</i>	Graminoid	192	June-July
Latnjajaure	<i>Minuartia biflora</i>	Forb	166	June
Latnjajaure	<i>Minuartia rubella</i>	Forb	184	June-July
Latnjajaure	<i>Minuartia stricta</i>	Forb	178	June
Latnjajaure	<i>Oxyria digyna</i>	Forb	159	May-June
Latnjajaure	<i>Oxytropis lapponica</i>	Forb	175	June
Latnjajaure	<i>Parnassia palustris</i>	Forb	193	June-July
Latnjajaure	<i>Pedicularis hirsuta</i>	Forb	172	June
Latnjajaure	<i>Pedicularis lapponica</i>	Forb	174	June
Latnjajaure	<i>Petasites frigidus</i>	Forb	167	June
Latnjajaure	<i>Phippsia algida</i>	Forb	207	June-July
Latnjajaure	<i>Phleum commutatum</i>	Graminoid	193	June-July
Latnjajaure	<i>Phyllodoce coerulea</i>	Evergreen shrub	170	June
Latnjajaure	<i>Pinguicula alpina</i>	Forb	159	May-June
Latnjajaure	<i>Pinguicula vulgaris</i>	Forb	175	June
Latnjajaure	<i>Poa alpina</i>	Graminoid	172	June
Latnjajaure	<i>Poa arctica</i>	Graminoid	182	June
Latnjajaure	<i>Poa glauca</i>	Graminoid	186	June-July
Latnjajaure	<i>Poa pratensis</i>	Graminoid	184	June-July
Latnjajaure	<i>Polygonum viviparum</i>	Forb	190	June-July
Latnjajaure	<i>Potentilla crantzii</i>	Forb	160	May-June
Latnjajaure	<i>Potentilla nivea</i>	Forb	160	May-June
Latnjajaure	<i>Pyrola grandiflora</i>	Forb	202	June-July
Latnjajaure	<i>Pyrola minor</i>	Forb	200	June-July
Latnjajaure	<i>Ranunculus acris</i>	Forb	172	June
Latnjajaure	<i>Ranunculus glacialis</i>	Forb	164	June
Latnjajaure	<i>Ranunculus nivalis</i>	Forb	167	June
Latnjajaure	<i>Ranunculus pygmaeus</i>	Forb	183	June
Latnjajaure	<i>Rhodiola rosea</i>	Forb	154	May-June
Latnjajaure	<i>Rhododendron lapponicum</i>	Evergreen shrub	158	May-June
Latnjajaure	<i>Rubus chamaemorus</i>	Forb	178	June
Latnjajaure	<i>Rumex acetosa</i>	Forb	172	June
Latnjajaure	<i>Salix glauca</i>	Deciduous shrub	154	May-June

