Pilot study to determine the Sample Size Required to Determine the Effects of Trampling at Bear-Trap Meadow

Natacha Merritt, Jessica Maxfield, Martha Berthelsen, Nancy Bruce, Amanda Jobbins, Adam Paranini, Hugh Freeman, Addie Evans, Vanessa Stevens

Instructor: Ed Connor

Abstract

Minimizing human impact while conducting field studies is of serious concern to many researchers. What is the best way to collect repetitive seasonal data and have the least amount of impact on a meadow? To address this compelling question we designed a preliminary study to determine the optimal sample size needed for statistically robust results when the treatments are applied to a sampling site, Bear Trap Meadow, located in the Sierra Nevada Mountains at approximately 7100ft. We looked at the difference in species richness and percent cover in "wet" and "dry" portions of the meadow. Our preliminary results suggest that an ANOVA study designed to test hypotheses about trampling, soil moisture, and their interactions on species richness in a mountain meadow would be feasible and capable of detecting effects of a biologically interesting magnitude.

Introduction

While observing the field monitoring for a bird study at Carmen Valley, CA, the field team noted the worn and obvious trails that had been created to collect data in a high elevation meadow. Since we were concerned about human impact of the environment, we wanted to determine if it were possible to minimize such impacts while conducting field studies.

These sensitive areas are often used by recreationalists, ecological researchers, and for cattle grazing. It is important to know what effect that trampling these areas might have on the overall composition and biotic richness of the area. It is often taught in Environmental Education to cross meadows by dispersing the group rather than crossing on a single track in order to reduce disturbance; this knowledge combined with our observation of the effects of trails in Carmen Valley were the catalysts for initiating this preliminary study.

In addition to the meadow used for bird monitoring, the field team observed a relatively unspoiled meadow, known in previous studies as Bear Trap meadow. Visiting this meadow with no obvious trails made us wonder what the best way to walk through these areas would be. If trampling through a meadow does have some effect on species richness, what is the best way to collect repetitive seasonal data and have the least amount of impact on the meadow? Considering the unique hydrology of a meadow, is species richness reduced by human trampling to a greater extent in wet saturated soils or in areas with drier soils?

We anticipate that varying degrees of trampling will have a direct effect on species richness of the biota and percent cover of plants; and that some relationship between these factors and moisture levels in the meadow would be observed. We designed this preliminary study to determine the optimal sample size needed for statistically robust results when the treatments are applied to the study site.

Methodology

The sampling site, Bear Trap Meadow is located in the Sierra Nevada Mountains at approximately 2100m asl. A preliminary walk through the area revealed two rather distinct conditions in the meadow. The eastern portion of the meadow had saturated soil and tree stumps and is defined as the "Wet area," the western majority had no saturated soil and is defined as the "Dry area." The two areas were clearly delineated by a row of standing conifers.

Randomization of Sample Plots

To create a randomized sample selection, we surveyed the dry and wet areas. We used a map generated by GPS points from a previous study of Bear Trap Meadow (Contois et al. 2004) to help us determine where to make the measurements. This was especially useful for the dry area, since its outline is a complex polygon. The wet area however approximates a rectangle and was much easier to measure.

We used the average width of the wet area and the length of the center to approximate its area to be a 7425 m^2 rectangle. We divided this area into fifty-five 15m x 15m grid cells.

We used a similar approach with the dry area. We used the longest width, 125m, and length, 450m, of the dry area. We drew a grid over the map of the dry area, with 90 cells of size 25m x 25m. Because several grid cells fell off of the map, the number of grid cells was reduced from 90 to 58. Fifteen of these grid cells contain part meadow and part forest. We estimated that the area of the dry area is between 26,875 m^2 and 36,250 m^2.

We used the urn and chip method, with one chip for every cell in the grid (picture 1). We drew a sample size of six, one at a time, with replacement so that each drawing would have the same probability. If we drew a number that we already had, we replaced it and drew again. If we drew a duplicate grid cell, we replaced it and drew again.

