Habitat Patch Size, Human Travel Corridors and the Spread of Invasive Range Plants in Eastern Montana

Rangeland community of Buffalo Creek Study Area (BLM), Powder River County, MT.

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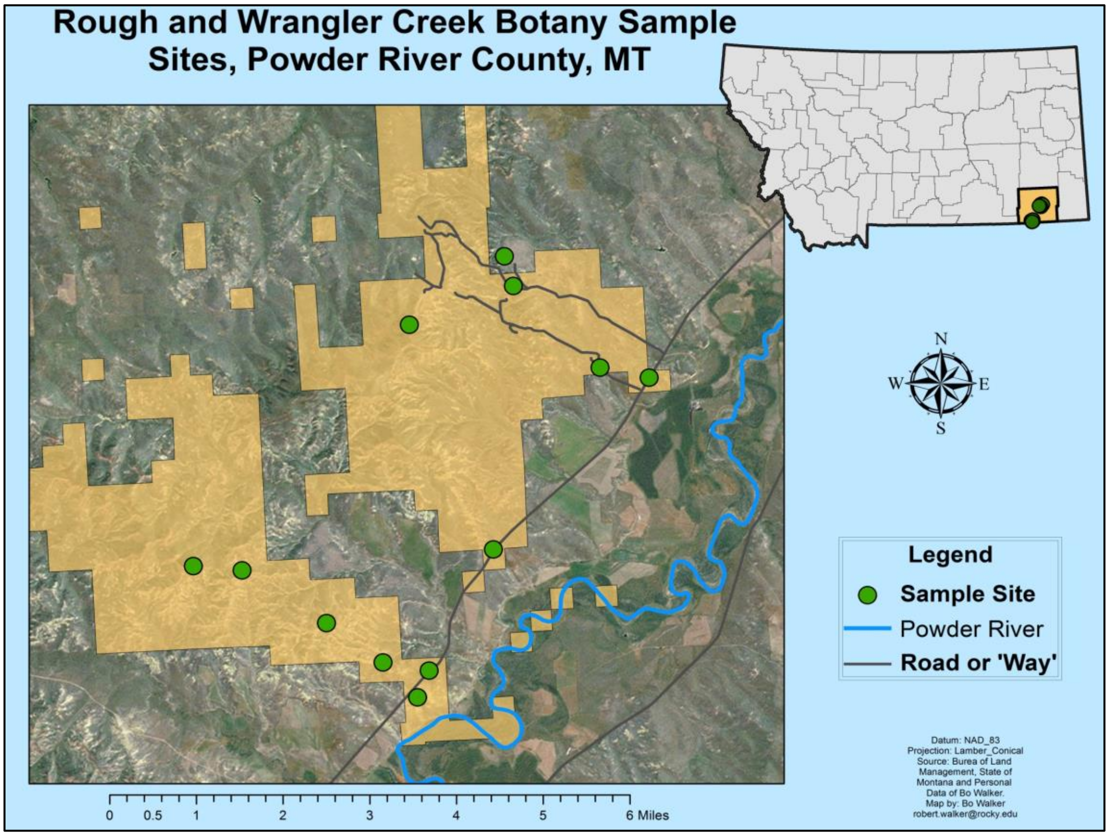
Introduction

