The effects of grazing and invasive plant species on butterfly communities in northwestern Montana

Mason Murphy

Abstract

In this study I examined how butterfly species richness, abundance and diversity differed under two different grazing methods: bison summer grazed and bison winter grazed plots. I also compared these data to plant diversity, invasive species cover, and habitat heterogeneity. In addition, I examined the differences in plant diversity and invasive species cover between the two different grazing patterns. I conducted 2 plant surveys to assess vegetation diversity, and also recorded flowering forb percentages. I found that butterfly diversity is significantly affected by both elevation and habitat heterogeneity, and that plant diversity has no effect on butterfly diversity. This knowledge will be helpful in designing conservation programs for threatened butterfly species.

Introduction

Overgrazing has led to a decline in pristine grasslands, and intensive grazing has caused habitat degradation (Dorrough 2007). The management of native grasslands is therefore an important conservation issue for both the flora and fauna that comprise them; including butterflies can be used as indicators of overall community health (WallisDeVries and Raemakers). Butterflies occupy an important ecological niche by acting as pollinators for many grassland forbs. Many species are also adapted to pollinating specific plants (WallisDeVries and Raemakers). Intensive grazing by livestock has been shown to negatively affect the richness and abundance of arthropods, including butterflies (Kruess 2002; Biagio 2011; Pöyry 2004) by reducing habitat complexity such as vegetation height as well as reducing plant-insect interactions. Conversely, moderate grazing has also been shown to increase butterfly abundance in dune habitats, as it increases habitat heterogeneity (WallisDeVries and Raemakers). Butterfly diversity could therefore be useful as an indicator for grassland community health under different grazing regimes.

Another concern regarding native grassland health is the invasion of exotic plant species. These invasive plant species can encroach on prairies, outcompeting native species. Once established in an area, these exotic plants can spread via wind, water, fire, and animals (U.S. Fish and Wildlife Service). These non-native species cause major environmental damages, such as displacement of native species, and degradation of natural areas. These damages cost the U.S. almost $120 billion per year (Pimental 2005). Invasive species control within national parks and wildlife refuges is of special concern, as these sites aim to preserve near pristine natural environments. Managing the spread of invasive species has become one of the most important duties of the fish and wildlife service and the national parks service (U.S. Fish and Wildlife Service). Invasive plant species have been shown to negatively affect Lepidoptera species along road verges (Valtonen et al) by outcompeting native species, which can reduce total nectar availability. Understanding the relationship between butterflies and invasive plant species abundance could be an important step in monitoring invasive species spread.

Information about grazing intensity and invasive plant species cover, and how they relate to butterfly diversity, could be very useful knowledge for butterfly conservation and for native grassland conservation.

Objectives

1) Analyze the difference in butterfly communities (richness, abundance, diversity) between two different grazing treatments

2) Analyze the relationship of butterfly populations and communities to invasive plant cover.

3) Analyze the difference in invasive plant cover and native plant diversity between grazing treatments

I predict that butterfly diversity will be greater within summer grazed plots. Bison feed almost entirely off of grasses, and therefore the reduced grass cover will not only lead to a more rich and varied habitat of nectar sources, but also to greater habitat heterogeneity. In addition, butterfly diversity will be greater in those areas with a low percentage of invasive plant species cover, as well as a high diversity of native species. As more ground is covered with invasive species, the abundance of native species that butterflies utilize is reduced.

Methods

Study Area

The National Bison Range (NBR) is a 7500 hectare National Wildlife Refuge in northwest Montana established in 1908 for the American Bison. The Bison Range consists of Palouse prairie habitat characterized by bunchgrasses and native forbs, and supports an abundance of wildlife. I chose this site because of the controlled grazing regime, which limits bison to one half for part of the year, creating sites that are specifically summer bison grazed and winter bison grazed.

Butterflies

I conducted initial checklist surveys with reference to species lists for Lake and Sander Counties in eastern Montana on the National Bison Range. A reference sample from each species was be caught and pinned. The process of pinning reference samples continued throughout the course of this study as new species were discovered.

To measure butterfly richness and abundance, I used the Pollard method (Pollard 1977) along 24 permanent 200 meter transects. I utilized 12 transects at least 500 meters apart in the summer grazed section, and 12 transects in the winter grazed section (Fig 1). I conducted three weekly butterfly counts for each transect. Counts were be made in the daytime between 1000 and 1600. Counts were not made when cold, rainy, or on days with over 25% cloud cover.

Specimens were visually identified at a distance, but stops along the transects were allowed for net capture and identification. If a butterfly could not be distinguished between two similar species, it was recorded as the more common of the two. In addition to butterfly richness and abundance, wind speed, cloud cover, elevation, and temperature were recorded at each transect. Species richness (total number of species observed), and abundance (sum of individuals from each census) were calculated, and Shannon's diversity index was used to assess butterfly diversity.

Vegetation

To assess vegetation diversity, toe points were made at 5 meter increments for a total of 40 points along each transect. Plants were identified by sight and with the use of dichotomous keys. At each point, the closest plant perpendicular to the ground at that point was measured. In the case of multiple plants per point, the plant first touched by a measuring rod was counted. Forbs were identified to species, grasses will not. In addition, I measured the flowering status of each marked plant, and of the closest flowering forb within 4 meters. Biomass was also measured using a Robel pole, and a coefficient of variation of biomass was calculated as a measure of habitat heterogeneity. Plant surveys were conducted two times to accommodate for the differing flowering times of the forbs and were matched with the butterfly sampling times.

Statistical Analyses

T-tests were used to compare butterfly richness, abundance and diversity in the winter grazed section versus the summer grazed section. Regressions were used to compare butterfly diversity along a gradient of plant diversity, as well as invasive species cover. A t-test was also used to compare separately plant diversity and invasive species abundance between the two different grazing treatments. To assess whether differences between the summer and winter grazed sites effect butterfly diversity, regressions were used to look at factors influencing butterfly diversity independent of site type, and then the significant factors (elevation and coefficient of variation of biomass) were used in a t-test to compare summer and winter grazed transects.

Results

Butterfly diversity and grazing patterns

Butterfly diversity was found to be significantly greater among the summer grazed sites compared to the winter grazed sites ($t(22)=-1.93$, $p= .017$, Fig.2). In addition, butterfly species richness was found to be greater in the summer grazed plots than in the winter grazed plots ($t(22)=1.33$, $p=.099$ Fig 3), but species abundance did not vary between the different grazing regimes ($t(20)=.13$, $p=.90$ Fig 4).

Butterfly diversity and plant diversity

Butterfly diversity was analyzed using least squares regressions, and was found to not vary with either total plant diversity, or flowering plant diversity ($p= .60$, $R^2= -.032$, Fig 5, and $p= .12; .7$, $R^2= .092; -.04$, Figs 6 and 7). I examined plant communities using Principle Components

Analysis and hierarchical cluster analysis, and found there to be no distinct relationship between different plant communities and butterfly diversity. Butterfly diversity was found to increase with an increase in the percent of invasive species cover ($p= .055$, $R^2=.119$, Fig 8)

Plant diversity and grazing patterns

Plant species diversity was not found to be significantly different between the winter and summer grazed plots ($t(22)=-.047$, $p=.96$ Fig 9). In addition, total invasive species cover was not found to be significantly different between the two types of sites ($t(22)=1.24$, $p=.11$, Fig 10). A more in depth look at invasive grasses and forbs revealed that summer grazed sites a significantly lower percentage of native grasses ($t(22)=-1.99$, $p=.059$, Fig 13). Summer grazed sites were all located at a mean of 2859 feet, while winter sites were located at a mean of 3432 feet, so although summer sites had significantly more invasive grasses ($t(22)=2.1$, $p=.048$, Fig 11), invasive grasses were also dependent on elevation (increasing with lower elevation, $R^2=.084$, $p=.091$ Fig 12). Elevation may thus confound the observed difference in invasive grasses between winter and summer grazed sites. Summer and winter sites did not differ in percent of invasive forbs ($t(22)=-.27$, $p=.60$, Fig 13).

Factors that influence butterfly diversity

To assess the factors that cause the difference in butterfly diversities between the summer and winter grazed sites, I regressed multiple variables against butterfly diversity. I found that both elevation and habitat heterogeneity were significantly related to butterfly diversity ($R^2=-.37$, $p=.001$, Fig 14; $R^2=.33$, $p=.049$ Fig 15). Summer grazed sites have a significantly lower elevation, (t(22)=-3.75, p=.001 Fig 16), as well as significantly more habitat heterogeneity (t(22)=3.3, p=.004 Fig 17).

Discussion

Though a significant difference was found in butterfly diversity between the summer and winter grazed transects, the only one of the hypothesized reasons accurately explained this result. Overall plant diversity remained the same between the summer and winter grazed sites, and no relationship between plant communities and butterfly diversity was found. Plant composition thus has little effect on butterfly diversity. One factor that was shown to have a large impact on butterfly diversity was elevation. This could be due to any number of factors, including soil moisture content, or proximity to standing water (Menedez *et al.* 2007), but neither were measured in this study. One factor that did correlate with butterfly diversity as well as elevation is habitat heterogeneity, as measured by the coefficient of variation of plant biomass. This supports previous findings that butterfly diversity increases with habitat heterogeneity (Kruess 2002; Biagio 2011; Pöyry 2004). This increase in habitat heterogeneity is most likely caused by bison grazing and wallowing, which increases the height variance of all plant species in the area.

