Assessing herbivory as a potential driver of woody encroachment using *Baccharis pilularis* as a model and analyzing the effects of woody encroachment on herbaceous plant and insect abundance

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Abstract

Recently woody plants have been encroaching upon ecosystems formerly dominated by herbaceous plants (grasslands) in California and the Southwest. This experiment examines this phenomenon and its effects at Jasper Ridge Biological Preserve, using *B. pilularis* as a model for woody encroachment. We particularly wanted to examine herbivory as a potential driver of this current trend. Data on herbaceous and woody plant abundance, herbivory, and insect diversity and abundance was obtained at a series of plots with differing levels of cover within Jasper Ridge. Results were insignificant, but a reading of trends in our results indicates that increasing cover does not inhibit herbaceous plant growth, that herbivory is negatively driving woody encroachment, and that insect abundance decreases with increased cover. More studies will need to be conducted, as a significant data set was not achieved. It will also be important to examine other potential drivers of woody encroachment (fires, climate change, grazing) in future studies.

Comment [DP1]: Actually, all over the world

Comment [DP2]: Nice!

Comment [DP3]: Were – data = plural

Comment [DP4]: What kind of cover?

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Introduction

Jasper Ridge Biological Preserve is an enclave of biodiversity near Stanford University. Recently there has been concern that the grassland ecosystems within Jasper Ridge are threatened by "woody encroachment"– the takeover of herbaceous plant-dominated grassland by woody plants. Grasslands are important in their production– they have high primary productivity that provides the foundation for a wide variety of organisms to survive. Their primary production is also essential in the nutrient cycling.[1]

Comment [DP6]: Very good intro paragraph!

It is believed that woody encroachment is not the result of natural succession, as grassland ecosystems bordered by shrubland in Jasper Ridge have been shown to have been stable for thousands of years prior to the recent onset of woody encroachment.[1] Thus it seems that a new outside factor may be implicated. Research has suggested that herbivory may be a factor driving woody encroachment. Small mammals often eat the seeds of herbaceous plants, potentially leading to less seedling development.[2] These animals tend to prefer covered (woody) habitats. Small patches of woody habitat within grasslands may provide an area for these small mammals to range from and further feed on herbaceous seeds and seedlings, thus driving woody encroachment by limiting competition by herbaceous plants. In addition, as the canopy of *B. pilularis* extends over herbaceous plants, sunlight is blocked and herbaceous plants have a harder time obtaining necessary sunlight, thus resulting in an "island" of *B. pilularis* cover. . Our study aimed to look at herbivory as a potential factor EITHER driving or inhibiting the encroachment of the woody shrub *B. pilularis* into grassland habitat. Recently islands of *B. pilularis* growth have been occurring in grasslands at Jasper Ridge. It is unknown whether herbivory is a driving or inhibiting factor in the encroachment of *B. pilularis*; small mammal herbivory on grass seeds could be resulting in an opportunity for *B. pilularis* to take over, or the small mammals could be

feeding on the *B. pilularis* seedlings themselves and thus be working to inhibit *B. pilularis'* encroachment into grasslands.[1]

Insect abundance and diversity, particularly that of pollinators, is generally higher in grassland ecosystems than in woody ecosystems.[1] Indeed, habitat fragmentation due to the presence of woody plants in traditionally grassland ecosystems has the potential to decrease insect diversity and abundance[3]. Thus it is predicted that woody encroachment will be associated with decreased insect abundance and diversity.

Our study first aimed to measure the amount of herbaceous versus woody vegetation as a function of overhanging plant cover (shade) in designated study plots. We then looked for evidence of herbivory on the *B. pilularis* seedlings planted in each plot. We hypothesized that higher cover would be associated with fewer herbaceous plants and more woody plants. We further hypothesized that herbivory was a factor driving *B. pilularis* encroachment (that significant herbivory would not be seen on the *B. pilularis* seedlings as compared to seedlings protected from herbivory by a copper mesh cage). Finally, we sought to……Our study aimed to test this theory. Insects were collected within each plot area and abundance was measured as a function of cover class. We hypothesized that plots with higher cover (woodier plots) would have lower insect abundance as opposed to plots with less cover (and thus more herbaceous plants).

