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**SMALL MAMMAL COMMUNITIES IN GLACIER NATIONAL PARK'S
FESCUE GRASSLANDS: IMPLICATIONS OF EXOTIC PLANT INVASIONS**

2000 REPORT

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Abstract Exotic plant invasions threaten to transform fescue grasslands within Glacier National Park, but little is known about how such changes from native to exotic vegetation may affect wildlife species. We surveyed small mammal communities in six fescue grassland sites on the east side of Glacier National Park (Belly River East, Belly River West, Windy Flats, Two Dog Flats, Saint Mary's Flats, and Two Medicine) to identify current small mammal communities and assess how small mammals may be affected by exotic plant invasions and reciprocally how exotic plant invasions may be facilitated by certain small mammal species. Deer mice (*Peromyscus maniculatus*) dominated small mammal communities followed by western jumping mice (*Zapus princeps*) and voles (Microtinae) in approximately equal numbers. Of four voles captured, there was only one trap mortality that could be positively identified as a western heather vole (*Phenacomys intermedius*) by dentition and skull characteristics. Other captured voles could be western heather voles, meadow voles (*Microtus pennsylvanicus*), or montane voles (*M. montanus*). Additionally, one long-tailed vole (*M. longicaudus*) was collected from a glass bottle found at Windy Flats. Low capture success precluded habitat selection analyses on all but Wind Flats and Two Medicine sites for all species but deer mice. Deer mice selected microsites with significantly more rock than expected at Windy Flats, but exhibited no detectable habitat selection at Two Medicine. No association with or avoidance of exotic plants was noted for any small mammals. However, sample sizes were small and inconclusive in this regard. Regression analysis of sign survey results for columbian ground squirrels indicated that significant, but weak positive correlations were found between the number of columbian ground squirrel (*Spermophilus columbianus*) holes and the abundance of exotic plants for two of the three locations where ground squirrel holes were sufficiently abundant for analysis. These data suggest that columbian ground squirrels may facilitate expansion of exotics such as timothy (*Phleum pratense*) and Kentucky bluegrass (*Poa pratensis*), but the inability to control for the manner in which exotics were seeded into the areas studied renders this relationship unclear. We suspect that small mammal populations were at a population low

during the June 2000 sampling period and recommend small mammals be sampled for two to four more years to increase sample sizes and incorporate year-to-year variability in understandings of community structure and habitat relationships.

INTRODUCTION

Exotic plants exact dramatic impacts on native ecosystems throughout the world by displacing native plants and in some cases even altering disturbance regimes – the very processes that define vegetative communities (Williamson 1996, Begley 1998, Mirsky 1999). However, not all plant communities are equally at risk. Arid grasslands of western North America have proven particularly susceptible to exotic plant invasions (e.g., Forcella and Harvey 1983, Mack 1986). For example, spotted knapweed (*Centaurea maculata*) and cheatgrass (*Bromus tectorum*) have come to dominate large expanses of western grasslands, establishing virtual monocultures in many locations (Harris and Cranston 1979, Mack 1981). Spotted knapweed releases secondary compounds as root exudates capable of inhibiting the growth of other plants (Kelsey and Locken 1987) and may employ mycorrhizal fungi to extract resources from native grasses such as Idaho fescue (*Festuca idahoensis*) (Marler et al. 1999). Cheatgrass insures its prominence in areas with historically infrequent fire return intervals by establishing fire as a rapidly recycled disturbance force that favors this fire-adapted annual to the exclusion of native species (Whisenant 1990).

Land management agencies in the West have responded to such highly invasive exotics by implementing chemical, mechanical, and biological control methods to combat their advance (e.g., Losensky 1987). Ironically, at the same time that such costly strategies are under way to control some exotic species, others are being intentionally planted by the very same agencies. For example, both the United States Forest Service and Bureau of Land Management revegetate areas disturbed by mining and wildfire using seed mixes comprised in part or whole of exotic plant seeds (Richards et al. 1998). In the case of fires, vast acreages may be treated with seed from exotic species that are chosen for their competitive abilities to successfully establish under a wide variety of conditions. Given these selection criteria, it is not

surprising that many of the species used for revegetation are already classified as invasive exotics. For instance, half (47%) of the 17 species of plants listed by the Lolo National Forest as seed cultivars for reseeding disturbed areas in the year 2000 (2000 Seeding Guidelines: Lolo National Forest) are exotics (as determined from their status in the USDA PLANTS database 1999: <http://plants.usda.gov/plants>) and 50% of these are currently recognized by The Nature Conservancy as invasive exotics based on their demonstrated ability to invade native systems (The Nature Conservancy Element Stewardship Database: <http://www.tncweeds.ucdavis/esadocs.html>). Other exotics used by the Lolo National Forest, but not yet recognized as invasive species, such as crested wheatgrass (*Agropyron cristatum*), are known to deleteriously impact soils (Lesika and DeLuca 1996).

