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Intermountain Journal of Sciences

The Intermountain Journal of Sciences (IJS) is a regional peer-reviewed journal that encourages scientists, educators and students to submit their research, management applications, or viewpoints concerning the sciences applicable to the intermountain region. Original manuscripts dealing with biological, environmental, health and human development, mathematics, molecular-cellular, pharmaceutical, physical and social sciences are welcome.

Co-sponsors/publishers include the Montana Academy of Sciences, the Montana Chapters of The Wildlife Society and The American Fisheries Society. It is the intent of the governing bodies of the co-sponsoring organizations that this journal replace and standardize printed proceedings from the respective annual meetings. Format and style should follow the *Guidelines for Meeting Abstracts Submitted to the Intermountain Journal of Sciences, 1st revision 2016.** It is the policy of the editorial board that abstracts from presentations at annual meetings be published in the last issue of ***IJS*** for that year of the annual meeting. Submission of manuscripts for review and publication without regard to membership is encouraged.

Baseline funding is provided by the co-sponsoring organizations. Long-term funding will be derived from page charges assessed manuscript authors at $60/page, sponsoring organizations at $40/page for annual meeting abstracts and annual subscriptions: student - $6, regular member - $15, patron member - $25, international member - $25 and library - $25. One time subscriptions are: life member - $150 and sustaining subscriber - $2,500.

The intent of the co-sponsors and editorial board is that ***IJS*** be expanded to a quarterly journal. Achieving that objective depends upon numbers of acceptable manuscripts received and available funding. The editorial board's policy is that contributing authors be assured of publication within 12 months of acceptance of their manuscript. An agreement has been established with the Montana State University Library to convert and archive IJS using an Open Journal Systems protocol.

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 editor-in-chief and managing editor. 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 supervisor for layout and printing and liaison to the sponsoring organizations. Associate editors and referees are selected on the basis of their field and specific area of knowledge and expertise.

Associate editors and referees judge submitted manuscripts on originality, technical accuracy, interpretation and contribution to the scientific literature. Format and style should follow the ***Guidelines for Manuscripts Submitted to the Intermountain Journal of Sciences, Dusek 1995, 2nd revision 2016.**** 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 (1/01/20 - 12/31/20)

Balance 01/01/20		**$2,824.86**
Income:		
Subscriptions:		
Regular Member	$45.00	
Library Subscriptions	$200.00	
International Member	$25.00	
	Subscriptions Subtotal	**$270.00**
MSU Library Services		$750.00
Page Charges		$5,249.07
Reprints and PDFs		$25.00
Bank Promotion (New Account)		$50.00
Back Issues		$5.00
Total Income		**$6,349.07**
Expenses:		
Design and Layout		$2,875.00
Printing		$827.57
Postage		$183.35
P. O. Box Rental		$168.00
Administrative and Bank Fees		$59.53
Warehouse Rental		$428.00
Website Hosting		$110.00
MSU Library Service (2019 Archiving Fee IJS)		$750.00
Bookkeeping Software		$49.99
Total Expenses		**$5,451.44**
Balance 12/31/20		**$3,722.49**

Nancy Hilder, 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 IJS. This review shall include, but not be limited to, appropriateness for publication in IJS, 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) available on the IJS website, www.intermountainjournal.org under the Publish tab. 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.

Hard or digital 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 copy of the manuscript and guidelines for his/her review, and submits the approprrate docments to each of two other reviewers. A minimum of two reviewers, including the Associate Editor, is recommended for each manuscript. The two reviewers are instructed to return the manuscript and their comments to the Associate Editor. The Associate Editor then returns all manuscript copies and reviewer comments plus a recommendation for publication, with or without revisions, or rejection of the manuscript to the EIC. The EIC then reviews the recommendations and all comments and 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 if further review is required. The revised manuscript shall be returned to the EIC within 14 days of 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 resubmitted manuscript. The resubmitted 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 ME or chairman of the editorial board, who will serve as the EIC for that manuscript.

Abstracts

Only abstracts submitted 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 (samjd@montana.com), on or before November 1. Each abstract shall be reviewed by the EIC to assure proper grammar, compliance with IJS Guidelines and for publication in the December issue of IJS. The Guidelines for Submitting Meeting Abstracts (Presentation or Poster) are available as a pdf on the IJS website under the Publish tab. (www.intermountainjournal.org)

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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Caragana Establishment, Survival and Regeneration in the Black Hills, South Dakota

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Abstract

The purpose of this study was to determine the adaptability and potential wildlife value of Caragana also known as Siberian peashrub for establishment, survival, growth, regeneration, and nutritional qualities. This study was initiated in 1968 in the Black Hills, South Dakota on the McVey Burn (1939), within an open stand of a ponderosa pine forest. Bare rootstock was planted in 1968, and after 35 years survival was 74 percent. Average height was 3 m (10 feet) and plants did regenerate by seed bt did not expand into adjacent habitat. Ideal growing condition evaluated at 35 years, was in a closed tree canopy with 35 percent overstory and basal area 17.7 m^2/ha (77 ft^2/ acre). Open growing conditions was had exposed areas, canopy cover 17 percent and basal area 5.4 m^2/ha (24 ft^2/acre). Tree overstory cover on North facing slopes was approximately 2 times greater than on more open south facing slopes. Caragana has not shown signs of spreading from original planting sites. A model developed for habitat assignment defining Closed and Open tree overstory cover for growth, regeneration, and establishment for future sites was 90 percent accurate. Utilization of Caragana by deer based on volume (length x width x height) was 77 percent, 12 years after establishment, with greatest use on south facing slopes. Nutritional qualities of Caragana are generally greater than native shrubs for winter use, with only phosphorous being marginal. The adaptability of Caragana and its qualities makes this browse species suitable for white-tailed deer use for winters. Plantations of Caragana in key wintering areas for white-tailed deer on south facing slopes with Open tree overstory cover and low basal area is recommended for restoration on over browsed ranges.

Key Words: Deer, Browse, Nutrients, Plantations, Growth, Forage, Sagebrush

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Introduction

A loss of deer habitat in the Black Hills of South Dakota has been documented for over 60 years, primarily with the deterioration of native browse plants (Berner 1953, Bever 1959). More recently, white-tailed deer (*Odocoileus virginianus*) has been in a steady decline (Peterson 1984, Deperno et al. 2002) which is related in part to heavy livestock grazing and consumption of shrubs, interspecific competition with elk (*Cervus canadensis*) (Wydeven and Dahlgren 1983, Uresk 1987, Uresk and Paintner 1985), and habitat loss due to land development.

Many native shrubs are not able to compete with livestock grazing that result in low plant vigor on over browsed ranges and competition with grasses and introduced species. Introduction of native or introduced shrubs may be the best way to improve the availability and utilization of browse species. Establishment from seeding depends upon adequate precipitation and absence of competition from grasses and with favorable temperatures in early spring (Dietz et al. 1980). Shrub planting is an alternative to seeding. However, there have been limited shrub planting trials in the Black Hills (McEwen and Hurd 1959). Dietz et al (1980) reported excellent results of establishing shrubs in the McVey Burn (wildfire 1939) area for browse improvement. Caragana or Siberian peashrub (*Caragana arborescens*) initially showed some promise based on limited plantings and may have potential for increasing the availability of winter browse on the McVey Burn site compared to other browse plantings (Dietz et al. 1980). Results from this study will aid in considering improvement of white-tailed deer habitat in key wintering areas.

The objectives of this study for Caragana were 1) determine long term survival of plantings, 2) regeneration, 3) utilization by white-tailed deer and nutritional qualities and 4) determine potential habitat conditions for plantings within the Black Hills of South Dakota.

Study Area

The study area was located on the McVey Burn, 16 km (10 miles) northwest of Hill City, South Dakota, near the center of the burn. It was a wildfire and encompassed 8,845 ha (21,857 acres) that burned in 1939 (Dietz et al. 1980). This area became one of the most used white-tailed deer ranges in the Black Hills during winter months. The elevation ranged from 1600 m to 1800 m (5249 feet to 5906 feet). Mean annual precipitation during the study period was about 51 cm (20 inches) and 80 percent of the moisture is from April to September. Current mean annual precipitation at Hill City, SD is 53 cm (21 inches) (Uresk and Dietz 2017). Growing season is approximately 89 days and temperatures range from -6.2^0 C (21^{0}F) to 35.5^0 C (96^{0}F).

The study area within the burn was an open stand of small immature ponderosa pines (*Pinus ponderosa*) with Saskatoon serviceberry (*Amalancher angustifolia*), Woods' rose (*Rosa woodsii*), little bluestem (Schizachyrium scoparium), prairie sagewort (*Artemisia frigida*), common snowberry (*Symphoricarpos albus*), and Kentucky bluegrass (*Poa pretenses*). Soils are of metamorphic schist parent material; top soil is 13-15cm (5-6 inches) (Dietz et al. 1980). Slopes range from 36 to 39 percent.

Methods

Ten rows (replications) of bare rootstock of Caragana were planted within an 8 ha (20-acre) area on the burn site (1939 wildfire) in the summer of 1968. Prior to planting, each individual plant location was grubbed to remove vegetation and planted 15 cm (6 inches) deep. Bare root plants were obtained from a nursery. Each replication consisted of Caragana planted within a row, 137 m (150 yards) in length along the contour of the slope at 2.4 m spacing (8 ft apart). Individual rows were marked with a rebar stake placed in the ground and information written on a metal tag tied to each stake. Each of the ten replications was planted with 56 plants for 560 plants. Plants were not protected from browsing.

Survival of plants was evaluated yearly for the first five consecutive years and then five additional years throughout the years including the 35th year. All parent plants (live and dead) were easily detected within rows. Heights of each plant were measured on each replicate (row). Regeneration from seeds of individual plants was counted in a 2.3 m^2 (25 ft^2) frame when densities were greater than 100 plants and when densities were less than 100 plants, they were counted within a 9.3 m^2 (100 ft^2) and standardized to plants/0.09 m^2 (1ft^2). All frames were spaced at a distance of 50 feet along each replication. Tree canopy cover (%) of ponderosa pine was estimated with a spherical densitometer at 15 m (50 foot) intervals at the same location. Basal area, m2/ha (ft^2/acre) was estimated with a 10-factor prism. Current annual growth of Caragana was collected during the winter and processed at the Rocky Mountain Research Station, Rapid City, SD. North and South Facing Slopes were defined and measured separately for basal area and canopy cover.

Caragana plants were measured for volume (length x width x height) pre and post use by white-tailed deer during winter months. The difference between pre and post volumes was estimated as use by deer. Pre was prior to deer arrival on the winter range and post was after the deer left the area.

All data were averaged by replicate (rows) for survival, height and density of Caragana, ponderosa pine (tree) canopy cover, and basal area. The four variables (height, density, canopy cover, basal area) were subjected to a nonhierarchical cluster analyses (ISODATA) and standardized for equal weightings (Ball and Hall 1967, del Morel 1975). Stepwise discriminant analysis selected key variables to be used in the habitat stratification model. The model from discriminant analyses provided Fisher classification coefficients for assignment as to habitat stratification. Misclassification error rates or accuracy of model was estimated with cross validation using a jackknife or "leave one row out" procedure (SPSS 2003). All data were analyzed as means per replication (SPSS 2003).

Results

Survival rate was 74 percent after 35 years and the average height of Caragana was 3m (10 feet) and ranged from 1.2 to 5.8 m (4 to 19 feet) (Table 1). Regeneration averaged 1.4 plants/0.09 m^2 (1ft^2) and ranged from less than 0.2/0.09 m^2 to 4.5/0.09 m^2 (0.2 to 4.5 plants/ ft^2) (Table 1). Canopy cover of ponderosa pine ranged from 10 to 42 percent with a mean of 29 percent (Table 1). Mean basal area was 14 m^2/ha (61 ft^2/acre) ranging from 0.9 m^2/ha to 20.4 m^2/ha (4 to 89 ft^2/acre). A comparison of Caragana densities between north and south facing slopes was 0.95 /0.09 m (0.95/ ft^2) and 0.17/0.09 m^2 (0.17/ ft^2) (Fig. 1), respectively. North facing slopes had greater tree canopy cover (33%), compared to the south facing slopes (12%).

Cluster analyses (ISODATA) resulted in two distinct stratifications, defined as Closed and Open habitat, based on tree overstory canopy cover and basal area (Table 2). Closed growing conditions for Caragana are defined with a mean tree canopy cover of 35 percent and basal area of 17.7 m^2/ha (77 ft^2/acre). Mean heights and densities were 4 m (13 feet) and 1.7/0.09 m^2 (1. plants per ft^2), respectively. Open growing conditions were variable for trees with open areas. Ponderosa pine canopy cover was 17 percent and basal area 5.4 m^2/ha (24 ft^2/acre). Height and density of Caragana was 1.4 m (4.6 feet) with 0.6 plant/0.09 m^2 (0.6 plant/ft^2), respectively.

Discriminant analyses provided Fisher's classification coefficients (model) to predict and assign the habitat conditions for future site selections for planting of Caragana (Table 3). An example of applying the Fisher discriminant function coefficients with new data to determine the assignment for habitat stratification (Closed, Open) is determined by multiplying pine basal area (m^2/ha) for each row (Table 3). The products are summed (+ and -) including the constants for the score in each row. The greatest positive or the least negative score assigns the habitat stratification for Caragana. Mean values describing each stratification (Closed and Open) are presented in Table 2. Accuracy of habitat assignment is 90 percent.

Utilization of Caragana by white-tailed deer during the winter months (12 years after planting) was 77 percent based on volume (length x width x height) of the plants, pre and post measurements (Messner and Uresk 1980). Mean values of nutritional

Table 1. Overall means and ranges of key variables for Caragana and ponderosa pine after 35 years in the Black Hills of South Dakota. Standard errors (in parentheses).

Variables	n	Mean	Minimum	Maximum
Height (m)	10	3.1 (0.5)	1.2	5.8
Density (plants/0.09 m^2)1	10	1.4 (0.4)	0.2	4.5
Pine Overstory Cover (%)	10	29.3 (3.2)	10.1	42.2
Pine Basal Area (m^2/ha)	10	14.0 (2.1)	0.9	20.5

n= number of replications.
[1] 0.09 m^2 = 1ft^2

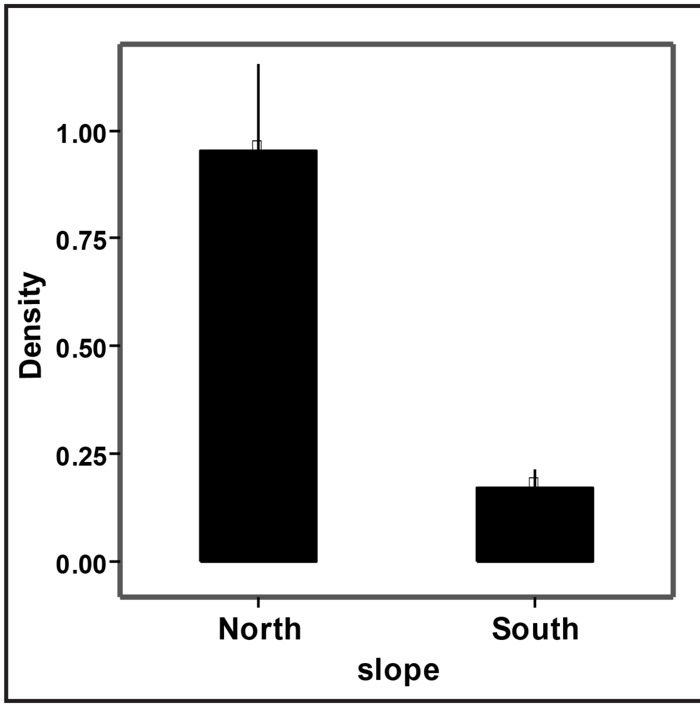

Figure 1. Regeneration (Density/0.09 m^2 ± standard error) of Caragana on north vs south facing slopes at 35 years after initial planting in the Black Hills of South Dakota. North facing slopes had a ponderosa pine overstory (33%) and south facing slopes are more open (12% overstory).

Table 2. Means of key variables and standard errors (Parentheses) for Caragana establishment within Closed and Open tree cover habitat stratification related to ponderosa pine overstory canopy and basal area at 35 years after establishment in the Black Hills of South Dakota.

Variable	Closed (n=7)[1]	Open (n=3)
Height (m)	4.0 (0.4)	1.4 (0.1)
Density (plants/0.09 m^2)[2]	1.7 (0.5)	0.6 (0.2)
Pine Overstory Cover (%)	34.6 (1.7)	16.9 (5.3)
Pine Basal Area (m^2 /ha)	17.7 (0.6)	5.4 (2.8)

[1] Replications
[2] 0.09 m^2 = 1ft^2

Table 3. Fisher's discriminant function coefficients for ponderosa pine basal area (m2/ha) stratified into two management options for planting Caragana in the Black Hills of South Dakota.

Variable[1]	Closed (n = 7)[2]	Open (n = 3)
Pine Basal Area (m^2/ha)	2.182	0.665
Constant	-20.037	-2.492

[1] Measurement Conversion: 1 m^2/ha = 4.356 ft^2/acre.
[2] Replications. Accuracy of stratification 90%.

constituents (%, oven dry basis) evaluated are: Protein (13.6), Acid Detergent Fiber (49.3), Acid Detergent Lignin (15.3), Ash (3.2), Calcium (1.0), and Phosphorus (0.1). Other nutritional values of native shrubs in the Black Hills for comparisons and related to deer requirements are presented by Dietz et al (1972a).

Discussion

Caragana known as Siberian pea shrub (legume) was introduced into the United States during the mid-1700s and is native to Siberia and Manchuria (Dietz et al. 2008). It occurs from southern Russia to China. The species readily adapts to a wide range of soils and unshaded areas. Contrary to information reported in the literature, the current study within a ponderosa pine forest provided different results. Caragana adapted to shaded, closed tree canopy cover, and was less common in open sunny areas as reported by others (Dietz et al. 2008, Shortt and Vamosi 2012, USDA-Forest Service 2019, USDA-NRCS 2019). Overall, regeneration at 35 years was 1.4 plants per $0.09m^2$ (ft^2). The number of plants represents an expanding population in shaded areas only, but very few plants are located outside the planted study area. Thus, from initial plantings to 35 years, Caragana is expected to have little potential for spreading beyond the initial planted site.

Caragana grew best in the model defined Closed habitat with tree overstory canopy (35 years after initial planting) that averaged 35 percent canopy cover and basal area of 17.7 m^2/ha (77 ft^2 per acre). Regeneration was occurring within and among the rows but was not spreading throughout the area by seeds. However, in contrast, Caragana was planted adjacent to an aspen (*Populus tremuloides*) deciduous forest and invaded the stand with open areas in Canada, requiring control (Henderson and Chapman 2006). Tree canopy cover in Black Hills ponderosa pine forest was variable in the Open habitat with exposed sunny areas. Little to no regeneration of Caragana and limited growth was present in this habitat.

Caragana densities on north facing slopes under ponderosa pine canopy cover was approximately two times greater than on open south facing slopes. Plants on south facing slopes were shorter than north facing slopes, although few individual shrubs escaped browsing. South facing slopes are warmer, drier, and received more browsing from white-tailed deer. Other factors may also contribute to less regeneration and growth of Caragana. Generally, Caragana has been planted extensively as shrub strips, windbreaks on farmlands in open sunny areas, and is only tolerant to marginal shade (Dietz et al. 2008, Shortt and Vamosi 2012, USDA-Forest Service 2019, USDA-NRCS 2019).

Long-term survival of Caragana was highly successful at 74 percent after 35 years. Other native shrubs planted on the McVery Burn had lower survival rates from initial planting to 10 years, ranging from 0 to 31 percent (Dietz et al. 1980). These plants included, chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), silverberry (*Elaeagnus commutata*), silver buffaloberry (*Shepherdia argentea*), common juniper (*Juniperus communis*), antelope bitterbrush (*Purshia tridentata*) and mountain mahogany (*Cercocarpus montanus*).

The multivariate model developed (Closed and Open habitat stratification) can be used to quantify the relationship of Caragana height, tree canopy cover, and basal area in assigning stratifications for future plantings that will be successful in providing key wintering areas for deer. This model is 90 percent accurate and quantitative. Each habitat stratification provides characteristics of Caragana related to height and density, associated with tree canopy cover and basal area. Depending upon management objectives for establishment of Caragana in key winter areas for deer, two options are available, closed and open habitats.

Utilization of Caragana (plant volume) by white-tailed deer was 77 percent during the winter months 12 years after planting and greatest on south facing slopes (Messner and Uresk 1980). A quicker snowmelt on south facing slopes than on north facing slopes allows deer easier access and longer access during the winter.

Nutritional qualities from winter samples of Caragana (current annual growth) are generally greater than native browse to meet winter requirements of white-tailed deer in the Black Hills based on studies by Dietz (1972a). Caragana has excellent nutrient values for maintaining and meeting white-tailed deer requirements for survival during the dormant winter season. Phosphorus is marginal for deer during winter months. Shrubs are also important food sources for both domestic, wild herbivores, birds, and other wildlife (Swihart and Yahner 1983, USDA-NRCS 2019, Dietz et al. 2008). Caragana is extremely important in providing pollinators with flowers and abundant seeds for insects (bees), many bird, and small mammal species that require food and shelter throughout summer and winter months (D. Mergen 2019, personal communication).

Based on deer use of Caragana, it is important to know the nutrient values as related to nutritional requirements of the animals during winter months. Dietz (1972a) presents an overview of shrubs, nutritional values and requirements for white-tailed deer in the Black Hills, SD. Native shrubs in the Black Hills generally have lower nutritive values for maintaining white-tailed deer during winter months than Caragana (Dietz 1972b, Dietz et al. 1980).

Shrub planting trials for improving white-tailed deer winter range have been limited in the Black Hills (Dietz et al. 1980). Caragana, based on survival, growth habits, utilization, and the nutritional qualities for a winter browse species has the potential to enhance the nutritional requirements and survival of deer during winter months on south facing slopes. The combination of characteristics possessed by the Caragana makes it suitable for wildlife "rescue" winter plantations on south facing slopes where native vegetation has been over utilized by livestock and native shrubs reduced or eliminated and not regenerating.

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Avian Response to Old-growth Maintenance Logging in the Swan River State Forest, Montana

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Abstract:

Old-growth maintenance silvicultural treatment is a tool implemented to retain old-growth forest attributes, remove shade-intolerant trees, and create canopy gaps. Our objectives were to examine how these treatments affect avian diversity and density. We used a Before-After/Control-Impact Pairs study design by pairing old-growth stands proposed for harvest with nearby untreated stands, based on their pre-treatment forest structure and composition similarity. Logging reduced basal area by 40 percent ($P < 0.05$), overstory canopy cover by 31 percent ($P < 0.05$), and the density of trees >42 cm dbh **(**$P < 0.05$). No major changes in bird species composition or diversity were detected. Only the relative densities of evening grosbeaks changed (58% reduction in density, $P < 0.05$), likely due to the removal of insect-infested trees. All old-growth associated bird species continued to occupy treatment stands under the landscape conditions we observed. We did not evaluate avian survival or reproductive success, which would provide beneficial metrics for further interpretation of the potential effects of old-growth maintenance treatments.

Key Words: old-growth, logging, avian diversity, species density, biodiversity, BACIP

Introduction

The impact of logging on old-growth forests and wildlife, and maintenance of this important forest age class on the landscape have long been a concern in the northwestern United States (Franklin et al. 1981, Harris 1984, Ruggiero et al. 1991, Bart and Forsman 1992, Hunter 1999). Increasingly, partial logging treatments to meet ecological objectives are implemented to balance the need to generate revenue, while also providing a steady, long-term timber supply (Gustafsson et al. 2012). Partial logging encompasses a variety of silvicultural treatments that retain a greater density of trees than traditional regeneration treatments such as clear cut and seed tree treatments. Such treatments are often selected to help retain biological diversity and to avoid adverse impacts to forest communities associated with regeneration treatments (Rosenvald and Lohmus 2008, Gustafsson et al. 2012).

