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REU Summer Project Proposal: First Draft

Soil Moisture Response to Ca addition

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Introduction: Calcium (Ca) is an integral nutrient in forested ecosystems, as it is used by trees to maintain structural integrity and for physiological functions, like stomatal regulation and cell division (Green et al 2013). The primary input of Ca into a forested ecosystem is through weathering, but in the Anthropocene, humans have manipulated meteorological input largely through sulfur pollution and combustion engine exhausts, causing acid rain (Likens and Borman 124). Acid rain causes the Ca to leach from the ecosystem, making it a limiting nutrient (Green et al 2013). In order to better understand the effects Ca has on a forested ecosystem, an application of wollastonite (CaSiO3) was added to Watershed 1 (W1) of Hubbard Brook in 1999 to return the concentration of Ca in the soil to pre-industrial levels (Green et al 2013). For the following three years, transpiration and primary productivity increased. However, after 2002, transpiration decreased to levels lower than prior to 1999. While this is not entirely understood, it is likely that the initial three year increase in transpiration after the 1999 CaSi addition at HBEF was caused by a short-term rapid increase in growth, including xylem and root growth, which increases water transport capabilities and thus primary productivity and transpiration. However, the long-term effects are stomatal growth and increased efficiency, which would result in the decrease in transpiration after 2002. While growth rates were still higher after 2002, rates of transpiration decreased, which leads us to believe that the trees simply became more efficient with water use.

In fall 2011, the Multiple Element Limitation in Northern Hardwood Forests (MELNHE) project added wollastonite to 6 plots in its experimental stands in the White Mountains of NH. Three stands are in Bartlett Experimental Forest (BEF), two stands in Jeffers Brook (JB), and one stand is in Hubbard Brook Experimental Forest (HBEF) and are of varying stand age and soil fertility. CaSi03 was added to stands C1 (young), C6 (mid) and C8 (old) of Bartlett, all of which are considered nutrient poor. It was added to the old stand at HBEF, which is considered more nutrient rich than Bartlett. Wollastonite was also added to the mid-aged stand and the old stand of Jeffers Brook, considered the most nutrient rich of the three sites. The calcium silicate additions were done to further the research at HBEF in 1999, to help determine how calcium effects evapotranspiration and productivity in a northern hardwood forest, especially with regards to stand age and nutrient content. According to Hamburg et al. (2003), calcium availability decreases as stands age, making it a more limiting factor for older stands.

Question: Did the one-time application of wollastonite effect the moisture content of the soil at various stand ages and nutrient content?

Hypothesis: Our plots will follow the trend of the 1999 HBEF wollastonite addition, but the trend will be more pronounced in older, less fertile stands, as the CaSi03 addition will bolster plants’ ability to retain moisture. Soil moisture will decrease more in older, nutrient poor stands, as the calcium addition will bolster plants' ability to retain moisture and it is limited mostly in older, nutrient poor stands.

Methods: In the calcium and control plots, soil moisture data will be collected using EC-5 soil moisture probes which measure volumetric water content at various depths. These probes will be connected to Decagon Em50 data loggers. There is a data logger in the calcium and control plots of all 6 stands being tested (C1, C6, C8, HBOCa, JBM, JBO). Each data logger is connected to three EC-5 probes at depths of 10cm, 30cm and 50cm. The probes are inserted with the flight side perpendicular to the surface of the soil to minimize the effects on downward water movement. The logger runs on 5 AA batteries and can run on its own without the change of batteries for up to three years. It has 1MB of memory, which equals about 36,000 data scans. As it has been for the last two years, soil moisture data will be collected by the Em50 data logger every 15 minutes.

While the focus of the study is mainly the wollastonite addition, since we also have experimental nitrogen (N), phosphorus (P) and nitrogen plus phosphorus (N+P) plots, we will be testing soil moisture in all of the Bartlett C8 plots, in order to see how the other fertilization plots compare to the calcium and control plots. The methods for the nitrogen (N), phosphorus (P) and nitrogen plus phosphorus (N+P) plots will be entirely the same, except we will be using ECHO Smart Sensor soil moisture probes instead of EC-5 probes. The ECHO Smart Sensor probes will be connected to HOBO data loggers. Unlike the calcium and control plots, the nitrogen and phosphorous plots do not have backlogged data from past years, so the data collected cannot be compared to past years or seasons and will be entirely new.

Analysis: Data will be collected from the loggers weekly all summer, and each calcium plot will be compared with its corresponding control plot, and in the case of C8, it will be compared to the N, P and N+P plots as well. Once evapotranspiration differences have been determined between our experimental plots for each individual stand, they can all be compared to shed light on differences between young and old, nutrient poor and more nutrient rich. Dependent on the availability of data already collected with the loggers, it may be possible to look at the differences in soil moisture between seasons, as summer would give the most telling results for evapotranspiration of most of the trees in the plots, but winter would give insight into the response of conifers which are productive year round.

Expected results: Since I have not yet seen data from the previous years of collection, it is difficult to determine what results to expect, as in the first couple of years after application, I would expect to see increased evapotranspiration rates, followed by a significant drop as water-use efficiency is improved. However, in the nitrogen plot, the nitrogen and phosphorous plot and possibly the phosphorus plot (all of C8), I would expect to see decreased soil moisture as a result of increased primary productivity. However, according to Mark green in his recent preliminary NSF proposal, it is possible that the soil moisture will not show much difference to the control plot, as the trees may become more efficient more in their resource use, not simply more productive (Mark Green, Binkley 2004)

Broader Impact/Implications: Firstly, we are trying to determine how calcium affects the hydrology of the northern hardwood ecosystem. Soil moisture content will correlate with the groundwater and adjacent watershed, so as fertilization becomes more prevalent in forested ecosystems, whether through intentional or unintentional additions, it is important to understand how this will affect the ecosystem as a whole, especially with regards to primary productivity and thus carbon sequestration. If limiting nutrients are better understood and fertilization is improved, the result will enhance primary productivity and thus more carbon will be sequestered. It will also help us understand how acid rain and subsequent nutrient leaching harms the ecosystem.

References:

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