Latnjajaure	<i>Salix hastata</i>	Deciduous shrub	156	May-June
Latnjajaure	<i>Salix herbacea</i>	Deciduous shrub	150	May
Latnjajaure	<i>Salix lanata</i>	Deciduous shrub	144	May
Latnjajaure	<i>Salix myrsinifolia</i>	Deciduous shrub	161	June
Latnjajaure	<i>Salix polaris</i>	Deciduous shrub	153	May-June
Latnjajaure	<i>Salix reticulata</i>	Deciduous shrub	155	May-June
Latnjajaure	<i>Saussurea alpina</i>	Forb	210	June-July
Latnjajaure	<i>Saxifraga aizoides</i>	Forb	188	June-July
Latnjajaure	<i>Saxifraga cernua</i>	Forb	181	June
Latnjajaure	<i>Saxifraga cespitosa</i>	Forb	158	May-June
Latnjajaure	<i>Saxifraga foliolosa</i>	Forb	196	June-July
Latnjajaure	<i>Saxifraga nivalis</i>	Forb	171	June
Latnjajaure	<i>Saxifraga oppositifolia</i>	Forb	134	May
Latnjajaure	<i>Saxifraga rivularis</i>	Forb	185	June-July
Latnjajaure	<i>Saxifraga stellaris</i>	Forb	189	June-July
Latnjajaure	<i>Saxifraga tenuis</i>	Forb	156	May-June
Latnjajaure	<i>Scirpus caespitosus</i>	Graminoid	184	June-July
Latnjajaure	<i>Sibbaldia procumbens</i>	Forb	169	June
Latnjajaure	<i>Silene acaulis</i>	Forb	158	May-June
Latnjajaure	<i>Silene dioica</i>	Forb	182	June
Latnjajaure	<i>Silene wahlbergella</i>	Forb	185	June-July
Latnjajaure	<i>Solidago virgaurea</i>	Forb	201	June-July
Latnjajaure	<i>Taraxacum croceum</i>	Forb	181	June
Latnjajaure	<i>Thalictrum alpinum</i>	Forb	166	June
Latnjajaure	<i>Tofieldia pusilla</i>	Forb	171	June
Latnjajaure	<i>Trientalis europaea</i>	Forb	188	June-July
Latnjajaure	<i>Trisetum spicatum</i>	Graminoid	179	June
Latnjajaure	<i>Trollius europaeus</i>	Forb	165	June
Latnjajaure	<i>Vaccinium myrtillus</i>	Deciduous shrub	191	June-July
Latnjajaure	<i>Vaccinium uliginosum</i>	Deciduous shrub	170	June
Latnjajaure	<i>Vaccinium vitis-idaea</i>	Evergreen shrub	194	June-July
Latnjajaure	<i>Veronica alpina</i>	Forb	183	June
Latnjajaure	<i>Veronica fruticans</i>	Deciduous shrub	189	June-July
Latnjajaure	<i>Viola biflora</i>	Forb	162	June
Latnjajaure	<i>Viscaria alpina</i>	Forb	198	June-July
Kangerlussuaq	<i>Betula nana</i>	Deciduous shrub	161	June
Kangerlussuaq	<i>Carex bigelowii</i>	Graminoid	164	June
Kangerlussuaq	<i>Cerastium alpinum</i>	Forb	167	June
Kangerlussuaq	<i>Draba cana</i>	Forb	159	May-June
Kangerlussuaq	<i>Kobresia myosuroides</i>	Graminoid	166	June
Kangerlussuaq	<i>Loiseleuria procumbens</i>	Evergreen shrub	164	June
Kangerlussuaq	<i>Luzula multiflora</i>	Graminoid	169	June
Kangerlussuaq	<i>Polygonum viviparum</i>	Forb	171	June
Kangerlussuaq	<i>Potentilla hookeriana</i>	Forb	164	June
Kangerlussuaq	<i>Rhododendron lapponicum</i>	Evergreen shrub	161	June
Kangerlussuaq	<i>Salix glauca</i>	Deciduous shrub	165	June
Kangerlussuaq	<i>Salix glauca</i>	Deciduous shrub	182	June

