

Supplementary Materials for
Global warming leads to more uniform spring phenology across
elevations

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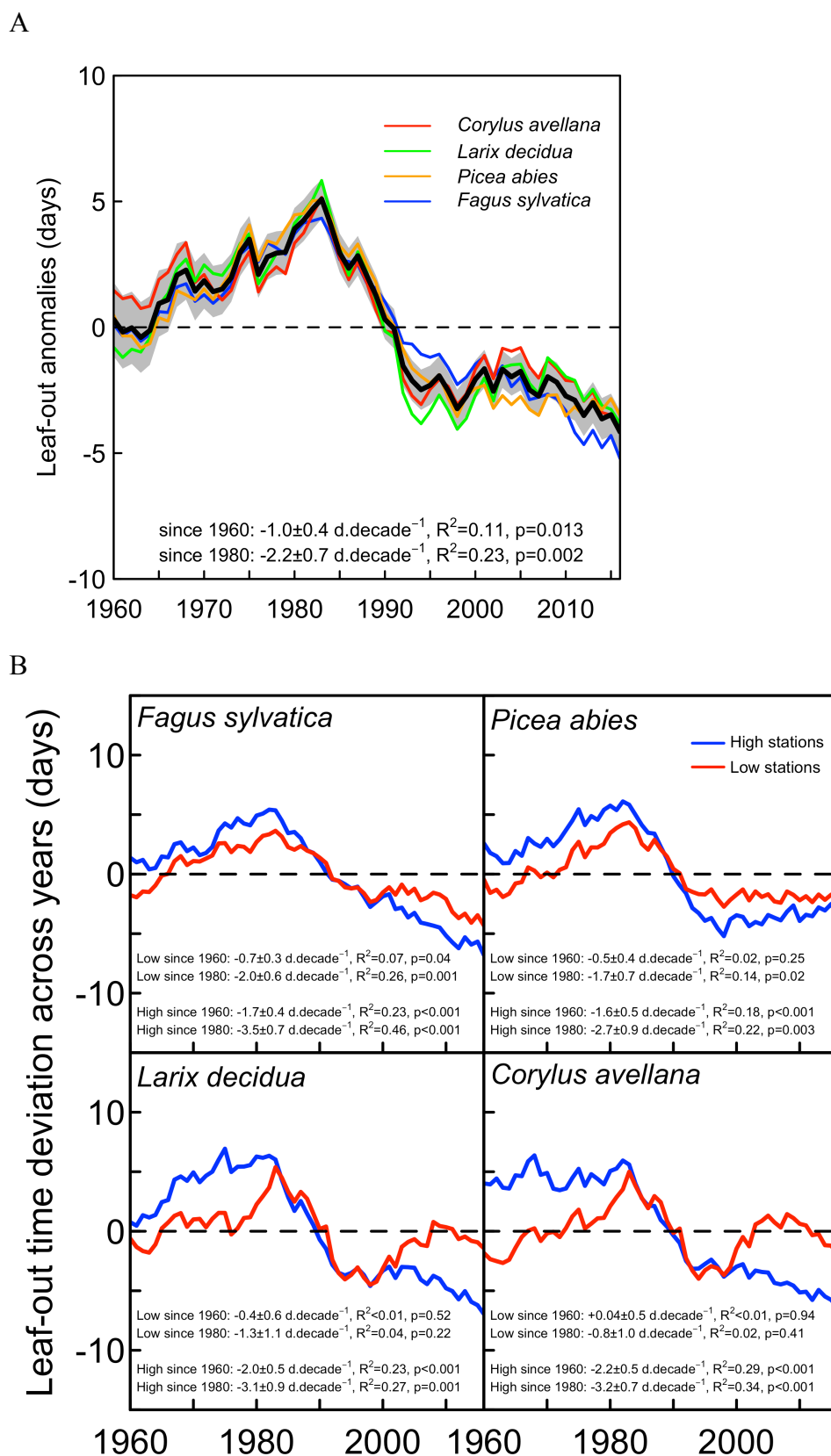


Fig. S2. Phenological anomalies during the period 1960–2016 for all stations (A) and for low- and high-elevation stations (B). Eleven-year moving averages were represented. Slopes values of the linear regression were reported for each species at low and high stations during the whole study period and since 1980. Low- and high-elevation stations were determined by using the 33th and 66th percentile of the species-specific elevational range.

