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Avian Abundance with Relation to Coverage of Invasive Grassland Plant Species, Plant Structure, and Grazing Patterns

Abstract

Invasive plant species can greatly alter plant community composition and habitat quality. Habitat heterogeneity, by way of plant structure, biomass, and herbivore grazing, impacts the fauna of the area. This study examines the effects of these factors on grassland bird populations in western Montana. Twenty-four study sites were selected on the National Bison Range, half in summer bison grazed pastures, and half in winter-grazed pastures. Plant species, structure, and biomass was recorded along each 200m transect to determine plant community composition. Point count surveys of birds were conducted along the same transects. Plant diversity positively related to bird abundance, $R^2 = 0.351$, $F(1, 22) = 11.897$, $p = 0.002$, and ground nesting bird abundance, $R^2 = 0.276$, $F(1, 22) = 8.394$, $p=0.008$. Seasonal grazing had little impact on bird populations, and though bird populations as a whole were not related to invasive plants or plant structure, further break downs revealed the importance of habitat heterogeneity

The intentional and unintentional introduction of plant species into a community can greatly alter the dynamics and structure of the existing plant and animal diversity. Presence of non-native plants has been shown to decrease native plant abundance and community diversity (Davies 2011). In turn, altering existing plant community structure can impact animal species in many ways. Among avian species, invasive and non-native plant species can offer less shelter and food availability for nesting birds (Kuvlesky *et al.* 2006). Grassland bird diversity in Eastern Europe was negatively impacted by invasive goldenrod populations, where goldenrod presence indicated lower food availability and plant species richness (Skorka *et al.* 2010). Grasshopper sparrows and savannah sparrows accustomed to native plant structure were negatively impacted by the invasion of leafy spurge in the northern Great Plains (Scheiman *et al.* 2003). The importance of a diverse, native habitat has been widely documented with relation to the survival of grassland bird species (Scheiman *et al.*2003, Kuvlesky *et al.* 2006, Skorka *et al.* 2010).

Suitability of habitat influences the composition of bird species found in specific environments. Presence of invasive plants, as well as plant structure can impact bird populations (Rodewald and Yahner 2001). Specifically for ground nesting bird species, plant structure can influence reproductive success and survival (Winter *et al.* 2005). Clay-colored sparrows have been shown to have more nesting success with an increase of nest cover from surrounding vegetation (Winter *et al.* 2005). Grazing can influence plant community structure by the selection of palatable plants; many invasive plants are avoided by grazers and become noxious in the absence of competitors (Stastney *et al.* 2005). Invasive species such as cheatgrass (*Bromus tectorum*) can be effectively controlled by grazing, but only if grazing occurs early in the growing cycle (Hempy-Mayer and Pyke 2008). For this reason, grazing plays an important role in invasive plant populations and by way of the effect on plant community structure, grazing may also impact bird abundance and diversity.

This study will examine the effects of invasive grassland plant species on the abundance of avian species in both summer and winter bison-grazed regions of the National Bison Range. Due to past studies which have shown the impact of invasive plant species on bird populations, I hypothesize that avian abundance and diversity will be lower in areas where more invasive species are present. Secondarily, I will also examine if plant structure, grazing, and habitat heterogeneity affects avian diversity and abundance.

Materials and Methods

Sites

Sites were selected from within winter-grazed and summer-grazed regions on the National Bison Range (NBR), Dixon, Montana. Twelve sites were selected in both grazing areas, for a total of twenty-four sites, Figure 1. Sites were no less than 500 meters apart to prevent the overlap of bird territories and calls during the point count surveys. Within each site, 200 meter transects were established for point count surveys and vegetation surveys.

Point Count Surveys

Point count surveys were used to determine avian abundance along each 200 meter transect. Surveys were conducted within 4 hours of sunrise to eliminate bias in detection of calls. Point counts were conducted both by sight and sound while walking at a steady pace along the transect, with each point count lasting no longer than fifteen minutes. Each species observed was recorded, as well as the number of individuals present within each species. A summary of bird species encountered, including species identified as ground nesting, can be found in Table 1.

Vegetation

Vegetation surveys were conducted along all twenty-four of the point count survey transects. At every 5 meter interval on the 200 meter transect, the species and plant structure was recorded. This yielded a total of 40 data points for vegetation on each transect. The vegetation at each interval was determined by recording the species whose roots lay directly below the 5, 10, 15, etc. meter mark. All plant species encountered can be found in Table 2. For each plant, structure was classified as none, disperse, dense, bunch, clump, or bush. Definitions of each term can be found in Table 3. All native grasses were recorded into one category to simplify identification. Standing biomass was estimated every 25 meters using a Robel pole to visually determine vertical density of vegetation (Robel *et al.* 1970).

Statistical Analyses

Shannon Diversity Indexes [H' = - $\sum p_i \ln(p_i)$] were calculated for plant communities, bird communities, ground nesting bird communities, and structural composition for each transect. Coefficients of Variance (CV) were calculated for plant biomass and structure. T-tests were conducted to analyze the relationship between summer and winter-grazed sites with relation to bird diversity, elevation, invasive plant abundance, structural diversity, and many other variables. Regression analyses were carried out on bird abundance/diversity and vegetation data. Alpha was set at $p = 0.10$, due to small sample sizes and limited resampling.

Results

Site Characteristics and Vegetation

The effects of bison grazing on the NBR were seen in the differences between the twelve winter-grazed and twelve summer-grazed plots. The summer-grazed plots were all located at significantly lower elevations, $t(22) = -3.74$, $p = 0.0011$, than the winter-grazed sites, Graph 1.

Plant diversity did not differ between summer and winter-grazed sites, $t(22) = -0.046$, $p = 0.963$, Graph 2, or with elevation $R^2 = 0.056$, $F(1, 22) = 1.31$, $p = 0.264$.

Total invasive plant abundance did not differ significantly across seasonal grazing sites, $t(22) = 1.34$, $p = 0.194$, Graph 3, however, invasive grasses were more prevalent in summer-grazed plots, $t(22) = 2.36$, $p = 0.047$, Graph 4. Structural diversity did not vary between summer and winter-grazed sites, $t(22) = 0.46$, $p = 0.64$, and neither did average plant biomass, $t(22) = -0.59$, $p = 0.61$. However, the amount of biomass variation (CV of biomass) along a transect was greater in summer-grazed plots than in winter-grazed $t(22) = 3.29$, $p = 0.0033$, Graph 5.

Bird Diversity and Abundance

A principal component analysis (PCA) was completed on the vegetation data collected during the study. From the factor scores obtained from the PCA, a hierarchical cluster analysis was performed. The vegetative grouping categories obtained from the cluster analysis did not exhibit a clear relationship with bird populations across the study sites. Individual vegetation variables and physical characteristics were analyzed to determine the change in bird diversity and abundance across sites.