Butterflies can have a wide variety of food sources, and some of the recorded species on the National Bison Range specifically are generalists when it comes to food (e.g. silvery blue, small wood nymph). Menendez *et al*. (2007) found that as butterfly species trend more toward generalists, they are less affected by host plant richness. Because of the generalized feeding habits of the butterfly species on the NBR, they are less affected by the diversity of plant species available, and more affected by habitat structure.

Total plant diversity did not change between the summer and winter grazed sites, nor did the total percentage of invasive species. Further examination did show that there was a significantly higher percentage of invasive grasses in the summer grazed plots. This could be due to bison acting as a vector of invasive species spread, which is in concordance with a study by Myers *et al.* (2004), who found that white- tailed deer act as vectors for invasive species spread. However, it could also have something to do with elevation, which was negatively correlated with invasive grasses, because the two grazing regimes had distinct elevation ranges. Further research on the interactions between these variables and the factor of grazing site is needed to determine whether the difference in invasive grasses between winter and summer sites is due to the grazing regime and bison as invasive species facilitators, elevation, or an interaction of the two.

This study demonstrates the importance of habitat heterogeneity for the butterfly populations on the National Bison Range, as well as potential drivers for invasive species spread. Future studies are needed to look at what specific invasive plant species have an effect on specific species of butterfly. This could be accomplished by examining caterpillar populations as well as adult butterfly populations. Quantifying the effect of specific invasive species will help to better understand butterfly habitat preference and give insight into which plants might most negatively affect butterfly conservation efforts.

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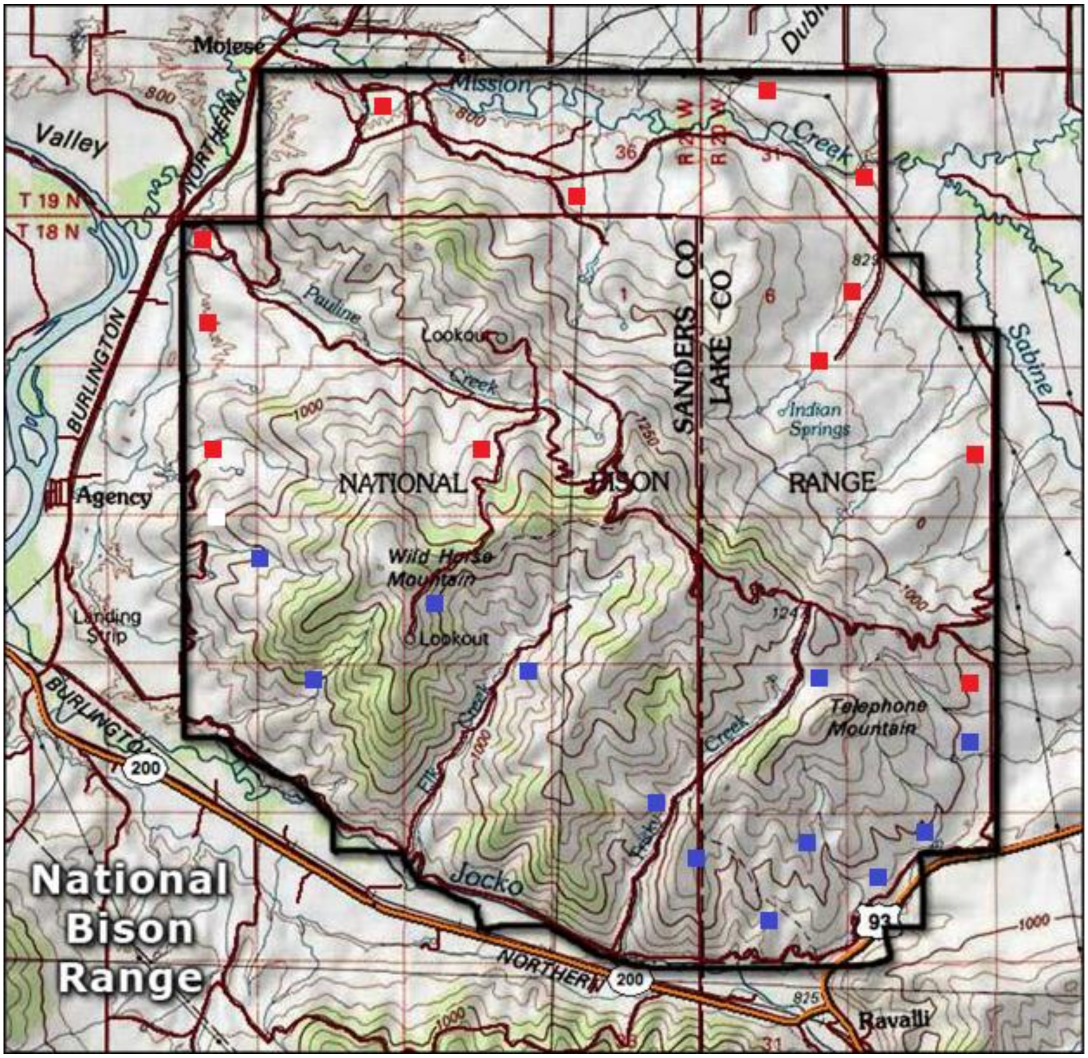

Figure 1: Map of the National Bison Range showing the location of the 12 summer grazed (red) and 12 winter grazed (blue) transects.

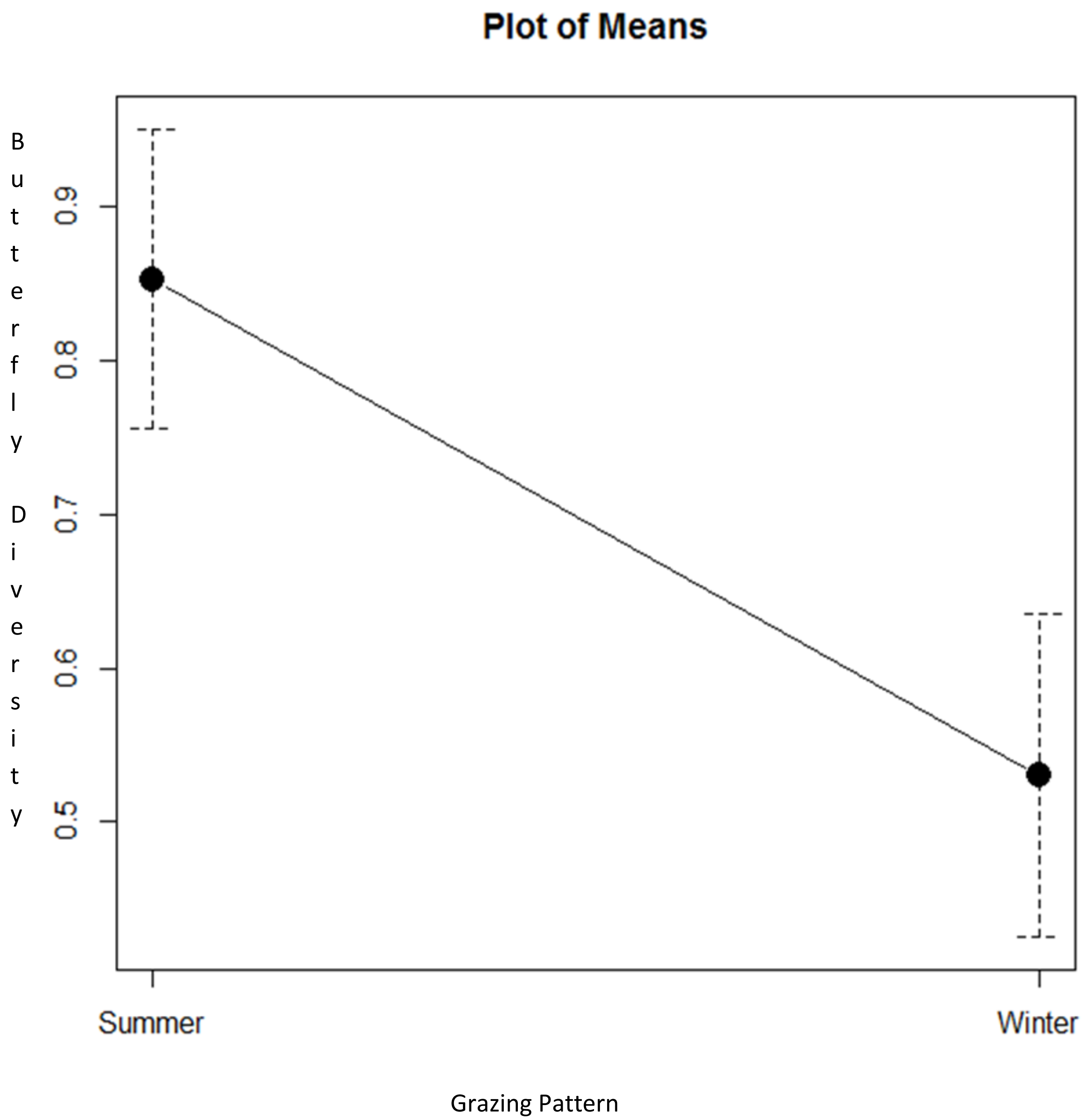

Figure 2: The comparison of butterfly diversity means (Shannon's) between summer and winter grazed transects with standard errors (p=. 017).