Old-growth maintenance silvicultural treatments are one of the partial logging treatments that the Montana Department of Natural Resources and Conservation (DNRC) implements to retain old-growth attributes, while also removing encroaching shade-tolerant tree species (e.g., grand fir {*Abies grandis*}). These treatments create small canopy gaps to encourage the regeneration of shade-intolerant tree species (e.g., western larch {*Larix occidentalis*} and ponderosa pine {*Pinus ponderosa*}). Old-growth forests in the Northern Rockies were shaped by periodic disturbance, such as wildfire (Pfister et al. 1977, Green et al. 1992). Hence, old-growth maintenance treatments are intended to imitate vegetation-altering effects of low to moderate-intensity fires (Bauhus et al. 2009, Larson et al. 2012). Harvest prescriptions are designed to meet or exceed old-growth definitions reported by Green et al. (1992), which specify minimum criteria for the number of trees of a given diameter, basal area, and age based on forest cover type and habitat type groups. However, these old-growth maintenance treatments still remove or alter old-growth forest attributes, such as the density of large live trees, coarse woody debris, snags, the amount of decadence, multistoried tree canopy, basal area, and crown cover, which may affect habitat quality and use by old-growth associated wildlife.

Effects of partial harvest of mature timber stands on birds vary due to differences in silvicultural treatments applied and local forest conditions. Some communities increased in species diversity while others decreased (Bakermans et al. 2012, Kendrick et al. 2015, Twedt and Somershoe 2009, Vanderwel et al. 2007). Overall, ground foragers and flycatchers tend to benefit from logging mature and old-growth stands while foliage gleaners and cavity nesters are negatively impacted (Tobalske et al. 1991, Beese and Bryant 1999, Vanderwel et al. 2007, Vanderwel et al. 2009). No avian species associated with old-growth are federally listed as Endangered or Threatened in Montana; however, some species do have moderate Conservation Concern Scores (CCS, see Apendix 1) or are declining regionally (Partners in Flight 2019). Some old-growth associated species, such as brown creepers (*Certhia americana*; moderate CCS) are especially sensitive to partial harvests with densities declining 50 percent when 30 to 40 percent of basal area is removed (Vanderwel et al. 2007, D'Astous and Villard 2012). In northwest Montana, researchers have not found large differences in avian community composition when comparing logged and unlogged dry Douglas-fir (*Pseudotsuga menziesii*) and western larch old-growth forest types (Hoffland 1995, Hutto et al. 2014). However, a restoration treatment appropriate for dry stands with frequent low-intensity burns was examined in those studies, whereas old-growth maintenance treatments applied in more mesic stands may produce different results.

We investigated the impact of old-growth maintenance treatments in mesic forest types found in the Swan Valley, Montana. We collected data on bird communities because they reflect the abundance and diversity of coexisting species and provide a cost-effective way to assess ecological community change (Hutto 1998). Our objectives were to examine how old-growth maintenance treatments affect avian diversity and the density of individual bird species, particularly old-growth associated species. Our null hypothesis was that old-growth maintenance treatments have no impact on bird species diversity or density. We also summarize post-logging changes to forest stand attributes so that our results can be compared to those of other studies.

Study Area

We conducted this study in the 22,787-ha Swan River State Forest, which is in a forested landscape surrounded by Flathead National Forest lands 16 km south of Swan Lake, MT (Fig. 1). Montana DNRC removes approximately 6.8 million board feet (MMBF) from the Swan River State Forest annually. Our study was conducted in the Scout Lake Multiple Timber Sales Project Area which involved the removal of 20.4 MMBF of timber (approximately 5,100 log truck loads) from 813 ha over a 4-year period (DNRC 2012). This logging operation occurred around the midpoint of the 6-year time frame of our study and involved multiple timber sale contracts. We selected old-growth timber stands below 1,200 m elevation consisting primarily of western larch and Douglas-fir with grand fir understories for monitoring. Old-growth maintenance treatments are infrequently applied, and we studied all available stands within the study area that were proposed for these treatment types during the time frame of the study.

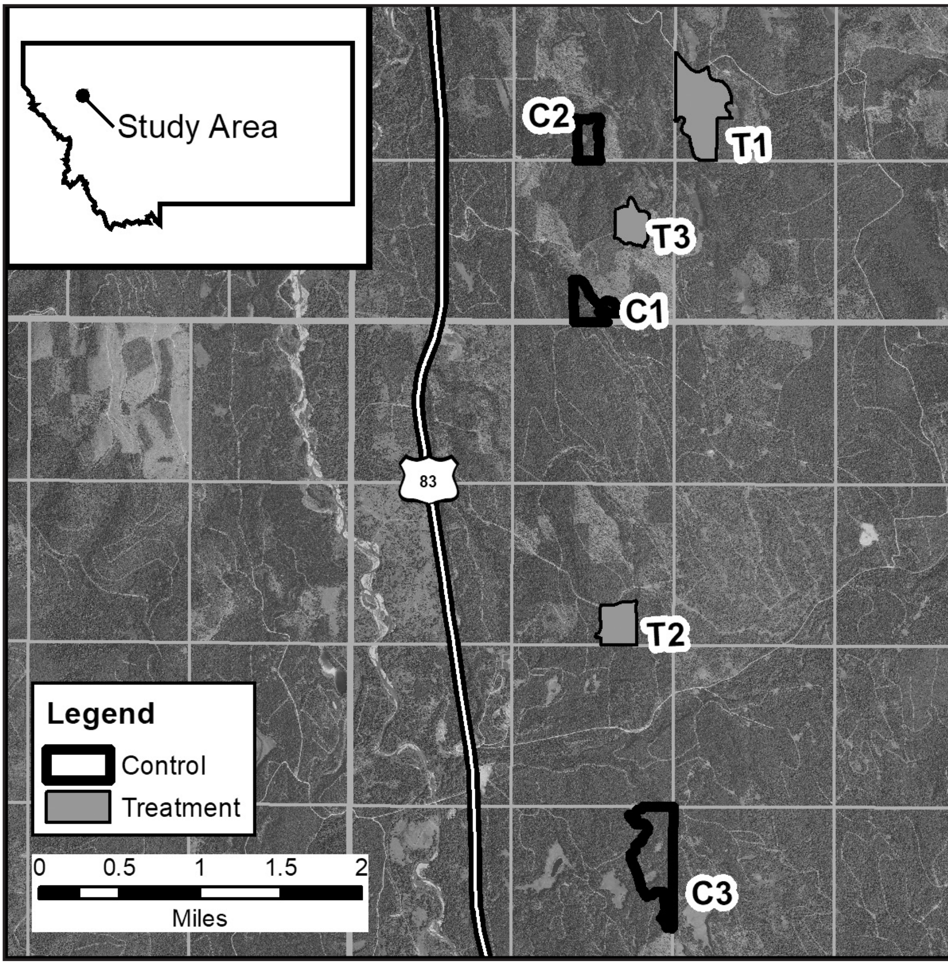

Figure 1. Location of six BACI study stands in the Swan River State Forest, Montana. C = control, T = treatment. Paired stands are assigned the same number.

Methods

Stand Sampling Design

We used a Before-After/Control-Impact Pairs (BACIP) experimental study design and paired three old-growth stands proposed for harvest (treatment) with three untreated old-growth stands (control) (Fig. 1, Stewart-Oaten et al. 1986). All study stands met old-growth definitions of Green et al. (1992). Treatment stands were selected by foresters to meet project objectives including generating revenue, reducing fuel loads, and improving forest health (DNRC 2012). We paired treatment stands with control stands based on their similarity regarding forest type, density of mature trees, density of all conifers, and dominant conifer species in the understory. When more than one match for a treatment stand was identified based on these criteria, control stands were selected randomly. Our pairing of control and treatment stands was intended to reduce the possibility that initial differences in vegetation parameters such as habitat type or conifer density might contribute to the differences in the bird species parameters we would be assessing. Additionally, treatment stands were logged under different timber sale contracts that were executed in different years, but the Before-After sampling period was the same for all control and treatment pairs, thus reducing the potential influence of weather-related factors. The distance between control and treatment stands ranged from 1.7 km to 5.6 km ($\bar{x}$ = 3.9, SD = 2.0) and the size of control and treatment stands ranged from 9 to 37 hectares ($\bar{X}$ = 19, SD = 12). The sizes of the treatment stands varied, and the corresponding control stands were not equal in size to their counterparts.

Bird Surveys

Point counts were conducted twice per summer between 15 June and 12 July 2012 to 2017 (Thompson 2002). Point counts began approximately 15 min before sunrise and ended by 1000 hrs. Point counts were conducted by a sole observer standing at a fixed point recording all bird species detected by sight or sound for 10 min. Distances from the observer to the bird were estimated to provide the necessary parameter for approximating a density value for each species (Buckland et al. 2015). Survey points were located within each stand using the ArcGIS (9.3.1) random point generator tool and were at least 250 m apart and 100 m from stand edges (ESRI 2009). The number of points within a survey stand varied according to size of the stand and ranged from two to seven per stand ($\bar{X}$ = 5, N = 22 control points, N = 24 treatment points).

At least 2 years of pre-harvest and 2 years of post-harvest bird survey data were collected in each control-treatment pair. The amount of pre- and post-harvest data collected varies depending on the year the treatment stand was logged (control/treatment one = 2 years pre-harvest, 3 years post-harvest; control/treatment two = 3 years pre- and post-harvest; control/treatment three = 4 years pre-harvest, 2 years post-harvest). Data from treatment stand one in the summer of 2014 when logging was incomplete in this stand was excluded from analysis.

Vegetation Surveys

Vegetation parameters were measured in control stands and treatment stands before and after logging to provide information on how old-growth maintenance treatments affected stand attributes and to estimate differences between control and treatment stands. Ten vegetation plots were randomly placed within each survey stand. Overstory canopy cover was estimated using a GRS densiometer with 10 readings taken every 15 m between vegetation plots. Basal area of trees >2 m tall was estimated in variable plots with a Relaskop, and tree species, dbh, and status (live or dead) was recorded. Trees per ha ≤2 m tall were counted in fixed 1/100-ha plots and categorized according to species and height class. We visually estimated the percentage ground cover of shrubs and grasses, the presence and abundance of conifer seedlings, hardwoods, coarse woody debris, moss, litter, rock, and bare soil within the 1/100-ha sampling plots and recorded the 10 dominant understory plant species. Coarse woody debris was sampled along a 15 m transect from plot center on a random azimuth obtained using a random number generator (Haahr 2012). Diameters of sound and decayed coarse woody debris >8 cm were recorded where they intersected transect lines (Brown 1974).

Data Analysis

We truncated our bird observations at 150 m (approximately 10% of observations were eliminated) to reduce the impact of birds located outside of the study stands on diversity estimates. Data were analyzed using R version 3.2.3 statistical software (R Core Team, 2015). The Shannon diversity index (*H*) (Shannon 1948), which accounts for species richness (*S*) and the relative abundance of each bird species, was calculated using the Vegan package in R (Oksanen et al. 2017). We used bootstrapping to calculate confidence intervals (Gardener 2014).

We calculated the density of bird species within each study stand before and after logging for species with at least 50 total detections. We selected the best detection function model for each bird species using the Program R Distance package (Miller 2017) according to the variable radius protocols described in Miller et al. (2017). Detection functions are corrective equations that account for differences in detectability among species including how loud and often birds sing, as well as their behavior. Logging removes vegetation and may increase detectability of birds because they may be easier to see and hear in a logged stand. We tested logging status (logged or unlogged) as a potential covariate in our models and selected detectability models based on Akaike's Information Criterion (AIC) (Akaike 1987). All models <2 AIC units greater than the best model were considered plausible models. Effect size is described in terms of relative density as indicated by the BACIP contrast, which represents the change in species density in treatment stands relative to the change in species density in paired control stands following logging. We also report the percent increase or decrease in relative density (BACIP contrast/pre-treatment density in treatment stands).

We used the Encounter Rate (ER, birds per point count) to assess impacts on brown creepers and pacific wrens (*Troglodytes pacificus*), which are of interest but had too few detections to estimate densities using detection functions. ER does not provide information on relative abundance differences among species and does not allow for analysis of covariates but does provide information on how observations increased or decreased post-harvest.

Vegetation characteristics of control plots and treatment plots pre- and post-harvest were summarized with descriptive statistics. T-tests (two-tailed) were used to test for differences in bird density in paired treatment stands and control stands post-harvest, encounter rates, and vegetation characteristics of treatment stands pre- and post-harvest. We used a modified version of the T-test to compare *H* in study stands before and after harvest (Gardener 2014, Hutcheson 1970). We accepted $P \leq 0.05$ as indication of difference and provide discussion of results with marginal significance $0.05 < P < 0.10$.

Results

Species Diversity

We observed 64 bird species and 5,331 individuals (Appendix A). H increased post-harvest in one control stand (control two, $P = 0.01$), but did not change post-harvest in treatment stands or the other control stands (control one, $P = 0.47$; control three, $P = 0.67$; treatment one, $P = 0.91$; treatment two, $P = 0.64$ treatment three, $P = 0.16$) (Fig. 2) . Fourteen common bird species such

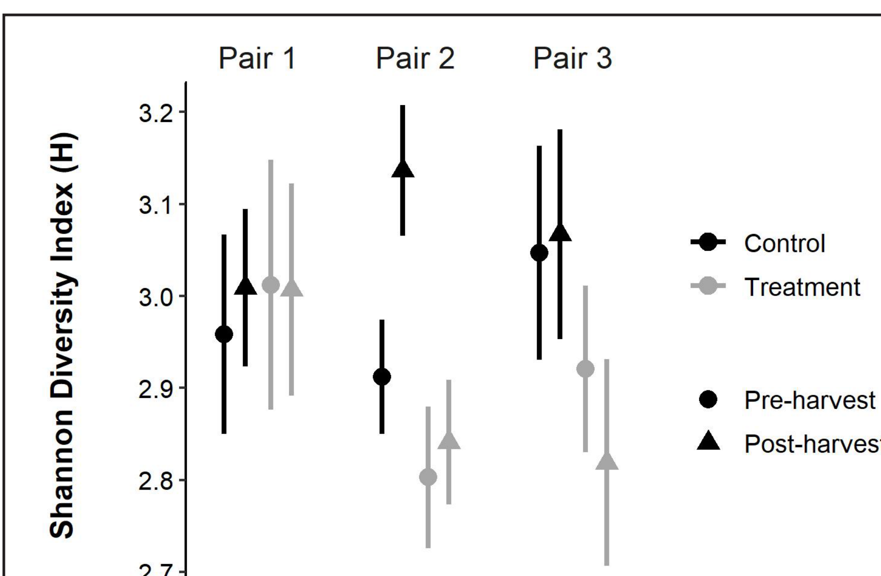

Figure 2. Shannon Diversity Indices (H) for control (black) and treatment (gray) stands pre- and post-harvest with 95% confidence intervals obtained by bootstrapping. Control stands were considered post-harvest based on if the paired treatment stand had been harvested. Higher values indicate higher species diversity.

as American robins (*Turdus migratorius*), common ravens (*Corvus corax*), and northern flickers (*Colaptes auratus*) were only observed in the post-harvest period in control stand two, influencing the increase in species diversity. Comparatively, new species detections in the post-harvest period ranged from 3 to 11 in the other study stands.

Species Density

We applied species-specific detection functions and estimated the densities of 22 species with ≥50 observations. Logging did not impact bird detection probability for those 22 species in our models. Relative densities of evening grosbeaks (*Coccothraustes vespertinus*) decreased 58% ($P < 0.05$), following old-growth harvest (see BACIP Contrast values, Table 1). Overall, a large shift in bird community composition did not occur and the density of the most common species did not appreciably differ following harvest (see *P*-values for bolded species, Table 1). Old-growth associated bird species continued using treated stands post-harvest, but no significant change was detected (Fig. 3, Table 1).

Brown creepers and pacific wrens also continued using treated stands post-harvest but no change in ER was detected (brown creeper: ER BACIP contrast = -0.14, P = 0.34; pacific wren ER BACIP contrast = -0.11, P = 0.28).

Stand Characteristics

Approximately 40 percent of live-tree basal area was removed by old-growth maintenance treatments, and canopy cover of mature trees declined from 59 percent to 41 percent (Table 2). Snags per hectare also declined from 37 to 13 per ha, although the average diameter increased, indicating that large snags were retained according to harvest prescriptions. Trees per ha ≤2 m tall decreased by 32 percent and coarse woody debris (tons per ha) decreased by 26 percent. Stand averages for the canopy cover of mature trees, basal area of green trees, trees/ha >2 m tall and >42 cm dbh, Douglas-fir trees ≤2 m tall, and the ground cover of coarse-woody debris and moss were reduced in treatment stands ($P < 0.05$; Table 2). Overall, common understory shrub, forb, and grass species did not change post-harvest although prince's pine (*Chimaphila umbellata*), which is associated with old-growth forests and sheltered stands (Freedman 1983), decreased following harvest. Example photographs depicting control stands and managed stands pre- and post-harvest are displayed in Fig.4.

Discussion

We reject our null hypothesis that old-growth maintenance treatments have no impact on bird communities considering that the relative densities of evening grosbeaks decreased following harvest. However, we did not observe large changes in species diversity, the composition of bird communities, or species density. Species diversity increased in control stand two post-harvest (Fig. 2), but surprisingly no change was detected in treatment stands. The increase in diversity in control stand two was caused by fourteen common bird species using this stand only in the post-harvest period. We believe that logging that occurred in two mature stands within 500 m of this stand may have displaced these birds into control stand two causing these results.

We did not detect a large shift in community species composition between harvested and unharvested old-growth stands. Townsend's solitaires (*Myadestes townsendi*), yellow warbler (*Setophaga petechia*), and western wood-pewee (*Contopus sordidulus*) were only detected in logged stands, however there were only five observations of these birds (Appendix A). Vegetation data suggest that sufficient vegetative structure and other favorable habitat attributes were retained in the old-growth maintenance treatments to prevent a dramatic alteration in bird species composition. Average overstory canopy cover in post-harvest treatment stands in our study was 41 percent. Previous research suggests that bird species occurrence or density does not change until canopy cover drops below 40 percent (Sallabanks et al. 2006).

Table 1. Density of birds/ha in control and treatment stands (± SE) before and after logging. BACIP contrast indicates relative density increase (+) or decrease (-) post-harvest in treatment stands in comparison to control stands. The percent change is calculated as BACIP contrast in density as a percentage of densities observed in treatment stands before logging (**P < 0.05, *P < 0.10). Abundant species are bolded.

Species >	CCS[1]	Control-Pre (N = 72)		Control-Post (N = 54)		Treatment-Pre (N=64)		Treatment-Post (N=66)		BACIP	%	P
50 Detections[1]		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Contrast	Change	
Pileated woodpecker, *Drycopus pileatus*[OGA]	7	0.0013	0.0006	0.0010	0.0003	0.0007	0.0005	0.0011	0.0003	0.0007	93%	0.068*
Hammond's flycatcher, *Empidonax hammondii*[OGA]	10	0.2386	0.0747	0.2099	0.1063	0.0423	0.0292	0.0873	0.0447	0.0737	174%	0.550
Cassin's vireo, *Vireo cassinii*	10	0.0169	0.0129	0.0432	0.0106	0.0173	0.0004	0.0343	0.0083	-0.0094	-54%	0.714
Canada jay, *Perisoreus canadensis*[OGA]	9	0.0106	0.0040	0.0100	0.0035	0.0071	0.0036	0.0058	0.0029	-0.0007	-10%	0.934
Black-capped chickadee, *Poecile atricapillus*	7	0.1195	0.0460	0.1574	0.0316	0.1254	0.0347	0.1125	0.0307	-0.0508	-40%	0.106
Mountain chickadee, *Poecile gambeli*	10	0.0323	0.0071	0.0502	0.0080	0.0523	0.0273	0.0713	0.0379	0.0010	2%	0.987
Chestnut-backed chickadee, *Poecile sclateri*	13	0.1577	0.0546	0.1787	0.0279	0.2436	0.0653	0.1804	0.0375	-0.0842	-35%	0.455
Red-breasted nuthatch, *Sitta canadensis*	6	0.0695	0.0118	0.0747	0.0093	0.0722	0.0157	0.0773	0.0089	0.0000	0%	1.000
Golden-crowned kinglet, *Regulus satrapa*[OGA]	**8**	**0.3358**	**0.0745**	**0.3530**	**0.0563**	**0.4224**	**0.0565**	**0.3079**	**0.0279**	**-0.1317**	**-31%**	**0.091***

Table 1. (Continued)

Species >	CCS[1]	Control-Pre (N = 72)		Control-Post (N = 54)		Treatment-Pre (N=64)		Treatment-Post (N=66)		BACIP	%	P
50 Detections[1]		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Contrast	Change	
Ruby-crowned kinglet, *Regulus calendula*	6	0.0294	0.0171	0.0330	0.0055	0.0223	0.0023	0.0277	0.0182	0.0018	8%	0.895
Swainson's thrush, *Catharus ustulatus*[OGA]	**10**	**0.2340**	**0.0457**	**0.2770**	**0.0186**	**0.2614**	**0.0211**	**0.3223**	**0.0099**	**0.0179**	**7%**	**0.790**
American robin, *Turdus migratorius*	5	0.0425	0.0207	0.0322	0.0134	0.0241	0.0017	0.0216	0.0046	0.0078	32%	0.713
Orange-crowned warbler, *Oreothlypis celata*	9	0.0115	0.0049	0.0086	0.0046	0.0144	0.0034	0.0281	0.0100	0.0166	115%	0.248
MacGillivray's warbler, *Geothlypis tolmiei*	12	0.0216	0.0073	0.0273	0.0073	0.0170	0.0104	0.0157	0.0035	-0.0070	-41%	0.602
Yellow-rumped warbler, *Setophaga coronata*	6	0.0400	0.0093	0.0734	0.0247	0.0483	0.0048	0.0800	0.0052	-0.0018	-4%	0.939
Townsend's warbler, *Setophaga townsendi*[OGA]	11	0.0723	0.0144	0.0732	0.0035	0.0960	0.0247	0.0541	0.0200	-0.0428	-45%	0.177
Chipping sparrow, *Spizella passerine*	**8**	**0.6998**	**0.0470**	**0.8316**	**0.0387**	**0.5528**	**0.0306**	**0.8815**	**0.0636**	**0.1970**	**29%**	**0.395**
Dark-eyed junco, *Junco hyemalis*	**8**	**0.1555**	**0.0204**	**0.2131**	**0.0298**	**0.1359**	**0.0141**	**0.2725**	**0.0149**	**0.0790**	**58%**	**0.061***
Western tanager, *Piranga ludoviciana*	9	0.0868	0.0169	0.0785	0.0069	0.1047	0.0110	0.1083	0.0118	0.0118	11%	0.606

Table 1. (Continued)

Species >	CCS[1]	Control-Pre (N = 72) Mean	Control-Pre (N = 72) SE	Control-Post (N = 54) Mean	Control-Post (N = 54) SE	Treatment-Pre (N=64) Mean	Treatment-Pre (N=64) SE	Treatment-Post (N=66) Mean	Treatment-Post (N=66) SE	BACIP Contrast	% Change	P
50 Detections[1]												
Red crossbill, *Loxia curvirostra*	8	0.0361	0.0099	0.0314	0.0088	0.0180	0.0030	0.0223	0.0064	0.0090	50%	0.265
Pine siskin, *Spinus pinus*[OGA]	10	0.1311	0.0365	0.1294	0.0236	0.1616	0.0323	0.1358	0.0089	-0.0636	-15%	0.516
Evening grosbeak, *Coccothraustes vespertinus*	13	0.0923	0.0157	0.1080	0.0352	0.1095	0.0181	0.0616	0.0119	-0.0242	-58%	0.034**

[1] Species status as old-growth associates (Hejl and Woods 1991 and Hejl and Paige 1994) labeled OGA.

[2] CCS = Conservation Concern Scores (Panjabi et al. 2019, Partners in Flight 2019). CCS ≥8 = moderate concern, CCS ≥14 = high concern

Comparison of the density of species with >50 detections pre- and post-harvest indicated that flycatcher and ground foraging bird densities slightly increased in harvested stands while foliage gleaners typically decreased, although results were not significant. These data are consistent with results from other researchers (Beese and Bryant 1999, Vanderwel et al. 2007, Vanderwel et al. 2009). We detected a decline in density in only one species, evening grosbeaks. This species is irruptive with large flocks often following outbreaks of insects, especially spruce budworm (*Choristoneura fumiferana*) (Bonter and Harvey 2008). Logging prescriptions often focus on removal of disease and insect-infested trees to promote stand health, and it is likely that insect foods were reduced in logged stands. Typically, evening grosbeaks are not found in greater densities in old-growth stands and are not considered an old-growth associated species; however, they are found in mature forest (Bonter and Harvey 2008).