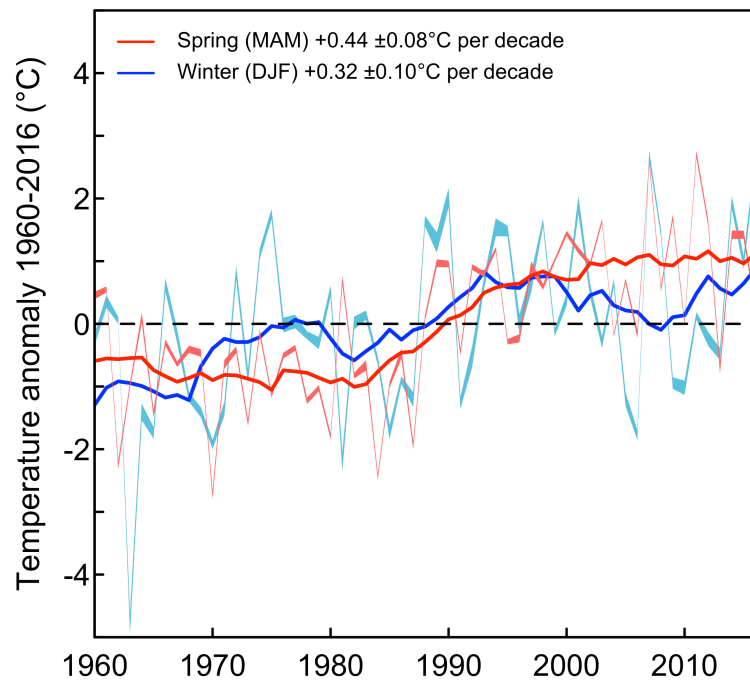


Fig. S3. Winter and spring anomalies during the study period 1960–2016 using all the 23 homogenized temperatures series at locations ranged from 200 m to 1800 m. Eleven-year moving averages were represented. Slopes values of the linear regression were reported for both winter and spring seasons.

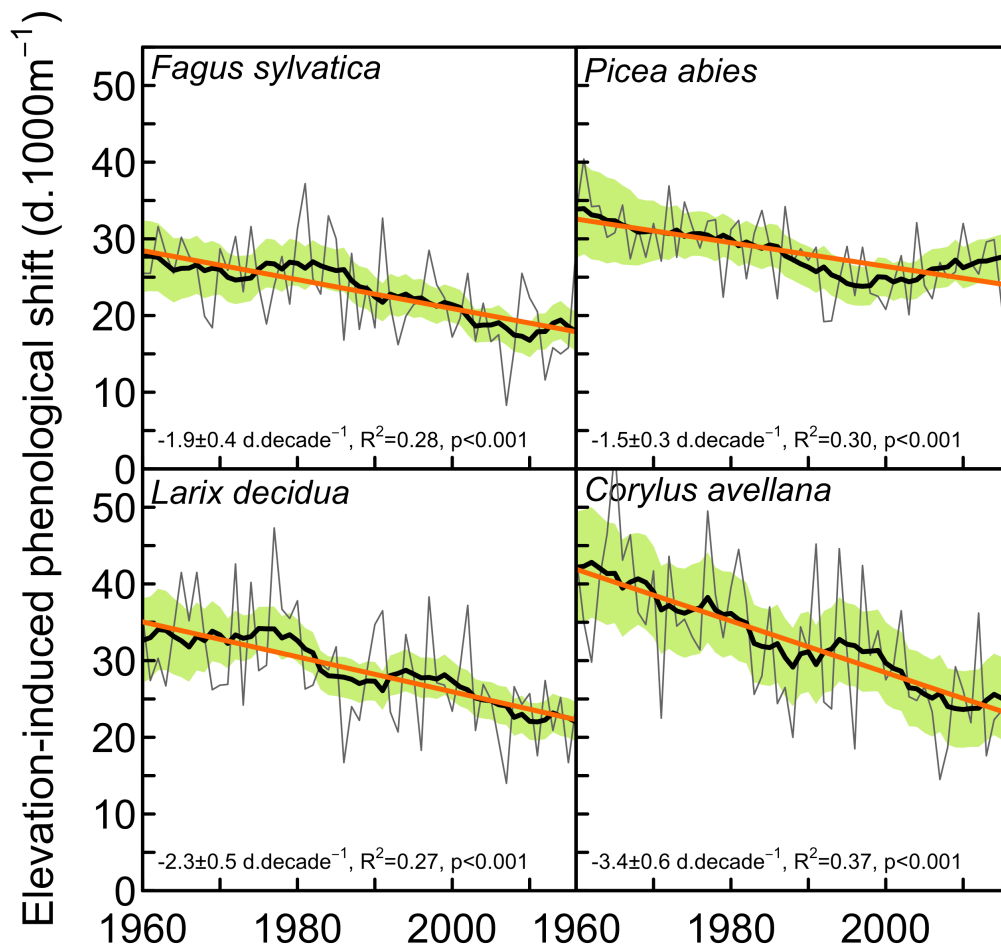


Fig. S4. Changes of the elevation-induced shift (EPS) of the leaf-out dates over the period 1960–2016 for four tree species in Switzerland. Eleven-year moving averages were drawn along with slopes of the linear regressions over time.

