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The Intermountain Journal of Sciences is a regional peer-reviewed journal that encourages scientists, educators and students to submit their research, management applications, or view-points concerning the sciences applicable to the intermountain region. Original manuscripts dealing with biological, environmental engineering, mathematical, molecular-cellular, pharmaceutical, physical and social sciences are welcome.

Co-sponsors/publishers include the Montana Academy of Sciences, the Montana Chapter of The Wildlife Society, and the Montana Chapter of The American Fisheries Society. This journal offers peer review and an opportunity to publish papers presented at annual meetings of the co-sponsor organizations. It is the intent of the governing bodies of the co-sponsor organizations that this journal replace printed proceedings of the respective annual meetings. Therefore, it is the policy of the editorial board that presenters at annual meetings of the co-sponsors be given priority in allocation of space and time of publication, although submission of other manuscripts for review and publication without regard to membership is encouraged.

Initial funding was provided by the co-sponsor organizations. Long-term funding will be derived from page charges assessed authors, sponsoring organizations or agencies at $60 per printed page upon acceptance of each manuscript and from annual subscriptions: student $6; regular member $15; patron member $25; overseas member $25; library $25; life member $150; and, sustaining subscriber $2,500.

The intent of the co-sponsors and editorial board is that ***The Intermountain Journal of Sciences*** be expanded to a quarterly journal. Achieving that objective depends upon numbers of acceptable manuscripts received and available funding. It also is the intent of the editorial board that contributing authors be assured of publication within 12 months of acceptance of their manuscript by the managing editor.

The organizational staff is voluntary and consists of an editorial board, an editor-in-chief, a managing editor, associate editors, a business manager and a panel of referees. The editorial board is responsible for establishing policy and the chair of the editorial board serves as liaison to the sponsoring organizations. The editor-in-chief is responsible for determining acceptability and level of revision of manuscripts based on referees' comments and recommendation of an associate editor. The managing editor serves as liaison for layout and printing. Associate editors include but are not limited to the section vice presidents of The Montana Academy of Sciences. Referees are selected on the basis of their field and specific area of knowledge and expertise.

Referees and associate editors judge submitted manuscripts on originality, technical accuracy, interpretation and contribution to the scientific literature. Format and style generally follow the *Guidelines for Manuscripts Submitted to the Intermountain Journal of Sciences, Dusek 1995, revised 2007*.* Organization may vary to accommodate the content of the article, although the text is expected to elucidate application of results.

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Financial Statement (1/01/13 - 12/31/13)

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Income:		
	Subscriptions:	
	Regular Member	$60.00
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	International Member	$25.00
	Subscriptions Total	**$410.00**
	Page Charges	$4,450.00
	Reprints	$441.07
	Back Issue Sales	$10.00
	Refund	$8.00
	Total Income	**$5,319.07**
Expenses:		
	Design and Printing	$3,839.47
	Postage	$198.50
	P. O. Box Rent	$62.00
	Administrative and Bank Fees	$103.50
	Reprints and Layout	$493.35
	Supplies	$100.15
	Storage	$346.00
	Total Expenses	**$5,142.97**
	Balance 12/31/13	**$1,683.47**

Fred Nelson, Business Manager

Editorial Review Policy

The *Intermountain Journal of Sciences* (IJS) is a fully refereed journal.

Manuscripts are submitted to the Editor-in-Chief (EIC) for initial consideration for publication in the IJS. This review shall include, but not be limited to, appropriateness for publication in this journal, correct formatting, and inclusion of a letter of submittal by the author with information about the manuscript as stated in the "Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*" (Dusek 1995, 2007). This cover letter must also include a statement by the author that this paper has not been submitted for publication or published elsewhere. The EIC notes the date of receipt of the manuscript and assigns it a reference number, IJS-xxxx. The EIC forwards a letter of manuscript receipt and the reference number to the corresponding author. The corresponding author is the author who signed the submittal letter.

Three hard copies of the submitted manuscript, with copies of the "Guidelines and checklist for IJS referees" attached are forwarded to the appropriate Associate Editor. The Associate Editor retains one coy of the manuscript and guidelines for his/her review, and submits a similar package to each of two other reviewers. A minimum of two reviewers, including the Associate Editor, is required for each manuscript. The two other reviewers are instructed to return the manuscript and their comments to the Associate Editor, who completes and returns to the EIC a blue "Cover Form" and all manuscripts and reviewer comments plus a recommendation for publication, with or without revisions, or rejection of the manuscript. This initial review process is limited to 30 days.

The EIC reviews the recommendation and all comments. The EIC then notifies the corresponding author of the results of the review and the publication decision.

Acceptance

For accepted manuscripts, each copy of the manuscript containing comments thereon and other comments are returned to the corresponding author. Revised manuscripts are to be returned to the EIC in hard copy, four copies if further review is required, or one hard copy plus the computer disk if only minor revision or formatting is necessary. The revised manuscript shall be returned to the EIC within 14 days of the notification. Review of the revised manuscript by the Associate Editor and reviewers shall be completed and returned to the EIC within 14 days. An accepted manuscript will then be forwarded to the Managing Editor (ME) for final processing.

Rejection

Each manuscript that is rejected for publication is returned by the EIC to the corresponding author along with the reasons for rejection. The author is also advised that the manuscript may be resubmitted, provided all major criticisms and comments have been addressed in the new manuscript. The new manuscript may be returned to the initial review process if deemed appropriate by the EIC. If the manuscript is rejected a second time by either the EIC or the Associate Editor and reviewers, no further consideration will be given for publication of the manuscript in IJS. The corresponding author will be notified of this decision.

Reviewer Anonymity

The identity of all reviewers shall remain anonymous to the authors, called a blind review process. All criticisms or comments by authors shall be directed to the EIC; they may be referred to the ME or the Editorial Board by the EIC for resolution.

Manuscripts Submitted by Editors

Each manuscript submitted by an Associate Editor shall be reviewed by the EIC and a minimum of two other reviewers with expertise in the subject being addressed. Each manuscript submitted by the EIC shall be forwarded with the necessary review materials to the Chairman of the Editorial Board of IJS, who will serve as the EIC for that manuscript.

Abstracts

Only abstracts from the annual meetings of the sponsoring organizations will be published in IJS. Other submissions of abstracts shall be considered on a case-by-case basis by the Editorial Board. Sponsoring organizations shall collect abstracts, review them for subject accuracy, format them in Microsoft Word and email them to Rick Douglass, the EIC (RDouglass@mtech.edu), on or before November 1. Each abstract shall be reviewed by the EIC to assure proper grammar, compliance with IJS "Guidelines for Abstracts Only" and for assignment to the appropriate discipline section. All abstracts will be published in the December issue only.

Commentary

Submissions concerning management applications or viewpoints concerning current scientific or social issues of interest to the Intermountain region will be considered for publication in the "Commentary" Section. This section will feature concise, well-written manuscripts limited to 1,500 words. Commentaries will be limited to one per issue.

Submissions will be peer reviewed and page charges will be calculated at the same rate as for regular articles.

Literature Cited

Dusek, Gary L. 1995, revised 2007. Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*. Int. J. Sci. 1(1):61-70. Revised guidelines are available on the Intermountain Journal of Sciences web site: (www.intermountainjournal.org)

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Diets of Cattle in North Central South Dakota

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Abstract

This study was conducted over a two year period during the summer months on the Grand River National Grasslands near Lemmon South Dakota on a 2,510 ha pasture to determine cattle diets. Cattle feces were collected monthly near each of 8 permanent water tanks located throughout the pasture. Microhistological analysis of cattle feces was used to identify and quantify diets by plant species. Eight common plant species comprised the greatest portion of the diet. Grasses and grass-like plants accounted for 84 percent to 99 percent of the diets with sedges common in spring (79%) and early summer (53%). Key forage species were, sedges (*Carex* spp), blue grama (*Bouteloua gracilis*), needle and thread (*Hesperostipa comata*) and green needlegrass (*Nassella viridula*) that comprised 82 percent of the diet. These plants are key forage species for monitoring seasonal grazing on the grasslands. Forbs ranged from less than 1 percent to 14 percent. Shrubs were a minor component of the diet making up less than 1 percent. Similarity indices changed throughout the season and ranged from 0 to 99 percent, indicating that some plants were highly selected or avoided by cattle (low similarities) and other plant species were consumed in the same proportions as available on the grassland. Rank order correlation indicated seasonal selectivity with an overall correlation of 0.75.

Key words: diets, livestock, northern Great Plains, monitoring, forage

Introduction

Quantitative information about livestock diets and selectivity for forage plants is essential for efficient and prudent management of our rangeland resources on the northern Great Plains. Diets provide useful information for resource managers to allocate forage resources while maintaining long-term productivity and sustainability of the grasslands.

Hart et al. (1983) reported on cattle diets in Wyoming. Vavra et al. (1977), Reppert (1960), and Walker et al. (1981) have reported on cattle diets in Colorado with few species common to rangelands of the Dakotas. Hirschfeld et al (1996) reported that graminoids made up most of the diet, ranging from 72 percent to 99 percent over a two-year period in central North Dakota. Uresk (1986) in western South Dakota reported that six plants made up 82 percent of the food items. Volesky et al. (2007) found that needle and thread, bluegrasses, and sedges together accounted for 74 percent of the cattle diets. Cattle diets provide information for sound management decisions and information for monitoring key forage species by season of use.

The purpose of this study is to determine forage availability, seasonal diets, and key forage species to monitor for livestock grazing in north central South Dakota.

Study Area

The study area was located on gently sloping mixed grasslands in one 2,510 ha pasture on the Grand River National Grasslands near Lemmon, South Dakota. The climate of this area is semiarid-continental and is characterized by cold winters and hot summers. The 102-year average precipitation for this area is 42.7 cm ((High Plains Regional Climate Center, 2012). Most precipitation falls as rain during the growing season, often in high intensity thunder showers. The pasture is grazed by cattle over a 6 month (from May through October) period of each year. The stocking rate for cattle was 1.154 ha/animal month with 362 cows on a 2,510 ha pasture.

Dominant native grasses are western wheatgrass (*Pascopyrum smithii* (Rydb.) Á. Löve) and blue grama (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths). Common sedges include threadleaf sedge (*Carex filifolia* Nutt.) and needleleaf sedge (C. duriuscula C.A. Mey.)_White sage (*Artemisia ludoviciana* Nutt.) and scarlet globemallow (*Sphaeralcea coccinea* (Nutt.) Rydb.) are common forbs. The most common shrub is prairie sagewort (*Artemisia frigida* Willd.). Introduced plant species include crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and sweet clover (*Melilotus officinalis* (L.) Lam.).

Methods

Canopy cover (Daubenmire 1959) for all plant species was estimated in June and September of 1983 and in July of 1984 on 30 m transects for each of nine vegetation sites defined according to Natural Resources Conservation Service descriptions. The number of transects to characterize the vegetation varied according to the area comprised by each vegetation type. Vegetation types with less than 40 ha had only a single transect. Vegetation types that ranged from 40 to 405 ha had two transects, and types with greater than 405 ha had three transects. A total of 21 transects (630 quadrats) for the entire pasture was sampled for each period.

Each transect consisted of 30 quadrats delineated by a 20 x 50-cm frame and separated by ten paces (10 m). Total length of each transect was 300 m. Canopy cover and frequency of occurrence were summarized for each transect. Each vegetation site was then averaged for cover and frequency to obtain values by plant species for the entire pasture.

The pasture was stratified into eight permanent areas based on locations of livestock water tanks. Three fresh fecal samples were collected at random near the water tanks each day over a two day sampling period for each month in May, June, July, August, September and October of 1983 and 1984. Water tanks were spaced from 1.1 km to 2.7 km apart. Each sampling period-month consisted of 48 fecal samples (8 areas x 3 samples x 2 days).

The three fecal samples collected each day from each of the eight sites were oven-dried, ground and composited into eight samples. Thus, each sampling period-site was represented by 16 samples and when sites were averaged over the two day period for microhistological analyses.

Plant fragments in the feces were identified and quantified by methods described by Sparks and Malechek (1968), Rogers and Uresk (1974) and Johnson et al. (1983). All fecal material was ground through a Wiley mill using a 1 mm screen. Five microscopic slides of each sample were made of the fecal material. Twenty fields per slide were viewed under a binocular microscope at 100 power for identifiable plant fragments. Hand compounded test mixtures of plants were used periodically to check accuracy and maintain quality control. A minimum similarity of 90 percent was maintained between actual test mixtures of plants and estimated values of plants (Rogers and Uresk 1974).

Canopy cover and frequency of occurrence for each plant species was summarized for each transect, and each vegetation type and was averaged to obtain a value for the entire pasture. Data from microhistological identification of plant fragments were reported as mean percent relative density per day for each plant species. Differences in dietary use of plant species and plant categories (grasses, forbs, shrubs) among months were determined using analyses of variance (SPSS, 2003). Differences were accepted as significant at $p < 0.10$. Where variances were determined to be heterogeneous, Dunnett's T3 method for non-homogeneous variances was utilized (Dunnett 1980).

Kulczyuski's similarity index (Oosting 1956) was used to compare cattle diets with plant canopy cover to determine degree of association. Spearman's rank order correlation (SPSS 2003) compared overall average canopy cover with cattle diets by total, grass, forbs and shrubs.

Results

Twenty common species were identified on the study site (Table 1). Measurements of average percent canopy cover and percent relative frequency of occurrence revealed crested wheatgrass, blue grama, threadleaf sedge (*Carex filifolia*), western wheatgrass, and needle and thread (*Hesperostipa comata*) to be the most common plants on the pasture. These plants averaged 39 percent, 47 percent, 36 percent, 42 percent and 43 percent frequency of occurrence, respectively. White sage was the most common forb and averaged 16 percent frequency of occurrence.

Eight common plant species were identified in microhistological examination of cattle feces with years combined (Table 2). Grasses and grass-like plants comprised most (84 to 99%) of cattle diets with sedges being by far the most important in this category in spring (79%) and early summer (53%). Five species made up approximately 92 percent of the total diet. Sedges were most abundant in the diet at 35 percent followed by needlegrasses, blue grama and wheatgrasses.

Seasonal trends of the major plants found in the diets during the grazing season were similar for both years and years were combined. Sedges made up most (79%) of the diet early in the season and decreased to a low of 11% in September (Fig. 1). Blue grama increased from a low of 2% in May and begin peaking in July and August at 30 % and 36% respectively in the cattle diets. Needlegrasses were dominate in diets during September (45%) and in October (64%). These key forage species made up 82 percent of the cattle diet. Wheatgrass species were less abundant in spring and late summer (Table 2). Blue grama was most abundant in diets during July and August both years. Consumption of wheatgrasses was consistent throughout the grazing season in diets. Use of forbs ranged from 2 percent to 14 percent, with an average of 4.9 percent. Forbs were abundant in diets during June and July (Table 2). Consumption of forb species increased from May to July and then declined. Shrubs in diets consisted of less than 1 percent during the grazing season.

Percent similarity between forage availability and cattle diets had similarities ranging from 0 percent to a high of 99 percent for grass-grasslike and forb species (Table 3). Low similarities indicate cattle are selecting or avoiding plants while high similarities indicated that cattle are consuming plants in the same relative proportion as available in the pasture. Similarities changed throughout the grazing season indicating seasonal selection of individual plant species. Spearman's rank order correlations were significant at $p=0.01$ for grasses at 0.71, forbs 0.76 and shrubs 0.74. Rank order correlation for all categories combined was significant ($p=0.01$) at 0.75.

Discussion

Sedges (*Carex* species), blue grama, and needlegrasses were important forage species for cattle on the study site and are designated as key species for management and for monitoring. The importance of sedges as forage are common in livestock diets during the spring and is consistent with previous studies in South Dakota, Wyoming, Colorado and Nebraska (Alexander et al. 1983; Hansen and Gold 1977; Hart et al. 1983; Samuel and Howard 1982; Uresk 1984, 1986; Volesky et al. 2007) and re-emphasizes the need for study and management of these species.

Blue grama was most frequent in the diets in mid-season. Needlegrasses and to a lesser degree wheatgrasses, became important late in the season. These changes in importance of forage species over the season should be taken into consideration by rangeland managers and in the evaluation of forage use and regulation of livestock numbers. Efforts to increase forage production should be directed at sedges,

Table 1. Average canopy cover (%C ± SE) and frequency of occurrence (%F ± SE) of plants during three months near Lemmon, South Dakota.

	June 1983		July 1984		September 1983	
Category	%C	%F	%C	%F	%C	%F
Grasses and Sedges						
Agropyron cristatum	25 ± 7	39 ± 11	28 ± 8	39 ± 10	20 ± 5	41 ± 10
Pascopyrum smithii	15 ± 5	43 ± 8	17 ± 4	42 ± 8	8 ± 2	40 ± 7
Aristida purpurea	<1 ± <1	2 ± 1	3 ± 1	11 ± 3	5 ± 1	22 ± 5
Bouteloua gracilis	14 ± 3	41 ± 8	26 ± 5	52 ± 8	15 ± 3	47 ± 7
Carex duriuscula	2 ± <1	6 ± 2	0 ± 0	0 ± 0	10 ± 2	36 ± 5
Carex filifolia	20 ± 5	40 ± 9	16 ± 4	38 ± 8	12 ± 3	29 ± 8
Carex inops	0 ± 0	0 ± 0	3 ± 1	8 ± 3	<1 ±<1	<1 ± 1
Calamovilfa longifolia	<1 ± 1	2 ± 6	0 ± 0	0 ± 0	1 ± <1	11 ± 3
Distichlis spicata	5 ± 3	10 ± 7	6 ± 4	<1 ± 6	5 ± 3	9 ± 6
Koeleria macrantha	3 ± 1	15 ± 4	3 ± 1	13 ± 3	3 ± 1	20 ± 4
Poa pratensis	4 ± 2	12 ± 4	5 ± 4	8 ± 5	4 ± 2	10 ± 4
Hesperostipa comata	7 ± 2	35 ± 8	10 ± 2	40 ± 8	15 ± 2	53 ± 7
Nassella viridula	2 ± 1	6 ± 5	1 ± <1	4 ± 2	2 ± 1	13 ± 4
Other species	1		2		5	
Total	99		120		105	
Forbs						
Ambrosia psilostachya	0 ± 0	0 ± 0	2 ± 1	9 ± 4	3 ± 1	13 ± 5
Artemisia ludoviciana	3 ± 1	15 ± 5	6 ± 2	17 ± 6	3 ± 1	15 ± 4
Symphyotrichum falcatum	0 ± 0	0 ± 0	2 ± 1	8 ± 2	1 ± <1	8 ± 2
Melilotus officinalis	3 ± 2	10 ± 4	<1 ± <1	5 ± 3	2 ± 1	11 ± 4
Sphaeralcea coccinea	1 ± <1	13 ± 4	2 ± <1	17 ± 4	<1 ± <1	11 ± 3
Other species	9		9		16	
Total	16		21		25	
Shrubs						
Artemisia dracunculus	2 ± <1	22 ± 3	5 ± 1	28 ± 4	4 ± 1	26 ± 5
Artemisia frigida	4 ± 1	34 ± 5	7 ± 1	38 ± 5	3 ± <1	32 ± 2
Other species	<1		<1		<1	
Total	6		12		7	

Table 2. Average relative density (%± SE) of plants in cattle diets, two years combined, over six months near Lemmon, South Dakota.