Bird diversity did not vary between winter and summer-grazed sites, $t(22) = 0.077$, $p = 0.939$, Graph 6. Although winter and summer-grazed sites varied based on multiple factors (CV of biomass, presence of invasive grasses, and elevation), these variables did not explain the variance of bird diversity across sites $R^2 = 0.11$, $F(3, 20) = 0.79$, $p = 0.51$. Bird diversity was not related to plant diversity $R^2 = 0.067$, $F(1, 22) = 1.59$, $p = 0.221$, Graph 7, or diversity of plant structure $R^2 = 0.008$, $F(1, 22)$, $p = 0.66$. However, the presence of invasive species did have a positive significant impact on bird diversity, $R^2 = 0.14$, $F(1, 22) = 3.45$, $p = 0.077$, Graph 8.

When examined separately, bird diversity in summer-grazed plots alone had a significant positive relationship with percent bunchgrass, $R^2 = 0.22$, $F(1, 10) = 2.85$, $p = 0.10$, Graph 9.

Similar to diversity, bird abundance did not vary between summer and winter plots, $t(22) = 1.31$, $p = 0.203$. Abundance was not correlated to abundance of invasive species, $R^2 = 0.039$, $F(1, 22)$, $p = 0.354$, or structure, $R^2 = 0.080$, $F(1,22) = 1.91$, $p = 0.18$. In contrast to bird diversity, bird abundance was positively correlated to plant diversity $R^2 = 0.351$, $F(1, 22) = 11.897$, $p = 0.002$, Graph 10.

Ground Nesting Bird Diversity and Abundance

Ground nesting bird populations were affected differently by vegetation and physical characteristics than the total population of birds. Ground nesting birds were more diverse, $t(22) = 2.83$, $p = 0.0096$, Graph 11, and abundant in summer-grazed plots $t(22) = 2.58$, $p = 0.017$. Ground nesting bird abundance was positively correlated to plant diversity $R^2 = 0.276$, $F(1, 22) = 8.394$, $p=0.008$, Graph 12, but neither ground nesting bird abundance, $R^2 = 0.080$, $F(1, 22) = 1.91$, $p = 0.18$, nor ground nesting bird diversity, $R^2 = 0.040$, $F(1, 22) = 0.093$, $p = 0.346$, responded to plant structure.

Discussion

Contrary to past studies on herbivore grazing, seasonal bison grazing had little impact on plant community composition and structure. Notable exceptions were the higher abundance of invasive grasses in summer-grazed plots. Crested wheatgrass (*Agropyron cristatum*) and cheatgrass (*Bromus tectorum*) are both invasive grasses that were present along the transects. However, crested wheatgrass was encountered only twice in vegetation surveys. In contrast, cheatgrass was found in seventeen of twenty-four plots, and all but one of the summer-grazed sites. Cheatgrass has been indicated as choice forage for mule deer in early spring and fall

(Austin *et al.* 1994). However, if these forage opportunities are missed, grazing may not occur and the invasive plant may continue to grow unhindered.

Although not much grazing occurred on the cheatgrass in summer-grazed plots, the influence of grazing did impact overall variation of biomass. Plant growth in summer-grazed regions is controlled largely by grazers, and selective foraging will alter plant heights and create variation in biomass. Additionally, among summer-grazed sites, bird diversity was positively related to percent bunchgrass. Although these plots were high in cheatgrass, the other available structure provided by plants seems to explain the higher diversity of birds with relation to invasive species. Where more invasive grasses were found, more bunchgrass was also present. The influence of structure on bird diversity is supported by past studies which indicate the importance of nesting structure and cover for grassland birds (Winter *et al.* 2005). Though differences did exist between the summer and winter-grazed sites, individual variables had a larger impact on total bird diversity than seasonal grazing patterns within the NBR.

While total bird diversity was impacted by invasive species, the variation among bird abundance was explained by plant diversity. In plots with higher plant diversity, total bird abundance was also higher. The greater plant diversity of these plots could indicate more varied nesting structure, food availability, and protection from predating. Any one of these factors could explain why bird abundance was higher in relation to plant diversity. This trend supports prior research that highlights the importance of plant community variation and diversity for grassland birds (Davies 2011).

Ground nesting birds differed from the larger population of grassland birds. Birds identified as ground nesting were more abundant in summer-grazed sites, where variation of biomass was higher. The variation of biomass could indicate a more productive habitat, more suitable for grassland birds. Ground nesting birds were also more abundant and diverse on transects with higher plant diversity, however, they showed no response to plant structure. Although past studies have highlighted the value of plant structure to grassland birds, plant diversity and habitat heterogeneity can also be an indicator of habitat health (Mooney 2011).

Conclusion

The impact of grazing on the National Bison Range is evident among the plant community. However, the variables impacting bird diversity and abundance have less relation to grazing than to plant diversity and heterogeneity of habitat. It is important to note the effects of habitat heterogeneity on grassland birds (Mooney 2011). These variables contribute to the overall diversity of the habitat, with regards to both flora and fauna. Though overall abundance of invasive species and plant structure did not impact bird populations as a whole, the change in density of invasives from year to year, and resulting structural changes, could have a significant impact on bird populations. It is important to continue to monitor the effects of environmental pressures on grassland bird populations, due to the loss of grassland habitat.

A sufficient number of study sites were used for this project, however, more intimate knowledge of grassland bird calls and plant species would have improved accuracy of this project. In the future, specific sites should be monitored year to year to see how changing plant structure, invasive plant density, seasonal grazing, and habitat heterogeneity impact site populations over time.