Intentional planting of exotics threatens not only the integrity of lands managed for multiple use, but also lands managed as natural areas, where maintenance of ecological integrity is the primary goal. For instance the Flathead National Forest, which borders Glacier National Park, includes timothy (*Phleum pratense*) and smooth brome (*Bromus inermis*) as seed cultivars for revegetating disturbed sites (Larsen and Lesika 1998). Both species are recognized as invasive exotics in Glacier National Park (Larsen and Lesika 1998). Although providing a source of invasive exotics adjacent to a large national park obviously threatens the potential for successfully maintaining a native grassland within the natural area, the origins of GNP's problem with timothy likely arose from intentional introductions of this and other species within the park to provide forage for stock used by concessionaires (Tyser 1991). Timothy is currently the most widespread exotic plant invading GNP's east-side fescue grasslands (Tyser 1991).

Given the potential impacts that exotics can incur upon natural systems, the intentional introduction of exotic species is a questionable practice at best. One possible explanation for such introductions is that research and management addressing issues of exotic plant invasions have focused on large, domestic and wild herbivores. Such research has shown that while forage for cattle and elk (*Cervus elaphus*) is diminished by the invasion of exotics such as spotted knapweed

(Watson and Renney 1974, Thompson 1996), Eurasian species such as timothy and orchardgrass (*Dactylis glomerata*) provide good forage for large grazers (Hash 1973, Stevens 1966). However, this is a rather limited perspective that ignores the complexity of outcomes that can result from exotic invasions. When intentionally or accidentally introduced exotic species expand, they displace native plants, reducing the diversity of the plant community. For example, expansion of spotted knapweed, cheatgrass, and timothy into native grasslands of GNP results in reduced species richness and diversity of native grasses and forbs (Tyser and Key 1988, Tyser 1992, Tyser and Whorley 1992). Losses of diversity at the level of primary productivity will necessarily induce impacts at other trophic levels as well.

For instance, larvae of insects such as butterflies (Lepidoptera) tend to be host-specific (Opler 1999). Therefore, reductions of native plant species will likely reduce diversity of native butterflies and other such host-specific insect herbivores. Pollinator communities can also be impacted by exotic invasions (Kearns et al. 1998), especially if the process involves a transition from a native grass-forb community to one dominated by an exotic grass. Since grasses use wind for pollination, they do not provide nectar resources for pollinating insects, which are likely to decline as a result. Such insects are critical for other flowering plants within the system and their declines could create a positive feedback loop contributing further to losses of native forbs.

Exotic plant invasions are also likely to affect small mammals. Recent work on the effects of exotic plant invasions and the associated release of exotic insects as biological control agents suggests that the outcomes on small mammals within the systems can be complex and quite dramatic (Pearson 1999a, Pearson et al. 2000). Small mammals play important roles in grassland (Curtin et al. 2000) and forest ecosystems (Pearson 1999b) such that impacts on small mammals are likely to cascade into effects elsewhere in the system, potentially affecting avian and small mammalian predators as well as disrupting ecological functions perpetuated by small mammals. Moreover, small mammal activities can affect the process of weed invasion (e.g., Pearson and Ortega in review).

Given the current status of exotic plant invasions in GNP's east-side fescue grasslands, our

objectives were to 1) determine the community composition and relative abundance of small mammals in order to provide baseline information on small mammal communities currently residing in GNP's grasslands, 2) identify the habitat relationships of small mammals within these grasslands, particularly as they relate to exotic plant invasions, 3) assess the potential impacts of exotic plants on small mammal communities within GNP's fescue grasslands, 4) assess the potential impacts of small mammals on exotic plant invasion.

