# Rethinking False Spring Risk

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## Tables and Figures

# 1 Determining Spring Onset

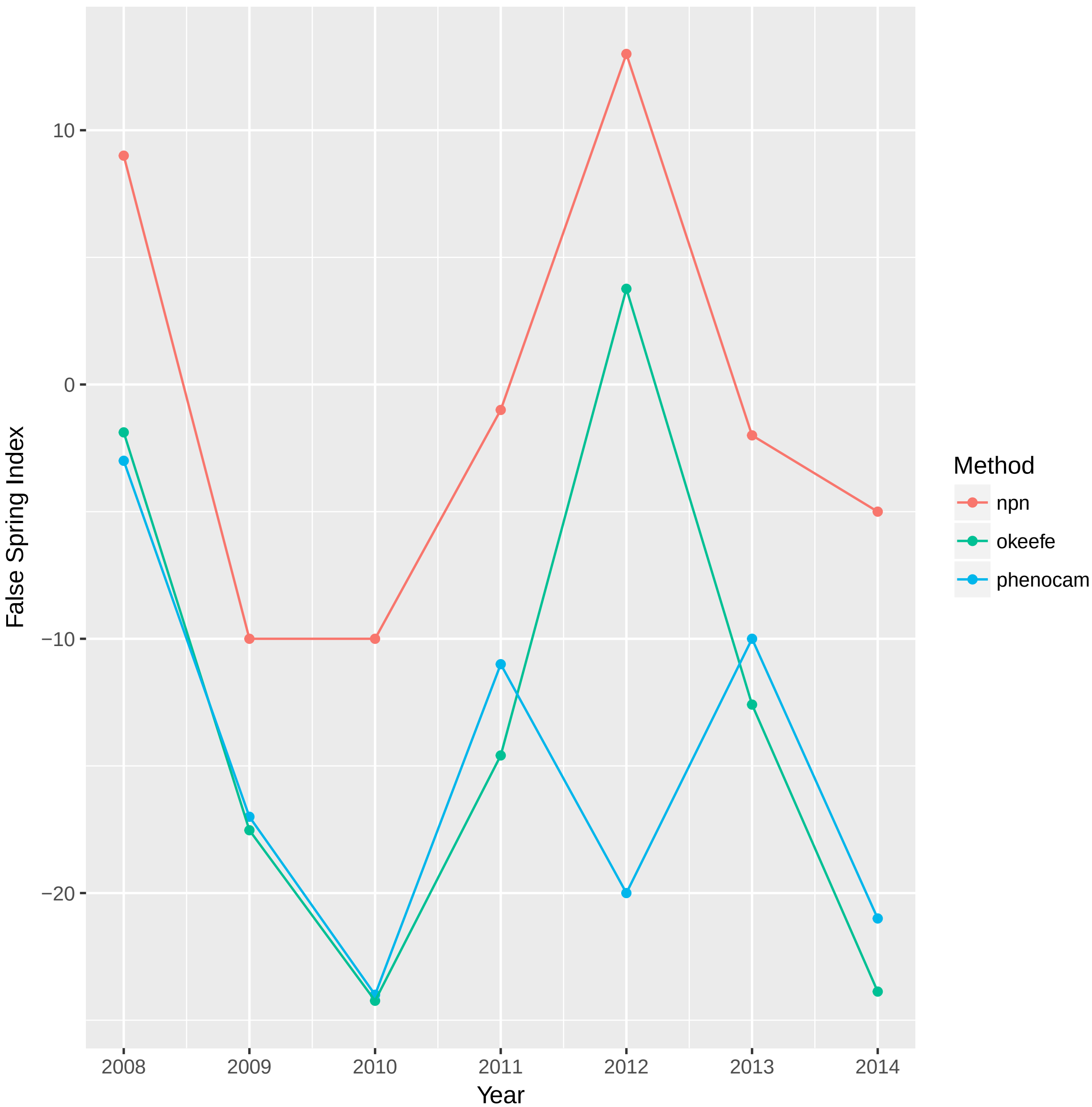


Figure 1: A scatterplot indicating FSI values from 2008 to 2014 for each methdology used in this study. PhenoCam FSI values are red, Observed FSI values are blue, and USA-NPN FSI values are green.

