Grazing Effects on *Lepidoptera* in the Sinlahekin Valley, WA

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Abstract

Grazing is a widespread anthropogenic influence in Western North America with effects on biodiversity that vary with region, ecosystem, and site-specific history. These effects span trophic levels, directly affecting plant communities and indirectly affecting herbivores and pollinators. Pollinators, specifically butterflies, are important indications due to their high responsiveness to disturbance and obligate relationships with larval foodplants. We sampled butterfly species richness and abundance along with dominance of vegetation and presence of larval foodplants in adjacent grazed and ungrazed fields in the Sinlahekin Wildlife Area. These data show higher species richness and abundance of butterflies in our grazed field. Additionally, we found a significant correlation between the abundance of butterflies in the Blues family and the dominance of Lupine.

Keywords

Grazing; Lepidoptera; Foodplants; Disturbance; Pollinators

Introduction

Grazing is a widespread anthropogenic influence in Western North American ecosystems (Wagner, 1978). Grazing effects are variable by region and ecosystem. While the grasslands east of the Rocky Mountains may be adapted to grazing by Bison, prairie and shrubsteppe systems in the intermountain west may have historically contained fewer wild grazing ungulates than today (Mack et al. 1982). Grazing by domesticated ungulates has direct effects on vegetation and indirect effects across trophic levels. A metanalysis of livestock grazer exclusion studies showed significant increases in diversity of invertebrate herbivores and pollinators as a result of exclusion (Filazzola et al., 2020). Grazing can also promote the growth of grasses over forbs, and invertebrates like butterflies (*Lepidoptera*) rely on specific forbs (larval foodplants) to reproduce (Stahlheber & D'Antonio 2013; Talle et al. 2016).

Butterflies are a valuable indicator species because of their sensitivity to disturbance and species richness has been demonstrated to respond directly to habitat fragmentation (Debinski and Holt, 2000, Summerville and Crist, 2001). Several studies of grazed and abandoned pastures have found that species richness and abundance were best predicted by grazing history, with richness and total abundance being highest in abandoned pastures (Pöyry et al., 2004, Smith & Cherry, 2014). The recent presence of grazing has been shown to favor disturbance tolerant species and reduce the abundance of habitat specialists that rely on specific host plants (usually forbs) and nectar resources (Debinski and Holt, 2000, Smith & Cherry, 2014a). Common species of butterfly may show little to no response to habitat fragmentation, while rare species are found in less abundance due to their sensitivity to host plant quality and availability of specific oviposition sites (Summerville and Moranz).

Here, we examine butterfly communities in grazed and ungrazed fields in the Sinlahekin Wildlife area (SWA), the oldest wildlife area in Washington State, (established in 1923 by the WDFW). The SWA allows domestic grazing in some areas and not others. This scenario represents a natural experiment to test the effects of grazing on a western semi-native grassland. We carried out a natural field experiment, sampling plant and butterfly populations in adjacent grazed and ungrazed fields in a nearby location. We then re-analyzed previously unpublished data from a similar study (Handy et al. 2018, *unpublished*) in a similar location in the SWA in 2018. We expected to find that grazed areas would contain different plant species, fewer host plants, and therefore fewer butterflies.

Study Site

We selected adjacent grazed and ungrazed sites by Forde Lake (coordinates for cattle gate between sites: 48.733629, -119.665127, see Figure 2). The average annual temperature is 8.1 C, with an average winter temp of –0.3 C and average summer temp of 18.9 C. This site receives an average annual precipitation of 3 cm per month, with 1.7 cm mo^{-1} in summer and 3.3 cm mo^{-1} during winter (Northwest Alliance for Computational Science & Engineering, 2023). Our ungrazed site has a Kartar ashy sandy loam soil type, and our grazed site has a Sinlahekin-Peka-Hodgson association soil type (United States Department of Agriculture, 2023). Satellite images from Google Earth, taken in 1995, revealed after the sampling occurred that a majority of the ungrazed field had been tilled. Visual evidence of this tilling disappears by 2017 (see Figure 1). The grazed field receives grazing on a three year rotation with other fields in the area and was grazed for two weeks in 2023. Both the fields were burned in 2013 (Personal Communication, Nathan Wehmeyer 2023).

Figure 1. Grazed and ungrazed fields in 1995, 2006, and 2017 showing evidence of tilling in 1995 that disappears by 2017 (Google Earth Pro, accessed 2023).