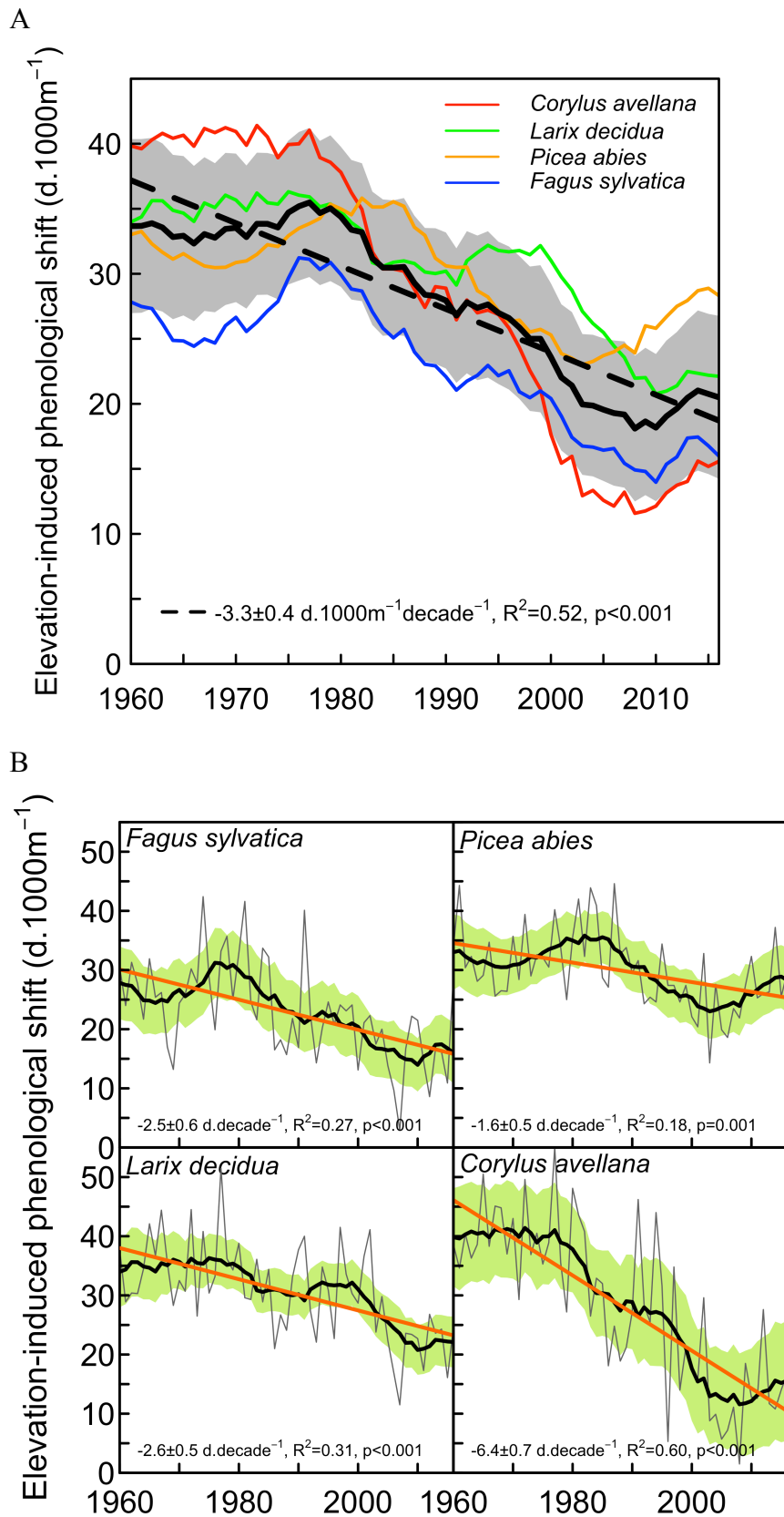


Fig. S5. Changes of the elevation-induced phenology shift (EPS) for the four study species over the period 1960–2016 in Switzerland using a subset of data (stations having at least 50 years of observations). A. for all the four species along with the average and the trend across species. B. for each species along with the species-specific trends. Eleven-year moving averages were represented (black lines) and slopes of the linear regression (dashed or orange lines) and standard deviation (grey or green areas) across (A) and within (B) species were reported.