METHODS

Trapping

We live trapped small mammals at six discrete fescue grasslands in four of the five primary drainages on the east side of GNP from 5 to 30 June 2000. Small mammals were sampled at each location using Sherman live traps placed along a transect at 10-m intervals (Pearson and Ruggiero in review). Each transect comprised 25 traps and spanned 250 m. We placed four transects in each location ≥ 50 m apart so as to maximize the effective sampling area within the grasslands while maintaining independence among transects (Spot Mountain had six transects). Start and end points of transects were GPS'ed to ± 3 m so that transects could be resampled in the future.

We baited traps with a mixture of peanut butter and whole oats, but did not supply traps with bedding material due to the potential for increased risk of Hantavirus associated with handling soiled bedding material (see Pearson and Ruggiero in review for discussion). Traps were run for four days and checked each morning between 0700 and 1100. Small mammals were tagged with #1005-1 monel ear tags (National Band and Tag Company, Newport, Kentucky 41072-0430), and species, age, weight, sex, and reproductive condition were determined before release at the trap station. Age categories were assigned for deer mice (*Peromyscus maniculatus*) based on body mass: juveniles < 14 g; subadults 14–18 g; adults > 18 g. Mammal nomenclature follows Jones et al. (1997).

Sign Surveys

We assessed recent activity of columbian ground squirrels (*Spermophilus columbianus*) and

northern pocket gophers (*Thomomys talpoides*), species not effectively sampled using Sherman traps, by counting the number of ground squirrel holes and estimating the percent cover (ocular estimate) of pocket gopher cores and mounds within a 5-m radius of the trap station. We collected these indices in order to assess whether the direct impacts these species have on soils might facilitate exotic plant invasion.

Vegetation

Small mammal habitat was assessed by ocular estimates of percent cover for vegetation categories within a 5-m radius of each trap station. We estimated percent cover for (1) total native bunchgrasses – including individual estimates for the three primary bunchgrasses: rough fescue (*Festuca scabrella*), Idaho fescue (*Festuca idahoensis*), and bluebunch wheatgrass (*Agropyron spicatum*); (2) total exotic grasses – including individual estimates for the two primary exotic species: Kentucky bluegrass and timothy; (3) shrubs; (4) kinnikinnick (*Arctostaphylos uva-ursi*) – estimated separate from other shrubs because of its low-grown stature; (5) native forbs; (6) exotic forbs; (7) ground cover; (8) woody debris ≥ 10 cm diam.; (9) rocks ≥ 10 cm diam. We also estimated topography of microsite (i.e., concave = 1 or not = 0; as an indicator for low, moist sites) at each trap station. Vegetation nomenclature follows Hitchcock and Cronquist (1973).

Analytical Methods

We used logistic regression (SPSS Inc.) to determine which habitat variables best differentiated trap stations that captured small mammals from those that did not. Traps having multiple captures were included only once in the analysis. Equations produced by logistic regression serve as resource selection functions and the coefficients serve as selection coefficients ($\hat{\beta}$) whose values indicate the relative importance of the predictor variables in the equation (Manly et al. 1993). Positive coefficients indicate selection for the resource and negative coefficients indicate avoidance when coefficients differ significantly

Table 1. Percent cover estimates ($\bar{x} \pm SD$) for variables collected at trap stations that were used in habitat analyses and estimated number of ground squirrel holes per station.

Variable	Location					
	Belly West	Belly East	Windy Flats	Two Dog Flats	Saint Mary's	Two Medicine
Bunchgrass	54.0 $\pm$ 10.9	54.7 $\pm$ 17.3	56.7 $\pm$ 14.3	26.6 $\pm$ 6.1	25.6 $\pm$ 7.4	59.4 $\pm$ 11.5
Native forbs	42.3 $\pm$ 5.1	37.4 $\pm$ 5.4	39.3 $\pm$ 10.0	39.4 $\pm$ 8.9	33.7 $\pm$ 11.0	42.6 $\pm$ 12.2
Exotics	11.2 $\pm$ 8.5	29.7 $\pm$ 14.1	2.8 $\pm$ 5.1	6.2 $\pm$ 7.2	3.4 $\pm$ 4.3	1.0 $\pm$ 2.1
Shrubs	7.9 $\pm$ 7.1	8.5 $\pm$ 8.5	17.5 $\pm$ 16.1	2.6 $\pm$ 2.3	3.3 $\pm$ 4.1	15.5 $\pm$ 13.9
Ground	6.9 $\pm$ 3.2	3.7 $\pm$ 3.3	8.3 $\pm$ 4.5	7.8 $\pm$ 3.4	9.4 $\pm$ 6.1	7.8 $\pm$ 4.8
Rocks	0.2 $\pm$ 0.6	0.1 $\pm$ 0.5	5.7 $\pm$ 6.6	1.0 $\pm$ 1.7	1.4 $\pm$ 2.4	1.0 $\pm$ 2.0
Ground squirrel holes	0.0 $\pm$ 0.0	0.0 $\pm$ 0.3	2.0 $\pm$ 2.9	1.8 $\pm$ 4.2	1.6 $\pm$ 2.4	0.2 $\pm$ 1.1