At a marginal significance level ($0.05 < P \leq 0.10$), we found pileated woodpecker and dark-eyed junco densities increased, while golden-crowned kinglet densities decreased (Table 1). The increase in pileated woodpecker density was small, but consistent across treated stands. In similar Montana studies, pileated woodpeckers continued to use logged stands (Brewer et al. 2008) and were more common in partially cut stands than uncut stands (Hutto and Young 2002). Thus, pileated woodpeckers appear to be somewhat tolerant of silvicultural treatments that retain ample large trees, snags and western larch trees with heart rot (McClelland and McClelland 1999). Reductions of mature coniferous canopy cover that occurred during our study on nearby non-study stands may also

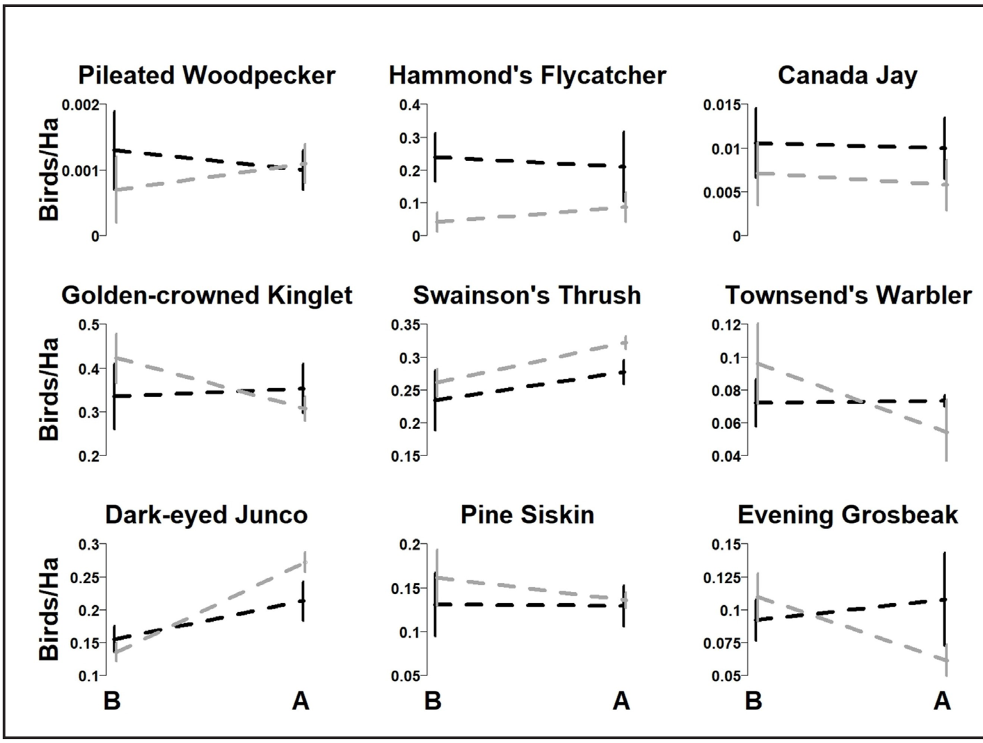

Figure 3. Densities of birds per ha in control (black) and logged (grey) stands before (B) and after (A) harvest (± SE). All species depicted are old-growth associates except for evening grosbeaks and dark-eyed juncos which are included because their densities changed significantly (evening grosbeak, P = 0.034; dark-eyed junco P = 0.061).

have influenced pileated woodpecker selection of old-growth stands that received maintenance treatments that occurred during our study. Dark-eyed juncos are ground feeders that will forage in logging slash (Nolan et al. 2002), which may explain density increases post-harvest in our study. Golden-crowned kinglets glean small insects and spiders from the tips of conifer branches and are associated with dense, old-growth forests (Swanson et al. 2012). Researchers have observed that golden-crowned kinglets are sensitive to logging with negative impacts observed even with 70 percent to 75 percent tree retention (Harrison et al. 2005, Vanderwel et al. 2007, Vanderwel et al. 2009), as compared to the 60 percent mature tree retention in the stands we studied, which may explain the post-treatment decreases we observed in this kinglet species.

Old-growth associated species continued using logged stands post-harvest with some species increasing (pileated woodpecker, Hammond's flycatcher, Swainson's thrush) and others decreasing (Canada jay, golden-crowned kinglet, Townsend's warbler, Pacific wren, brown creeper); however, these results were not significant at the $\alpha = 0.05$ level (Table 1). Of these species, population trends overall of golden-crowned kinglets, Townsend's warblers, and Swainson's thrush in the Northern Rockies Bird Conservation Region indicate declines of ≥15 percent from 1970-2017 (Partners in Flight 2019).

We acknowledge that we were unable to assess how the survival and reproductive success of birds may have been affected by their use of logged stands, as compared to unlogged stands for breeding habitat. Additionally, we are unable to ascertain if the results we observed will continue to occur as trends, or if some of these results are one-time occurrences. Given that maintenance of biodiversity of forest ecosystems and the population status of old-growth associated species are likely

Table 2. Stand characteristics in Control and Treatment stands logged with an old-growth maintenance treatement pre- and post-harvest (*P < 0.05).

Stand Characteristic`	Control Mean	Control SE	Treatment Pre-harvest Mean	Treatment Pre-harvest SE	Treatment Post-Harvest Mean	Treatment Post-Harvest SE
Canopy Cover Percent						
(Mature Trees ≥23 cm dbh)	51.7	0.9	59.0	6.1	41.0*	2.6
Basal Area Snags >2 m Tall, m²/ha	3.7	0.5	4.3	2.0	1.7	0.8
Basal Area Green Trees >2 m Tall, m²/ha	28.8	1.1	33.1	4.7	19.9*	2.7
Total Trees ≤2 m Tall/ha	1,235.5	275.2	1,606.2	605.8	1,087.2	197.7
CWD Metric Tons/ha	35.6	3.7	40.1	6.9	29.5	6.2
Snags/ha >23 cm dbh	32.1	4.9	37.1	14.9	13.2	6.4
Trees/ha >2 m Tall by Size Class						
≤10 cm dbh	94.5	68.0	350.3	74.7	184.6	96.8
10-20 cm dbh	206.2	44.4	238.0	20.0	158.2	48.0
21-41 cm dbh	124.2	13.8	129.1	23.3	53.2	3.2
42-52 cm dbh	23.6	4.8	42.7	11.5	27.4*	10.0
≥53 cm dbh	32.9	5.8	30.5	5.9	22.2*	4.9
Trees/ha >2 m Tall by Species						
Western Larch	49.3	7.7	97.4	48.9	83.8	49.8
Douglas-fir	113.1	35.8	228.7	54.1	95.0	30.8
Grand Fir	209.9	155.5	305.6	154.7	146.5	87.0
Engelmann Spruce	58.9	15.1	88.8	61.2	59.3	41.7
Lodgepole	21.5	14.6	27.3	27.3	31.1	25.7
Total Trees ≤2 m Tall/ha by Species						
Douglas-fir	345.9	107.7	56.7	10.7	271.8	65.4
Grand Fir	716.6	285.0	149.7	70.6	617.8*	130.8
Engelmann Spruce	98.8	49.4	52.6	28.3	65.9	43.6
Ground Cover Percent						
Shrub	16.3	4.2	20.8	4.0	21.4	1.2
Forb	21.5	0.7	6.4	0.2	12.9	2.3
Grass	13.1	4.1	24.8	1.3	20.8	4.3
Conifer Seedling	4.2	2.3	3.4	0.5	2.6	0.4
Hardwood <2 m	1.1	0.5	0.0	0.0	1.6	1.2
Rock	0.3	0.1	0.2	0.2	0.3	0.2
Bare Soil	0.8	0.4	1.1	0.8	1.6	0.9
CWD	10.9	0.9	4.3	0.7	8.2*	1.2
Moss	2.7	1.7	8.9	1.9	2.2*	0.4
Litter	29.0	6.6	30.0	2.3	29.2	1.9

to remain issues of concern, additional research investigating the underlying causes for the changes in population trends and the reproductive success of birds in logged stands would be useful.

Management Implications

We found that habitat generalist and old-growth associated birds continued to occupy old-growth maintenance logging treatment stands after harvest in the mesic forest communities we examined. This suggests that light to moderate intensity harvest of old-growth forests, with attention to retaining large trees, snags, large pieces of coarse woody debris, and a multi-storied canopy structure may be compatible with providing habitat conditions usable by many bird species. A decline in density was only

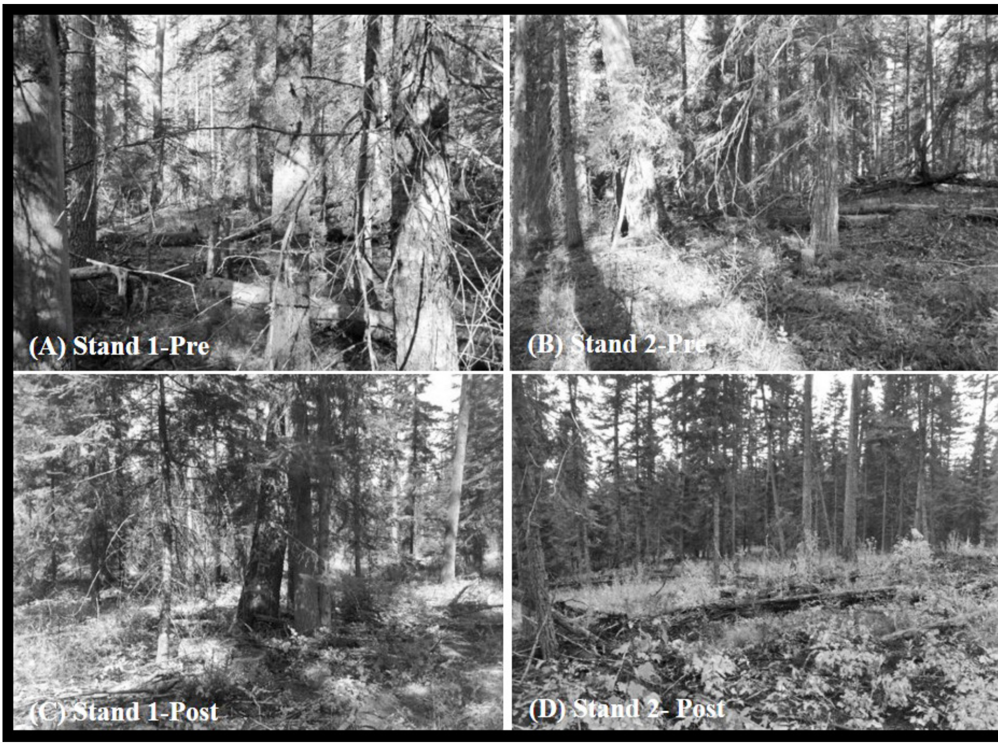

Figure 4. Repeat photographs in two vegetation plots pre- and post-harvest. The two photographs on the left (A, C) show a typical decrease in stand density post-harvest. The two photographs on the right show an example of one of the 0.4 to 0.8 ha cut patches designed to increase larch regeneration and stand variability as a part of old-growth maintenance logging prescriptions (B, D).

detected for evening grosbeaks, an irruptive species that feeds on insects such as spruce budworm.

Old-growth maintenance treatments, such as those examined in our study maintained high levels of forest structural diversity, as well as diverse bird communities. Forest communities with high structural diversity have long been known to support greater levels of biodiversity (Harris 1984, Hunter 1999). We believe the treatments we studied may provide a tool for forest managers to maintain bird species diversity, promote sustainability of old-growth forests, while continuing to provide revenue generation from forest products in working forest landscapes.

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Appendix A. Counts of 64 bird species by year.

Species	CCS[1]	2012	2013	2014	2015	2016	2017	Grand Total
Canada goose	5					1		1
Branta canadensis								
Mallard	7					2	2	4
Anas platyrhynchos								
Northern goshawk	10		1	1			2	4
Accipiter gentilis								
Red-tailed hawk	6	4	1		1	1		7
Buteo jamaicensis								
Ruffed grouse	8				1			1
Bonasa umbellus								
Sora	9				1			1
Porzana carolina								
Sandhill crane	8		2			2		4
Antigone canadensis								
Wilson's snipe	9						3	3
Gallinago delicata								
Rufous hummingbird	14				1			1
Selasphorus rufus								
Williamson's sapsucker	12		1	4	2	4	4	15
Sphyrapicus thyroideus								
Red-napped sapsucker								
Sphyrapicus nuchalis	9		3	3	11	12	9	38
Downy woodpecker								
Picoides pubescens	7			2	4		1	7
Hairy woodpecker								
Picoides villosus	6	1	4	1	6	3	5	20
American three-toed woodpecker								
Picoides dorsalis	8	2			1			3
Northern flicker								
Colaptes auratus	9		1	2	8	2	2	15
Pileated woodpecker								
Dryocopus pileatus	7	8	10	10	8	8	15	59
Olive-sided flycatcher								
Contopus cooperi	13	4		1	2	4	3	14
Western wood-pewee								
Contopus sordidulus	12						1	1
Hammond's flycatcher								
Empidonax hammondii	10	11	13	15	17	11	13	80
Dusky flycatcher								
Empidonax oberholseri	11		4	2	1	1	3	11
Cassin's vireo								
Vireo cassinii	9	4	9	11	13	20	17	74
Warbling vireo								
Vireo gilvus	8	4	8	1	3	3	2	21

APPENDIX A. Continued

Species	CCS[1]	2012	2013	2014	2015	2016	2017	Grand Total
Red-eyed vireo	6		1	1		1	2	5
Vireo olivaceus								
Canada jay								
Perisoreus canadensis	8	10	16	17	15	22	11	91
Common raven								
Corvus corax	6	14	8	6	17	15	8	68
Tree swallow								
Tachycineta bicolor	10			2			1	3
Black-capped chickadee								
Poecile atricapilla	7	13	27	14	19	28	13	114
Mountain chickadee								
Poecile gambeli	11	10	7	18	5	28	33	101
Chesnut-backed chickadee								
Poecile rufescens	12	19	27	18	34	36	27	161
Red-breasted nuthatch								
Sitta canadensis	6	44	28	44	43	53	56	268
Brown creeper								
Certhia americana	8	3	7	10	10	3	11	44
Pacific wren								
Troglodytes pacificus	11	6	9	8	1	12	2	38
Golden-crowned kinlget								
Regulus satrapa	8	46	29	72	49	82	54	332
Ruby-crowned kinglet								
Regulus calendula	6	16	16	34	30	10	27	133
Mountain bluebird								
Sialia currucoides	11			1				1
Townsend's solitaire								
Myadestes townsendi	10				2	1		3
Swainson's thrush								
Catharus ustulatus	10	116	139	147	141	168	151	862
American robin								
Turdus migratorius	5	24	37	12	24	19	21	137
Varied thrush								
Ixoreus naevius	12	5			1			6
Cedar waxwing								
Bombycilla cedrorum	6		2	2	14	8	18	44
Orange-crowned warbler								
Oreothlypis celata	9	9	7	14	13	12	14	69
Nashville warbler								
Oreothlypis ruficapilla	9		1					1
Yellow warbler								
Setophaga petechia	8					1		1
Yellow-rumped warbler								
Setophaga coronata	6	13	18	27	39	28	48	173

Appendix A. Continued

Species	CCS[1]	2012	2013	2014	2015	2016	2017	Grand Total
Townend's warbler *Setophaga townsendi*	12	34	43	49	39	26	42	233
American redstart *Setophaga ruticilla*	10				1	3	5	9
Northern waterthrush *Parkesia noveboracensis*	8		2	3		1	1	7
MacGillivray's warbler *Geothlypis tolmiei*	12	12	5	9	10	13	11	60
Common yellowthroat *Geothlypis trichas*	9		4	5	6	10	6	31
Wilson's warbler *Cardellina pusilla*	10	8	3		1	3		15
Western tanager *Piranga ludoviciana*	9	47	68	71	72	68	53	379
Chipping sparrow *Spizella passerina*	9	54	71	59	64	94	82	424
Song sparrow *Melospiza melodia*	8	1		1		3		5
Lincoln's sparrow *Melospiza lincolnii*	7				3			3
Dark-eyed junco *Junco hyemalis*	8	32	49	63	66	62	77	349
Black-headed grosbeak *Pheucticus melanocephalus*	9	7	3	5	2	2	1	20
Lazuli bunting *Passerina amoena*	9		6	4		1		11
Red-winged blackbird *Agelaius phoeniceus*	8			3	1			4
Brown-headed cowbird *Molothrus ater*	7		1	1	1	9	1	13
Pine grosbeak *Pinicola enucleator*	10		1					1
Cassin's finch *Haemorhous cassinii*	13	1						1
Red crossbill *Loxia curvirostra*	8	46	4	37	19	10	48	164
Pine siskin *Spinus pinus*	10	131	39	4	105	92	56	427
Evening grosebeak *Coccothraustes vespertinus*	13	40	22	20	19	17	18	136
Grand Total		**799**	**757**	**834**	**946**	**1,015**	**980**	**5,331**

[1] CCS = Conservation Concern Scores (Panjabi et al. 2019, Partners in Flight 2019). CCS ≥8 = moderate concern, CCS ≥14 = high concern.

Long-Term Band Encounters of Rehabilitated North American Eagles

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Abstract

Between 1973 and 2020, 122 Golden Eagles and 115 Bald Eagles submitted to veterinary medical rehabilitation were banded and released upon recovery in three western states. Adults of both species comprised the most commonly banded age class of rehabilitated (rehab) eagles. Bald Eagles admitted for toxins spent less time in rehabilitation than for those admitted for collision trauma. Encounter (band read for any reason) data from banded eagles provided by the Bird Banding Laboratory (BBL) were analyzed and fitted to appropriate functions in an attempt to describe underlying distributions inherent in the data. Up to March 2020, 28 (12.2%) rehab eagles had been encountered. Encounter rate was 7.4% for rehab Golden Eagles and 16.5% for rehab Bald Eagles, slightly different than those reported by BBL overall (8.0%, 12.2%, respectively). All Golden Eagles were recovered (encountered dead) but 26.3% of Bald Eagles were encountered alive. Days in rehabilitation were not different between species or between Bald Eagles encountered dead or alive. Sex ratio of encountered eagles was not different from ratio of banded eagles of either species. Median time between release and encounter for Golden Eagles was 1.75 yr and 1.42 yr for Bald Eagles. Median distance from banding to encounter site for Golden Eagles was 7.5 km and 115.7 km for Bald Eagles. Number of encounters per year was not related to number of rehab eagles banded that year or for any year previous. Encounters of live Bald Eagles > 30 yr old are discussed. Rehab Golden Eagles may have originated predominantly from western Canada and Alaska while Bald Eagles may have been a mix of a local, non-latitudinal migratory population and seasonal latitudinal migrants. Small sample sizes and lack of precise encounter data prevents utility of rehab eagle encounters to contribute to demographic vital rate estimates needed for effective management of either species. Banding rehab eagles may not justify the manpower investment by BBL required to manage data from banders that band rehab eagles exclusively. Falconry training may be warranted to increase survival potential of rehab Golden Eagles. If recent trends continue, increased rehabilitation effort focused on Golden Eagles may be warranted.

Key Words: Golden Eagle, Bald Eagle, rehabilitation, longevity, median ($\tilde{x}$).

Introduction

Leg banding has made an important contribution to the understanding of movements and longevity of birds (Wood 1945). Prior to the mid-1970s the Bird Banding Laboratory (BBL) did not encourage banding birds that were rehabilitated (i.e., held in captivity >24 hrs) and relatively few birds were banded annually. Since then, some raptor rehabilitation groups have focused primarily on auxiliary markers (e.g., radio/GPS/GSM transmitters, wing tags, colored leg bands) rather than just leg bands, especially on eagles, as more effective tools to evaluate success of rehabilitation efforts (e.g., Martell 1991) but others only band. Other than Lutmerding et al. (2012), we know of no other reports concerning long-term banding of rehabilitated (hereafter referred as "rehab" or "rehabbed") Golden Eagles (*Aquila chrysaetos*) and Bald Eagles (*Haliaeetus leucocephalus*) based exclusively on encounters of leg bands. Here, we report on encounters of rehab eagles banded and released over 46 yr in the Rocky Mountain west.

Methods

Between May 1973 and March 2020, 634 Golden Eagles and 1002 Bald Eagles were banded under the authority of Federal Bird Banding Permit No. 20357 (A. Harmata) and sub-permits A-G and State Permits appropriate at the time. Of those, 237 were eagles submitted for veterinary care for a variety of reasons to individuals, informal groups, and the Montana Raptor Conservation Center, and were banded upon release (Table 1). Rehab eagles were released as early as August 1973 until October 2019. Eagles were released near Ft. Collins, Colorado (3 GOEA [1], 1 BAEA[2]), northwest Wyoming (1 GOEA, 3 BAEA), and across the state of Montana (118 GOEA, 111 BAEA). All eagles were banded with US Fish & Wildlife (USFWS now US Geological Survey) issued, pop-rivet metal leg bands. Age class at release was determined by methods consistent with Bloom and Clark (2001) for Golden Eagles and McCullough (1989) for Bald Eagles. Golden Eagles were sexed by methods described by Harmata and Montopoli (2013) and Bald Eagles sexed by methods modified from Bortolotti (1984). Nonadult age classes followed BBL classifications at banding and were Local or nestling (L), Hatch Year (HY), After Hatch Year (AHY), Second Year (SY), After Second Year (ASY), and Third Year (TY). Only After Third Year (ATY) did not follow BBL criteria. All ATY age class eagles were adults at least 5 yr of chronological age.

Records were scant for most eagles admitted to rehabilitation, especially between 1973 and 1995. However, reason for admittance could be determined or at least surmised for some. These reasons were condensed into three major categories: 1) collision-related injury, including head trauma, contusions, fractures, dislocations, etc.; 2) toxicity, mostly from lead (Pb) and other unknown substances and; 3) "other" which included an imprinted eagle (*N* = 1) and electric shock injuries (*N* = 2).

Consistent with BBL terminology we considered a band encounter as determination of a band number regardless of condition of the bird (i.e., dead, captured and released, remotely read on live bird). A band recovery was an encounter only of a dead, banded eagle. We compiled banding and encounter data from BBL records and data were manipulated in Excel™ or Statistica 6.0 (Statsoft 2003) spreadsheets. Only eagles that were held in captivity for > 24 hr were included in analysis i.e., Banding Status Code 2 (Transported to a different 10-minute block), 4 (Hacked), 5 (Sick, Exhausted) or 7 (Rehab and Held) were included. Distance between release and encounter site was calculated for latitude-longitude (Lati-Long) coordinates if known but precise encounter coordinates of several encounters were unknown. Thus,

[1] Golden Eagle

[2] Bald Eagle

Table 1. Age classes of eagles rehabilitated, banded, and (encountered) in Colorado, Montana, and Wyoming, 1973-2019. See narrative for age class acronym.

	Age Class at Banding							
	L	HY	AHY	SY	ASY	TY	Adult	Total
Golden Eagle	2 (1)	31 (1)	5 (1)	21 (3)	11 (1)	8 (1)	44 (1)	122 (9)
Bald Eagle	4 (1)	16 (4)	7 (2)	8	12 (1)	14 (1)	54 (10)	115 (19)
Total	6 (2)	47 (5)	12 (3)	29 (3)	23 (2)	22 (2)	99 (11)	237 (28)

Lati-Long coordinates of the southeastern corner of the 10-minute block provided by BBL were used. Distance ($D_{(x)}$) was calculated by:

$D_{(x)}$ =ACOS(COS(RADIANS(90- *LatR*)) *COS(RADIANS(90- *LatE*)) +SIN (RADIANS(90- *LatR*)) *SIN(RADIANS(90- *LatE*)) *COS(RADIANS(LongR -*LongE*))*6371;

where:

LatR = latitude of release site, *LatE* = latitude of encounter/recovery site, *LongR* = Longitude of Release site, *LongE* = Longitude of encounter/recovery site.

Time or duration between banding and encounter was calculated by determining accrued number of days between dates and dividing by 365 (= yr). Some encounter dates were not known because Federal Wildlife Agents often failed to include encounter data when submitting dead eagles to the Federal Eagle Repository in Denver, Colorado. In such cases the band encounter creation date provided by BBL minus 6 months was used as encounter date.