Sampling Design

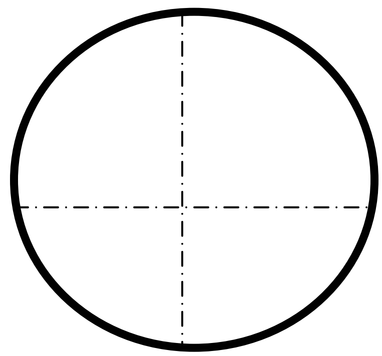


Figure 1

Our sampling units were constructed of black irrigation tubing forming a circle having a diameter of 0.80m and an area of 0.5 meter^2. A cross hatch of string marked in 5 cm increments identified the 30 sampling points for assessing vegetation cover. (see Figure 1).

Once the plot was located in the sampling grid, the observers tossed a poker chip to define the center crosshatch placement of the sampling Unit (Picture 1). The plots in the wet area were 15m x 15m and the poker chip was tossed in a random direction from a flag marking the center of the plot. The dry area plots were larger (25m x 25m) so to avoid under sampling of the edges; we randomly selected varying locations from which to toss the poker chip.

Picture 1: This picture shows the chip toss in the center of the sample plot

Two observers made four separate observations within each sampling unit in the following order:

a.) Number of different arthropod species found inside the hoop in 3 minutes

b.) A photograph of the area encompassed by the sample hoop
c.) A determination of percent plant cover was made by observing the color directly under each crosshatch point. When the point intersected green leaves it was rated "green" and when it intersected bare ground, downed wood or dead leaf litter it was rated "brown".

$$\text{Percent cover} = \frac{\text{Number of green points}}{\text{Total number of points}}$$

d.) Number of different plant species found inside the sampling unit

There were two groups consisting of two observers, each group observed 3 wet and 3 dry sampling units.

Picture 2: Species richness and percent cover estimation unit

Results and Analysis

Species Richness

We used the field data from this preliminary study to conjecture the effect size for each treatment and to obtain an estimate of the inherent observational variability (σ).

In order to generate an alternative hypothesis we calculate the mean species richness for the wet and dry areas of the meadow. We then found the percent difference of the means to estimate the effect size (Table 1).

Table 1.

	Low Moisture	High Moisture
Control	16 (=mean richness)	13.6 (16X15%)*
Trampled	12 (16X75%)**	6.8 (13.6X50%)**

*The difference in species richness between the high and low moisture was conjectured to be 15%.

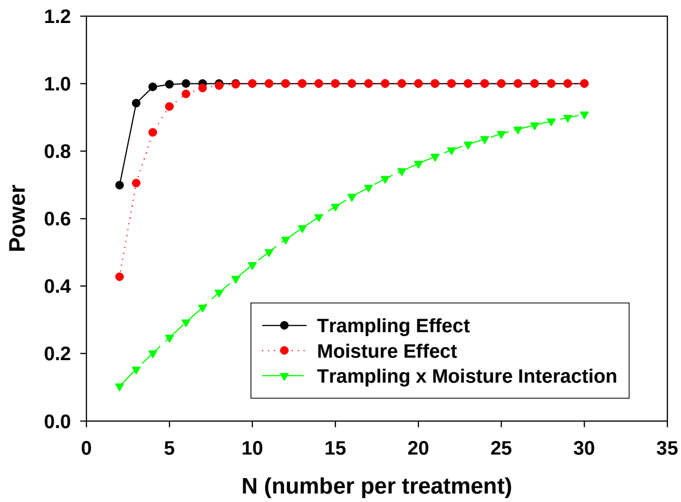
** We used these effect sizes because we thought that a 25% percent reduction in the low moisture site, and a 50% reduction in the high moisture site when the treatment is applied will be biologically interesting. The percentages respectively reflect the expected observed differences.

We set our Type I error rate to be $\alpha = 0.05$, this gives us a 95% chance of not committing a type I error.

We then estimated σ by calculating the standard deviation of species richness (3.459).