from zero. We chose likelihood ratio tests over Wald tests to determine the significance of selection coefficients because of their greater reliability (Hauck and Donner 1977). Simple linear regression was used to examine the relationship between columbian ground squirrel holes and percent cover of exotic plants.

RESULTS

Vegetation

It should be noted that vegetative cover estimates represent the transect rather than a random sampling of the site. In cases such as Two Medicine and Windy Flats where transects essentially systematically sampled the entire study area, vegetation data should largely reflect the vegetation for the grassland (though 5-m radius ocular estimates are somewhat crude). However, because an effort was made to balance sampling between exotic and native vegetation whenever possible in order to better examine the effects of exotic plants on small mammals, exotics may be over-represented on sites such as Belly River East, Belly River West, Two Dog Flats, and Saint Mary's Flats where large but discrete patches of exotics were targeted.

Native bunchgrasses exhibited similar cover values for Belly River East, Belly River West, Two Medicine, and Windy Flats, which all had average total bunchgrass coverages between 50 and 60% (Table 1). Saint Mary's Flats and Two Dog Flats, which both occur in the Saint Mary's Drainage, had total bunchgrass coverages of around 25% or half that of the other sites. Average percent cover for exotic grasses was <10% for all sites except for Belly River East, which had an average cover of over 20% for exotic grasses. Two Medicine had the lowest mean percent coverage of exotic grasses

at about 1%. The primary exotic grass on all sites was timothy. Total native forb cover was comparable among all sites and generally averaged around 40% cover. Exotic forbs, which were primarily comprised of dandelions (*Taraxacum officinale*), had substantially higher average cover values on Belly River East and Belly River West than elsewhere. Shrub cover was comparable among sites, though the Two Medicine and Windy Flats sites had somewhat higher shrub cover than the other sites. Kinnikinnick was similarly more abundant on these two sites than the others, but the discrepancy was even greater. Coarse woody debris occurred primarily on portions of one or two transects on the Two Medicine cite where old logs indicated historical sporadic tree coverage. Woody debris

were rare otherwise within the grasslands. Bare ground averaged from 5 to 10% cover on all sites except Belly River East, which had the lowest ground cover at <5%. Percent cover of rock was highest at Windy Flats and lowest at Belly River East and Belly River West, but ranged only from near zero percent to approximately 5%. The degree of microsite topography varied little among sites.

Trapping

Trapping at six locations in four drainages resulted in 2600 trapnights that produced 68 captures of 48 individuals representing three species of small mammals (Table 2). Deer mice (*Peromyscus maniculatus*) were most abundant with 39 individuals captured at four of the six locations. Five western jumping mice (*Zapus princeps*) were captured at Windy Flats in Many Glacier Drainage, and four voles were captured, two at Belly River West and two at Two Medicine.

Table 2. Small mammals detected by sign surveys or trapping in fescue grasslands on the east-side of Glacier National Park.

Species	Location					
	BW	BE	WF	TD	SM	TM
PEMA			X	X	X	X
ZAPR			X	X ^a		
VOLE	X			X ^a		X
MILO			X ^b			
PHIN						X
SOCI				X ^a	X ^a	
SPCO ^c		X	X	X	X	X
THTA ^c						X

a - Indicates species detected by Tyser (1991) that were not detected in this study.

b - This individual was collected from a glass bottle (see results).

c - Indicates species sampled using sign surveys rather than trapping data.

PEMA = *Peromyscus maniculatus*, ZAPR = *Zapus princeps*, MILO = *Microtus longicaudus*, PHIN = *Phenacomys intermedius*, SOCI = *Sorex cinereus*, SPCO = *Spermophilus columbianus*, THTA = *Thomomys talpoides*.

