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 and to remove collinearity issues. 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 the regression (Equation S1) to use as our Y values in our eigenvector selection. The eigenvector selection method we used was 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 Equation S1. The fitted values from this final regression were used as the space parameter in our models.

Species rate of budburst calculations

We used data from a growth chamber experiment (Flynn2018) to determine the average number of days between budburst and leafout for our study species. 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). 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. Phenological observations of each cutting were made every 2-3 days over 82 days. Phenology was assessed using a BBCH scale that was modified for trees (Finn *et al.*, 2007). 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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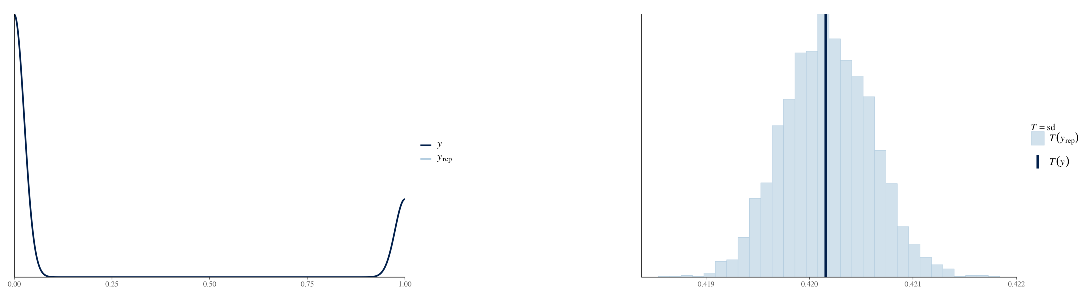
Supplement: Tables and Figures

Table 1: Data collected from PEP725 for each species

Species	Num. of Observations	Num. of Sites	Num. of Years
Aesculus hippocastanum	156468	10157	66
Alnus glutinosa	91094	6775	65
Betula pendula	154897	10139	66
Fagus sylvatica	129133	9099	66
Fraxinus excelsior	92665	7327	65
Quercus robur	131635	8811	66



(a) (b)

Figure 1: (a) Posterior predictive check comparing the simulated model estimates to the raw data. The curves overlap greatly, which suggests our model is valid and fit the data. (b) Posterior predictive check comparing the standard deviation from our model output to the data. The model fits our data well, which suggests our model is valid.

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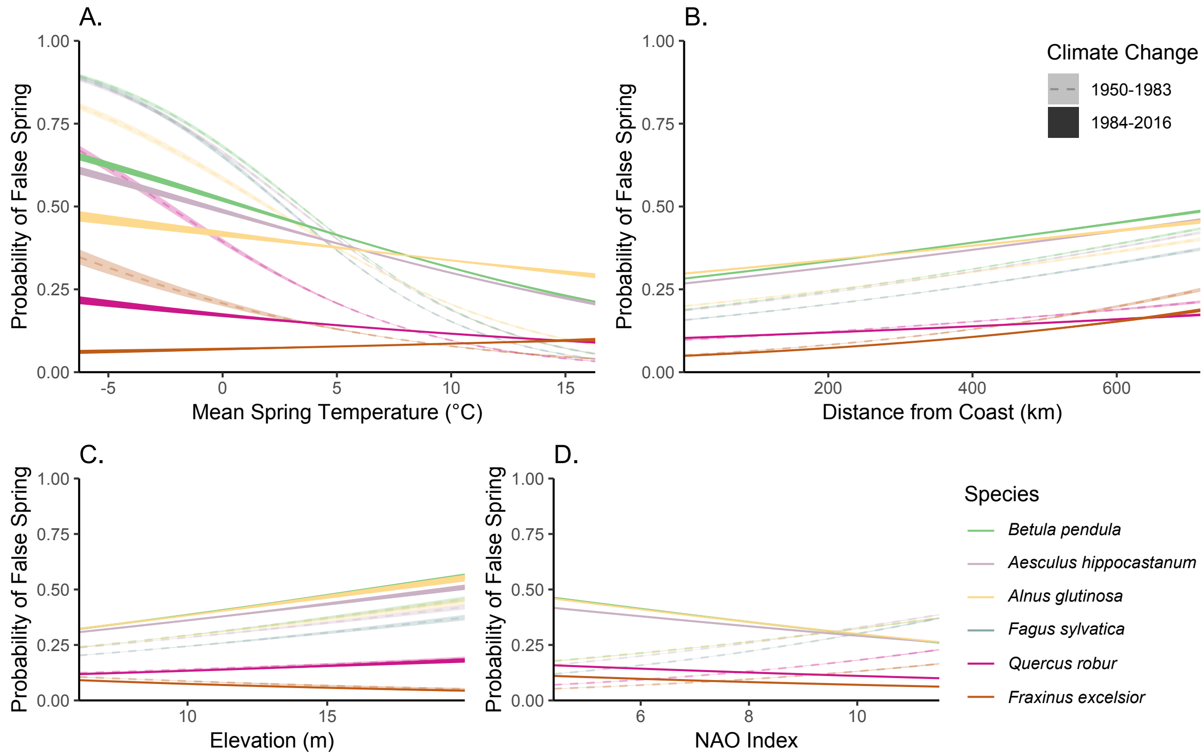

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Figure 2: Average predictive comparisons for all climate change interactions with each of the main effects (i.e., mean spring temperature, distance from the coast, elevation, and NAO index). All species are represented.

