Sample Size Analysis for Soil Moisture and Plant Species richness in Bear Trap Meadows (Plumas National Forest, California), July 2004

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Abstract

We examined the relationship between plant species richness and soil moisture in Bear Trap Meadows in the Sierra Mountains in July 2004. We initially used both a within- and between-subjects sampling design, but soon realized that a within-subject sampling design was not feasible for our study. We collected additional information on the grazing intensity in each of our sampling plots to determine if grazing intensity was more strongly associated with plant species richness than soil moisture. Based on our preliminary data, we determined that 22 samples would be needed to detect a decline of one species for a 10% increase in soil moisture with α=0.05 and 80% power. Our overall results indicate that plant species richness is higher at drier locations within Bear trap meadow.

Introduction

Bear Trap Meadows is a high elevation meadow located in the Plumas National Forest at 2167 meters. It is surround by a riparian community of willow and alder to the north and conifer forest to the west, east, and south. Vegetation at the study site was relatively heterogeneous, with patches of flowering forbs and grasses at the south and center part of the site, sedge/corn lily meadow at the northwestern section, and wet, logged area at the eastern tip of the site. Based on our visual observations, different sections of the site seemed to differ in plant species richness and soil moisture. In this study, we examined the correlation of those two parameters: soil moisture and plant species richness. We also attempted to find determine if with species richness is associated with the impact of grazing. The purpose of the study was to illustrate the role of preliminary data in determining the appropriate sampling design and sampling size for an actual experiment or study.

Methods

To determine if plant species richness is associated with soil moisture in Bear Trap Meadow, we estimated plant species richness and soil moisture in a series of fifteen 1 meter x 1 meter plots. Our research team created a map of Bear Trap Meadow, to facilitate the random selection of sample sites. In an effort to obtain accurate estimates of plant species richness, independent estimates obtained by five observers were averaged. In the center of each plot at approximately one inch in depth, a sample of soil was collected, stored in a sealed plastic bag to prevent moisture loss, and transported to the lab. During the collection process, we were careful not to collect unwanted material such as rocks, roots, or detritus. The fresh mass of each sample was determined by weighing. Samples were then dried in a conventional oven at 350^{o} F for 3 hrs, and reweighed to obtain dry weight. The percent moisture content was calculated as the difference in sample weight divided by the initial weight. Grazing impact was assessed base on visual observations. The level of impact was classified as the following: plots with most of the top vegetation clipped off were considered to have high grazing impact, plots with half of the top vegetation clipped off were classified as medium grazing, and plots with little vegetation being clipped off were classified as low grazing.

In each plot the amount of vegetation ranged from dense patches of corn lily (*Veratrum californicum*) to sparsely vegetated plots. The sampling region was irregular in shape and including a logged area. The widest stretch (east-west direction) of the sampling region was about 235 meters, and the longest stretch (north-south direction) was about 340 meters. In the event our randomly selected sample plot contained a tree stump, the sample area was shifted to an adjacent location without a stump. Samples were collected on Tuesday, July 6^{th} 2004 at approximately 1:00 p.m.

Results

Plant species richness varied between 4.6 and 12.6 species/m^2 (mean = 8.16±0.74, mean±standard error). The percent moisture content of soils ranged between 2.4 and 50% (mean = 23.46%±4.10, see Table 1).

Table 1. Average diversity counts, dry and wet weights, and % moisture of sample plots

Plot #	Average Diversity	Wet Weight (grams)	Dry Weight (grams)	%Moisture
1	12.6	17.1	14.8	13.5
2	8.4	15.1	12.2	19.2
3	8.4	24.7	24.1	2.4
4	10.2	18.6	16.1	13.4
5	10.8	19.9	19.2	3.5
6	9.8	15.4	11.6	24.7
7	5.8	14	10.3	26.4
8	7.6	13.3	10.4`	21.8
9	4.8	13.9	10.4	25.2
10	4.6	11.5	9.9	13.9
11	9.29	19.5	10.5	46.2
12	7	21.4	10.7	50.0
13	2.6	21.5	11.5	46.5
14	8.2	17.5	10.5	40.0
15	12.4	19.4	18.4	5.2

In general sample plots, with lower percent moister had higher counts in richness of species (Figure 1). We plotted plant species diversity as a function of percent soil moisture (Figure 1). A linear regression trend line was added to indicate a slope of –0.88. The standard error of the estimate was 2.5988.