Due to small sample sizes precluding rigorous, statistical evaluation, number of encounters of nonadult age classes (L – TY) were pooled and compared with Adult age class for proportional analysis of encounters. Nonadults were composed of at least 4 yearly age classes (<1, 1, 2, 3) while adults composed of many (4 – 30). Encounter distances(x) and time between release and encounter in $yr_{(x)}$ were compiled sequentially from shortest to longest, $log10_{(x)}$ transformed, and regressed with cumulative proportion of encounters (y). Results were fitted to appropriate functions (logarithmic, exponential, polynomial) and displayed in an attempt to describe distributions inherent in the data. Bearing ($B_{(x)}$) from release site to encounter site was calculated by:

$B_{(x)}$=DEGREES(ATAN2(COS(RADIANS(*LatR*))*SIN(RADIANS(*LatE*))-SIN (RADIANS(*LatR*))*COS(RADIANS (*LatE*))*COS(RADIANS(*LongE* - *LongR)*), SIN(RADIANS(*LongE* - *LongR*))*COS(RADIANS(*LatE*)), (see $D_{(x)}$ above for variable names).

We used nonparametric tests when applicable because distribution normality was seldom achieved, sample sizes were small, and medians ($\tilde{x}$) tended to reduce the effect of outliers. We accepted *P*-values of ≤ 0.05 as significant and indicative of difference but considered *P*-values of ≤ 0.10 as potentially indicating trend.

Results

Number of in days in captivity needed for rehabilitation of Golden Eagles ($\tilde{x}$= 39) was not different than Bald Eagles ($\tilde{x}$= 50) (*Mann-Whitney* $U = 39.0$, $P = 0.19$). Adults of both species comprised the most commonly banded age class of rehab eagles. Up to March 2020, 28 (12.2%) rehab eagles had been encountered; 9 Golden Eagles (Table 2) and 19 Bald Eagles (Table 3). Bald Eagles tended to be encountered over twice as often as Golden Eagles relative to number banded (*Fisher's Exact Test*, one-tailed, $P = 0.039$). Golden Eagles banded as SY were the most frequently encountered age class while Adult was the most frequently encountered age class of Bald Eagles. Proportion of non-adult (L – TY) Golden Eagles recovered was greater than Adults (two-proportion *z* test: $z = 3.373$, $P < 0.01$) but no proportional differences in encounters by age class banded was detected for Bald Eagles ($z = 1.087$, $P = 0.277$). All Golden Eagles were recovered dead while 26.3% (banded as 1 ASY, 1 TY, 3 Adult) of Bald Eagle encounters were live captured and released or band numbers on healthy birds read by observers. Sex ratio of encountered eagles was not different from ratio of banded eagles of either species (Pearson $x^2_{(4)} = 6.0$, $P = 0.20$).

Number of days Bald Eagles spent in rehabilitation was not different whether encountered dead or alive (*Mann-Whitney* $U = 29.5$, $P = 0.96$) although rehabilitation time tended to be less for live encounters ($\bar{x}$ 9 days). For banded Golden Eagles subsequently encountered after release, collision trauma comprised 62.5% of known injuries ($N = 8$) requiring a $\tilde{x}$ of 30 d (range 21-81) in captivity. One additional Golden Eagle electrocution injury required 39 d

Table 2. Recovery (all dead) statistics for 9 rehabilitated Gold Eagles banded and released, 1979-2020.

Band #	Age[1]	Sex	State Banded	Injury	Days Captive	Date Release	Years Out	Encounter[2] Distance (km)	Direction Degrees
62947438	HY	F	Montana	Pelvis	30	8/12/2013	0.25	0.10	307.6
70908619	TY	U	Montana	Head Trauma	23	1/18/2019	0.25	7.58	286.6
62922749	ASY	F	Montana	Head Trauma	21	1/16/1999	2.92	284.47	300.9
62932043	SY	M	Montana	-[3]	-	2/2/1995	20.08	3019.45	300.2
62944031	SY	F	Montana	Pb[4]	64	4/12/2002	0.75	520.48	87.8
62905359	L	M	Colorado	Orphan	-	6/13/1979	0.58	0.10	270.0
67900454	SY	M	Montana	Electro	39	4/27/2007	1.75	7.41	359.4
67904274	Adult	M	Montana	Wing	34	1/25/2012	1.75	6.80	53.1
109800215	AHY	M	Montana	Wing	81	1/1/2010	4.25	$\tilde{x}$ 60.78	180.6

[1] At Banding. Bird Banding Lab classification.
[2] From Release Site.
[3] No record.
[4] High lead concentration in blood.

of rehabilitation while Pb toxicity of another required 64 da of rehabilitation. For banded Bald Eagles subsequently encountered after release, collision trauma comprised 60.0% of known injuries (N = 15) requiring a $\tilde{x}$ of 60 d (range 25-147) in captivity. Days in rehabilitation were considerably less for Bald Eagles treated for toxins including lead (Pb) than for known collision trauma ($\tilde{x}$ = 34 da, range 16-47) (*Mann-Whitney* U = 3.0, P = 0.052).

Time between release and encounter for Golden Eagles ($\tilde{x}$= 1.75 yr) and Bald Eagles ($\tilde{x}$= 1.42 yr) was not different (*Mann-Whitney* U = 74.5, P = 0.94). Half of rehab Golden Eagle encounters may be expected within 1.07 yr of release and 95% within 9.3 yr. Half of rehab Bald Eagle encounters may be expected within less than 1 yr of release and 95% within nearly 10.7 yr (Fig. 1).

Distance from banding to encounter site for Bald Eagles ($\tilde{x}$= 115.7 km) was farther (*Wald-Wolfowitz runs test, Z adj*. = -3.44, P < 0.01) than Golden Eagles ($\tilde{x}$= 7.5 km). Half of rehab Golden Eagle recoveries may be expected within 9 km and 95% within 1996 km (Fig. 2). Fifty percent of encounters of rehab Bald Eagles may be expected within 108 km and 95% within nearly 1077 km of the release site.

Number of encounters per year was not related to number of rehab eagles banded that year or for any year previous for either

Table 3. Encounter statistics for 19 rehabilitated Bald Eagles, 1976-2020.

								Encounter[2]		
Band #	Age[1]	Sex	State Banded	Injury	Days Captive	Release Date	Years Out	Distance (km)	Direction Degrees	Condition
62932069	Adult	F	Montana	-[3]	-	2/4/1991	0.50	109.13	260.7	Dead
62932097	Adult	M	Montana	-	-	3/25/1994	2.58	924.54	310.7	Dead
62922593	AHY	F	Montana	-	151	4/11/1997	0.17	1009.86	251.5	Dead
62922594	Adult	F	Montana	-	45	6/15/1997	0.33	22.59	145.1	Dead
62903448	HY	F	Montana	Wing	50	8/22/2001	1.25	31.66	234.3	Dead
62950142	L	U	Montana	Pelvis	25	7/12/2005	0.17	18.53	360.0	Dead
62950150	Adult	M	Montana	Toxin	16	6/17/2006	0.17	39.27	160.7	Dead
62933040	Adult	F	Montana	Pb[4]	47	4/29/2000	6.67	253.56	198.5	Alive
62900173	AHY	M	Colorado	Impact	86	2/25/1976	31.83	1416.23	65.7	Alive
67902215	Adult	F	Montana	Wing	85	8/14/2009	1.42	67.61	343.2	Dead
67903699	Adult	F	Montana	Wing	39	7/14/2010	0.75	9.07	253.8	Dead
109800256	HY	M	Montana	Imprint	16	9/1/2009	3.58	51.96	142.7	Dead
67903156	TY	F	Montana	Eye	50	11/25/2009	3.42	164.24	226.5	Dead
70902997	Adult	M	Montana	Pelvis	75	3/15/2014	1.75	280.28	86.6	Dead
109800224	HY	M	Montana	Wing	68	9/1/2014	0.33	115.74	80.9	Dead
67904293	HY	F	Montana	Wing	147	11/30/2012	5.33	41.28	44.1	Dead
62950459	Adult	M	Montana	Visual[5]	59	8/25/2015	2.92	201.03	244.2	Alive
78851934	ASY	M	Montana	Visual[5]	45	9/14/2018	0.08	1242.23	182.7	Alive
62932527	Adult	M	Wyoming	Impact[6]	34	5/18/2018	1.67	169.57	292.2	Alive

[1] Bird Banding Lab. Classification.
[2] From Release Site.
[3] No record.
[4] High lead concentration in blood.
[5] Band read by ornithologist.
[6] Blood Pb concentration also high.

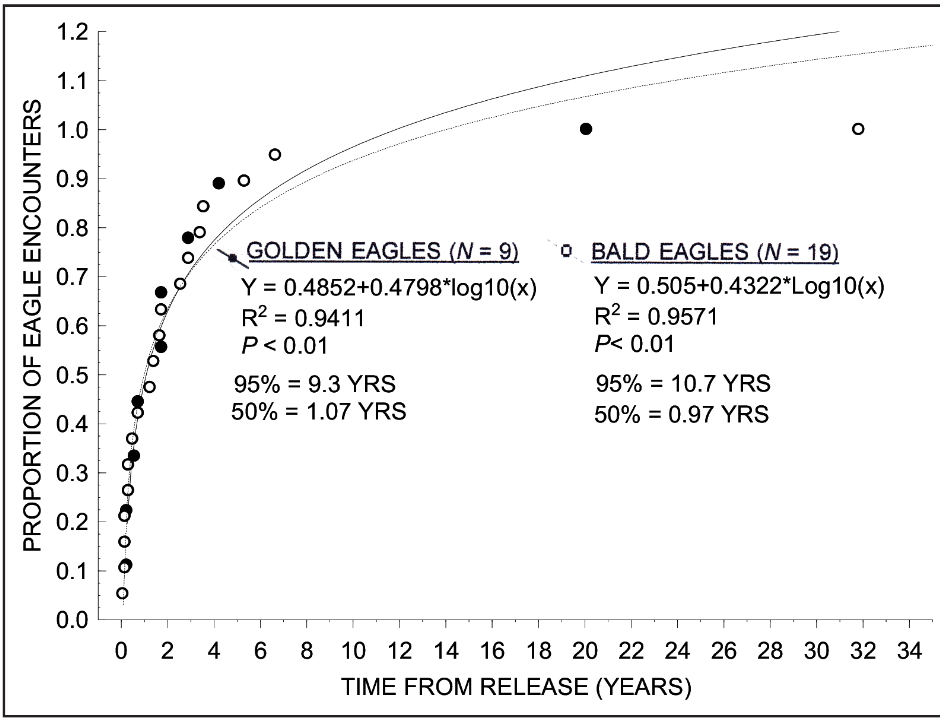

Figure 1. Time between release and encounter of banded, rehabilitated Golden and Bald Eagles.

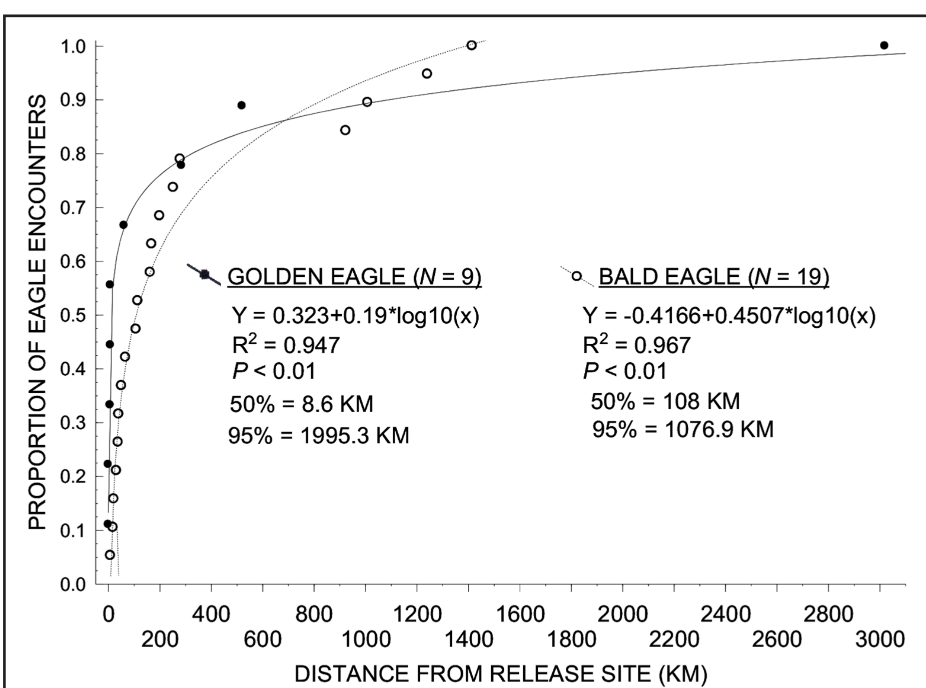

Figure 2. Distance between release and encounter of banded, rehabilitated Golden and Bald Eagles.

species (Figs. 3 & 4) ($r < 0.397$, $P > 0.66$). Distance of encounter from release site was strongly correlated with time since release for Golden Eagles ($r = 0.96$, $P < 0.01$) but slightly less so for Bald Eagles ($r = 0.53$, $P = 0.02$). Compass quadrant (NE/NW/SE/SW) of encounter from release site was not different for Golden Eagle recoveries or Bald Eagle encounters (Figs. 5 & 6) ($x^2(1) < 0.22$, $P > 0.63$).

Notable Bald Eagle Encounters

Three encounters of live, banded Bald Eagles are noteworthy. One (629-32527, Table 3) was originally banded (and colorbanded) as L in a nest at the confluence of Butler Creek and the Snake River (43.402661 -110.823989) south of Jackson, Wyoming on 23 May 1989. He was encountered alive on 4 April 2018, 14.5 km north of Pinedale, Wyoming (83.6 km, 125.7^0 from natal nest), a victim of a vehicle impact and remanded to rehabilitation at Wind River Raptors, Lander, Wyoming. At just under 30 yr old, blood analysis indicated elevated levels of Pb and on X-ray, he had a 3-part ulnar fracture, all bones appeared very thin, and there were several skeletal breaks that had healed (Barnes, N., Wind River Raptors, pers. comm.). He was administered chelating therapy, healed quickly, and was released on 18 May 2018 near Lander, Wyoming. On 28 January 2020 he was again encountered alive at Hoback Junction, Wyoming (43.3243 -110.7282) having impacted a living room picture window, ending up inside the house. He was again remanded to rehabilitation, chelated for elevated blood Pb, and released near the Snake River, Wilson, Wyoming on 6 March 2020 at near 32 yr old.

The second encounter of note was 629-00173 (Table 3). After recovering in captivity from a minor impact injury to the phalangeal portion of the wing, the Colorado Division of Wildlife provided the eagle to a research project in the San Luis Valley of Colorado (Harmata 2002a) to serve as a lure bird. After a winter season of use, the SY Bald Eagle was released near Waverly,

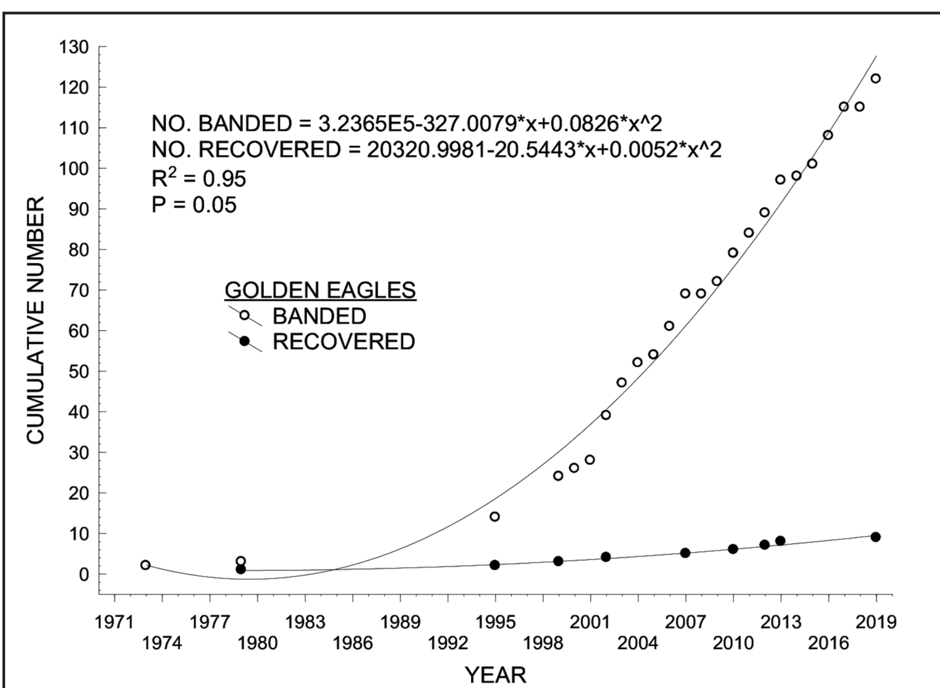

Figure 3. Relationship of cumulative number of recoveries to cumulative number banded per year for rehabilitated Golden Eagles.

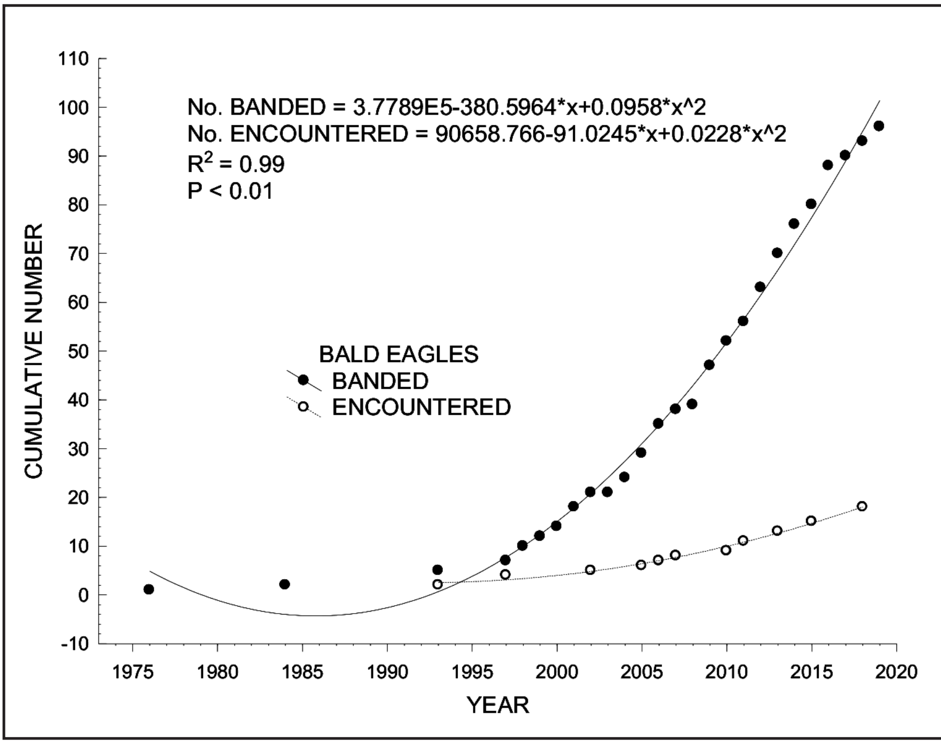

Figure 4. Relationship of cumulative number of recoveries to cumulative number banded per year for rehabilitated Bald Eagles.

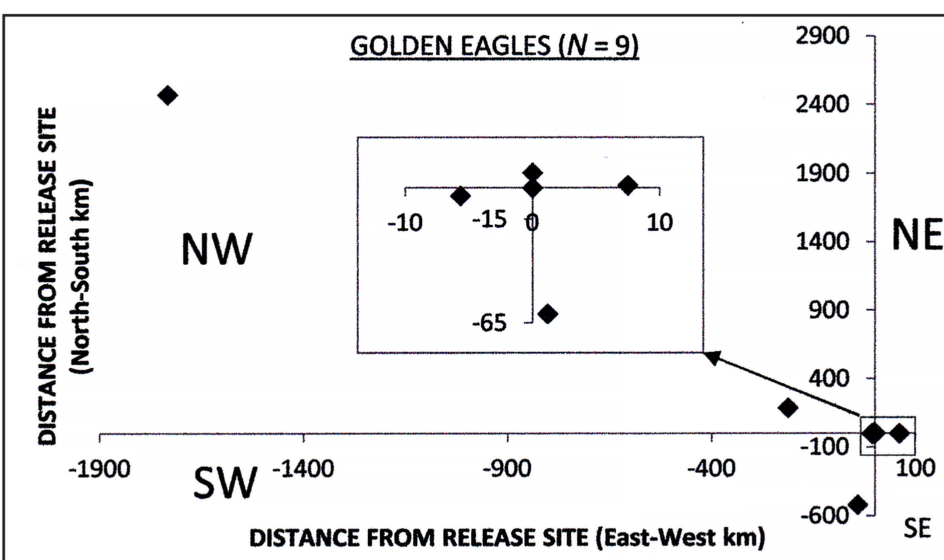

Figure 5. Directional dispersion and x- y- distance (km) of Golden Eagle recoveries from release sites.

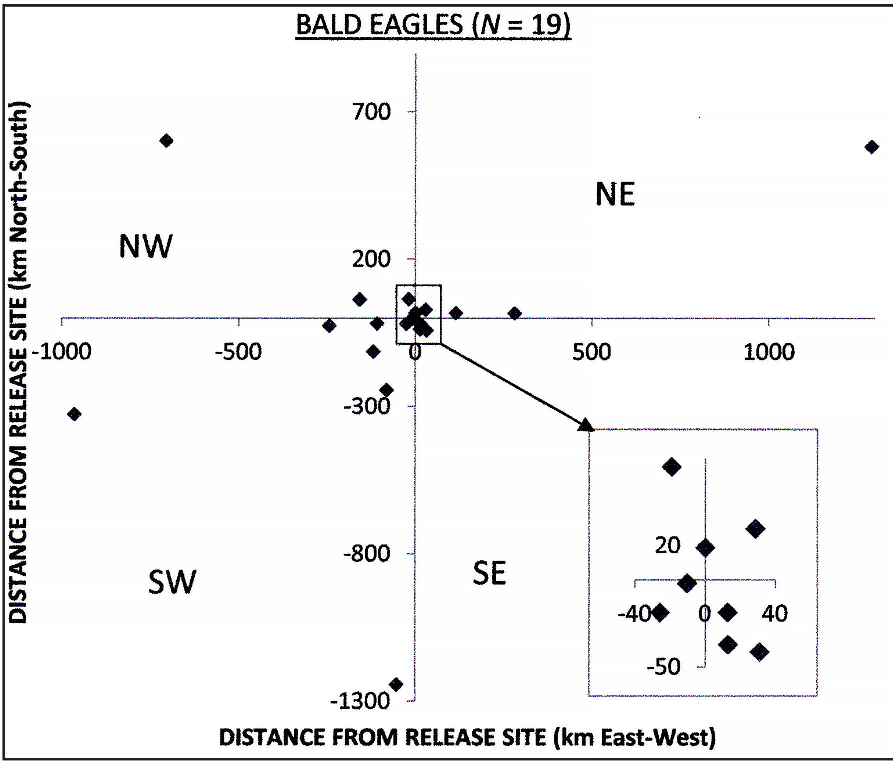

Figure 6. Directional dispersion and x- y- distance (km) of Bald Eagle encounters from release sites.

Colorado (40.7767 -105.0774) on 25 February 1976. She was encountered alive on Menominee Tribal Lands in northeastern Wisconsin in 2008 (date uncertain), 31 yrs later. The encounter was not reported to BBL by Tribal Authorities due to initial confusion over the band number and Sovereignty concerns but was released to the wild after a successful rehabilitation for Pb poisoning (Gibson, M., Raptor Education Group, Inc, Antigo, WI, pers. comm.).

A third encounter of a live eagle involved rehabilitation effort but is notable primarily because of longevity. A nestling Bald Eagle was banded (and colorbanded) along the Snake River near Hoback, Wyoming (43.2504 -110.7776) on 12 June 1982. On 12 March 2016 the eagle was found alive beneath a power pole (43.5094 -110.7564) suffering from severe electric burn damage on one wing. She was remanded to rehabilitation which was unsuccessful and she was euthanized at age 34, an age second only to a 38 yr old Bald Eagle banded and recovered in New York (https://www.pwrc.usgs.gov/BBL/longevity/Longevity_main.cfm).