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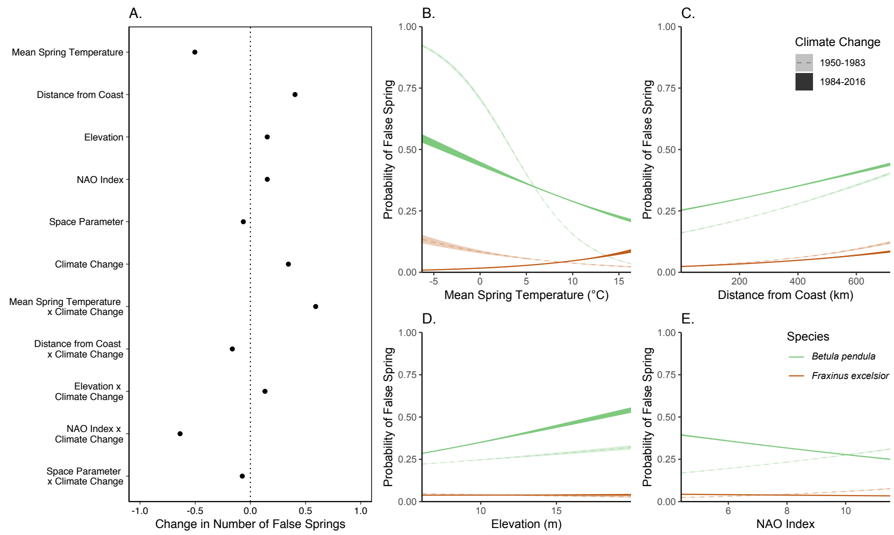

Figure 3: (A) Model output with different durations of vegetative risk for each species. More positive parameter effects indicate an increased probability of a false spring whereas more negative effects suggest a lower probability of a false spring. Uncertainly intervals are at 50%. Parameter effects closer to zero have less of an effect on false springs. There were 622,565 zeros and 132,463 ones for false spring in the data. Panels B-E breakdown the interactions of each of the main effects with climate change (i.e., Mean spring temperature, distance from the coast, elevation, and NAO index). The two extreme species – *Betula pendula* and *Fraxinus excelsior* — were chosen to best represent the variation across all species.

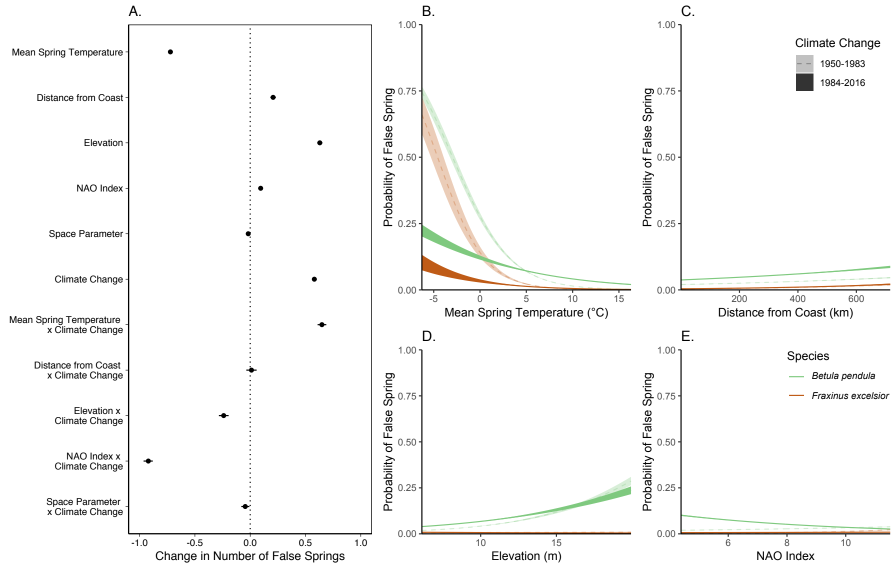

Figure 4: (A) Model output with a lower temperature threshold (-5°C) for defining a false spring. More positive parameter effects indicate an increased probability of a false spring whereas more negative effects suggest a lower probability of a false spring. Uncertainly intervals are at 50%. Parameter effects closer to zero have less of an effect on false springs. There were 730,996 zeros and 23,855 ones for false spring in the data, rendering a less stable model. Panels B-E breakdown the interactions of each of the main effects with climate change.