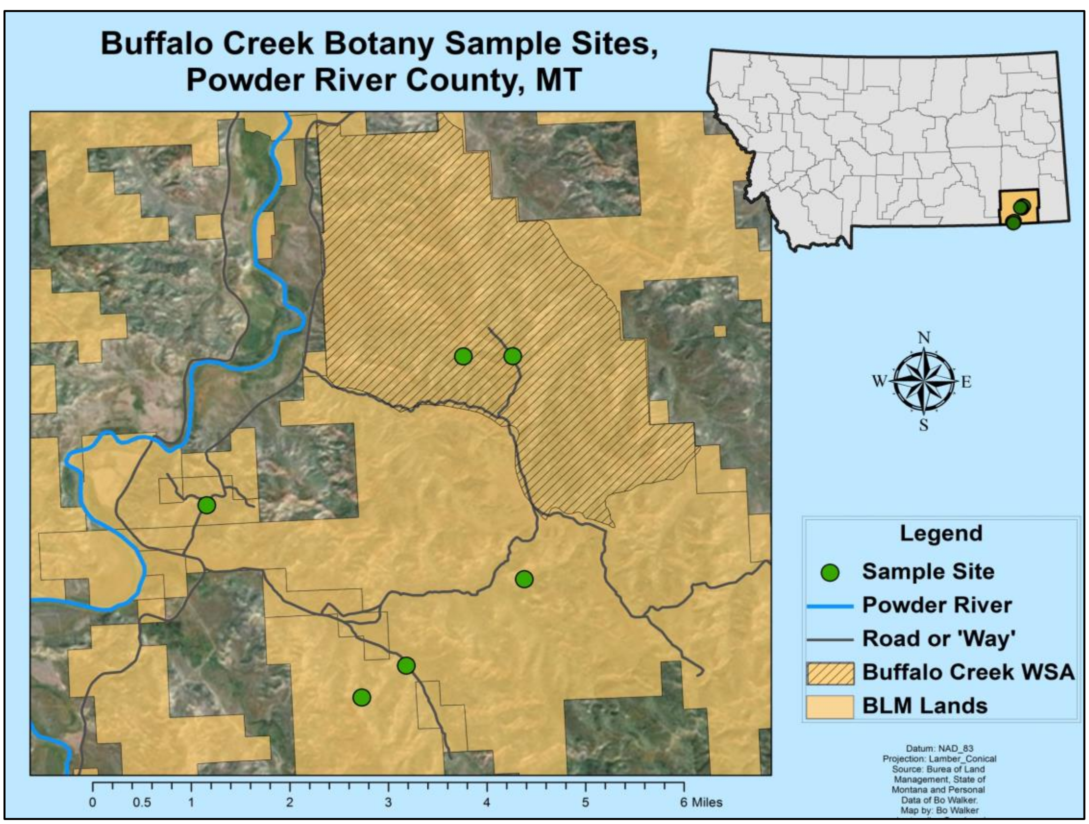
<u>Research Question:</u> How do habitat patch sizes and human travel corridors affect the spread of nonnative and invasive plants on landscapes with potential wilderness characteristics in eastern Montana? This project was designed to answer this question as well as the following sub-questions through fieldwork conducted in Buffalo Creek, Rough Creek and Wrangler Creek study sites (figure 1):

1) Do the Bureau of Land Management (BLM) owned study areas possess wilderness characteristics (*Wilderness Inventory Handbook*) that suggest they ought to be managed as wilderness areas?
2) Are there significant populations of native or invasive plant species within the study areas?
3) Do habitat patch size and the density of human travel corridors (i.e roads, ATV tracts, hiking trails, 'ways', etc.) affect the distribution of nonnative and invasive plant species?

There were two main objectives of this study. The first was to help land managers determine whether the human travel corridors in these areas fit the BLM's definition of a 'road' or 'way'. The second was to examine the relationship between such corridors and the spread of invasive plant species.

Figure 1 – Bureau of Land Management Study Areas in southeastern Montana.





Hypothesis:

The project was designed to test the following hypotheses about the relationship between habitat patch size, human travel corridors and the spread of invasive and nonnative plant species:

1) Certain parts of the three study sites do possess wilderness characteristics befitting a wilderness study area (*Wilderness Inventory Handbook)*;
2) Plant communities nearer to roads and ATV tracts will have higher instances of nonnative and invasive plant invasion when compared to natural areas further from human travel corridors;
3) Larger habitat patches – areas undivided by human travel corridors – will have more intact native plant communities at their centers.