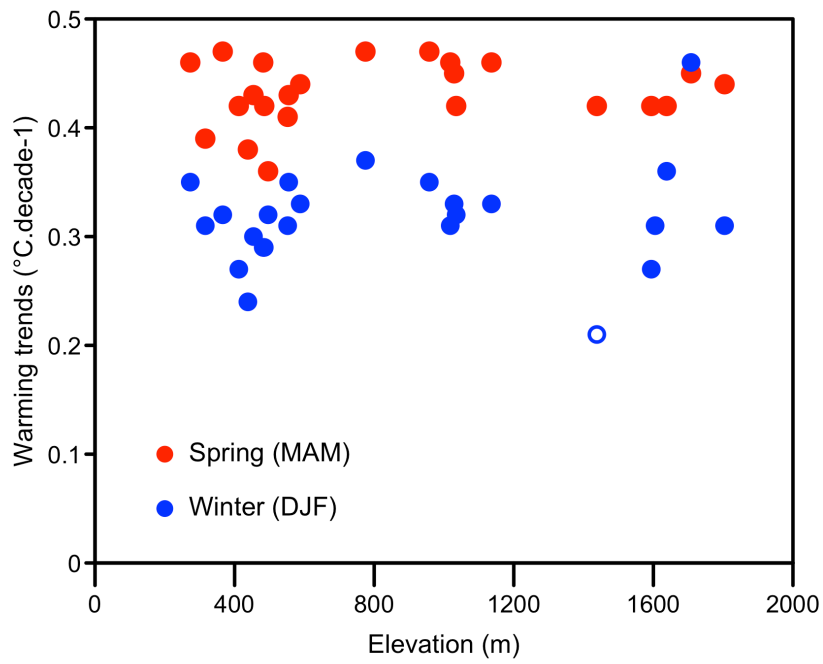


Fig. S6. Warming trends in spring (MAM) and winter (DJF) along elevation using all 23 long-term series of homogenized temperature. Significant trends at $p < 0.05$ are represented with filled circles and non significant trends with open circles.

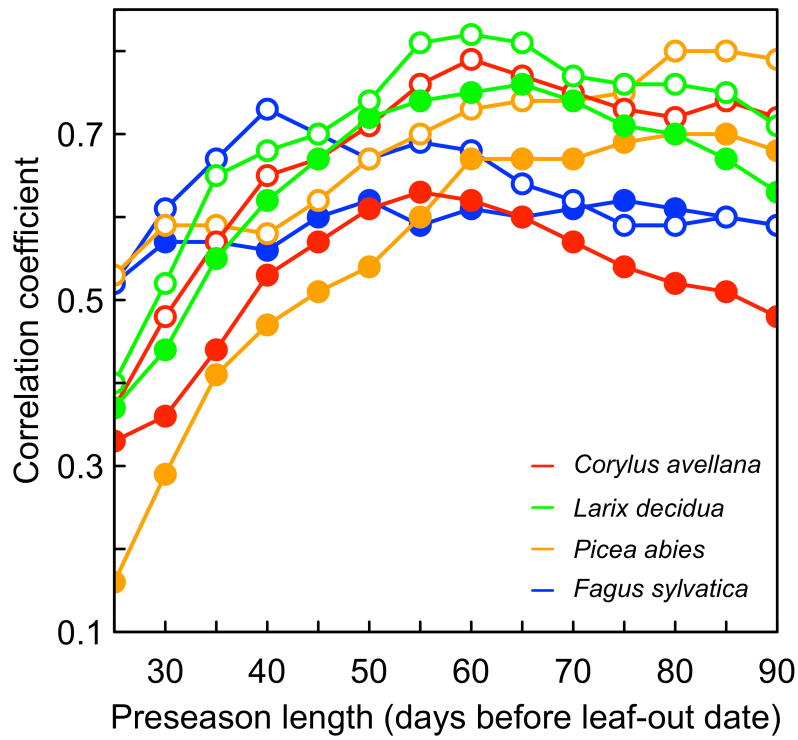


Fig. S7. Coefficient of correlations between leaf-out dates and mean temperature before leaf-out using different pre-season periods from 25 to 90 days (5 days step). Filled circles correspond to low-elevation stations and open circles correspond to high-elevation stations. Low- and high-phenological stations were determined by using the 33th and 66th percentile of the species-specific elevational range.