One of the voles captured at the Two Medicine location died in the trap and was identified by skull and dentition as a western heather vole (*Phenacomys intermedius*). Other voles were released alive and so could not be positively identified to species. They may have been western heather voles, meadow voles (*Microtus pennsylvanicus*), or montane voles (*M. montanus*), though montane voles have not been identified within Glacier National Park to date (Shea 1971). Additionally, we recovered the skeleton and skull of one individual long-tailed vole (*M. longicaudus*) from inside an old glass bottle lying within the trapping area at Windy Flats. The skeleton was firmly attached to the inner bottle surface and positioned at the bottom of the bottle suggesting that it had not been disturbed since the animal died within, i.e., the animal had been captured on site.

Demographic data for deer mice are pooled across all sites due to small sample sizes. The sex ratio for deer mice was approximately equal with 48.7% of the population comprised of males. Reproductive activity was low with only 1 of 19 males scrotal (5%) and only 3 of 20 females assessed as pregnant (15%). None of the 20 females showed clear signs of lactation. Adults comprised 64% of the population with subadults and juveniles each making up about 18% of the population. We observed no evidence of breeding in any of the voles or western jumping mice captured. Numbers of these species were too few

to assess sex ratios and population age structure, but males and females were captured for both voles and jumping mice.

Sign Surveys

We observed northern pocket gopher sign at only one of the 650 trap stations surveyed. This station was located on transect 2 at the Two Medicine site. Columbian ground squirrel holes were observed at all locations except for Belly River West (Table 1). Moreover, only three holes were observed at one trap station at Belly River East, indicating that little or no ground squirrels reside within these grasslands. Ground squirrel holes were also rare at Two Medicine. Holes were relatively common at Windy Flats, Two Dog Flats, and Saint Mary's Flats where ground squirrels were commonly seen during the day while trapping.

Linear regression analysis of the raw data indicated there was a significant positive linear correlation between the number of columbian ground squirrel holes at a trap station and the percent cover of exotic grasses and forbs for Windy Flats ($F = 7.43$, $df = 1$, $P = 0.008$, $r^2 = 0.070$) and Two Dog Flats ($F = 6.15$, $df = 1$, $P = 0.015$, $r^2 = 0.059$), but not for Saint Mary's Flats ($F = 0.15$, $df = 1$, $P = 0.698$, $r^2 = 0.002$). However, the r-squared values were very low for all sites. The other three sites had insufficient data for analysis.

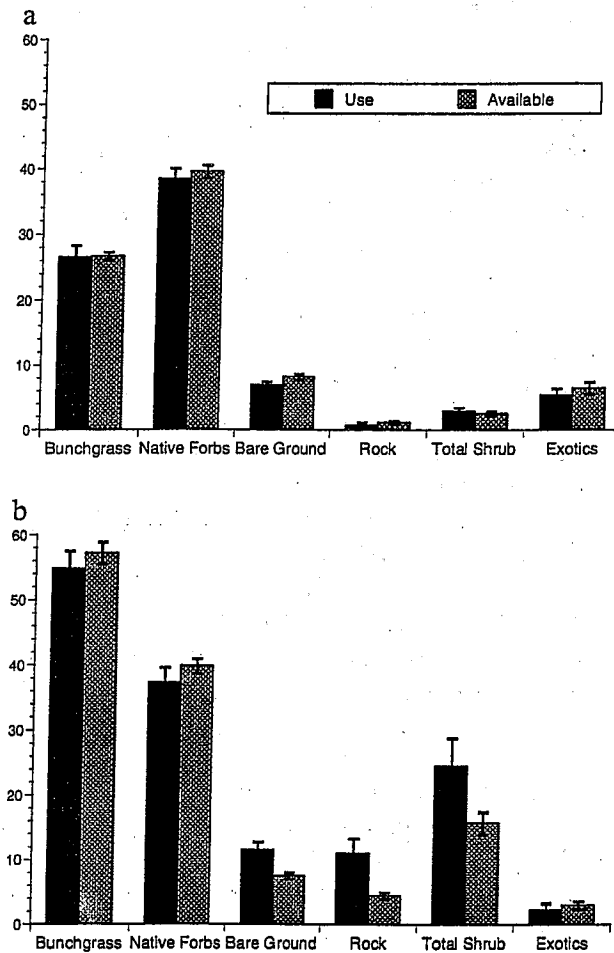


Figure 1. Estimated percent cover values ($\bar{x} \pm SE$) for habitat variables at used versus available trap stations for a) Two Dog Flats and b) Windy Flats in Glacier National Park.

