

# Regional Risk: Supplement

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## Methods: Space Parameter

The ultimate intent for the space parameter is to control for spatial autocorrelation in the model. To do this, we needed to ensure that the space parameter does not “interfere” with other spatially-structured parameters in the model. Thus, we first ran a linear model to estimate the number of false springs using all model parameters except for space.

$$\begin{aligned} y_i \sim N(\alpha(i)) &+ \beta_{NAO(i)} + \beta_{MeanSpringTemp(i)} + \beta_{Elevation(i)} + \beta_{DistanceCoast(i)} \\ &+ \beta_{ClimateChange(i)} + \beta_{NAO \times Species(i)} + \beta_{MeanSpringTemp \times Species(i)} + \beta_{Elevation \times Species(i)} \\ &+ \beta_{DistanceCoast \times Species(i)} + \beta_{ClimateChange \times Species(i)} \\ &+ \beta_{NAO \times ClimateChange(i)} + \beta_{MeanSpringTemp \times ClimateChange(i)} + \beta_{Elevation \times ClimateChange(i)} \\ &+ \beta_{DistanceCoast \times ClimateChange(i)} + \sigma_{sp(i)} \end{aligned}$$

We then took the residuals of that regression to use as our Y values in our eigenvector selection — using a minimization of Moran’s *I* of the residuals (David *et al.*, 2017, MIR). We then took the calculated eigenvectors determined from the MIR approach and regressed these against the residuals from ???. The fitted values from this regression were used as the space parameter in our models.

## Species rate of budburst calculations

1. We used data from a growth chamber experiment (Flynn2018) to determine the average number of days between budburst and leafout for our study species.
2. Cuttings for the experiment were made in January 2015 from two field sites: Harvard Forest (HF, 42.5°N, 72.2°W) and the Station de Biologie des Laurentides in St-Hippolyte, Québec (SH, 45.9°N, 74.0°W).
3. The experiment examined budburst and leafout for *Acer saccharum* (Marshall), *Alnus incana* (L.), *Betula papyrifera* (Marshall), *Fagus grandifolia* (Ehrh.), *Fraxinus nigra* (Marshall), and *Quercus alba* (L.) in a fully crossed design of three levels of chilling (field chilling, field chilling plus 30 days at either 1 or 4 °C), two levels of forcing (20°C/10°C or 15°C/5°C day/night temperatures, such that thermoperiodicity followed photoperiod) and two levels of photoperiod (8 versus 12 hour days) resulting in 12 treatment combinations.
4. Phenological observations of each cutting were made every 2-3 days over 82 days.
5. Phenology was assessed using a BBCH scale that was modified for trees (Finn *et al.*, 2007).
6. We used data from *Acer saccharum* for *Aesculus hippocastanum* (Buerki *et al.*, 2010), *Alnus incana* for *Alnus glutinosa*, *Betula papyrifera* for *Betula pendula* (Wang *et al.*, 2016), *Fagus grandifolia* for *Fagus sylvatica*, *Fraxinus nigra* for *Fraxinus excelsior* and *Quercus alba* for *Quercus robur* (Hipp *et al.*, 2017).

## References

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# Supplement: Tables and Figures

Table 1: Data collected from PEP725 for each species

Species	Num. of Observations	Num. of Sites	Num. of Years
<i>Aesculus hippocastanum</i>	156836	10158	66
<i>Alnus glutinosa</i>	91182	6775	66
<i>Betula pendula</i>	155251	10139	66
<i>Fagus sylvatica</i>	129133	9099	66
<i>Fraxinus excelsior</i>	92665	7327	65
<i>Quercus robur</i>	131635	8811	66

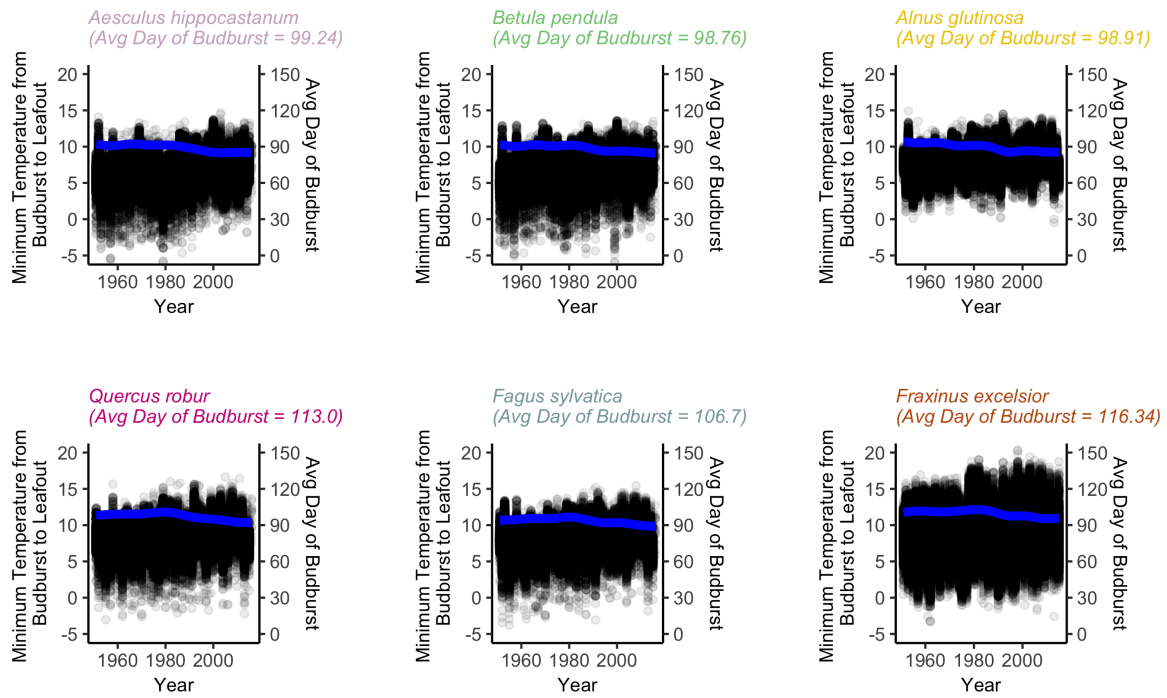


Figure 1: Minimum temperatures between budburst and leafout are plotted for each site over time (from 1951-2016) for each species. The blue line is a smoothing spline, indicating the trend of average day of budburst for each year for each species. Species are ordered by average day of budburst, with the earliest being *Betula pendula* and the latest being *Fraxinus excelsior*.