Invasive Species and the Greater Yellowstone River Watershed: Invasive species are a leading cause of worldwide biodiversity decline (Dillemuth et al. 2008 Clavero and Garcia-Berthou 2005 and Wilcove et al. 1998). In eastern Montana, nonnative and invasive plant species threaten the integrity of rangeland communities and natural areas in the following ways: 1) alteration of erosion and sedimentation rates; 2) alteration of the hydrological cycle; 3) alteration of the biogeochemical cycle, like soil chemistry and nutrient cycling; 4) alteration of the natural disturbance and succession regimes; and 5) alteration of native plant and animal community and population structures (Macdonald et al. 1989). The focus of this study was to investigate the impact of human travel corridors on disturbance and succession regimes as well as on native plant communities in Eastern Montana.

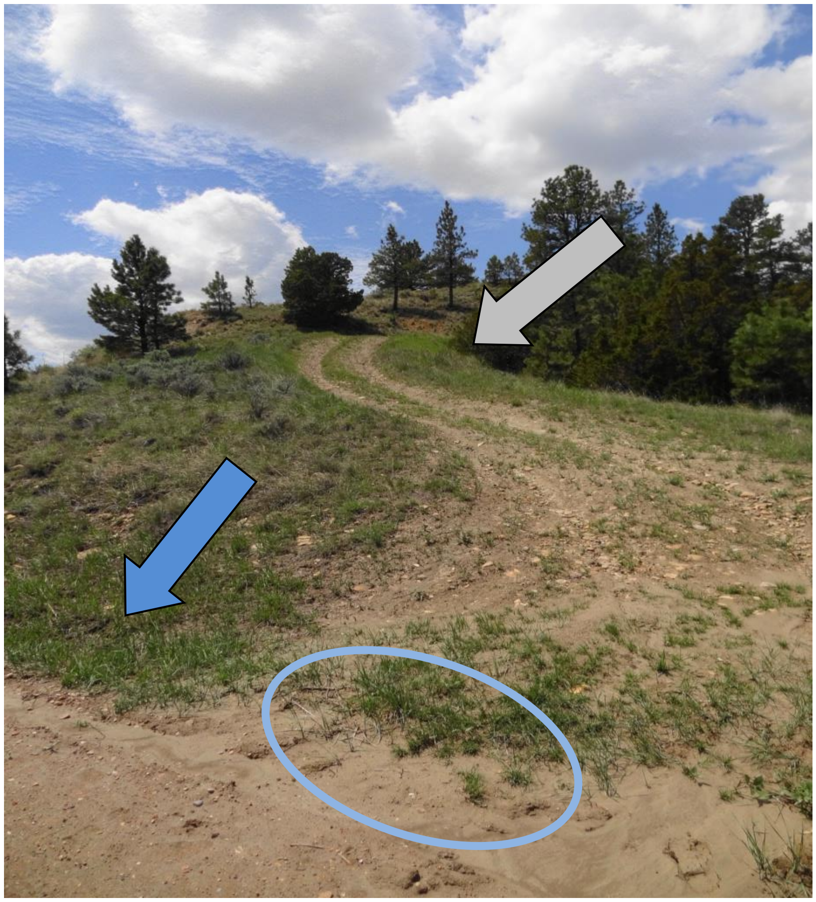
Nonnative plant dispersal: Nonnative and invasive plants are dispersed in many ways – both naturally and by humans. Wind, waterways and wildlife are often natural agents of seed dispersal and thus the spread of nonnative plants into new habitats (Goodwin et al. 2012). Nonnative plant dispersal by humans tends to occur along roads, ATV tracks, hiking and biking trails, and other routes of human traffic (Goodwin et al. 2012). Livestock activity – an indirect means of human seed dispersal – is also a factor affecting the spread of nonnative and invasive plants (Beslky and Gelbard 2000). The selected sampling areas of this study were located on BLM lands crossed by many types of human travel corridors and thus offer study areas that, because of their characteristics, afford a great opportunity to study the relationship between human travel corridor locations and the spread of nonnative plants.