Figure 2. Grazed and ungrazed fields showing locations of grazed and ungrazed transects in green and coordinates of of cattle gate in purple (Google Earth Pro, accessed 2023).

Field Methods

Butterfly abundance and species richness were sampled using approximately 100m long zig zag transects: 10 transects in the grazed and ungrazed areas for a total of 20 (Figure 2). Transects were established using a combination of Gaia GPS and physical meter tapes. Actual lengths ranged from 96 meters to 113 with the total transect length in the grazed field being 4% less than in the ungrazed. Transect starting points were randomly chosen using the second hand of a timer to determine strides between transects. Each transect was set a minimum of 10 meters apart and a maximum of 60 meters apart. Transects in the grazed and ungrazed fields were sampled simultaneously by two groups of two researchers to control for weather related changes in butterfly activity. Each group completed surveys in both grazed and ungrazed fields to eliminate group effect as a variable. During the transect survey, two individuals walked the transect in a zigzag pattern, going 5 meters in either direction from the center of the transect (10m span). Butterflies were either identified

visually or were caught with bug nets, transferred to jars, and identified using Butterflies of the Sinlahekin Wildlife Area by Caitlin Labar (LaBar, 2015) before being released. When butterflies could not be identified to species level they were identified to family.

Dominant vegetation was determined using point-line transects with 1m increments along a meter tape, using the same start and end point as the butterfly transects. Vegetation was identified at each point increment with emphasis on flowering plants for their relevance to butterfly activity. Grasses were lumped into short stature and tall stature categories. Fescue (*Festuca idahoensis*; a conspicuous bunchgrass) was given its own category.

Foodplant information for butterflies was found in a Washington State Butterfly Checklist and foodplants that appeared in the vegetation transects were noted for further analysis (Pelham et al., 2023).

Statistical Methods

We compared average butterfly species richness and abundance per transect in grazed and ungrazed areas. When calculating species richness, a butterfly identified to only family was not considered a unique species if a butterfly of that family was already identified to species in the same transect. For example, if an unidentified *Polyomattinae* and an *Plebejus acmon* were recorded in the same transect that was considered a species richness of one. If only unidentified blues were recorded in a transect, that was also considered a species richness of one. Average species richness and abundance of the grazed and ungrazed transects were compared using a two tailed t-test. Average abundance per species were individually compared using two tailed t-tests as well.

For vegetation, percent cover for each species was calculated using the following formula: *# of point-line intercepts of species/# of meters in transect,* and then averaged across the grazed and ungrazed samples. These averages (per species) were compared using two tailed t-tests to determine if differences were significant. Frequency was determined with the following equation: *# of transects in which species was present/# of transects in plot*.

To determine correlation between specific butterfly species and specific foodplants, percent cover of a given food plant was plotted against species abundance for each transect and a regression test was used to determine R^2 and p values. All statistical analysis was conducted in Microsoft Excel *Version 16.80*.

Results

The grazed field had a significantly higher average lepidopteran species richness (7.4 species per transect) than the ungrazed field (5.1 species per transect; p < 0.01; Figure 3A). The grazed field also had significantly higher abundance (30.5 counts) than the ungrazed
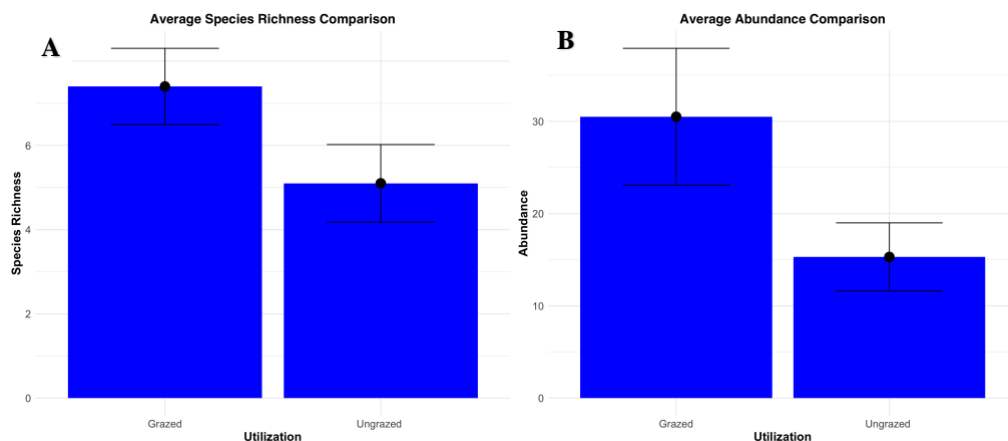
field (15.3 counts; $p < 0.01$; Figure 3B).

