

Supplementary materials

Table S1. Climate regions and locations used to compare the responses of plant species with differing spring phenology to climate warming.

Climate region/location	Latitude and longitude	Annual mean temperature (°C) (1981 – 2010)
Boreal Canada		
St. John's, Baie-Comeau, Timmins, Kapuskasing, Sioux Lookout, Thompson, Fort McMurray, La Ronge, High level, Fort Nelson, Yellowknife, Whitehorse	47°37' – 62°28'N; 52°44' – 135°04'W	-4.3 – 5.0
Temperate Canada		
London, Toronto, Montreal, Sherbrooke, Quebec City Ottawa, Sudbury, North Bay, Sault Ste. Marie	43°01' – 46°48'N; 71°23' – 84°30'W	4.0 – 7.9
Cold temperate China		
Shenyang, Changchun, Tonghua, Baicheng, Xilingol, Shihezi, Jiamusi, Mudanjiang, Harbin, Yichun, Dedu, Nenjiang	41°25' – 49°06'N; 85°56' – 130°11'E	0.1 – 8.5
Warm temperate China		
Baoji, Luoyang, Taian, Jinan, Xingtai, Dezhou, Minqin, Taiyuan, Tianjin, Yixian, Qinhuangdao, Beijing	34°13' – 39°31'N; 103°03' – 119°37'E	8.8 – 14.8
Temperate United Kingdom		
Belfast, Harris, Thurso, Inverness, Aberdeen, Edinburgh, Sunderland, Chester, Norwich, Brighton, Plymouth, Pembroke	50°49' – 58°35'N; 0°08' – 7°18'W	7.8 – 11.2

Table S2. Phenological models for different species/specie groups listed by increasing forcing requirements (early to late season species) within each climate region.

Species	Model^a	Parameters (a, b, c, d)
Boreal Canada		
<i>Pinus banksiana</i>	3-exponential	2013, 10993, 0.0049
<i>Populus balsamifera</i>	4-sigmoid	3266, 51776, 247, -107
<i>Betula papyrifera</i>	3-exponential	5819, 50394, 0.0054
<i>Populus tremuloides</i>	4-sigmoid	6217, 53076, 304, -115
<i>Picea glauca</i>	3-exponential	6505, 21558, 0.0080
<i>Picea mariana</i>	3-exponential	8768, 18145, 0.0118
Temperate Canada		
<i>Pinus strobus</i>	4-sigmoid	1438, 29274, 429, -165
<i>Larix laricina</i>	4-sigmoid	2769, 199142, -297, -248
<i>Betula alleghaniensis</i>	4-sigmoid	1311, 88151, 332, -263
<i>Pinus resinosa</i>	4-sigmoid	5175, 113800, 17, -221
<i>Thuja occidentalis</i>	4-sigmoid	5742, 80365, 376, -124
<i>Picea rubens</i>	4-sigmoid	10771, 59227, 430, -176
Cold temperate China		
<i>Salix babylonica</i>	2-exponential	104.2, 0.0170
<i>Salix matsudana</i>	2-exponential	117.4, 0.0266
<i>Populus simonii</i>	2-exponential	127.8, 0.0139
<i>Ulmus pumila</i>	2-exponential	86.5, 0.0080
<i>Populus X canadensis</i>	2-exponential	375.1, 0.0090
<i>Amorpha fruticosa</i>	2-exponential	294.6, 0.0078
<i>Koelreuteria paniculata</i>	2-exponential	175.7, 0.0110
<i>Fraxinus chinensis</i>	2-exponential	136.1, 0.0048
<i>Ailanthus altissima</i>	2-exponential	210.1, 0.0088
<i>Ginkgo biloba</i>	2-exponential	256.8, 0.0156
<i>Morus alba</i>	2-exponential	284.1, 0.0110
<i>Sophora japonica</i>	2-exponential	115.6, 0.0083
Warm temperate China		
<i>Prunus davidiana</i>	2-exponential	190.4, 0.0178
<i>Platycladus orientalis</i>	2-exponential	385.6, 0.0150
<i>Juglans regia</i>	2-exponential	263.7, 0.0183
<i>Malus pumila</i>	2-exponential	305.1, 0.0071
<i>Euonymus alatus</i>	2-exponential	61.2, 0.0457
<i>Prunus kansuensis</i>	2-exponential	182.5, 0.0107
<i>Amygdalus persica</i>	2-exponential	161.0, 0.0110
<i>Robinia pseudoacacia</i>	2-exponential	162.1, 0.0065
<i>Gleditsia sinensis</i>	2-exponential	177.1, 0.0099
<i>Toona sinensis</i>	2-exponential	221.1, 0.0083
<i>Ziziphus jujuba</i>	2-exponential	174.7, 0.0075

<i>Pinus tabuliformis</i>	2-exponential	724.2, 0.0094
Temperate United Kingdom		
Group 1 ^b	3-exponential	41.4, 548, 0.0391
Group 2	3-exponential	35.3, 410, 0.0228
Group 3	3-exponential	34.8, 545, 0.0200
Group 4	3-exponential	19.1, 664, 0.0142
Group 5	3-exponential	-15.1, 1143, 0.0139

^aThree model types, 2-parameter exponential decay, $y=a*\exp(-bx)$ (Zhang et al., 2018), 3-parameter exponential decay, $y=a + b*\exp(-cx)$ (Murray et al., 1989; Man et al., 2017), and 4-parameter sigmoid curve, $y=a +b*(1+ \exp((x-c)/d))^{-1}$ (Man et al., 2020).

^bGroup 1 – *Populus trichocarpa* and *Crataegus monogyna*; Group 2 – *Sambucus nigra*, *Rosa rugosa*, *Salix viminalis*, *Larix decidua*, and *Prunus avium*; Group 3 – *Rubus idaeus*, *Sorbus aucuparia*, *Betula pendula*, and *Corylus avellane*; Group 4 – *Robina pseudoacacia*, *Tsuga heterophylla*, and *Picea sitchensis*; and Group 5 – *Fagus sylvatica*. As the reported model parameters are not consistent with the model types presented, models were refitted with data extracted from the graphical presentations using the distance measuring tool in Adobe Acrobat Reader DC.