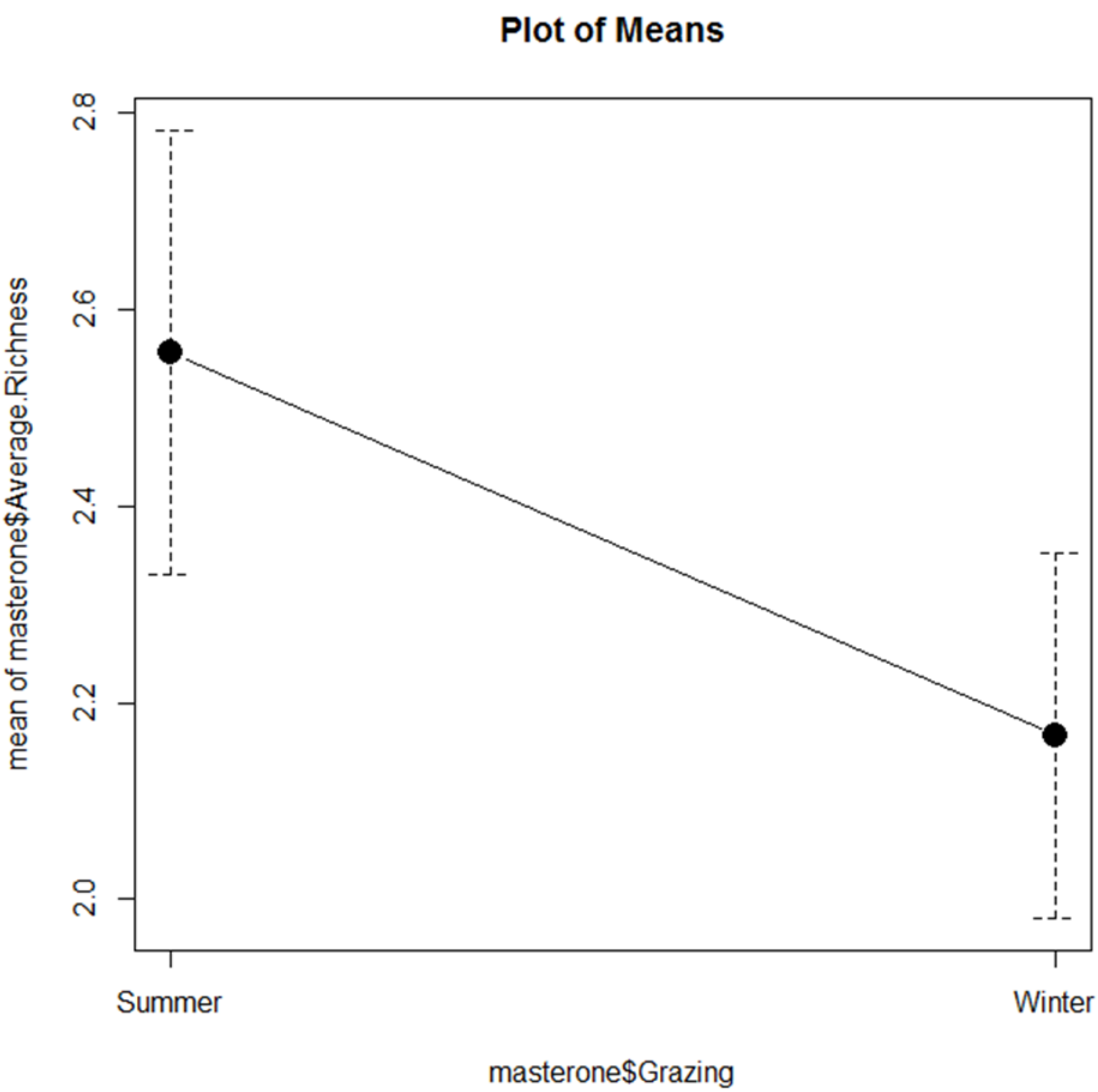

Figure 3: A comparison of mean butterfly species richness between the summer and winter grazed plots. p=.099

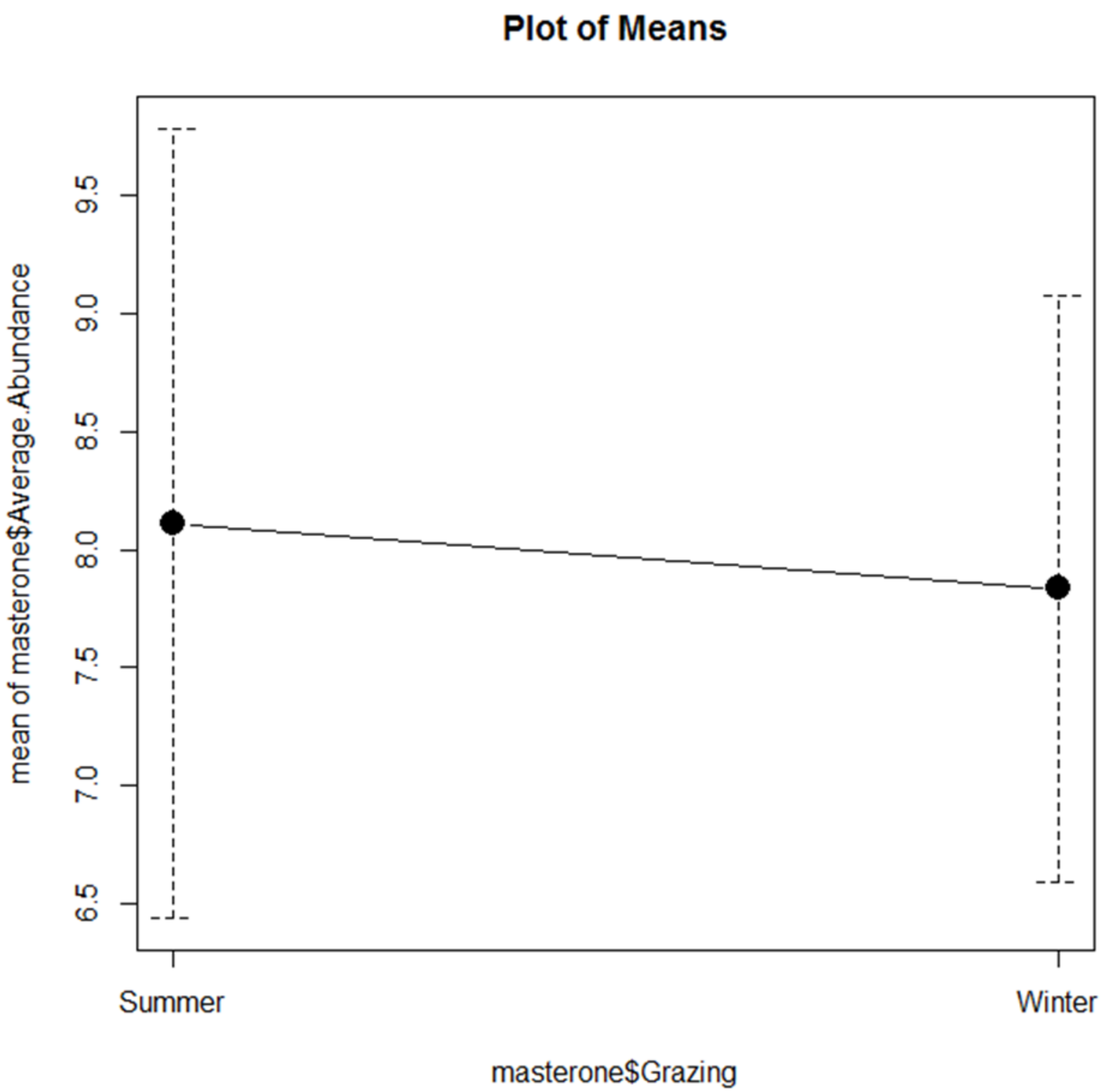

Figure 4: T-test with standard error comparing species abundance between summer and winter grazed transects. p=.90

