Kearney Foundation Fellowship Final Report Summary

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Proposed Project Title: Testing multiple nutrient limitation of plant species and ecosystem productivity in Southern California grasslands

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Nutrients that plants require in order to grow and maintain their tissues are constantly cycling through ecosystems. The productivity of these ecosystems may be limited by the amount of nutrients existing in this cycle. As such, plants must evolve different strategies in order to extract these nutrients. We expect that the species that is best able to draw one of these limiting resources from the system is the best competitor for that resource (Tilman 1982). Our project sought to answer whether different species are limited by different macronutrients. A second objective was to determine whether nutrient drawdown is an effective predictor of plant competition when species are grown in a mixture. We concentrated on six plant species. Three were annual grasses, one was an exotic annual forb, one was a native perennial forb, and the other was a native perennial grass. We grew these species in monoculture and polyculture plots and applied N,P, and K in a factorial design. There were 7 species treatments, 8 nutrient treatments, and 5 replicates totaling in 280 pots plus 3 controls for each species treatment for a total of 301 pots. Our project had a number of expected and also interesting results. For species grown in monocultures, we found that the growth of all the species was enhanced the most by the N application ($p<0.01$ for all species, F value always largest). The species L. multiflorum, which is a exotic annual grass, produced the most above ground biomass in monoculture and in mixtures. L. multiflorum also stimulated by P addition, but, interestingly, this stimulation was suppressed by K when the two nutrients were applied together. There was no evidence between the three macronutrients that the species were limited by different resources. For the plots where the species were grown together, we had several unexpected results. NP additions increased biomass less than originally expected based on what we saw from the growth response to N or P alone ($N*P$ $p=0.01$).

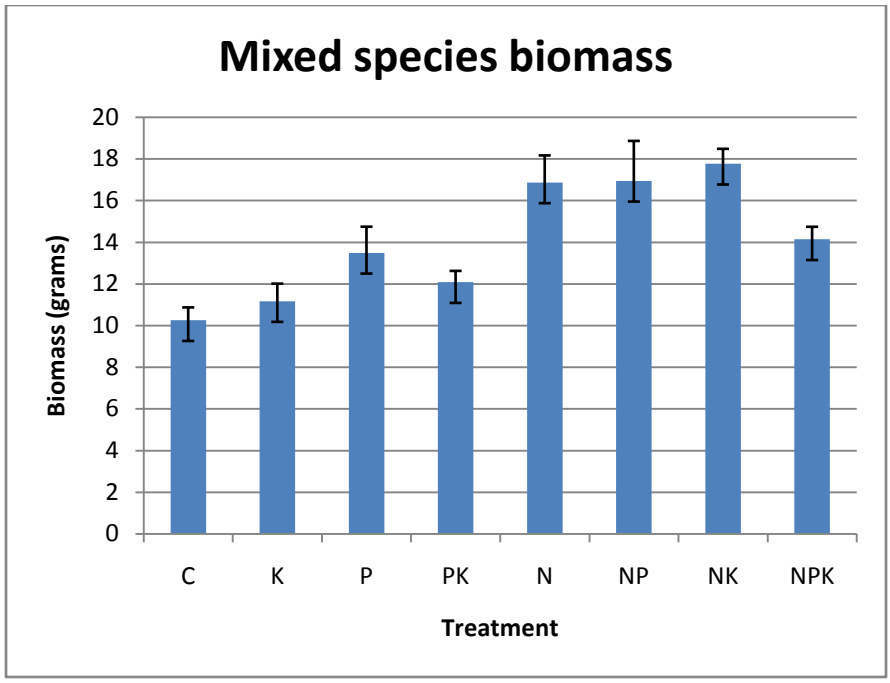

Figure 1: Example of Biomass (in g) Graph for species grown together for the respective nutrient additions

K addition also tended to suppress the enhancing effect observed by P addition (P*K p=0.04). When we analyzed the nutrient concentrations that were left in the soil of our pots, we found that there was no significant variation among treatments or species in their effects on ending soil nitrate concentrations. Soil phosphate increased with P additions ($p<0.01$), but there was no significant variation observed between the six species. So what do these results indicate to us? We didn't see the multiple nutrient limitation for growth in our species, rather the evidence indicated that they were limited by a single nutrient. There was little variation among the species in their nutrient drawdown from the soil. Our hypothesis that species vary in their nutrient limitation was not supported by the evidence either. Rather limitation by N was acting. The Nitrate levels in the soil were remarkably non-responsive to treatments, indicating that this resource was efficiently captured by plants or leached from the soil. These findings question the classical ecological theories regarding trade-offs among species in strategies for resource capture, competitive abilities, and growth rates. In general, the phosphate additions increased soil phosphate levels, which tells us that P was not limiting growth or it was not as mobile in the soil as nitrate was. Our project has produced stimulating results and also gives some possible direction for future research. Because our experiments ran for a relatively short time with a small number of species, we would like to repeat these experiments under field conditions and with a higher diversity of species. This has already begun on a large scale through the Nutrient Network Research Cooperative and we will be adding our research to their efforts. We are very grateful to the Kearney Foundation for Soil Science for their support of our research this summer.