# Species Differences and Vegetative Risk

## Treespotters Data

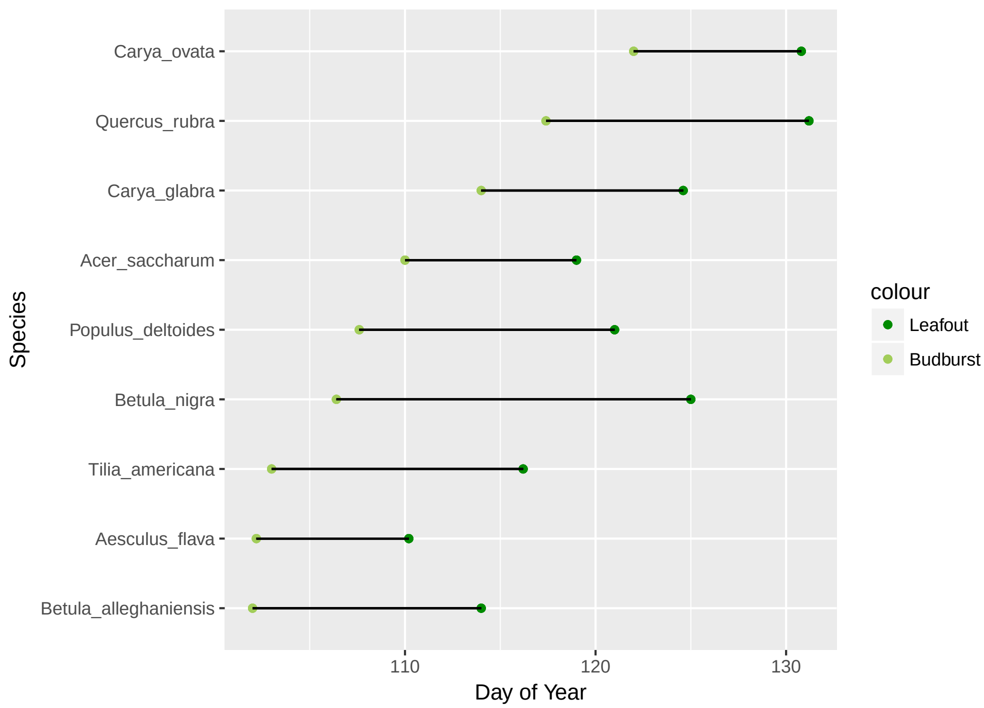


Figure 2: Duration of vegetative risk for 9 native tree species in New England. Data was downloaded from the US-NPN data download tool (http://data.usanpn.org/observations/get-started) and observations were collected from the Arnold Aboretum - Tree Spotters program.

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 7.0456 | 9.4102 | 0.75 | 0.4575 |
| Budburst | 0.0549 | 0.0858 | 0.64 | 0.5250 |