Methods

Each student was assigned to a designated plot (one of 12) within the study area. Plots differed in degrees of "cover class" based on the amount of shade/woody plant overhanging. Cover class was divided into 4 groups: A (0-20% cover), B (20-50% cover), C (50-80% cover) and D (80-100% cover). 4 A plots, 5 B plots, 1 C plot, and 2 D plots were surveyed. Students first collected the specimens within the two insect traps (pans A and B) within their plots. Students then proceeded to measure the amount of vegetation in each of six points within the plot, marked by a wire tomato cages. The pin drop technique was used to measure the amount and size of vegetation in the plot; the number of touches on the pin by vegetation was recorded based on height class (every 10 centimeters up to 40 centimeters) and vegetation type (woody or herbaceous). Then students analyzed the amount of herbivory and growth of the *B. pilularis* seedlings in each plot. Each plot contained 4 exclosure *B. pilularis* seedlings surrounded by copper wire so that no herbivores could enter, and 4 control seedlings, which were not enclosed. Herbivory was ranked on a scale of 0-5, with 0 being extremely minimal or no herbivory, based on a close analysis of the seedling leaves. The volume of each seedling was recorded by measuring the height of the plant, the width at the widest point, and the width perpendicular to that measured distance.

Upon returning to the laboratory with the collected insects, students identified the insects based on class under a microscope. Class and number of insects was recorded for each pan and for each plot surveyed.

Data were compiled and analyzed. Cover classes were analyzed against average insect abundance, number of herbaceous and woody plant touches, and herbivory rating. Error bars were used to test for statistical significance.

Results

Comment [DP8]: This paragraph is a very good introduction to the "DRIVER" aspect of our experiment. But, you didn't introduce the IMPACTS we're studying and why……specifically, the impact on baccharis encroachment and the impact on pollinator diversiy

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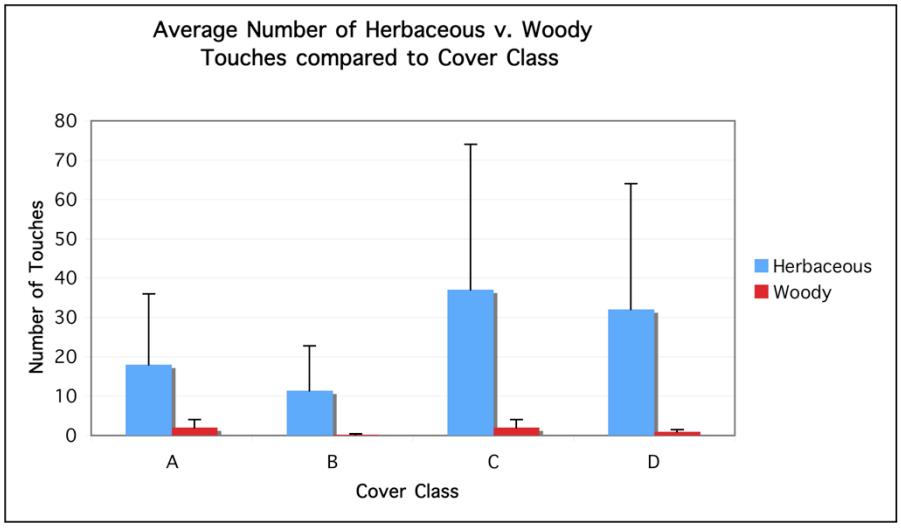
Comment [DP9]: The final paragraph should say what we did and what we measured…..the rest of the intro is an intro to concepts

Deleted: Insect abundance and diversity, particularly that of pollinators, is generally higher in grassland ecosystems than in woody ecosystems.[1] Indeed, habitat fragmentation due to the presence of woody plants in traditionally grassland ecosystems has the potential to decrease insect diversity and abundance[3]. Thus it is predicted that woody encroachment will be associated with decreased insect abundance and diversity. Our study aimed to test this theory. Insects were collected within each plot area and abundance was measured as a function of cover class. We hypothesized that plots with higher cover (woodier plots) would have lower insect abundance as opposed to plots with less cover (and thus more herbaceous plants).