Discussion

Encounter Rate

As of 2008, encounter rates reported by BBL for Golden Eagles and Bald Eagles were 8.3% and 14.0%, respectively, the highest of all raptors. Eliminating multiple encounters of the same eagle (i.e., unique), encounter rate of Golden Eagles reported by BBL (8.0%; Lutmerding et al. 2012) was still slightly greater than that reported here (7.4%). Unique encounter rate reported by BBL for Bald Eagles (12.2%) was less than rehab Bald Eagles reported here (16.5%). Lower rates for rehab Golden Eagles than those reported by BBL were possibly a function of age at banding. BBL rates are likely composed of a much higher proportion of younger, i.e., mostly L or nestling age classes at banding (e.g., 43% L for Permit 20357) and younger age classes notoriously have less environmental awareness fostering reduced survival potential than older age classes (e.g., McIntyre et al. 2006). A higher proportion (73%) of rehab eagles were >1 yr old and despite getting into some difficulty that required treatment/captivity, likely had a higher post-release survival potential than young eagles banded as nestlings (L). A greater preponderance of rehab Bald Eagles (83%) were banded older than nestlings also, but higher encounter rate (16.5%) than rehab Golden Eagles may be a function of naturally associated habitat. Bald Eagles are associated with environments more commonly frequented by recreationists (marine, riparian, or lacustrine systems; Stalmaster 1987, Gerrard and Bortolotti 1988) and thus more likely to be encountered, while Golden Eagles are more often found in more remote, upland environments (Gordon 1955; Palmer 1988; Watson 1997) that most humans avoid.

Origins of Rehab Eagles

Golden Eagle recoveries were focused more closely to the release site, i.e., 50% within 9 km, while Bald Eagles traveled farther with 50% of encounters within 108 km (Fig.2). Median distance from banding and encounter site of rehab Golden Eagles ($\tilde{x}$ = 7.58 km) and Bald Eagles ($\tilde{x}$ = 112.44 km) was well within a single day's cruising distance for both species (Yates et al. 2001, Harmata 2002a) and therefore of little indication of origin.

Date of admission to rehabilitation may be more instructive as to origins of rehab eagles rather than movement distance or direction subsequent to release. Eighty-five percent (85%) of recorded admission dates (*N* = 7) of rehab Golden Eagles occurred within months when migrant eagles from northerly latitudes would be present in the Continental US (late autumn to early spring). In fact, the only admittance dates in summer were of L and HY age classes i.e., locally produced eagles. Wintering Golden Eagles in the western Continental US have been shown to originate from western Canada and Alaska (McIntyre 2006, Harmata 2015 App. Fig. 17) and in fact, bearing and distance of one outlying Golden Eagle recovery clearly indicates origin from an Alaskan population (Fig. 5).

Rehab Bald Eagles ranged farther than rehab Golden Eagles (*c.f.*, Figs. 5 & 6). However, 79% of known admission dates (*N* = 14) of rehab Bald Eagles were within months when migrant eagles from boreal forests of Canada (see Gerrard and Bortolotti 1988, Harmata 2002a) would be absent in the Continental US (late spring to early autumn). As no difference was detected between species in time from release to encounter, Bald Eagles may have been predominantly from a local, non-latitudinal migratory population (Harmata et al. 1999). However, outliers (Fig.6) indicate there also were latitudinal migrants not nesting/summering within the vicinity of regional rehabilitation facilities.

Utility of Banding Rehab Eagles

Small sample sizes, lack of precise encounter data (date of demise, cause, exact location), and unknown age of Adult subjects prevents utility of rehab eagle encounters to contribute to demographic vital rate estimates needed for effective management of either species (USFWS 2016, Hunt et al. 2017). One aspect of demography to which banding may contribute is longevity. Few permanent electronic tracking devices and/or attachment methods (back pack harness) persist longer than a decade and generally inflict unacceptable damage or mortality (Lockhart and Kochert 1980, Withey et al. 2001, Reynolds et al. 2004, Steenhof et al. 2006, Baron et al. 2010). Leg bands endure for the life of an eagle and several > 30 yr old eagles have been encountered (see Notable Bald Eagle Encounters, above) However, considering number of eagles banded, those encounters are exceedingly rare.

Reduced survival potential of previously compromised, rehab eagles is almost intuitive. Most rehab Golden Eagles here were recovered within 9.3 yr

(95%, Fig. 1); somewhat less than expected longevity found by Harmata (2002b) at just over 11 yr and may hint at reduced survival of rehab Golden Eagles. Proportionately more nonadult age classes were recovered than Adults. McIntyre (2012) found 82% of known mortalities (*N* = 11) of wild non-adult Golden Eagles were from starvation, revealing a possibly additive but generally unrecognized role of natural mortality. Increased investment of time and training such as employing licensed falconers to intensively train nonadult Golden Eagles prior to release may help offset natural mortality (Mauch 1998). Although Adult rehab Golden Eagles may have an increased survival potential over nonadults without training, no recovered rehab Golden Eagle approached the documented longevity record of 60 yr (Sweden, Staav 1990). However, one was near published accounts of wild Golden Eagles of notable age (> 20 yr) (Harmata 2012, Harmata and Restani 2015). Such an encounter may hint at efficacy of rehabilitation efforts if encounter date matches actual age.

We know of no published reports of Golden Eagles breeding subsequent to rehabilitation but Martel et al. (1991) reported successful breeding of a rehabilitated Bald Eagle. Lack of measurable difference in proportion of encounters between age classes of Bald Eagles suggests falconry training to increase survival potential prior to release may not be as efficacious as for Golden Eagles. Bald Eagles taken from the wild are notably difficult to adequately train (compared to Golden Eagles) to take naturally associated prey (fish, waterfowl; AH pers. obs.) thus effort may be futile from an enhanced survival perspective.

Ninety-five percent of rehab Bald Eagles were encountered within 11 yrs (Fig. 1). Martell et al. (1991) reported on survival of 19 radio-tagged, rehab Bald Eagles. Longest survival was 3 yr but all remaining were < 1 yr. They reported no band recoveries but several were again remanded to rehabilitation. Median values of time between release and encounter reported here are likely representative of actual time rehab Golden Eagles (1.75 yr) and Bald Eagles (1.58 yr) survive in the wild post-release. Unfortunately, how representative these values are of actual survival is equivocal as many recovery reports to BBL usually do not include information on carcass age or cause of death.

Considering the extended time to develop adequate sample sizes of encountered eagles experienced during this study, banding rehab eagles may not justify the manpower investment by BBL required to manage data from banders that band rehab eagles exclusively, without auxiliary markers. Few eagles are banded annually and encounters rare. Best practice may be for rehab centers to employ established Master Bird Banding Permit holders familiar with banding codes, schedules, and reporting procedures to band rehab eagles and record and submit data.

Most (87.5%) Golden Eagles and virtually all Bald Eagles were originally admitted to rehabilitation due to conflicts with humans or their artifacts (e.g., vehicles, power lines, contaminants) and likely met their ultimate demise for similar reasons (Russell 2014). Although contaminants appear to be declining (Stauber et al. 2010) and electrocutions actively managed (APLIC 2006, 2014), a comparatively high rate of anthropogenic mortality continues to affect North American Eagles and is likely limiting populations west-wide (USFWS 2016).

Evidence is emerging of population and productivity declines of Golden Eagles in the western US (Millsap et al. 2013, Watson et al. 2020). However, Montana currently (ca. 2020) supports over 500 active Bald Eagle territories in the state, which far surpasses the estimated carrying capacity of 352 territories identified by the Montana Bald Eagle Working Group in 1994 (MBEWG 1994) and the population in Montana and surrounding States continues to expand (USFWS 2016). If trends continue, rehabilitation effort focused on primarily on Golden Eagles may be warranted.

Acknowledgements

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Snowshoe Hare use of Silviculturally Altered Conifer Forests in The Greater Yellowstone Ecosystem

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Abstract

Information about snowshoe hare habitat use in key Canada lynx recovery areas, such as the Greater Yellowstone Ecosystem, is critical for the conservation of lynx. Although research conclusions differ in regard to the types and ages of forests preferred by snowshoe hares, restrictions on silvicultural practice have been implemented by forest managers to protect snowshoe hares in this area. However, some research suggests that regenerating lodgepole pine stands associated with silvicultural treatments benefit snowshoe hares. We evaluated three indices of snowshoe hare use within a timber management area in southwest Montana, inside the Greater Yellowstone Ecosystem (1999–2012) to assess the relative use of forest types. We analyzed: 1) 11 years of data collected from 280 pellet plots using linear mixed models and AIC_c model selection, 2) 13 years of track counts from 2,202 km of roadway travel using Chi-squared goodness-of-fit tests of proportional segment lengths and the associated cover types, and 3) 76 nights over one winter of live-trapping using a hare/night index. Overall, we observed the greatest use within the youngest two classes of regenerating lodgepole pine stands that were associated with clear cutting and pre-commercial thinning. These results suggest snowshoe hares prefer silviculturally influenced 30–60 years old lodgepole pine forests

Key words: Snowshoe hare, *Lepus americanus*, lodgepole pine, *Pinus contorta*, pellet plots, track counts, pre-commercial thinning, clear-cutting

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Introduction

Snowshoe hares (*Lepus americanus*) are an important prey species throughout the boreal forests of North America (Murray et al. 2008). Many forest carnivores feed on snowshoe hares and, in some instances, depend on them for survival (Hodges 2000a). Snowshoe hare are the primary prey base of Canada lynx (*Lynx canadensis*), such that lynx populations are directly linked to snowshoe hare populations (Ruggiero et al. 2000). In 2000, the Canada lynx was listed as threatened in the contiguous United States under the Endangered Species Act (US Fish and Wildlife Service 2000). The Greater Yellowstone Ecosystem (GYE) has been designated as critical habitat for sustaining and recovering lynx (US Fish and Wildlife Service 2014). This area encompasses Yellowstone and Grand Teton National Parks, as well as the surrounding mountain ranges in southwestern Montana, northwestern Wyoming, and southeastern Idaho. Based on historical evidence, the GYE has likely only supported small resident populations of lynx, though this area may be important for dispersal and connectivity (US Fish and Wildlife Service

2017) and is home to the most southern population of naturally occurring lynx (Squires et al. 2003). However, relatively limited research has been conducted on lynx or snowshoe hares within the GYE compared to other portions of their range.

Snowshoe hares are generally found in forests with dense understory where horizontal cover is high (Litvaitis et al. 1985, Berg et al. 2012, Holbrook et al. 2017). Snowshoe hares rely on dense cover for concealment from ground and avian predators, as well as adequate forage to survive the harsh winter months (Litvaitis et al. 1985, Zimmer et al. 2008a, Berg et al. 2012). Snowshoe hares feed on a variety of plant species. During the winter in the GYE they feed mainly on low hanging needles and twigs of lodgepole pine (*Pinus contorta*), Douglas fir (*Pseudotsuga menziesii*) and subalpine fir (*Abies lasiocarpa*) (Zimmer et al. 2008a). As a result, snowshoe hares select for forest types that offer an optimal combination of cover and forage (Zimmer et al. 2008a;b).

While various landscape level factors such as climate, fire, insect infestation, and ungulate browsing have the potential to affect forest age and structure, managers can often have direct control over silvicultural practices in order to influence snowshoe hare habitat. In many parts of their range, snowshoe hares are more abundant in younger classes of regenerating conifer stands with high stem densities (Litvaitis et al. 1985, Hodges 2000b, Fuller et al. 2007). For example, one study within the GYE concluded that snowshoe hares were more likely to be found in relatively young classes of regenerating lodgepole pine forests (Zimmer et al. 2008b). However, other studies in the GYE indicate that snowshoe hares are more abundant in late successional forest types, associated with a multi-storied canopy and dense understory (Hodges et al. 2009, Berg et al. 2012). There have been relatively few snowshoe hare studies within the GYE and the results are not consistent as to what forest stand types snowshoe hares are more likely to use (Zimmer et al. 2008b, Hodges et al. 2009, Berg et al. 2012). Consequently, there are still many uncertainties regarding the best timber management practices to employ in the GYE to promote snowshoe hare habitat.

Although the GYE is associated with Yellowstone National Park, much of the snowshoe hare habitat in this region is under the jurisdiction of the U.S. Forest Service, which has a multi-use management mandate that allows timber management prescriptions. These activities can result in drastic changes to vegetation and cover and cause significant impacts on snowshoe hare populations (Murray et al. 2008). Clear-cutting and pre-commercial thinning are two of the main silvicultural treatments affecting forests in the GYE. Clear-cutting involves harvesting all the trees in a stand, thereby removing the cover on which hares rely. Snowshoe hares may avoid clear-cut areas immediately after treatment (Ferron et al. 1998). However, human replanted clear-cuts typically result in dense regenerating conifer forests which provide desirable cover for snowshoe hares (Litvaitis et al. 1985, Hodges 2000b, Fuller et al. 2007). Pre-commercial thinning involves selectively removing trees to attain a prescribed density or spacing to reduce competition, reduce fuel load, and promote tree growth, thus reducing the time stands take to reach maturity (Griffin and Mills 2007). Research has suggested that pre-commercial thinning negatively impacts snowshoe hares for at least the first two to five years post-treatment due to a decrease in horizontal cover (Griffin and Mills 2007, Homyack et al. 2007, Abele et al. 2013). However, research in the GYE found that the long-term effects of pre-commercial thinning may benefit snowshoe hares (Zimmer et al. 2008b). It was concluded that thinning reduced self-pruning of lodgepole pine trees so that trees in thinned stands maintained lower lateral branches, which provided favorable cover and forage during winter months when the stands are in early stages of succession (Zimmer et al. 2008b).

We assessed the relative use of snowshoe hares among forest types within a silviculturally-impacted portion of the GYE, using three indices of snowshoe habitat use, during a 13-year period in southwest Montana. Our goal is to provide insight into snowshoe hare use among common forest types within a silviculturally altered portion of the GYE to inform forest managers on snowshoe hare habitat management practices. By associations, these techniques will also favor Canada lynx. We predict that we will observe the greatest relative snowshoe hare use in early to mid-successional lodgepole pine stands based on previous work done within the area (Zimmer et al. 2008b). Therefore, the objective of this study was to evaluate the association between snowshoe hare use and vegetative cover types using long term indices.

Study Area

Our study area was located in the Bear Creek drainage of southwest Montana in the Custer-Gallatin National Forest approximately 8 km from the town of Gardiner, MT (Fig. 1). The study area was approximately 11.7 km^2 (1172 ha) of a US Forest Service timber management area. The elevation ranged from approximately 2100–2600 m, with winter snow depths during the study period averaging 83 cm at a SNOTEL location at 2560 m in elevation approximately 4 km from our study area (NRCS 2017).

The Bear Creek study area is a mosaic of conifer forests resulting from various silvicultural treatments intermixed with old growth stands. Predominate conifer species include lodgepole pine, Douglas fir, subalpine fir, and Engelmann spruce (*Picea engelmannii*). The forest cover types sampled in this study area were grouped into eight classifications based on dominant species and age classes using standard classifications for the region (Table 1; Mattson and Despain 1985).

Materials And Methods

Pellet Plots

We counted snowshoe hare fecal pellets from 2002–2012 as an index of snowshoe hare use in the Bear Creek study area, using surveying methods similar to Litvaitis et al. (1985) and Ferron et al. (1998). We selected 29 sample sites in our study area with three to four of the sites in each of the eight dominant cover types (Table 1; Figure 1). We identified forest stands of each cover type that were large enough to contain the configuration of pellet plots and randomly oriented the sites within these stands. Sites consisted of 10, 1-m radius plots established in two parallel lines, 50 m apart with 5 plots on each line. Plots were spaced 20 m apart along transects. This resulted in a sampling effort of 30 to 40 pellet plots in each of the eight cover types for a total of 290 plots. We systematically counted and removed snowshoe hare fecal pellets from each plot every spring after snow had completely melted. No other lagomorph species had been documented or observed in this study area. Thus, we were confident pellets were deposited from snowshoe hares only. We additionally counted and cleared pellet plots again in the fall during the years of 2009–2012. For these years, we totaled annual counts so that for all years, pellet counts represented an annual accumulation of pellets.

We used linear mixed effects models to evaluate the association between snowshoe hare use, as indexed through pellet plot counts, and forest stands in the Bear Creek study area. We excluded pellet counts from site 29, as field investigation into this site revealed that the forest characteristics did not fall into any defined cover type categories. We conducted mixed effects multiple regression using package ‘lme4’ (Bates et al. 2015) in program R (R Core Team 2017). We set the response variable to mean pellet counts at each site for each year. To meet assumptions of homogeneous variance and normally distributed error, we added 0.01 to the mean pellet counts and log-transformed the values. We included random intercept terms for ‘site’ and ‘year’ in all models to account for the inclusion of counts from the same site each year and to account for study area wide effects related to environmental conditions, population changes or changes in sampling frequency

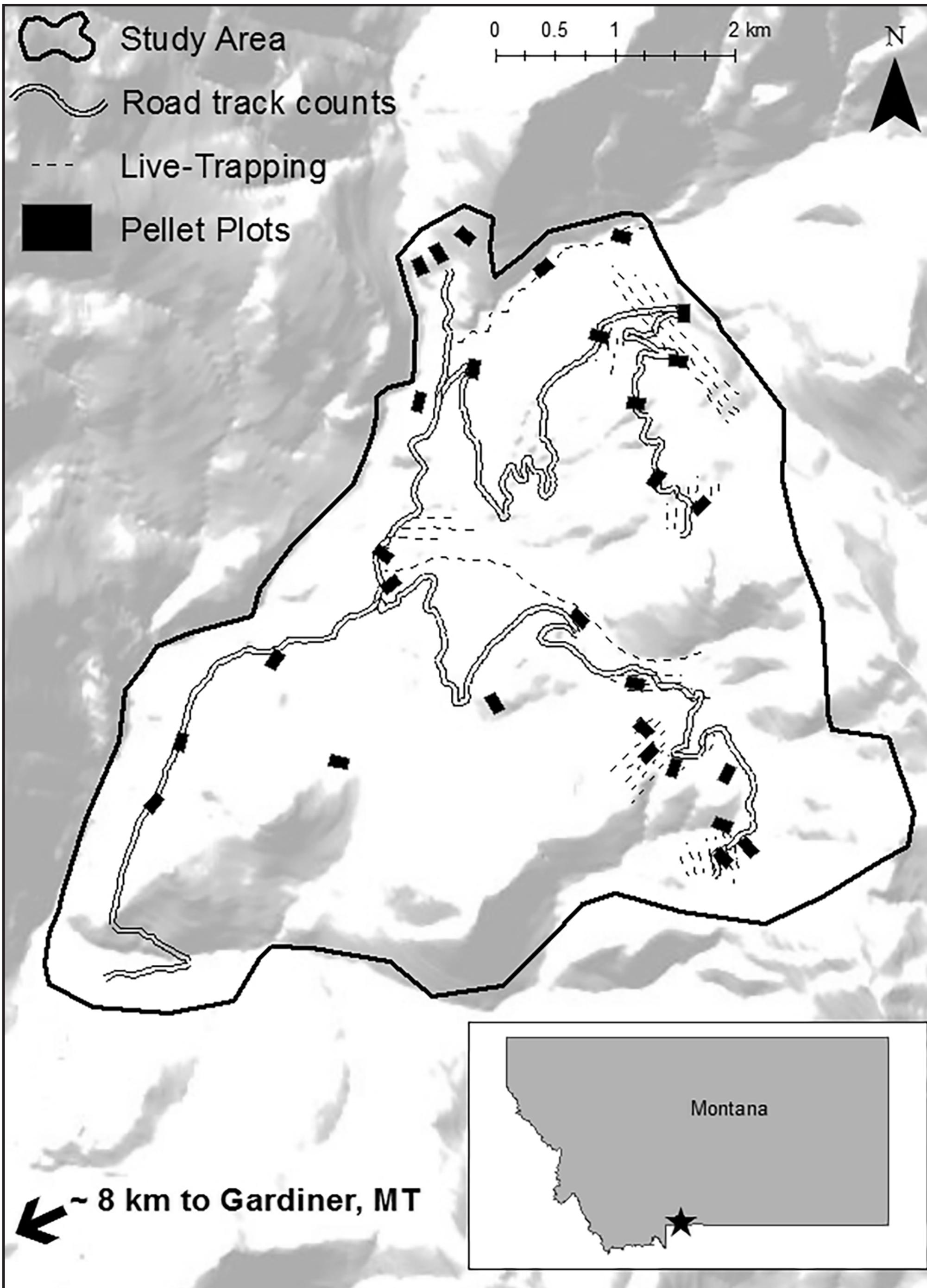

Figure 1. Location of the Bear Creek study area (1172 ha) and distribution of pellet plots, road track counts, and live-traps implemented to evaluate snowshoe hare use of coniferous forests.

Table 1. Dominant forest cover types within the Bear Creek study area where three indices of snowshoe hare use were implemented during 1999–2012.

Forest Cover Types*	Abb.*	Descriptions*	Proportion of Study Area (%)
Young regenerating lodgepole pine	LP0	Dense regenerating lodgepole pine stands resulting from clear-cutting between 1974–1976.	15
Middle-aged regenerating lodgepole pine	LP1	Regenerating lodgepole pine stands resulting from clear-cutting between 1950–1955 and Pre-commercial thinning 18 to 27 years later.	16
Mature lodgepole pine	LP2	Closed canopy dominated lodgepole pine stands estimated to be 100–300 years old with limited understory comprised of small to medium Englemann spruce and subalpine fir seedlings and saplings.	18
Late successional lodgepole pine	LP3	Broken canopy old growth lodgepole pine stands estimated to be > 300 years old. Small to large Englemann spruce and subalpine fir seedlings and saplings in understory.	13
Mixed forest	MF	Old growth late successional stands with varied age classes of trees and multiple species represented in the overstory	8
Spruce - fir	SF	Mature forests dominated by Englemann spruce and subalpine fir in both overstory and understory, typically found along drainage corridors in this area.	16
Douglas fir	DF	Old growth Douglas fir stands with a broken canopy, lacks understory, some spruce and fir present.	8
Sanitation salvage	SS	Mature mixed forest stands defined by a partial harvest of dead trees that occurred in 1986. Broken overstory with dense regenerating understory.	6

*Cover type classifications, abbreviations and descriptions were developed by Mattson and Despain 1985 with the exception of Sanitation salvage.

that could have been influencing all sites on an annual basis (Zuur 2009).

To address the association between snowshoe hare use and forest stand attributes, we reclassified the cover types into groupings based on stand commonalities described in cover type descriptions (Mattson and Despain 1985) and confirmed in the field (Table 2). The fixed effects for our models were developed using combinations of the groupings of cover types that were developed based on common stand attributes (Table 2).

We developed six *a priori* candidate models to test biological hypotheses regarding snowshoe hare use among the forest stands in our study area (Table 3). To compare silvicultural treatments to the absence of silviculture represented by late successional stands (Table 3), we considered M2 as the null model, instead of the intercept only model (M0). We ranked models using Akaike's Information Criterion adjusted for small sample sizes (AIC_c; Burnham and Anderson 2002; "AICcmodavg" package for R; Mazerolle 2017). The model with the lowest AIC_c was considered the most parsimonious. We calculated evidence ratios using AIC_c weights (ω_i) to demonstrate model support (Burnham and Anderson 2002). We evaluated model fit using marginal R^2 as a description of the variation accounted for by the fixed effects and conditional R^2 as a description of the variation accounted for by both the fixed effects and random effects in each model (Nakagawa and Schielzeth 2013; "MuMIn" package for R; Barton 2018). Models were developed using groupings of categorical variables that were not combined in the same way within each competing model, therefore models were non-nested and model averaging was not considered (Burnham and Anderson 2002). We reported on all parameter estimates due to the non-sequential model fitting approach and discussed effects of both informative and uninformative parameters based on an 85% confidence interval (Arnold 2010).

Table 2. Forest cover type groupings based on stand commonalities for modeling snowshoe hare use based on pellet counts within the Bear Creek study area from 2002–2012.