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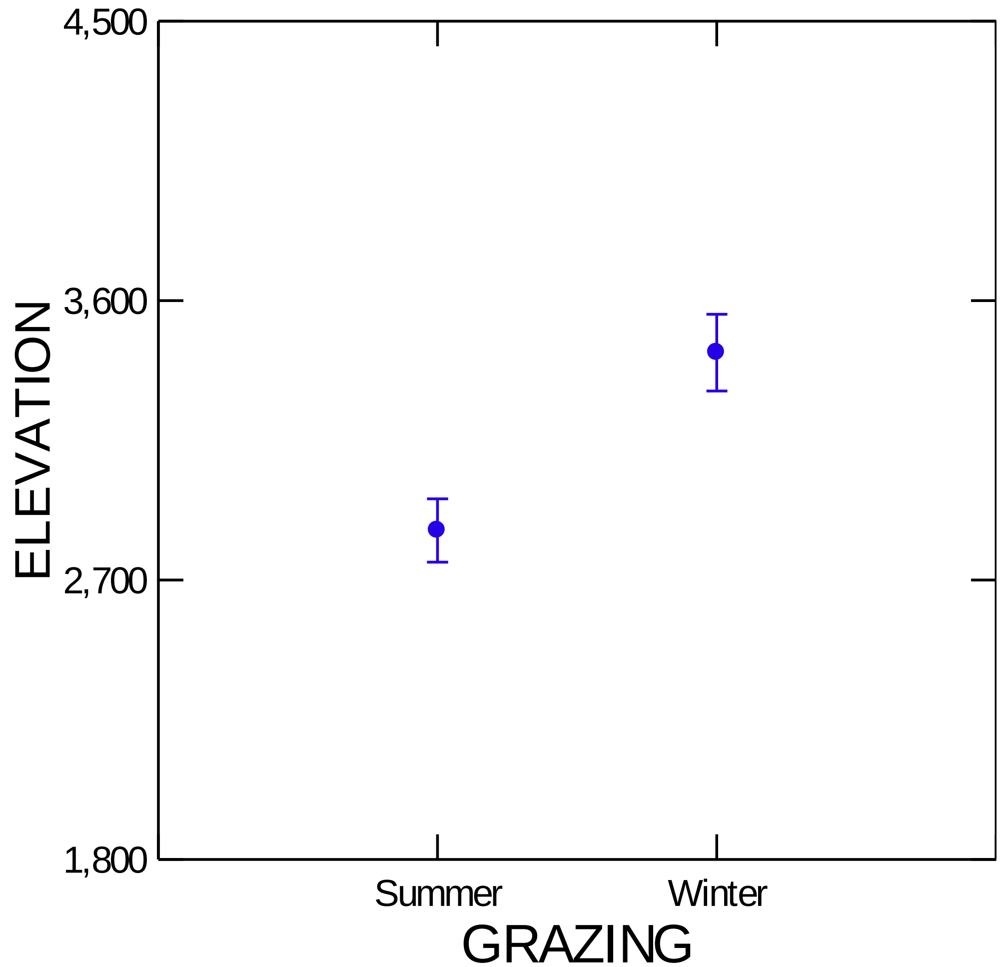
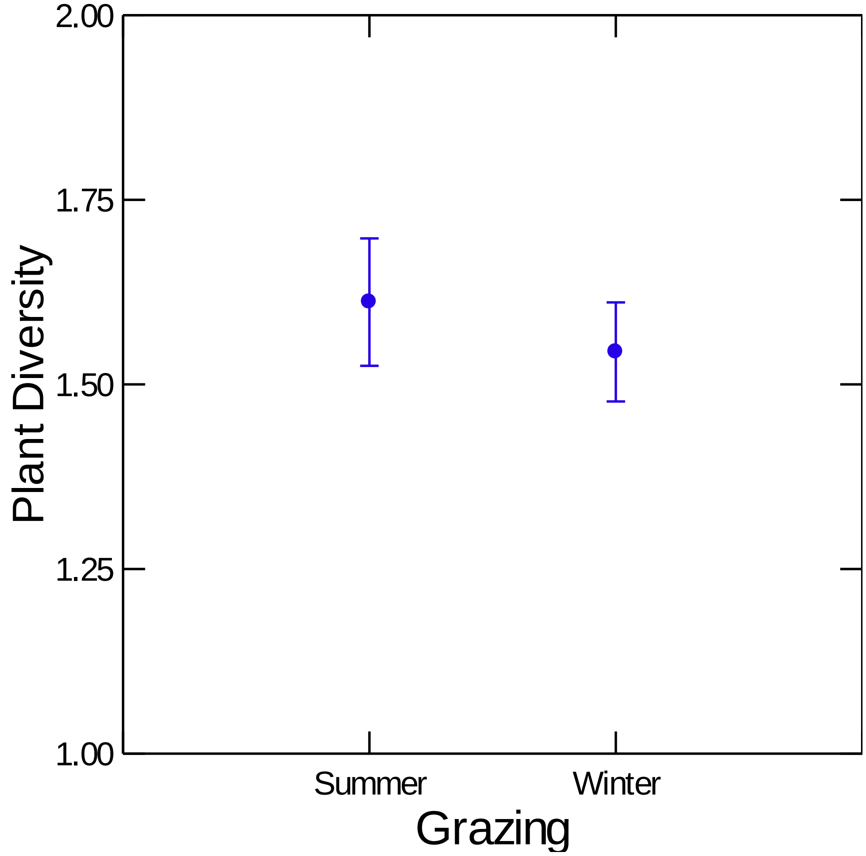
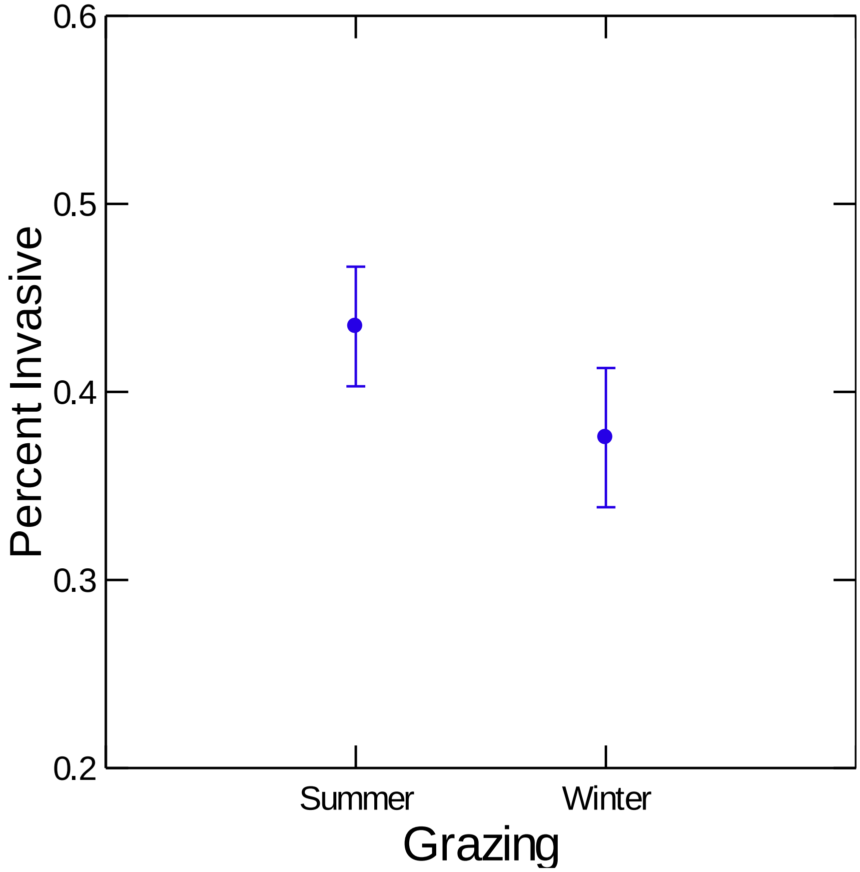