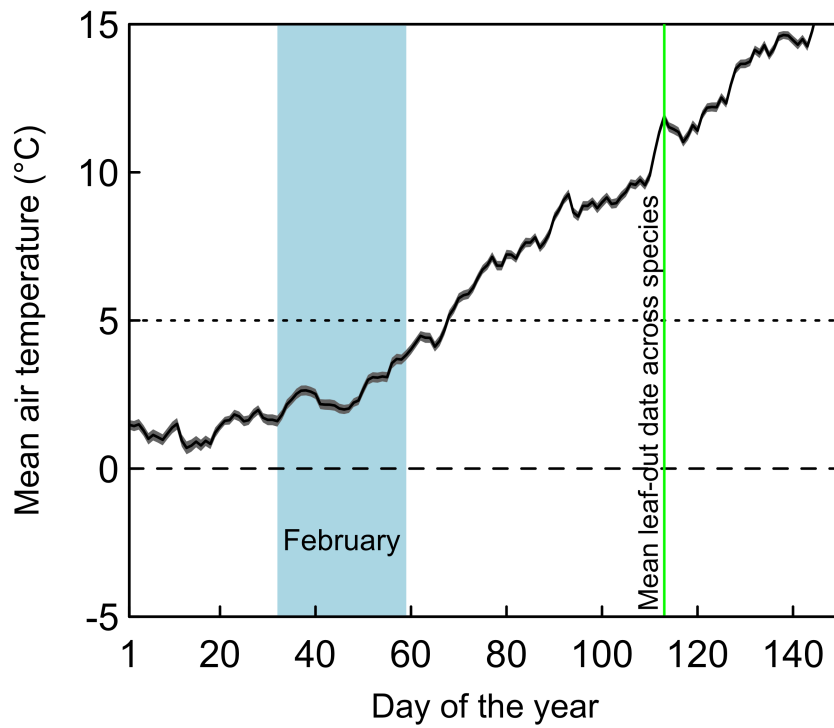


Fig. S8. Mean temperature in February at the lower elevation sites from January to May. The black line is the average temperature day per day across low-elevation stations (33th percentile of the elevational range) over the study period surrounded by the error standard. The blue rectangle represents the month of February. The mean leaf-out date across species at the low-elevation sites is represented by the green vertical line (DOY 113).

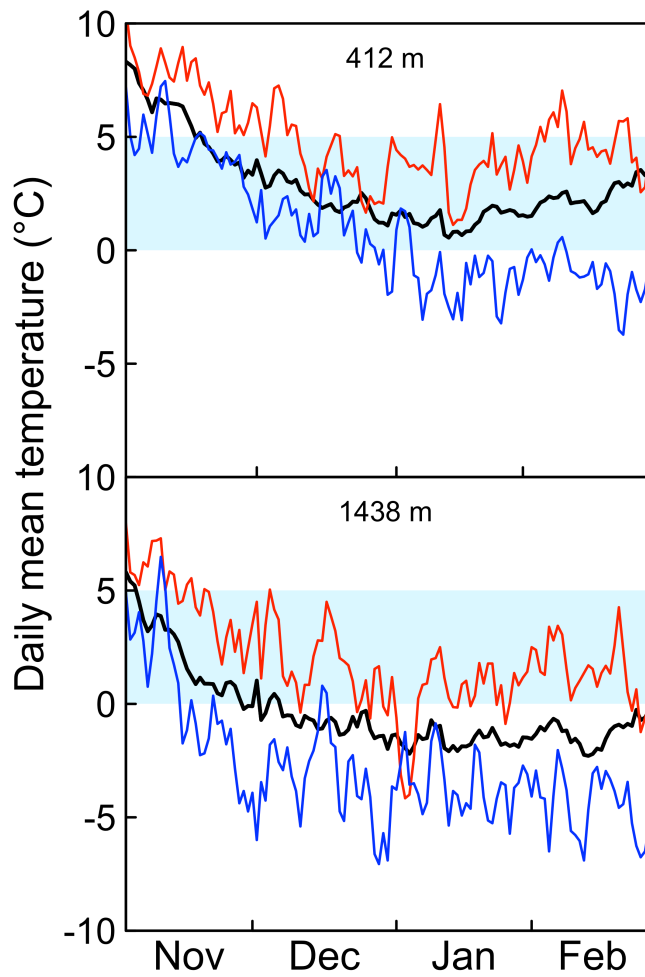


Fig. S9. Daily mean temperature at a low and a high elevation station from November to February (period of chilling accumulation) during the five warmest and five coldest winters over the period 1960–2016. The upper panel show the temperature for a low-elevation station (ALT, 438 m asl.) and the lower panel for a high-elevation station (ANT, 1438 m asl.). For a given station, red lines correspond to the five warmest winters, blue lines correspond to the five coldest winters and black lines is the average across all years.

Table S1. Warming trends during the species-specific pre-season temperatures at low- and high-elevation sites. Low- and high-phenological stations were determined by using the 33th and 66th percentile of the species-specific elevational range.

Species	Slope Low (°C.decade ⁻¹)	Slope High (°C.decade ⁻¹)	ANCOVA
<i>Fagus sylvatica</i>	+0.40±0.09***	+0.49±0.10***	ns
<i>Picea abies</i>	+0.39±0.09***	+0.45±0.08***	ns
<i>Larix decidua</i>	+0.32±0.12**	+0.46±0.09***	ns
<i>Corylus avellana</i>	+0.36±0.12**	+0.47±0.09***	ns
Across species	+0.35±0.10***	+0.49±0.09***	ns

Table S2. Elevation-induced phenology shift (EPS) for *Fagus sylvatica* every during the period 1960–2016. Standard errors of the linear regressions are reported along with the corresponding R^2 and P-values, the number of stations and the maximum elevation difference among the stations (amplitude).