Figure 3. Mean species richness and abundance for all transects compared between grazing histories. Error bars show 1 SE from the means.

Overall species composition also differed slightly between the ungrazed and grazed fields, with *Limenitus lorquini* being detected only in the ungrazed field and the *Celastrina echo*, *Plebejus melissa*, and *Erynnis persius* being detected only in the grazed field.

Table 1. Complete list of butterfly species separated by grazing history.

Ungrazed	Grazed
Glaucopsyche lygdamus	Glaucopsyche lygdamus
Plebejus icarioides	Plebejus icarioides
Glaucopsyche piasus	Glaucopsyche piasus
Plebejus acmon	Plebejus acmon
Euchloe ausonides	Euchloe ausonides
Colias interior	Colias interior
Colias philodice	Colias philodice
Erynnis persius	Erynnis persius
Papilio glaucus	Papilio glaucus
Papilio zelicaon	Papilio zelicaon
Limenitus lorquini	Limenitus lorquini
Coenonympha tullia	Coenonympha tullia
Lycaena helloides	Lycaena helloides
	Plebejus melissa

The most abundant species group in the grazed transects was *Polyomattinae*, and the most abundant butterfly identified beyond family was the *Coenonympha tullia*. Average abundances per species in the grazed and ungrazed fields was significantly higher for *Plebejus icarioides*, *Glaucopsyche lygdamus*, *Plebejus melissa*, and *Plebejus acmon* ($p < 0.05$; Figure 4). Six species of butterfly were detected only in the grazed field: *Colias philodice*, *Colias interior*, *Erynnis persius*, *Celastrina echo*, and black unknown. Two species were detected only in the ungrazed field: *Limenitus lorquini* and red unknown. These differences were not statistically significant ($p > 0.05$) and represent one or two

specimens only in each case. While there were more *C. tullia* detected in the ungrazed field, this difference is also not statistically significant ($p > 0.05$; Figure 4).
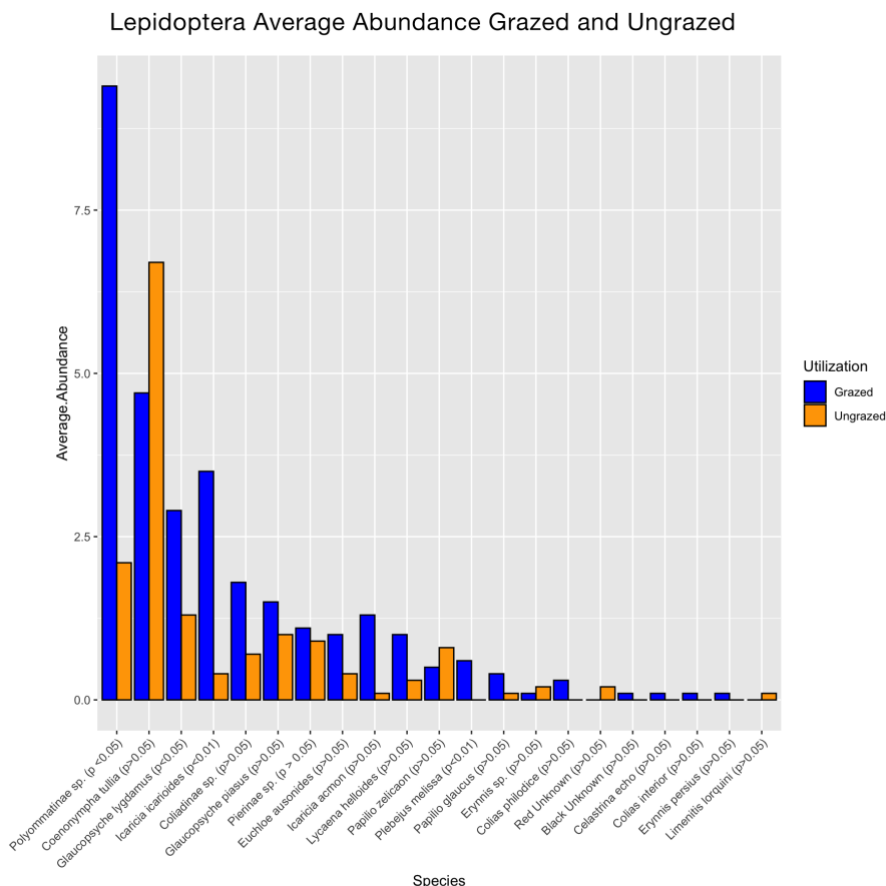

Figure 4. Average abundances of each butterfly species in grazed and ungrazed fields with p values in parentheses.

