Observed Phenology and Winter Injury of Seedlings Within the Northern Forest Mesocosm (NFoRM) Climate Change Experiment

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Introduction

One of the most observable responses to global climate change is the alteration of plant phenology, which has large effects on productivity and species interactions [1]. Climatic change may also have increased effects on plant injury, which could influence phenological cycles directly by altering a plant's ability to break bud [2]. These interactions will be explored within this study which consists of two main parts, 1) a review of phenological data taken from the mesocosms and 2) a sampling and analysis of winter injury to the seedlings.

The overall hypothesis of the Northern Forest Mesocosm (NFoRM) is that seedlings will respond to warming and snow removal with nutrient losses, leaving seedlings more susceptible to stress in calcium depleted soils. This stress may cause seedlings to exhibit increased winter injury signs, which also may cause phenological consequences. The study will also explore individual species' responses based on their native habitat range and rooting depth characteristics.

Figure 1. One of 24 experimental mesocosms

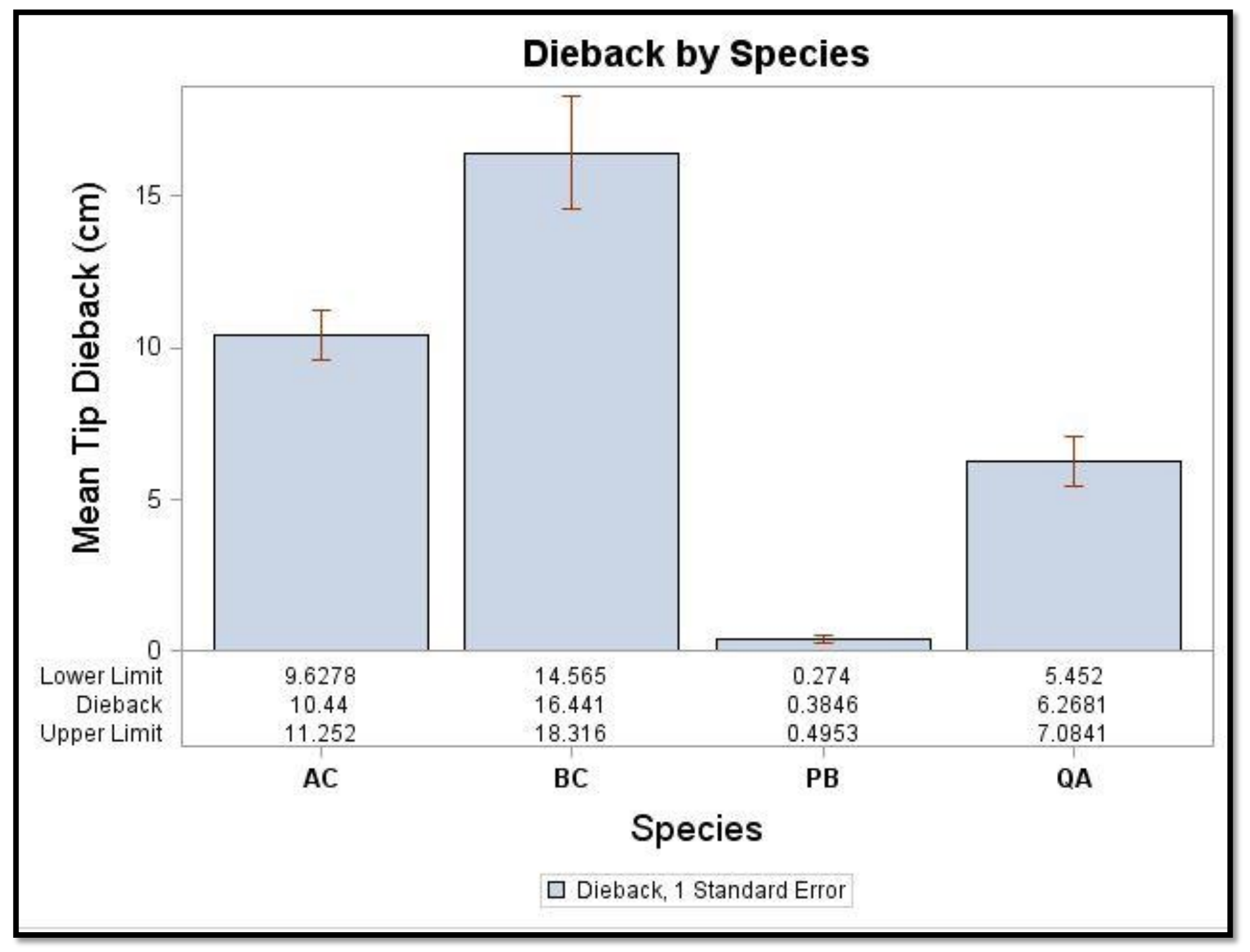
Background

The Northern Forest Mesocosm (NFoRM) Climate Change Experiment began in 2013 at the Aiken Forest Sciences Laboratory in South Burlington, VT. Twenty-four mesocosms are studied to quantify the possible effects of increased warming and reduced snowpack caused by global climate change on the ecosystem processes of the Northern Forest. Each mesocosm contains either Milton (low Ca content) or Kullman (high Ca content) soil [3], and one climate-related treatment (increased warming or reduced snowpack). Eighty seedlings of four tree species (*Castanea dentata*, *Prunus serotina*, *Populus tremuloides*, *Betula papyrifera)* were planted within each mesocosm.

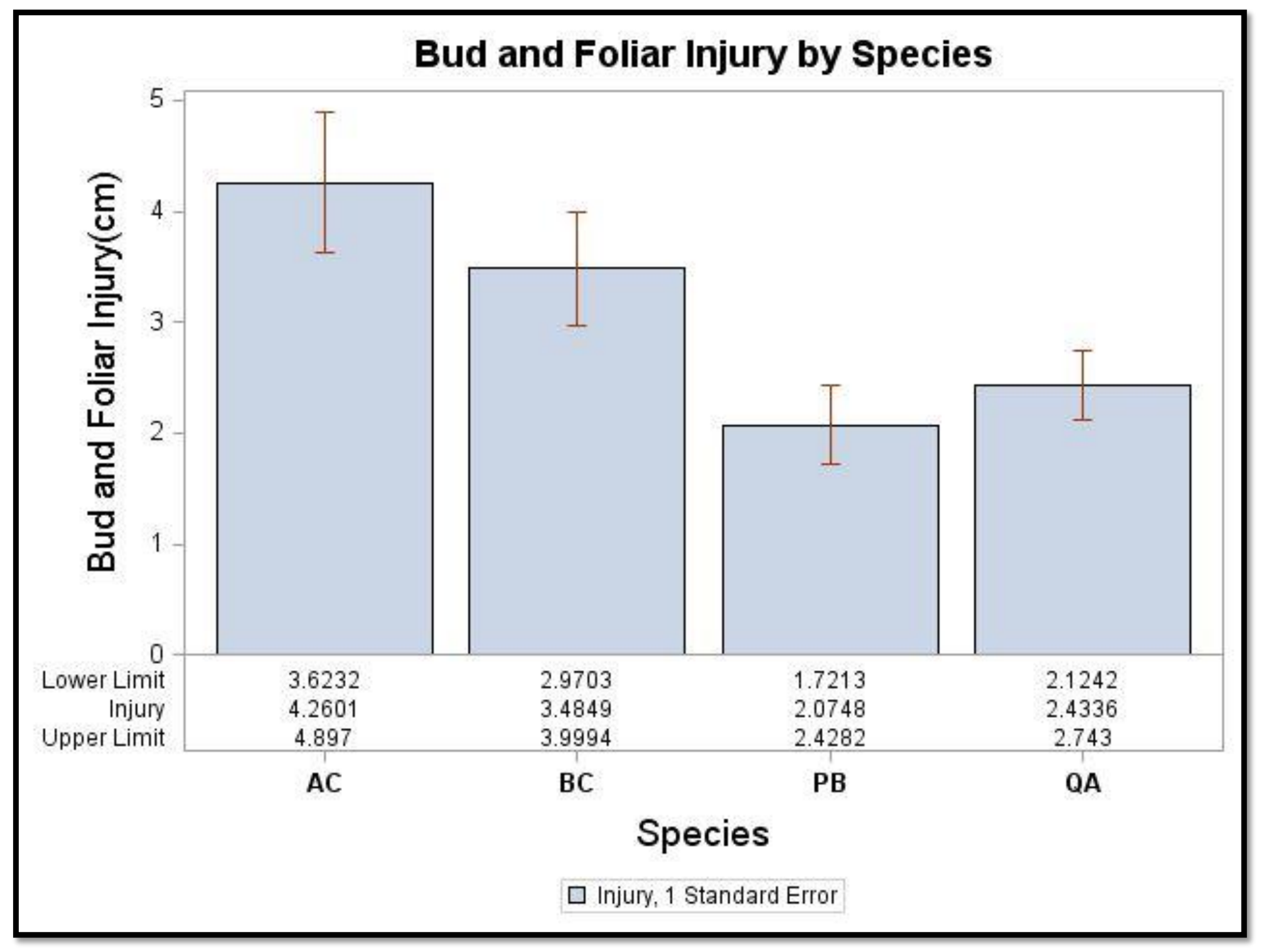
Table 1. Species' native ranges and rooting depths