Using patch size to investigate weed invasions: Habitat patch sizes may play a role in weed dispersal and colonization and may also affect rangeland systems' resistance to invasion by nonnative plants. According to the Theory of Island Biogeography, the larger a habitat patch size, the greater the species diversity and richness within the patch (MacArthur and Wilson 1967). Maron and Marler (2007) and Pokorny et al. (2005) both found that diversity within native rangeland plant systems led to increased resistance to invasion by nonnative plant species. Therefore, large areas of undisturbed rangelands may offer excellent habitat for diverse and rich native rangeland flora and fauna species compositions. Due to the increasing spread of invasive and noxious plants in eastern Montana, it is important to inventory local rangelands – especially those found on large tracts of public land – in order to better understand the dynamics of nonnative invasions, human activity and local plant community resistance to these invasions.

Methods

<u>Road Inventories and Wilderness Characteristics Surveys to answer RQ1:</u> BLM lands were surveyed in order to determine whether they possess "wilderness characteristics" as described in the BLM's *Wilderness Inventory Handbook*. The focus of the surveys was on the condition of existing travel corridors (whether they should be classified as 'roads' or 'ways' – see Figure 2). Each travel corridor was driven or hiked to and extensively photographed. Photos were georeferenced and used along with GPS tracks of each travel corridor to create a GIS feature class containing current human travel corridors.

Figure 2 – Distinguishing ‘roads’ from ‘ways’.

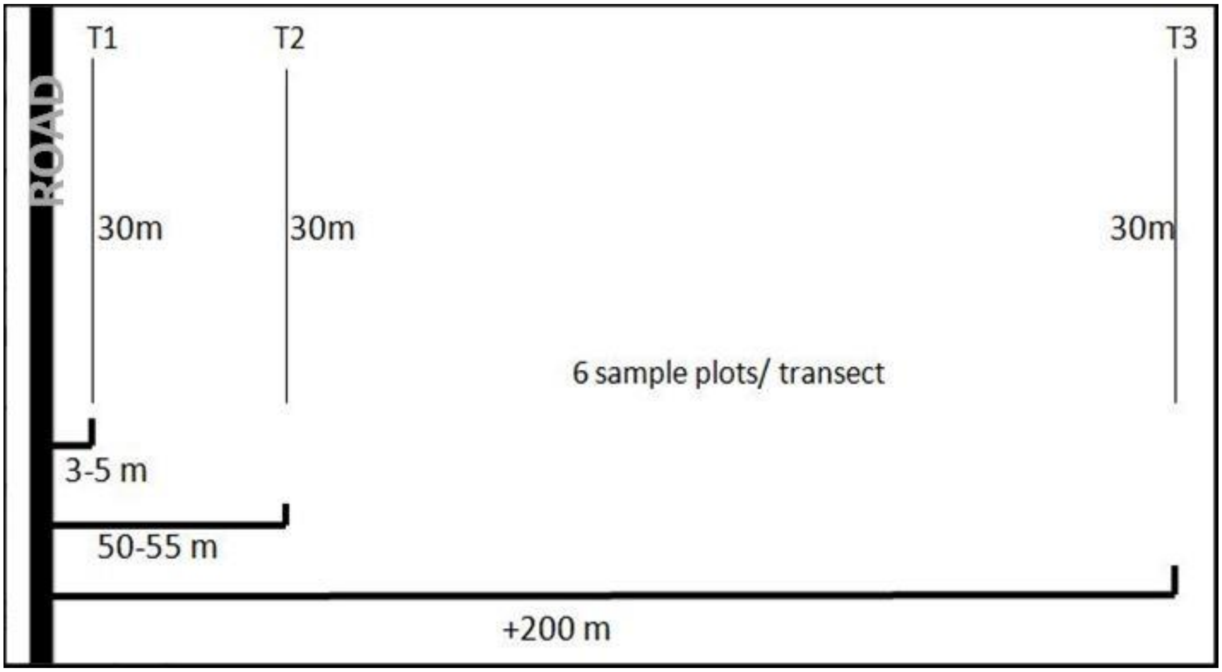


The BLM’s wilderness policy states that a ‘way’ is a travel corridor maintained solely by the passage of vehicles (grey arrow). If a ‘way’ is used on a regular and continuous basis, or was originally constructed by mechanical means but is no longer being maintained by mechanical methods, it is not a road. A road (blue arrow), by comparison, is a vehicle route that has “been improved and maintained by mechanical means to ensure relatively regular and continuous use” (*Wilderness Inventory Handbook)*. Note the blue circle which highlights the berm of the road caused from regular grading of the roads surface. Grading is considered mechanical maintenance.