## Dan's Data

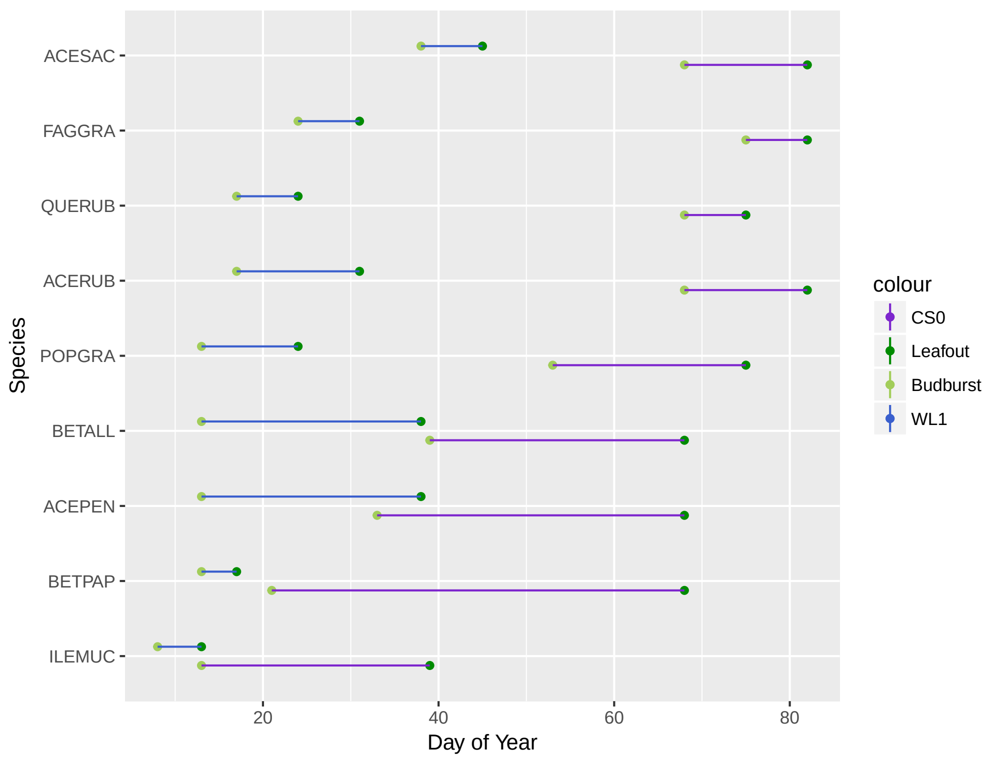


Figure 3: Day of budburst and the day of leaf out for native tree species in New England. Data was collected from a growth chamber experiment using any combination of two photoperiod treatments, two forcing treatments, and three chilling treatments. The standard deviation is represented in blue for budburst and green for leaf out.