Figure 1. Plant species richness in relation to percent soil moisture.

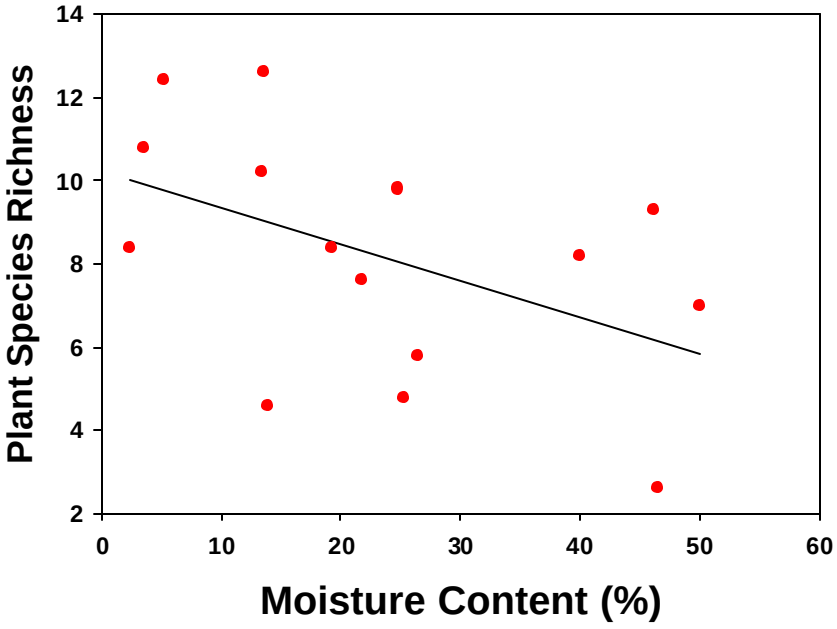
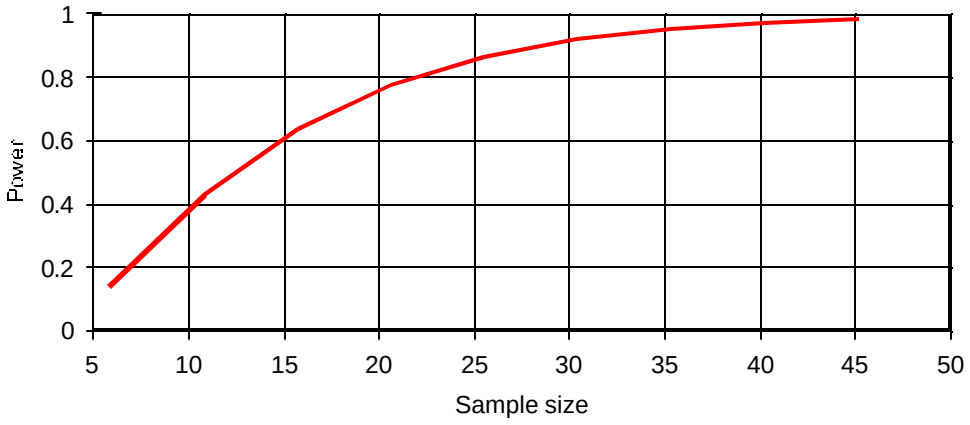


Table 2. Key soil moisture and species richness data:

Std Dev of Soil Moisture: 15.8683
Std Dev of Species Diversity: 2.8663
Std Error of Estimate: 2.5988
Slope: -0.88
Sigma: 2.50303
Optimal slope for desired effect size: -0.10