Kangerlussuaq	<i>Silene acaulis</i>	Forb	170	June
Niwot Ridge	<i>Artemisia scopulorum</i>	Forb	175	Experiment
Niwot Ridge	<i>Polyginum bistortoides</i>	Forb	185	Experiment
Niwot Ridge	<i>Polyginum viviparum</i>	Forb	190	Experiment
Niwot Ridge	<i>Caltha leptosepala</i>	Forb	164	Experiment
Niwot Ridge	<i>Carex scopulorum</i>	Graminoid	175	Experiment
Niwot Ridge	<i>Carex spp.</i>	Graminoid	183	Experiment
Niwot Ridge	<i>Castilleja occidentalis</i>	Forb	184	Experiment
Niwot Ridge	<i>Chionophila jamesii</i>	Forb	187	Experiment
Niwot Ridge	<i>Deschampsia caespitosa</i>	Graminoid	182	Experiment
Niwot Ridge	<i>Erigeron simplex</i>	Forb	183	Experiment
Niwot Ridge	<i>Gentianoides algida</i>	Forb	213	Experiment
Niwot Ridge	<i>Gentianella amarella</i>	Forb	207	Experiment
Niwot Ridge	<i>Geum rossii</i>	Forb	179	Experiment
Niwot Ridge	<i>Lewisia pygmaea</i>	Forb	178	Experiment
Niwot Ridge	<i>Luzula spicata</i>	Graminoid	178	Experiment
Niwot Ridge	<i>Mertensia lanceolata</i>	Forb	180	Experiment
Niwot Ridge	<i>Potentilla diversifolia</i>	Forb	182	Experiment
Niwot Ridge	<i>Stellaria longipes</i>	Forb	190	Experiment
Nuuk	<i>Loiseleuria procumbens</i>	Evergreen shrub	164	June
Nuuk	<i>Salix glauca</i>	Deciduous shrub	182	June
Nuuk	<i>Silene acaulis</i>	Forb	169	June
Stillberg	<i>Empetrum nigrum</i>	Evergreen shrub	164	June
Stillberg	<i>Loiseleuria procumbens</i>	Evergreen shrub	174	June
Stillberg	<i>Vaccinium myrtillus</i>	Deciduous shrub	174	June
Stillberg	<i>Vaccinium uliginosum</i>	Deciduous shrub	189	June-July
Tanquary Fiord	<i>Dryas integrifolia</i>	Evergreen shrub	182	June
Tanquary Fiord	<i>Saxifraga oppositifolia</i>	Forb	164	June
Toolik Lake	<i>Andromeda polifolia</i>	Evergreen shrub	175	June
Toolik Lake	<i>Arctostaphylos alpina</i>	Deciduous shrub	160	May-June
Toolik Lake	<i>Betula nana</i>	Deciduous shrub	163	June
Toolik Lake	<i>Carex bigelowii</i>	Graminoid	163	June
Toolik Lake	<i>Cassiope tetragona</i>	Evergreen shrub	167	June
Toolik Lake	<i>Diapensia lapponica</i>	Forb	166	June
Toolik Lake	<i>Dryas octopetala</i>	Evergreen shrub	165	June
Toolik Lake	<i>Empetrum nigrum</i>	Evergreen shrub	161	June
Toolik Lake	<i>Eriophorum vaginatum</i>	Graminoid	152	May-June
Toolik Lake	<i>Ledum palustre</i>	Evergreen shrub	173	June
Toolik Lake	<i>Loiseleuria procumbens</i>	Evergreen shrub	164	June
Toolik Lake	<i>Polygonum bistorta</i>	Forb	180	June
Toolik Lake	<i>Rubus chamaemorus</i>	Forb	174	June
Toolik Lake	<i>Salix phlebophylla</i>	Deciduous shrub	165	June
Toolik Lake	<i>Salix pulchra</i>	Deciduous shrub	164	June
Toolik Lake	<i>Vaccinium uliginosum</i>	Deciduous shrub	167	June
Toolik Lake	<i>Vaccinium vitis-idaea</i>	Evergreen shrub	176	June
Val Bercla	<i>Bartsia alpina</i>	Forb	179	Experiment
Val Bercla	<i>Leucanthemopsis alpina</i>	Forb	198	Experiment

Val Bercla	<i>Leucanthemum halleri</i>	Forb	192	Experiment
Val Bercla	<i>Pedicularis verticillata</i>	Forb	192	Experiment
Val Bercla	<i>Polyginum viviparum</i>	Forb	195	Experiment
Val Bercla	<i>Primula integrifolia</i>	Forb	174	Experiment
Val Bercla	<i>Salix retusa</i>	Deciduous shrub	175	Experiment
Val Bercla	<i>Salix reticulata</i>	Deciduous shrub	177	Experiment
Val Bercla	<i>Saxifraga oppositifolia</i>	Forb	168	Experiment
Val Bercla	<i>Silene acaulis</i>	Forb	181	Experiment
Val Bercla	<i>Soldanella alpina</i>	Forb	166	Experiment
Zackenberg	<i>Cassiope tetragona</i>	Evergreen shrub	187	June-July
Zackenberg	<i>Dryas octopetala</i>	Evergreen shrub	186	June-July
Zackenberg	<i>Papaver radicatum</i>	Forb	197	June-July
Zackenberg	<i>Salix arctica</i>	Deciduous shrub	171	June
Zackenberg	<i>Saxifraga oppositifolia</i>	Forb	157	May-June
Zackenberg	<i>Silene acaulis</i>	Forb	185	June-July

Supplementary Table 3. Information on the warming experiments in the study. Temp. increase (°C) is the average increase in summer (June-Aug.) temperatures in plots with open top chambers (OTCs) compared to controls. Years indicates the number of years that OTCs were placed on plots in the experiment, although this number can be greater than the number of years phenology measurements were taken, and ‘Duration’ indicates if OTCs were left on plots year-round, or only placed over plots in summer.