## Harvard Forest Data

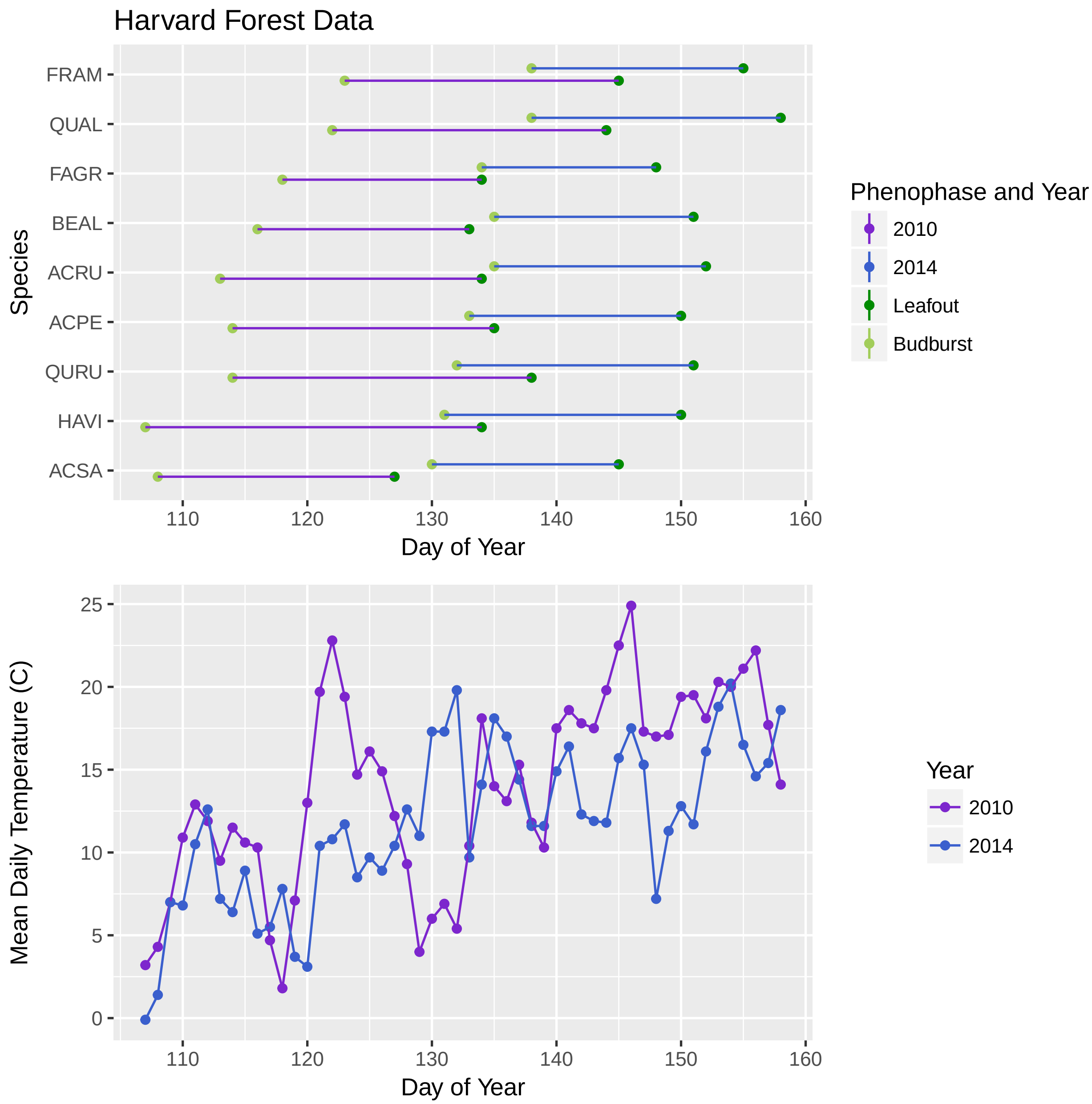


Figure 4: A timeline plot indicating the duration of vegetative risk for each species from collected from Harvard Forest.