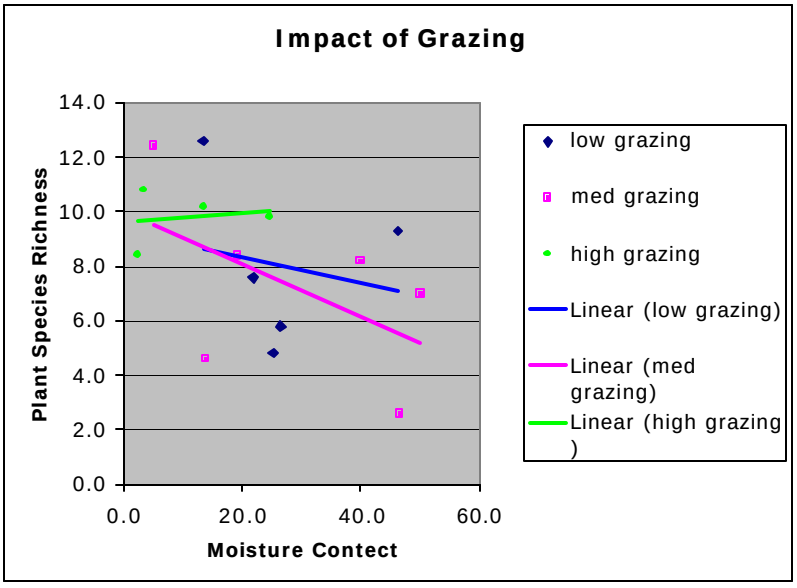
To determine the sample size necessary for a more thorough study of the association between plant species richness and moisture content, we decided to calculate the power of a regression analysis to detect a decrease of 1 plant species for a 10% reduction in soil moisture (Dupont and Plummer 1997). We used the preliminary estimate of variability obtained from our sample data (s = 2.50303, Table 2) and performed a power calculation with $\alpha = 0.05$. The resulting calculation indicates that a sample size of 22 plots would be necessary for 80% power and of 35 plots would be necessary to achieve 95% power (Figure2).

Figure 2. Power Calculation. For 80% power, sample size indicated is 22 and for 95% power, sample size indicated is 35.



No clear pattern of the relationship between plant species richness and grazing emerged from our analysis (Figure 3).

Figure 3. Impact of grazing.



Discussion

To our surprise, plant species richness at Bear Trap Meadows appears to decline with increasing soil moisture. In areas where the soil was moist, a few species, mostly sedges and rushes, tended to dominate the sample plot. This may be the case because only a limited number of species are adapted periodic immersion or saturated soil conditions.

The impact of the different levels of grazing on plant species richness is not clear in this study. For the actual complete study, we need to improve the method for estimating the level of

grazing occurred at the site. Coordinating with or contacting local ranchers regarding grazing time and locations within the meadow may be helpful.

We could not apply a within-subjects design to this particular research problem, since adjacent areas of high and low soil moisture were not available in Bear Trap meadow. Soil moisture is spatially autocorrelated among sample sites. Therefore we could only use a between-subject sampling design.

Several changes to our sampling methods might improve the efficiency of the test for association between plant species richness and soil moisture. A more rigorous approach to the selection of sample sites might better protect against the biased selection of sites. Due to time constraints and the lack of appropriate equipment, the sampling points chosen in our study might not be entirely "random samples." In the actual study, sample points could be generated using ArcGIS software and located in the meadow using a GPS unit. We could also explore the possibility of using an alternative sampling design. Perhaps a stratified random sampling design may have resulted in a lower estimate of variability. Instead of drawing random samples from the whole site, we could divide the study site into three strata: the drier part of the meadow with flowering forbs, the sedge/corn lily area, and the wet, logged area, and draw simple random samples from each strata. Finally, we might reduce variability by reducing the measurement error in our estimates of soil moisture. To obtain more accurate measurements of soil moisture, we could use a soil corer to collect soil samples so that the sample volume and sample depth could be standardized. However, sample sizes in the range of 22-35 sample plots would provide high power to test for an association between plant species richness and soil moisture in Bear Trap meadow.

Literature Cited

Dupont, W.D. and Plummer, W.D. 1997. PS power and sample size program available for free on the Internet. Controlled Clinical Trials 18: 274.