Plant taxa	May	June	July	Aug	Sept	Oct
Grasses and Sedges						
Pascopyrum smithii *Agropyron cristatum*	7±<1a*	8 ±<1a	6±<1a	9± 1a	18± 2b	7±<1a
Bouteloua gracilis	2±<1a	14± 2b	30± 1c	36± 2c	20± 2d	13± 1b
Sporobolus cryptandrus	<1±<1a	<1±<1a	<1±<1b	3±<1b	<1±1b	<1±<1a
Hesperostipa comata *Nassella viridula*	9± 2a	14± 1a	14±<1a	24± 2b	45± 3d	64± 2e
Carex duriuscula *Carex filifolia*	79± 2a	53± 3b	30± 2c	23± 3c	11± 1d	13±<1e
Other grasses[1]	<1±<1a	3±<1b	4±<1b	2±<1b	2±<1b	1±<1c
Total grasses	98±<1a	93±<1b	84± 2c	99± 3a	97±<1d	99±<1a
Forbs						
Sphaeralcea coccinea	<1±<1a	<1±<1b	2±<1b	<1±<1b	<1±<1b	<1±<1b
Meliotus officinalis	1±<1a	5±<1b	10±<1b	<1±<1a	0b	0b
Other forbs	1±<1a	2±<1a	2±<1a	2±<1a	2±<1a	<1±<1b
Total forbs	2±<1a	7±<1b	14± 2b	3±<1c	2±<1a	<1±<1d
Total shrubs	<1±<1a	<1±<1a	<1±<1a	<1±<1a	<1±<1a	<1±<1a

* Means for each row followed by a similar letter are not significantly different at p>0.05.
[1] Other plant species that comprised less than 0.7% of the diet by category included: 10 grasses and sedge species, 13 forbs and 4 shrubs.

blue grama, needlegrasses and wheatgrass species. Blue grama can be increased and maintained by season long grazing at 40 percent-55 percent utilization (Johnson et al. 1951). When the management goal is to increase or maintain needlegrasses, sedges and western wheatgrass, a reduced stocking rate (light grazing) with a lower utilization rate is required (Van Poolen and Lacey 1979; Kipple and Bement 1961; Lewis et al. 1956).

Dietary use of forbs by cattle can vary between years and is attributed to differences in precipitation, especially annual forbs (Rutherford 1980). Use of forb species increased from May to July of each year and then declined. Similar trends have been reported in studies on other rangelands (Uresk and Paintner 1985; Holechek et al. 1982a, 1982b).

Shrubs are generally consumed by cattle late in the growing season when grasses and forbs are mature and less digestible while shrubs remain green and are more palatable.

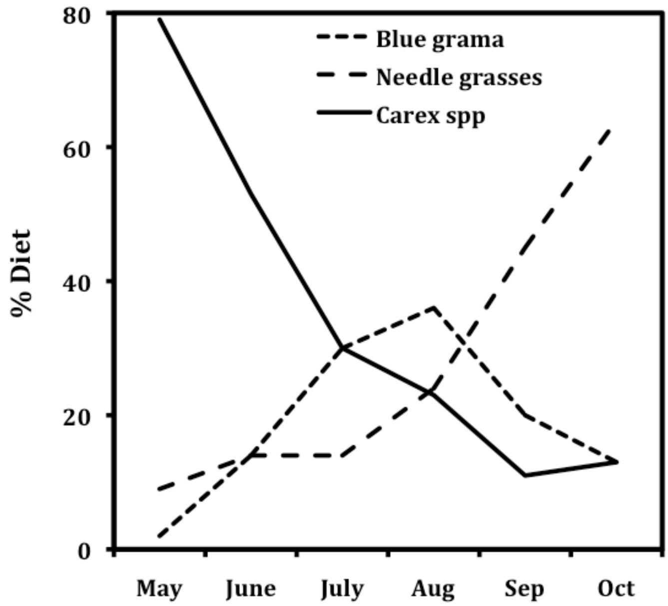

Figure 1. Seasonal trends of blue grama, needlegrasses and sedges in cattle diets from May through October based on average relative density (%) making up 82 percent of the cattle diet.

Table 3. Percent similarity between forage availability and cattle diets during three months at Lemmon, SD.

Category	June 1983	September 1983	July 1984
Grass and Sedges			
Agropyron cristatum *Pascopyrum smithi*	31	33	28
Bouteloua gracilis	95	88	70
Carex filifolia *Carex duriuscula*	66	0	78
Sprobolus spp.	88	77	65
Hesperostipa comata *Nassella viridula*	69	38	99
Forbs			
Meliotus officinalis	60	0	90
Sphaeralcea coccinea	39	34	27

Similar trends have been noted in other studies on other areas (Uresk and Paintner 1985; Holechek et al. 1982b, 1982c; Roath and Krueger 1982).

Several forage species with high similarity indices included blue grama , needlegrasses and Sprobolus spp. High similarity indices indicate that cattle were consuming these forage plants in the same proportions as availability in the pasture. Other plants such as the sedges are highly variable throughout the grazing season. Plants with low similarity indices are highly selected or avoided by cattle. It is apparent from the information that selectivity or avoidance for certain plants changed with seasonal availability in the pasture as demonstrated by Reppert (1960). Spearman rank order correlations by category ranged from 0.71-0.76, indicating that forage were not always selected for by cattle in the same portions as their availability in the pasture.

This study, although conducted in one 2, 510 ha pasture, provides information that is useful to range managers for improvement of range management practices and more efficient allocation of forage for sustained plant productivity. This study shows that dietary variations in plant species do occur throughout the grazing season. Key plants would allow efficient monitoring of the grassland throughout the grazing season. These plants include blue grama, needle and thread, green needlegrass (*Nassella viridula*), needleleaf sedge (*Carex duriuscula*) and threadleaf sedge. Similarity indices and Spearman correlations indicated that selectivity on particular species of plants varied throughout the grazing season by cattle.

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Effects of Cattle Grazing on Small Mammal Communities at Red Rock Lakes National Wildlife Refuge, Montana

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Abstract

Cattle grazing is a common land-use on public land in the Intermountain West that often has varied and complex effects on wildlife. We undertook the current study to better understand the response of small mammals to the frequency of cattle grazing in wet meadow habitats on Red Rock Lakes National Wildlife Refuge. Three adjacent grazing units were selected for study that provided a range of rested grazing units (one, three, and eight years of rest). We captured and marked 363 individuals, and had 174 recaptures on six 1.8 ha grids over 27 days. Voles (*Microtus* spp.) comprised 99 percent of individuals captured, with two deer mice (*Peromyscus maniculatus*), and one common shrew (*Sorex cinereus*). Vole abundance increased with increasing rest from grazing. Nearly 61 percent (221) of voles were captured in the unit with 8 years of rest from grazing; 26 percent (94) and 13 percent (48) of total captures were in units of three and one year of rest, respectively. Apparent 8 day survival probability estimates were 0.45 (±0.12 SE), 0.62 (±0.12) and 0.35 (±0.09) for treatments with one, three and eight years of rest, respectively. Litter depth and physiognomic classes litter, and forb, and bare ground approached an asymptote after three years rest from grazing.

Key Words: abundance, *Microtus*, Robust Design, survival, vole, wet meadow.

Introduction

Population dynamics of small mammals are often characterized by inter- and intra-annual fluctuations in abundance that can range across several orders of magnitude. Population fluctuations have been attributed to a number of variables, including plant biomass. For example, as plant biomass increases from spring to fall, small mammals are afforded increased food and cover which can allow populations of voles (*Microtus* spp.) to reach an intra-annual peak in the late summer/early fall (Birney et al. 1976, Abramsky and Tracy 1979, Erlinge et al. 1983). Peles and Barrett (1996) described a reduction in vole density as a result of decreasing plant biomass in grassland habitat. Mean vole densities were nearly 1.5 times lower in reduced plant biomass treatments than densities in the control or enhanced plant biomass treatment. Similarly, Runge (2005) found meadow voles (*M. pennsylvanicus*) and montane voles (*M. montanus*) avoided grazed grasslands with lower plant biomass than otherwise similar non-grazed grasslands.

Survival of small mammals is also shown to be linked to vegetative cover. For example, Birney et al. (1976) and Peles and Barrett (1996) demonstrated vole survival to be asymptotically related to vegetative cover with marked declines in survival below a threshold level of cover. Getz et al. (2005) showed that differential survival, among habitats and between species of *Microtus*,

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correlated with increased vegetative cover. Greater amounts of vegetative cover likely benefits small mammals through improved protection from predators, reduced territorial conflicts, and increased availability of favorable microhabitats (Birney et al. 1976, Erlinge 1987, Douglass and Frisina 1993, Korpimäki and Krebs 1996, Peles and Barrett 1996). Grazing reduces vegetative cover through consumption and trampling, and therefore may reduce small mammal survival by increasing the efficiency of avian (Baker and Brooks 1982) and mammalian (Bowman and Harris 1980) predators. Schmidt et al. (2005) found survival of field voles (*M. agrestis*) in Danish wet meadows was generally lower in plots heavily grazed by cattle relative to non-grazed plots.

Anthropogenic land-uses can also greatly affect small mammal populations, largely through one or a combination of the processes outlined above. Cattle grazing, a common land-use across the Intermountain West reduces small mammal populations by reducing plant biomass within a field (Birney et al. 1976, MacCracken et al. 1984, Fleischner 1994). Keesing (1998) has shown that pocket mouse (*Saccostomus mearnsi*) density increased as much as 100 percent in previously grazed habitats after the exclusion of large animals. Rosenstock (1996) describes non-grazed sites as having 50 percent greater species richness and 80 percent higher small mammal abundance than similar grazed sites.

Although livestock grazing is a controversial public land-use in western North America (Fleischner 1994), grazing by large herbivores is a disturbance that Intermountain West grasslands and wet meadows evolved with over recent millennia (e.g., Carpenter 1940, Russell and Haines 1965, Frisina and Mariani 1995). Grazing as a land management tool, if timed properly, can provide diverse and favorable habitat for small mammals (Clark et al. 1997, Bouska and Jenks 2006). While continuous grazing may reduce plant biomass and structure, negatively affecting small mammal communities, periodic grazing has been shown to increase abundance of small mammals such as voles and mice (*Peromyscus* spp.) (Bouska and Jenks 2006). Light or moderate levels of herbivory can also increase plant productivity in some systems (Dyer et al. 1993, Milchunas and Lauenroth 1993, Frank et al. 2002). Moreover, the mechanical action of hooves can help break up hard soil as well as aid in seed dispersal and establishment (Frisina and Keigley 2004). Therefore, periodic grazing may provide greater biomass and diversity of vegetation favorable to small mammals.

The current study investigated the response of small mammal abundance, survival, and community composition to the frequency of cattle grazing in wet meadow habitats on Red Rock Lakes National Wildlife Refuge. We hypothesized that species diversity, apparent survival and abundance would be positively related to time since last grazed (Reynolds and Trost 1980, Fleischner 1994, Rosenstock 1996, Keesing 1998). Deer mouse (*Peromyscus maniculatus)* abundance is positively related to disturbances that produce lower vegetation biomass and increased proportions of exposed soil (Grant et al.1982, Fleischner 1994, Matlack et al. 2001, Hadley and Wilson 2004). Therefore, we also hypothesized that deer mouse abundance would decrease as the time since grazed increased.

Study Area

The study was conducted on Red Rock Lakes National Wildlife Refuge (hereafter Refuge) in southwestern Montana. The Refuge encompasses 18,210 ha of the Centennial Valley, with elevations ranging from 2013 m above mean sea level (msl) to > 2926 m msl. Average annual precipitation, as measured at Refuge headquarters (2039 m msl), is 49.5 cm with 27 percent occurring during May and June. Annual average temperature is 1.7º C. The *Juncus balticus – Carex praegracilis* vegetative alliance (National Vegetation Classification Standard [NVCS]; Anderson et al. 1998) (hereafter wet meadow), is a predominant habitat on the Refuge, covering ~2,869 ha.

Wet meadow habitat is characterized by an elevated water table, which results in relatively dense graminoid ground cover.

The Refuge grassland management plan (USFWS 1994) recommended two full growing seasons of rest between grazing treatments. Cattle were put on units no earlier than 10 July of the third year since last grazed. Stocking rates (Animal-unit-month, or AUM) for each grazing unit were determined by a US Soil Conservation Survey range assessment conducted in 1987 (USFWS unpubl. report). Grazing units were grazed at ~100 percent of the recommended AUMs during the year of grazing treatment (Table 1).

Methods

Three adjacent Refuge grazing units that differed in the number of years rested since grazed (one [1YSG], three [3YSG], and eight [8YSG] years) were selected for study (Table 1; Fig. 1). Two trapping grids per unit were located by selecting random points within wet meadow habitat using the Systematic Point Sampling tool extension (Minnesota DNR Sampling Tool V. 2.8) in ArcView GIS 3.3 (ESRI, Redlands, California) and a 100 m buffer from the grazing treatment boundary. Small mammal trapping followed Hadley (2002). Grids comprised 100 Sherman© live traps (23.5 x 8 x 9 cm in size) placed in a 10 trap x 10 trap configuration (1.8 ha), with traps spaced 15 m apart.

Trapping followed a Robust Design (Pollock 1982; see Data Analysis below) procedure with three primary trapping occasions each divided into 18 secondary trapping occasions (*2 secondary occasions day-1x3 days unit-1x3 grazing units*). Between the primary sampling occasions the population was open to gains and losses; during secondary sampling occasions the population is assumed to be closed. Trapping grids were deployed for three days in each unit during each of three nine-day primary trapping occasions. Traps were checked twice daily before 1200 hrs, resulting in two secondary occasions each day. Traps were closed after the second daily check and reopened each evening. Primary occasions were separated by two days during which trapping did not occur, resulting in eight days between primary occasions for a given grazing unit. The order of trapping by unit in the first primary occasion was randomly selected; the same order was followed during the second and third primary occasions. Traps were baited with rolled oats and peanut butter and a polyester wad was placed in each trap to reduce small mammal deaths due to hypothermia. A cedar shingle was placed over each trap to provide shade in order to reduce the risk of hyperthermia for trapped individuals. Individuals were identified according to species, gender, weighed, and on first capture marked with a uniquely numbered ear tag (size 1005-1, National Band and Tag Company, Newport, Kentucky). Ear tag number was recorded each time the individual was captured. We were not able to accurately differentiate between montane and meadow voles in the field for this study, therefore interpretations and discussions are presented for these species combined.

Vegetation Characteristics

To quantify vegetation characteristics in each trapping grid, we used the point-line intercept method (Bonham 1989). We

Table 1. Grazing unit area and grazing history for units selected for small mammal trapping at Red Rock Lakes National Wildlife Refuge, 2007.

Grazing unit	Total area (ha)	Wet meadow (ha)	Year last grazed	Recommended AUMs	AUMs Used
15a	358	237	2004	608	700
15b	348	278	1999	643	605
15c	502	421	2006	1035	1031

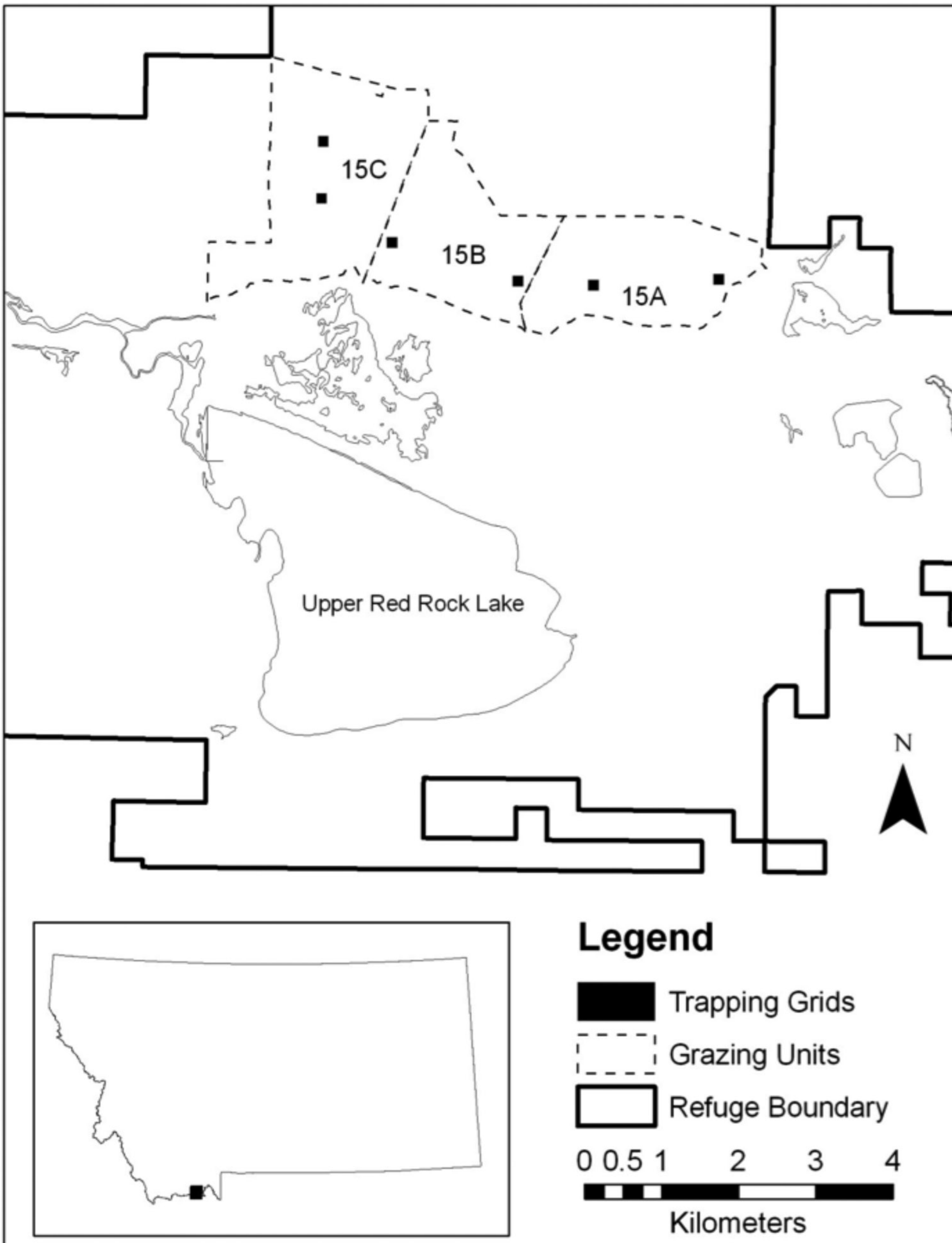

Figure 1. Location of study area, grazing units, and small mammal trapping grids at Red Rock Lakes National Wildlife Refuge, Montana. Grazing treatments were one, three, and eight years of rest for units 15c, 15a, and 15b, respectively. Inset map shows the Refuge location within Montana.

established four 25-m line transects within each trapping grid by randomly generating Universal Transverse Mercator (UTM) locations and randomly selecting a north or south orientation to place the transect. Transects were placed due north or south of random points to prevent intersecting a trap line and the associated vegetation disturbance created from repeatedly checking traps. We used point-intercept methods to measure percent cover of herbaceous vegetation, litter, and bare ground and litter depth (± 0.1 cm). Point intercept data were recorded at one meter intervals with a vertically placed five mm diameter sharpened dowel marked at decimeter intervals. We recorded each physiognomic class (shrub, bunchgrass, rhizomatous grass, forb, litter, and bare ground) that intercepted the dowel. We included height data for litter and number of hits per transect for other physiognomic groups.