## Regional Differences in Vegetative Risk?

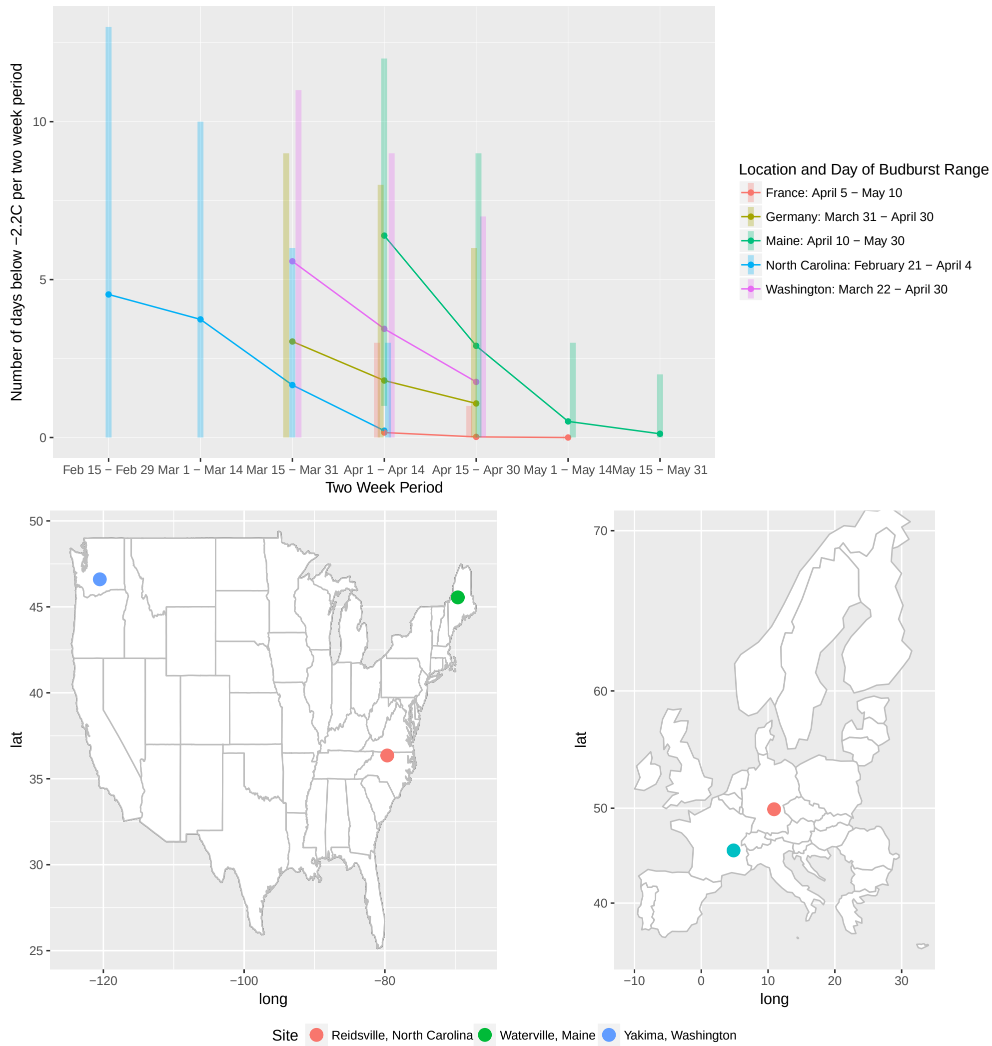


Figure 5: Risk of a false spring event across five archetypal climate regions. The data was subsetted for each region based on earliest historical spring onset date to the latest historical leafout date and was divided into biweekly time periods (USA-NPN, 2016; Soudani *et al.*, 2012; Schaber & Badeck, 2005). We calculated the mean number of days that were -2.2°C (Ault *et al.*, 2015; Schwartz *et al.*, 2006; Schwartz, 1993) or below for each two week period that fell within the budburst to leafout timeframe in each region.

## Temperature Thresholds for Damage: Agricultural vs Ecological

Table 1: Comparing damaging spring temperature thresholds in ecological and agronomical studies across various species and phenophases.

| **Sector** | **BBCH** | **Species** | **Temperature (°C)** | **Type** | **Source** |
|---|---|---|---|---|---|
| Ecological | 9-15 | Sorbus aucuparia | -7.4 | 50% lethality | Lenz *et al.* (2016) |
| Ecological | 9-15 | Prunus avium | -8.5 | 50% lethality | Lenz *et al.* (2016) |
| Ecological | 9-15 | Tilia platyphyllos | -7.4 | 50% lethality | Lenz *et al.* (2016) |
| Ecological | 9-15 | Acer pseudoplatanus | -6.7 | 50% lethality | Lenz *et al.* (2016) |
| Ecological | 9-15 | Fagus sylvatica | -4.8 | 50% lethality | Lenz *et al.* (2016) |
| Ecological | 9+ | All | -2.2 | hard | Schwartz (1993) |
| Ecological | 9+ | All | -1.7 | soft | Augspurger (2013) |
| Ecological | All | All | 2 SD below winter TAVG | cold-air outbreaks | Vavrus *et al.* (2006) |
| Ecological | 9+ | Eucalyptus pauciflora | -5.8 | elevated CO2 and temperature threshold | Barker *et al.* (2005) |
| Ecological | 9+ | All | -2.2 | 7 day threshold | Peterson & Abatzoglou (2014) |
| Agrinomical | 9+ | All | 2 | Risk threshold for clear nights | Cannell & Smith (1986) |
| Agrinomical | Floral | Vaccinium spp. | -4.4 to 0 | sprinkler protection threshold | Longstroth (2012) |
| Agrinomical | 9 | Rosaceae | -7.2 | 10% lethality | Longstroth (2013) |
| Agrinomical | 9 | Rosaceae | -13.3 | 90% lethality | Longstroth (2013) |
| Agrinomical | All | All | Varies | Radiation Frost | Barlow *et al.* (2015) |
| Agrinomical | Floral | Wheat | -4 to -5 | 10-90% lethality | Barlow *et al.* (2015) |
| Agrinomical | Vegetative | Wheat | -7 for 2hrs | 100% lethality | Barlow *et al.* (2015) |
| Agrinomical | Vegetative | Rice | 4.7 | lethal limit | Sánchez *et al.* (2013) |
| Agrinomical | Vegetative | Corn | -1.8 | lethal limit | Sánchez *et al.* (2013) |
| Agrinomical | Vegetative | Wheat | -17.2 | lethal limit | Sánchez *et al.* (2013) |

# Conclusion - Box

**Box 1: Key Indicators for Modeling False Spring Risk and Damage**
In order to properly evaluate the expected level of damage sustained from a false spring event key indicators should be included in the model.

I. Life Stage of the Individual(s) (Caffarra & Donnelly, 2011)
   (i) Seedlings and saplings will begin budburst earlier than adults
   (ii) The duration of vegetative risk may vary between life stages
   (iii) Long-term effects may vary

II. Location Within a Forest (Augspurger, 2013)
   (i) Individuals along the forest edge are more likely to experience a false spring
   (ii) Level of damage is likely to be higher at forest edges

III. Amount of Winter Chilling (Flynn & Wolkovich, 2017?)
   (i) Will affect the timing of budburst in the spring
   (ii) Will affect the duration of vegetative risk

IV. Proximity to Water
   (i) Large bodies of water are expected to act as a buffer to spring freezes

V. Precipitation Prior to Budburst (Anderegg *et al.*, 2013)
   (i) Will a drought increase cavitation and heighten damage from a false spring?
   (ii) Or will a drought decrease the risk of damage due to a lower chance of intracellular frost damage?

