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Mapping and Inventory Proposal

**Background:**

Nutrient limitation is a key aspect to predicting how forests will progress. Nitrogen (N) has been recognized as one of the most prominent limiting nutrients in temperate forests, especially in young stands (Walker and Syers 1976). N increases primary production of plants and contributes to the growth in many stages. Net primary production (NPP) limitations can be largely attributed to a lack of N in the ecosystem. In a meta-data report based on global studies, David S. LeBauer found that increasing N at a rate of 14.3 g per year would increase NPP by 30% (LeBauer and Treseder 2008). Nitrogen is required by primary producers at a higher rate than any other nutrient, while at the same time being one of the harder nutrients to obtain. This makes N much more likely to be a limiting factor of an ecosystem as the plants must put more effort into taking up the N required to continue NPP (Vitousek and Howarth 1991). However, as we continue to generate N into the atmosphere through pollution from cars and other sources, N deposition is beginning to overtake the amount of N usable in ecosystems. N deposition is an excess of N in the soil, more so than can actually be used by the plants of the ecosystem which causes it to mineralize in the soil and damage the soil balance (Aber et al 1989). Therefore other macronutrients, such as phosphorus (P), can become limiting as well (Elser et al 2007).

The Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE) project looks at possible co-limitation of N and P in the Northern hardwood forest. The Multiple Element Limitation (MEL) model was developed to test how much of the plant’s energy it uses to acquire resources such as water or nitrogen, from the environment (Rastetter 1997). Optimization theory states that the plants will devote the majority of their resources to obtain the nutrients which are most difficult to uptake (Mooney 1972). This includes factors such as P and calcium (Ca) as possible limiting nutrients. The issue which arises with adding only one macronutrient, for example N, P, or Ca, to a plot is that as it becomes easier to find N, plants will devote less resources to finding N, and may not show as much growth. The plant will then devote more resources to finding other limiting nutrients, such as P, which begin to limit the growth of forests (Vadeboncoeur 2010). Because limiting nutrients affect the entire nutrient cycle, it is expected that changing availability of nutrients in the soil may have some effect on concentrations of elements which haven’t been added. There has been no confirmation of this hypothesis in stands with only one nutrient added. In N+P plots however, there has been a larger increase in N available for plant use when P is added, than when just N is added alone (Fisk et al 2014). As higher levels of N are available in a stand we see an increase in tree diameter growth. Therefore when adding both N+P we see a larger increase in available N and expect a larger growth rate. In a study that looked at plots throughout the Northeastern hardwood forest, it was found that fertilized forest had an 85% positive growth response rate to the added nutrients (Vadeboncoeur 2010).

I will be inventorying the stands to see the changes in growth in accordance to the various treatments of the forest. The stands that I will be sampling directly are C1 young, C2, C6 mid, C8 old and the Jeffers Brook site old and mid. By including stands of different age groups across a geographic area, we hope to account for the difference in effectiveness of fertilization treatments at increasing stand growth rates.

**Methods:**

*Inventory sampling:*

In 2011 the MELNHE project began a study where stands within the forest were fertilized yearly with nitrogen and phosphorus, to better understand nutrient co-limitation within temperate forests. There have been 9 stands of clear cuts (C1-C9) in Bartlett Experimental Forest (BEF) of varying age groups (young stands of around 20 years, mid aged of around 30 years and mature stands of older than 100 years) as well as old and middle aged stands in Jeffers Brook and Hubbard Brook that have been designated for yearly treatments of N and P. Each of these stands has been divided into four 50x50 meter plots with a 10 meter buffer zone (see *Figure 1* for layout of the plots). Some stands have a calcium silicate (CaSiO3) plot as well, but not every stand includes one. Each plot is fertilized with N, P, or N+P with a control plot where no fertilizer has been added. Nitrogen is applied as ammonium nitrate (NH4NO3) at the rate of 30 kg of N per hectare and P is applied at the rate of 10 kg of phosphorus (NaH2PO4) per hectare to each plot.

The sampling inventory for this year will take place in stands C1, C2, C6, and C8 of the Bartlett Experimental Forest, as well as Jeffers brook old and mid aged stands. These stands were selected as the most likely to show recognizable growth in reaction to the treatments. In these stands, all trees with a diameter of 10 cm or greater at DBH (Diameter at breast height, 1.37 m) have a tag nailed into the tree. The method we currently use is to drive a nail into the tree at 1.57 m or 20 cm above DBH. This is because sometimes, a tree will attempt to heal the nail wound by growing out over the area causing a bulge. To ensure that this does not affect our data, a 20 cm dowel will be hung from the nail in the tree and DBH is taken with a measuring tape at the bottom of that dowel.

All tagged trees in stands C1, C2, C6, C8 and Jeffers Brook will be measured and compared to past data, last taken in late July and August of 2011. Trees that have diameters of greater than or equal to 10 cm that have not been tagged will have a nail and a tag assigned to them, and will have diameters measured and recorded. All trees will be measured by hanging a dowel from the nail holding the tag and the measurement will be recorded at the same point as previous years.

*Stem mapping:*

Mapping of the stands is based on using the corner post with the lowest alphanumerical value (for example in the upper left plot of figure 1, the A1 post would be used) as a set distance from which the trees will be measured. The distance and angle of all trees in the stand with diameters equal to or greater than 10 cm will be measured using a hypsometer and a compass. Trees below this size class are not going to be mapped as they are much less permanent within the stand and still have time to die off and fall out of the plot.

**Expected Results**

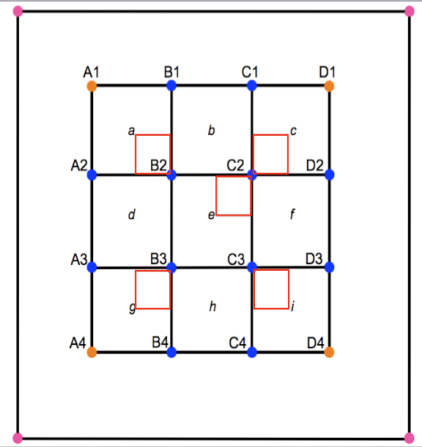
I expect to see positive growth in all stands where fertilizer has been added, with more growth in N plots of younger stands and in P plots in the old. I expect the most growth will be found in N+P plots at young ages, as that is where added N is the most limiting and beneficial for growth.

**Implications:**

Taking inventory of the stands spread between young, mid aged and old under all different treatments will show the relationship of fertilizers and ages in the forest. While theoretical practice has shown that the trees should be affected by fertilizer, a tree growth inventory proves growth and gives quantifiable data on how stands are reacting to treatments. This is important in that it justifies the further study of the stands whether or not anything has happened. If something has happened further study is necessary to understand why this is happening and if there is no growth further study will explain why the nutrient additions have not affected the forest.

This data can also be used for helping the timber industry understand if it is actually economical to fertilize forests and can have wide impacts on silvicultural systems in the Northeast. The other issue that this study addresses is the N deposition of the forests. As N levels saturate the soils we see other limiting factors instead. The study done here will give some insight on how forests will evolve with the excess of N available to their systems.

**Index:**



*Figure 1: The layout of the subplots with circles representing posts at each corner, picture taken from unpublished data from Matt Vadeboncoeur*

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