Phenology at Bear Brook Watershed in Maine: Foliar Chemistry and Morphology

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Background

Growing concerns regarding the impacts of climate change on natural systems have fueled a greater interest in phenology. Phenology helps scientists understand the complex effects of climate change on biotic systems (Schwartz 2003, Menzel 2003). Research on morphological and chemical phenology was done at the Bear Brook Watershed in Maine (BBWM), a long-term, paired watershed study. BBWM is located in Eastern Maine on the southeast slope of Lead Mountain. The West Bear watershed has been treated with $(NH_4)_2SO_4$ bimonthly since 1989. The East Bear watershed has been left as a reference. The chemical treatment mimics chronic acid deposition that is experienced by northeast forests.

Important Terms

Phenology: the study of periodic biological events and how they are affected by the environment (Schwartz, 2003).

Phenological development stage: a visible, morphological event that occurs during seasonal development (Brügger 2003).

Phenophase: a phenological development stage at a defined frequency (Brügger 2003).

Objectives

1. Compare phenophases of West Bear and East Bear trees by observing morphological changes of tree canopies from March through October 2010.
2. Compare the chemical phenology of West Bear and East Bear trees by analyzing foliar samples taken from May through October 2010.

Methods

1. Observations were made of 60 canopy trees: 10 red maple, 10 sugar maple, and 10 red spruce per watershed. Observations were taken through 10 x 42 binoculars from the south side of the trunk. The maple trees were monitored for budburst, flowering, leaf unfolding, fall color change, and leaf fall. The spruce trees were monitored for budburst, needle emergence, and needle elongation.

2. Foliar samples were taken from 30 trees: 5 red maple, 5 sugar maple, and 5 red spruce per watershed. Samples were taken from the mid-canopy on the south side of the tree. The maple trees were sampled once a month from May through September. The spruce trees were sampled once a month from June through October. Foliar samples were rinsed with deionized water, dried, and then ground in a Wiley mill with a 40 mesh screen.

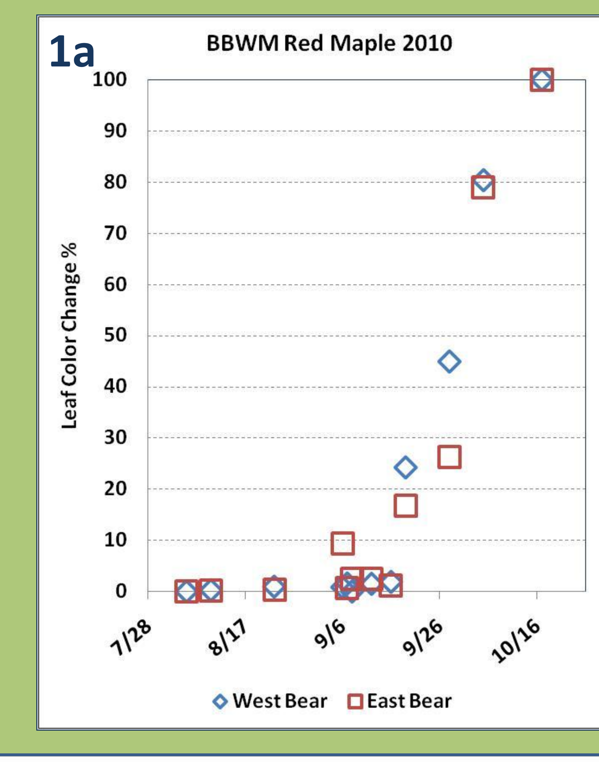
   Chemical analyses for N, C, Ca, K, Mg, P, Al, B, Cu, Fe, Mn concentrations were performed by the Analytical Laboratory of the Maine Agricultural and Forest Experiment Station at the University of Maine. Results were compared between species and watersheds.