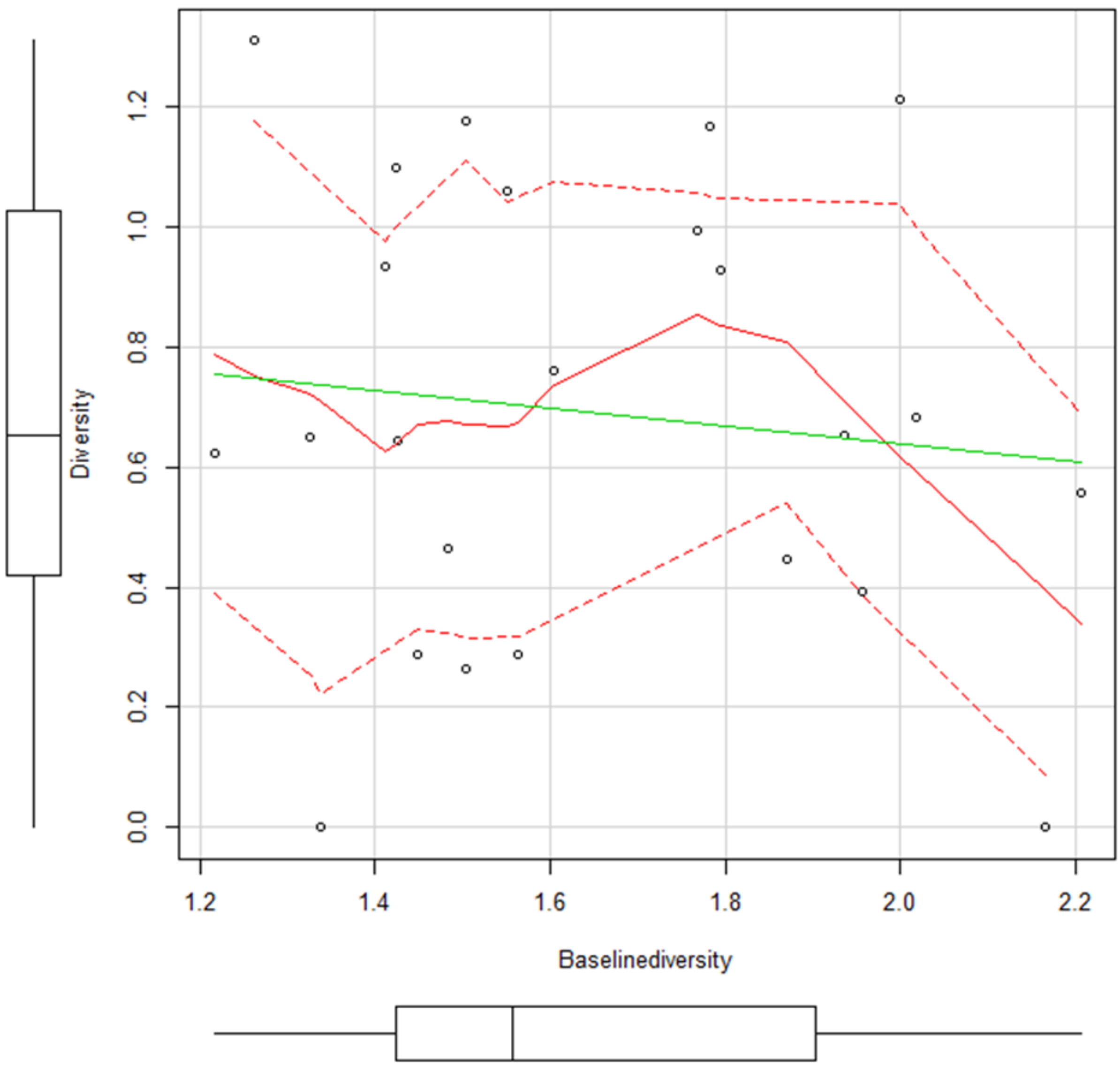

Figure 5: Regression comparing butterfly diversity to total plant diversity. p=.60

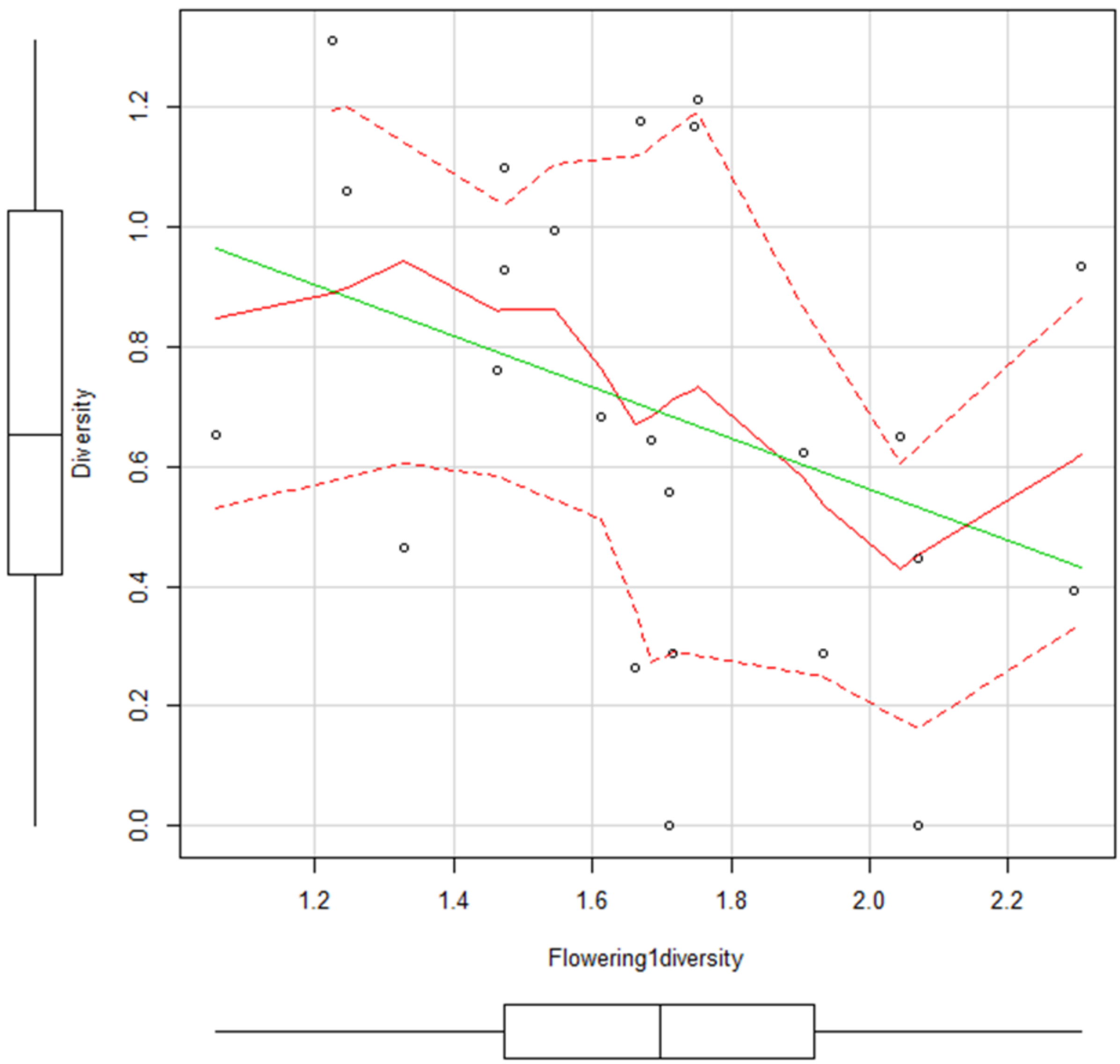

Figure 6: Regression comparing butterfly diversity to first round of flowering plant diversity. p = .12