Data Analysis

We modeled vole apparent survival using Robust Design capture-recapture models (Pollock 1982) in Program MARK (White and Burnham 1999). To test for differences in vole apparent survival among grazing units, we compared models with grazing unit as a categorical covariate (*g*) to models of constant (.) and time varying (*t*) apparent survival. Because vegetation structure as measured during this study did not differ between units 3YSG and 8YSG (see Results below), we included models that allowed survival to differ between the most recently grazed unit (1YSG) and the other units to test for a relationship between vegetation structure and vole apparent survival. Models allowed capture (*p*) and recapture (*c*) probabilities to be constant or vary by grazing unit or time. Due to low number of captures during the first primary occasion, we also tested models in which *p* during the first occasion differed from *p* during the second and third occasions. Due to modest sample sizes, we did not examine additive models in our model set. Candidate models were ranked using Akaike's Information Criterion corrected for small sample size (AIC_c) (Burnham and Anderson 1998). From the most parsimonious model of apparent survival, we derived vole abundance by grazing unit using Huggins' conditional likelihood method (Huggins 1989, 1991).

We further investigated relationships among grazing and small mammals using vegetation characteristics. We tested for differences among grazing treatments for each physiognomic class with one-way ANOVAs. *P* values < 0.05 were considered significant. For physiognomic classes that did not have constant variation among treatments (i.e., failed a Fligner–Killeen test at $\alpha = 0.05$), we employed a nonparametric Kruskal–Wallis test (Crawley 2007).

Effective trap area was estimated by adding the area of the grid (1.8 ha) to the area of the buffer determined by the mean maximum distance moved (MMDM) (Wilson and Anderson 1985).

Results

We captured 363 individuals and had 174 recaptures during 54 secondary occasions from 9 July – 7 August 2007. Close to 61 percent (221) of small mammals marked were captured in the grazing unit with eight years of rest. The number of individuals captured in the grazing units with three years of rest and in one year of rest was 25.9 percent (94) and 13.2 percent (48), of the total captures, respectively. Voles comprised 99 percent of the small mammals captured, with only two deer mice and one common shrew (*Sorex cinereus*) comprising the remaining nearly one percent of individuals captured. Of the 26 vole mortalities occurring during capture, seven were processed with four identified as meadow voles, two montane voles, and one undetermined.

Our most parsimonious model of survival indicated that 1) vole apparent survival (φ) varied among grazing units; 2) capture rates (*p*) varied among grazing units and between capture sessions one and capture sessions two and three; and, 3) recapture rates varied among capture sessions but not among grazing units (Table 2).

Vole apparent survival, i.e., the combined probability of surviving and not permanently emigrating, was greatest in the unit rested for three years from cattle grazing, lowest in the unit with eight years of rest, and intermediate in the unit most recently grazed. Apparent survival estimates, for the eight day interval between primary occasions, were 0.45 (±0.12 SE), 0.62 (±0.12) and 0.35 (±0.09) for treatments

Table 2. Ranking of Robust Design capture-recapture models investigating effects of cattle grazing on vole (*Microtus* spp.) apparent survival (ψ), capture (p), and recapture (c) probabilities. We tested models in which φ, p and c were constant (.) or varied with time (t) or grazing unit (g). Models with φ differing between the most recently grazed unit (1 year since grazed [YSG]) and units with more rest (3YSG and 8YSG) were also included to test for an influence of vegetation structure on φ (VS). Due to low number of captures during the first primary occasion, we also tested models in which p(g) during the first occasion differed from $p(g)$ during the second and third occasions ($p2\&3(g)$). Only the 95% confidence interval of models (i.e., model weights sum to ≥ 0.95) are given. For models presented immigration (γ') and emigration (γ'') = 0.

Model structure	ΔAIC_c [a]	Akaike weight[b]	k[c]
$\psi_{(g)} + p1_{(g)} + p2\&3_{(g)} + c_{(t)}$	0.00	0.490	12
$\psi_{(g)} + p1_{(g)} + p2\&3_{(g)} + c_{(.)}$	1.79	0.200	10
$\psi_{(g)} + p_{(t*g)} + c_{(t)}$	4.06	0.064	15
$\psi_{(t)} + p1_{(g)} + p2\&3_{(g)} + c_{(t)}$	4.21	0.060	11
$\psi_{(VS)} + p1_{(g)} + p2\&3_{(g)} + c_{(t)}$	4.23	0.059	11
$\psi_{(t*g)} + p1_{(g)} + p2\&3_{(g)} + c_{(t)}$	5.93	0.025	15
$\psi_{(t)} + p_{(t1*g)} + p_{(t2\&t3*g)} + c(.)$	6.03	0.024	9
$\psi_{(VS)} + p1_{(g)} + p2\&3_{(g)} + c(.)$	6.04	0.024	9

[a] The difference in AIC_c scores between the present model and the best model (1534.19).
[b] Normalized relative model likelihood.
[c] Number of estimated parameters in the model.

with one, three and eight years of rest, respectively (Fig. 2). We did not find support for our hypothesis that vole survival would be influenced by vegetation structure; models that included vegetation structure as a covariate were >4.2 AIC_c units from the best model. Capture rates were 0.43 (±0.18 SE), 0.23 (±0.05), and 0.38 (±0.10) for treatments with one, three and eight years of rest, respectively. The recapture rates did not vary among grazing treatments but did vary among primary sessions. Recapture rates were 0.11 (±0.07 SE), 0.26 (±0.04), and 0.17 (±0.02) for primary session one, two and three, respectively.

Vole abundance increased with increasing rest from grazing, and throughout the trapping period for units with at least three years of rest from grazing. Too few captures occurred during the first primary occasion to allow estimation of vole abundance corrected for detection probability. Estimated vole abundances by treatment during the secondary occasion were 35.7 (±8.0 SE), 59.0 (±12.7) and 108.4 (± 22.5) individuals for one, three and eight years of rest, respectively. Estimated vole abundances during the third primary occasion were 30.2 (± 6.9 SE), 82.3 (± 17.3 SE) and 196.1 (± 40.1 SE) individuals for treatments with one, three and eight years of rest, respectively (Fig. 3).

Litter depth did not differ between units with three and eight years of rest, but was significantly lower in the unit with only one year of rest, apparently approaching an asymptote (Fig. 4). Mean litter depth was 3.3 cm (±0.23 SE), 9.5 cm (±0.42), and 9.6 cm (±0.34) for treatments with one, three, and eight years of rest, respectively. Physiognomic classes that differed significantly for ground cover among grazing treatments included forbs, bare ground and litter (Table 3). Both forb and litter cover increased with time since last grazed, while bare ground decreased

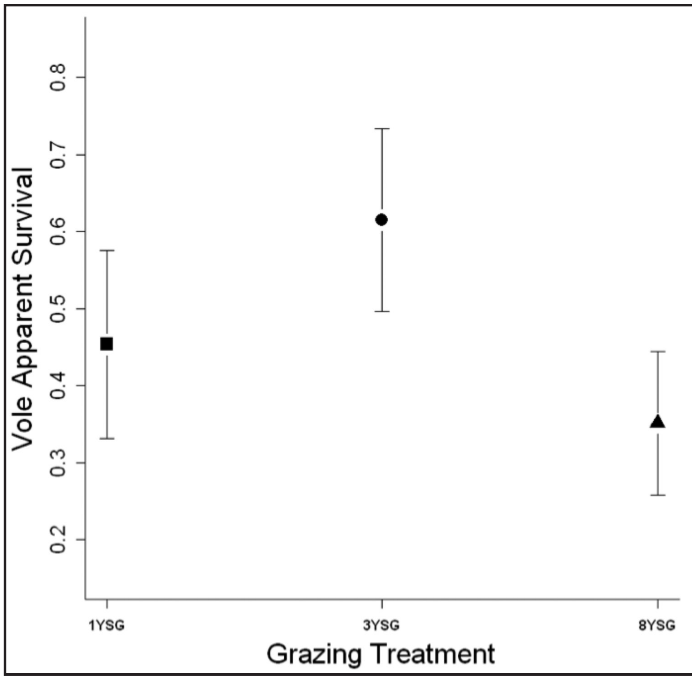

Figure 2. Apparent survival (±1 SE) by grazing treatment in grazed wet meadow at Red Rock Lakes National Wildlife Refuge, Montana, 2007. Grazing treatments include one year since grazed (1YSG), three years since grazed (3YSG), and eight years since grazed (8YSG).

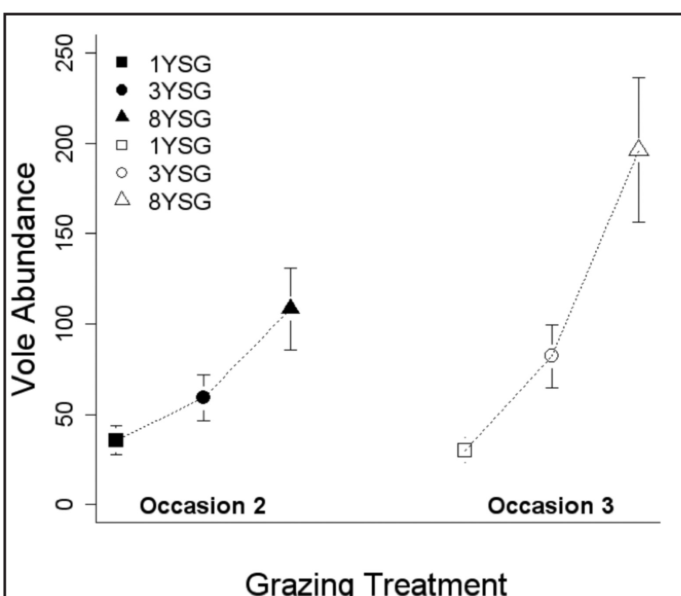

Figure 3. Vole abundance (±1 SE) by grazing treatment and primary trapping occasion (second and third occasions only) in grazed wet meadow, Red Rock Lakes National Wildlife Refuge, Montana, 2007. Grazing treatments include one year since grazed (1YSG), three years since grazed (3YSG), and eight years since grazed (8YSG). Abundance estimates for primary session one were imprecise due to small sample size and are therefore not given.

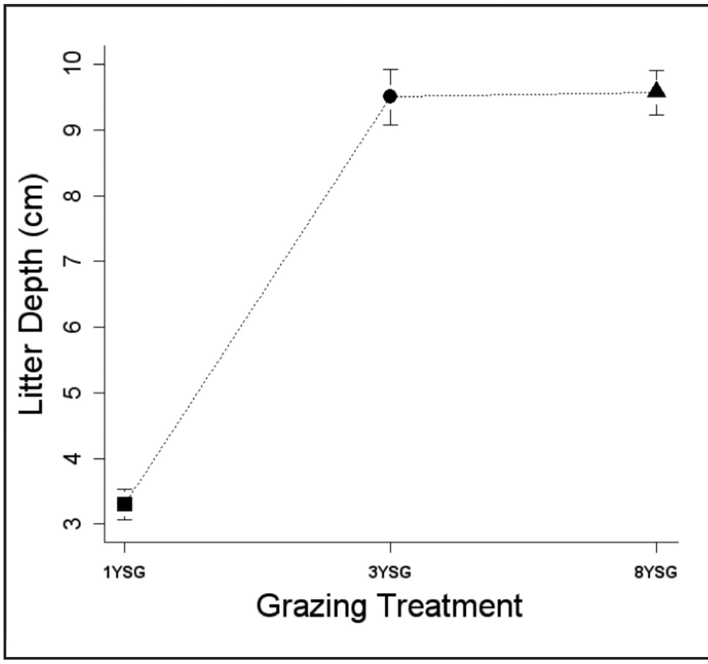

Figure 4. Mean litter depth (±1 SE) by grazing treatment in grazed wet meadow at Red Rock Lakes National Wildlife Refuge, Montana, 2007. Grazing treatments include one year since grazed (1YSG), three years since grazed (3YSG), and eight years since grazed (8YSG).

Table 3. Vegetation physiognomic class ground cover frequency by grazing treatment and results of one-way ANOVA tests of mean hits by transect. *F* statistics and *P* values for each test are given. Grazing treatments are one year since grazed (1YSG) (15 C), three years since grazed (3YSG) (15 a), and eight years since grazed (8YSG) (15 B).

Class	15A (%)	15B (%)	15C (%)	$F_{2,21}$	P
Bunch grass	1.13	2.17	2.61	0.40	0.674
Rhizomatous grass	29.43	28.16	30.88	2.43	0.112
Sedge/ Rush[a]	15.47	17.33	11.40	5.22	0.074
Forbs	16.41	16.25	10.21	4.17	**0.030**
Bare ground	0.56	0.18	3.33	15.59	**<0.001**
Moss	1.13	0.72	0.00	1.14	0.339
Litter	35.85	35.20	39.68	4.71	**0.020**
Standard Error	±1.35	±1.31	±1.41		

[a] A Kruskal–Wallis nonparametric test was run on this vegetation class, therefore the result is a χ^2 statistic and not an *F* statistic.

(Fig. 5). Mean forb hits per transect by grazing treatment were 5.38 (±2.3 SE), 10.88 (±2.3), and 11.25 (±2.3) for one, three, and eight years of rest, respectively. Mean litter hits per transect by grazing treatment were 20.88 (±1.22 SE), 23.75 (±1.22), and 24.38 (±1.22) for one, three, and eight years of rest, respectively. Mean bare ground hits per transect by grazing treatment were 1.75 (±0.31 SE), 0.38 (±0.31), and 0.13 (±0.31) for one, three, and eight years of rest, respectively. Similar to litter depth, lack of significant differences between treatments with three and eight years of rest across these habitat attributes indicated little change in vegetation structural attributes with additional rest from grazing.

Discussion

Small mammals are important components of grassland ecosystems. They provide prey for meso-predators and aid in seed dispersal and vegetative recovery of the habitats in which they reside (Milton et al. 1997, Fields 1999). Cattle grazing, a common practice on western grasslands, has been shown to have varied effects on small mammal populations. Grazing has been demonstrated to both increase and decrease small mammal abundance. Keesing (1998) showed continual cattle grazing decreased small mammal populations as much as two-fold. However, Bouska and Jenks (2006) demonstrated an increase in deer mice and meadow vole abundance in a rest rotation grazing system. Our results provide further insight into the effects of cattle grazing on small mammal communities in a wet meadow habitat.

Similar to studies that found decreased vole abundance in grazed grassland (Reynolds and Trost 1980, Fleischner 1994, Rosenstock 1996, and Keesing 1998), we found support for our prediction of increasing vole abundance with increasing rest from grazing. Vole abundance was consistently highest in the unit with the longest rest from grazing. In the two units with at least three years of rest, vole abundance increased during the study;

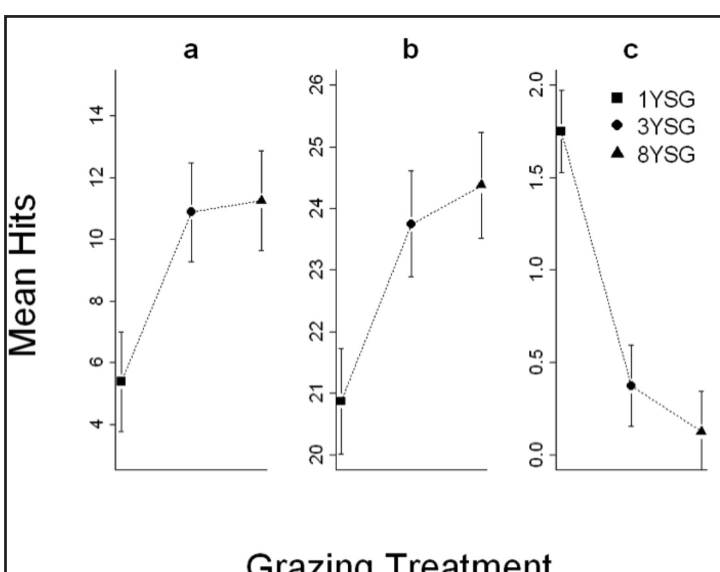

Figure 5. Mean a) forb, b) litter cover, and c) bare ground hits (±1 SE) per point-intercept transect by grazing treatment at Red Rock Lakes National Wildlife Refuge, Montana, 2007. Grazing treatments are one year since grazed (1YSG), three years since grazed (3YSG), and eight years since grazed (8YSG).

these units also had similar litter depth and litter and forb cover. Vole abundance did not increase during the study in the most recently grazed unit, which had significantly lower litter depth and litter and forb cover than the other treatments. This provides further evidence of the link between vole abundance and plant biomass (Peles and Barrett 1996).

We predicted that vole apparent survival would be positively related to vegetation structure. However, models that allowed survival to vary between units based on vegetation structure were not well supported. Instead, apparent survival was lowest in the grazing unit with the most rest from grazing and greatest in the unit with an intermediate level of rest from grazing. Vegetative cover did not differ between these two units, but vole abundance was significantly higher in the unit with the lowest estimated apparent survival. Reduced survival in an area of high small mammal abundance could be due to a positive response of predators to prey density. Korpimäki and Norrdahl (1989, 1991) described rapid immigration of raptors to areas of high vole density. Alternatively, emigration of voles from the unit with greatest abundance could have also accounted for lower apparent survival. We assumed a closed population, i.e., no emigration or immigration, in our modeling of apparent survival due to modest sample sizes. However, emigration is common in high-density small mammal populations (Runge 2005), and if occurring, would result in a low-biased estimate of apparent survival (Runge et al. 2006).

The community composition of small mammals during this study was very homogenous; virtually all of the small mammals captured were *Microtus* spp. We hypothesized that deer mice would represent a high percentage of captures in the most recently grazed unit due to the species' affinity for disturbed habitat (Grant et al.1982, Fleischner 1994, Matlack et al. 2001, Hadley and Wilson 2004). However, only two deer mice were captured during this study, and none were captured in the most recently grazed unit. Disturbance levels from grazing were apparently not enough to attract deer mice. Alternatively, deer mice may negatively select for wet meadow habitats. Austin and Pyle (2004) similarly had very low capture rates for deer mice in montane wet meadow habitat. Contrary to our original prediction that species diversity would increase with time since last grazed, species diversity did not appear to be linked to grazing treatment.