Vegetation Results

The average percent cover of dominant vegetation ($> 1\%$ cover) differed between grazed and ungrazed fields both in species and in percent cover. Both areas were dominated by short stature grass, *Festuca idahoensis*, *Phacelia* sp., *Achillea millefolium*, *Artemisia* sp., *Tragopogon* sp., and *Taraxacum officinale*. Average percent cover of short stature grass and *F. idahoensis* was significantly larger in the grazed field (73% short stature grass in the grazed field vs. 44% in the ungrazed field and 35% *F. idahoensis* in the grazed field vs 6% in the ungrazed field; $p < 0.01$ in both cases; Figure 5). The ungrazed field was dominated by tall stature grass (25%) compared to less than 1% in the grazed field. The grazed field was dominated by *Lupinus* sp. (15%) compared to less than 1% in the ungrazed field.
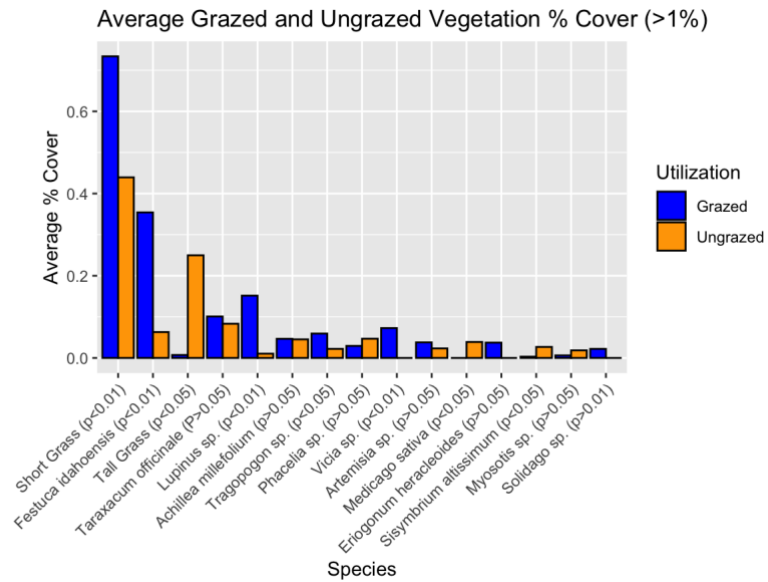
Figure 5. Average percent cover of each plant species with a percent cover value over 1% compared between grazed and ungrazed fields. Parentheses in axis label show p values.

Examination of vegetation frequency (Figure 6) revealed differences in the presence of nondominant species (<1% average cover) between grazed and ungrazed fields. Vetch (*Vicia*), Nodding Onion (*Allium* sp.), wild buckwheat (*Eriogonum heracleoides*), goldenrod (*Solidago* sp.), desert parsley (*Lomatium* sp.), rosemary (*Salvia sp.*), arrowleaf balsamroot (*Balsamorhiza sagittata*), and serviceberry (*Amelanchier alnifolia*) were recorded in the grazed field but not the ungrazed field. Hounds tongue (*Cyanoglossum* sp.), horsetail (*Equisetum* sp.), *Buglossoides* sp., and alfalfa (*Medicago sativa*) were recorded in the ungrazed field but not the grazed field.
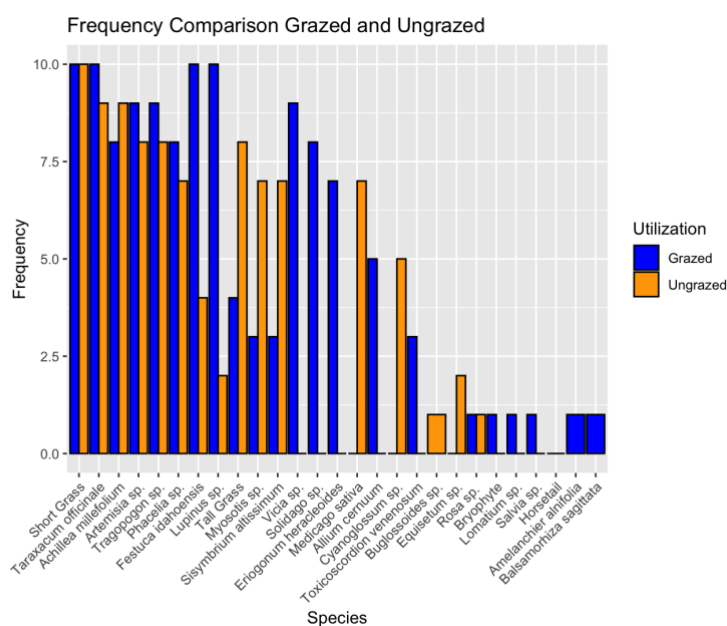
Figure 6. Frequency of each species in grazed and ungrazed fields.