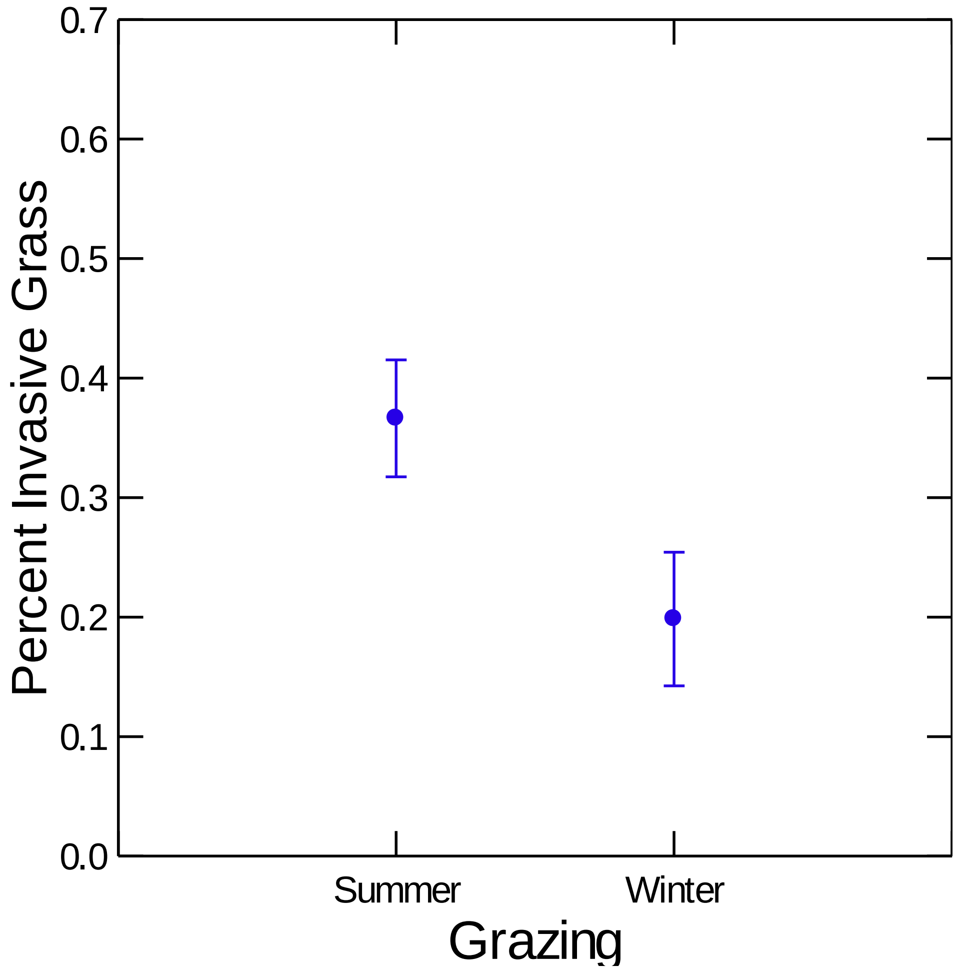
Graph 1. T-test of elevation between summer-grazed and winter-grazed plots; $t(22) = -3.74$ $p = 0.0011$



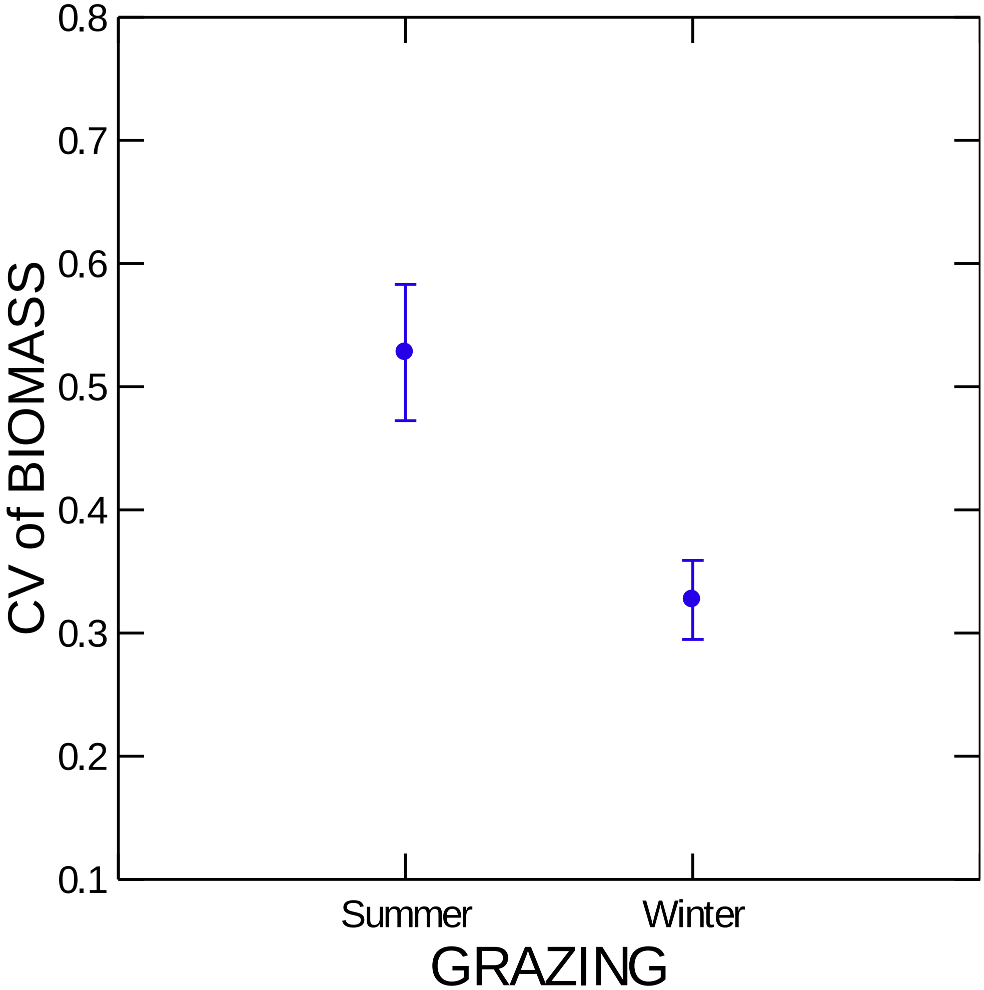
Graph 2. Results of two-sample t-test on plant diversity in summer-grazed and winter-grazed plots