Using the conjectured treatment means from Table 1, as well as our α and σ values, we ran a power analysis using the PASS statistical software package (Figure 2). This allowed us determine how many samples would be required in order to achieve a power >0.8 for each of our three effects (the main effect of moisture, the main effect of trampling, and the interaction of trampling and moisture).

To achieve 80% power for the trampling and moisture effects we conjectured would require a sample size of 6 per treatment, totaling 24 samples. In order to detect the interaction effect (moisture x trampling) we conjectured would require approximately 30 samples for each treatment, for a total of 120 samples (Graph 1). Given that data collection required approximately 15min per sample after sample sites were located, annual monitoring of these sample sites would require approximately one week of work for a field crew of two biologists and all summer for a crew of two mathematicians.



Graph 1 - Power curves for trampling, moisture, and interaction effects on species richness ($\alpha = 0.05$, $\delta_{tramp} = 1.169$, $\delta_{moist} = 0.823$, $\delta_{interaction} = 0.303$).

Percent Cover

Percent cover of vegetation was collected to conjecture the effect size for each treatment and to obtain a preliminary estimate of the inherent observational variability (σ).

In order to generate an alternative hypothesis we calculated the percent cover for the wet and dry areas of the meadow; and determined the percent difference of the means to estimate the effect size (Table 2).

Table 2.

	Low Moisture	High Moisture
Control	44.06 (55.06 x 80%)*	55.06 (mean % coverage)
Trampled	33 (44.06 x 75%)**	27.53 (55.06 x 50%)**

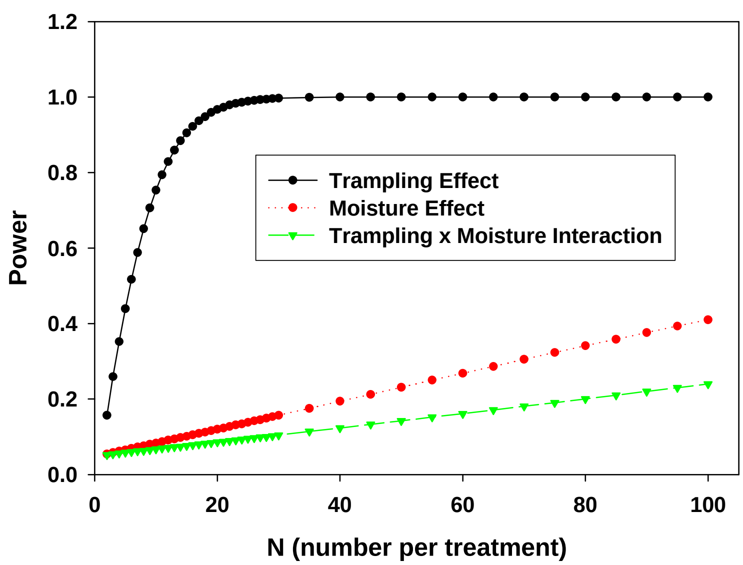
*The difference in percent cover between the high and low moisture was calculated to be approximately 3%; and determined to be uninteresting biologically. Therefore, we used 20% to reach a more appropriate quantitative value.

** We used these effect sizes because we thought that a 25% percent reduction in the low moisture site, and a 50% reduction in the high moisture site, correlated effect estimate to our effect concerning species richness. The percentages respectively reflect the expected observed differences.

We set our Type I error rate at $\alpha = 0.05$. Our estimate of σ for percent cover was (16.01).

Using the conjectured treatment means from Table 2, as well as our α and σ values, we ran a power analysis using the PASS statistical software package. This allowed us determine how many samples would be required in order to achieve a power >0.8 for each of our three effects (the main effect of moisture, the main effect of trampling, and the interaction of trampling and moisture).

To achieve 80% power for the trampling we conjectured would require a sample size of 8 per treatment, totaling 24 samples. The effect of moisture on percent coverage was so insignificant over 50 samples for each treatment would be required. In order to detect the interaction effect (moisture x trampling) we conjectured would require approximately 30 samples for each treatment, for a total of 120 samples. Given that data collection required approximately 15min per sample after sample sites were located, annual monitoring of these sample sites would require approximately one week of work for a field crew of two.