Grouping	Description
Regenerating	Young successional lodgepole forests (LP0 + LP1)
Late Successional	Young successional lodgepole forests (LP0 + LP1)
DF	Stands dominated by Douglas fir Same as DF cover type (DF)
LP	Forests dominated by lodgepole pine (LP0 + LP1 + LP2)
MIX	Forests with a Mixed spp. overstory (MF + SS)
SF	Same as spruce-fir cover type (SF)
Understory_LP	Forest with lodgepole in understory same as Regenerating (LP0 + LP1)
Understory_SF	Forests with spruce and sub-alpine fir in the understory (LP3 + MF + SS + SF)
Young	The youngest age stand, same as LP0 cover type (LP0)
Middle	Middle-aged stand, same as LP1 cover type (LP1)
Mature	Old aged stand, same as LP2 cover type (LP2)

Table 3. Six a priori models designed to test alternative hypotheses regarding the association of snowshoe hare pellet counts and forest stand characteristics in the Bear Creek study area from 2002–2012

Models*	Variables/Tested hypothesis
M0	Intercept only Hypothesis: Cover type is not a good predictor of snowshoe hare use as measured through mean pellet counts
M1	Regenerating Hypothesis: Mean pellet plot counts are only associated with the two regenerating lodgepole pine stand types
M2	Late Successional (Null) Hypothesis: Mean pellet plot counts are only associated with the late successional forest stand types indicating a lack of any timber management
M3	DF + LP + MIX + SF Hypothesis: Mean pellet plot counts are associated with the dominant overstory species of the site based on a reclassification of cover type categories.
M4	DF + Understory_LP + Understory_SF Hypothesis: Mean pellet plot counts are associated with the dominant conifer understory species of the site based on a reclassification of cover type categories.
M5	Young + Middle + Mature + Late Successional Hypothesis: Mean pellet plot counts are associated with age class of the site based on a reclassification of cover type categories

* Random intercepts for site and year included in all models.

Road Track Counts

We counted snowshoe hare tracks by travelling a road network within the Bear Creek study area during January–March, 1999–2012, except 2005 (Figure 1). We used a track-intercept design identical to Zimmer et al. (2008b). Track counts from 1999–2003 were published in previous work (Zimmer et al. 2008b) and were also included in our results in order to better understand trends over a longer time span. We divided the approximately 18-km road network into segments based on the cover type on either or both sides of the road (Table 1). Road segments with differing cover types on each side of the road were assigned combination classifications resulting in 11 unique road segment classifications (Table 2). We travelled the road network on snow machines 12–72 hours after snowfall events. We recorded fresh snowshoe hare tracks per road segment once for each time they intersected the roadway, regardless of the direction of the tracks, and recorded the time since snowfall.

We standardized snowshoe hare track counts by dividing the number of tracks by nights since last snowfall. We conducted Chi-square goodness-of-fit tests using Program R (R Core Team 2017) to assess if the proportion of tracks on each road segment classification was proportional to the respective distance. We averaged all survey counts from each year into a single measure to account for repetition of sampling and conducted tests of each individual year to assess changes in snowshoe hare use over the study period.

Live-Traps

We live-trapped snowshoe hares in the Bear Creek study area to assess use of different forest cover types during January–March, 2009. The labor and resources required to continue this effort was not available in any other winter of the study. Capture methods were similar to those used by Mills et al. (2005) and Berg and Gese (2010). All trapping protocols were approved by the Montana Fish, Wildlife and Parks Institutional Animal Care and Use Committee (IACUC # 8-2008). We set 80-traps with 50-m spacing between traps within each cover type. The cover types trapped were young regenerating lodgepole pine, middle-aged regenerating lodgepole pine, mature lodgepole pine, late successional lodgepole pine, and spruce-fir (Table 1). We modified trapping grids within each cover type by adjusting individual gridline lengths to preserve the 50-m spacing and to conform to the size and shape of the forest stands within the Bear Creek study area (Figure 1). This resulted in spatially independent sub-grids within the cover types, with the exception of the young regenerating lodgepole pine cover type and the mature lodgepole pine cover type which had stand sizes large enough to support a single contiguous trapping grid.

We checked traps daily and marked first time captures with unique numbered ear tags (National Band and Tag Company, 721 York St, PO Box 72430 Newport, KY 41072, USA, style 681). We documented location of capture, sex, body measurements and collected biological samples for additional research interests and released hares on site. Upon recapture, we recorded ear tag numbers, capture location, and re-collected measurements prior to release. Our trapping effort was divided into two trapping periods for each cover type. The first trapping period lasted 7–13 days followed by a 13–32 day rest between sequences then a final trapping period of 5–7 days. The length of the trapping periods was inconsistent due to adjustments made to minimize the impact on captured snowshoe hares while maximizing sample size (Mills et al. 2005). Forest carnivores, namely red fox (*Vulpes vulpes*) and American marten (*Martes americana*), at times discovered traplines, harassing and occasionally killing hares inside traps, causing us to end the trapping period.

In order to account for heterogeneity in trapping effort we calculated the number of unique snowshoe hares captured per trap night for each cover type trapping grid as an index of relative abundance (Dice 1931) or snowshoe hare use. Previous research in northern Montana found no justification for assuming unequal trappability of individual snowshoe hares or at different sites (Mills et al. 2005), thus we considered captures per night comparable among cover types. We summed the number of unique snowshoe hares captured in each cover type and divided it by the number of nights that traps were open for each respective cover type trapping grid. We also measured individual trapping period hare movements by comparing hare capture records with trap locations and ArcMap software and tools (ESRI 2011).

Results

Habitat Use: Pellet Plots

We surveyed 280 plots in the Bear Creek study area for 11 consecutive years during 2002–2012 resulting in 8,832 snowshoe hare fecal pellets counted. Average pellet counts per cover type varied between 0.36 in the Douglas fir cover type and 8.77 in the young regenerating lodgepole pine cover type (Fig. 2).

Results from the AIC_c model selection indicated that the model developed based on the dominant conifer understory species (M4) best explained mean snowshoe hare pellet plot counts among the candidate models and had 79% of the support of the data (Table 4). The remaining five models received relatively little support (Table 4). Evidence ratios between the top model and competing models suggested the top model was supported 3.95 times more than the second ranked model and 558 times more than the null model (M2).

The top model indicated that snowshoe hare pellet counts were associated with the conifer understory species as defined by the cover type classifications found in the Bear Creek study area. The estimated mean pellet counts were 0.05 (85% C.I. = 0.01,

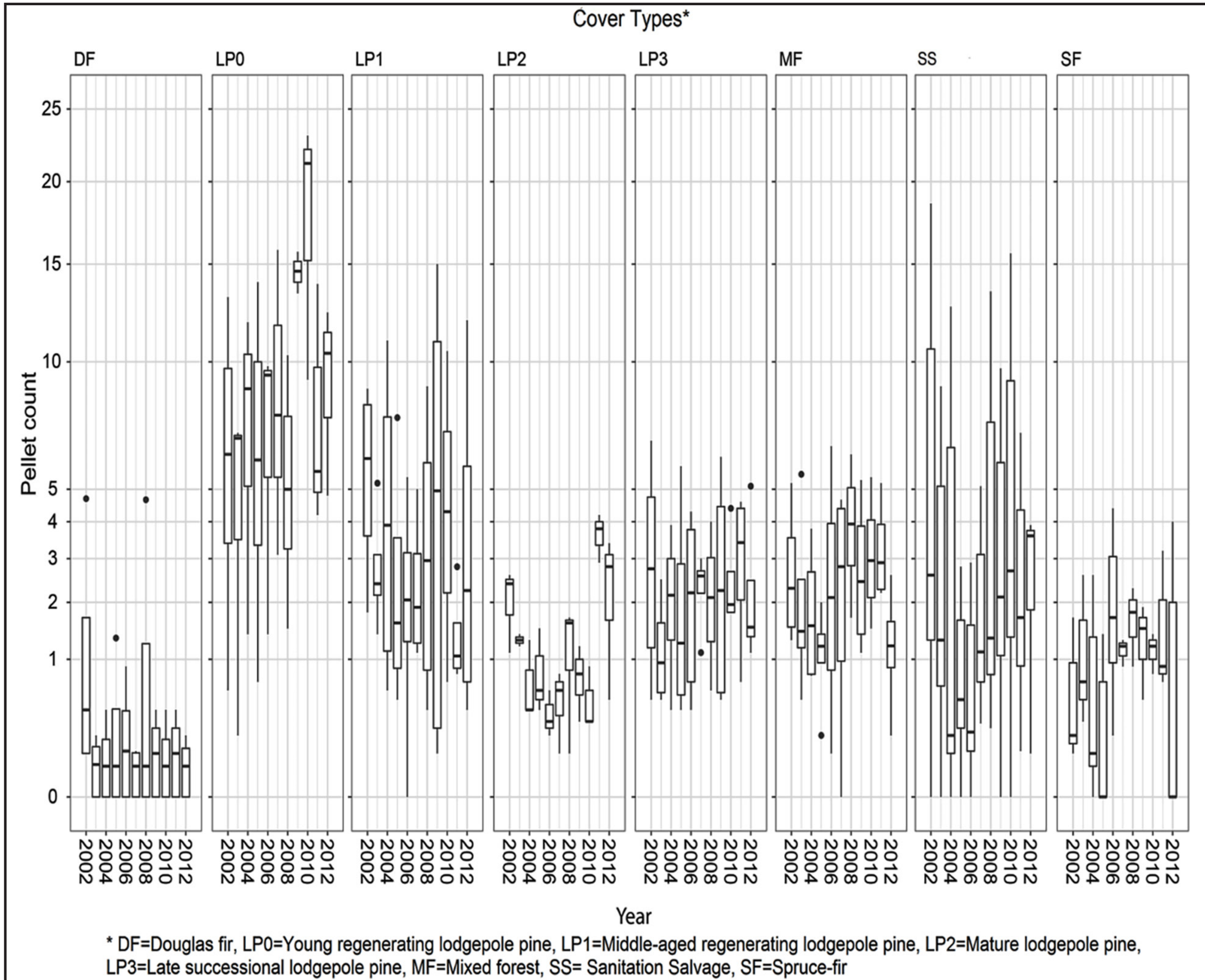

Figure 2. Boxplots of the average pellets recorded per cover type by year in the Bear Creek study area during 2002–2012 as an index of snowshoe hare use.

0.14), 3.19 (85% C.I. = 1.60, 6.36), and 1.14 (85% C.I. = 0.64, 1.59) pellets per plot for sites with Douglas fir, lodgepole pine, and spruce and subalpine fir dominance in the understory, respectively (Table 5). Sites that were dominated by lodgepole pine understory had approximately 61 times more pellets per plot than sites whose understories were dominated by Douglas fir, and approximately 3 times more than sites in which the understory was dominated by spruce and subalpine fir (Table 5). The marginal R^2 for the top model was 0.35 indicating 35% of the variation in pellet counts was accounted for by the fixed factors, the redefined cover types, while the conditional R^2 suggested that 72% of the variation was accounted for by both the fixed and random factors of year and site (Table 4).

Habitat Use: Road Track Counts

We counted a total of 14,324 snowshoe hare tracks intersecting the roadway by travelling approximately 2,202 km on snow machines over 13 winters during 1999–2012. The number of surveys conducted per year ranged from 5 in 2010 to 17 in 2002, due to the variability in snow events and timing. The annual average number of snowshoe hare tracks per night varied between 3.87 in the spruce-fir cover type and 386.51 in the middle-aged regenerating lodgepole pine cover type.

Snowshoe hare track counts of each individual year indicated that snowshoe hares did not use the cover type combinations proportional to availability the road segments ($P < 0.001$ each year). Small sample sizes of track counts for the individual years of 1999 and 2001 resulted

Table 4. Support for candidate models using AIC_c to test models developed from hypotheses regarding the association between snowshoe hare pellet counts and forest stand characteristics within the Bear Creek study area during 2002–2012.

Models*	K	AICc	∆AICc	□i	cR2	mR2
M4 = DF + Understory_LP + Understory_SF	6	1015.09	0.00	0.79	0.72	0.35
M3 = DF + LP + MIX + SF	7	1017.84	2.75	0.20	0.72	0.35
M1 = Regenerating	5	1026.30	11.21	0.00	0.71	0.09
M2 = Late Successional (Null)	4	1027.74	12.65	0.00	0.71	0.02
M5 = Young + Middle + Mature +						
Late Succesional	7	1029.41	14.32	0.00	0.72	0.15
M0 = Intercept only	4	1029.77	14.68	0.00	0.72	0.00

* Random intercepts for site and year included in all models.

Table 5. Estimates from the most parsimonious model (M4 = DF + Understory_LP + Understory_SF), determined through AIC_c, for explaining snowshoe hare pellet plot counts in the Bear Creek study area during 2002–2012.

Variable (understory spp.)	Estimate	Std. Error	Mean Pellet Count*	(85% CI)- Mean Lower*	(85% CI)- Mean Upper*
Douglas fir (DF)	-2.78	0.62	0.05	0.02	0.14
Understory_LP	1.16	0.47	3.19	1.60	6.37
Understory_SF	0.02	0.31	1.14	0.64	1.60

*Calculated using the inverse transformation (exponentiated coefficients -0.01) in violations of Chi-square test assumptions which prohibited us from conducting analysis for these years. We observed that segments defined by Douglas fir (DF) on both sides of the road as well as segments defined by meadows on both sides of the road were consistently used less than expected. Segments defined by middle-aged regenerating lodgepole pine stands on both sides (LP1) were consistently used more than expected. Track counts in the segments defined by young regenerating lodgepole pine stands on both sides (LP0) trended upward as time progressed (Fig. 3).

We found the highest positive difference between the observed proportion of tracks and the expected proportion of tracks on road segments defined by middle-aged regenerating lodgepole pine stands on both sides (LP1), with the exception of 2009, when the highest positive difference was documented on road segments with young regenerating lodgepole pine stands on both sides (LP0; Fig. 3). We observed the highest negative difference between the observed and expected proportion of use on road segments with Douglas fir (DF) stands on both sides each year. We observed the greatest change of use from the road segments in the young regenerating lodgepole pine stands (LP0). We documented a -0.08 proportional difference between observed and expected track counts in 2000, indicating use less than expected, and by the last year of the study (2012) we observed a 0.11 difference, indicating use greater than expected.

Habitat Use: Live-Trapping

We live-trapped a total of 59 unique snowshoe hares from all trapping grids within the Bear Creek study area during January–March of 2009. Nine of the 59 hares were recaptured in a second cover type trapping grid resulting in those individuals being considered unique snowshoe hares twice, once for each cover type. Our traps were set for a total of 76 nights for all five of the 80-trap grids combined, equating to 6,080 trap nights. The number of unique snowshoe hares captured in each trapping grid range from four in the mature lodgepole pine cover type to 20 in the young regenerating lodgepole pine cover type (Table 6).

The number of snowshoe hares captured per trap night was highest in young regenerating lodgepole pine stands (1.33 hares/night), followed by the spruce-fir stands (1.15 hare/night), middle-aged regenerating lodgepole pine stands (0.90 hares/night), late successional lodgepole pine stands (0.79 hares/night) and mature lodgepole pine stands (0.29 hares/night; Table 6). Recaptured snowshoe hare average movements, within a single trapping session, ranged from 85 m– 231 m. Notably, we observed two individual movements of >500 m within a single trapping period.

Discussion

Our pellet plot analysis revealed that relative snowshoe hare use was greatest in areas found in the two youngest classes of lodgepole pine stands (categories LP0 and LP1) that progressed in age from approximately 27–37 and 50–60 years old during the study. A considerable amount of variation in our pellet plot counts was explained by our site and year random effects with a higher range in variation among sites. We recognize that variation attributed to each site is likely related to site characteristics that we did not measure, however, we accounted for these potential effects in our models with the inclusion of the random effect variables. Annual variation may be related to the maturing and changing of forest stands over the study period. Specifically, we would expect to see the greater variations we observed over time in cover types that were going through successional changes related to silviculture and less variation in mature, stable forest types (Figure 2).

Our road track count analysis suggested that use of young regenerating lodgepole pine (LP0) and middle age regenerating pine stands (LP1) was higher than expected based on proportional availability of road segments in these same stands. Long-term,

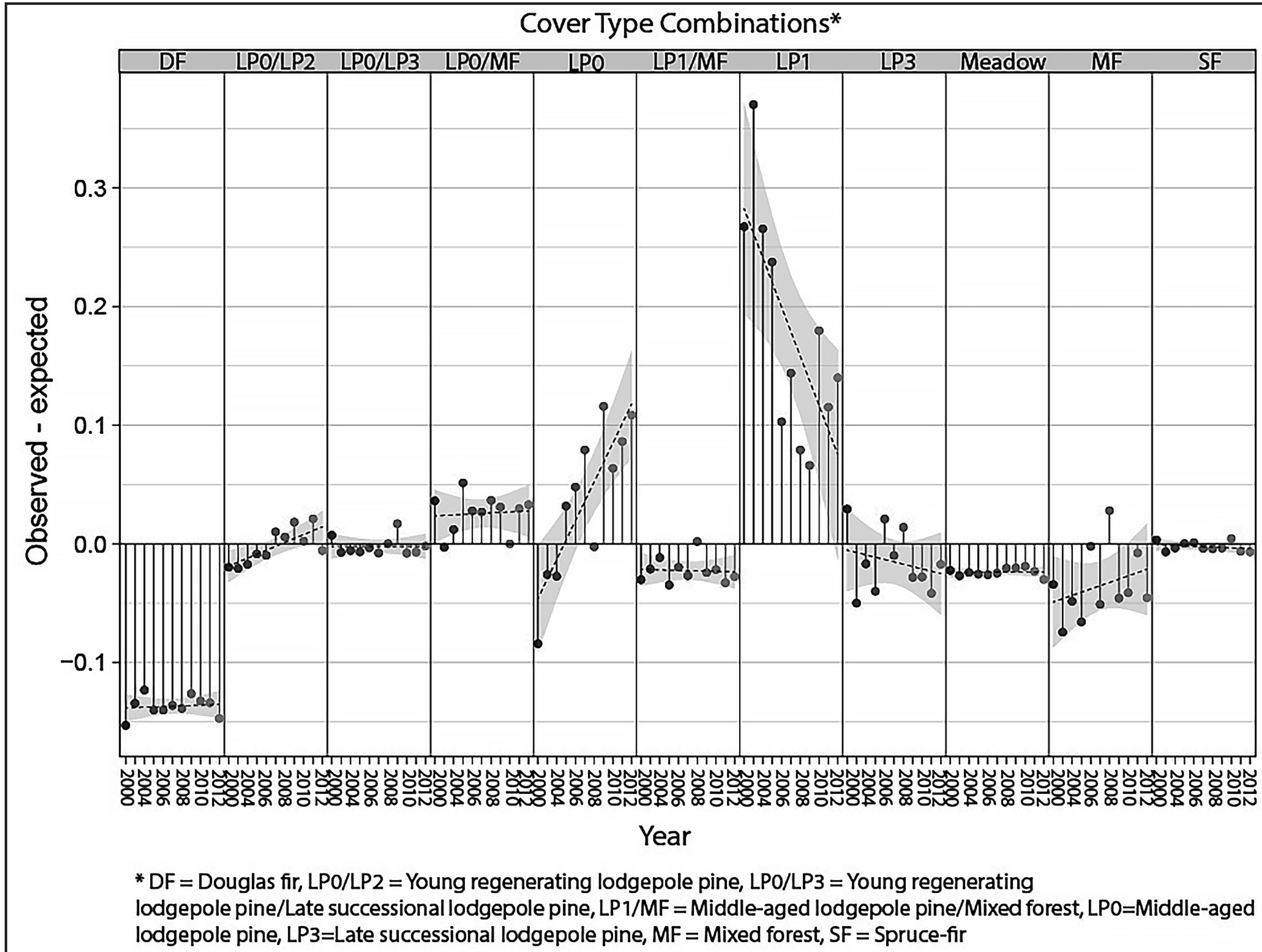

Figure 3. The difference between the observed and expected proportion of standardized track counts based on cover type combinations of road segments of individual years within the Bear Creek study area during 1999–2012 assessing snowshoe hare use among cover types

Table 6. Snowshoe hare live-trapping capture results from the Bear Creek study area during January–March of 2009 to assess relative snowshoe hare use among five dominant cover types.

Cover Type*	Traps	Nights	Individual Hares Captured	Hares / Night
Young regenerating lodgepole pine	80	15	20	1.33
Middle-aged regenerating lodgepole pine	80	20	18	0.90
Mature lodgepole pine	80	14	4	0.29
Late successional lodgepole pine	80	14	11	0.79
Spruce - fir	80	13	15	1.15

* Developed from Mattson and Despain (1985)

annual data also allowed us to assess trends and changes of use over time. Notably, we found that the young regenerating lodgepole pine stands were not used more than expected until they reached an age of approximately 31 years post clear-cutting. We recognize that track counts can be considered a weak index of snowshoe hare use due to the high variability of snowshoe hare activity and that tracks that were observed near the ends of each segment may have been correlated with the adjacent segment cover types. However, by standardizing counts and repeating our surveys multiple times per year over 13 years we feel that our results accurately demonstrate the disparity in relative use of cover types by hares. Our track count results were also corroborated by results from the pellet plot sampling.

The greatest numbers of snowshoe hares captured per night were in the young regenerating lodgepole pine stands. These stands were approximately 34 years old. We recognize that inferences about snowshoe hare use may be limited by a lack of replication of our efforts across space for each of the cover types or across time to account for annual variation. Also, the unstandardized shapes of the trapping grids have the potential to bias the number of snowshoe hares that encountered our 80-trap array. Nevertheless, results of our live-trapping effort were fairly consistent with the other indices of use. This consistency not only lends itself to strengthening our conclusions from individual indices, but more importantly solidifies our inferences regarding snowshoe hare use on a broader scale. The congruity of our results suggests that within the Bear Creek study area, within this time period, we were accurately observing snowshoe hare use among cover types. Collectively, our three independent indices suggest that relative snowshoe hare use was high in the younger classes of lodgepole pine stands.

The relative high use of the available cover types by snowshoe hares may be related to forage preferences of snowshoe hares. Other research related to snowshoe hare diet observed that lodgepole pine is a preferred food source for snowshoe hares during winter months due to a higher nutritional quality than other available forage (Sullivan and Sullivan 1988, Zimmer et al. 2008a, Ellsworth et al. 2013, Hutchen and Hodges 2018). However, the mature forest stands in our study area may have had slightly less horizontal cover than the younger regenerating lodgepole pine stands, as did some mature mixed conifer forests in the southern GYE (Berg et al. 2012). Thus, our findings may also be correlated to the structural density of younger lodgepole pine stands (Fuller et al. 2007, Zimmer et al. 2008b). We observed that the young regenerating lodgepole pine stands appeared to be at an age when self-pruning was limited and tree size was large enough to still provide cover during periods of deep snow accumulation. We also observed that middle-aged lodgepole pine stands had maintained low lateral branches, likely due to pre-commercial thinning. This provided snowshoe hares with low hanging branches for cover and forage, especially during periods of deep snow (Ivan et al. 2014).

Our pellet plot count index of snowshoe hare use was based on annual accumulations of pellets, thus our counts were related to habitat use of all seasons combined. Snowshoe hare track counts and live-trapping occurred in the winter, thus were only reflective of snowshoe hare use during the winter season. Similar results among methods suggest that young and middle-aged regenerating lodgepole pine stands were disproportionately used throughout seasons and throughout the study period. Although conditions and needs are likely to change throughout the year, winter is a season of increased predation pressure and decreased availability of forage species for snowshoe hares (Zimmer et al. 2008a, Squires et al. 2010). Thus, winter habitat is likely to be a central aspect to the survival of snowshoe hares. Quality habitat, as defined by Hall et al. (1997), is related to environmental conditions that allow individuals or populations to persist. Our study suggests that young and middle-aged regenerating lodgepole pine stands likely provided the cover and forage that snowshoe hares needed to survive the crucial winter months and thus should be considered a main component of quality snowshoe hare habitat in the northern GYE.

Forest stand size and connection to other stands are factors that may have also influenced snowshoe hare use in our study area. Snowshoe hare movements based on live-captures indicated that snowshoe hares used multiple stands within our study area. The intense timber management in our study area produced a mosaic of varied forest stand types and ages which may also benefit lynx (Holbrook et al. 2019). Holbrook et al. (2017) noted the importance of multi-use lands, such as National Forests, for snowshoe hares, which may be a reflection of the potential positive effects silviculture and a mosaic of smaller stands can have on snowshoe hare habitat. Snowshoe hares may be able to take advantage of multiple forests types for forage and cover if the heterogeneity of a landscape is such that hares can easily relocate if conditions or needs change (Hutchen and Hodges 2018).