Vegetation structure in wet meadow habitat at the Refuge did not change significantly with rest from grazing greater than three years. Results indicated litter depth and forb and litter cover in grazed wet meadows approached an asymptote with no significant increase between three and eight years of rest from grazing. Bare soil was significantly greater in the most recently grazed unit, but similarly did not differ significantly between units with three and eight years of rest. Most studies of riparian or wet meadow habitat vegetation response to grazing compare grazed to non-grazed sites (e.g., Leege et al 1981, Schulz and Leininger 1990), which generally precludes comparison of our results with existing work. For example, Leege et al. (1981) found more abundant litter in moist and wet montane meadow sites in Idaho after 12 years of excluding grazing. No interim data were collected during this study, however, so it is not possible to determine when, or if, litter approached an asymptote in the exclosures similar to what was observed in this study. Results such as ours provide greater understanding of temporal changes in vegetation structure in habitats that are managed using periodic disturbance.

Our results indicated complex relationships among vole abundance and apparent survival, and vegetation structure, on grazed wet meadow habitat at Red Rock Lakes National Wildlife Refuge. The recommended two years of rest between grazing treatments utilized by the Refuge (USFWS 1994) appeared to have been sufficient for recovery of vegetation structure in wet meadows during this study.

However, vole abundance consistently increased with the number of years of rest from grazing, indicating two years of rest was not adequate for vole populations to reach maximum abundance in the wet meadow habitats. Vole apparent survival did not appear to be related to wet meadow vegetation structure. Given the dynamic inter-annual variation commonly observed in vole populations, multiple year studies similar to ours would be beneficial in more thoroughly understanding the interactions of vole population dynamics and cattle grazing in wet meadow habitat.

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Heart Rate Effects of Longboard Skateboarding

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Abstract

The longboard skateboard has a longer, and usually wider, deck than the standard skateboard to provide greater support of the rider during the higher speeds attained on this version of the skateboard. Fourteen volunteer subjects participated in downhill and uphill longboarding trials. Heart rates were monitored during both trials, and the downhill and uphill average heart rates were compared with resting heart rates and then compared with accepted intensity recommendations for health and fitness benefits. The study questions were: Does longboarding have an acute effect on heart rates? If so, will longboarding uphill and/or downhill cause heart rate changes to levels recommended to improve cardiorespiratory health and fitness? With these questions as guidance we developed four hypotheses. With an average resting heart rate of 59.9 beats/minute, average downhill heart rate of 131.4 beats/minute and average uphill heart rate of 167.8 beats/minute statistical analysis showed statistically significant p values < .0001 and each null hypothesis was rejected in favor of their respective research hypotheses. Based on average age and average resting heart rate, average age-predicted maximum heart rate was 193.2 beats/minute and heart rate reserve was 133.2 beats/minute. The average percentages of heart rate reserve for the downhill section (131.4 beats/minute) and the uphill section (167.8 beats/minute) were 54% and 81%, respectively. Downhill heart rates are within moderate intensity levels, 40% to 60% of heart rate reserve, and uphill heart rates are within vigorous intensity levels, greater than 60 % of heart rate reserve. These results indicate that longboarding can increase heart rate to suggested levels suggested by the American College of Sports Medicine for improving cardiovascular health and fitness.

Key words: skateboarding, longboarding, heart rate, effects

Introduction

We examined the heart rate responses to longboard skateboarding uphill and downhill on a two mile section of a walking trail in uptown Butte, Montana with a two percent grade. According to Josh Friedberg of the International Association of Skateboard Companies, skateboarding first originated in California in the 1950s; surfers made their own skateboards out of wood and metal rollerskating wheels. These early skateboards were used for surfing the streets. In the 1970s, the invention of polyurethane wheels revolutionized the skateboarding scene. These wheels were much smoother, faster and safer, and they made skateboarding more fun. Since the 60s and 70s, skateboarding has taken on a different look altogether. The tricks that are done today were unfathomable in the early 70s. Usually measuring between 90 and 150 centimeters in length, the longboard skateboard has a longer, and usually wider, deck than the standard skateboard to provide better support of the rider during the higher speeds attained on this version of the skateboard. It was created for cruising and carving as opposed to the tricks that are common to the standard skateboard (personal interview, 2012).

Studies show that American children are becoming increasingly overweight, which may lead to chronic lifestyle related diseases at an accelerated pace (Strauss and Pollack 2001, Troiano and Flegal 1998) . In fact obesity in the 6-19 year age category has more than tripled in the last 30 years from 5% to 18%. In 2008, more than 1/3 of children and adolescents were considered overweight or obese (Centers for Disease Control, 2012). Children should be encouraged to participate in a variety of activities that exercise all major muscle groups. Identifying activities, such as longboarding, that may be healthy but are somewhat non-traditional are important because these activities may be a part of the solution for many American adults and children.

Americans are encouraged to exercise at a moderate intensity at least 150 minutes/week (ACSM 2009, United States Department of Health and Human Services 2012). Heart rate reserve (HRR) is the difference between a person's maximum heart rate and resting heart rate, and exercise professionals use a percentage of HRR to prescribe cardiovascular exercise intensity for improving fitness (ACSM 2009). Moderate intensity is defined by the American College of Sports Medicine (ACSM) as 40% to <60% of heart rate reserve and vigorous intensity is defined as > 60% of heart rate reserve (ACSM 2009, Swain & leutholtz 1997). A comprehensive literature review found no studies focusing on the heart rate effects of skateboarding or longboarding. The vast majority of articles in the peer-reviewed literature focused on skateboarding injuries.

Research Questions/Hypotheses

An inverse relationship exists between physical activity and lifestyle related chronic disease such as cardiovascular diseases, hypertension, obesity and type 2 diabetes (ACSM, 2009). Any movement may increase heart rate and, therefore, may have beneficial effects on health. However, some may perceive longboarding downhill as simply going for a ride down a hill with little, if any, physical work done during this activity. Does longboarding have an acute effect on heart rates? Will uphill longboarding have an effect on heart rate? Will downhill longboarding have an effect on heart rate? If so, will it be enough to improve cardiorespiratory fitness? With these questions in mind we developed the following hypotheses:

- **Null Hypothesis 1:** There will be no significant difference between resting heart rate and average heart rate during the downhill portion of the course.
- **Research Hypothesis 1:** There will be a significant difference between resting heart rate and average heart rate during the downhill portion of the course.
- **Null Hypothesis 2:** There will be no significant difference between resting heart rate and average heart rate during the uphill portion of the course.
- **Research Hypothesis 2:** There will be a significant difference between resting heart rate and average heart rate during the downhill portion of the course.
- **Null Hypothesis 3:** The heart rate during the downhill portion of the course will be less than or equal to moderate intensity (40 %) heart rate reserve.
- **Research Hypothesis 3:** The heart rate during the downhill portion of the course will be greater than moderate intensity (40 %) heart rate reserve.
- **Null Hypothesis 4:** The heart rate during the uphill portion of the course will be less than or equal to vigorous intensity (60 % heart rate reserve).
- **Research Hypothesis 4:** The heart rate during the uphill portion of the course will be greater than vigorous intensity (40 % heart rate reserve).

Methods

The study and each subject followed the following steps:

- Resting heart rate measured while seated
- Heart rates monitored and recorded every ½ mile during the descent of a two mile section of the "uptown walking trail" in Butte, Montana, which was the Butte Anaconda Pacific Railway and has a grade of about one to two percent. The longboarders were instructed to ride the descent as they normally would.
- 15 minute rest to pre-trial resting heart rate levels.
- Once the descent was finished, the subjects ascended, or skated, back to the starting point. Again, heart rates were recorded at half-mile intervals.

The subjects wore a Polar FS2 Heart Monitor while riding to record real time heart rates, and were compared with palpated heart rates to ensure accuracy. Trial orders were not randomized; each subject started with the descent to control for previous exertion as a possible cause of heart rate elevation during the downhill portion.

Fourteen volunteer subjects were chosen based on current or previous experience and credentials, and consisted of 12 adults and 2 children (ages twelve years and ten years) with parental supervision and permission. The inclusion criteria were set so only those with previous experience who could demonstrate proficiency were allowed to participate. The demonstration of proficiency involved riding a longboard through a slalom course without falling and coming to a complete stop using a foot-brake. Foot-braking involves dragging one foot, and is a technique used by skateboarders to decelerate and/or stop the skateboard.

The exclusion criteria included any current student of the researcher's and were guided by the American College of Sports Medicine risk stratification process. American College of Sports Medicine (ACSM) guidelines suggests a pre-participation screening that identifies current medical conditions that would exclude those who are at risk for adverse conditions that would cause adverse responses to exercise (ACSM, 2009). The list of conditions that excluded a subject included:

- Pregnancy
- Diabetes
- Hypertension or are taking blood pressure medication
- Asthma
- Concerns about safety of exercise or swimming ability
- Heart surgery
- Chest discomfort with exercise
- Unreasonable breathlessness with exercise
- Unexplained dizziness or fainting
- Musculoskeletal problems that limit functional capacity
- Current smoker

All subjects completed the pre-participation screening to identify anyone who should be eliminated. Additionally, all subjects were under the age of 50 years.

Safety was ensured by direct supervision and monitoring of each subject during the entire process. All subjects gave written, informed consent prior to participating, and an Institutional Review Board approved all procedures.

Results

The average resting heart rate for all subjects was 60 beats/minute with a standard deviation of 3.63. The average heart rate for the downhill portion of the study was 131.4 beats/minute + sd 25.64 and the average for the uphill portion was 167.8 beats/minute + sd 16.02 (Table 1). The complete set of heart rate changes can be seen in Table 1. Examination of a normal quantile plot for the data as well as the results of a Shapiro-Wilk test for normality, verified that an underlying normal distribution was not a reasonable assumption. Therefore, a two-

Table 1. Results of resting, uphill longboarding and downhill longboarding heart rates.

		Subjects													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Resting		59	61	50	58	60	60	58	60	64	64	63	58	60	64
Miles DH	0.5	168	101	155	135	101	111	137	78	111	134	155	124	167	157
	1	158	89	148	105	113	136	125	80	142	125	145	136	177	159
	1.5	163	124	140	124	93	143	131	88	151	135	169	145	170	160
	2	173	137	134	116	80	140	140	88	137	119	167	122	160	156
Avgerage DH		**165.5**	**112.75**	**144.25**	**120**	**93**	**118**	**136**	**83.5**	**121**	**126**	**162**	**138**	**163**	**157**
DH Time		**10:01**	**12:20**	**11:00**	**13:00**	**13:30**	**13:30**	**14:50**	**14:22**	**14:22**	**14:22**	**12:46**	**12:46**	**9:42**	**10:00**
Miles UH	0.5	157	148	175	170	160	173	181	132	187	197	197	176	171	175
	1	154	166	181	167	167	168	177	132	183	198	196	176	171	176
	1.5	155	160	175	174	168	168	171	120	175	185	197	168	179	180
	2	170	150	202	178	160	148	151	120	176	187	200	180	171	173
Average UH		**159**	**156**	**183.25**	**172.25**	**161**	**165**	**174**	**126**	**163**	**181**	**195**	**170**	**166**	**176**
UH Time		**13:01**	**13:10**	**12:14**	**12:45**	**13:00**	**13:00**	**12:14**	**17:26**	**17:26**	**17:26**	**12:14**	**12:14**	**13:03**	**13:03**
Age		**21**	**20**	**19**	**20**	**20**	**20**	**20**	**43**	**10**	**12**	**20**	**20**	**21**	**21**

sample paired t-test was used to compare the average resting heart rate with the average downhill heart rate when longboarding. The resulting t-value was -10.3 (P< 0.0001) (Table 2). Thus, our conclusion was to reject null hypothesis 1 in favor of research hypothesis 1. That is, we have strong evidence that the average heart rate when longboarding downhill is significantly higher than the average resting heart rate.

Using a similar process to compare the average uphill and resting heart rates, a two-sample paired t-test produced a t-value of -24.3 (P < 0.0001). Based on this we rejected null hypothesis 2 in favor of research hypothesis 2. That is, we have strong evidence that the mean heart rate when longboarding uphill is significantly higher than the mean resting heart rate.

Age Predicted Maximum Heart Rate (APMHR) can be calculated using 206.9 – (0.67 x age) (ACSM, 2009). The sample average APMHR was 193.2 beats/minute. The percentage of HRR for the downhill portion, on average, was 53.5% ± sd 19.3%. Note the percentage per individual is calculated as [(downhill HR – resting HR)÷HRR] ×*100%*. When testing that the average percentage of HRR will be greater than 40%, i.e., research hypothesis 3, we obtain a t-value of 10.30 (P < 0.0001) . Thus, we have strong evidence that the downhill portion produces a HR that is classified as moderate intensity.

For the uphill portion, the average percentage of HRR for the sample was 80.8% ± sd 10.5%. When testing research hypothesis 4, that the uphill portion will produce an average percentage of HRR greater than 60%, we obtain a *p-value* < 0.0001(t-value = 28.63). That is, we have strong evidence that the uphill portion engenders a HR that is at the level of vigorous intensity.

Table 2, Statistical Results of Downhill and Uphill Longboarding Heart Rates

	Mean	Standard deviation	t-value	p-value
Resting Heart Rate	59.9	3.63		
Downhill Heart Rate	131.4	25.64	-10.3	p<.0001(0.00000013)
Downhill percentage of HRR	53.5	19.28	10.3	P<.0001(0.000000063)
Uphill Heart Rate	167.8	16.02	-24.3	p<.0001(0.000000000000321)
Uphill percentage of HRR	80.8	10.5	28.63	P<.0001(0.000000000000198)

Limitations/Challenges to the Study

The limitations to this study included the small sample size (N = 14) and our lack of control over each riding style. Each individual was instructed to "ride as they normally would," which had the potential for a wide variety of physiological responses. Some riders would carve actively during the descent and some would do so less actively. Additionally, different people had different boards with different components so some boards were faster than others, which made a difference in the time and effort spent during the ascent.

One challenge that had to be addressed was traffic safety. We designated one person to approach each intersection on a bike and the longboarders were instructed to stop at the major intersections. Another challenge was weather; the data collection for this project took place in April in Butte, Montana. Unfortunately, some of the worst snow storms in Butte occur in April but luckily a window of opportunity opened up between snow storms and we were able to complete the data collection in a timely fashion.

Discussion

We expected an increase in heart rate for the uphill portion of the study, and we were curious as to what the heart rate effects of the downhill portion would be. We were unaware the downhill portion would show such a large increase in heart rate. There may be two causes for the increase during the downhill. One is that the downhill was exciting and this exhilaration may possibly have effected heart rate. The other cause, and one most commonly accepted by longboarders, is the result of the required carving and pumping actions to control the board during the descent. These actions require alternating hip flexion/extension and torso rotation movements that may have some metabolic cost and may cause heart rate to increase to perform these rhythmic actions.

The ACSM recommends a combination of moderate intensity exercise between 40% and >60% of heart rate reserve, and vigorous intensity exercise ≥ 60% heart rate reserve for improving cardiovascular fitness. The intensity ranges are intentionally broad to meet the various needs of all Americans. The heart rate reserve intensity levels of 53% and 81% that we found are considered moderate and vigorous, respectively, and fall within the recommended ranges for improving cardiovascular fitness (ACSM, 2009). The American College of Sports Medicine and the Centers for Disease Control categorize the following activities as moderate intensity: downhill skiing (cruising with light effort), ice skating < 9 miles/hour, surfing (body or board), slowly treading water and flat-water kayaking. The following activities were categorized as vigorous: downhill ski racing or skiing with vigorous effort, fast paced ice-skating or speed-skating, treading water with vigorous effort, and whitewater kayaking (U.S.

Department of Health and Human Services, 2012).

This study indicates that longboarding can increase heart rate to levels suggested for improving cardiovascular health. It is important to note, however, that the trail used during this study was a gentle grade of 1-2%. Longboarding can be dangerous. If speed increases beyond the riders' ability to control the board or come to a stop, serious injuries can be sustained. We do not recommend longboarding, or skateboarding in general, to everyone. We are suggesting that those who do participate in this activity are receiving some cardiovascular benefit.

Future studies should be conducted using different distances and grades, if they can be done so safely. Additionally, it would be interesting to see what the effects of standard park skateboarding would have on heart rate and what the difference in heart rate would be between longboarding and skateboarding.

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Biological Sciences – Terrestrial

Presentation Abstracts

Montana Chapter of the Wildlife Society 51st Annual Meeting

Wildlife and Change: The Influence of Climate, Politics and Social Dynamics on Wildlife Conservation and Management

February 27 - March 1, 2013

Whitefish, Montana

Alphabetical By First Author's Last Name
(* Denotes Presenter)

Sarcoptic Mange in Yellowstone's Wolves: Dynamics, Impacts, and the Role of Citizen Science

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Sarcoptic Mange, caused by the mite (*Sarcoptes scabiei*) invaded the wolf (*Canis lupus*) population within Yellowstone National Park in 2007. Since its invasion, we have followed the mite's spread throughout the park, conducting monthly observational surveys to assess individual infection status and pack prevalence. The spatio-temporal patterns of mange invasion have been largely consistent with patterns of host connectivity and density, and we demonstrate that the area of highest resource quality, supporting the greatest density of wolves, have been the region's most susceptible to parasite-induced declines. Heavily infected individuals suffer twice the mortality rate as uninfected individuals and pack growth rates are much more likely to decline in the presence of mange. Future monitoring will be augmented by a new citizen science website, aimed at collecting visitor photographs of wolves and acting as an interactive public resource for information and research updates on Yellowstone's wolves.

Out of the Limelight: Searching for Three Rarely Seen Species in Montana

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In the summer of 2012 Montana Fish, Wildlife and Parks conducted surveys to document three little known species of concern in northwest Montana. Each inventory supplied a snapshot of information to continue monitoring their presence on the landscape. The unique life history of the black swift (*Cypseloides niger*), Coeur D'Alene salamander (*Plethodon idahoensis*), and northern bog lemming (*Synaptomis borealis*) excludes them from detection during standard multi-species surveys. In addition, previous diversity surveys in Montana that did not employ targeted surveys failed to detect these species. We found that with targeted surveys we could detect all three. These species are all closely tied to water and are potentially vulnerable to climate change and a diminished water resource. Any concerns are speculative however, because we lack basic life history knowledge. We recommend further monitoring and research to understand how to keep these unique species present on the landscape.

Wildlife Research and Service Learning in Undergraduate Courses: Potential and Pitfalls

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The benefit of authentic research for student learning in undergraduate biology curricula is well documented, with examples of innovative investigations at a wide variety of colleges and universities around the United States. Similar benefits in undergraduate wildlife programs are anticipated but less broadly documented. The block scheduling available at The University of Montana Western (UMW) provides unique opportunities to pursue long-term research projects across multiple science courses. Examples are presented of undergraduate research and management projects conducted in Southwest Montana in cooperation with the Fish and Wildlife Service, Forest Service, Bureau of Land Management, The Nature Conservancy and the Ecological Research as Education Network over the last three years. Research projects entail investigating wildlife habitat, non-game and game species. The potentials and pitfalls inherent in designing research protocols, collaborative investigations, peer mentoring, obtaining funding, and publishing research are reviewed. Prospects for refining existing projects and implementing new investigations will be discussed.