Foodplant Results

Six foodplants of our identified butterfly species were detected by our vegetation surveys. Butterflies in the blues family (*Polyommatinae*) use *Lupinus* sp. as a foodplant. *Plebejus acmon* in particular use *Vicia* sp. as a foodplant, and this plant taxa was recorded in our surveys. *Euchloe ausonides* use *Sisymbrium altissimum* as a foodplant. *Colias philodice* use *Medicago sativa* as a foodplant. *Papilio zelicaon* use *Lomatium* sp. as a foodplant. *Coenonympha tullia* use *Festuca sp.* and *Bromus* sp. as foodplants (Pelham et al., 2023). While grasses were not identified beyond stature, analysis of grass samples taken from our site confirms the presence of *Bromus* sp. within the tall grass category.

Frequency and average % cover of foodplants in the grazed and ungrazed fields (Figure 7) indicate differences in distribution of foodplants. While *Lupinus* was recorded in both grazed and ungrazed fields, frequency and average % cover reveal a significantly higher % cover in the grazed field ($p < 0.01$), the same being true of *Festuca* species. *Sisymbrium* sp. was recorded in both fields but particularly average % cover reveals its presence to be very low ($p < 0.01$% cover) in the grazed field. *Lomatium* sp. and *Vicia* sp. were only recorded in the grazed field, while *Medicago sativa* was only recorded in the ungrazed field.
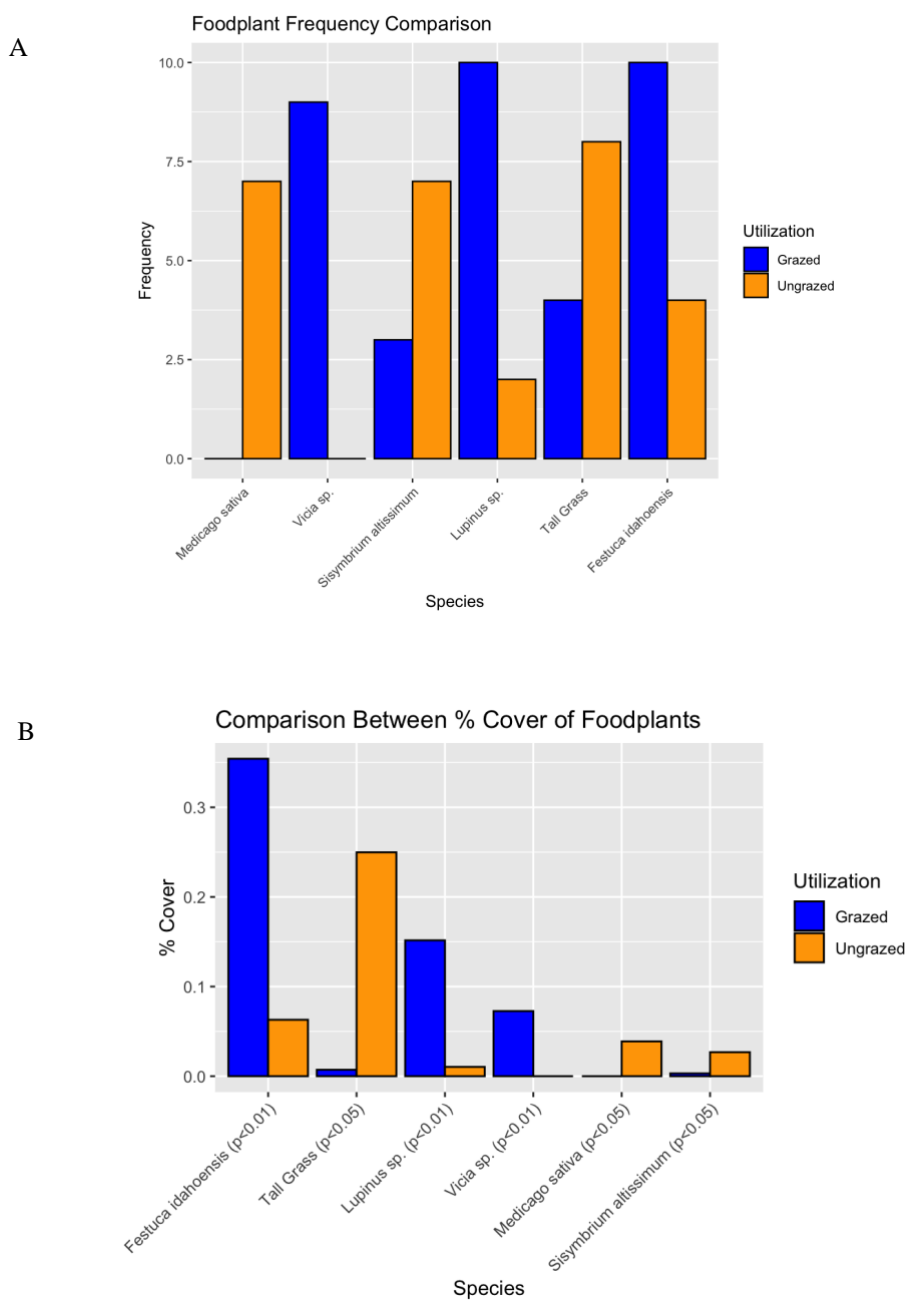
Figure 7. Average % cover (A) and frequency (B) of foodplants compared between grazed and ungrazed fields.