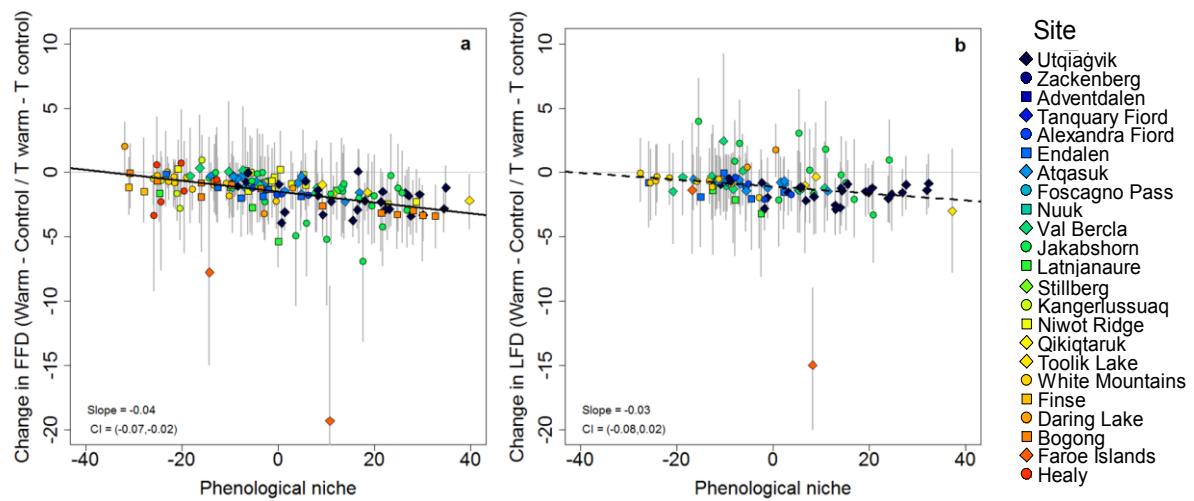
Site	Subsite	Temp. increase (°C)	Years	Duration	Reference
Alexandra Fiord, Canada	Dry	1.78	19	year-round	Bjorkman et al. 2015
	Mesic	0.91	19	year-round	Bjorkman et al. 2015
Atqasuk, USA	Dry Heath	1.5	11	summer	Hollister et al. 2006
	Wet meadow	0.9	11	summer	Hollister et al. 2006
Utqiagvik, USA	Dry Heath	1.7	15	summer	Hollister et al. 2006
	Wet meadow	1.8	15	summer	Hollister et al. 2006
Daring Lake, Canada		0.5	18	summer	K. Clark, <i>pers. comm</i>
Endalen, Svalbard		1.2	4	summer	Dollery et al. 2006
Bogong, Australia		1.0	6	summer	Bokhorst et al. 2013
Faroe Islands		0.77	4	year-round	Elmendorf et al. 2015
Finse, Norway	Meadow	2.3	4	year-round	Totland 1999
	Snow-bed	2.3	3	year-round	Totland and Alatalo 2002
Healy, USA	Tussock tundra	0.5	5	summer	Natali et al. 2011; Mauritz et al. 2017
Jacabshorn, Switzerland		1.2	1	summer	C. Chisholm, <i>pers. comm</i>
Niwot Ridge, USA		1.0	2	summer	Smith et al. 2012
Val Bercla, Switzerland		1.0	2	year-round	J. Prevéy, <i>pers. comm</i>
White Mountains, USA	Low	1.8	3	year-round	Kopp and Cleland 2015
	High	2.4	3	year-round	Kopp and Cleland 2015
Kangerlussuaq, Greenland		2.0	4	year-round	Hoye et al. 2007
Latnjajaure, Sweden		2.4	4	year-round	Wolkovitch et al. 2012
Toolik Lake, USA	Dry	2.0	8	summer	Oberbauer et al. 2007
	Moist	1.5	8	summer	Oberbauer et al. 2007

Supplementary Table 4. Slopes and credible intervals for all analyses of the effects of mean site summer temperature (MST, °C) and species' phenological niches on temperature sensitivity of first flowering dates (FFD) from long-term monitoring plots. Variables used for the sensitivity models were: "Summer temperature" - average monthly temperature from June through the average month of flowering for each species and site, "June temperature" - average June temperature per site and year, "Daily temperature" - average daily air temperature from the date of snowmelt through the average flowering date for each species and year, and "Snowmelt date" – the day of year that the snow completely melted, per plot, site and year. Bold values indicate parameter slopes with significant credible intervals that do not cross zero.