Preliminary Findings of an Elk Brucellosis Surveillance and Epidemiology Project in Southwestern Montana

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Brucellosis is a bacterial disease that causes abortions in cattle, bison (*Bison bison*) and elk (*Cervus elaphus*). Transmission of the disease from wildlife to cattle has serious financial implications to producers and the livestock industry in Montana. Brucellosis in elk populations of southwestern Montana results in reduced tolerance for elk on private property and can influence management of elk populations. In the winter of 2010/2011, Montana Fish, Wildlife and Parks initiated a five-year project with the goals of delineating the geographical distribution of brucellosis in elk populations, enhancing our understanding of how brucellosis functions in elk populations, and evaluating factors that may influence the spread and prevalence of brucellosis in elk. One-hundred adult female elk were captured in hunting districts (HD) 324 and 326 in the winter of 2010/2011 with eight testing positive on blood tests(seropositive) in the field for exposure to *Brucella*. Ninety-three adult female elk were captured in HD 325 in the winter of 2011/2012, five of which were seropositive. Elk testing positive in the field were fitted with a GPS collar and, if pregnant, implanted with a vaginal implant transmitter (VIT). Seropositive pregnant elk were tracked from the ground and air 2-3 times/week in order to locate birth or abortion sites. *B. abortus* was not cultured from VITs or samples collected at birth sites in the first year of the project. *B. abortus* was cultured from tissues or VITs associated with two aborted calves in 2012. The known distribution of brucellosis in elk has expanded based on information obtained in this study.

Home Alone: Influence of Individual, Pack, and Environmental Variation on Pup Attendance in Gray Wolves

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Pup-guarding is an important aspect of helping behavior exhibited in some cooperatively breeding species. Within cooperatively breeding species, groups of animals lacking the ability to adequately attend and guard young can have decreased fecundity. We studied pup attendance in gray wolves (*Canis lupus*) using location data from 17 GPS radio-collared wolves from seven packs in Idaho. Breeding females had the highest attendance rates, however once pups were weaned nonbreeding wolves increased their attendance. We hypothesize that attendance behavior of nonbreeding wolves has benefits for their own, subsequent pup-rearing. The dominant predictor of pup attendance rates after weaning was the number of helpers in the pack, where attendance rates of individuals dropped by 7.5 percent with each additional helper. Our results suggest that wolves in small packs experience a costly tradeoff when they forego foraging time in order to attend pups adequately. Preliminary results from additional analyses using data from wolves in Alberta, Idaho, Montana, and Yellowstone National Park indicate sex of the helper, genetic relatedness, and surrounding predator and prey densities may also influence pup attendance rates.

How do Nonnative Plants Affect Small Mammals? Effects of Vegetation Structure on Escape Ability of Small Mammals

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Nonnative plants can alter habitat of native animals through changes in vegetation structure and availability of food resources. Invasion of nonnative cheatgrass (*Bromus tectorum* L.) is an acute threat to persistence of native wildlife in the sagebrush steppe ecosystem of southwestern Montana. Cheatgrass invasion increases vegetation density and litter depth between shrubs, potentially increasing risk of predation by impeding an animal's ability to escape. We examined how vegetation density and litter depth affects maximum sprint speed, as one component of a project investigating how changes in the structural complexity of vegetation due to cheatgrass invasion affects small mammals. Using artificial materials to mimic cheatgrass structure and litter, we timed deer mice (*Peromyscus*

maniculatus) sprinting through a range of litter depths and structure densities along a 2 m-long track, to assess each animal's ability to flee from a predator. We found that median sprint time increased 15 percent (95% CI = 13-18%) for every additional 1000 stems/m^2; increases in litter depth ≤ 9 cm had little effect on sprint speed. If predation is a limiting factor for small mammal populations within sagebrush steppe, management tools that can reduce vegetation density of nonnative plants may be beneficial. Litter removal may only benefit small mammals if accumulations are reduced to less than 9 cm in depth. Increasing our understanding of how small mammals respond to changes in vegetation architecture caused by nonnative plants may help inform management and restoration efforts, especially when complete eradication is unlikely.

Volunteer Contributions to Montana's Statewide Bat Monitoring Project

Bob Bastasz*, Northern Rocky Mountain Grotto of the National Speleological Society

Mandy Derber and Hans Bodenhamer, Bigfork Cave Club, Big Fork, Montana 59911

Lauri Hanauska-Brown, Montana Department of Fish, Wildlife and Parks, Helena, Montana 59620

Bryce Maxell, Montana Natural Heritage Program, Helena, Montana 59620

Over the last two years, the State of Montana has established a network of passive acoustic monitors to study bat activity patterns at selected locations throughout the state. These monitors, many of which are in remote areas, record bat calls each evening of the year. Their purpose is to document the number and species of bats as a function of time and location, with the intention of generating a statewide database on bat activity. These data could serve as an "early warning system" for the appearance of white-nose syndrome, a deadly fungal infection caused by *Geomyces destructans* that is ravaging bats in eastern portions of North America. WNS has not been detected in Montana, so the data being presently collected can be considered to be representative of bat behavior in the absence of the disease. A noticeable change in recorded bat activity could be an early indicator of the arrival of WNS. Whether or not WNS reaches Montana, the network is generating an extensive knowledge base about Montana's bats that will help address a variety of management issues. The Montana caving community has provided help in installing and maintaining the bat monitoring network and in recording observations about bats. Cavers are familiar with the state's caves, are experienced in working safely in caves, and have an interest in cave biota and the welfare of bats. They are well-suited to assist in a number of capacities, including maintaining the monitoring equipment, recording observations of bats, identifying hibernacula, and installing data loggers. This talk will describe volunteer activities around the state and the partnership between cavers and state organizations to increase the effectiveness of the bat monitoring project.

Passing the Stewardship Baton

Thomas R. Baumeister, Montana WILD, Montana Fish, Wildlife and Parks, Helena, Montana 59620

"*Montana is wild, it's ours to learn from and care for.*" This is the central theme FWP adopted to bring to life Montana WILD—the department's first conservation education center located in Helena. Housed in a historic building adjacent to

Spring Meadow Lake State Park, the facility, the exhibit, and the programs honor the deep connection people have with Montana's fish and wildlife. Here we tell the story of how we came to have this richness today, how all citizens of the state have a part in this history and a stake in its future, and how through individual action we can achieve great things for ourselves and the future of fish and wildlife. Guided by core beliefs of the department and its hope for an informed and engaged citizenry, the statewide facility serves a variety of interests related to fish and wildlife. The objective for this presentation is to give an overview of what has been accomplished to date with regards to Montana WILD, to illuminate the challenges we face as professionals to help others commit to fish and wildlife, and to offer an inclusive framework for how to engender a compelling stewardship ethic.

The Science – and Art – of Moose Management in the Big Hole Valley, Montana

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Moose (*Alces alces*) management can be challenging because of the difficulty of quantifying population trends consistently. Because of their solitary nature and penchant for fairly dense cover, moose can be hard to see. Also, their presence in more open habitat is highly dependent on weather conditions. Where done, aerial surveys serve more as an index of population trend than as a census and should be combined with other indices to make management decisions. In the Big Hole Valley in southwestern Montana, aerial survey data is combined with harvest data when setting license quotas. Specifically, three indices are used: calf:100 adult, days per hunter, and hunter success. Results from the past 4 years suggest that this suite of indices is effective at meeting management objectives.

Population Density, Group Size or Something in Between: Effects of a Variable Social Structure on Parasite Transmission

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Paul Cross, U.S. Geological Survey, Northern Rocky Mountain Science Center, Bozeman, Montana 59715

Megan Higgs, Department of Mathematical Sciences, Montana State University, Bozeman, Montana 59717

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Critical to our understanding of disease dynamics and effective disease control strategies is the relationship between host density and parasite transmission rates. To accurately describe this relationship, it is important to measure host density at the scale in which transmission is occurring. In social species, for example, transmission may be more related to group size than the population as a whole. But when aggregation patterns vary in size across space and time, our ability to quantify the density-transmission relationship may depend on measuring density somewhere in between population density and group size. To address this issue, we examined elk (*Cervus elaphus*) populations in western Wyoming that have been exposed to the bacteria

(*Brucella abortus*) that causes brucellosis. We measured elk density at multiple scales ranging from population density to group size, and evaluated the functional relationship between density and brucellosis seroprevalence. Our study found that low elk density did not explain why *Brucella* had not effectively invaded several populations. However, in populations with multiple years of seropositive test results, the rates of increase in seroprevalence saturate with increasing elk density regardless of the density measure used. The different densities were poorly correlated with one another, and therefore high elk densities at broad scales did not guarantee high elk densities at fine scales, but both may be important to the transmission of *Brucella*. This suggests that reducing or altering elk density may not effectively reduce transmission.

Correlates of Recruitment in Montana Bighorn Sheep Populations: An Initiative to Synthesize Montana Bighorn Sheep Recruitment Data and Gain Biological Insight

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Bighorn sheep (*Ovis Canadensis*) populations in Montana have been strongly affected by disease outbreaks in recent years, resulting in the death of approximately 1500 bighorns as well as depressed recruitment rates in some affected herds. The ecology of these disease outbreaks is not well understood and there have been several proposals for a state-wide research project addressing disease ecology of bighorns in Montana. Such a project is a large investment and any extra knowledge of the bighorn populations that can be gained from existing data would improve study design and enhance the success of any future research effort. Last year we used management data to index bighorn recruitment rates of 23 bighorn herds in the Greater Yellowstone Area (GYA) and found strong correlations between recruitment and both annual and regional climate patterns. This year we have received funding from Montana Fish, Wildlife and Parks to conduct a similar analysis of bighorn recruitment rates across Montana. The planned analysis will investigate potential correlations between bighorn recruitment and climate covariates, similar to the GYA effort, but will also explore additional covariates to capture differences in management strategies, genetics, disease history, migration patterns, and population connectivity among the state's bighorn sheep populations. The presentation will focus on the goals of our work as well as the advantages of conducting preliminary data analysis prior to implementing large scale research projects.

Inhabiting the Nexus of Wildlife Science, Policy and Conservation

Amy B. Cilimburg, Montana Audubon, Missoula, Montana 59802

As biologists, we have charismatic wildlife species, trials and tribulations from the field, data, and, hopefully, valuable conclusions. What is our role in connecting our work to conservation and policy issues and to the larger community? What and how can our scientific findings influence policy at the local, state, or federal level? In these times of climate disruption, dispassionate reiteration of our research makes less impact than revealing our research findings via a good story and message. For the past five years with Montana Audubon, Amy has worked at the nexus of climate policy, ornithology, wildlife conservation, and community organizing. She will share some best practices for climate communications, gleaned from the experts, so that different audiences (public lecture participants, cocktail party goers, skeptical uncles, newspaper readers, etc.) can take something away and be part of the solution. Citizen scientists, Black Swifts, and Corvids combine to provide examples of communicating wildlife science, climate impacts, and inspiring action and optimism.

Twenty-Three Years of Harlequin Duck Surveys on The Rocky Mountain Front: Do We Know Anything Yet?

Wendy Clark, Wildlife Biologist, Rocky Mountain Ranger District, Lewis and Clark National Forest, Choteau, Montana 59422

Harlequin duck (*Histrionicus histrionicus*) surveys have been carried out continuously on the Rocky Mountain Ranger District (RMRD) for 23 years, beginning in 1990. Streams are surveyed on foot in spring to assess occupancy by breeding pairs, and in summer to count broods. Habitat and activity data have been collected for 260 separate observations (comprising over 700 individual ducks). We have summarized the habitats in which harlequins have been observed, including potential differences between pair and brood observations. Harlequins on the RMRD tend to be found in habitats similar to those described for other areas: in fast-moving segments of streams and in areas with shrub or tree overstory. Most observations are in areas accessible to, but not immediately adjacent to areas of human use. Most observations do not occur in proximity to within-stream woody debris, which may differ from findings elsewhere. We have not yet collected data with which to evaluate whether harlequin ducks actively select for any of these habitat characteristics. In 2007 three major fires burned on the RMRD, affecting several key harlequin breeding streams. We altered our survey areas to focus on the most historically productive stream system in the hopes of detecting any impacts of fire on harlequin occupancy or productivity. We have also begun to survey streams that have not been surveyed since the original 1990-1992 inventory. We provide possible explanations for the absence of harlequin ducks on several apparently suitable stream systems. We also discuss the direction we hope to take with future surveys and analyses.

How Will Wildlife Crossings Mitigate Roads for Wildlife in the Face of Climate Change?

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Robert F. Hamlin, Logan, Utah 84321

This paper will address the developing trends in wildlife crossing structure research across the western U.S. and along US 93 South in Montana. This discussion may help to better design and retrofit structures to facilitate wildlife movement in the face of climate change. The objectives of our wildlife crossing structure research across the west are to determine wildlife use of crossing structures and structure designs that work best in passing large and medium mammals. Many of today's wildlife crossing structures and existing culverts and bridges along roadways were designed before the science of transportation ecology had developed enough to understand what designs worked for different species. Our method of evaluating these new and existing structures is to place motion-sensed camera traps 10 m from the entrances to the culverts and bridges to monitor wildlife reactions to the structures. Wildlife approaches, successful passages through the structure, and repels away from the structure are tallied for every individual. Species' reactions to culverts and bridges differ. White-tailed deer are willing to use many different sized culverts and bridges, while mule deer are more cautious. Carnivores use structures of all types, although the landscape factors such as human development may play a role in their willingness to use some structures. These and other results have greater implications for species adaptations to climate change: it will be critical that roads be permeable for the entire suites of species in an area as they need to move to adapt to changing conditions.

Identifying Factors Influencing Presence and Reproductive Success of a Golden Eagle Population in South Central Montana

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Golden Eagles (*Aquila chrysaetos*) in the western U.S. have received increased attention due to an apparent decline in the number of annual migrants and expected increased risk from energy development. Long-term research focused on resident, breeding Golden Eagles in this region is rare and sorely needed to assess the degree of population decline. In addition, managers require the identification of factors that influence presence and breeding success of Golden Eagles to create an effective management strategy. Beginning in 2010, we revisited a historically surveyed study site near Livingston, Montana. Our objective was to compare the current status of the Golden Eagle breeding population to that from the 1960's and to identify factors necessary for maintaining Golden Eagle populations. In the last 3 breeding seasons, we have documented a near 100-percent occupancy rate of historic territories and a marked increase in the number of breeding pairs. Our results also indicate that factors related to prey availability most strongly influenced nest site selection and reproductive success. Based on our current results, we suggest Golden Eagle populations may remain strong in some locations and management strategies should focus on maintaining prey habitat.

Elk Contact Patterns and Potential Disease Transmission

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Understanding the drivers of contact rates among individuals is critical to understanding disease dynamics and implementing targeted control measures. We studied the interaction patterns of 149 female elk (Cervus elaphus) distributed across five different regions of western Wyoming over three years, defining a contact as an approach within one body length (~2m). Using hierarchical models that account for correlations within individuals, pairs and groups, we found that pairwise contact rates within a group declined by a factor of three as group sizes increased 30-fold. Meanwhile, per capita contact rates increased with group size due to the increasing number of potential pairs. We found similar patterns for the duration of contacts. Supplemental feeding of elk had a limited impact on pairwise interaction rates and durations, but increased per capita rates more than two times higher. Variation in contact patterns were driven more by environmental factors such as group size than either individual or pairwise differences. Female elk in this region fall between the expectation of contact rates that linearly increase with group size (as assumed by pseudo-mass action models of disease transmission) or are constant with changes in group size (as assumed by frequency dependent transmission models). Our statistical approach decomposes the variation in contact rate into individual, dyadic, and environmental effects, which provides insight into those factors that are important for effective disease control programs.

Linking Habitat Selection and Predation Risk to Spatial Variation in Fitness for Woodland Caribou

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A central assumption underlying niche theory and the study of habitat selection is that selected habitats confer enhanced fitness. Here, we separately measured spatial patterns of both resource selection and predation risk and tested their relationships with a key demographic fitness trait, adult female survival, for a threatened ungulate, woodland caribou (*Rangifer tarandus caribou*). We used Cox-proportional hazards spatial survival modeling to assess support for various selection- and risk-based estimates of habitat quality using previously developed caribou resource selection functions and wolf predation risk models. Indeed we found positive relationships between the predicted values of a scale-integrated resource selection function and survival, yet subsequently incorporating predation risk greatly improved models further. Predation risk was an additive source of hazard beyond that detected through selection alone, and selection thus shown to be non-ideal. Furthermore, by combining spatially-explicit adult female survival predictions with herd-specific estimates of recruitment in matrix population models, we demographically estimated a fitness landscape for this threatened species.

British Columbia's Mountain Caribou Recovery Project – Where We Have Been and Where We Are Going

Leo DeGroot, Mountain Caribou Project Lead, BC Ministry of Forest Lands and Natural Resource Operations, Nelson, British Columbia, Canada

The southern part of the Purcell Mountains has been identified provincially as the Southeast Kootenay planning unit for mountain caribou (Rangifer tarandus caribou) recovery. Within it, caribou are only known to remain within the Purcells-South herd near Cranbrook, and the 14 caribou there are normally separated into two bands. Recovery without population augmentation is very unlikely. Augmenting the herd, if successful, would dramatically increase genetic diversity, decrease the risk from random events, speed growth, and be consistent with provincial direction to augment herds having <50 caribou. Translocations of 15 to >100 caribou have been successful at many sites across North America, including locations where predators include wolves or cougars. This presentation provides a project update and details plans for future work.

Preliminary Results of Occupancy Surveys for Modeling Habitat Selection of Sympatric Bighorn Sheep and Mountain Goats in the Greater Yellowstone Area

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Introduced and expanding mountain goat (Oreamnos americanus) populations in the greater Yellowstone area (GYA) have generated significant concern regarding impacts to natural communities, and especially to native and restored bighorn sheep (Ovis Canadensis) populations. To provide natural resource managers with useful and applicable information for managing and conserving these species, occupancy surveys based on rigorous field studies were implemented in 2011 and 2012 to develop summer habitat models for bighorn sheep and mountain goats in the GYA. To enhance the applicability and accuracy of these models, occupancy probabilities obtained from presence and absence observations are integrated with detection probabilities gained from double independent-observer sampling. Between the two field seasons, a total of 361 surveys were performed over 350 observer-days, capturing spatially-precise locations of 80 bighorn sheep groups and 138 mountain goat groups. Preliminary analyses of the data obtained to date were performed for each species to gauge the utility of the field studies and to provide insights for improved study design and implementation of future field work. This presentation reports on the accomplishments from the first two field seasons, including what we have learned from preliminary analyses and the plans for an additional field season for summer 2013.

Habitat Use of Over-Wintering Adult Golden Eagles in the Western U.S.