Year	Slope	SE	R^2	P	NB	Amplitude (m)
1960	25.5	5.3	0.39	0.001	36	895
1961	25.6	3.9	0.65	0.001	23	895
1962	31.6	4.2	0.61	0.001	37	895
1963	28.0	5.0	0.48	0.001	34	895
1964	25.5	5.7	0.38	0.001	31	895
1965	30.3	3.9	0.61	0.001	38	1045
1966	27.8	3.8	0.56	0.001	42	1045
1967	26.6	3.8	0.54	0.001	42	1045
1968	19.9	3.6	0.40	0.001	47	1045
1969	18.4	3.0	0.43	0.001	49	1045
1970	28.7	1.9	0.78	0.001	62	1135
1971	25.9	2.9	0.55	0.001	65	1135
1972	30.2	4.2	0.45	0.001	64	1135
1973	23.0	1.9	0.67	0.001	73	1135
1974	31.6	4.7	0.43	0.001	59	1135
1975	23.7	2.7	0.51	0.001	76	1135
1976	18.8	3.1	0.32	0.001	78	1135
1977	23.9	3.2	0.42	0.001	76	1135
1978	27.6	2.8	0.53	0.001	85	1135
1979	21.5	2.8	0.42	0.001	79	1135
1980	31.2	2.8	0.60	0.001	82	1135
1981	37.2	4.0	0.53	0.001	78	1135
1982	24.8	2.6	0.53	0.001	82	1135
1983	22.7	2.2	0.56	0.001	84	1135
1984	33.0	2.8	0.63	0.001	86	1135
1985	30.0	3.4	0.51	0.001	74	1135
1986	16.8	1.5	0.59	0.001	86	1135
1987	28.0	2.8	0.55	0.001	82	1135
1988	18.2	2.1	0.47	0.001	83	1135
1989	23.8	3.4	0.39	0.001	78	1135
1990	18.4	2.8	0.35	0.001	80	1135
1991	32.7	4.2	0.45	0.001	76	1135
1992	21.3	2.3	0.48	0.001	91	1135
1993	16.2	2.0	0.43	0.001	89	1135
1994	19.9	2.3	0.47	0.001	86	1135
1995	21.4	2.4	0.48	0.001	87	1135
1996	22.0	1.7	0.65	0.001	87	1135
1997	28.5	3.2	0.49	0.001	83	1135
1998	24.0	2.3	0.56	0.001	88	1135
1999	22.3	2.3	0.52	0.001	90	1135
2000	17.2	1.9	0.49	0.001	88	1135
2001	19.6	2.7	0.37	0.001	86	1135
2002	25.5	2.3	0.59	0.001	84	1135
2003	16.7	2.2	0.40	0.001	87	1135
2004	21.6	2.3	0.51	0.001	88	1135
2005	16.6	2.0	0.46	0.001	81	1135
2006	17.4	2.1	0.46	0.001	84	1135
2007	8.30	2.1	0.17	0.001	75	1135
2008	15.6	1.7	0.48	0.001	86	1135
2009	25.5	2.5	0.57	0.001	77	1135
2010	22.2	2.1	0.57	0.001	83	1045
2011	20.5	2.8	0.47	0.001	59	1045
2012	11.6	2.0	0.30	0.001	82	1045
2013	15.8	2.2	0.39	0.001	82	1045
2014	15.1	2.6	0.31	0.001	74	1045
2015	15.8	2.5	0.34	0.001	78	1035
2016	28.8	3.3	0.52	0.001	70	1035

Table S3. Elevation-induced phenology shift (EPS) for *Picea abies* every during the period 1960–2016. Standard errors of the linear regressions are reported along with the corresponding R^2 and P-values, the number of stations and the maximum elevation difference among the stations (amplitude).