<u>Plant Surveys to answer RQ2 and RQ3</u>: Surveys were conducted from June 1st, 2013 – June 9th, 2013. Three types (T1, T2 and T3) of transect lines were used to examine the relationship between nonnative invasion and the distance from human travel corridors. For two of the types, a set of transects were laid out 3-5 meters from the road and 50-55 meters parallel to the road, respectively. For the third type, transects were placed anywhere between 200 meters and 5 kilometers from the road (Figure 3). Following Island Biogeography Theory (MacArthur and Wilson 1967), these transects were considered "interior" transects and presumed to be the most ecologically intact plant community sites given their distance from any human travel corridor (*Personal Communication with Wendy Velman 2013, Personal Communication with Jennifer Lyman 2013*). Although extensive pre-field GIS work was conducted in order to find interior transects centered in varying sizes of habitat patches, some sample site locations were adjusted in the field for logistical reasons.

During sampling, a Daubenmire sampling frame was placed every 10m on alternating sides of a 50m long transect line beginning at 0m. (Daubenmire 1968, Bonham 1989). Plant species within the square were identified and the total canopy cover occupied by each species within the square was recorded. Total canopy cover was calculated by estimating the amount of ground covered by a vertical projection of the outermost perimeter of the natural spread of plants rooted within the sampling frame (Bonham 1989). In total, 162 sample plots of data were collected.

Figure 3 – Plant survey methodology diagram.



The degree of grazing was also estimated for each sample plot. A value of 1, 2, 3, or 4 was assigned to each plot based on the apparent amount of recent grazing in the area. Plots that appeared to have not been grazed since the previous growing season were assigned a value of 1, while plots that had cattle grazing at the time of survey and/or very low vegetation height were assigned a value of 4 (*Rangleland Analysis and Management Training Guide*). Sites with grazing degrees between these two extremes were assigned a 1 or a 2 depending on the height of vegetation in the area and the amount of cattle sign (i.e. tracks, dung, etc.).

Data Analysis: Percentage of total canopy cover occupied by nonnative and invasive species was calculated for each sample plot. The mean value native species canopy cover was calculated for each transect type and compared to distance of each plot from road (3-5m, 50-55m, or +200m) using a standard Analysis of Variance statistical test (ANOVA). The mean value of native species canopy cover was also compared to the degree of grazing value (0, 1, 2, or 3) using a standard ANOVA. The mean value of total species per plot was calculated and compared to the degree of grazing using a standard ANOVA. The results of the ANOVA tests were used to help determine the relationship between the distribution nonnative and invasive species in relation to human travel corridors.

Results

A total of 65 five species were identified during sampling, of which 55 species were native and 10 species were nonnative. All three of the BLM managed properties were recommended for designation as "Lands with Wilderness Characteristics".