Relationship between Foodplants and Butterfly Species Abundance

Abundance of blues (*Polyommatinae*) showed a significant positive relationship with % cover of *Lupinus* sp. ($p < 0.01$; $R^2 = 0.58$; Figure 8).
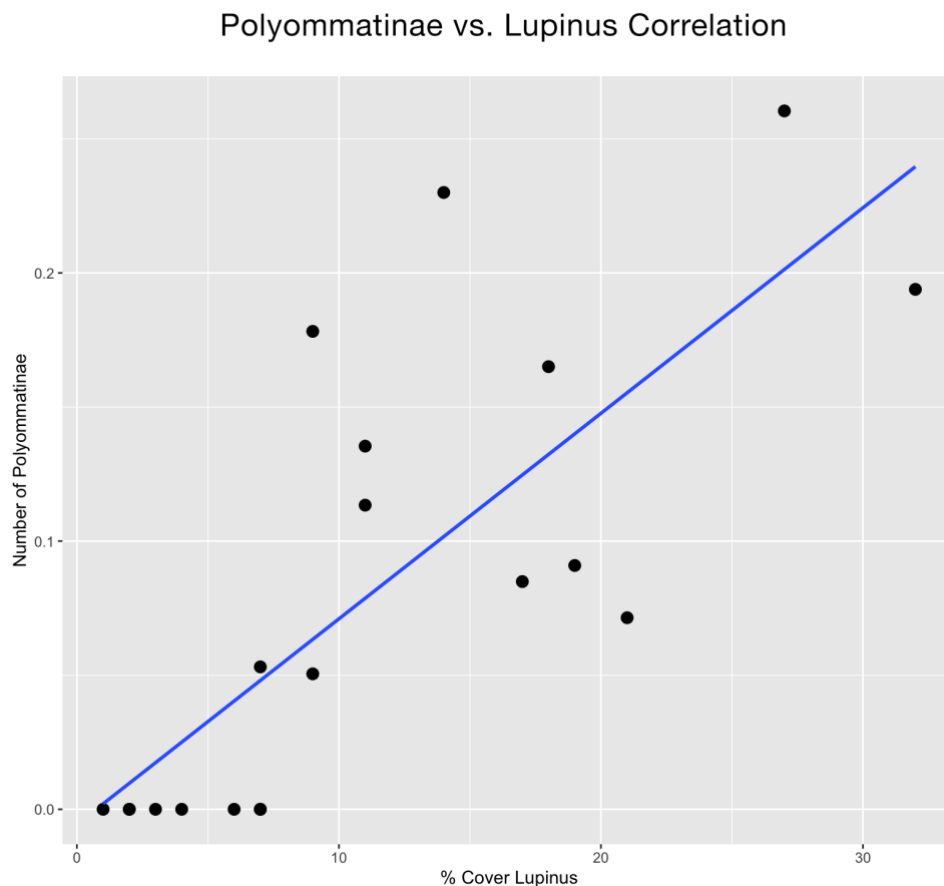