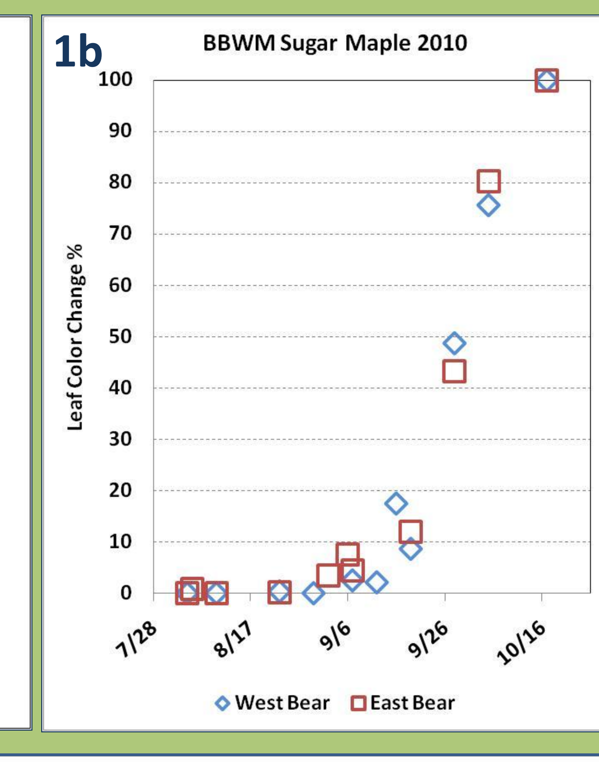
Morphological Phenology Results

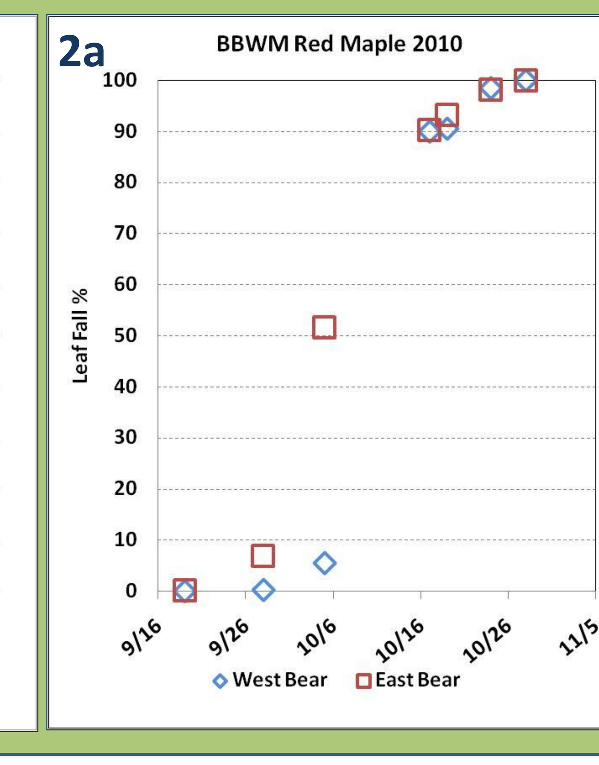
Figure 1a and 1b compare leaf color change in maple trees of the treated West Bear and the reference East Bear watershed. There were no clear differences between watersheds or among species.

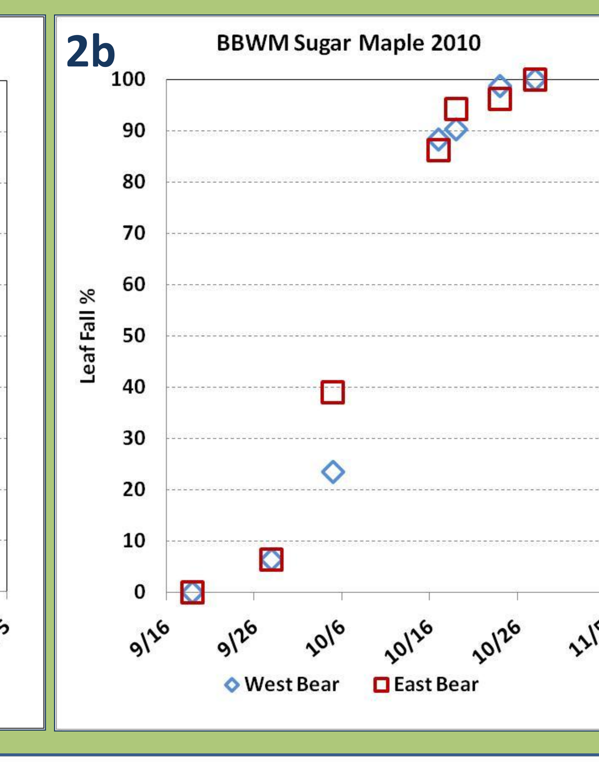
Figures 2a and 2b compare seasonal leaf fall in maple trees of the treated West Bear watershed and the reference East Bear water-Shed. There were no clear differences between watersheds or among species.