Silvicultural practices have been restricted to maintain older seral classes of forests within the GYE (US Forest Service 2007). However, our results indicate the two youngest regenerating lodgepole pine forests were preferred by snowshoe hares within our study area, conflicting with recent policy related to silvicultural practices in the GYE. Pre-commercial thinning specifically has been restricted in lynx recovery areas, including the GYE. However, our results suggest that middle-aged regenerating lodgepole pine stands which had been thinned were generally used more by snowshoe hares than mature forest types. Zimmer et al. (2008a;b) suggested that delayed self-pruning due to pre-commercial thinning may extend the time that middle-aged lodgepole pine stands provide suitable forage and cover for hares and documented that these stands, which had been thinned, typically retained branches within 2-m of the ground. We advocate for more specific research into seasonal and long-term use of these silviculturally influenced cover types as well as stable mature stands, as use may relate to shifting resource needs and availability as well as life cycle events. We also advocate for more research on the effects pre-commercial thinning on snowshoe hare use, based on the relatively high use of middle-aged regenerating stands (LP1) within our study area, which had been the result of pre-commercial thinning. Our results suggest that silvicultural practices have the potential to at least create a temporal window of high snowshoe hare use of regenerating lodgepole pine stands.

Conclusions

Our research indicated that snowshoe hare use was greatest in lodgepole pine stands that were ≤ 60 years post clear-cut based on 13 years of data, and our results were consistent across three indices of snowshoe hare habitat use. Overall, we conclude that snowshoe hares demonstrate a preference for lodgepole pine stands that are approximately 30–60 years post-disturbance. We found evidence of an upward trend in snowshoe hare use in young regenerating lodgepole pine stands (LP0). This trend becomes apparent around 30 years post-disturbance. Comparably, there was a decreasing trend in the middle-aged lodgepole pine stand (LP1; Figure 3). We hypothesize that we were observing a shift in use from the middle-aged regenerating lodgepole pine stand to the young regenerating lodgepole pine stands due to the structural maturity in the younger stand and the onset of self-pruning in the middle-aged stands. We observed that snowshoe hare use was generally not as high in mature forest types. However, we did observe some use by snowshoe hares in the mature stand types as well as relative consistency of use over time (Figure 1, Figure 2). Thus we agree with past research that use of mature stands may be more temporally stable and thus important for long-term snowshoe hare habitat (Hodges 2000b).

Regional and intra-regional differences should be considered as our findings are translated by managers outside of our study area, since our study site represents such a small proportion of the GYE. Resource managers must also take into consideration important factors related to Canada lynx other than snowshoe hares, such as lynx reproductive success, other prey species and lynx hunting success (Ivan and Shenk 2016, Holbrook et al. 2019). Ultimately, as resource managers manage forests for snowshoe hares, we recommend that they reconsider blanket prohibitions on silvicultural practices and continue long-term research on the effects of silviculture on snowshoe hares.

Acknowledgements

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Private Lands Conservation:
Where it has gone and where it is going

February 3-7, 2020
Copper King Hotel & Convention Center
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Brett Dorak, President Elect 2019-20
Montana Chapter of The Wildlife Society

Introduction

Our theme for this year's conference takes a look at what is going on across the state on private lands and how landowners are working with different agencies, NGOs, developing grass root programs, and utilizing other avenues to improve and conserve the resources right here in our backyard. Approximately two thirds of Montana is privately owned, and without private lands conservation, many of the flora and fauna species that call this place home would not be as abundant as they are now. For the most part, wildlife does not understand anthropogenic lines drawn on a map, but the mosaic of landownership across the state requires everyone to do their part to conserve not only the wildlife, but also the way of life and traditions that have been associated with these lands for centuries.

Plenary Session Abstracts

Ranching, Conservation and Community; A Winning Team

Leo Barthelmess, The Rancher's Stewardship Alliance, Malta, MT

The Ranchers Stewardship Alliance (RSA) works in the northern great plains focusing on the high-lighted area of the state of Montana, Blaine Phillips and Valley counties. As our capacity to help other communities grow, we are reaching across the Missouri River to help other areas develop community-based conservation. The Rancher's Stewardship Alliance works with many different partners. Our partners from the conservation community include NGOs, wildlife agencies, state and federal conservation/management agencies, as well as contributions from livestock organiza-tions and livestock businesses.

What is the value of community-based conservation, who should participate and what components will lead to success of local efforts to preserve grasslands and local communities? There are many components that lead to successful communities and conservation, many of these components are overlooked or undervalued. I will discuss successful strategies for community-based conservation. This discussion will include identifying positive programs and or skill sets that create success as well as behaviors that detract from positive outcomes.

I will be using the evolution of RSA as an example of a community led organization that tries to preserve local culture and implement landscape scale conservation. As with any start up organiza-tion growth and change are difficult.

An Overview of FWP's Wildlife Habitat Program

Rick Northrup, Habitat Bureau Chief, Montana Fish, Wildlife and Parks, Helena

The state of Montana Fish and Game purchased the Judith River Game Range in 1940 in response to wintering elk conflicts on private ranchland. Additional acquisitions over subsequent decades set a direction for the agency to invest in habitat conservation as an alternative to artificially-feeding wild ungulates. Habitat acquisitions focused on big game winter range, river-bottom riparian, and wetland habitats. With the establishment of new programs in the late 1980s, Montana Fish, Wildlife and Parks (FWP) has integrated a palette of incentive-based habitat protection and enhancement options for private landowners. These options involve both perpetual and term agreements. Habitat conservation emphasis has also broadened and now includes key threatened habitats for game and species of concern and connectivity habitats for terrestrial wildlife. The strengths of FWP's habitat program are its supporting partners, the agency's extensive field-level interaction with private landowners, dedicated staff and funding, emphasis on working lands and public access, strategic implementation, and an extensive history of landscape-scale conservation successes.

The Nature Conservancy Work on the Northern Great Plains

Brian Martin, Montana Grasslands Conservation Director, The Nature Conservancy, Helena

The Nature Conservancy is working across the Northern Great Plains to retain functioning grasslands and other natural habitats that provide habitat for wildlife and economic and cultural values for human communities. Working with and respecting the needs and interest of local communities is one of the Conservancy's organizational values, and we have strived to implement strategies that benefit both people and nature. Using the best available science, we recognize that ranch operations are compatible with maintaining habitat. In Montana, we have permanently conserved over 100,000 acres of private land through purchase and ownership of land and use of conservation easements. The protection efforts have contributed toward maintaining the continuity of over 250,000 acres, when public lands are also considered. Easements have created opportunities for multi-generation ranches to grow their operations to allow family members to stay on the ranch or facilitate transfer between generations. Our Matador Ranch Grassbank has facilitated best management practices for wildlife and habitat on 295,000 acres, and we are also supporting planning and enhanced management through our Candidate Conservation Agreement with Assurances for sage-grouse and four species of grassland songbirds. The challenge in private lands conservation is to continue to work with people to create a virtuous cycle where conserving grasslands and wildlife is a recognized and widely adopted element of sustainable ranch operations and those efforts are supported by the public at-large

Ducks Unlimited Collaboration and Patnerships on Montana's Landscape

Bob Sanders, Manager Conservation Programs - Montana, Ducks Unlimited, Inc., Elliston.

Ducks Unlimited, in collaboration with its many federal, state, NGO and private partners has delivered over 328,000 acres of habitat conservation in Montana since 1984. As most of these acres (73%) have been on private lands, being able to work with private landowners is paramount. DU works state-wide with an emphasis on waterfowl breeding habitat along Montana's Hi-Line. Keeping ranchers on the landscape ensures that adequate grass and water will be available for livestock, waterfowl and other wildlife. Delivering private land conservation involves four basic components: 1) knowing the landscape and the needs of the wildlife species you are targeting, 2) having the technical skills to deliver projects that create, restore and protect those habitat values, 3) understanding and connecting with the human communities and the individuals that make up those landscapes and, 4) having the leadership, funding sources and inspired dedication to drive yourself and others to achieve mutually beneficial conservation goals.

Communities, Economics, and Conservation

Greg Neudecker, State Coordinator, Montana Partners for Fish and Wildlife Program, U.S. Fish and Wildlife Service, Ovando

Private lands conservation in Montana has progressed from a mindset of buying isolated parcels of private lands and micro managing each individual tract to one that focuses on high priority landscapes using conservation easements and stewardship practices. This change has also included adjustments for agencies and conservation groups to move a single individual or agency approach to one that is partnership centric focusing on both the natural and human components of conservation. As the science of private lands wildlife biology has evolved, the picture being painted is one of fish and wildlife species population's dependence on large intact landscapes. With over sixty percent of Montana in private ownership it is incumbent upon biologists to look beyond public lands and build relationships with private landowners. The biology requires us not just work with individual private landowners but linking multiple private landowners across a large landscape that often includes a mixture of public lands. As conservationists we would do well to embed ourselves in local rural communities and adopt a "neighboring up" mentality in high priority landscapes that focuses on the triple bottom line (communities, economics and conservation) if we are going to be successful.

American Prairie Reserve's Land Conservation Project

Damien Austin, VP and Reserve Superintendent of American Prairie Reserve, Malta, MT

What is the American Prairie Reserve and how they are building the largest land conservation project in the lower forty-eight states? Leveraging philanthropy and utilizing of private property rights to construct a 21st Century protected area, to preserve an ecosystem and expand public access.

Presentation Abstracts

Alphabetical By Presenter's Name

*** Denotes Presenter**

**** Indicates Student Presentation**

Montana Rangeland Resources Program

Stacey Barta*, Conservation and Resource Development Division, DNRC, Manhattan, MT

1977 legislation created the Rangeland Resources Program (RRP) MCA 76-14-102. The purpose is to establish a program of whereby; the importance of Montana's rangeland with respect to livestock, forage, wildlife habitat, high-quality water production, pollution control, erosion control, recreation, and the natural beauty of the state is recognized; cooperation and coordination of range management activities between persons and organizations charged with or having the management of rangeland, whether private or public, can be promoted and developed; and those who are doing exceptional work in range management can receive appropriate recognition. The program is guided by 6 ranchers from across Montana whom serve at the pleasure of the Governor. The Coordinator has specific roles outlined in 76-14-105, to serve as an advisor, counselor, and coordinator for and between persons and agencies involved in range management; strive to create understanding and compatibility between the many users of rangeland, including sportsmen, recreationists, ranchers, and others; promote and coordinate the adoption and implementation of sound range management plans to minimize conflicts between governmental agencies and private landowners; participate in zoning and planning studies to insure that native ranges are adequately represented at sessions for development of zoning and planning regulations; and coordinate range management research to help prevent duplication and overlap of effort in this area.

Rangeland Resources Program serves as a credible source of information, unbiased, and non-political. RRP fosters understanding and creates collaborative partnerships to sustain healthy rangelands by building relationships with diverse groups and creating positive relationships proactively working together.

Performance and Trend of Remotely Sensed Forage Phenology and Productivity Metrics Across the Western United States

Ethan Berman*, Northern Rocky Mountain Science Center, U.S. Geological Survey, West Glacier, MT

Tabitha Graves, Northern Rocky Mountain Science Center, U.S. Geological Survey, West Glacier, MT

Nate Mikle, Northern Rocky Mountain Science Center, U.S. Geological Survey, West Glacier, MT

Jerod Merkle, Department of Zoology and Physiology, University of Wyoming , Cheyenne

Aaron Johnston, Northern Rocky Mountain Science Center, U.S. Geological Survey, Bozeman, MT

Geneva Chong, Northern Rocky Mountain Science Center, Jackson Hole, WY

Forage drives many important wildlife habitat, movement, and demographic processes, yet few studies assess the best remote sensing datasets for use in wildlife research and management. We compare phenology and productivity metrics from 10 leading remote sensing datasets against a network of PhenoCam near-surface cameras throughout the Western

United States from 2002-2014 to guide users in dataset selection. Overall correlations and mean bias varied substantially by dataset, metric, and land cover. The best performing phenology metrics calculated a date rather than a duration (length of season, duration of spring greenup) with R2 ranging from 0.04â€“0.69. Datasets performed best in shrubland, grassland, and deciduous/broadleaf forest land cover types, and weakest in evergreen forests. Productivity metrics performed worse overall than phenology metrics, though some datasets showed strong results in deciduous/broadleaf forests. Using the two best performing datasets with a long historical record, we analyzed changes to growing seasons from 1982-2016 and compared results of the competing datasets. The direction of trend generally agreed but the strength of the trends differed. This study provides the first comprehensive comparison of remote sensing datasets across many important phenology and productivity metrics. We discuss considerations for users to make informed decisions about their data choices.

Do American Black Bears Track Resource Waves in Yellowstone National Park? **

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Andrea R. Litt, Department of Ecology , Montana State University, Bozeman

Kerry A. Gunther, Yellowstone Bear Management Office, National Park Service, Yellowstone National Park, WY

Jerod A. Merkle, Wyoming Coop Unit, University of Wyoming, Laramie

Frank T. van Manen, Interagency Grizzly Bear Study Team , United States Geological Survey, Bozeman, MT

American black bears (*Ursus americanus*) are opportunistic omnivores that consume diverse foods, allowing them to maintain a macronutrient diet and optimize body mass gains. During the spring in the Northern Range of Yellowstone National Park, black bears may synchronize their daily movements to resource waves, including when green vegetation reaches peak foraging quality (green wave) and a pulse of neonate elk (*Cervus canadensis*, calving wave). To understand how resource waves might influence black bear movements in spring, we instrumented 8 black bears with GPS collars in 2017 and 2018 and estimated fine-scale resource selection based on used and available locations with integrated step-selection functions. Our findings indicate that black bears selected areas with high forage quality, suggesting they followed the green wave during spring. Although the calving wave was an important covariate associated with black bear resource selection, bears avoided elk calving areas, suggesting that they instead consumed elk calves opportunistically. Due to their smaller body size and lower metabolic needs, black bears might be able to capitalize on the green wave, potentially providing an advantage if grizzly bears (*Ursus arctos*) are better competitors for neonate elk. Given that the distribution of foods may change due to variation in climatic patterns, understanding how black bears use resource waves may be vital, especially if nutrient-rich foods become limited, which could impact the growth and expansion of bear populations in the region.

Fisher Occupancy Twenty-Five Years after Translocation in the Rocky Mountains of Montana

Jessy Coltrane*, Montana Fish, Wildlife and Parks, Kalispell
Robert Inman, Montana Fish, Wildlife and Parks, Helena

The historical distribution of fisher (*Pekania pennanti*) throughout Montana and the northern Rocky Mountains of the United States is uncertain, and most fishers in Montana appear to be descendants from translocated animals originating from the midwestern United States and British Columbia; however, a genotype that is unique and native to the Northern Rockies of Idaho and Montana exists in west-central Montana. Predictions based on Idaho models depict potential suitable habitat for fishers throughout the Cabinet Mountains of northwest Montana, yet distribution, occupancy and population status is currently unknown for these fishers. We conducted the first comprehensive monitoring of fishers in the Cabinet Mountains of Montana using baited camera/DNA stations. We detected fishers at 7 out of 21 cells, which resulted in a 0.43 probability that fishers occupied a grid cell. Detection probability was low, but increased slightly throughout the sampling periods. Genetic analysis revealed a minimum population count of 4-6 individual fishers in the study area, but all individuals successfully identified were males and of midwestern genetic origin. The low number of fisher detections may indeed reflect low abundance of fisher, yet these results also raise questions about our study design and sampling regime. We recommend future monitoring to increase precision of the occupancy estimate and determine the reason for a lack of female detections. We also recommend maintaining a closed trapping season on fisher, until data exists to indicate a population large enough to sustain harvest.

A Home on the Prairie? Restoration Potential of Bighorn Sheep in Montana's Prairie Region

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Kelly Proffitt, Wildlife Division, Montana Fish, Wildlife & Parks, Bozeman
Robert Garrott, Ecology Department, Montana State University, Bozeman

Efforts to recover Montana's bighorn sheep (*Ovis canadensis*) have focused primarily in the mountainous western region; however, rugged areas in the eastern prairie region were historically occupied by bighorn sheep. Currently, only 4 populations exist in this region and are some of the state's most abundant and stable populations. We predicted that potential habitat and restoration opportunity likely exists in the prairie. We used GPS collar data collected during 2014-2018 from 2 bighorn sheep populations located along the Missouri River in Montana to estimate a resource selection model. We first extrapolated model predictions across Montana's prairie region to understand the spatial distribution of predicted habitat and restoration potential of bighorn sheep. Second, within an estimate of bighorn sheep historic range, we estimated the abundance of bighorn sheep that the predicted habitat could potentially support. Resource selection was most strongly associated with terrain slope and ruggedness, canopy cover, and an NDVI metric. Within currently unoccupied areas of the historic range, the model predicted 7,211 km^2 of habitat, with about half (55%) managed by public land agencies. We estimated that these unoccupied areas of habitat could support 1,327-3,457 bighorn sheep, an increase in the abundance of Montana's prairie bighorn sheep of 1.9-3.2 times. Our results demonstrate substantial potential for restoration opportunities of bighorn sheep in eastern Montana. Broad restoration of bighorn sheep across the prairie

region would likely require strong collaboration among and between public resource managers and private landowners given the heterogeneous landownership patterns.

Interspecific Competition and Seasonality Correlate with Determinants of Hantavirus Transmission in Deermice **

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Infectious wildlife diseases are becoming more common, causing population declines and species extinctions. Ecological and environmental factors can influence disease spread in wildlife, through effects on parasite transmissibility (regulated by host immunity), and contact rates. These factors can induce chronic stress, which can depress host immunity, and thus influence disease spread. Glucocorticoids are hormones, which are called fecal corticosterone metabolites (FCMs) when excreted in feces, and are typically used to measure chronic stress. Sin Nombre virus (SNV) is carried by deermice (*Peromyscus maniculatus*), and in western Montana grasslands, deermice compete with voles (*Microtus* spp.) and shrews (*Sorex* spp.). Because voles are dominant over deermice, they could increase SNV prevalence in deermice via stress-induced immunosuppression and/or alteration in contact rates, while shrews may have a lesser effect. Seasonal changes in these same measures may explain higher SNV transmission typically observed in spring/summer. We live-trapped small mammals over 2 years in western Montana grasslands and evaluated deermice for scar numbers (proxy for contact rates), demography, and body condition scores (BCSs; another measure of chronic stress). Deermouse blood was evaluated for white blood cell (WBC) counts/differentials, and SNV antibodies, and feces for FCMs to measure stress (baseline and stress-induced). Using mixed effect regression trees, we found that higher vole density was correlated with lower BCSs and scar numbers. Higher shrew density was correlated with lower stress-induced FCMs, lower BCSs, and higher scar numbers. Neutrophil/lymphocyte (N/L) ratios (another measure of chronic stress) were highest in spring/summer and WBC counts (a measure of immunity) were lowest during the summer. Due to low SNV prevalence, we could not evaluate effects on infection. Interspecific competition may influence SNV spread via effects on chronic stress (i.e. lower stress-induced FCMs and BCSs), and scar numbers. Higher N/L ratios in spring/summer, suggestive of chronic stress, and lower WBC counts in summer, suggestive of immunosuppression, may provide an ideal time for SNV transmission. Our findings may extend to other directly-transmitted wildlife diseases.

Influence of Livestock on Grizzly Bear Habitat Selection **

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When encounters between carnivores, livestock and humans result in conflict or livestock depredation, the safety of both wildlife and humans are at risk. Reducing livestock depredation by grizzly bears (*Ursus arctos*) is crucial to the continued recovery of the species. We used 5 years of grizzly bear location data in the Mission Valley, Montana, to analyze habitat selection. Bear use indicated preference to areas in closer proximity to streams and wetlands than to livestock sites. Bears also showed a positive association with the density of homes. Our results showed that livestock were not being selected as a resource by grizzly bears, but also highlighted the importance of protecting livestock near riparian habitats to prevent depredation. These mapping methods can be used to identify how and where electric fencing, bear resistant garbage bins and other conflict mitigation efforts should be focused.

Evaluating Bighorn Sheep Restoration Using Genomics **

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Wildlife restoration often involves translocation efforts to reintroduce species and enhance genetic diversity of small, fragmented populations. We examined the genomic consequences of bighorn sheep (*Ovis canadensis*) translocations and population isolation, to enhance understanding of evolutionary processes that affect population genetics and inform future restoration strategies. We conducted a population genomic analysis of 511 bighorn sheep from 17 areas, including native and reintroduced populations with contrasting translocation histories. Using the High Density Ovine array, we generated datasets of 6,155 to 33,289 single nucleotide polymorphisms and completed clustering, phylogenetic, and kinship analyses. Our study design maximized insight by employing standardized sampling of bighorn sheep herds, a standardized set of genomic markers, and a suite of contemporary analytical tools. Our analyses determined that most examined populations were isolated from recent, unassisted gene flow, including two pairs of native herds that had past connectivity but were recently fragmented. To identify which augmentation and reintroduction efforts made a genetic contribution, we synthesized genomic evidence across analyses to evaluate 24 different translocation events. We detected five successful augmentations and eight successful reintroductions based on genetic similarity with the source populations. A single native population founded most of the reintroduced herds, suggesting that genetic diversity of founders may have been more important to successful reintroduction than matching environmental conditions. Our results provide insight on genomic distinctiveness of native and reintroduced herds, the relative success of reintroduction/augmentation efforts and their associated attributes, and guidance for genetic rescue augmentations and reintroductions to aid in bighorn sheep restoration.

Microhabitat Selection by Reproductive State in Greater Sage-Grouse **

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Greater sage-grouse (*Centrocercus urophasianus)*; hereafter "sage-grouse", are the focus of much research and conservation efforts owing to their obligate relationship with sagebrush (*Artemisia* spp.) and dramatic population declines over the last 50 years. Research suggests female survival and chick survival are two of the most important demographic parameters for sage-grouse. In addition, recent research has shown habitat partitioning occurs between broodless (i.e., females without a brood) and brood-rearing females and that broodless females have lower mortality risk than females with chicks. Thus, habitat used by both reproductive states must be considered in management plans. Our study was initiated in spring 2018 in Carbon County, Montana to identify seasonal habitat use and compare landscape and microhabitat characteristics between brood-rearing and broodless females. Identifying

differences in habitat use between reproductive states can inform better management to account for all life stages of sage-grouse. We monitored 39 and 43 females captured at 7 leks in 2018 and 2019, respectively, with the use of GPS transmitters. We monitored 17 broods in 2018 and 21 broods in 2019 until 5 weeks post-hatch. We examined 5-minute locations for females to focus vegetation surveys during different behaviors-day and night roosts and active day locations. We measured vegetation characteristics (e.g., shrub, grass, forb, and ground cover) at 66 early brood-rearing (0-2 weeks post-hatch), 72 late brood-rearing (3-5 weeks post-hatch), 75 broodless locations, and 123 random locations. Understanding female sage-grouse habitat use during both reproductive states will better inform wildlife practitioners to manage habitat for all sage-grouse life stages.

Western Bumble Bee Declines in Us and Sample Design for Filling Range-Wide Information Gaps

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In recent decades many bumble bee species have declined due to changes in habitat, climate, and pressures from pathogens, pesticides, and introduced species. The western bumble bee (*Bombus occidentalis*), once common throughout western North America is a species of concern and will be considered for listing by the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act (ESA). We attempt here to improve the alignment of data collection and research with USFWS needs to consider redundancy, resiliency, and representation in the upcoming species status assessment. We reviewed existing data and literature on B. occidentalis, highlighting priority topics for research. We used existing data to model changes in B. occidentalis occupancy from 1998 to 2018. The probability of local occupancy in the continental United States declined by 93% over 21 years from 0.81(95%CRI = 0.43, 0.98) in 1998 to 0.06 (95%CRI = 0.02, 0.16) in 2018. The decline in occupancy varied spatially by landcover and other environmental factors. However, we found considerable spatial gaps in recent sampling, with limited sampling in many regions, including most of Alaska, northwestern Canada, and the southwestern U.S. We therefore propose a sampling design to address these gaps to best inform the ESA species status assessment through improved assessment of the spatial drivers of occupancy changes. Finally, we request involvement via data sharing, participation in occupancy sampling with repeated visits to distributed survey sites, and complementary research to address priorities outlined in this paper.