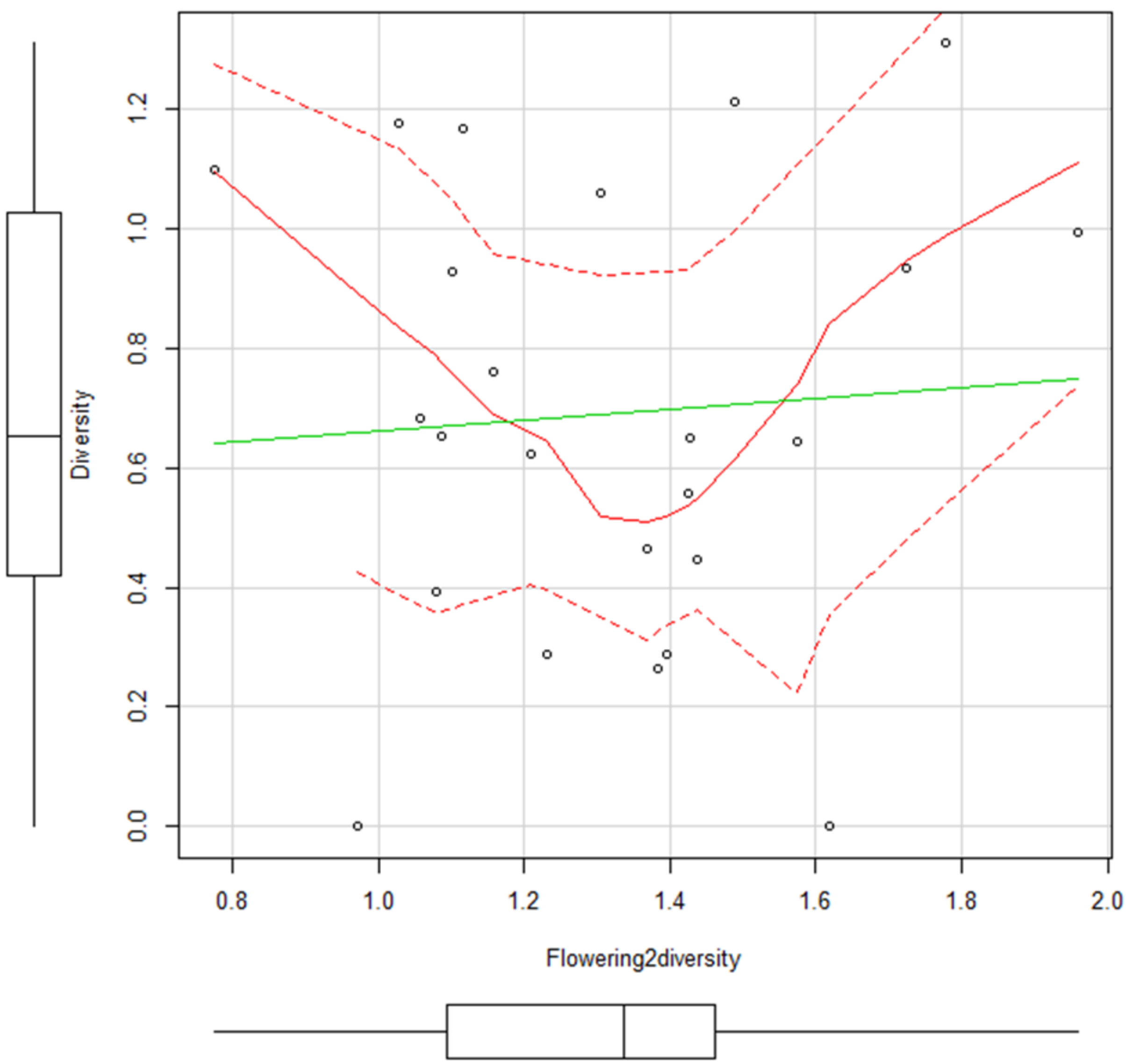

Figure 7: Regression comparing butterfly diversity to first round of flowering plant diversity. p =.70

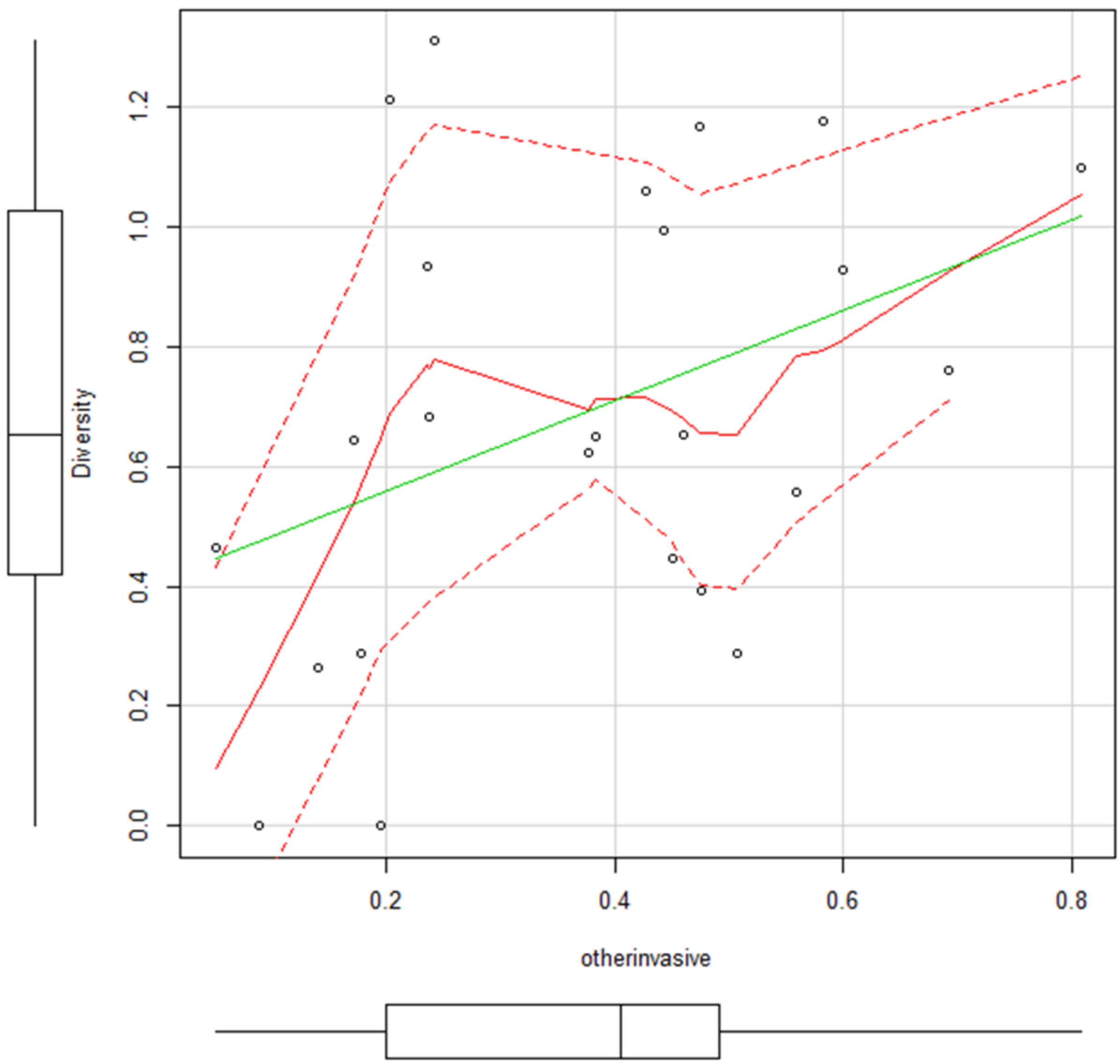

Figure 8: Regression comparing butterfly diversity to invasive species cover p=.055

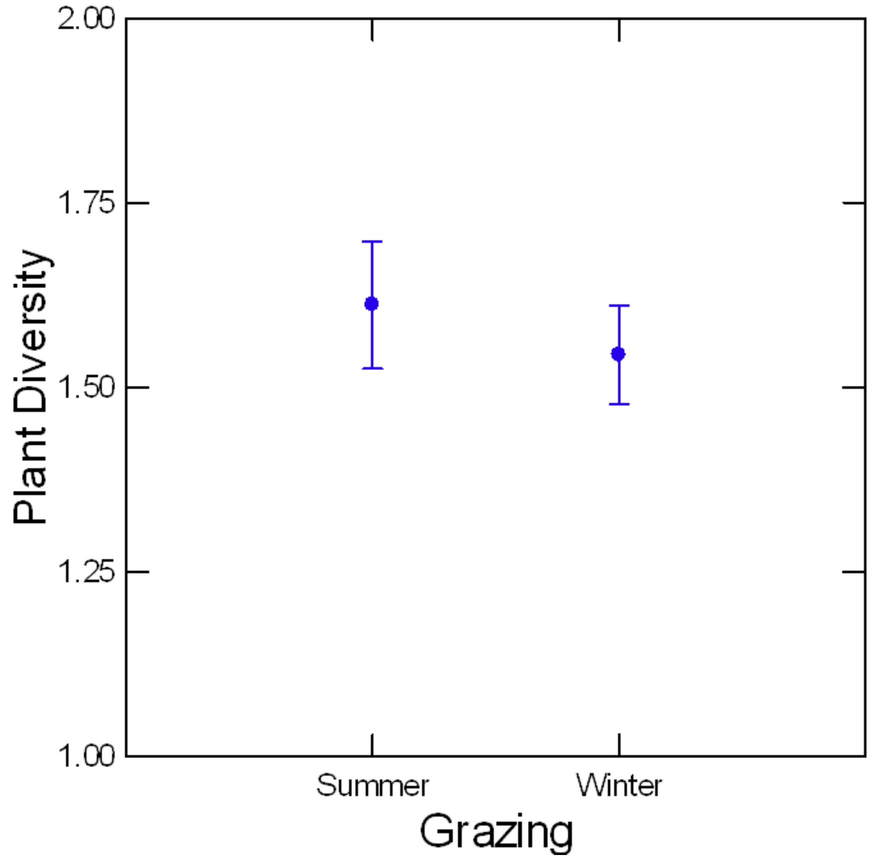

Figure 9: Results of two-sample t-test on plant diversity in summer-grazed and winter-grazed plots p= .96