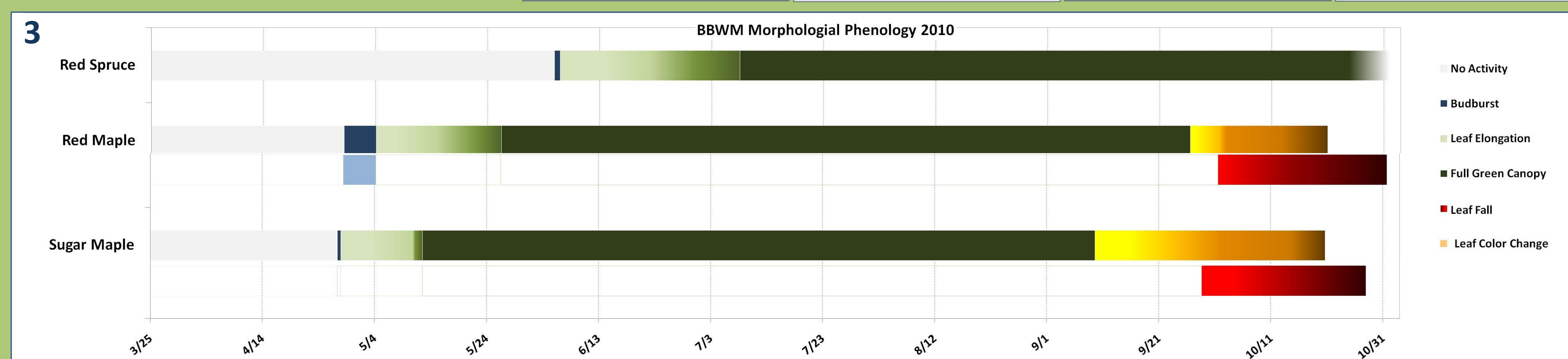
Figure 3 shows the progression of phenological development stages in red spruce, red maple, and sugar maple trees across the growing season.