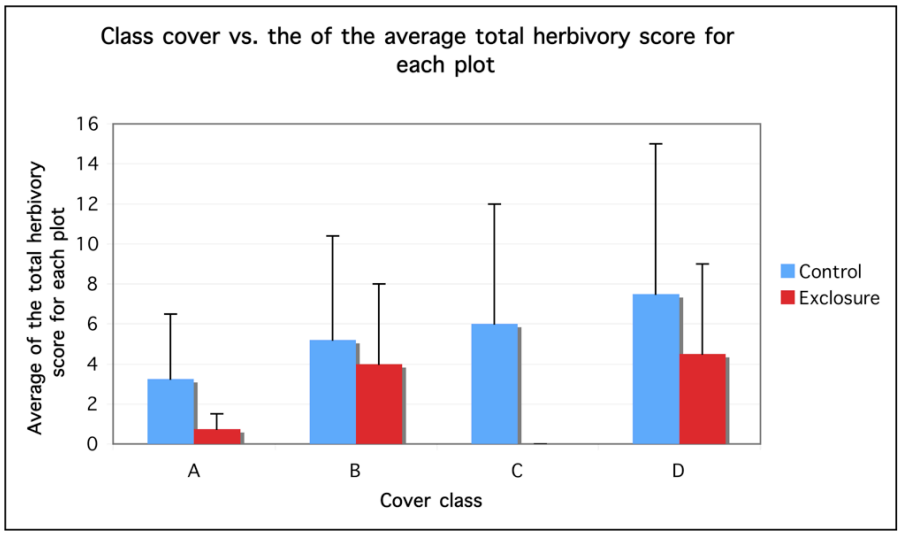
Comment [DP10]: This should be stated more as a fact and less as a set of instructions. We collected insects using pan traps at each experimental plot and identified insects to the level of order using a dissection microscope. See the difference?

Figure I. Number of herbaceous versus woody touches plotted as a function of cover class



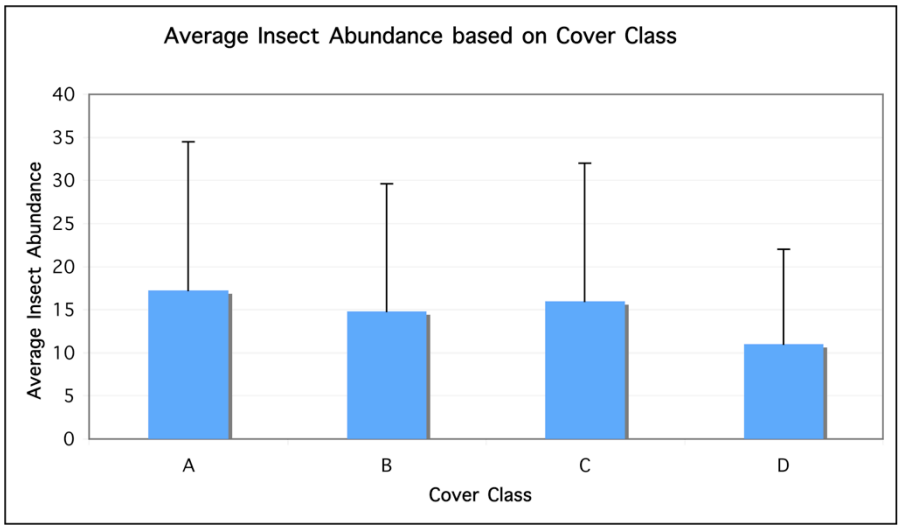
Cover class was compared to the average number of touches on the pin for plots within that cover class for both woody and herbaceous plants. Cover classes were designated as follows: A=0-20%, B=20-50%, C =50-80%, D=80-100%.

Figure II. Herbivory ratings as a function of cover class



Herbivory scores for control and exclosure conditions were added up (separately) for each plot. The averages for the total scores for each plot were obtained and plotted against cover class.