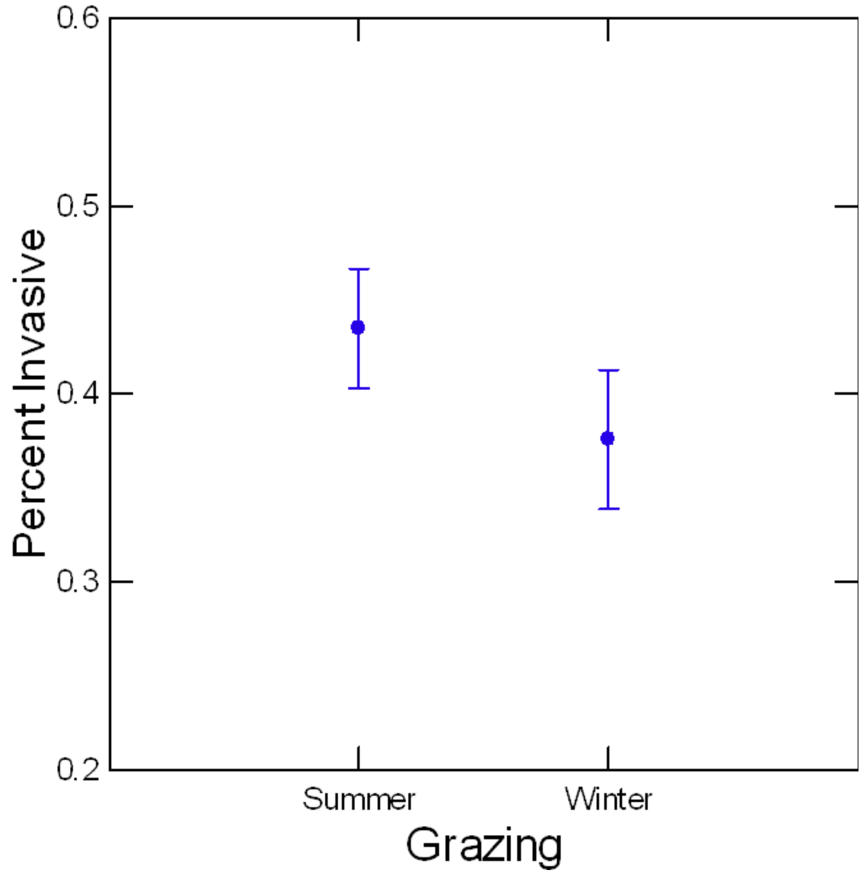

Figure 10: Results of two-sample t-test of percent invasive plants between summer and winter-grazed plots. p= .11

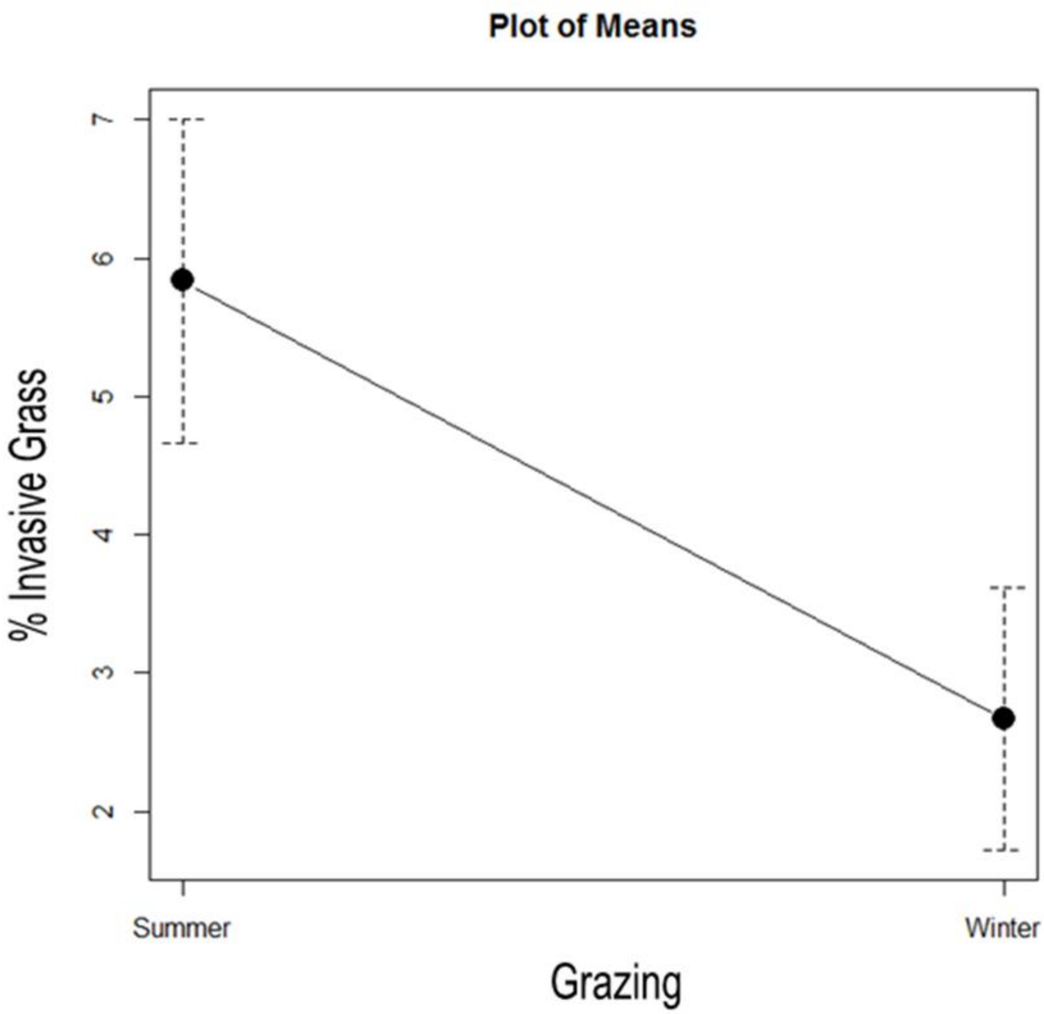

Figure 11: T-test with standard error comparing percent invasive species cover between summer and winter grazed sites. p= .048