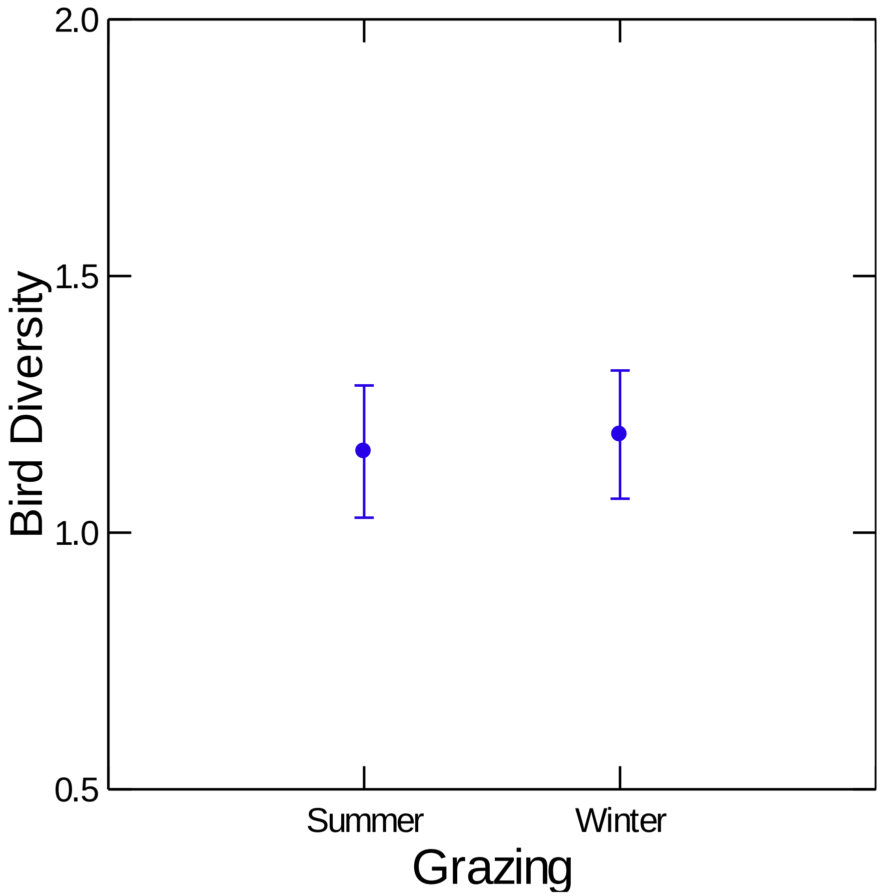
Graph 3. Results of two-sample t-test of percent invasive plants between summer and winter-grazed plots



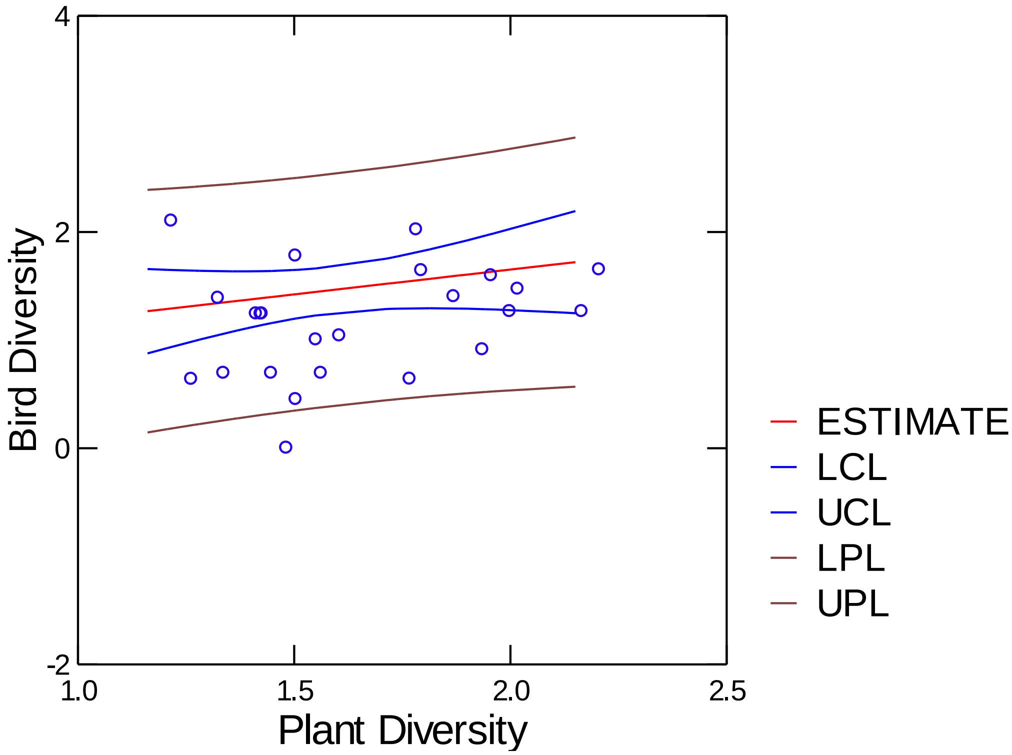
Graph 4. Results of two-sample t-test showing percent invasive grass between winter and summer-grazed sites



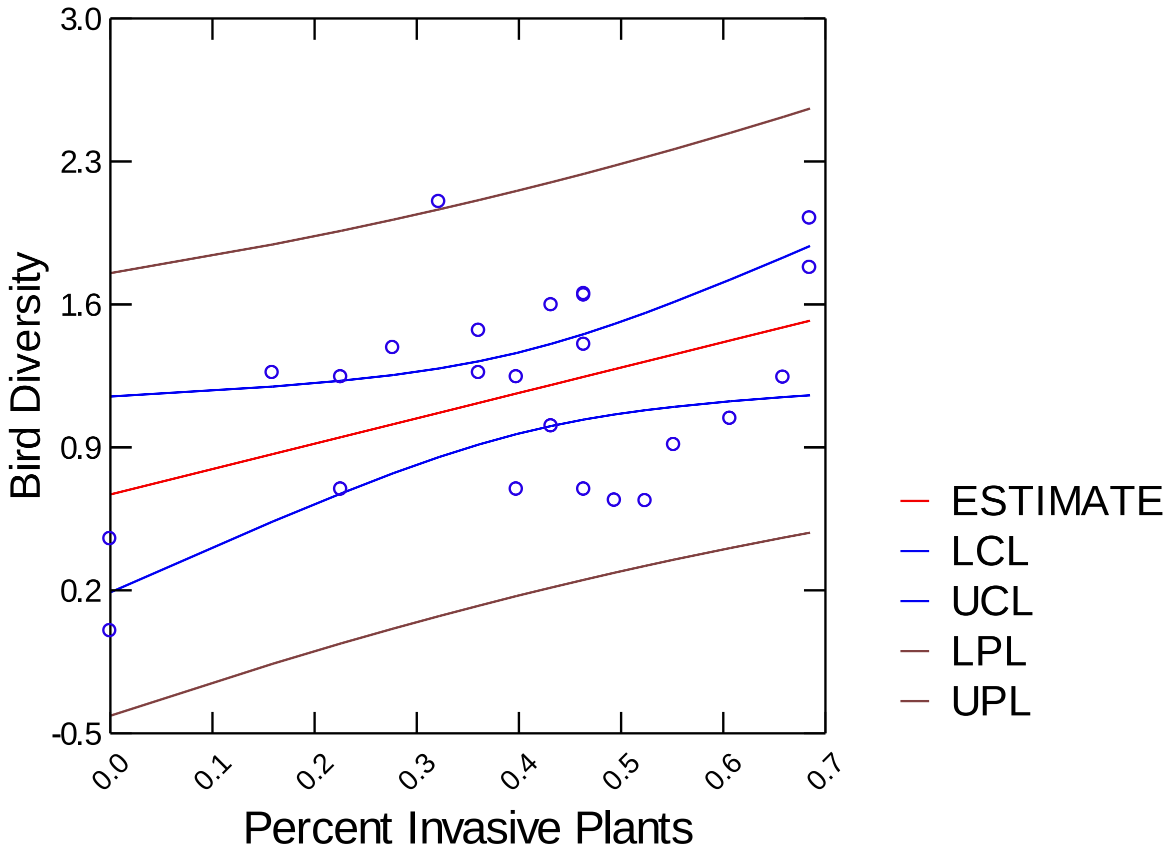
Graph 5. Results of two-sample t-test showing Coefficient of Variation of biomass between summer and winter-grazed plots



