The Effect of Soil Conditions on Tip Dieback and Subsequent Nutrient Loss

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Background

The Northern Forest Mesocosm (NForM) Climate Change Experiment is a forest warming study examining soil and plant dynamics under various treatments that simulate expected conditions produced by climate change. The experiment looks at how these conditions impact plant growth and carbon and nutrient cycling [1].

Treatments

- Soil
  - Milton: low calcium content
  - Kullman: high calcium content
- Climatic
  - Control
  - Warming
  - Snow exclusion (warming reduces snowpack which induces soil freezing)

Mesocosm Composition

- 80 tree saplings of four species in each of the 24 tanks

Figure 1. View of experimental mesocosms

Introduction

Increased soil freezing is expected to alter nutrient and carbon losses in ecosystems [5]. Greater freezing events cause more damage to vegetation. This is compounded by soils with less calcium because calcium is essential to plant protection and recovery from freezing events. Therefore, plants in soils with low calcium content are more prone to damage [4]. Damage to the plants can be quantified by examining tip dieback. Greater amounts of winter injury suggest that plants cannot take up as many nutrients and it has been found that low winter soil temperatures reduce nutrient uptake during the growing season [6]. The amount of nutrients that remains in the soil can be quantified ıgh leachate water samples. These observations lead to the hypothesis that plants in low calcium soils under the snow exclusion treatment will have the most tip dieback and reduced nutrient uptake resulting in more nutrients in leachate samples.

Figure 2. Example of tip dieback

Methods

Tip dieback is the dying of plant shoots beginning at the tip due to climatic conditions or disease. Tip dieback was measured in July 2015 using a ruler to measure the length of dead tissue in centimeters and comparing it to the total height of the tree. The average dieback was calculated for each mesocosm.

For nutrient analysis, water (leachate) samples were taken five times over the summer when the mesocosm tanks were emptied of water. Samples were analyzed for nitrate content. The total nitrate loss in mg was calculated for each mesocosm across the five dates.

Statistical analyses were done with JMP. A one way ANCOVA to analyze the effect of soil, treatment and tip dieback on total nitrate loss and a repeated measures ANOVA to analyze the effect of soil and treatment on nitrate loss across the five dates were performed.

Results

1. Soil and climatic treatments had no significant effect on tip dieback.
2. Climatic treatments and the amount of tip dieback had no significant effect on total nitrate content found in the leachate samples. However, soil type did, with much more nitrate measured in leachate samples taken from mesocosms with Kullman soil (Figure 3).
3. Climatic treatments had no significant effect on nitrate content over time. However, soil type and specific dates did have significant effects as well as soil*date interactions (Figure 4).

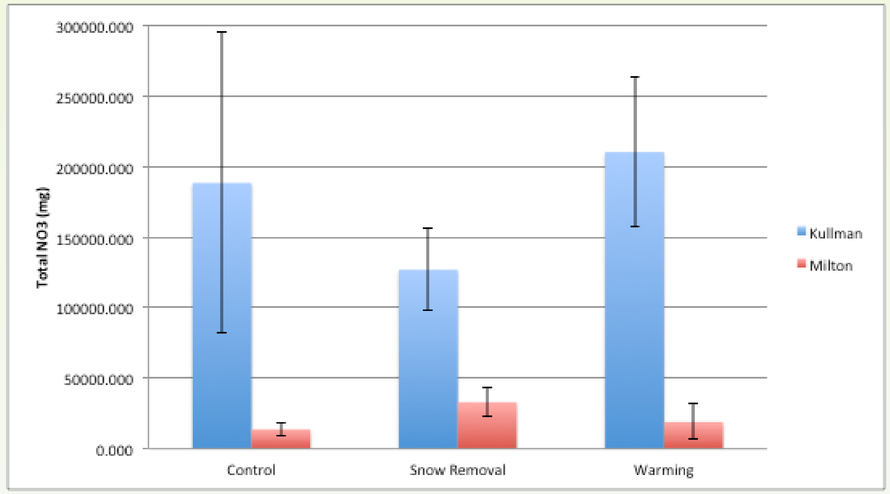

Figure 3. Effect of soil and climatic treatments on total nitrate loss. A significant difference between the soil types can be seen (p = 0.0015)

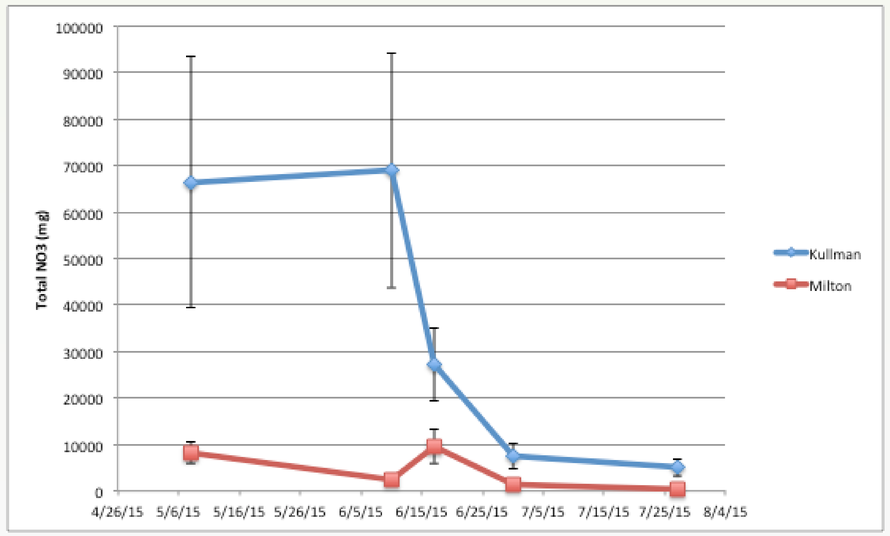

Figure 4. Effect of soil type on nitrate loss over time. There is a significant difference between the soil types (p = 0.0016). The leachate sampling date also had a significant effect on nitrate loss on 05/07/15 (p = 0.0313). There was also a significant soil*date interaction on 06/10/15 (p = 0.0277).

Discussion

In contrast to our hypothesis, we found no connection between tip dieback and nitrate loss.

There was a significant difference between the soil types when looking at the total nitrate collected. Leachate samples from mesocosms with Kullman soil contained much more NO3. Although the Kullman soil has higher calcium content than Milton soil, its composition is much coarser. This may explain the higher amounts of nitrate measured as water and nutrients flowed more readily through this soil.

Soil type also had a significant effect on nitrate loss over time. Sampling date was found to have a significant effect as well. The sample from 05/07/15 contained more NO3 than other dates possibly due to the time in the growing season in that saplings, despite any tip dieback, would be coming out of dormancy and may not be taking up as many nutrients. We also observed a significant soil*date interaction on 06/10/15. The leachate samples from the Kullman soil contained much more nitrate than the Milton samples on this date.

These results are preliminary and would benefit from a larger sample size. To expand on this experiment, data from other years should be analyzed to see if a similar temporal pattern arises. To gain a better understanding of the role winter injury of the saplings plays in the amount of nitrate lost, root damage may be a better gauge than tip dieback [2,3]

References

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