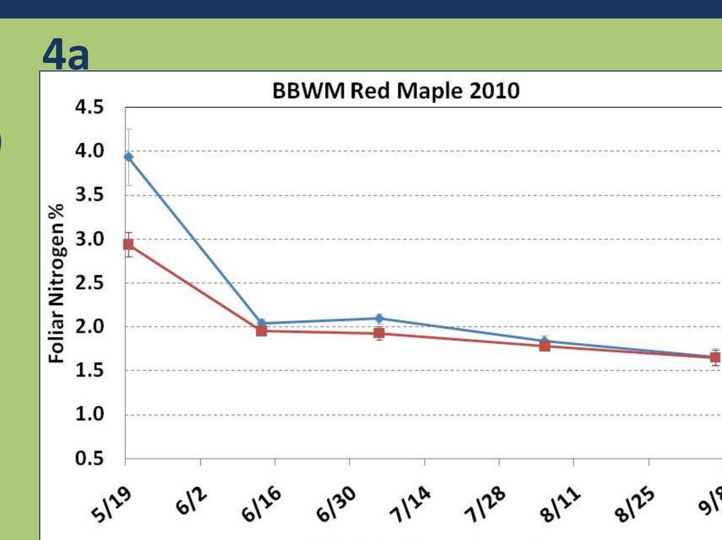


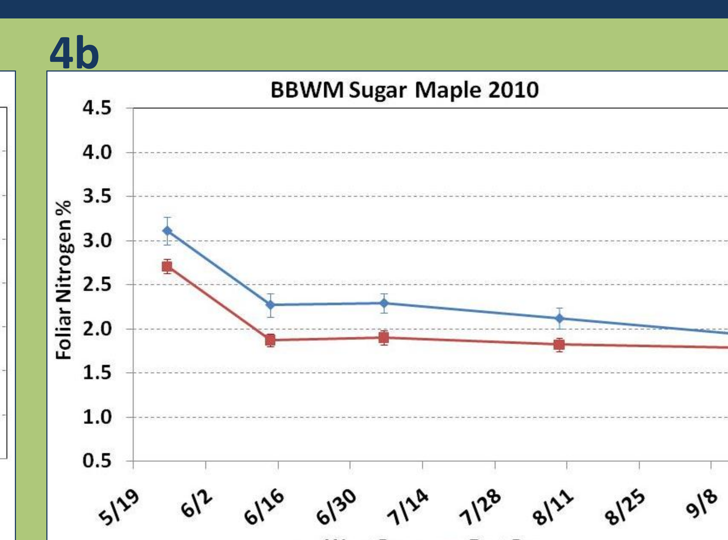


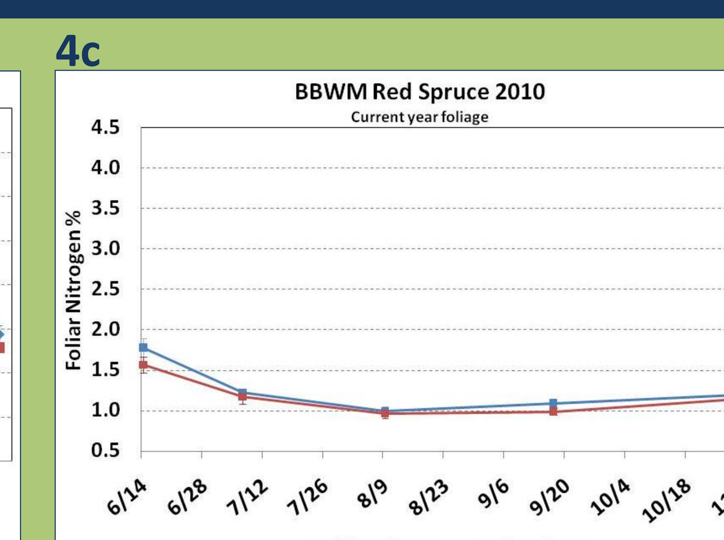
Chemical Phenology Results

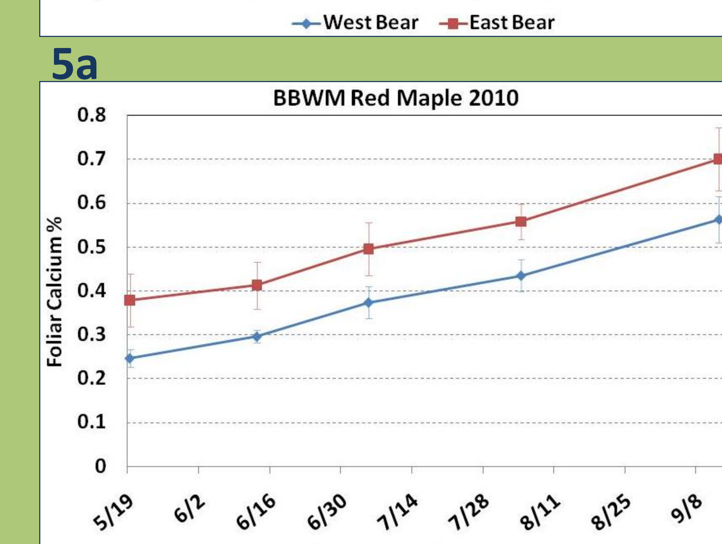
Nitrogen: Figures 4a, 4b and 4c compare foliar nitrogen concentrations (N) of the treated West Bear (WB) and the reference East Bear (EB) watersheds throughout the 2010 growing season. Red maple N (Figure 4a) was significantly higher in the WB watershed than in the EB watershed in the month of May only. Red maple N in the WB watershed was significantly higher in May than N in all other months. Red maple N in the EB watershed was only significantly higher in May compared to N in August and Sept-ember. Sugar maple N (Figure 4b) was consistently higher in the WB watershed than in the EB watershed. May N in both treatments was significantly higher than N in all other months. Red spruce N (Figure 4c) did not differ between treatments or among months.