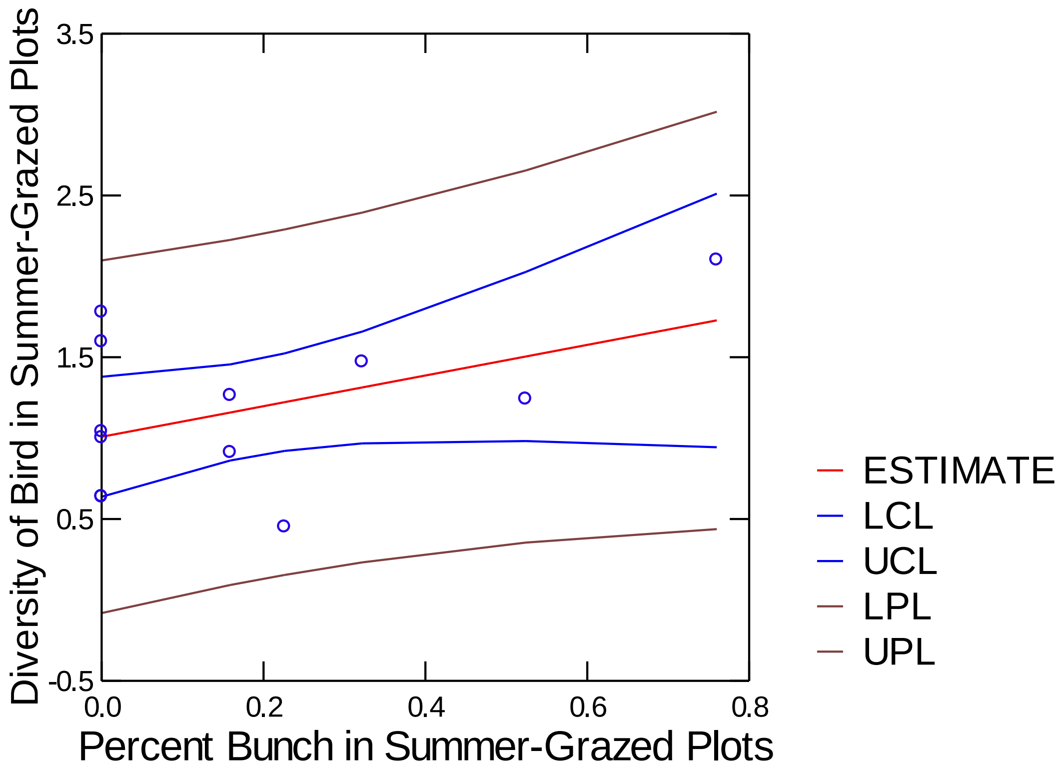
Graph 6. Results of two-sample t-test showing bird diversity in summer and winter-grazed plots



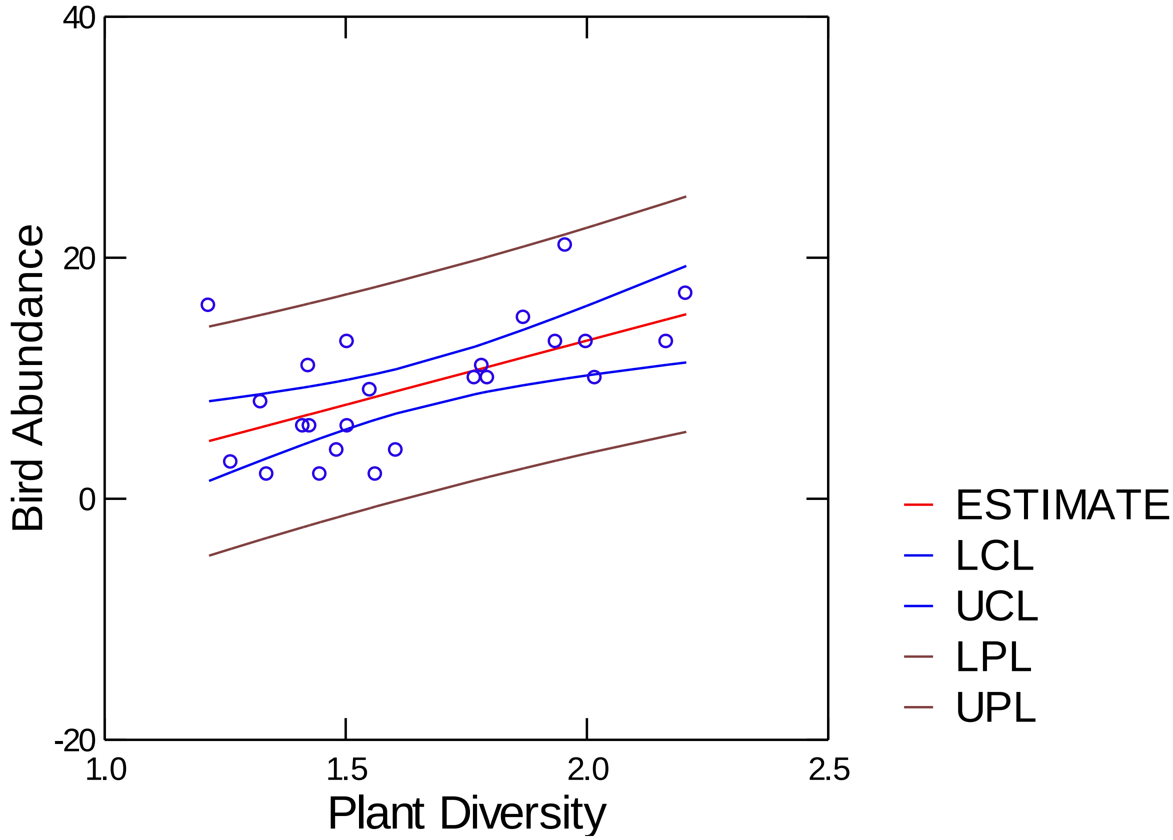
Graph 7. Results of regression of bird diversity with relation to plant diversity