VI. Freeze Duration and Intensity
   (i) How should we define freezing temperatures?
   (ii) At what point is a freezing event severely damaging and xylem embolism occurs?
   (iii) How long must a false spring be to cause xylem embolism?

VII. Range of the Species
   (i) Species that have a more northern range may be more photoperiod than temperature sensitive

# References


Anderegg, W.R.L., Plavcová, L., Anderegg, L.D.L., Hacke, U.G., Berry, J.A. & Field, C.B. (2013) Drought's legacy: Multiyear hydraulic deterioration underlies widespread aspen forest die-off and portends increased future risk. *Global Change Biology* **19**, 1188–1196.

Augspurger, C.K. (2013) Reconstructing patterns of temperature, phenology, and frost damage over 124 years: Spring damage risk is increasing. *Ecology* **94**, 41–50.

Ault, T.R., Zurita-Milla, R. & Schwartz, M.D. (2015) A Matlab{©} toolbox for calculating spring indices from daily meteorological data. *Computers {&} Geosciences* **83**, 46–53.

Barker, D., Loveys, B., Egerton, J., Gorton, H., Williams, W. & Ball, M. (2005) Co2 enrichment predisposes foliage of a eucalypt to freezing injury and reduces spring growth. *Plant, Cell and Environment* **28**, 1506–1515.

Barlow, K., Christy, B., O'Leary, G., Riffkin, P. & Nuttall, J. (2015) Simulating the impact of extreme heat and frost events on wheat crop production: A review. *Field Crops Research* **171**, 109–119.

Caffarra, A. & Donnelly, A. (2011) The ecological significance of phenology in four different tree species: Effects of light and temperature on bud burst. *International Journal of Biometeorology* **55**, 711–721.

Cannell, M. & Smith, R. (1986) Climatic Warming , Spring Budburst and Forest Damage on Trees Author ( s ): M . G . R . Cannell and R . I . Smith Published by : British Ecological Society Stable URL : http://www.jstor.org/stable/2403090 JSTOR is a not-for-profit service that helps schol. *Journal of Applied Ecology* **23**, 177–191.

Lenz, A., Hoch, G., Körner, C. & Vitasse, Y. (2016) Convergence of leaf-out towards minimum risk of freezing damage in temperate trees. *Functional Ecology* pp. 1–11.

Longstroth, M. (2012) Protect blueberries from spring freezes by using sprinklers. url.

Longstroth, M. (2013) Assessing frost and freeze damage to flowers and buds of fruit trees. url.

Peterson, A.G. & Abatzoglou, J.T. (2014) Observed changes in false springs over the contiguous United States. *Geophysical Research Letters* **41**, 2156–2162.

Sánchez, B., Rasmussen, A. & Porter, J.R. (2013) Temperatures and the growth and development of maize and rice: a review. *Global Change Biology* **20**, 408–417.

Schaber, J. & Badeck, F.W. (2005) Plant phenology in germany over the 20th century. *Regional Environmental Change* **5**, 37–46.

Schwartz, M.D. (1993) Assessing the onset of spring: A climatological perspective. *Physical Geography* **14(6)**, 536–550.

Schwartz, M.D., Ahas, R. & Aasa, A. (2006) Onset of spring starting earlier across the Northern Hemisphere. *Global Change Biology* **12**, 343–351.

Soudani, K., Hmimina, G., Delpierre, N., Pontailler, J.Y., Aubinet, M., Bonal, D., Caquet, B., de Grandcourt, A., Burban, B., Flechard, C. & et al. (2012) Ground-based network of ndvi measurements for tracking temporal dynamics of canopy structure and vegetation phenology in different biomes. *Remote Sensing of Environment* **123**, 234–245.

USA-NPN (2016) USA National Phenology Network Data Visualizer Tool.

Vavrus, S., Walsh, J.E., Chapman, W.L. & Portis, D. (2006) The behavior of extreme cold air outbreaks under greenhouse warming. *International Journal of Climatology* **26**, 1133–1147.