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A number of studies show declining migration count trends and breeding abundance in Golden Eagles (*Aquila chrysaetos*) in the West. We outfitted 13 adult, migrant Golden Eagles with transmitters from 2007-2012 with battery powered Argos Platform Terminal Transmitters (PTT) or 70-g solar-powered GPS/PTTs. Eagles wintered across the West, from central Montana to Arkansas. We gathered data on winter territory size, time spent on wintering grounds, and the habitat use of eagles during the winter. We measured a large degree of variability in both winter home range size and duration of winter range use. We found an average 50-percent Minimum Convex Polygon (MCP) home range estimate of 1680 km^2 (range 8-14,881 km^2) and an average 95-percent MCP of 6578 km^2 (range 85- 36,143 km^2). Winter home range estimates were extremely variable between individuals and even within the same individual between years. Eagles spent an average of 105 days on their wintering

territories (range 60-179 days). We found the most common habitat types were pinyon-juniper, coniferous forest, grassland, shrub, and sagebrush habitats which all comprised ≥10 percent of core wintering areas. Several habitat types were correlated to latitude and longitude: the percentage of coastal habitat within winter home ranges increased as eagles wintered further south, riparian and logged habitats increased to the north and west, and shrub habitat percentage of the home range decreased with an increase in latitude. Understanding wintering needs of Golden Eagles is essential to the long-term health of this species across the West.

Changes in Nest Density and Daily Nest Survival of Two Woodpecker Species in Relation to a Mountain Pine Beetle Epidemic

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The Mountain pine beetle (*Dendrotonus ponderosae*) is a bark beetle native to western North America capable of large-scale population eruptions, resulting in high tree (*Pinus* spp.) mortality that alters resource availability to wildlife, particularly snag-associated species. Many woodpecker species rely on conifer snags for nesting and foraging substrate. We studied nesting survival of two woodpecker species in relation to a recent mountain pine beetle outbreak in western Montana. American three-toed woodpecker (*Picoides dorsalis*) is a bark-drilling specialist that feeds on beetle larvae and frequently nests in conifer snags, whereas red-naped sapsucker (*Sphyrapicus nuchalis*) specializes on consuming sap of live trees and rarely nests in conifer snags. Based on *a priori* hypotheses we modeled daily nest survival (DSR) as a function of biotic (nest height) and temporal (beetle period [before and after outbreak], date trend, and a quadratic date trend) factors using seven competing models. Results for both species showed high model uncertainty and the constant DSR model was the most parsimonious model. These results did not support our predictions about beetle period or nest height affecting DSR, although DSR was lower during pre-outbreak (0.985, 95% CL [0.965, 0.995]) versus post-outbreak (0.993, 95% CL [0.981, 0.997]) for American three-toed woodpecker. Future analyses will investigate the effects of other covariates such as snag density, daily temperature, and precipitation on DSR. Our results will inform management activities for post-beetle forests that will help maintain habitat of disturbance specialist species.

Using Climate Data to Understand the Response by Wildlife and Fisheries

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Montana's water supply varies from about 40 to 160 percent average. This is due to a large variability in the mountain snowpack, spring and summer precipitation and temperature. Nearly all of these parameters that determine the runoff will impact fish and wildlife throughout the year. Time of various climatic events in Montana, such as when snowpack starts to accumulate, when it reaches it season's maximum, when it melts out, winter temperatures, when streams reach their annual peak flow, and when plants break dormancy (spring green-up), forage production, whether or not there is fall green-up and the time of fall green-up all have had a historical variation spanning about eight weeks. In addition, there is annual variation in climatic conditions across the state. Wildlife and fisheries managers need to take this variability into account when managing wildlife. Tools to help assess the potential variability and timing of various climatic, hydrologic and phenological parameters will be presented. Using observed climatic and hydrologic data collected over the past 100 years can be further interpreted to help understand and predict the response and effects on fish and wildlife. Relating these responses to these parameters provide better relationships than by using calendar dates.

Monitoring Greater Sage Grouse Populations and Habitat Use in the Southeast Montana Sage-Grouse Core Area

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Sage grouse (*Centrocercus urophasianus*) core areas support Montana's highest densities of sage grouse, and are deemed vitally important to sage grouse conservation long term. The Southeast Montana Sage Grouse Core Area (SEMT SGCA) consists of large expanses of intact sagebrush-steppe habitat and is important for connectivity among populations in Montana, South Dakota and Wyoming. Relatively little development has occurred in the area, but there is potential for energy development to have large-scale impacts on the area in the near future. Little was known about sage-grouse use of the area during critical periods outside of the breeding season or factors underlying local sage-grouse population dynamics. Therefore, we radio collared 94 sage grouse hens between 2009-2011 to quantify movements, habitat use, and population vital rates. Overall, hen locations tended to be within the SEMT SGCA during spring-summer and expanded to adjacent areas of Wyoming and South Dakota during winter. Wide annual fluctuations in weather conditions drove annual variation in population demographic rates, habitat conditions, and habitat use. Apparent nest success (34-68%) and average chick production per hen that began the breeding season (0.72-1.12 chicks/hen) varied among years with extreme to mild weather. Annual hen survival varied from a low of 46 percent under extreme winter conditions to > 60 percent under milder weather. Vegetation characteristics at nest, brood-rearing, and winter locations will be presented. Results from this project will aid in land use planning, prioritization of conservation efforts, and provide information to assess the effects of future land use change. The project is conducted by MFWP and funded by the BLM.

Telemetry Studies of Mountain Ungulates in the Greater Yellowstone Area: A Progress Report

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We report on the progress that has been made on initiating long-term telemetry studies of mountain goats (Oreamnos *americanus*) and bighorn sheep (*Ovis Canadensis*) in the GYA to better understand spatial ecology, demography, potential competition, and disease ecology. Six study areas representing a variety of ecological settings have been established throughout the GYA that include areas where bighorn sheep and mountain goats are sympatric as well as where each species exists in the absence of the other. We are employing a novel dual radio collar strategy and have successfully evaluated the use of drop net systems to capture groups of bighorn attracted to bait as an economical alternative to standard helicopter-based single animal capture techniques. Chemical immobilization of bighorn using BAM as an alternative to carfentanil was also tested and evaluated. A break-down Clover trap was designed for ease of transportation via horse for backcountry trapping and summer salt baiting for bighorn sheep and mountain goats was evaluated. We have initiated the first systematic disease sampling of mountain goats in the GYA using the standard protocols employed for bighorn sheep health assessments to evaluate the potential for mountain goats to influence the disease ecology of bighorn sheep in areas where they are sympatric. The research goals, strategies, and methodologies developed, tested, and employed on the collaborative GYA mountain ungulate research program are similar to those proposed for a long-term bighorn sheep research program in Montana.

Limited Maternal Gene Flow Amongst Elk in the Greater Yellowstone Ecosystem Revealed by Mitochondrial DNA

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Gordon Luikart, Flathead Lake Biological Station, Fish and Wildlife Genomics Group, University of Montana, Polson, Montana 59860.

We quantified maternal patterns of population genetic structure to help understand gene flow among elk (*Cervus elaphus*) populations across the Greater Yellowstone Ecosystem. We sequenced 596 base pairs of the mitochondrial (mt)DNA control region of 407 elk from nine populations. Our analysis revealed high mtDNA diversity within populations including 12 haplotypes per population on average, and a mean haplotype diversity (i.e., gene diversity) of 0.84. The F_{ST} from mtDNA was high (mean $F_{ST} = 0.162$; $P = 0.0001$) compared to F_{ST} for nuclear microsatellites data ($F_{ST} = 0.006$, $P = 0.125$), which suggested relatively low female movement among populations, perhaps due to female philopatry. Genetic distance (mtDNA pair-wise F_{ST}) was not significantly correlated with geographic (Euclidean) distance between populations (Mantel's $r = 0.274$, $P = 0.168$). The lack of isolation-by-distance and large genetic distance between geographically close populations (< 65 km) suggest that maternal gene flow is reduced by certain landscape features (e.g., large, non-forested valleys with roads), which is important for understanding and modeling landscape connectivity and related processes.

Elk Habitat Use on Degraded Rangeland

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Philip Ramsey, MPG Ranch, Missoula, Montana 59801

We monitored winter range use of elk (*Cervus elaphus*) in the Northern Sapphire Mountains of the Bitterroot Valley, Montana over the winters of 2011-2012 and 2012-2013. The goal of the project was to acquire baseline data on elk habitat use and grazing preference on a 3845 ha former cattle ranch. The property includes 2130 ha of rangeland with altered plant communities due to intensive grazing, exotic forage grass seeding, and herbicide applications. Of these 2130 ha, cheatgrass (*Bromus tectorum*) dominates 32 percent, seeded exotic forage grasses dominate 20 percent, and perennial invaders dominate 6.8 percent. Pristine or less-degraded plant communities dominated by native grasses cover 681 ha and irrigated agricultural crops cover 71 ha. An average of around 300 elk spend most of the winter on or near the study site, and the highest number was 426, recorded in November 2011. We collected data through observation, scat density surveys, diet analysis, and forage availability estimates through biomass collection. Areas with high elk use are grouped by the dominant vegetation, slope, and aspect. Elk spent the most time feeding in lower elevation benchland and native bunchgrass communities, loafing on ridges and open areas typically with degraded to severely degraded vegetative communities, and traveling across exotic forage grasses and through draws with variable vegetation. Elk pellet cluster density was highest in lower elevation grassland and foothills and irrigated agricultural fields. This baseline data will allow us to assess elk response to restoration efforts that seek to replace many weed-dominated communities with diverse native vegetation.

Evaluating Bottom-Up and Top-Down Effects on Elk Survival and Recruitment: Year Two Update of a Case Study in the Bitterroot Valley

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Understanding the contribution of recruitment to population growth rate in ungulates is a fundamental challenge to wildlife managers attempting to integrate carnivore and ungulate management. Like much of western Montana, in the Bitterroot Valley, the decline of elk (*Cervus elaphus*) populations and calf recruitment occurred concurrently with wolf (*Canis lupus*) recovery. However, a multitude of abiotic, bottom-up and top-down factors likely affect recruitment rates. We studied cause-specific mortality of elk calves to understand the role of competing mortality risk on calf recruitment in the East Fork and West Fork of the Bitterroot Valley, Montana. A total of 66 and 76 neonatal elk calves were captured in spring 2011 and 2012, respectively, and an additional 31 and 29 6-month-olds in late November 2011 and 2012. We analyzed calf survival using a Weibull parametric survival model, and cause-specific mortality using cumulative incidence functions. Preliminary analyses for the first 20 months of the research indicate mountain lions as the leading cause of mortality for elk calves

during both summer and winter. We are also evaluating the role of summer forage resources on maternal condition, calf birth weights and survival. Preliminary results from nutritional work suggest potential bottom-up differences influencing resilience of elk populations to top-down predation. Our study fills a critical knowledge gap regarding the role of summer vs winter mortality in elk and the role of nutrition. The study will complement previous studies and help wildlife managers integrate carnivore and ungulate management across western Montana following carnivore recovery.

Habitat Shifts in Montane Riparian Areas in the Centennial Mountains of Southwest Montana

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Deciduous riparian communities (DRC) are functionally and biologically unique habitats that influence ecosystems at local and watershed scales. Since Euro-American settlement, fire exclusion has shifted montane forests in the Centennial Mountains of the Greater Yellowstone Ecosystem from mosaics with variable stand structure and composition, including deciduous communities, to more homogeneous, closed-canopy coniferous forests. Deciduous riparian communities differ from coniferous riparian habitats many ways: fire behavior, post-fire recovery, insect and bird diversity, contributions to aquatic detritus, light regimes of aquatic ecosystems, and habitat suitability for beaver. To characterize the extent of current and historic deciduous riparian communities, we sampled riparian communities along three priority montane streams in the Centennial Mountains, mapped willow and aspen skeletons, and dated dominant conifers. We found widespread shifts in the dominant vegetation at mid-elevation montane sites upstream of the sagebrush-forest ecotone, though less evidence of vegetation change at higher elevation montane sites. The shifts we documented have only occurred in recent decades due to the decomposition of our primary evidence: dead wood. The lower primary productivity associated with these shifts affects native westslope cutthroat trout, birds, bats, and ungulates. Shifts from deciduous shrubs and trees to closed-canopy conifer forest also increases likelihood of local high-intensity fires and increases recovery times after those disturbances. Promoting deciduous riparian communities through prescribed fire and mechanical removal of conifers can increase the productivity of riparian and aquatic systems, while also reducing threats to these systems from climate change, including uncharacteristically severe fire and water shortages.

Determining Resilient Watersheds for Long-term Conservation in a Changing Climate

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Streams and riparian areas are highly productive habitats for wildlife and fish. To maintain these critical habitats, rigorous prioritization of conservation and restoration efforts is necessary to make the best use of limited resources. In a changing climate, identifying sites with the ability to buffer change is essential for managing Rocky Mountain water resources.

Watersheds in the northern Rockies require persistent snowpack for late-season stream flows and cool water temperatures, yet snowpacks are declining and climate models forecast that this trend will continue. We hypothesize that in the US Northern Rocky Mountains, high-elevation watersheds that receive less solar radiation due to slope, aspect, and shading by steep slopes will have significantly greater ability to maintain cooler water temperatures and higher late summer discharges under warming climate conditions. We also hypothesize that the magnitude of the aspect-shading effect will override other controlling variables. A GIS model of southwest Montana was developed to select sites for preliminary testing of our framework. Discharge data was collected for six paired watersheds with opposing aspects, similar high elevation area, and similar geology. Preliminary results show that basins dominated by steep north and northeast slopes (> 50 %) produce baseflow discharges that are 2 to 4 times larger than baseflows in basins dominated by steep southerly aspects. The project is ongoing, but our framework based on topographic attributes may be successfully used to inform land managers and restoration efforts about which watersheds are most likely to support stream and riparian habitats under changing climate conditions.

Ensemble Habitat Suitability Modeling to Guide Conservation of Black-Backed Woodpeckers

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Conservation of black-backed woodpecker (*Picoides arcticus*), a burned-forest specialist, is challenged by the unpredictable availability of suitable habitat. Habitat models calibrated with data from previous wildfires can be used to predict habitat suitability in newly fire-affected areas. Predictive accuracy of habitat models depends on how well statistical relationships reflect actual ecological relationships. We predicted habitat suitability for Black-backed Woodpecker at Montana post-wildfire forests (≤ 6 years postfire) east of the continental divide using models calibrated with nest location data from wildlfire locations in Idaho, Oregon, and Washington. We developed 6 habitat models, including one partitioned Mahalanobis model, two Maxent models, and 3 weighted logistic regression models with combinations of seven environmental variables describing burn severity, topography, and pre-fire canopy cover. We converted continuous habitat suitability indices (HSIs) into binary predictions (suitable or unsuitable) and combined predictions using and ensemble approach; we compiled the number of models (0–6) predicting locations (30×30-m pixels) as suitable. Habitat models represented different hypotheses regarding true ecological relationships, making inferences from ensemble predictions robust to uncertainties in the form of these relationships. Thirty-five percent of the area burned by eastside Montana wildfires was predicted suitable by either all seven habitat models or none of them (i.e. complete agreement among models). We recommend conservation of areas (e.g., exclusion of post-fire salvage logging) that were consistently predicted suitable by most models, e.g., 32 percent of burned areas predicted suitable by ≥ 5 models. Additionally, we recommend surveying areas where models disagree to help validate and refine models.

Biology is Easy, Understanding People is Hard. Musings of a Wolf Biologist with a lot of Windshield Time

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Our ability as natural resource professionals to measure, analyze, and thereby describe natural world complexities has reached unprecedented levels. But simultaneously our poor understanding of how society assimilates information limits the efficacy of articulating those concepts to the public. Yet effective public dialogue is critical for informed natural resource management, conservation, and policy. Our traditional public relations methods of continuously distributing information at lower comprehension levels may be inadequate. Here, I will discuss how the synergy of misinformation, groupthink, bias, politics, media, and the blogosphere impedes our ability to convey factual information to the masses. I hope to show why we need a new public communication approach and offer some examples as catalysts to initiate the conversation.

Grizzly Bear Population Vital Rates and Trend in the Northern Continental Divide Ecosystem, Montana

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We estimated grizzly bear (*Ursus arctos*) population vital rates and trend for the Northern Continental Divide Ecosystem, Montana, between 2004–2009 by following radio-collared females and observing their fate and reproductive performance. Our estimates of dependent cub and yearling survival were 0.612 (95% CI = 0.300–0.818) and 0.682 (95% CI = 0.258–0.898). Our estimates of subadult and adult female survival were 0.852 (95% CI = 0.628–0.951) and 0.952 (95% CI = 0.892–0.980). From visual observations, we estimated a mean litter size of 2.00 cubs/litter. Accounting for cub mortality prior to the first observations of litters in spring, our adjusted mean litter size was 2.27 cubs/litter. We estimated the probabilities of females transitioning from one reproductive state to another between years. Using the stable state probability of 0.322 (95% CI = 0.262–0.382) for females with cub litters, our adjusted fecundity estimate (m_x) was 0.367 (95% CI = 0.273–0.461). Using our derived rates, we estimated that the population grew at a mean annual rate of approximately 3 percent ($\lambda = 1.0306$, 95% CI = 0.928–1.102), and 71.5% of 10,000 Monte Carlo simulations produced estimates of $\lambda > 1.0$. Our results indicate an increasing population trend of grizzly bears in the NCDE. Coupled with concurrent studies of population size, we estimate that approximately 1000 grizzly bears reside in and adjacent to this recovery area. We suggest that monitoring of population trend and other vital rates using radioed females be continued.

Statewide Efforts to Monitor Year-Round Bat Activity Patterns and Characterize Cave and Mine Roost Habitats

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Montana's bat populations face a wide array of conservation issues, including loss of roosting sites, pesticide impacts to prey species, collision and drowning hazards at sites where they forage and drink, barotrauma and collisions with wind turbines, and the potential arrival of *Geomyces destructans*, the cold-adapted soil fungus that causes White-Nose Syndrome and has decimated bat populations in eastern North America. These conservation issues, and the low reproductive output of bats, highlight the need to gather baseline information that can be used to mitigate impacts to populations. Beginning in the fall of 2011, a collaborative effort was initiated to document roost habitat characteristics and year-round spatial and temporal activity patterns of Montana's bats. To-date, collaborators have deployed over 30 temperature and relative humidity data loggers near known winter bat roosts; most known bat hibernacula in Montana are now being monitored. Collaborators have also established a nearly statewide array of 42 passive ultrasonic detector/recorder stations that are deployed year-round and powered by solar panels and deep cycle batteries. Through December 2012, these recording stations have resulted in more than 750,000 sound files containing nearly 3 terabytes of information. Highlights to-date include numerous first records of species in regions with previously limited bat survey effort, numerous first records of bat activity during the fall, winter, and spring months, documentation of temperatures at which bats are active year-round, documentation of winter bat roost temperatures, documentation of nightly activity patterns throughout the year, and the potential year-round presence of species previously considered migratory.

Recovery of Wolverines in the Western United States: Recent Extirpation and Re-Colonization or Range Retraction and Expansion?