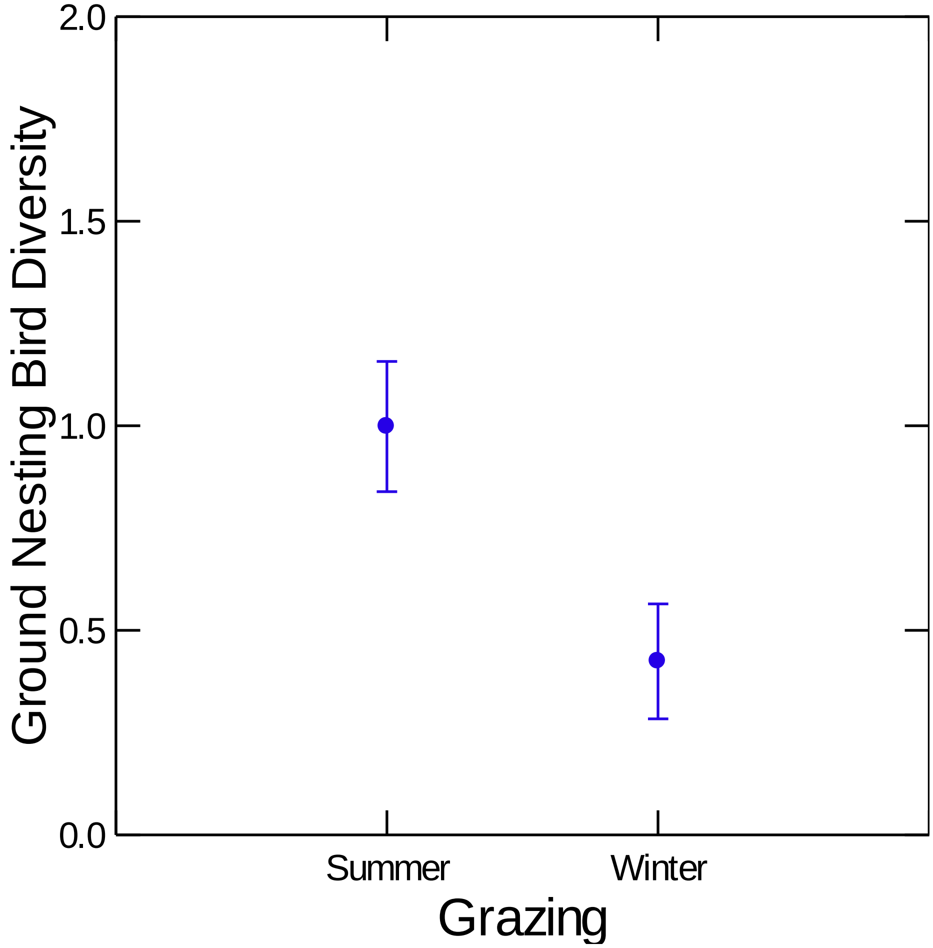
Graph 8. Results of regression comparing bird diversity to percent invasive plants



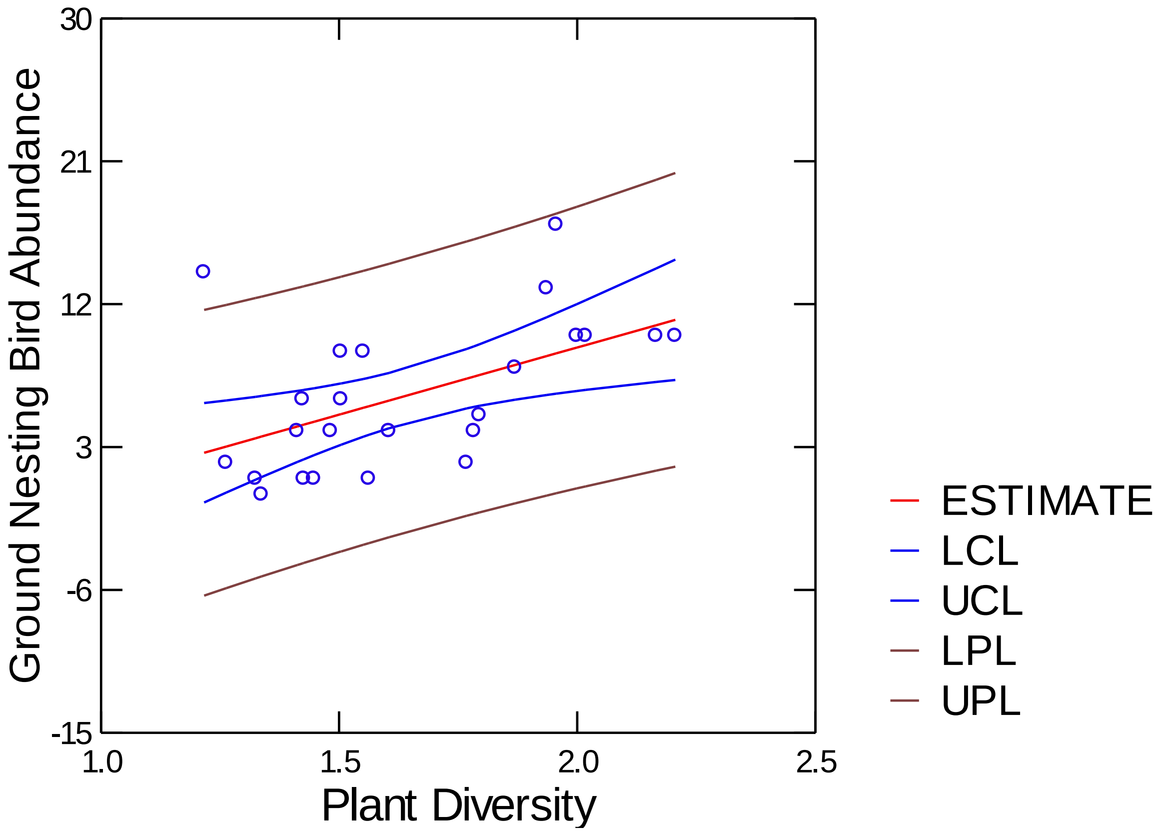
Graph 9. Results of regression of bird diversity in summer-grazed plots compared to percent bunch structure



Graph 10. Results of regression with bird abundance compared to plant diversity



Graph 11. Results of two-sample t-test comparing ground nesting bird diversity between summer and winter plots



Graph 12. Results of regression comparing ground nesting bird abundance compared to plant diversity