FFD Sensitivity Model	Intercept	Predictor variable	Slope	CI
Summer temperature	-1.13	MST (°C)	0.63	(0.15, 0.96)
		Phenological niche	-0.08	(-0.12, -0.04)
		MST* phenological niche	0.008	(-0.006, 0.02)
June temperature	-1.81	MST (°C)	0.39	(0.06, 0.77)
		Phenological niche	-0.06	(-0.09, -0.03)
		MST* phenological niche	-0.003	(-0.01, 0.008)
Daily temperature	-0.04	MST (°C)	0.20	(0.009, 0.44)
		Phenological niche	-0.04	(-0.10, -0.006)
		MST* phenological niche	0.014	(-0.001, 0.03)
Snowmelt date	0.37	MST (°C)	-0.01	(-0.11, 0.1)
		Phenological niche	0.0004	(-0.007, 0.009)
		MST* phenological niche	- 0.0003	(-0.007, 0.0002)

Supplementary Table 5. Slopes and credible intervals for all analyses of the effects of mean site summer temperature (MST, °C) and species' phenological niches on temperature sensitivity of last flowering dates (LFD) from long-term monitoring plots. Variables used for the sensitivity models were: "Summer temperature" - average monthly temperature from June through the average month of flowering for each species and site, "June temperature" - average June temperature per site and year, "Daily temperature" - average daily air temperature from the date of snowmelt through the average flowering date for each species and year, and "Snowmelt date" – the day of year that the snow completely melted, per plot, site and year.

LFD Sensitivity Model	Intercept	Predictor variable	Slope	95 % CI
Summer temperature	-1.19	MST (°C)	0.07	(-0.21, 0.23)
		Phenological niche	-0.05	(-0.15, 0.006)
		MST* phenological niche	0.002	(-0.02, 0.02)
June temperature	-1.94	MST (°C)	0.16	(-0.37, 0.73)
		Phenological niche	-0.001	(-0.12, 0.21)
		MST* phenological niche	0.006	(-0.02, 0.06)
Daily temperature	-0.04	MST (°C)	0.09	(-1.89, 2.35)
		Phenological niche	-0.10	(-0.90, 0.80)
		MST* phenological niche	0.003	(-0.01, 0.02)
Snowmelt date	0.36	MST (°C)	-0.08	(-0.21, 0.10)
		Phenological niche	0.008	(-0.007, 0.022)
		MST* phenological niche	0.001	(-0.007, 0.006)



Supplementary Figure 1. Relationships between phenological niches of species and timing of (a) first flowering dates (FFDs) and (b) last flowering dates (LFDs) in experimentally warmed plots compared to control plots, per °C of warming in experimental chambers per subsite. Mean temperature increases from experimental chambers are listed in Table S3. Points represent the estimated temperature sensitivities for each species at each site, and vertical gray lines span the 95% credible intervals for each species-by-site level estimate. Colors and symbols correspond to site names in Fig. 2. The ‘phenological niche’ is the average flowering date of a species compared to the site-level mean-flowering date of all species at a site. Solid black lines denote significant hierarchical model slopes, dashed black lines indicate non-significant model slopes, and the horizontal grey line denotes the zero line. Hierarchical model slopes and 95% credible intervals (CIs) are listed in the bottom left of each graph. The phenological niches significantly predict phenological responses (at the 5% level) if the 95% credible intervals do not overlap zero.

Supplementary Table 6. Overall and site-level slopes and credible intervals for analyses of the effects of summer temperature and time on the proxy for flowering season length at six sites with more than ten years of phenology observations. Bold values indicate significant parameter slopes with credible intervals that do not cross zero.

Predictor Variable	Site	# obs.	Intercept	Slope	95% CI
June-July temp.	Overall slope (b_s)	82	0.09	-3.96	(-7.31, -0.79)
	Alexandra Fiord	18	0.07	-4.54	(-8.25, -1.41)
	Atqasuk	11	0.08	-2.22	(-5.14, 1.80)
	Daring Lake	10	0.12	-3.50	(-6.03, -0.32)
	Toolik Lake	11	0.10	-3.81	(-6.99, -0.30)
	Utqiāgvik	13	0.09	-3.86	(-7.39, 0.60)
	Zackenberg	19	0.10	-6.60	(-10.92, -3.31)
Year	Overall slope (b_s)	82	0.67	-0.43	(-0.87, 0.06)
	Alexandra Fiord	18	0.49	-0.47	(-0.97, -0.002)
	Atqasuk	11	0.49	-0.38	(-0.90, 0.22)
	Daring Lake	10	0.50	-0.53	(-1.39, -0.09)
	Toolik Lake	11	1.72	-0.23	(-0.72, 0.48)
	Utqiāgvik	13	0.09	-3.86	(-7.39, 0.60)
	Zackenberg	19	0.37	-0.63	(-1.32, -0.14)

