The Effects of Soil Nutrients on the Morphology and Reproductive Strategy *of Understory Plant Species in the Boreal Forest*

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Background:
Higher temperatures associated with global climate change are predicted to cause an increase in soil nutrients, such as nitrogen, at northern latitudes. I am studying how the addition of high concentrations of nitrogen-phosphorus-potassium fertilizer over several years has affected four species of boreal plants.

Over the summer I sampled plants in experimental plots near Kluane Lake, Yukon, which have been fertilized every year for the past 22 years. Previous work in these plots has shown that while some species increase in abundance when fertilized, others are out-competed and decline to local extinction. I am comparing fertilizer response at the individual plant level (changes in growth, morphology and investment to reproduction) to larger-scale changes in the plant community (relative abundance of each species before and after fertilization treatment) to determine whether effects at the two levels are related. In terms of investigating how these species change at the individual level, I have two main questions:

1. Do plants invest more energy into reproduction when fertilized?
2. When more nutrients are available, do plants change their growth rates or physical morphology?

Experimental Design:
These experimental plots were originally set up to test the effect of both fertilizer addition and a reduction in grazing by herbivores (accomplished by chicken wire fencing). The study site has sixteen 5m x 5m plots with fully crossed fertilizer and fencing treatments (+/0 fertilizer, +/0 fencing) for a total of four treatments, and treatments were randomly assigned to each plot for a total of four replicates on each treatment. Other research conducted in these plots has found no effect of fencing on any plant traits, so although I plan to test for fencing effects, I suspect there will be none and I will be able pool data from fenced and unfenced plots.

Statistical Questions:

I would appreciate advice on include any or all of the following:

1. To determine how increased soil nutrients affect investment to reproduction, I am comparing reproductive traits such as probability of flowering, weight of reproductive parts, and seed germinability for each species in fertilized and unfertilized plots. Each species will be considered separately for all analyses, as sampling techniques differed between species due to the unique morphology of each species. This part of my analysis should be able to be accomplished using t-tests or the non-parametric equivalents. One complication is that much of the sampling in unbalanced due to a scarcity of some species in certain plots, so tests will have to be robust to an unbalanced design.

Statistical help needed: Determining the best t-test equivalent to use on an unbalanced design.

2. Many other studies have looked at how investment to reproductive parts changes depending on the size of the plant, and I would like to analyze my data in a similar way to determine whether the relationship between size and investment to reproductive parts is affected by treatment with fertilizer.
   Statistical help needed: Determining how to quantify the effects of fertilizer on the relationship between size of reproductive parts (as a fraction of total plant size) and total biomass of the plant.

3. I measured various parts of each species (stem widths, number of leaves, length of longest leaf, height) that have been used in previous work on these species to create allometric equations to estimate biomass. Given that plants are known to change shape when fertilized (investing more energy into leaves, for example), I would like to use my various measurements (and the associated biomass, which I also collected by harvesting and weighing each plant) to determine whether the same allometric equation for predicting biomass can be used for both fertilized and unfertilized plants.
   Statistical help needed: Determining how to test whether allometric equations for estimating biomass of each species are significantly different in fertilized and unfertilized plants.