Species	Code	Range	Rooting Depth
American chestnut	AC	South	Deep
Black cherry	BC	South	Shallow
Quaking aspen	QA	North	Deep
Paper birch	PB	North	Shallow

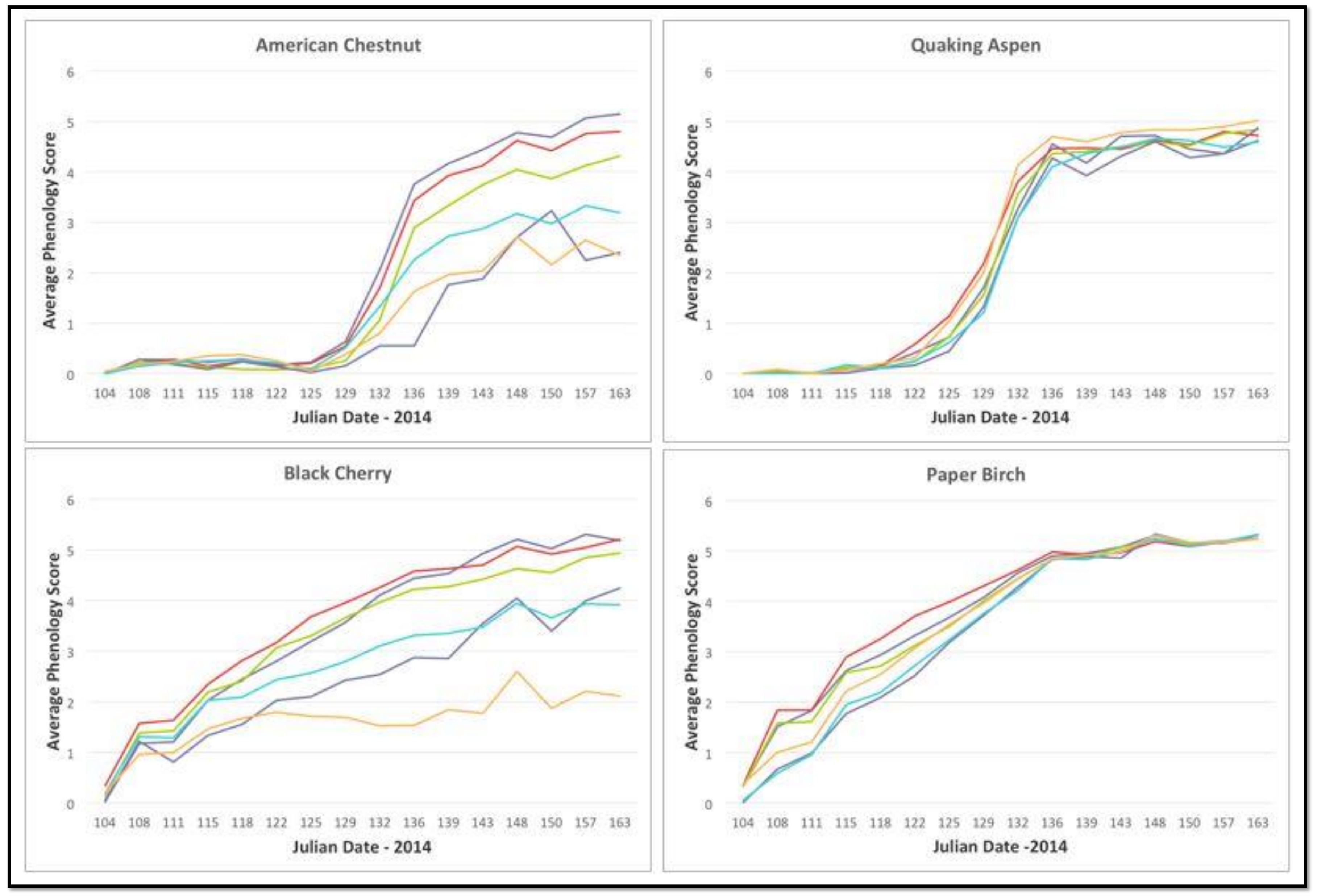
Results



Relationship between seedling species and amount of tip dieback (cm) observed. The amount of tip dieback differed significantly based on species (SP-ANOVA, p=<.0001), where all species except paper birch had an individual significance of p=<.0001. Species range and rooting depth were both significant at p=<.0001. Treatment and soil were both significant under α=0.1 (p=0.062 and p=0.066, respectively).



Relationship between seedling species and amount of bud and foliar injury on the main stem. Injury differed significantly based on species (SP-ANOVA, p=.0033), where all species had an individual significance of p=<.0001. Species range was found significant at p=.0006; AC was also found significantly different than PB and QA, the northern species. Treatment*Species was significant under α=0.1 (p=.0768).



Mean phenology score for species across all mesocosms, separated by treatment. General trends in species phenological development are displayed by the graphs:

- Southern range species exhibited lower phenology scores than northern range species.
- AC and QA demonstrated a later initial bud break than BC and PB.
- Phenology scores were lower in Kullman soils.

Legend

Methods

Phenology was assessed weekly from April 14th to June 12th 2014. Scoring was based on five phenological stages (Figure 2). A value between 0 and 5 was given to each seedling, describing the most advanced phenological stage occurring on the plant and the percentage of buds on the seedling that have developed to that. For example, a seedling with terminal buds at stage 3 and 50% of buds