Figure 8. For all 20 transects, percent cover of Lupine and total number of butterflies detected in the Blues family showed a significant positive relationship ($R^2 = 0.58$, $p < 0.05$).

The other species of foodplants did not show significant positive relationships with their butterfly counterparts ($p > 0.05$).

Discussion

We hypothesized that butterfly species richness and abundance would be higher in the ungrazed field than the grazed field and that this would be supported by a greater abundance of foodplants in the ungrazed field, providing a mechanism for causation. However, both species richness and abundance were significantly higher in the grazed field. Additionally, of the seven larval foodplants we detected in our vegetation transects, two were detected

only in the grazed field while one was detected only in the ungrazed field. *Lupinus* sp., a host of butterflies in *Polyomattinae*, was significantly more abundant in the grazed field.

Our proposed mechanism that butterfly abundance would correlate with abundance of their host plants was supported by our data in the case of *Polyomattinae* and *Lupinus* sp. with significant correlation between abundance of *Polyomattinae* and percent cover of *Lupinus* sp. across the grazed and ungrazed fields. The other six foodplants did not show significant correlation with their butterfly counterparts, which may be due to insufficient data as many butterfly species were only caught once and our point line transect method for vegetation may have missed foodplants with a percent cover less than 1%.

Our results for species richness and abundance conflict with the results of previous unpublished research from 2018 examining Lepidoptera in this area, where, upon a reanalysis of original data (Handy et al. *unpublished data*; Field Ecology Program Archives, Evergreen State College), recorded significantly higher species richness in an ungrazed plot using a one tailed t-test ($p < 0.05$), with a low sample size ($n = 6$).

These conflicting results may be partially explained by our site selection. While we sampled the same grazed field as the prior unpublished study, we chose a single ungrazed field adjacent to a single grazed field (separated by a wire fence), on the assumption that it would be a better control due to proximity. Examination of our vegetation data and in situ observations indicate striking vegetation differences between our grazed and ungrazed fields that may not be the result of differences in grazing history. Our ungrazed field had a flatter grade, different soil type (Kartar ashy sandy loam in ungrazed vs. Sinlahekin-Peka-Hodgson association in grazed) and contained a higher proportion of tall grasses and horsetails that indicate a wetter microclimate. The images from 1995 indicating agricultural tilling (Figure 1) also support the possibility of differences beyond grazing history.

It is also possible that grazing has had a positive effect on butterfly species richness and abundance in this area. In some areas in the intermountain west, continued grazing with periods of rest can be used to manage invasives like cheatgrass (*Bromus tectorum*) particularly in combination with prescribed burning (Diamond et al. 2012). The dominance of invasives like Kentucky bluegrass (*Poa pratensis*) have been shown to negatively correlate with flowering forb diversity and obligate butterfly species richness/abundance (Kral-O'Brien et al., 2019). Short vegetation stature and heterogeneity of plant communities, on the other hand, has been shown to positively correlate with butterfly species richness and abundance (Berg et al., 2013). *Bromus* sp. were present in our tall stature grass category which had significantly higher percent cover in our ungrazed transects, indicating that grazing may have reduced the dominance of tall stature grasses and created a more heterogenous landscape. Intensity of grazing is an important variable in determining effects on the landscape, with lower intensities reducing negative effects

(Milchunas et al. 1998). The three-year grazing interval in our grazed site represents low intensity grazing.

Over-all, these data suggest the potential for interesting dynamics between grazing history and butterfly diversity that may yield non-intuitive results at this site. Future work that addresses relationships between specific butterfly species and larval foodplants will help further clarify these relationships. Differences between two rounds of sampling separated by more than eight years suggest soil type and moisture may also affect results.

Acknowledgments

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