Supplementary Table 7. Overall and site-level slopes and credible intervals for analyses on the effect of time on summer temperatures at six sites with more than ten years of phenology observations. Bold values indicate significant parameter slopes with credible intervals that do not cross zero.

Site	# obs.	Intercept	Slope	95% CI
Overall slope (b_s)	82	0.008	0.07	(0.02, 0.12)
Alexandra Fiord	18	0.01	0.06	(0.02, 0.12)
Atqasuk	11	0.02	0.07	(0.01, 0.13)
Daring Lake	10	0	0.08	(0.02, 0.18)
Toolik Lake	11	0.00	0.07	(0.005, 0.12)
Utqiāgvik	13	0.002	0.07	(0.02, 0.12)
Zackenberg	19	0	0.07	(0.03, 0.13)

S7. Bayesian hierarchical model descriptions and Stan model specifications for hierarchical Bayesian analyses presented in the main text. All code was run in RStudio version 0.99.483 and R version 3.2.2 using the package ‘rstan’.

S7.1 Model for long-term monitoring plots

We modeled the date of the phenological event (*doy*) as a function of temperature at site s in year y ($\text{temp}_{s,y}$), with $a_{sp,s}$ being the site-by-species-level intercept, $b_{sp,s}$ the site-by-species-level slope, a_p a random plot effect (when a site had multiple phenology observations for the same species in different plots p)

$$\text{doy}_{sp,s,p,y} \sim \text{Normal}(a_p + a_{sp,s} + b_{sp,s} \cdot \text{temp}_{s,y}, \sigma_{sp,s}).$$

We assessed the site-level relationship of species' temperature sensitivities of flowering ($b_{sp,s}$) to the phenological niche of the species (*phenological niche* $_{sp,s}$)

$$b_{sp,s} \sim \text{Normal}(\alpha_s + \beta_s \cdot \text{phenological niche}_{sp,s}, \sigma_{b,s}),$$

as well as overall relationships between site-level intercepts (α_s) and slopes (β_s) and the site mean summer climate (*summer climate* $_s$)

$$\alpha_s \sim \text{Normal}(\gamma_0 + \gamma_1 \cdot \text{summer climate}_s, \sigma_\alpha),$$

$$\beta_s \sim \text{Normal}(\gamma_2 + \gamma_3 \cdot \text{summer climate}_s, \sigma_\beta).$$

Stan model specification for long-term monitoring plots data

```
data {
  int<lower=0> Nobs;
  int<lower=0> Nsiteyr;
  int<lower=0> Nsitespp;
  int<lower=0> Nplotspp;
  int<lower=0> Nsite;
  int<lower=0> Nplot;
  int<lower=1,upper=Nsiteyr> siteyr[Nobs];
  int<lower=1,upper=Nsitespp> sitespp[Nobs];
  int<lower=1,upper=Nplotspp> plotspp[Nobs];
  int<lower=1,upper=Nsite> site[Nobs];
  int<lower=1,upper=Nplot> subsite[Nobs];
  int singleobs[Nsiteyr];
  int singleplot[Nsite];
  int<lower=1,upper=Nsite> xsite[Nsiteyr];
  int<lower=1,upper=Nsite> ysite[Nsitespp];
```

```

int<lower=1,upper=Nsite> zsite[Nplot];

vector[Nobs] doy;
vector[Nobs] temp;
vector[Nsitespp] phenoniche; # phenological niche
vector[Nsite] summerclim; # summer climate
}
parameters {
real<lower=-30,upper=30> a_year[Nsiteyr];
real<lower=-30,upper=30> a_plot[Nsubsite];
real<lower=100,upper=300> a_spp[Nsitespp];
real<lower=-20,upper=20> b [Nsitespp];

real<lower=-10,upper=10> alpha[Nsite];
real<lower=-10,upper=10> beta[Nsite];

real<lower=0,upper=30> sigma_a_year[Nsite];
real<lower=0,upper=30> sigma_a_plot[Nsite];
real<lower=0,upper=30> sigma_obs[Nsitespp];
real<lower=0,upper=5> sigma_b[Nsite];
real<lower=-10,upper=10> g0;
real<lower=-1,upper=1> g1;
real<lower=-1,upper=1> g2;
real<lower=-1,upper=1> g3;
real<lower=0,upper=5> sigma_alpha;
real<lower=0,upper=5> sigma_beta;
}

model {

alpha ~ normal(g0 + g1 * summerclim, sigma_alpha);
beta ~ normal(g2 + g2 * summerclim, sigma_beta);

for (i in 1:Nsitespp){
  bsitespp[i] ~ normal(alpha[ysite[i]] + beta[ysite[i]]*phenoniche[i], sigma_b[ysite[i]]);
}

for (i in 1:Nsiteyr){
  if(!singleobs[i])
    a_year[i] ~ normal(0, sigma_a_year[xsite[i]]);
}

for (i in 1:Nplot){
  if(!singleplot[zsite[i]])
    a_plot[i] ~ normal(0, sigma_a_plot[zsite[i]]);
}

for (i in 1:Nobs){
  if(!singleplot[site[i]]){
    if(!singleobs[siteyr[i]])