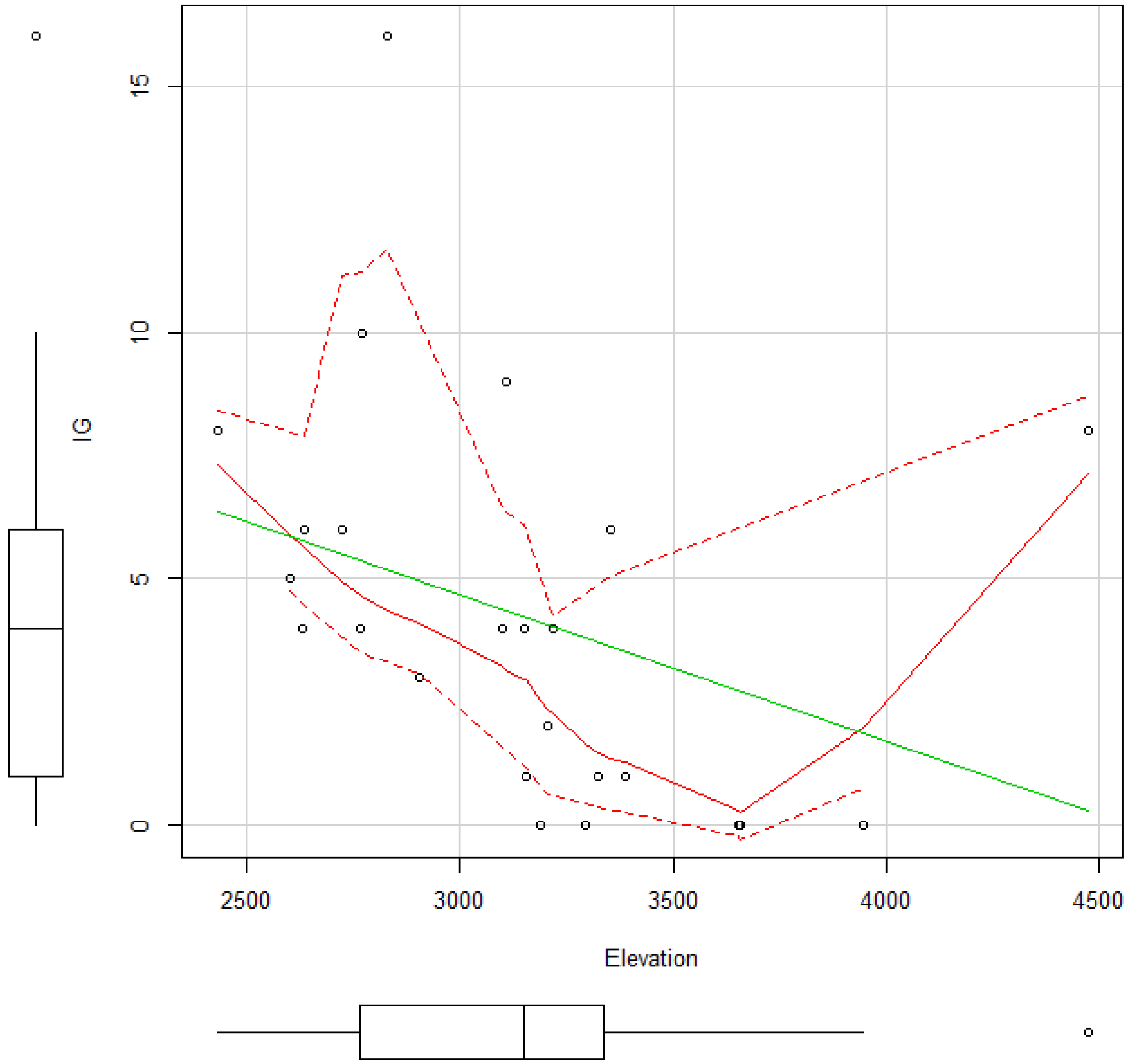

Figure 12: Regression comparing percent of invasive grasses to elevation p=.091

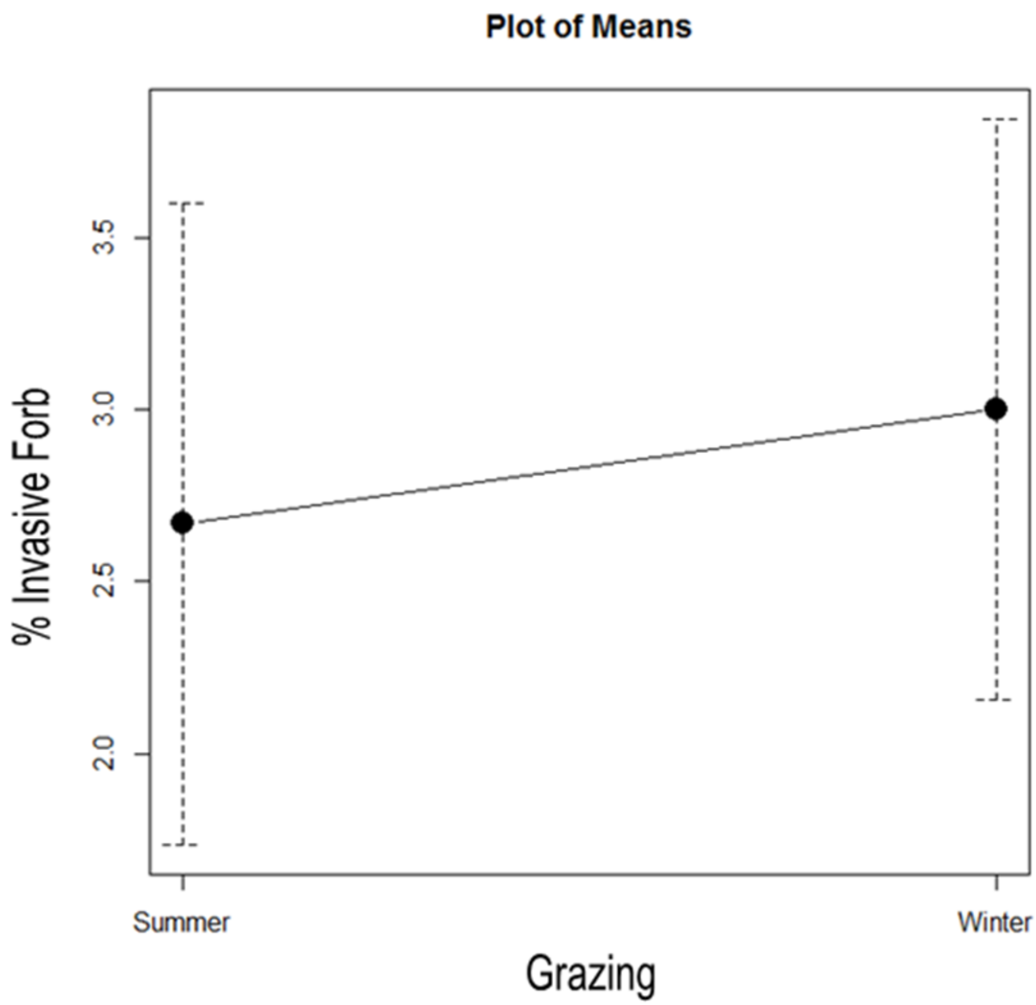

Figure 13: T-test comparing percent invasive forb cover between summer and winter grazed sites p= .60