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Wolverines (*Gulo gulo*) were greatly reduced in number and possibly extirpated from the contiguous U.S. by the early 1900s. Wolverines currently occupy much of their historical range in Washington, Idaho, Montana, and Wyoming, but are absent from California, Utah, and Colorado. In response, the reintroduction of wolverines to California and Colorado is being considered. If wolverines are to be reintroduced, it will be necessary to determine the genetic affinities of historical and modern wolverine populations, and identify appropriate source populations. We amplified the mitochondrial control region of 13 museum specimens dating from the late 1800s to early 1900s and 202 wolverines from modern populations in the contiguous U.S. and Canada, and combined resulting data with previously published haplotypes. Collectively, these data indicated that historical wolverine populations in the contiguous U.S. were likely extirpated by the early 20th century. The "Cali1" haplotype previously identified in California museum specimens was also common in the southern Rocky Mountains, and likely evolved in isolation in the southern ice-free refugium that encompassed most of the contiguous U.S. during the last glaciation. Modern wolverines in the contiguous U.S. are primarily haplotype "A" which is the most common and widespread haplotype in Canada and Alaska. For the reintroduction of wolverines to California, Colorado, and other areas in the western U.S., potential source populations in the Canadian Rocky Mountains may provide the best mix of genetic diversity and appropriate learned behavior.

Biodegradable Shooting Targets Acidify Soils, Limit Plant Growth, and Mobilize Lead

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Environmental waste from recreational shotgun shooting includes lead pellet and target debris. The main risk of lead pellets is that they can be ingested by birds as they swallow pebbles and grit that aid in digestion. Another possible vector of toxicity is when acidic soil conditions mobilize lead ions from the solid pellets into the soil and groundwater. Historically, secondary waste resulted from petroleum pitch based targets that persisted in the environment for years. To reduce the environmental lifetime of targets, biodegradable targets were developed. At a former sporting clay shooting range in Florence, Montana, we found that as biodegradable targets degraded, their sulfuric components oxidized to release acid; as a result, soil pH was as low as 2. Target abundance correlated with decreased soil pH (ρ=-0.681, P<0.001) and decreased plant cover (p=-0.770, P<0.001). These acidic soils increased the mobility of lead from shot pellets and now lead concentrations exceed background. Our results demonstrate that biodegradable shooting targets exacerbate the environmental hazards that result from lead shotfall. Careful considerations regarding target composition and shooting locations may minimize environmental exposure to toxicants.

A Correction for Overestimation Bias in Estimates of Black-Tailed Prairie Dog Abundance Based on Aerial Surveys of Colony Sites in Colorado and Montana.

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Estimates of abundance of black-tailed prairie dogs (*Cynomys ludovicianus*) are obtained by estimating the area occupied by colonies. An approach for estimating this area used in Colorado and Montana was based on aerial survey transects that recorded the end points where transects intercepted and exited colony sites. Line intercept mathematical techniques were applied to these intercept data to obtain estimates of occupied area. We define a "colony site" as an aggregation of prairie dog burrows while a prairie dog "colony" is defined as the portion of a colony site that is occupied by living prairie dogs. Because of poisoning, plague and other factors, colony sites are commonly not completely occupied by colonies. In both Colorado and Montana, however, estimates obtained were estimates of the area occupied by colony sites that had some undetermined level of occupancy by colonies. We show for Colorado that the difference between estimates of area occupied by colonies was much less than the area occupied by colony sites. We provide an approach to correct estimates based on the extent of colony sites. This approach requires ground surveys of a sample of aerial

intercepts of colony sites to document the proportion that is actually occupied by colonies of living black-tailed prairie dogs. Black-tailed prairie dogs were found as not-warranted for listing in 2004 in part because of inflated estimates of abundance obtained in Colorado that incorrectly equated the extent of colony-sites as equivalent to the extent of colonies in that state.

Decreased Plant and Arthropod Richness in Landscapes Dominated by Old World Bluestem Grasses: Implications for Wildlife

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Old World bluestem grasses (OWBs, e.g., *Bothriochloa*, *Dichanthium* spp.) have become dominant throughout the southern and central Great Plains, altering native plant communities with concomitant effects for native wildlife. We examined plant and arthropod communities in areas dominated by native plants and areas dominated by OWBs at the Welder Wildlife Refuge in southern Texas. We sampled vegetation and arthropods on research plots (6 x 9-m, 5 each) every 4 weeks during summer 2011 and 2012. We found, on average, 2 (SE=0.2) more plant species, and 12-13 (SE=1.0) more arthropod species on native plant-dominated plots compared to OWB-dominated plots. Native plant-dominated plots also had 273 (SE=18.8) more individual arthropods in 2011, but 75 (SE=16.6) fewer than OWB-dominant plots in 2012, resulting from a population explosion and crash of woodlice in native plant-dominated plots. We recorded only 1 species of herbivorous arthropod from OWB-dominated plots in 2012; native plant-dominated plots had 5-6 (SE=0.68) additional herbivore species, suggesting that increased dominance by OWBs may create cascading effects on trophic dynamics. Because many species of wildlife depend on plants and arthropods for food, these changes in species richness and abundance suggest that restoration tools are required to reduce the competitive ability of OWBs. Traditional management strategies have not successfully reduced OWBs; as part of our research, we are modifying soil properties to attempt to provide novel management strategies for landowners to increase diversity of native species and habitat quality in grasslands impacted by OWBs.

Intact Pathway Successfully Buffers Sage Grouse Migration

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Landscape conservation is the mechanism for conserving migratory wildlife in sagebrush ecosystems. We studied a greater sage grouse (*Centrocercus urophasianus*; hereafter 'sage-grouse') population with the longest-known annual migration, ≤ 240 km round-trip, between summer and winter ranges in Saskatchewan, Canada, and northcentral Montana. We asked: Do birds fly quickly through a corridor, or do they use stopovers within a larger pathway? GPS-tracking revealed that migrating grouse frequent stopovers along multiple routes that coalesce to form an integrated pathway. Month-long fall migration in November contrasted with punctuated spring migration lasting ~2 weeks in late March/early April. Individual birds typically spent ~1 day at 9 different stopovers, migrating 71-91 km in 11-15 days. Migrating grouse used native sagebrush rangeland in proportion to its availability and avoided cropland and badlands. Birds responded to record-breaking snowfall in winter 2011 (>274 cm) by migrating another ≤ 50 km south onto windswept ridge tops where sagebrush remained above snow. Grouse selected habitat on Charles M. Russell National Wildlife Refuge most similar to typical winter habitat. Doing so was without consequence to winter survival; such was not the case for a nearby resident population. Newly identified winter range suggests that high site fidelity is tempered by an ability to adapt quickly when resources become scarce. We recommend public land policy that provides grazing opportunities while precluding large-scale energy development or whole scale removal of sagebrush. Management actions that maintain sagebrush as an emergency food source in newly identified sage grouse wintering grounds will help conserve this migratory population.

High, Wide And Handsome – A Review of Wildlife and Aquatic Crossing Technology Over the Last Decade (2001-2011)

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Ten years ago, at the 2001 International Conference on Ecology and Transportation in Keystone, Colorado, Ruediger (2001) presented a paper entitled High, Wide and Handsome: Designing More Effective Wildlife and Fish Crossings for Roads and Highways. At the time (2001), the paper provided a biologists perspective of how wildlife and fish crossing should be designed. Since that time, hundreds of wildlife and aquatic crossings have been built, monitored and researched. The authors will explore how wildlife and aquatic organism crossing knowledge has evolved from 2001 to 2011. The authors will explore how monitoring and research information gained over the last decade on structure height and width requirements, bottom material, location and structure type has modified current wildlife and aquatic crossing design. Information on noise impacts, moisture content of soil, light, human activities and vegetation associations relative to structure designs will be updated. Also, use of structures by elk (*Cervus elaphus)*, deer (*Odocoileus spp)*, moose (*Alces alces)*, antelope (*Antilocarpra americana)*, bighorn sheep (*Ovis canadensis)* and various carnivores will be discussed based on current knowledge. The information presented will help transportation agencies, wildlife agencies and land management agencies design crossing structures that are effective in reducing animal-vehicle collisions, improving habitat and population connectivity, and are cost-effective. The authors have been involved with over 100 major wildlife and aquatic highway crossings in North America, particularly in the Rocky Mountain States, and have extensive experience in structure location, design, costs and the interagency coordination required to implement effective highway mitigation.

Differences in Bird Diversity on Bison vs. Cattle Grazed Ranches in Northeastern New Mexico

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Large ungulate grazing has played a significant role in shaping grassland habitats of the Great Plains in North America. American Bison (*Bison bison*) once roamed the plains in herds estimated to be around 30 million, playing a major role in maintaining abundance and diversity of plain's biota. Today most of these areas are primarily grazed by cattle. Changes in grass height, ground cover, and shrub abundance can have profound impacts on grassland wildlife species, especially birds. Grassland birds are some of the most threatened birds in North America due to habitat loss and overgrazing. Although bison and cattle are functionally similar as large grass-feeding herbivores, differences exist in grazing behavior that suggests bison may be a key species for maintaining diversity in grasslands. This study compared bird diversity on two neighboring ranches, one bison grazed, and the other cattle-grazed. Bird

diversity was measured in riparian and grassland habitat using point-count surveys during 2011. We found statistical evidence that bird diversity was higher in grassland habitat on the bison grazed ranch. We also found that bird diversity was higher in grazed vs. nongrazed grassland on the cattle grazed ranch. These results suggest that low-intensity to moderate grazing by both cattle and bison supports grassland biodiversity, and further suggests that native grazers (bison) can help restore grassland plant communities and structures, reestablishing important habitat for birds and other wildlife.

The Accomplishments of a Network— Priceless Resources: A Strategic Framework for Wetland and Riparian Area Conservation and Restoration in Montana 2008-2012—and Prioritization for 2013-2017

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The Montana Wetland Council provides a forum for scientists, mangers, regulators, and others to network and collectively advance wetland and riparian conservation. While these professions aren't typically known for their social dynamism, the passion for the resource holds together and propels this functioning network and has resulted in three National Wetland Award winners in the last 7 years. Five-year accomplishments include: Montana now has digital wetland and riparian maps for a majority of the state and these important aquatic resources are one of the state's supported 14 Montana Spatial Data Layers. Montana also has a new statewide In-Lieu Fee Program for impacts to aquatic resources throughout Montana under the auspices of the Corps' 404 and Section 10 regulatory programs. These and other accomplishments from the State's 2008-2012 Wetland and Riparian conservation strategy will be described along with what difference the accomplishments have made and opportunities they leverage for increased wildlife habitat protection and restoration. The next 5-yr strategy is currently in the makings. Hear about the 2013-2017 draft priorities and share your input to shape the collective direction of the Montana Wetland Council network.

Progress Toward Grizzly Bear Recovery: The Current Status of Grizzlies in the Yellowstone and The Northern Continental Divide Ecosystems

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The grizzly bear (*Ursus arctos*) was listed as a threatened species in the lower 48 states in 1975. Formal recovery efforts started in 1981 with the completion of the first Recovery Plan. The state and federal agencies, tribes, and Canadian provinces were organized in 1983 into a cooperative structure called the Interagency Grizzly Bear Committee to work together to implement the Recovery Plan. At the time of listing, the exact number of grizzly bears was unknown but probable numbers in the Yellowstone ecosystem were approximately 250, in the Northern Continental Divide Ecosystem (NCDE) approximately 400. In 2012, population estimates in the Yellowstone ecosystem are approximately 700 and approximately 1000 in the NCDE. Both of these populations appear to be approaching the carrying capacity of their ecosystems as evidenced by reduced subadult survival in the core areas of the Yellowstone ecosystem and dispersal of primarily subadults into peripheral habitats in both ecosystems. The expanding range and numbers of grizzlies is resulting in re-occupancy of habitats in Montana where grizzly bears had been extirpated for over 100 years. The objective of the Endangered Species Act (ESA) is to get listed species to the point at which protection of the ESA is no longer required. We review progress toward recovery and delisting and the reasons the grizzlies in these ecosystems have recovered including mortality control, habitat management, nuisance bear management, and outreach and education. We also describe future management once recovery and delisting have been achieved and how this management will assure the long-term future of this species in Montana.

Elk Movements and Brucellosis Transmission Risk in Southwest Montana

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The presence of *Brucella abortus* within free-ranging elk populations is an important conservation and management issue because of the risk of brucellosis transmission to livestock. Understanding elk distributions is necessary to forecast elk and livestock spatial overlap and the potential for brucellosis transmission. As part of a 5-yr brucellosis surveillance project, 30 adult female elk were captured and fitted with GPS collars in each of the winters of 2010, 2011 and 2012 in three southwest Montana study areas. We used elk location information to assess elk movements, and spatial overlap with livestock and adjacent elk herds. The elk movement results were further augmented with data from Wyoming and Idaho elk herds. The elk movement data shows interchange of females between elk herds during the transmission risk period. Resource selection models predicting elk distribution and spatial overlap with livestock during the transmission risk period were developed and extrapolated across the designated brucellosis surveillance area of Montana. We used the elk location data collected in this study to validate and refine models predicting elk distributions and spatial overlap with livestock during the risk period. Predictive models may be used as a tool for focusing management actions aimed at minimizing elk and livestock spatial overlap during the transmission risk period.

Estimating Lynx Habitat Under Future Fire Management and Climate Change Scenarios

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Climate changes have the potential to considerably alter the habitat of Canada lynx (*Lynx canadensis*), which are dependent on snowshoe hare throughout their range. Both species occupy areas of high altitude forest with dense cover of shrubs and saplings. The Fish and Wildlife Service has designated critical habitat for lynx, but there is little research on how these areas will change with a changing climate. We use the simulation model FireBGCv2 to run scenarios comparing climate change, fuel treatments, and fire suppression. Our results suggest that fire suppression has the most important future benefit in maintaining lynx habitat, as allowing natural fires to burn reduces the quality of lynx habitat over a fifty year modeling period. Although fires can generate the early seral stage that defines quality lynx habitat, their frequency prevents much of the modeling landscape from reaching this stage. Simulation modeling can provide a valuable platform to view the future of lynx habitat under climate change, but the limitations are numerous.

Winter Wheat – Finding a Balance Between Modern Agriculture and Prairie Nesting Ducks

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The Prairie Pothole Region (PPR) of North America is a highly valuable landscape for breeding waterfowl that has been predominantly converted to some form of agriculture in the last century. This is cause for concern since the extent of cropland has been strongly associated with declining numbers and nest success of ducks. With the recent increase in economic value of some cash crops and the potential to lose highly valuable nesting habitat in the Conservation Reserve Program (CRP), there has been an interest in evaluating alternative farming practices as potential breeding habitat for waterfowl. While past research has shown nest success of waterfowl to be very low in spring-seeded crops, limited research has assessed the potential of winter wheat, a fall-seeded crop, as a nesting habitat. We wanted to assess and compare the use and success of prairie-nesting ducks in winter wheat to perennial cover (CRP, grassland, etc.) in the PPR of North Dakota. We monitored duck nests (*Anas* spp.) in winter wheat (n = 1284) and perennial cover (n = 3244) from 2010-2012. We will use a model-selection based approach to evaluate nest survival after accounting for a variety of environmental (wetland density, vegetation density, etc.) and temporal covariates (initiation date, nest age, etc.) and predict that daily nest survival will be similar in both habitats. Results from this study will provide valuable insight for wildlife managers on the benefits and weaknesses of winter wheat as a breeding habitat for waterfowl.

Using Advanced Technology to Evaluate the Effects of Restoration Treatments on Bird Use of Shrubby Draws During Fall Migration

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In 2012, the MPG Ranch initiated efforts to restore ground cover and woody structure in several draws degraded by decades of cattle grazing. To evaluate the effects of restoration treatments, we are studying bird use of draws during fall migration, tracking changes in bird use as restoration progresses. To map bird occurrence at the scale of restoration treatments, we developed and tested an iPad application that allowed us to place bird detections directly onto high-resolution, geo-referenced aerial imagery. Along with an exact location, the application allows us to record descriptive information such as species, behavior, and substrate used. In our pilot season, we recorded observations of 1,061 birds. The Vesper Sparrow was the most commonly observed species. We were able to detect spatial and temporal trends in bird use of shrubby draws, with notable clustering in areas of established woody vegetation. We also detected several species using shrubby draws during fall migration that would not typically be found in this habitat type in the breeding season. In the future, we will make quantitative associations between bird detections and the presence of features such as shrub and tree cover or the presence of water. Given what we deemed a successful pilot season, we plan to continue the use of the iPad application during subsequent fall migrations as draw conditions change and habitat conditions presumably improve.

Twenty Years of Human-Grizzly Bear Conflict Management in Northwest Montana

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This paper examines and summarizes twenty years of human-grizzly bear (*Ursus arctos*) conflicts and management actions in northwest Montana from 1993 through 2012. Initial responses to the reported conflicts usually involved identifying the attractant and securing or removing the attractant. In many situations, the decision was made to trap and capture the grizzly bear. A total of 193 individual grizzly bears were captured 344 times in management actions which ranged from grizzly bears frequenting yards to grizzly bears breaking into cabins. When grizzly bears were captured their fate depended upon their age, sex, level of conflict, and classification based on the Interagency Grizzly Bear Guidelines. Grizzly bears were released on-site, translocated, or removed from the population. Translocations included long distance out of home range moves to short distance moves within the home range. Aversive conditioning techniques were tried involving the use of bean bag and rubber bullet rounds, cracker shells, and Karelian Bear dogs. New technology such as remote cameras, automated traps, and use of DNA were also used on this project. The success or failure of the different management actions is discussed and recommendations are made for future human-grizzly bear conflict management actions.

Montana Peregrine Falcon Survey: 2012

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The release of 617 captive-bred young during the 1980's and 1990's sparked the recovery of the Peregrine Falcon (*Falco peregrinus*) in Montana. By 1994, a mix of state, federal, and private biologists (Montana Peregrine Falcon Working Group) documented 13 known active Peregrine Falcon territories. For the following four years, the number of known territories averaged about 16, but then intensive survey efforts in 1999 documented a total of 28 territories. The number of active Peregrine Falcon territories discovered in Montana has increased yearly. Montana had a record number of 108 active Peregrine Falcon nests recorded during the 2012 field season. Montana Peregrine Falcon surveys are conducted in conjunction with the USDI Fish and Wildlife Service national surveys scheduled every 3 years, beginning in 2002 and ending in 2015. Annual survey objectives include the establishment of a citizens group (Project Peregrine Watch) to monitor individual Peregrine territories throughout the state, determine status and trends of Montana's Peregrine Falcon population, study all known historic Peregrine Falcon eyries, record occupancy and productivity at all active territories, locate new Peregrine Falcon territories, seek confirm and consolidate information from all public and private sources, record activity and locations of neighboring cliff-nesting raptors (Prairie Falcon (*Falco mexicanus*), Golden Eagle (*Aquila chrysaetos*), and the Red-tailed Hawk (*Buteo jamaicensis)*, and develop , a long-term and cost-effective monitoring program for determining annual status and population trends of the State's Peregrine Falcon population.

History of Woodland Caribou in Montana

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Within the contiguous U.S., woodland caribou (*Rangifer tarandus caribou*) were historically a resident of mature, deep-snow forests of northwest Montana, north Idaho and northeast Washington. Because of habitat changes, predation, and unregulated hunting, numbers dwindled to remnant populations or even extinction throughout their distribution within the U.S. By the 1950s, any caribou that might be observed in Montana were considered transitory from either southern British Columbia or north Idaho, where remnant populations still remain. In this paper, we review historical and current records of woodland caribou in Montana, discuss their biological requirements and legal status, and offer comments on future recovery efforts.