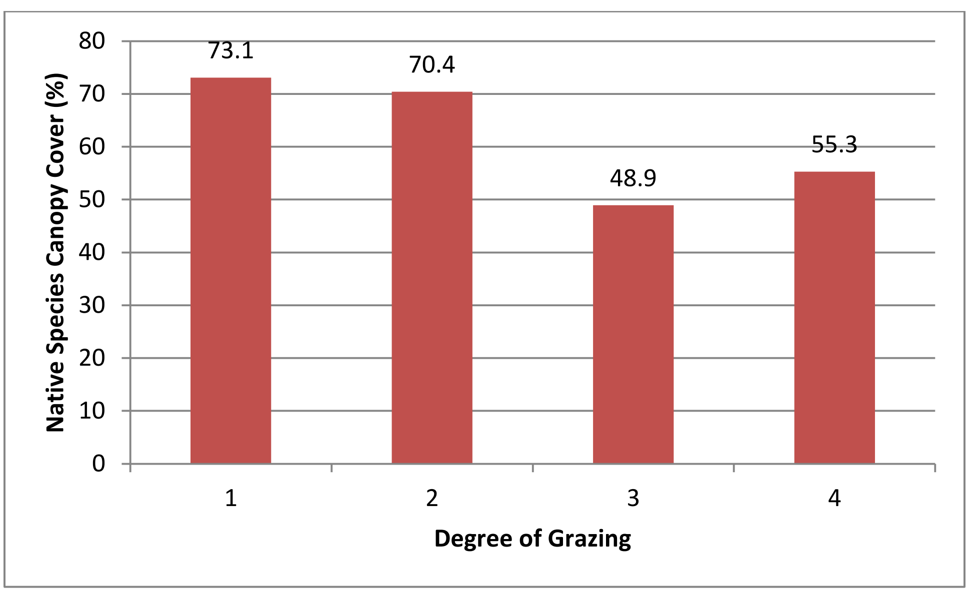
Statistical significance was defined by a p-value of .05 or less. A significant relationship between the mean value of percent native species canopy cover and distance from road was found ($p = .01$). The mean percent of native species canopy cover for 3-5m transects was 67%; the mean percent of native species canopy cover for 50-55m transects was 46.5%; and the mean percent of native species canopy cover for interior transects was 64% (Table 1). These findings suggest that while roads may be a common means of nonnative distribution, something else is also increasing the distribution of nonnatives in the study areas.

Table 1 – Distance from road and mean percent of native species canopy cover (p =.01).

Transect Type	Distance From Road (m)	Mean Value of Native Species Canopy Cover (%)
1	3-5	67
2	50-55	46.5
3	+200	64

A significant relationship between the mean value of percent of native species canopy cover and the degree of grazing was also found (p = .007). The mean percent of native species canopy cover for 1 degree of grazing was 73.1%; the mean percent of native species canopy cover for 2 degree of grazing was 70.4%; the mean percent of native species canopy cover for 3 degree of grazing was 48.9%; and the mean percent of native species canopy cover for 4 degree of grazing was 55.3% (Figure 4). This indicates that degree of grazing may play a role in the distribution of nonnative plants.

Figure 4 - Degree of grazing and mean percent of native species canopy cover (p=.007).



No significant relationship was found between the average total species per plot and the degree of grazing was found (p = .13).

Discussion

This study suggests two important conclusions: 1) roads may not be the primary vector of nonnative plants in eastern Montana rangelands, and 2) cattle grazing may play a larger role in nonnative plant invasion than previously thought. These findings should be taken into account when considering the management of rangelands in eastern Montana.

Roads and Nonnatives: Roads and other human travel corridors are well known vectors of nonnative plants (Ruiz and Carlton 2003). The initial hypothesis for this study, involving roads and nonnative plants, was based on the idea that sample sites near the road would have a higher percentage of nonnative plant species canopy cover than sites further from the road. The idea behind this is that the degree of nonnative plant species cover would likely be higher near the nonnative seed vector (the road) and that invasion would stem from the road side and spread toward interior sample sites. However, as Figure 4 shows, no direct gradient pattern of higher nonnative cover to lower nonnative cover was discovered. Instead, interior transects (+200 m from the road) had a higher percent cover of native species (64%) than did the 50-55 m transects (46.5%). Interestingly, sample sites 3-5 m from the road had the highest mean value of native cover, with a mean value of 67% native, while transects 50-55 m from the road had the lowest percentage of native canopy cover.

One possible explanation of these results may be road type. Brothers (1992) found that different road types (paved, gravel, graded, dirt, etc.) actually create different microclimates around their edges. The transects used to survey these areas were primarily set along two-track ‘ways’ (see Figure 2) and unmaintained BLM travel corridors. Only three sampling transects were located adjacent to a graded county road. This means that many of the travel corridors along which sampling occurred likely see mostly light and seasonal use. Gelbard and Belnap (2003) found the level of nonnative plant invasion was correlated with road type (i.e. paved, improved, graded and two-track), with more developed roads having higher degrees of nonnative invasion. This implies that road type and corresponding usage may play a significant role in determining the rate and degree of invasion by nonnative plants.