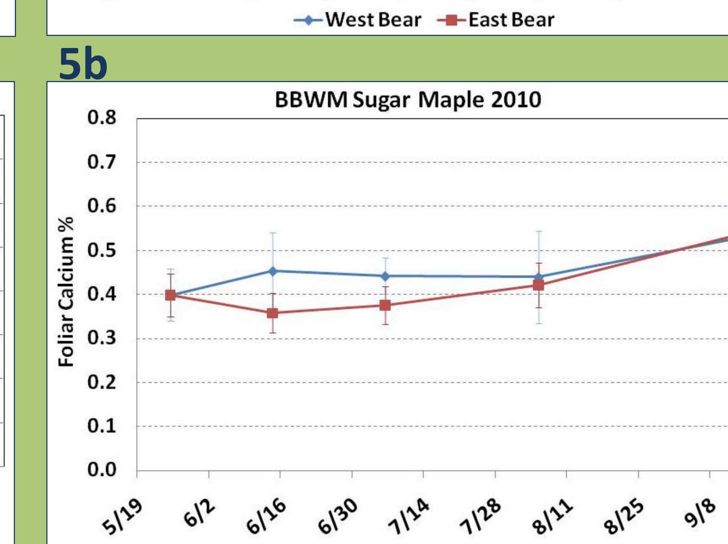
Calcium: Figures 5a, 5b, and 5c compare foliar calcium concentrations (Ca) of the WB and EB watershed throughout the 2010 growing season. Red maple Ca (Figure 5a) was consistently lower in the WB watershed than in the EB watershed. Red maple Ca in both watersheds increased as the season progressed. Neither sugar maple nor red spruce Ca (Figures 5b and 5c) differed between treatments or among months.

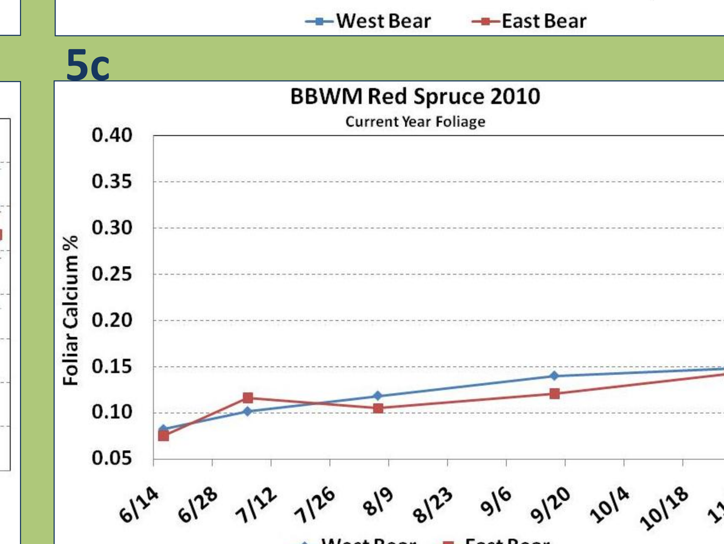












Standard error bars are shown on graphs.

Conclusions

Based on visual observations of tree canopy morphological characteristics, the progression of phenological development stages revealed notable differences among species. There were, however, no significant differences in morphological phenology observed within red maple, sugar maple, or red spruce species between the treated and reference watersheds. Monthly foliar nutrient concentration patterns (i.e., chemical phenology) showed distinct patterns across the growing season. These patterns varied between watersheds for each species and nutrient. This research was intended as an initial investigation into the use of phenological indicators of environmental change that would provide the groundwork for future phenology research at BBWM and in other forested ecosystems. The study underscored the need for practical classifications of phenological data both at the tree and stand level, the importance of temporal intensity during key periods of forest phenology, and explored the merits of chemical phenology as a metric of forest response to environmental change. This study also reinforced the need for consistency in the time of sampling for foliar nutrient evaluations. Research such as this should be continued given the importance of long-term, decadal scale observations necessary to understand forest effects in a changing climate, and additional research coupling biogeochemical and morphological phenology at the ecosystem and watershed scale should be pursued.

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