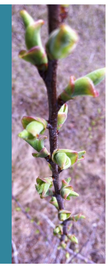
Phenological response to earlier spring: Opportunities and challenges in a changing climate

Sarah T. Bois, PhD
Linda Loring Nature Foundation, Nantucket, MA
stbois@llnf.org www.llnf.org



Introduction

Anticipated consequences of climate change already seen in temperate regions include early spring warmup. These early warm temperatures may mean that certain species can extend their growing seasons and take advantage of favorable conditions. However, we are also seeing warm springs punctuated by intermittent hard freezes. Warm weather can accelerate leaf flush in perennial woody species, potentially exposing vulnerable young tissues to damaging frosts. Earlier warming temperatures may also limit the winter chill accumulation necessary for many temperate woody shrubs.

Research Goals

Long term (10+ years) research objective:

- Create a standardized, long-term dataset as a baseline for research on climate change impacts, climate sensitivities, and species interactions

Differential frost kill of woody species.

Short term (3-5 years) research questions:

- Vulnerability of our study species to earlier spring?
- Are there winners and losers to warming temperatures?

Phenological Observations

Using a combination of field observations and twig warming experiments, we study the effects of early spring warmup on six species of native shrubs characteristic of our study landscape (Nantucket, Massachusetts). These shrubs represent a variety of plant families and constitute the dominant, native shrubs of the study ecosystem. Loggers record hourly temperature at each of eight survey locations.

Breaking Bud Phenology Calendar

Figure 1. Phenology calendar of average bud break timing based on field observations

Twig Warming Experiment

We used woody cuttings of dormant twigs to investigate leaf out and the chilling requirement (recorded in # of days) for each species. Chilling requirements serve as a way to protect plants from leafing out too early in the spring in response to short warm spells, when they would be most vulnerable to frosts.

We collected 10 twigs of each species at three intervals (January, February, and March) over two years mimicking early spring.

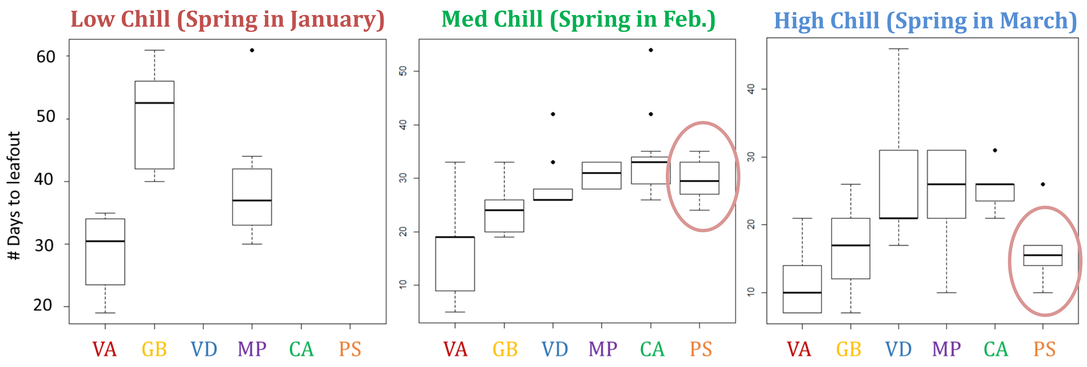


Figure 2. The results of three different "chill levels" experienced by individual twigs. Low Chill mimicked the earliest spring and experienced the lowest total chill hours (number of hours < 7°C) followed by Medium Chill. High Chill experienced the greatest number of chill hours.

- *Vaccinium angustifolium* (lowbush blueberry) leafs out first regardless of # chill hours, but the # days to leaf-out decreases with more chill hours
- *Prunus serotina* (black cherry) has delayed leaf out without sufficient chill requirement
- Few species leafed out at all with the lowest chill hours (mimicking earliest spring temps; January Spring)
- *Morella caroliniensis* (Northern bayberry) is the most consistent leafing out 25 to 35 days after warming regardless of # chill hours

Early leafing species with lower chilling requirements (e.g. *V. angustifolium*) might profit from warming winters, potentially extending their growing seasons and reproductive potential, barring any effect of late spring frosts. **Species more reliant on winter chilling requirements (e.g. *P. serotina*) cannot similarly respond to earlier warming**, potentially limiting any advantage to longer growing season.

Winter chill requirements

Lowbush blueberry *(Vaccinium angustifolium)* — Mild

Black huckleberry *(Gaylussacia bacata)* — Moderate

American hazelnut *(Corylus americana)* — Mild?

Northern bayberry *(Morella caroliniensis)* — Mild?

Arrowwood *(Viburnum dentatum)* — Mild

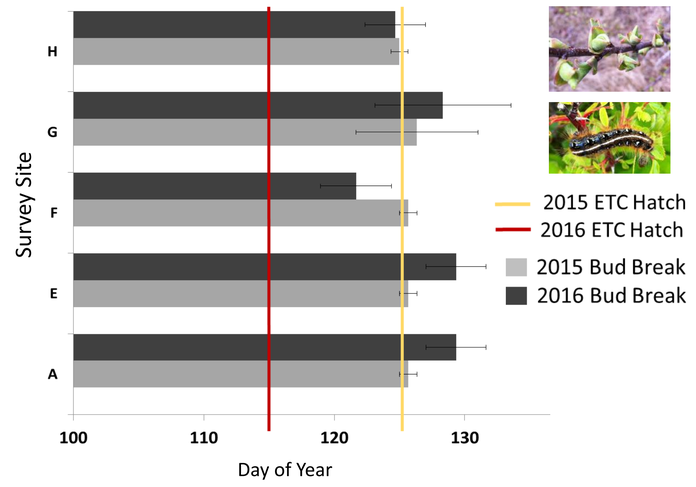
Black cherry *(Prunus serotina)* — Moderate

*calculated based on the difference between the number of days to leaf out at the highest and lowest # chill hours

Ecological Mismatch?

Prunus serotina is the primary host plant of the eastern tent caterpillar, *Malacosoma americanum,* which has been shown to be particularly sensitive to temperature, hatching soon after the onset of spring. Our twig experiments and field observations demonstrate that the stricter winter chill requirements of *P. serotina* prohibit early spring leaf out. This could have negative effects for *M. americanum* as well. Field observations show that, in early spring years (e.g. 2016), *M. americanum* can hatch earlier in response to warming temps, but *P. serotina* cannot, limiting food availability for the caterpillar.

Prunus serotina bud break



- 2016, advanced spring temperatures brought earlier caterpillar hatching, a full 12 days in advance of 2015 (red line above)
- *Prunus serotina* had delayed leaf out, limiting food availability for developing caterpillars (dark gray bars above)
- *M. americanum* caterpillars fed on leaf buds with more caterpillar mortality observed prior to leaf-out of *P. serotina* plants

Future Work

- Building our baseline
- Complimentary frost experiments
- Are anomaly years predictors of potential ecological mismatch?
- How will continued early spring warming affect leaf out and caterpillar hatching?