Figure III. Insect abundance as a function of cover class



Total number of insects were obtained for each plot (summing the totals for pans A and B). Plots were grouped by cover class, and the average number of insects per plot for each cover class was determined.

Discussion

In contrast to our predictions, the amount of herbaceous versus woody coverage did not vary based on cover class (Figure I). Our data, as indicated by the error bars, is not statistically significant; however, there is a surprising downward trend in the amount of herbaceous plants in the lower cover classes (A and B) as opposed to the more shaded/woody ones (C and D). This conflicts with the idea that herbaceous plant growth would be inhibited in areas of greater overhead cover, as well as with the idea that more woody growth necessary implies less herbaceous plant growth.

As in Figure I, the data compiled for cover class compared with herbivory ratings is not statistically significant (Figure II). There is a slight upward trend in herbivory in woody environments (more cover), which fits with the idea that small mammal herbivores like to live in woody patches within grasslands. It does appear that something likes to eat *B. pilularis* seedlings, but herbivory was generally low. However, the general upward trend with increasing cover class fits with the idea that herbivory may be negatively driving *B. pilularis* encroachment. This contrasts with our hypothesis, in which we predicted that herbivory was positively driving woody encroachment. However, we don't really see a significant difference in the rates of herbivory between the control and exclosure locations. The idea was that herbivory would be higher in the control plots compared to the exclosure plots, and this data could be used to see if the difference between the control and exclosure plots increased or decreased with cover class. In cover class C there is a significant difference– but we also only had one plot in cover class C from which we obtained data. There's also a significant difference in cover class A, but without significant differences between exclosure and control plots in all cover classes it is difficult to tell whether herbivory is really varying based on cover class.

Figure III demonstrates how insect abundance changed based on cover class. Again, the differences are not statistically significant. However, there is a slight downward trend in insect abundance as cover increases, which supports our hypothesis that insect abundance would decrease as cover increased, based on the knowledge that insects (particularly pollinators) are more abundant and diverse in herbaceous as compared to woody environments. However, we cannot draw clear conclusions as the results are not robust.

There were several issues in our experiment that could use adjusting. First, a greater number of data points and plots surveyed could have helped to make our results more statistically significant. Second, the exclosures used in the herbivory analyses were far from herbivore-proof, leading to a non-significant difference between the exclosure and control seedlings. Exclosures should be more secure in future experiments. Third, insect abundance measurements should perhaps be taken over a period of several weeks, so that more data points are recorded. Finally, a wider data analysis could be performed to see if there were any significant correlations in the data that were not investigated in this report.

Future studies can further investigate herbivory as a potential driver of woody encroachment, as the results of this study were inconclusive. As woody encroachment could be driven by multiple factors, it would also be beneficial to study these factors (fire, grazing, climate change) and their interactions and look at their effects on woody encroachment. Further

Comment [DP12]: More analysis must be done and on a larger data set in order to confirm that this trend is meaningful, however.

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studies could also be performed to provide more conclusive results on the effects of woody encroachment on insect abundance and diversity, specifically on pollinators. It would also be interesting to examine the mutualistic interactions of insect abundance upon herbaceous plant abundance– that is, whether herbaceous plant coverage declines in response to insect pollinator declines instead of always following a one-way pattern (decreases in herbaceous plant abundance precede decreases in insect abundance).

This study serves to highlight the importance of grassland ecosystems and serves as a model for the pattern of woody encroachment that has recently been occurring in California and the Southwest. It's important that we learn to understand the causes of the changes that are taking place so that we can model their potential effects on grassland ecosystems and the organisms that inhabit them.

Comment [DP17]: Not sure how you came to this conclusion based on our inconclusive dataset ☺

References

1. Ed. Nees, A. Ecology: introduction to Jasper Ridge and the causes and effects of woody encroachment. Bio 44Y Lab Manual. Ed. Malladi, S. 2010-2011.

2. Hulme, P. E. 1994. Post-dispersal seed predation in grassland: its magnitude and sources of variation. Journal of Ecology: 645-652.

3. Collinge, S. 2000. Effects of grassland fragmentation on insect species loss, movement, and colonization patterns. Ecology: 2211-2226.

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