Habitat Selection

Due to low numbers of captures on most sites, we were only able to examine habitat relationships for deer mice at Windy Flats and Two Dog Flats. Since topography varied very little and woody debris were largely absent from these sites, these two variables were not included in the logistic analysis. Additionally, since initial runs indicated that shrubs and kinnikinnick were not separately important and both were strongly correlated these two variables were combined into a single shrub category. Similarly there were few exotic forbs, so we combined exotic forbs and exotic grasses into a single variable representing all exotic plants. The result was that the original 10 variables collected were reduced to six

variables that made up the final analysis: total bunchgrass, native forbs, bare ground, total shrubs, total exotics, and rocks. Logistic regression results indicated that deer mice exhibited significant selection for microhabitats at Windy Flats ($\chi^2 = 17.01$, $df = 6$, $P = 0.009$), but not at Two Dog Flats ($\chi^2 = 2.71$, $df = 6$, $P = 0.844$). Both forward and backward stepwise logistic regression resulted in a single-variable model based on percent cover of rock for deer mouse microhabitat selection at Windy Flats ($\chi^2 = 12.62$, $df = 1$, $P < 0.001$). Both methods indicated that deer mice selected rockier microsites more than expected (Wald = 9.34, $df = 1$, $P = 0.002$) at this site. However, percent cover of rock was significantly positively correlated with percent cover of bare ground ($r = 0.51$, $P < 0.001$) and shrubs ($r = 0.53$, $P < 0.001$), and percent cover of shrubs ($\chi^2 = 8.19$, $df = 1$, $P = 0.004$) and bare ground ($\chi^2 = 7.27$, $df = 1$, $P = 0.007$) also result in significant selection models when run independently of all other variables, indicating these variables may also be of importance in deer mouse microhabitat selection.

DISCUSSION

Vegetation

Vegetation within GNP's fescue grasslands is generally similar to that observed for other fescue grasslands within the Northern Rocky Mountains where small mammal communities have been studied (e.g., Pearson et al. in press, 2000) except that rough fescue and native forbs are far more prominent in GNP resulting in a condition of higher total ground cover and thereby less interstitial space or bare ground. For instance, rough fescue was rare at small mammal study sites in westcentral Montana while forb cover was less than half that for GNP grasslands, and bare ground cover was more than twice that observed in GNP using the same methods employed in this study (see Pearson et al. in press). These conditions probably result from higher soil moisture, since rough fescue, which is abundant in GNP, is known to favor more mesic conditions than Idaho fescue and bluebunch wheatgrass, the other prominent bunchgrasses within fescue grasslands (Mueggler and Stewart 1980).

With regard to exotic plant invasions, GNP's fescue grasslands lie toward the lower end of the invasion gradient. Although timothy and Kentucky bluegrass are prominent and even locally

heavy within some of GNP's east-side, fescue grasslands, GNP's grasslands are relatively pristine when compared to grasslands heavily infested with exotics such as Mount Sentinel near Missoula, Montana where spotted knapweed commonly reached >45% cover (Pearson et al. 2000), though GNP's grasslands are somewhat more heavily infested than the most pristine sites that could be found within westcentral Montana (Pearson et al. in press).

Small Mammal Communities

Trapping in GNP's east-side fescue grasslands produced relatively few species of small mammals. Deer mice were common at Windy Flats and Two Dog Flats and dominated the small mammal communities overall, but were not captured at Belly River East or Belly River West. Voles and western jumping mice were captured, but both were relatively rare and occurred at only one or two sites. Of the four voles trapped, only one western heather vole could be positively identified to species. It is therefore unclear as to whether the other three voles that were live trapped were heather voles, meadow voles, or montane voles. Although montane voles are not presently known from GNP (Shea 1971), their current range encompasses GNP (Jannett 1999), and they appear to be the primary species of *Microtus* found in the dry conditions of fescue grasslands elsewhere in the state (Hodgeson 1972, Grant et al. 1982, Pearson et al. in press, 2000).