Table 1. Bird Species Observed with Ground Nesting Species Indicated

American Kestrel	
American Robin	
Black-billed Magpie	
Black-capped Chickadee	
Brewer's Blackbird	Ground Nesting
Cedar Waxwing	
Chipping Sparrow	Ground Nesting
Clark's Nutcracker	Ground Nesting
Clay Colored Sparrow	
Common Yellowthroat	
Eastern Kingbird	
Grasshopper Sparrow	Ground Nesting
Gray Catbird	
Grey Partridge	Ground Nesting
Killdeer	
Lark sparrow	Ground Nesting
Lazuli Bunting	
Red Tailed Hawk	
Red Winged Blackbird	
Ring-necked Pheasant	Ground Nesting
Short eared owl	
Song Sparrow	Ground Nesting
Spotted Towhee	
Swainson's Thrush	
Vesper Sparrow	Ground Nesting
Western Meadowlark	Ground Nesting

Table 2. Species and Common Names of Native and Invasive Species

Vicia americana	American Vetch	Native
Balsamorhiza sagittata	Arrowleaf Balsamroot	Native
Galium spp.	Bedstraw	Native
Astragalus crassicarpus	Buffalo Plum	Native
Cirsium arvense	Canada Thistle	Invasive
Bromus tectorum	Cheatgrass	Invasive
Achillea millefolium L.	Common Yarrow	Native
Agropyron cristatum	Crested Wheatgrass	Invasive
Linaria dalmatica	Dalmatian Toadflax	Invasive
Erigeron spp.	Fleabane spp.	Native
Heterotheca villosa	Hairy False Goldenaster	Native
Aster ericoides	Heath Aster	Native
Plantago patagonica	Indianwheat	Native
Lupinus spp.	Lupine	Native
	Native Grass	Native
Lepidium spp.	Pepperweed	Native
Potentilla gracilis	Slender Cinquefoil	Native
Potentilla recta	Sulphur Cinquefoil	Invasive
Sisymbrium altissimum L.	Tall Tumblemustard	Invasive
Orthocarpus tenuifolius	Thin-leaved Owl Clover	Native
Phaceliali linearis	Thread-leaf Scorpion Weed	Native
Arenaria serpyllifolia	Thyme-leaved Sandwort	Native
Collomia linearis	Tiny Trumpet	Native
Symphyotrichum ascendens	Western Aster	Native
Symphoricarpos occidentalis	Western Snowberry	Native
Lithospermum ruderale	Western Stoneseed	Native
Artemisia ludoviciana	White Sagebrush	Native
Rosa woodsii	Woods' Rose	Native
Rhinanthus minor	Yellow Rattle	Native
Tragopogon dubius	Yellow Salsify	Invasive

Table 3. Vegetation Structure Definitions

None	No upright structure
Disperse	Upright plants, bare ground/litter visible between individual plants
Dense	Plants upright, do not grow in bunchgrass pattern, but enough individuals are present to prevent bare ground from being visible
Bunch	Upright plant; several individual plants grow from the same root system, less than 1 foot in diameter (species grows in bunchgrass structure)
Clump	Single, upright plant large enough to cover a circle 1 foot in diameter
Bush	Similar to clump; woody plants large enough to cover a circle with a diameter of 2+ feet

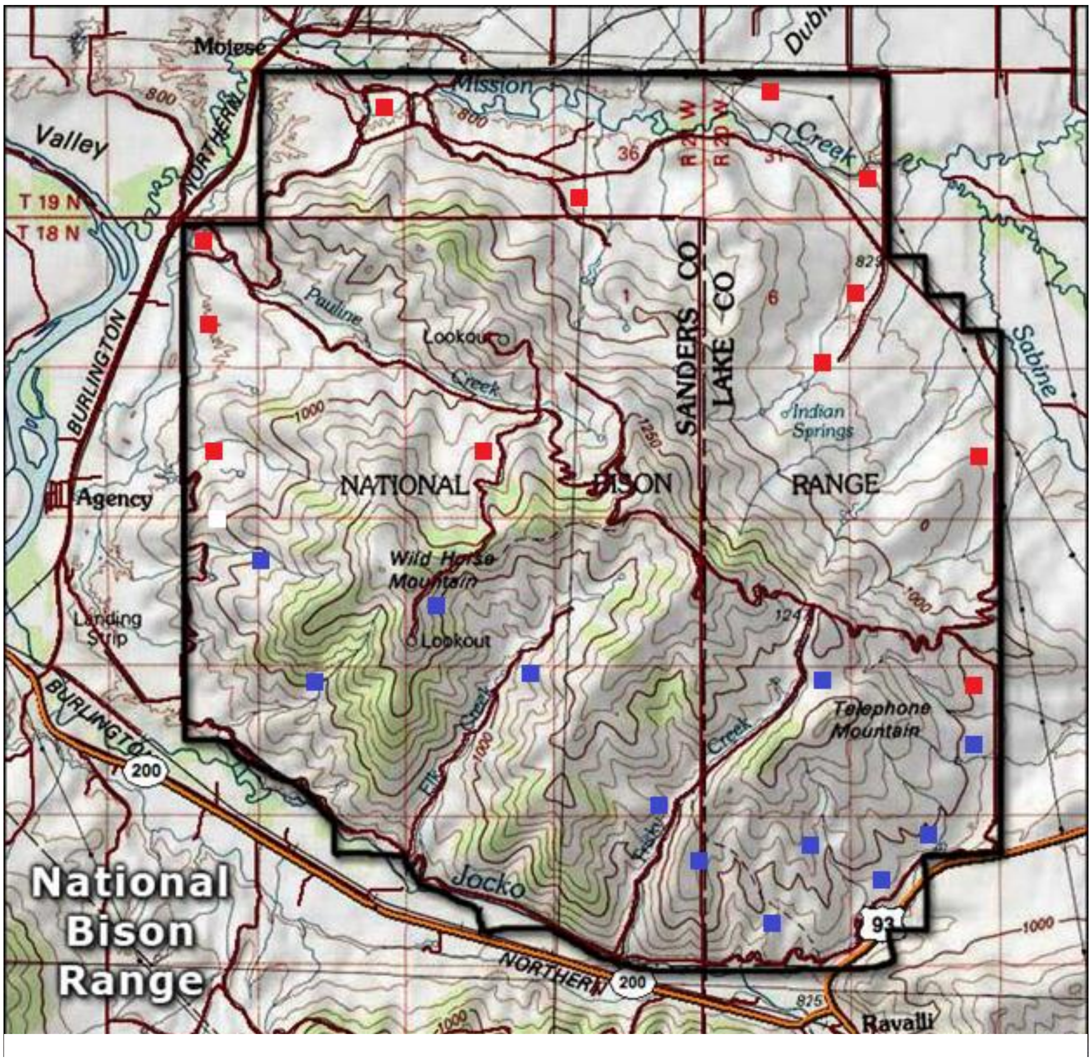


Figure 1. NBR Map with Winter-grazed Sites in Blue and Summer-grazed Sites in Red