Degree of Grazing and Nonnatives: Belsky and Gelbard (2000) site several ways in which cattle are thought to contribute to nonnative plant invasion including: 1) transporting nonnative seeds via coats, feet and guts; 2) preferentially grazing native plant species; 3) creating patches of bare and disturbed soil; 4) destroying microbiotic crusts; 5) creating patches of nitrogen-rich soils; 6) reducing the mycorrhizea in soils; and 7) accelerating soil erosion (and thus creating disturbed areas). Several studies conducted have found that cattle possess the ability to significantly change a plant community’s composition (Armour et al. 1990, Painter 1995, and Milchunas 2006).

Degree of grazing showed a strong correlation with percent cover of native species. The lower the degree of grazing, the higher the percent of native cover (see Figure 5 above). Sample sites with a degree of grazing value of 1 had a mean value of 73.1% native cover, while sample sites with a degree of grazing value of 4 had a mean value of 55.3% native cover. This implies that the higher the amount of cattle activity in an area, the more susceptible the area may be to nonnative invasion and distribution.

Cattle possess the ability to move large amounts of seed from one area to another. Belsky and Gelbard (2000) note that one cow deposits an average of 37,000 viable seeds of late-season annuals in dung per day in the fall season. Similarly, Dore and Raymond (1942) found that one cow in pasture can redistribute over 900,000 viable seeds in a single grazing season. Cattle can also reduce the competitive ability of native species by selecting such species for graze over nonnatives (Olson and Wallander 1997, Belskey and Gelbard 2000) and by creating disturbed sites which nonnative seeds can colonize (Belskey and Gelbard 2000, Milchunas 2006). This suggests that grazing management and degree of grazing may be one of the most important factors in protecting rangelands systems from nonnative plant invasion.

Lands With Wilderness Characteristics: Each of the three BLM areas surveyed were recommended for designation as "Lands with Wilderness Characteristics" (*Wilderness Inventory Handbook*). If the BLM accepts these recommendations, the Wrangler Creek, Rough Creek and Buffalo Creek Areas will be protected from further development and managed more like traditional wilderness areas. The "Lands with Wilderness Characteristics" designation helps protect lands qualified as such from development that "may impair wilderness characteristics" (*Wilderness Inventory Handbook*). In some cases, however, the BLM may decide that development which may compromise the wilderness characteristics of some areas is appropriate. In this case, the impacts of development are required to be kept to a minimum (*Wilderness Inventory Handbook*).

Conclusion

Nonnative plant species can greatly alter ecosystems and potentially lead to a decrease in biodiversity (Dillemuth et al. 2008 Clavero and Garcia-Berthou 2005 and Wilcove et al. 1998). Human travel corridors, such as roads, are thought to be common vectors of nonnative seeds (Goodwin et al. 2012). The results of this study suggest that other vectors, including livestock, may also play a significant role in the spread of nonnative seeds. Further study of potential nonnative seed vectors should be conducted in order to better understand rangeland plant invasions and the subsequent effects on plant community dynamics.

Although the results of this study showed little correlation between habitat patch size and rangeland plant communities' resistance to invasion by nonnative species, further study of how Island Biogeography Theory relates to nonnative invasion may be worthwhile. Conducting a similar study on a lightly or non-grazed rangeland study site may shed more light on the relationship between habitat patch size and nonnative plant invasion.

Federal lands with little human development, like the study areas chosen for this study, offer excellent opportunities for scientific study and serve as important landscapes for native flora and fauna. Protecting such landscapes from development and degradation helps ensure that wild lands and open spaces will be preserved for both wild plant and animal communities as well as for future human generations. On a landscape affected by increasing human development and activity, extending extra legal protection like the "Lands With Wilderness Characteristics" designation, can help ensure that such places retain their wild characteristics and the floral and faunal communities that depend on these characteristics.

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