```

```

doy[i] ~ normal(a_year[siteyr[i]] + a_plot[plot[i]] + a_spp[sitespp[i]] + bsitespp[sitespp[i]] *
temp[i], sigma_obs[sitespp[i]]);
else
  doy[i] ~ normal(a_plot[plot[i]] + a_spp[sitespp[i]] + bsitespp[sitespp[i]] * temp[i],
sigma_obs[sitespp[i]]);
}
else{
  if(!singleobs[siteyr[i]])
    doy [i] ~ normal(a_year[siteyr[i]] + a_spp[sitespp[i]] + bsitespp[sitespp[i]] * temp[i],
sigma_obs[sitespp[i]]);
  else
    doy[i] ~ normal(a_spp[sitespp[i]] + bsitespp[sitespp[i]] * temp[i], sigma_obs[sitespp[i]]);
}
}
}

```

S7.2 Warming experiment model

We analyzed these data using the same hierarchical Bayesian approach, however, here we used the difference between the day of year of flowering - either FFDs or LFDs - ($flowdiff_{p,sp,s,y}$) between warmed and control plots (DOY warmed – DOY control), in place of the plot-level flowering dates. Here, $b_{sp,s}$ is the average site-by-species-level difference and $\sigma_{sp,s}$ the variation of observed differences ($flowdiff_{sp,s,p,y}$)

$$flowdiff_{i,p,y} \sim Normal(a_p + a_y + b_{sp,s}, \sigma_{sp,s}).$$

In this model, we included a random plot effect a_p (when a site had multiple phenology observations for the same species in different plots p) as well as a random year effect a_y (when a site had multiple phenology observations the same year y).

We then assessed the relationship of the species-by-site-level difference in the day of year of flowering ($b_{sp,s}$) to phenological niche ($phenological\ niche_{sp,s}$) and site mean summer climate ($summer\ climate_s$).

$$b_{sp,s} \sim Normal(\alpha_s + \beta_s \cdot phenological\ niche_{sp,s}, \sigma_{b,s}),$$

as well as overall relationships between site-level intercepts (α_s) and slopes (β_s) and the site mean summer climate ($summer\ climate_s$)

$$\alpha_s \sim Normal(\gamma_0 + \gamma_1 \cdot summer\ climate_s, \sigma_\alpha),$$

$$\beta_s \sim Normal(\gamma_2 + \gamma_3 \cdot summer\ climate_s, \sigma_\beta).$$