Year	Slope	SE	R^2	P	NB	Amplitude (m)
1960	33.3	5.1	0.56	<0.001	34	1255
1961	40.4	6.3	0.60	<0.001	27	1255
1962	34.2	9.1	0.34	<0.001	27	1255
1963	34.3	6.2	0.50	<0.001	30	1255
1964	30.2	4.3	0.66	<0.001	26	1255
1965	30.8	7.1	0.37	<0.001	31	1255
1966	34.4	3.5	0.74	<0.001	34	1360
1967	27.4	4.9	0.46	<0.001	37	1360
1968	31.4	5.3	0.48	<0.001	38	1360
1969	27.6	4.3	0.49	<0.001	44	1600
1970	32	3.0	0.67	<0.001	55	1600
1971	27.1	2.7	0.60	<0.001	66	1600
1972	36.9	3.6	0.61	<0.001	67	1600
1973	27.6	3.1	0.53	<0.001	68	1600
1974	34.8	3.1	0.67	<0.001	64	1600
1975	31.6	2.7	0.63	<0.001	83	1600
1976	28.8	2.1	0.70	<0.001	82	1600
1977	32.3	3.1	0.57	<0.001	80	1600
1978	32.5	2.7	0.64	<0.001	85	1600
1979	22.4	2.4	0.52	<0.001	84	1600
1980	31.2	3.0	0.56	<0.001	83	1600
1981	32.4	3.6	0.50	<0.001	83	1600
1982	24.8	2.9	0.45	<0.001	90	1600
1983	30.7	2.7	0.59	<0.001	89	1600
1984	33.7	2.7	0.68	<0.001	74	1600
1985	29.1	2.2	0.68	<0.001	85	1600
1986	22.2	2.2	0.53	<0.001	89	1600
1987	34.2	2.9	0.62	<0.001	86	1600
1988	27	2.4	0.60	<0.001	87	1600
1989	28.7	3.0	0.51	<0.001	87	1600
1990	27.2	2.9	0.50	<0.001	85	1600
1991	28.9	3.5	0.46	<0.001	79	1600
1992	19.2	2.4	0.41	<0.001	90	1600
1993	19.3	2.7	0.36	<0.001	91	1600
1994	24.6	2.6	0.53	<0.001	82	1600
1995	29	3.0	0.51	<0.001	91	1600
1996	22.6	2.7	0.47	<0.001	81	1600
1997	28.9	2.5	0.63	<0.001	79	1600
1998	22.9	2.2	0.57	<0.001	83	1600
1999	22.5	2.1	0.56	<0.001	88	1600
2000	20.8	2.2	0.51	<0.001	86	1600
2001	24.3	2.7	0.49	<0.001	82	1600
2002	27.8	2.8	0.56	<0.001	77	1600
2003	20.1	2.4	0.46	<0.001	78	1600
2004	32.1	2.6	0.66	<0.001	77	1600
2005	23.9	2.3	0.57	<0.001	80	1600
2006	22.2	2.5	0.53	<0.001	72	1600
2007	26.9	2.6	0.58	<0.001	76	1600
2008	24.9	2.3	0.60	<0.001	81	1600
2009	25.7	2.5	0.55	<0.001	85	1600
2010	32	2.8	0.63	<0.001	76	1600
2011	26.9	2.9	0.54	<0.001	72	1600
2012	25.4	2.8	0.52	<0.001	78	1600
2013	29.6	3.1	0.56	<0.001	71	1600
2014	29.9	3.0	0.57	<0.001	75	1600
2015	21.1	2.9	0.41	<0.001	77	1600
2016	28.4	3.4	0.49	<0.001	73	1600

Table S4. Elevation-induced phenology shift (EPS) for *Larix decidua* every during the period 1960–2016. Standard errors of the linear regressions are reported along with the corresponding R² and P-values, the number of stations and the maximum elevation difference among the stations (amplitude).

Year	Slope	SE	R ²	P	NB	Amplitude (m)
1960	35.9	4.80	0.55	<0.001	45	1495
1961	27.3	4.50	0.46	<0.001	44	1495
1962	30.4	5.90	0.37	<0.001	44	1495
1963	26.4	5.20	0.34	<0.001	49	1495
1964	32.8	4.60	0.54	<0.001	42	1495
1965	41.5	6.70	0.47	<0.001	43	1495
1966	35.3	4.50	0.56	<0.001	48	1495
1967	41.5	4.90	0.59	<0.001	51	1495
1968	33.8	3.90	0.59	<0.001	54	1495
1969	26.4	3.10	0.53	<0.001	62	1495
1970	25.8	2.40	0.60	<0.001	80	1495
1971	27.4	2.40	0.61	<0.001	86	1495
1972	43.3	3.40	0.65	<0.001	88	1495
1973	24.2	2.80	0.48	<0.001	85	1495
1974	40.2	3.20	0.65	<0.001	87	1495
1975	28.7	2.30	0.62	<0.001	95	1495
1976	30.4	2.40	0.61	<0.001	102	1495
1977	47.3	3.60	0.65	<0.001	92	1495
1978	36.8	2.90	0.61	<0.001	102	1495
1979	36.1	2.70	0.63	<0.001	106	1495
1980	37.8	2.70	0.68	<0.001	98	1495
1981	27.1	2.80	0.47	<0.001	104	1495
1982	26.4	2.90	0.45	<0.001	101	1495
1983	30.6	2.70	0.55	<0.001	102	1495
1984	29.7	2.50	0.60	<0.001	95	1495
1985	31.3	2.50	0.61	<0.001	103	1495
1986	17.1	1.70	0.48	<0.001	106	1495
1987	25.2	1.90	0.63	<0.001	107	1495
1988	22.7	1.80	0.60	<0.001	105	1495
1989	29.3	2.80	0.52	<0.001	103	1495
1990	34.9	3.30	0.54	<0.001	97	1495
1991	37.1	3.50	0.52	<0.001	104	1495
1992	23.4	2.40	0.46	<0.001	109	1495
1993	21.2	1.80	0.57	<0.001	108	1495
1994	33.6	3.00	0.56	<0.001	103	1495
1995	28.7	2.60	0.53	<0.001	110	1495
1996	18.4	2.20	0.41	<0.001	102	1495
1997	38.8	3.00	0.64	<0.001	96	1495
1998	27.7	2.60	0.52	<0.001	104	1495
1999	26.8	2.40	0.54	<0.001	109	1495
2000	23.8	2.10	0.56	<0.001	103	1495
2001	29.2	2.90	0.50	<0.001	103	1495
2002	37.5	3.10	0.61	<0.001	99	1495
2003	21.4	2.30	0.46	<0.001	101	1495
2004	27.6	2.30	0.61	<0.001	96	1495
2005	24.9	2.30	0.57	<0.001	93	1495
2006	19.6	1.90	0.51	<0.001	96	1495
2007	14.1	2.30	0.29	<0.001	95	1495
2008	26.6	2.20	0.58	<0.001	102	1495
2009	24.3	2.40	0.50	<0.001	103	1495
2010	25.7	2.60	0.50	<0.001	98	1495
2011	17.6	2.60	0.33	<0.001	90	1495
2012	27.5	2.90	0.49	<0.001	95	1495
2013	20.9	2.40	0.46	<0.001	92	1495
2014	25.2	2.70	0.48	<0.001	91	1495
2015	16.6	2.00	0.42	<0.001	93	1470
2016	24.1	2.80	0.46	<0.001	89	1470