Graph 2 - Power curves for trampling, moisture, and interaction effects on percent cover ($\alpha = 0.05$, $\delta_{tramp} = 0.430$, $\delta_{moist} = 0.087$, $\delta_{interaction} = 0.062$).

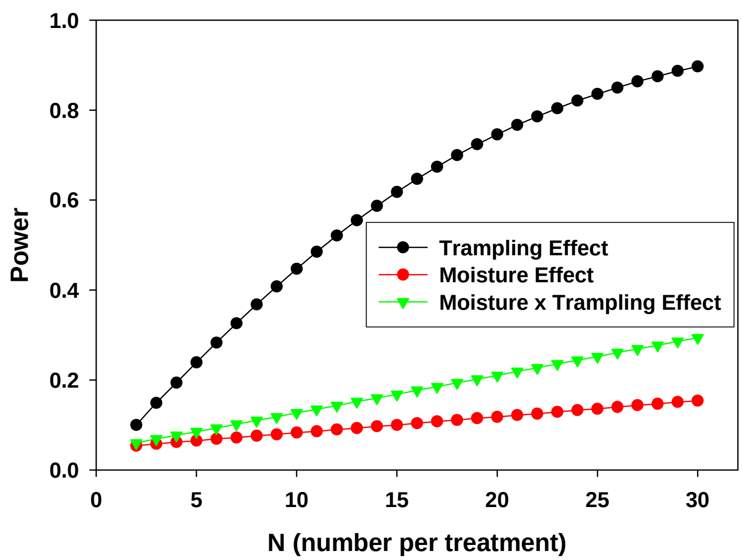
Percent Cover - Alternative Power Analysis

We calculated the power for sample sizes 2-30 using percent cover as a response variable and moisture and trampling as treatment variables. We conjectured an effect size of a 10% decrease in cover due to trampling in the low moisture area and 25% in the high moisture area. We used the observed 3% reduction in cover due to moisture, since we wanted to see how low the power would drop for an effect size this small (Table 3).

Table 3. Conjectured Means for Alternative Power Analysis

	Low Moisture	High Moisture
Control	53.65	55.06
Trampled	48.29 (0.9 x 53.65)	41.3 (0.75 x 55.06)

Our results indicate that even with a sample size of 30 per treatment, we would only achieve 15% power for moisture. We would have 90% power for trampling, but the interaction between moisture and trampling still would only have 29% power.



Graph 3 – Alternative Power curves for trampling, moisture, and interaction effects on percent cover ($\alpha = 0.05$, $\delta_{tramp} = 0.297$, $\delta_{moist} = 0.086$, $\delta_{interaction} = 0.130$).

Conclusions

Our preliminary results suggest that a two-factor fixed effects ANOVA study designed to test hypotheses about trampling, soil moisture, and their interactions on species richness and percent cover in a mountain meadow would be feasible and capable of detecting effects of trampling of a biologically interesting magnitude. However, it would be very difficult to detect reasonable effects of moisture and an interaction between moisture and trampling. Given that we anticipate greater soil compaction from trampling in wet areas of a meadow than in dry areas, perhaps an alternative design using more than two levels of moisture would be necessary to detect such an interaction. Future studies examining the effects of human trampling on vegetative species richness in nearby high elevation meadows in the Sierra Nevada should also consider the effects of trampling by cattle and sheep.

We suggest that future studies should implement the sampling design outlined here, requiring at least 8 samples per treatment combination potentially using three levels of trampling – none, moderate and high levels of trampling.

Literature Cited

Contois, M., J. Cahill, A. Chavez, C. Cacace, G. Wechsler, M. Pauli, and E. Kosman. 2004. Estimating Corn Lily Abundance in Bear Trap Meadow, July 2004. (http://userwww.sfsu.edu/~efc/classes/biol315/cornlily.pdf)

Hintze, J. 2001. NCSS and PASS. Number Cruncher Statistical Systems. Kaysville, Utah.