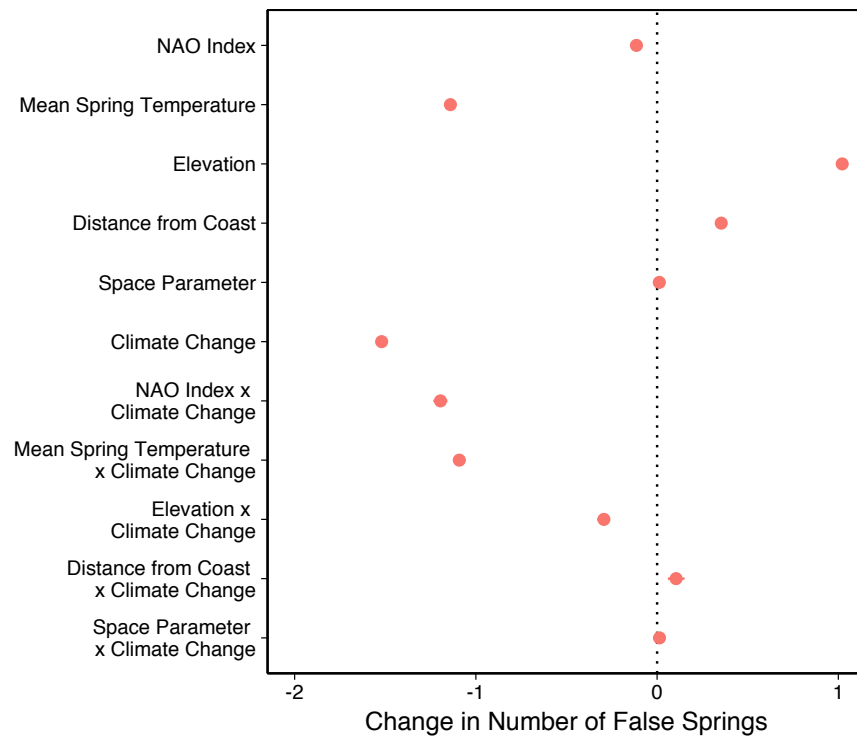


Figure 2: Model output with different durations of vegetative risk for each species. More positive parameter effects indicate an increased probability of a false spring whereas more negative effects suggest a lower probability of a false spring. Uncertainty intervals are at 50%. Parameter effects closer to zero have less of an effect on false springs. There were 744,295 zeros and 10,491 ones for false spring in the data.

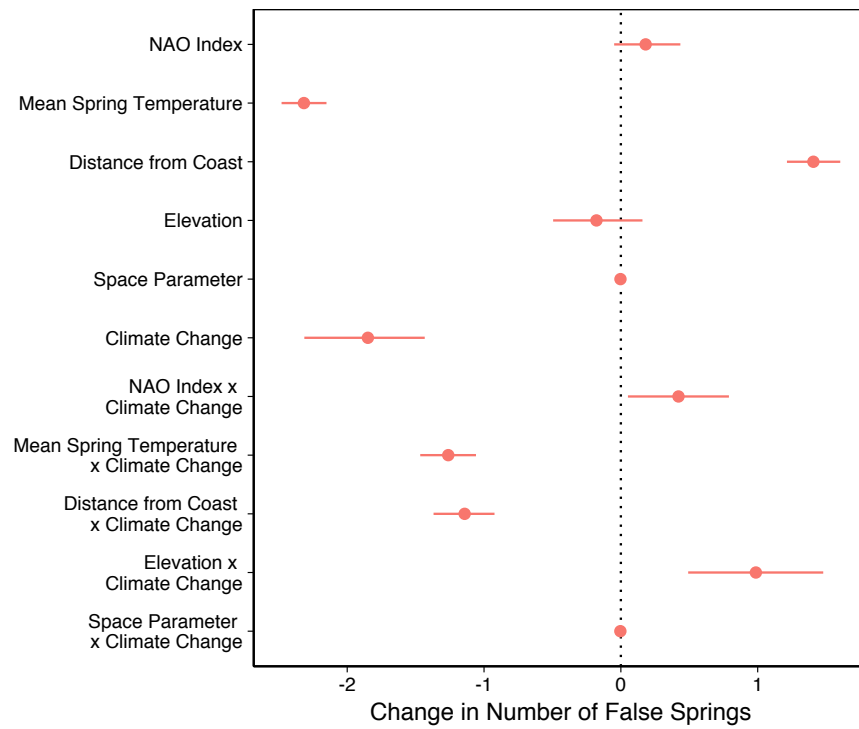


Figure 3: Model output with a lower temperature threshold ( $-5^{\circ}\text{C}$ ) for defining a false spring. More positive parameter effects indicate an increased probability of a false spring whereas more negative effects suggest a lower probability of a false spring. Uncertainty intervals are at 50%. Parameter effects closer to zero have less of an effect on false springs. There were 755,677 zeros and 1,025 ones for false spring in the data, rendering a less stable model.