Nesting Ecology of Spiny Softshell Turtles on the Missouri River in Montana: Zoogeographic and Management Implications

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The nesting ecology of western spiny softshell turtles (*Apolone spinifera hartwegi*) in Montana, where they are at the northern extent of their range and a state Species of Concern, is poorly known. We used telemetry, visual surveys, observation from shore-based blinds, and remote cameras to document nesting behavior, habitat, and timing in a 97-km reach of the Missouri River. We located 25 nests in 2011 and 97 in 2012. Most nests were in mixed-gravel substrates; only 3 percent were in pure sand. Vegetative cover at nest sites was sparse. Mean distance of nests to the water's edge was 13.7 m and mean height above the water surface elevation was 0.7 m. Proportion of nests found on island and mainland habitats were similar in 2011, but 90 percent of nests were on islands in 2012. Predation occurred on 46 nests; mainland nests incurred higher predation rates than island nests. Nesting followed annual peak river stage, and mostly occurred in the afternoon. Durations of nesting, incubation, and emergence periods were similar in both years, but nesting and emergence occurred about three weeks later in 2011 than in 2012. Only 36 percent of nests were successful in 2011, but 60 percent were successful in 2012. Flooding in 2011 probably decreased nesting effort and success by reducing habitat availability and delaying the onset of nesting, which thereby prematurely ended incubation. However, flood events maintain and create nesting habitats by clearing vegetation and depositing substrates. Premature termination of incubation suggests that the northern range of this species is probably limited by successful incubation.

Wolverine Food Habits and Foraging Strategies in Glacier National Park, Montana

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From 2003-2007 we captured and instrumented 28 wolverines (*Gulo gulo*) in Glacier National Park to investigate reproduction and recruitment. We collected 189 scat samples at reproductive den, forage and rendezvous sites, and documented 90 prey species through observation and prey remains found at similar sites. Seasonal scat analysis provided evidence of differences in prey species consumed during winter (n = 170), summer (n = 19), and reproductive den (n = 103) periods. Ungulates were the most frequently observed prey found in all scats (71%; N=135), with Cervid remains being observed most often (37%; n = 70).

Hibernating rodents (ground squirrels and marmots) (36%; *n* = 68) were the next most utilized prey, with the third most documented prey being mice and voles (31%; *n* = 56). Vegetation (72%; *n* = 169), soil material (31%; *n* = 59), and bone (90%; *n* = 171) were also found in scats. Seasonal importance of prey was documented, with ungulates being the most observed prey in winter scats (75%; *n* = 128) and den period scats (79%; *n* = 81), and hibernating rodents being most observed in summer scats (47%; *n* = 9). A similar condition was found with analysis of all prey remains (*n* = 90); ungulates were consumed most often (69%; *n* = 63), with hibernating rodents as the second most documented prey (12%; *n* = 11). Wolverines exhibited seasonal dietary shifts in that ungulates were consumed most frequently during winter (77%; *n* = 55) and the den period (78%; *n* = 17), with hibernating rodents the most frequent prey documented in summer (50%; *n* = 9). Wolverine foraging strategies, including searching tree wells, fishing, decapitation, and food caching are also discussed.

Untangling Rocky Mountain Elk Ecology and Population Dynamics: A Regional Synthesis Across the Northwestern U.S.

Western Elk Research Collaborative (representatives from 7 state wildlife management agencies, 4 Cooperative Wildlife Research Units, 1 university, USDI National Park Service)

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The Western Elk Research Collaborative (WERC) is a group of state and federal biologists and university faculty that is pooling Rocky Mountain elk data from 7 states to understand factors affecting elk (*Cervus elaphus*) population dynamics at broad spatial and temporal scales. These “value-added” analyses leverage the considerable investment collaborators made to develop their respective datasets. Our initial efforts pooled data from 12 elk populations to evaluate calf survival and cause-specific mortality (Journal of Animal Ecology 80:1246-1257) and 45 datasets to assess adult female survival and cause-specific mortality (Journal of Applied Ecology in press). We will briefly describe those findings. We also seek to understand how reproductive output varies across space and time as a function of factors such as weather, plant productivity, and predation. Therefore, we are assembling population and reproduction data from our 7 state study area. The spatial and temporal (≤ 25 years) scales are unique and may provide insight into the effects of climate change on elk population dynamics. As a direct result of the exceptional cooperation and communication among collaborators … a signature success of WERC … we are developing an unprecedented Rocky Mountain elk dataset that will provide a fertile arena to investigate relevant management and research questions.

Camouflage Mismatch in Seasonal Coat Color Due to Decreased Snow Duration

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As a result of climate change, the duration of the ground snow cover in the temperate regions has shortened. We describe a novel and striking climate change effect on wildlife, whereby seasonal coat color becomes mismatched with background snow or lack of snow. Our objective was to quantify for snowshoe hares *(Lepus americanus)* the phenology of seasonal coat color change and potential for coat color mismatch, as first step in exploring whether hares can adapt to a decreasing snowpack. We quantified snowshoe hare molt phenology, mismatch and survival for three years at two sites in western Montana. We monitored over 450 hares weekly with radiotelemetry, quantifying the progression of the molts and snow cover. We observed considerable mismatch between hare coat color and their background during spring and fall seasons. Some level of plasticity was observed in the rate of the spring molt which mitigated the color mismatch. By contrast, onset of coat color molts remained constant. We used global circulation model downscaling at ecologically relevant scales (30m resolution) to predict changes in snowpack hares are likely to face in the future. According to our analysis annual average duration of snowpack will decrease by 29-35 days by mid-century and 40 - 69 days by the end of the century. Without evolution in coat color phenology, the reduced snow duration will increase the number of days that white hares will be mismatched on a snowless background by 3- 8 fold.

Poster Abracts

Citizen Scientists add to our Understanding of Bird Populations and Status Across Montana

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Montana Audubon, our partners, Audubon Chapter members, and bird enthusiasts across the state are increasingly involved in contributing time and talents to understanding bird populations, habitat associations, and trends. Birders contribute sightings to *eBird* or *Tracker*, reporting their observations from field excursions and their backyards. This information helps inform Montana Species of Concern listings and influences bird conservation and science priorities in the state and beyond. Montana Audubon also encourages citizen monitoring projects for single species and guilds, from Black Swifts to Golden Eagles. We are now home to the greater sage grouse (*Centrocercus urophasianus*) Adopt-a-Lek program which coordinates citizen scientists to monitor sage-grouse on over 50 breeding leks across Montana every spring. Finally, our Audubon chapters adopt and monitor Important Bird Areas across the state in order to conserve species of conservation concern and their habitats. Find out more about these volunteer efforts.

Black-Footed Ferret Recovery: Things are Looking Up!

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The black-footed ferret (*Mustela nigripes*) is considered one of the most endangered mammals in the world. Hindering the success of recovery efforts is the presence of Sylvatic Plague and a general intolerance of the ferrets primary prey, the prairie dog. To date, the only tools against plague at reintroduction sites have been vaccination of ferrets prior to release, application of pesticides, and translocation of prairie dogs into sites following an epidemic plague event. In addition to the high cost of plague management, ferret recovery is hampered by loss of habitat to sod-busting and development and ESA regulations that make landowners wary of finding or hosting a listed species. However, in recent years, innovative approaches to plague management, prairie dog conservation and ESA regulation have laid a new path for ferret recovery across Western states. These approaches include the following: 1) An MOU signed in 2012 by the USFWS, NRCS, USGS, Wildlife Services, and the Western Association of Fish and Wildlife Agencies facilitating cooperative conservation efforts with willing landowners to maintain ranch land in prairie habitat and the livestock operations that they support *while* providing for the conservation and recovery of wildlife species associated with prairie dogs, 2) Development of a safe harbor agreement that would provide regulatory assurances to land owners willing to allow ferret re-introductions, and 3) Development of a sylvatic plague vaccine meant to be dispersed at ferret reintroduction sites. Successful implementation of these new tools could result in ferret recovery within the next decade.

Where are Long-Toed Salamanders Found in a Game of Hide-And-Seek With Trout?

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In many alpine lakes, trout have been introduced for recreational fishing and have replaced native amphibians as top predators. In these systems, trout are associated with reducing the abundance of amphibians and have extirpated populations of long-toed salamanders (*Ambystoma macrodactylum*) from many lakes. Although rare, salamander coexistence with trout may occur in some lakes where habitat characteristics such as emergent vegetation and physical barriers are present, as these environments can provide refugia from predation. We sought to identify what key habitat features might allow this co-occurrence. We sampled seven lakes with salamanders and fish and seven with only salamanders in northwestern Montana between July and August 2012. We used minnow traps to capture salamander larvae and we quantified habitat characteristics (e.g., vegetation density, structural complexity) where salamanders were captured. We compared capture rates and habitat characteristics to determine whether lakes with and without fish differed. Preliminary results suggest that salamander capture rates were higher in lakes with fish (33%, 95% CI = 13-84%), but salamanders were smaller, as larvae had 68 percent shorter tails (51-91%) in lakes with fish. Despite these differences, we did not detect any differences in habitat characteristics. Unless minnow traps were used as refugia, our findings suggest that salamanders utilize similar habitat in these lakes regardless of the presence of fish. Future work will examine factors influencing salamander growth and tail length and determine whether adding habitat complexity is an effective strategy to facilitate coexistence of salamanders and fish.

Avian Monitoring with Autonomous Recording Units in the Bitterroot Valley, Montana

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Monitoring avian species over a vast landscape challenges researchers and land managers. Many current monitoring programs rely on point counts, banding stations, and other methods requiring skilled observers. Autonomous recording units (ARUs) compliment data from these more common field techniques. In September 2012, MPG Ranch installed three ARUs at low-, mid- and high-elevation locations to supplement concurrent data collected at passerine banding stations. A preliminary analysis of migrating passerine nocturnal flight calls revealed distinct temporal and spatial trends between sites and through the season. We detected more sparrow, warbler and thrush flight calls in September than in October and at the low-elevation site than at the high-elevation site. We plan to compare this analysis to the banding data collected by the University of Montana's Avian Science Center for additional patterns. The ARUs also recorded several infrequently detected or new species on the ranch. We detected a barn owl (*Tyto alba*) 16 times at the low- and mid-elevation

ARUs over a 29-day period in September and October. These detections represent the first documentation of a barn owl since property monitoring began in 2010. Additional acoustic monitoring will help determine if this was a migration or some other phenomena. The common poorwill (*Phalaenoptilus nuttallii*) was another uncommon species documented via ARUs. In the future, we plan to use ARUs to document the presence and vocalization phenology of several species (e.g., Flammulated Owl, Common Poorwill) breeding in difficult-to-access areas of the property. We also plan to acoustically monitor the 2013 spring passerine migration.

Montana Prairie Pothole Joint Venture Breeding Shorebird Monitoring Project

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Populations of several shorebird species in the Prairie Pothole Region (PPR) appear to be declining, largely because of loss of grasslands and wetlands. Marbled godwit (*Limosa fedoa*), long-billed curlew (*Numenius americanus*), willet (*Tringa semipalmata*), Wilson's phalarope (*Phalaropus tricolor*), upland sandpiper (*Bartramia longicauda*), American avocet (*Recurvirostra americana*) and Wilson's snipe (*Gallinago delicata*) are listed as priority species by Partners in Flight or the U.S. Shorebird Plan. In 2004, the USDI Fish and Wildlife Service, Habitat and Population Evaluation Team (HAPET) began conducting breeding shorebird surveys to complement existing waterfowl population and habitat evaluations for the partners of the Prairie Pothole Joint Venture in North Dakota, South Dakota and northeast Montana. Survey methodology was modeled after the Breeding Bird Survey (BBS) but modified to fit the breeding ecology of these shorebirds. In 2012, surveys were expanded to include the western portion of the Montana PPR. Data from these surveys will be used to estimate shorebird population densities and distribution; however, current survey methods do not take into account areas where shorebirds may have been present but undetected, possibly resulting in an underestimation of shorebird densities. Surveys will be modified in 2013 in an effort to allow for estimation of shorebird detection probabilities, while maintaining compatibility with previous data collection methods. Results from this research will allow land managers to integrate breeding shorebird conservation with ongoing waterfowl conservation actions in the Montana PPR. We summarize the objectives and field design of the project and report results of preliminary modeling from our 2012 efforts.

Assessing Genetic Diversity Between Bighorn Sheep Populations in Western Montana

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This study investigates two remote bighorn sheep populations in the southern Bitterroot Valley affected by a pneumonia outbreak in 2010. Limited information is available regarding the genetic relatedness among bighorn sheep populations and how pneumonia related die offs could impact genetic diversity and herd resilience to future outbreaks. To contribute to local research efforts we developed scat collection and DNA extraction protocol for advanced high school students in a community science program. This study gathers baseline information about the genetic relatedness between two relatively close but isolated populations, and will estimate the heterozygosity and the number of distinct alleles at several microsatellite loci. DNA from bighorn sheep scat was collected, extracted, and genotyped from samples in June of 2011 (n = 19) and 2012 (n = 25). The small sample size will reduce our ability to make broad conclusions; the number of samples represents about 20 percent of the estimated herd size in 2011 and 2012. Although our ability to make conclusions may be limited, this data could contribute to bighorn sheep management strategies for the Bitterroot and long term genetic monitoring for a sustainable population. Additional samples will be collected and analyzed yearly to look for changes in heterozygosity over time and in response to any future translocations.

Migrating and Overwintering Populations of Diurnal Raptors in the Bitterroot Valley, Montana

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We identified a major spring and fall migration of diurnal raptors over a low-elevation foothills site in the northeast Bitterroot Valley. We conducted full-time migration surveys in both seasons for 2 years. Red-tailed Hawks were the most abundant species counted in both seasons. During fall migration, species composition differed from other Montana hawk watch sites located on high-elevation ridges. We used a combination of survey techniques to assess overwintering populations of raptors in the Bitterroot Valley during the winter of 2012-2013. We developed an iPad application that allows us to map fine-scale occurrence of birds and used this method to document raptor presence at the north end of the valley. Citizen Scientists affiliated with Bitterroot Audubon performed systematic, broader-scale surveys at the south end of the valley. These two methods will likely document over 3,000 raptor observations by the end of winter 2013. Rough-legged and Red-tailed Hawks comprise the majority of raptor detections. We will examine these data for spatial and temporal trends in raptor occurrence.

Occupancy Dynamics of Avian Species in Relation to A Mountain Pine Beetle Epidemic

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Recent epidemics of mountain pine beetles (*Dendroctonus ponderosae*) will fundamentally alter Rocky Mountain forests, impacting management decisions related to fire, logging, and wildlife habitat. We evaluated effects of a recent mountain pine beetle epidemic on occupancy dynamics of 46 avian species. Seventy-six point count stations were randomly located in four, 250 ha study units within pine (*Pinus* spp.) forests in the Elkhorn Mountains, Montana. Each point was visited 3 times during the breeding seasons (May-Jul) 2003-2006 (pre-outbreak) and 2009-2011 (post-outbreak). We used a Bayesian hierarchical model of multi-species occupancy that accounts for imperfect detection and allows for estimates of rare, as well as common species. Occupancy was modeled for all species with respect to pre-outbreak years, year since the outbreak, and proportion of ponderosa pine. Results supported our prediction that occupancy rates would increase after the outbreak for bark-drilling woodpeckers (*Picoides* spp.). Occupancy rates of foliage-gleaning chickadees (*Poecile* spp.) and bark-gleaning nuthatches (*Sitta* spp.) declined soon after the peak in beetle-induced tree mortality (2008); however, their rates began to rise within 3 years. Bark-gleaning species' occupancy relationships with ponderosa pine changed after the outbreak. Our results will help inform forest management activities for the persistence of species that evolved with large-scale disturbances.

Proactive Management of Pneumonia Epizootics in Bighorn Sheep in Montana—Project Update

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Pneumonia epizootics are a major challenge for effective management of bighorn sheep (*Ovis canadensis*). Approximately half of the herds in Montana have suffered die-offs since the 1980s, many of which were pneumonia events. A set of models that identify risk of pneumonia and the best management decisions given that risk would be of great value for proactive management of pneumonia epizootics. Our first objective is to design and test a risk model that will help predict a herd's risk of pneumonia. We hypothesize that various factors increase risk through pathogen exposure, pathogen spread, and disease susceptibility. Analysis of these factors comparing herds with and without recent pneumonia histories using Bayesian logistic regression will allow us to design a risk model. Our second objective is to develop a proactive decision model that incorporates estimates of pneumonia risk to help evaluate costs and benefits of alternative proactive actions appropriate to those estimates. We will use a Structured Decision Making framework, which provides a deliberative, transparent, and defensible decision-making process that is particularly valuable in complex decision-making environments such as wildlife disease management. Together the resulting risk and decision models, to be completed this year, will help managers estimate pneumonia risk and identify the best management action based on both the severity of each herd's predicted risk and costs and benefits of competing management alternatives. Ultimately, this project will demonstrate the development and application of risk and decision models for proactive wildlife health programs in Montana Fish, Wildlife and Parks.

Exploring Adaptive Management for Greater Sage Grouse in Northern Montana in the Face of Climate Change

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A collaboration has begun in Montana among several state and federal agencies and non-governmental organizations interested in the management of greater sage grouse (*Centrocercus urophasianus*) in a > 5,000,000-ac (> 20,234-ha) landscape including the Charles M. Russell National Wildlife Refuge. The first step was conducting personal interviews with field biologists and managers in the general area to assess what management actions they are making. Using this information, we conducted an on-line survey to further identify those actions and how they are made. Finally, almost 40 managers and scientists met to discuss whether an adaptive management approach might be useful to gain an understanding of the interaction among habitats and management actions and how this will be affected by annual weather and climate patterns. A conceptual model of how these factors affect the life cycle of grouse has been drafted, and we are gathering comments on it. The intent is for that to be used as an ecological response model for assessing the effects of possible climate change scenarios. Future work will entail: (1) further delineation of management actions and the social networks associated with them, (2) building and evaluating a working model using rapid prototype methods, (3) conducting futures analyses of associated landscapes, (4) continuing to foster collaborative effort, and (5) working one-on-one with managers to evaluate model and adaptive management applicability using such tools as LCMAP (Landscape Conservation Management and Analysis Portal).

Montana Golden Eagle Conservation Guidelines

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The Montana Golden Eagle Working Group is preparing guidelines to address conservation concerns for golden eagles (*Aquila chrysaetos*) related to land use change and population-level mortality factors. The guidelines focus primarily on avoiding, minimizing and mitigating adverse impacts to golden eagles. The USDI Fish and Wildlife Service Draft Conservation Plan Guidance explains the Service's approach to issuing programmatic permits for eagle take and provides adaptive management guidance for the conservation of golden eagles related to land-based wind energy facilities. The Montana guidelines are intended to address a wider array of golden eagle conservation concerns and potential anthropogenic impacts, and compliment implementation of the industry-focused Draft Eagle Conservation Plan Guidance in Montana. We will present a summary of the status of and threats to golden eagle populations and habitats. Then we will discuss our draft conservation guidelines that outline strategies for maximizing reproductive potential and survival of the eagle population in Montana. We also will present some options for mitigation when negative impacts to eagles cannot be avoided or minimized.

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