at this stage would receive a score of 3.5. Winter injury of seedlings was assessed in July 2014 over the course of 4 days. The amount of tip dieback, bud, and foliar damage was measured to the nearest centimeter. Other elements of injury including chlorosis, necrosis, and fungal damage were also recorded.

A split-plot ANOVA (SP-ANOVA, complete randomized design) was completed in SAS 9 for data analysis of winter injury. The whole-plot factors represented are treatment and soil, while the split-plot factor is species. For statistical purposes, winter injury was separated into two categories, tip dieback and bud and foliar injury to the main stem. A log transformation was run on both datasets, and all significance values are based on that analysis.

Figure 2. Sample phenology scoring for American Chestnut

Conclusions

Species is found to have a significant effect on seedling winter injury, despite other factors. Southern species (AC and BC) which in Vermont are at the northern edge of their range, exhibit more winter injury than northern species, which may be attributed to winter chilling, photoperiod, and temperature. These factors are driving forces in influencing dominant tree species phenology in the Northeast [4], which may explain the lower phenology scores for these species.

There was only a slightly significant treatment effect on winter injury. It is not understood how warming and snowpack removal affect individual species, but repeated annual measurements of the seedlings may provide a clearer answer. Treatment effect on phenology can be visualized (but, not statistically) more clearly; warming and snowpack removal treatments on Kullman soil impacted *all* species negatively.

Literature cited

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