Table S5. Elevation-induced phenology shift (EPS) for *Corylus avellana* every during the period 1960–2016. Standard errors of the linear regressions are reported along with the corresponding R^2 and P-values, the number of stations and the maximum elevation difference among the stations (amplitude).

Year	Slope	SE	R^2	P	NB	Amplitude (m)
1960	43.7	6.7	0.72	<0.001	17	1045
1961	35.0	8.9	0.49	0.001	16	1045
1962	29.8	7.7	0.45	0.001	18	1045
1963	40.5	5.8	0.72	<0.001	20	1045
1964	46.5	6.2	0.80	<0.001	15	1045
1965	57.5	8.3	0.72	<0.001	19	1045
1966	43.1	7.9	0.63	<0.001	18	1045
1967	46.4	6.1	0.72	<0.001	23	1045
1968	36.3	4.8	0.67	<0.001	28	1045
1969	34.7	4.6	0.66	<0.001	29	1045
1970	41.7	4.3	0.76	<0.001	30	1045
1971	22.5	5.3	0.34	<0.001	35	1045
1972	43.6	8.0	0.43	<0.001	38	1045
1973	34.5	4.5	0.61	<0.001	38	1045
1974	35.4	7.7	0.33	<0.001	42	1045
1975	33.1	4.2	0.59	<0.001	44	1045
1976	31.4	5.8	0.38	<0.001	47	1045
1977	49.5	6.9	0.54	<0.001	44	1045
1978	38.6	6.3	0.44	<0.001	47	1045
1979	33.0	6.3	0.37	<0.001	46	1045
1980	39.5	5.9	0.51	<0.001	44	1045
1981	44.5	4.9	0.66	<0.001	44	1045
1982	37.5	4.1	0.64	<0.001	46	1045
1983	25.6	4.6	0.40	<0.001	47	1045
1984	28.0	5.2	0.40	<0.001	43	1045
1985	37.0	5.5	0.49	<0.001	47	1045
1986	24.4	4.1	0.42	<0.001	48	1045
1987	26.5	4.3	0.45	<0.001	46	1045
1988	20.0	4.4	0.29	<0.001	47	1045
1989	34.4	5.8	0.43	<0.001	47	1045
1990	31.3	6.3	0.34	<0.001	46	1045
1991	45.2	6.8	0.48	<0.001	48	1045
1992	24.6	5.0	0.32	<0.001	51	1045
1993	23.7	4.2	0.39	<0.001	50	1045
1994	44.6	6.1	0.53	<0.001	48	1045
1995	31.1	5.1	0.43	<0.001	49	1045
1996	18.5	4.5	0.26	<0.001	46	1045
1997	42.4	6.3	0.49	<0.001	48	1045
1998	30.7	5.5	0.39	<0.001	48	1045
1999	33.9	4.7	0.52	<0.001	49	1045
2000	27.5	4.6	0.42	<0.001	48	1045
2001	29.3	5.7	0.36	<0.001	47	1045
2002	36.5	5.9	0.46	<0.001	45	1045
2003	25.3	5.1	0.34	<0.001	47	1045
2004	24.8	5.2	0.33	<0.001	44	1045
2005	26.6	6.0	0.30	<0.001	44	1045
2006	23.3	4.3	0.40	<0.001	45	1045
2007	14.5	3.4	0.29	<0.001	44	1045
2008	18.7	4.8	0.23	<0.001	47	1045
2009	29.2	4.7	0.45	<0.001	46	1045
2010	26.1	5.6	0.30	<0.001	48	1045
2011	21.9	4.4	0.36	<0.001	44	1045
2012	36.2	5.8	0.45	<0.001	46	1045
2013	17.6	5.4	0.18	0.002	44	1045
2014	22.3	6.1	0.23	<0.001	42	1045
2015	23.5	4.4	0.37	<0.001	47	1035
2016	28.0	6.0	0.32	<0.001	44	1035