Tyser (1991) trapped Two Dog Flats and Saint Mary's Flats in 1989 and 1990 and observed results similar to ours. Deer mice dominated his captures followed by western jumping mice and voles, which were uncommon, and shrews, which were rare. Tyser (1991) tentatively identified his voles as meadow voles based on pelage characteristics (R. Tyser, University of Wisconsin-La Crosse, pers. comm.), but dentition and skull characteristics are necessary to conclusively distinguish among heather voles, meadow voles, and long-tailed voles (Hoffmann and Pattie 1968). It is therefore possible that his voles were any of these species. The small mammal results of Tyser (1991) are quite comparable to ours for GNP's east-side grasslands, except that heather voles and cinereus shrews were each captured in only one of the two studies.

Together this study and that of Tyser (1991) suggest that fescue grasslands in GNP are, like other grasslands, relatively species-poor communities dominated by deer mice. However, GNP's grasslands contain western jumping mice as well as potentially several species of voles in small numbers and shrews as rare components, suggesting that these grasslands may exhibit higher species richness than other fescue grasslands in the Northern Rocky Mountains. Pearson et al. (in press) and Grant et al. (1982) both found fescue grasslands to be species-poor small mammal communities mostly dominated by deer mice. Pearson et al. (in press) hypothesized that deer mice generally dominate fescue grasslands in the Northern Rocky Mountains, but that voles may at times predominate within these habitats. That deer mice seem to generally dominate these systems is supported by the current study and that of Tyser (1991). However, the potential for voles to become abundant or numerically dominant in these systems remains to be seen and will likely require longer-term studies (four to five years) to decipher. This remains an important question given the distinctly unique ecological roles these species play and the potentially different ways in which they may be impacted by exotic plant invasions (Pearson et al. in press, 2000).

Demographic data for deer mice indicated that little breeding was underway well into the breeding season and that few juveniles and subadults were being recruited into the populations from earlier breeding activity. We attribute the low capture success to a low in the populations of deer mice, though it is unclear as to whether jumping mice and voles were similarly at population lows or were simply uncommon within these habitats.

Sign Surveys

Sign surveys indicated that northern pocket gopher sign was rare, occurring only at one trapping station at the Two Medicine site. Although additional pocket gopher sign was seen off the official survey transects, northern pocket gopher sign was not abundant during the June survey. Columbian ground squirrel holes were common at Windy Flats, Two Dog Flats, and Saint Mary's Flats, and present though not common at Two Medicine. Columbian ground squirrel holes were not detected at Belly River West and only three holes were observed at one trap station at

Belly River East, indicating little columbian ground squirrel activity in this unroaded drainage. Tyser (1991) also surveyed for columbian ground squirrel sign, but not for northern pocket gopher sign. He found ground squirrel sign to be common at Two Dog and Saint Mary's Flats, but observed no sign of ground squirrels in the Belly River drainage. It would appear that columbian ground squirrels are common in most of GNP's fescue grasslands, but that they are absent or nearly absent from the Belly River drainage. The three ground squirrel holes we observed at the Belly River East site could have either been misidentified as columbian ground squirrel holes, or they could indicate that ground squirrels are very rare within the Belly River or just beginning to disperse there from other locations. Holes of golden mantled ground squirrels (*Spermophilus lateralis*) could be misidentified as columbian ground squirrel holes, but golden-mantled ground squirrels, which are effectively sampled using Sherman traps (D. E. Pearson, personal observation), were not captured or reported as sighted within the fescue grasslands in either Tyser's (1991) study or ours.

Soil disturbance produced by columbian ground squirrel digging activity may facilitate invasion of timothy in particular and possibly Kentucky bluegrass to a lesser extent. However, the regression relationships were very weak probably because historical direct planting of timothy still weighs more heavily on its distribution than ground squirrel activity. Since the effects of planting on the distribution of these exotic grasses cannot be controlled for in the regression models, it is difficult to assess the relative effects of ground squirrels in this regard. Literature searches produced no other studies examining this question. The role that small mammals play in facilitating exotic plant invasions is an important component of the ecology of exotic invasions and should be studied in more detail. However, it is unclear whether such studies can be effectively conducted in GNP given the historical importance of direct sowing of exotic grasses within this area.