Stan model specifications for phenology data from warming experiments

```

data {
  int<lower=1> Nobs;
  int<lower=1> Nsite;
  int<lower=1> Nsitespp;
  int<lower=1> Nsiteyr;
  int<lower=1> Nplot;
  int<lower=1,upper=Nsitespp> sitespp[Nobs];
  int<lower=1,upper=Nsite> site[Nobs];
  int<lower=1,upper=Nsiteyr> siteyr[Nobs];
  int<lower=1,upper=Nplot> plot[Nobs];

  vector[Nobs] flowerdiff;
  vector[Nsitespp] phenoniche;
  vector[Nsite] summerclim;

  int yeareffect[Nsite];
  int ploteffect[Nsite];
  int<lower=1> xsite[Nsitespp];
  int<lower=1> ysite[Nplot];
  int<lower=1> zsite[Nsiteyr];
}

parameters {
  real<lower=-30,upper=20> bsitespp[Nsitespp];
  real<lower=-10,upper=10> aplot[Nplot];
  real<lower=-10,upper=10> asiteyr[Nsiteyr];

  real<lower=-10,upper=10> alpha[Nsite];
  real<lower=-10,upper=10> beta[Nsite];

  real<lower=0,upper=10> sigma_a_plot[Nsite];
  real<lower=0,upper=10> sigma_a_year[Nsite];
  real<lower=0,upper=10> sigma_b[Nsite];
  real<lower=0,upper=10> sigma_obs[Nsite];
  real<lower=0,upper=10> sigma_alpha;
  real<lower=0,upper=10> sigma_beta;
  real<lower=-30,upper=20> g0;
  real<lower=-1,upper=1> g1;
  real<lower=-5,upper=5> g2;
  real<lower=-1,upper=1> g3;
}

model {

```

```

alpha ~ normal(g0 + g1 * summerclim, sigma_alpha);
beta ~ normal(g2 + g3 * summerclim, sigma_beta);

for(i in 1:Nsitespp){
  bsitespp[i] ~ normal(alpha[xsite[i]] + beta[xsite[i]]*phenoniche[i], sigma_b[xsite[i]]);
}

for(i in 1:Nsiteyr){
  if(yeareffect[zsite[i]])
    asiteyr[i] ~ normal(0, sigma_a_year[zsite[i]]);
}

for(i in 1:Nsubsite){
  if(ploteffect[ysite[i]])
    aplot[i] ~ normal(0, sigma_a_plot[ysite[i]]);
}

for (i in 1:Nobs){
  if(yeareffect[site[i]]==0 && subsiteeffect[site[i]]==0)
    flowerdiff[i] ~ normal(bsitespp[sitespp[i]],sigma_obs[site[i]]);
  else {
    if(yeareffect[site[i]]==1 && ploteffect[site[i]]==0)
      flowerdiff[i] ~ normal(bsitespp[sitespp[i]] + asiteyr[siteyr[i]],sigma_obs[site[i]]);
    else
      if(yeareffect[site[i]]==1 && ploteffect[site[i]]==1)
        flowerdiff[i] ~ normal(bsitespp[sitespp[i]] + asiteyr[siteyr[i]] + aplot[plot[i]],sigma_obs[site[i]]);
  }
}
}

```

S7.3 Flowering season duration model

We examined how average June-July temperatures and year were influencing flowering season duration by comparing a proxy for the community flowering season (the number of days between the average FFD of the earliest flowering species at a site per year and the average LFD of the latest flowering species at a site per year ($duration_{p,y,s}$) to June-July temperatures ($temp_{s,y}$), or change over time ($year_s$)

$$(duration_{p,y,s} \sim Normal(a_s + b_s \cdot temp_{s,y}, \sigma_{obs}),$$

with intercept (a) and slope (b) varying by site.

Stan model specifications for flowering season length analyses

```
data {  
    int<lower=0> Nobs;  
    int<lower=0> Nsite;  
    vector[Nobs] duration;  
    vector[Nobs] temp;  
    int site[Nobs];  
}  
parameters {  
    real<lower=-10,upper=10> a[Nsite]; # site intercept  
    real<lower=-15,upper=10> b[Nsite]; # site slope  
    real<lower=-5,upper=5> mu_a; # overall intercept  
    real<lower=-15,upper=10> mu_b; # overall slope  
    real<lower=0,upper=5> sigma_a;  
    real<lower=0,upper=10> sigma_b;  
    real<lower=0,upper=20> sigma_obs;  
}  
model {  
    a ~ normal(mu_a, sigma_a);  
    b ~ normal(mu_b, sigma_b);  
  
    for(i in 1:Nobs){  
        duration[i] ~ normal(a[site[i]] + b[site[i]] * temp[i], sigma_obs); # assuming that variation of  
        observations around predictions is the same for all sites  
    }  
}
```

Supplementary Information References

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