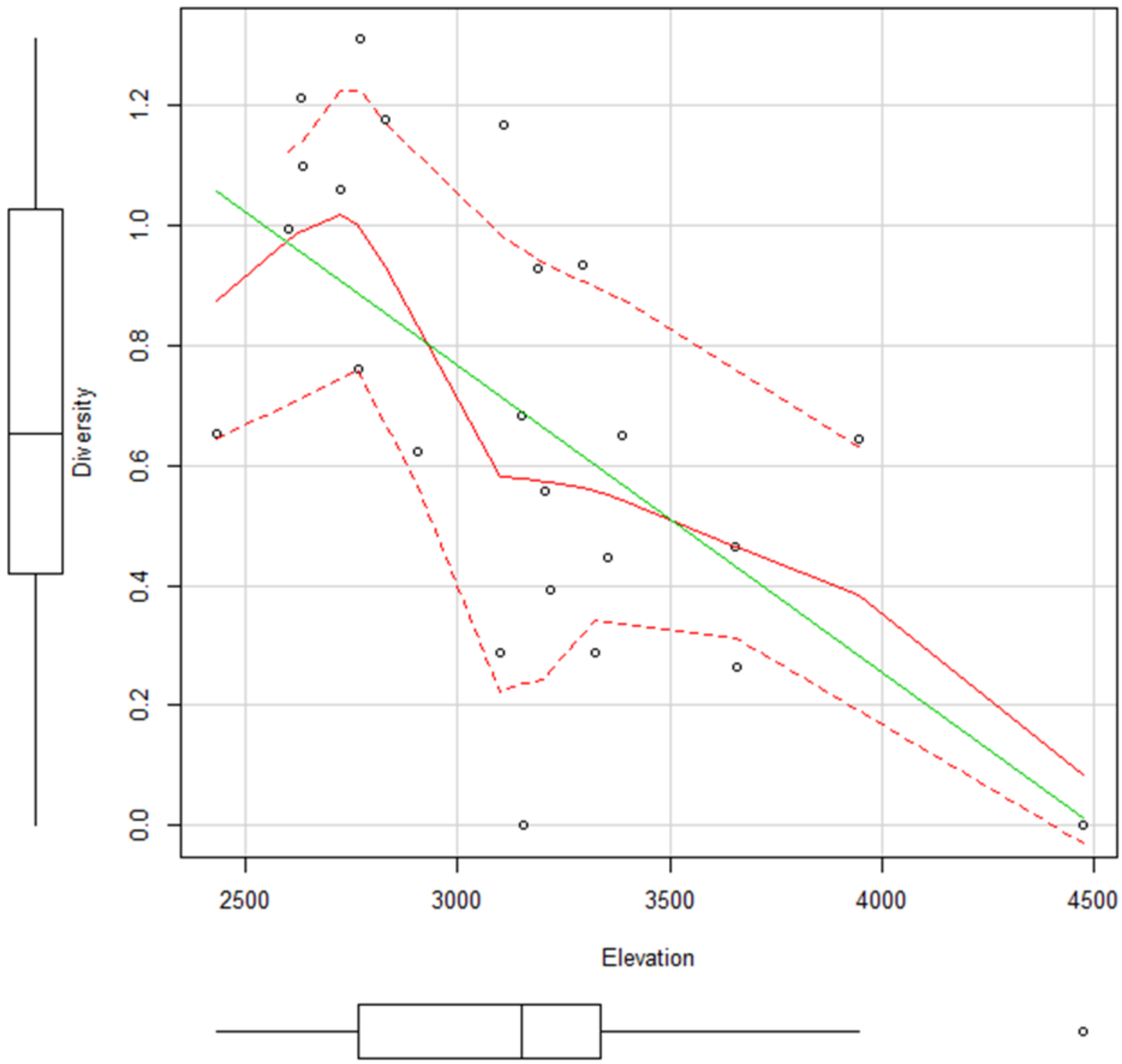

Figure 14: Regression comparing elevation to butterfly diversity p= .001

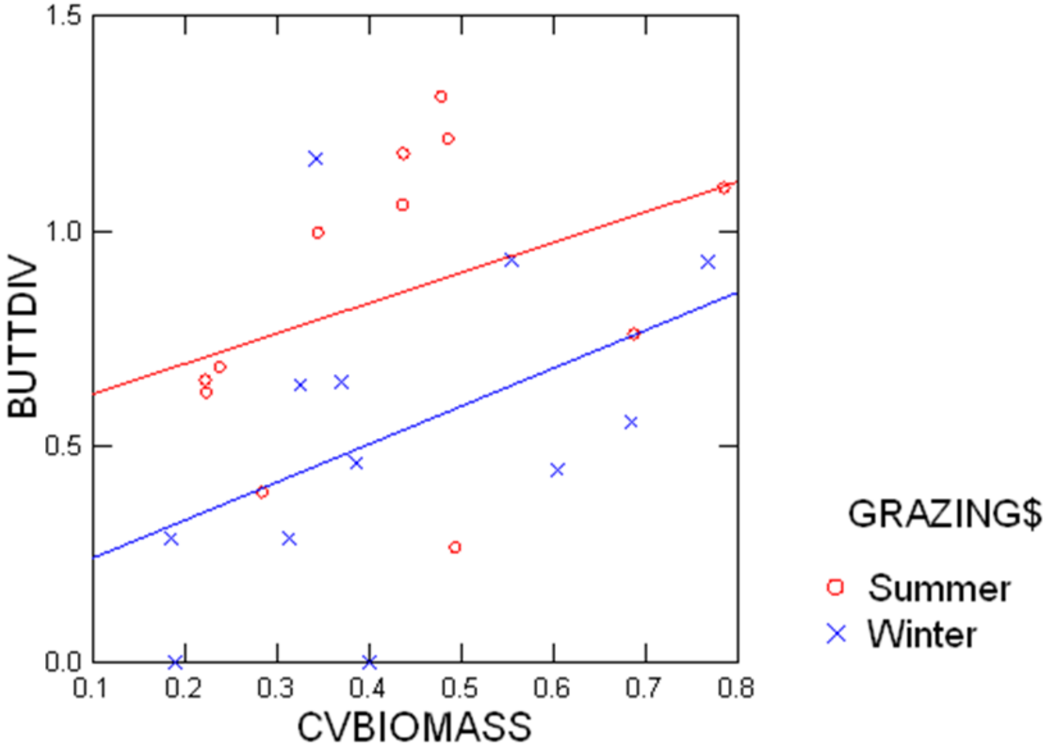

Figure 15: ANCOVA comparing coefficient of variation of biomass and butterfly diversity between summer and winter grazed transects p= .049

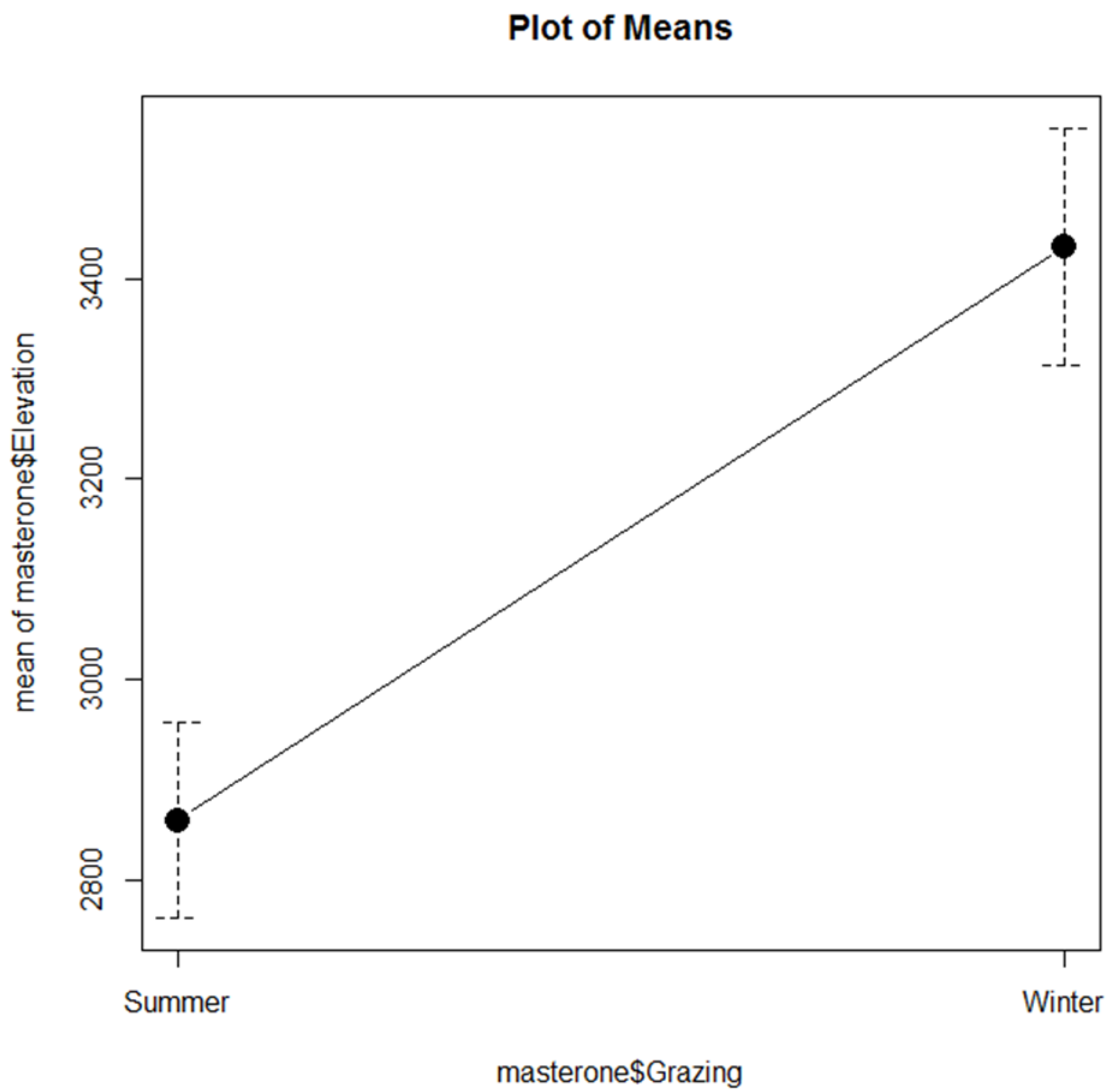

Figure 16: T-test comparing elevation between the two types of transects p=.001

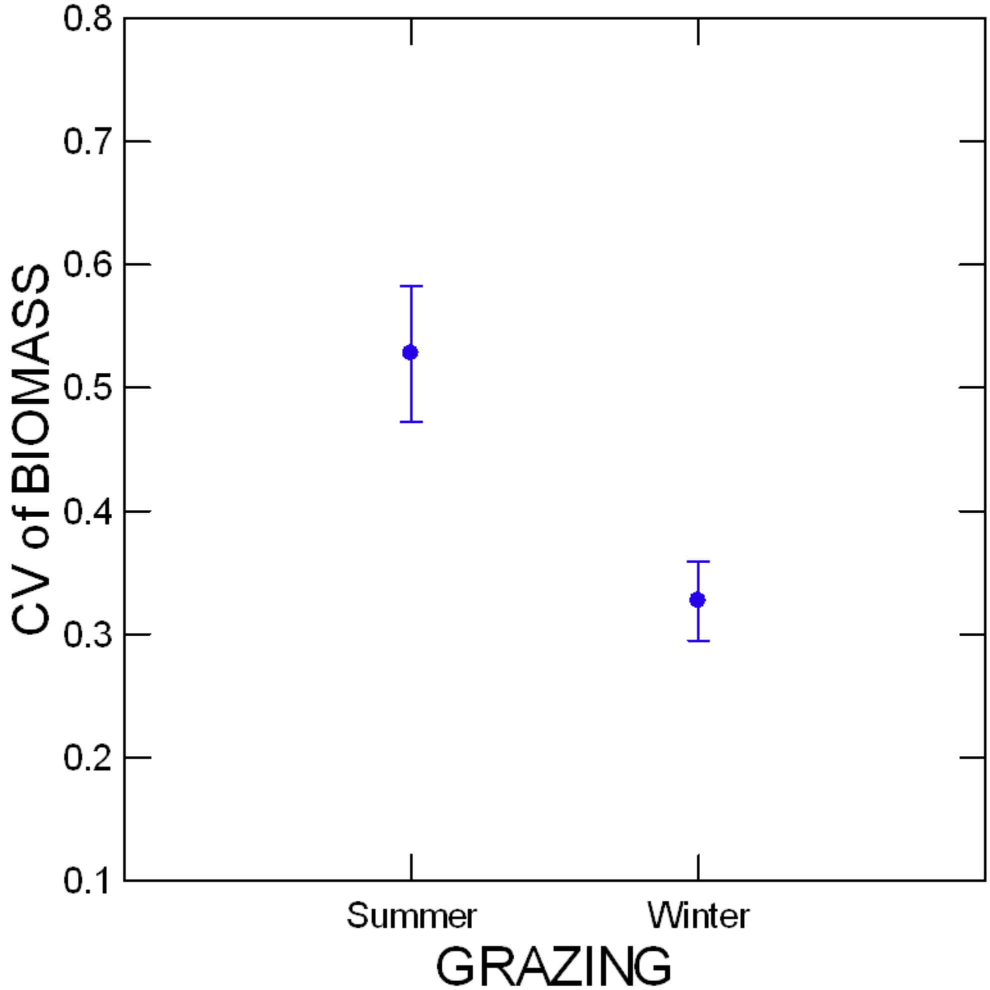

Figure 17: Results of two-sample t-test showing Coefficient of Variation of biomass between summer and winter-grazed plots p=.004