Habitat Selection

Habitat selection was difficult to assess due to the low capture success. We were only able to examine habitat selection for deer mice at two sites where captures were sufficient to justify analysis:

Windy Flats and Two Dog Flats. At Windy Flats deer mice selected for microsites with higher percent cover of rocks, but at Two Dog Flats, we detected no habitat selection by deer mice. This may have been because deer mice were nonselective in their use of the habitat variables that we measured, or it may have been that there was simply insufficient power (due to the low captures) to detect habitat selection at Two Dog Flats. Although the two data sets were fairly comparable (about 20% of the 100 trap stations were visited by mice at each), both were somewhat marginal for detecting habitat selection unless selection was reasonably strong. For this same reason it is also important to consider that the variables, percent cover of bare ground and percent cover of shrubs, may also play important roles in deer mouse selection of microhabitats at the Windy Flats site. Although these variables were rejected in the stepwise regression process of seeking the most parsimonious selection model, they were the last to be removed from the backward stepwise logistic regression and are both strongly correlated with percent cover of rock. Moreover, each of these variables produces a significant selection model itself, if entered independent of the other habitat variables measured.

Deer mouse selection for microsites with higher percent cover of rock is consistent with results observed by Pearson et al. (in press) for similar though somewhat drier grasslands in southcentral Montana. These data also suggest that deer mice at Windy Flats may have selected for microsites with more bare ground and shrub cover, but these results are less conclusive given the small sample sizes and correlations between these variables and the percent cover of rock. Pearson et al. (in press) also found that deer mice selected for microsites with less vegetative cover, i.e., higher percent cover of bare ground. However, shrubs occurred rarely within the range of their trap stations so that the effect of shrubs on deer mouse microhabitat selection was not well assessed. In Wyoming grasslands, Elliott et al. (1997) similarly found that deer mice avoided heavy vegetative cover in favor of sites with more bare ground exposed, and deer mice have been shown to increase in response to grazing, which also reduces vegetative cover (Larrison and Johnson 1973, Grant et al. 1982, Rosenstock 1996). Previous work in GNP grasslands by Tyser (1991) did not

include habitat analyses, so we could not compare our results with his data.

RECOMMENDATIONS

In general, the small mammal community composition we observed in GNP's fescue grasslands is consistent with other studies conducted to date in similar habitats in the Northern Rocky Mountains, except that GNP may have higher species diversity than the dryer fescue grasslands that dominate much of the region. The presence of western heather voles as a potential member of the fescue small mammal community is so far unique to Glacier's grasslands, though this is not a surprising finding given the somewhat generic and generally grassy habitat associations of this species (see Pearson 1999b). The potential for voles to periodically, numerically dominate these systems however, remains an unresolved question. Analysis of deer mouse habitat selection was also consistent with other work in similar habitats, but was inconclusive with regard to some of the variables that appear to be selected for such as bare ground and shrubs, due to the small sample sizes. Similarly, it was not possible to conclusively assess the role of exotic plant invasions on deer mice or other small mammals due to low sample sizes. Capture rates observed in this study were much lower than those observed in other small mammal studies within fescue grasslands (Grant et al. 1982, Pearson et al. in press, 2000). Demographic data suggest that the low capture rates were due to a low density in the small mammal populations, at least for deer mice.

We recommend that trapping be implemented on the same transects for two to four additional years to sample through a full theoretical vole population cycle in order to determine the long-term potential role voles play in fescue grasslands. In conjunction with the continuation of the current sampling regime, additional sites should be added where possible (e.g., Red Eagle Meadows) as well as additional trapping within current sites where possible (e.g., Two Dog and Saint Mary's Flats). Obtaining additional years of data on the current sites, followed by adding new sites, and finally by adding transects to the current sites should be the order of priorities for follow up trapping within GNP's fescue grasslands. In conjunction with future sampling, a small proportion of voles should be collected from each study site for positive

identification based on dentition, given that several superficially similar voles may occur within GNP's fescue grasslands. Such sampling would better resolve the small mammal community composition within Glacier's grasslands including possibly documenting new species of small mammals for the park. Moreover, the larger samples will provide more conclusive habitat analyses especially with regard to the impacts of exotic plant invasions on GNP's fescue grassland small mammal communities. Resolving questions about small mammal community composition and habitat relationships is more critical in GNP than elsewhere, because Glacier may have more diverse small mammal communities than elsewhere in the Northern Rockies and thereby have more species to potentially be disrupted or lost to exotic plant invasions. Moreover, GNP has the potential to serve as a conservation reserve for fescue grasslands in the face of exotic transformation of these vegetative communities in the Northern Rocky Mountains. Better understandings of small mammal communities and habitat relationships in GNP's fescue grasslands will be necessary to achieve such goals.

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