Bison Conservation and Management in Montana, What FWP's Decision on the Final Statewide EIS Means and What it Does Not

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In 2012, Montana Fish, Wildlife and Parks (FWP) began a process to evaluate opportunities for restoring bison (*Bison bison*) through development of a Programmatic Environmental Impact Statement (EIS). The purpose of this EIS was to determine if bison restoration is appropriate and if so, what opportunities are feasible and consistent within Montana's laws, policies, and regulations. A formal public scoping process identified concerns, opportunities, and stakeholders around the issue of bison as wildlife. Passionate support for and against bison was expressed during public hearings and the working group meetings were sideboards for any restoration of effort were developed. FWP finalized a draft EIS in 2015 and in January 2020 released a decision that supports the idea of bison restoration somewhere on the landscape. The decision does not choose any one of the action alternatives over another, rather it says bison restoration may be appropriate within well thought out project specific guidelines and with lots of stakeholder involvement. The decision does not select any particular site for a restoration effort, rather it provides FWP with great flexibility and leaves the framework for future discussions of specific project ideas at specific sites. Completion of the necessary steps to implement any restoration project as required by FWP process will take considerable time for even the smallest of test projects. The decision on the EIS has been misinterpreted, misrepresented, and misunderstood much like bison and their status in Montana overall. This talk hopes to clear up at least some of the confusion.

Effects of Wildfire and Logging on Forage Availability and Mule Deer Habitat Selection **

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In many western forests, anthropogenic disturbance has increasingly replaced wildfire as the predominant source of landscape alteration. Recent declines in mule deer (*Odocoileus hemionus*) population estimates and hunter harvests have been linked to changes in the availability and distribution of nutritional resources in northwest Montana. However, the relationship between the spatial configuration of disturbances and resource selection is not fully understood, particularly for lesser-studied mule deer populations in Montana's northern forests. We conducted a 3-year study to quantify selection of mule deer for forest disturbances from wildfire and logging in the southern Rocky Mountain Front, Cabinet-Salish Mountains, and Whitefish Mountains. We predicted that forage availability would vary with disturbance age and configuration at individual and population scales. We evaluated movements of 131 GPS radio-collared adult female mule deer and documented forage composition and quantity in disturbed and undisturbed forests in all three study areas. Abundance and configuration of wildfire and harvest varied between study areas, and deer resource selection was influenced by the age and type of disturbance and associated forage response. Determining the factors driving mule deer use of disturbances can help managers identify potential strategies for land management and to identify treatment sizes and configurations that are accessible and beneficial for mule deer.

Modeling the Effects Of Habitat, Livestock Grazing and Climate on Greater Sage-Grouse Population Dynamics in Central Montana **

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Lorelle Berkeley, Wildlife Biology, Montana Fish, Wildlife and Parks, Helena

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Access to quality habitat is a key driver of population dynamics for many wildlife species. To direct habitat conservation efforts and to determine if these efforts are successful, habitat models should be linked with population models at local scales. This project addresses this need by providing information about relationships among greater sage-grouse (*Centrocercus urophasianus*) habitat, livestock grazing, and demographic rates in central Montana. This work is based on a collaborative, decade-long effort among multiple resource agencies and private landowners in central Montana. It is led by Montana Fish, Wildlife & Parks and the University of Montana, and data collection is nearly complete. First, we will establish the habitat components that sage-grouse select at each life stage in a local population. We will include both livestock grazing and climate variables that affect greater sage-grouse habitat. Second, we will use a population model to relate habitat components to demographic rates that are known to influence greater sage-grouse population dynamics. We will examine these relationships during multiple life stages and across spatial scales. We will also examine the relationship between demographic rates and lek-based abundance estimates to evaluate lek counts as an indicator of population health. Our effort will identify components of the sagebrush steppe ecosystem in central Montana that are important to the persistence of sage-grouse in this region, and how livestock grazing affects these components. Our findings will be used to evaluate and update sage-grouse habitat conservation strategies and management plans in central Montana.

Characterizing Summer Roosts of Male Little Brown Myotis in Lodgepole Pine-Dominated Forests **

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Although bat roosts have been well-studied in the eastern United States, we know less about roosts in the west. Western bats may make use of trees and snags, as in the east. However, the topography of the Rocky Mountains provides more exposed rock, and western bat species likely use different roosting features compared to the eastern US. Some western bats use rock features as autumn and winter roosts, but we know little about use as summer roosts. Additionally, roost studies often focus on maternity colonies, and information on roosts used by male bats is limited. Given that roosting sites may be limiting, we aimed to quantify characteristics of male roosts in lodgepole pine-dominated forests during the summer. We mist-netted for bats during summer 2017 and 2018 and attached transmitters to 34 male little brown myotis (*Myotis lucifugus*). We located at least 1 roost for 20 individuals (average = 1.6 roosts/bat; range = 1 â€“ 5). Although snags were available, most bats roosted in rock features (15% in snags, 85% in rocks). Rock-roosting bats mainly used crevices (85%) instead of rock

cavities (15%) and were more likely to select roosts with less canopy cover that were closer to water. They were also more likely to select roosts with wider entrances that provide access to a skyward-facing crevice. These results suggest that rock features may provide important summer habitat for male little brown myotis roosting in lodgepole-dominated forests. Understanding roost selection in these forests will help inform management decisions for conserving western bats.

Drivers of Elk Aggregation on the National Elk Refuge, WY

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In North America, diseases in ungulates have elicited increased attention due to direct impact on populations and indirect effects on outdoor recreational industries. Chronic wasting disease (CWD) has been found in 21 US states and 2 Canadian provinces over the last 40 years and is rapidly spreading in Montana. Degree of sociality and aggregation can drive disease spread and transmission. In Wyoming, supplemental feeding of elk (*Cervus canadensis nelsoni*) during winter occurs on 22 feedgrounds, including the National Elk Refuge (NER), and concern that feeding increases elk aggregation and thus disease spread has been rising. However, the comparison of feeding to other factors, including abiotic drivers of aggregation, such as snow levels has been underexplored. The winter of 2017-2018 had relatively high forage and little snow, which led to a rare non-feeding year on the NER, providing a unique opportunity to evaluate the role of feeding in aggregation relative to other conditions. We examined data from 2016 to 2019 for 68 elk fitted with GPS collars resulting in 223,526 elk relocations. We used a proximity index to assess daily joint space use of elk and modeled proximity using beta regression as a function of 13 variables including abiotic weather-related effects, biotic effects such as supplemental feeding and hunting pressure, and aggregation from the prior day. This approach may be useful for assessing management implemented with the intent of reducing aggregation. Mean daily elk aggregation was 1.7 times larger during winters with feeding but was also strongly regulated by snow cover and hunting pressure.

Grizzly Bear Population Augmentation in the Cabinet Mountains of Northwest Montana

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Hilary Cooley, Grizzly Bear Recovery, Missoula, MT

The Cabinet Mountains grizzly bear(*Ursus arctos*) population was estimated at 15 or fewer individuals in 1988 and believed to be declining toward extinction. In response to this decline, a test of population augmentation techniques was conducted during 1990-1994 when four subadult female grizzly bears were transplanted to the area from southeast British Columbia. Two criteria were identified as measures of success: bears must remain in the target area for one year, and bears should ultimately breed with native male grizzly bears and reproduce. Reproductive success of any of the remaining individuals could not be established until 2005 when genetic analysis of hair snag samples collected from 2002-2005 indicated that one of the transplanted bears remained in the Cabinet Mountains and had reproduced. Success of the grizzly bear augmentation test prompted continuation of this effort. The Northern Continental Divide Ecosystem area of north central Montana has been the source of an additional 10 female and 8 male bears transplanted to the Cabinet Mountains during 2005-19. Genetic analysis has determined that two females and one male have produced at least 14 first generation offspring, 19 second generation offspring and 3 third generation offspring. Seven bears are known to have left the target area but two have returned. Six augmentation bears are known dead. Fates and movements of these bears are discussed. The augmentation effort appears to be the principal reason that grizzly bears remain in the Cabinet Mountains today.

Finding Fishers: Factors Affecting Fisher Distribution in the Northern Rocky Mountains

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The Northern Rocky Mountain (NRM) fisher (*Pekania pennanti*) population is of special concern to conservation and management professionals and has been petitioned for listing as threatened under the Endangered Species Act. In partnership with Montana Fish, Wildlife & Parks and the Idaho Department of Fish and Game, we assessed the current distribution of fishers across their Northern Rocky Mountain range through a large-scale, multi-state baited camera and hair snare study. In the winter of 2018/19 we deployed baited remote cameras and hair snare stations in randomly selected grid cells containing plausible fisher habitat throughout Washington, Idaho and Montana, spanning the purported geographic range of the NRM fisher population. We used single-species, single-season occupancy modelling while considering several covariates that might contribute to their distribution such as existing fisher habitat models, site-level habitat characteristics, distance from population centers, the influence of past translocation sites and the effect of harvest, to estimate occupancy and detection probabilities of fishers across their NRM range. By incorporating our understanding of fisher habitat with contemporary analytical techniques, we estimated the current distribution of fishers in the northern Rockies and addressed the primary uncertainties about drivers of fisher distribution. The results of our project will help Idaho and Montana effectively prioritize areas for future fisher conservation in the hopes of maintaining the distribution of fishers across suitable habitat in the Northern Rocky Mountains.

Grassland Ghosts Keeping an Eye on the Recovering Swift Fox 2018 International Census

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Swift Fox (*Vulpes velox*) were extirpated from Canada in 1938 and in Montana in 1969, largely due to federal eradication campaigns in the 1930s targeting coyote and wolves. Reintroduction efforts in Canada occurred from 1983 until 1997. By 2001, swift fox were thought to be established in Northern Montana. In Montana, survey efforts began in 2000/2001, then repeated in 2005/2006, 2014/2015, and most recently the summer of 2018. Surveys in the winter of 2014/2015 consisted of two methods, live trapping and camera trapping. The goal was to determine changes in demography and distribution, but also to assess the feasibility of switching exclusively to camera traps for future survey efforts. There was little difference in detection probability between the two methods suggesting camera trapping is an effective alternative to live trapping. This resulted in only camera trapping being used for the 2018 census. Analysis comparing occupancy between 14/15 and 2018 showed that swift fox populations in the sampling area remained stable and relatively unchanged despite the harsh winter of 2017/2018. Through a finer scope, the Montana populations seem to have experienced a slight increase. The swift fox population in Canada and northern Montana is interdependent and continued collaboration for monitoring across jurisdiction and boundaries is important. Management of swift fox in Montana will continue to follow the Swift Fox Conservation Strategy.

Estimating Abundance of Dusky Grouse for Population Monitoring **

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Dusky grouse (*Dendragapus obscurus*), are a forest grouse species found throughout mountainous regions of western Montana. Despite being a game species, population monitoring has been inconsistent in recent years. Our objective is to develop, test, and evaluate sampling and statistical methods for unbiased population monitoring to inform management. We developed a spatially explicit model of dusky grouse relative habitat suitability in Montana to identify suitable survey sites for population monitoring. Prior to sampling in the field, we conducted statistical simulations to evaluate efficacy of potential survey protocols. Results from the simulations suggested that a minimum of 100 independent sites surveyed three times within a period of closure had the potential to yield unbiased and reasonably precise estimates for regional population abundance. During a pilot study in 2019, we conducted surveys during two sampling periods, spring and summer, within Montana, Fish, Wildlife, and Parks administrative region 3. Field methods included point counts with and without the use of electronic playback and walking transect surveys. We used N-mixture models and distance sampling to estimate abundance, density, and detection for each of the survey methods in each sampling period. We observed significantly more grouse during spring surveys than summer surveys, which yielded more precise estimates of abundance and

density. The use of electronic playback calls increased detection probability during spring surveys but had no effect on summer detectability. Future work includes evaluating current and other potential survey protocols using simulations and estimates produced from the pilot study.

The Montana Big Game Migration and Seasonal Range Mapping and Research Initiative

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Kelly Proffitt, Montana Fish, Wildlife and Parks, Bozeman
Nick DeCesare, Montana Fish, Wildlife and Parks, Missoula
Justin Gude, Montana Fish, Wildlife and Parks, Helena

For the last 15 years, Montana Fish Wildlife and Parks and collaborators have been deploying GPS collars across the state to help address local and regional management and research objectives. The continuous capture and instrumentation efforts have resulted in large and ever-growing spatial data sets for elk, mule deer and pronghorn. For elk (*Cervus canadensis nelsoni*) in particular, the aggregated datasets now include over 850 individuals sampled from over 20 populations and nearly 10 million GPS locations. Montana Fish, Wildlife and Parks recently prioritized a broad effort to delineate migration routes and seasonal ranges of elk, mule deer and pronghorn using rigorous methodologies that account for varied terrain, habitat, and big game migration behaviors across the state. This effort has been bolstered by Sectorial Order 3362, which mandated that Department of Interior bureaus work with state wildlife agencies to enhance and improve habitat quality of big game winter range and migration corridors. The broad mapping effort and associated new research will help fulfill local information needs as well as contribute towards regional coordinated mapping efforts across the western US. Spatial files and maps from the mapping effort will be made available to Fish, Wildlife and Parks staff and the public. Our talk will provide an overview of the aggregated data sets to be used in the mapping effort, initial data summaries of migratory behaviors and land ownership use, and the planned methods to delineate migratory corridors and seasonal ranges.

Behavior-Specific Habitat Models as a Tool to Inform Ungulate Restoration

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GPS data is broadly used in wildlife research and management to construct habitat models and can help to inform translocation efforts. However, for species with both resident and migratory behaviors, a single population habitat model may not predict the varying selection patterns of residents and migrants as well as separate resident and migrant habitat models. Moreover, through developing behavior-specific habitat models managers can strategically target source populations with the behaviors that best match the landscape attributes of the areas being restored. Such targeted translocations may increase translocation success and help to build diverse migratory portfolios in restored populations. We used resource selection functions to develop an annual resident model as well as summer and winter migrant models using GPS locations from female bighorn sheep (*Ovis canadensis*) in eight (resident = 2, migrant = 6) populations that were broadly distributed across western Montana. We extrapolated each model with the purpose of generating broad spatial predictions of bighorn sheep habitat and informing future translocations. Terrain and landscape covariates most strongly influenced resource selection for both behaviors in all seasons. The habitat predictions from the annual resident and winter migrant model strongly overlapped on rugged and steep slopes at low to mid elevations across western Montana. The habitat predictions from the summer migrant model were largely nonoverlapping with residents and broadly distributed across high elevations. Our behavior-specific habitat extrapolations across western Montana serve as a tool to inform future translocations into new areas or expand the distribution and migratory portfolio of existing populations.

Using Ecological Site Condition to Evaluate Habitat Selection by Sharp-Tailed Grouse Broods **

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Brood survival, an important vital rate affecting population viability of sharp-tailed grouse (*Tympanuchus phasianellus*), is largely determined by the selection of brood-rearing habitats by females. The abundance and quality of brood-rearing habitat is often influenced by land management decisions. Thus, improper rangeland management may lead to habitat degradation and impair sharp-tailed grouse populations. Many rangeland management decisions affecting brood habitats (e.g., livestock grazing, prescribed burning) are based on the type and condition of ecological sites in rangelands. However, associations between brood habitat use and ecological site condition have not been evaluated. We examined habitat selection of brood-rearing females in eastern Montana using radio-marked hens. We stratified our field sampling based on pre-existing ecological site maps prepared by the USDA-NRCS. We assessed the condition of each ecological site polygon by comparing the current plant community composition to the historic climax plant community composition (i.e., similarity index) across our study area. We then evaluated selection ratios of radio-marked brood hens in relation to ecological sites and their similarity index. We found that when selecting a home range, the interaction between ecological site type and similarity index was important. When selecting habitat within their home ranges, females selected for sites with a lower similarity index. We found little evidence that ecological site type was a driver of habitat selection once females had selected a home range. Our results provide useful information on brood habitat selection relative to habitat assessment frameworks used by rangeland managers and have implications for the management of sharp-tailed grouse brood habitats.

The Continental-Scale Implications of Point Source Lead Exposure in Golden Eagles

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Lead poisoning threatens many species of raptors, including golden eagles (*Aquila chrysaetos*). Much of this lead likely comes from bullet fragments that remain in carrion after hunting. The likelihood of lead exposure in golden eagles may peak when migratory and nonmigratory birds congregate in the fall and winter. From 2011 to 2018 in western Montana, we captured 91 golden eagles in the winter, tested their blood lead levels (BLL), and outfitted a subset of birds (n = 30) with GPS transmitters to determine their migratory status. Nearly all golden eagles (94.5%) had elevated BLL (â‰¥ 10 Î¼g dL-1), and eight of them had BLL at or above concentrations expected to cause clinical lead poisoning. Blood lead levels decreased as the winter progressed because hatch-year and juvenile birds tended to have lower BLL later in the season. At least two-thirds of the golden eagles equipped with GPS transmitters migrated northward, spending the summer throughout Alaska and northwestern Canada. Blood lead levels did not differ between migratory and nonmigratory golden eagles. Overall, we show that elevated BLL are widespread among golden eagles overwintering in western Montana, regardless of sex, age, and whether they migrate.

Integrated Monitoring in Bird Conservation Regions (IMBCR) - Avian Monitoring for Management & Conservation

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The 2019 field season marks the 10th consecutive year of statewide implementation of the Integrated Monitoring in Bird Conservation Regions program (IMBCR) in the state of Montana. Today, the IMBCR program represents the second largest breeding landbird monitoring program in the US. IMBCR is made possible via a broad partnership of government and non-government agencies from the Great Plains to the Intermountain West. The randomized, hierarchical sampling design allows for sampling on private and public lands and within all vegetation types. The sampling framework allows for inference about avian populations at multiple scales, from a National Forest or Bureau of Land Management field office, up to the regional level. Using a spatially-balanced, hierarchical study design, the IMBCR program provides density and occupancy estimates for bird species at various spatial extents across the western U.S. Managers can use these baseline estimates and habitat-specific information for project-level planning and environmental assessments. The IMBCR program also provides context for targeted monitoring in project areas to evaluate impacts of land-use change or conservation actions. We highlight several case studies where short-term monitoring efforts leverage the long-term IMBCR data to evaluate avian response to land management practices.

Seasonality of Bobcat Resource Selection

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Home range size of bobcats (*Lynx rufus*) varies by sex, season, and latitude, with bobcats reducing home range size in winter. Additionally, bobcats may shift habitats seasonally, but may also reduce movements to conserve energy in winter. We found that bobcats on the Flathead National Forest, Montana seasonal home ranges did not change size significantly for all bobcats pooled; thus, bobcats did not reduce winter home range size as compared to other seasons. For all bobcats combined, winter home ranges (N = 3) were 65.3 ± 37.5 km^2, spring home ranges (N = 5) were 74.2 ± 16.7 km^2, summer home range (N = 4) were 81.4 ± 13.9

km2, and fall home ranges (N = 4) were 72.0 ± 10.9 km^2. Bobcats significantly reduced daily movement distances dependent on season, specifically reducing movement distances in winter and increasing movements summer. Habitat selection differed significantly for both 2nd order (home range to study area) and for 3rd order habitat selection (GPS locations to home range), but did not differ across seasons, or for the interaction of 2nd and 3rd order selection*season. Specifically, habitat selection differed with burned and wetland habitats being avoided, and lodgepole and dry site mixed species coniferous stands being preferred. Bobcats on the Flathead exhibited seasonal movements comparable to Canada lynx. If bobcats were typical of the broader population, bobcats in northwest Montana may demonstrate a mixture of behaviors characteristic of both bobcats and lynx that allow them to be successful in deep winter snows of this region.

Grizzly Bear and Human Use at Moth Aggregation Sites, Wyoming **

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The objective of our study was to quantify human-bear interactions associated with moth aggregation sites in the greater Yellowstone ecosystem. Our field work was conducted during the summers of 2017 and 2018, and focused on two of the most human-accessible sites within the Shoshone National Forest, Wyoming. Occupancy surveys of grizzly bears (*Ursus arctos horribilis*) were conducted and evaluated using a resource selection function to quantify bear use patterns. Human use was quantified through trailhead monitoring, peak log entries, and opportunistic documentation. Interactions were documented through written or verbal surveys at peaks and trailheads. GPS tracking units were distributed at trailheads to quantify human use patterns. Bear and human use patterns were analyzed in ArcMap to identify areas of overlap. We documented 84 and 182 bears and 37 and 39 human use groups in 2017 and 2018, respectively. Bear use was most strongly associated with landcover and temperature, and to a lesser degree terrain ruggedness and curvature, slope, and moisture. Human use was largely concentrated on published routes from internet resources that overlapped predicted high-use bear areas. We documented 18 bear-human interactions, 12 of which were within predicted high-use bear areas. All interactions resulted in bear displacement with no aggressive behavior toward humans. Human use and bear-human interactions appear to be relatively low but will continue to increase with human use, particularly in high-use bear areas. In the future, managers may consider measures to educate visitors or manage human access to promote human safety and minimize disturbance of grizzly bears.

Bird Community Responses to Habitat Manipulations **

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Habitat treatments such as prescribed burning and mechanical thinning are commonly conducted across the United States for many reasons including reducing fuel loads, increasing habitat quality for wildlife, and modifying forest structural diversity. The Rocky Mountain Elk Foundation has implemented numerous habitat treatments in the Western US to increase

habitat quality for elk (*Cervus canadensis nelsoni*) and other species. Understanding how habitat treatments impact bird communities is important in conserving their habitat and preserving ecosystem services and recreational opportunities that they provide. The objectives of this study are to 1) determine how prescribed burning and mechanical thinning impact occupancy and species richness of birds and 2) determine how these impacts change over time since treatment and in different landscape contexts. To determine these impacts, we sampled the bird community at paired treated-control sites across eastern Oregon, northern Idaho, and western Montana. We sampled sites 1-30 years post treatment. We visited sites three times between May and August, 2018-2019. We conducted point counts and sampled forest and vegetation characteristics along randomly located points within all site pairs. We measured treatment effects on bird communities using changes in occupancy of our focal species (Western Bluebird (*Sialia mexicana*), Dark-eyed Junco (*Junco hyemalis*), Mountain Chickadee (*Poecile gambeli*), and Woodpeckers), and species richness. Our results indicate that there is no significant treatment effect on species richness or occupancy of our focal species.

Microbiome Analysis Enables Future Non-Invasive
Microbiome Analysis Enables Future Non-Invasive Wildlife Monitoring of Rocky Mountain Elk Populations **

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Rocky Mountain Elk (*Cervus canadensis nelsoni*) seasonal migration, body-condition and sex ratios are important parameters for characterizing populations at high risk of disease or population decline but, so far, have been outside the scope of currently available non-invasive methods. Fecal microbiomes can be surveyed non-invasively and model systems indicate that microbiome compositional differences are associated with changes in diet, stress, disease and physical condition of the host. With this in mind, we set out to examine the host-microbiome connection in scat samples from 4 populations of elk in western Montana. The elk sampled, varied geographically (i.e. by population/herd), by body condition and by sex. We built a supervised-machine learning classifier on bacterial taxa with cross validation (CV) to predict each fecal microbiome's affiliation to known host categories. The microbiome classifier predicted host population, sex, and body-condition measurements with promising CV results for each classifier. The fecal microbiome classifier developed here may be useful for detecting the sex and relative body condition of elk from other populations or tracking variations within the sampled populations across years. Monitoring wildlife fecal microbiomes would represent a breakthrough for non-invasive conservation biology, and we provide proof of concept for obtaining low cost, fine scale, management-relevant information from scat samples that can be expanded to non-invasive applications and other animal species in the future. Future efforts may also explore training new classifiers to detect wildlife diseases such as Brucella, Anthrax, Tuberculosis or Chronic Wasting Disease that may also be associated with microbiome composition.

Polygyny, Parturition and Calf Survival in a Translocated Eastern Elk Population **

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Colter Chitwood, Wildlife Biology, University of Montana, Missoula

Barbara Keller, Fish and Wildlife, Minnesota Department of Natural Resources, St Paul

Aaron Hildreth, Research Science, Missouri Department of Conservation, Columbia

Leah Berkman, Research Science, Missouri Department of Conservation, Columbia

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Translocated populations may undergo exceptional changes in physiology, behavior, genetics, and demography following release into their new environment. Understanding implications of translocation on population processes remains increasingly relevant as number and type of conservation translocation activities increase worldwide. We reintroduced a population of elk (*Cervus canadensis nelsoni*) to the Missouri Ozarks over the years 2011-2013 by translocating 106 individuals from Kentucky. Following translocation efforts we investigated changes in sire structure and consequences on male reproductive success and calf survival. All translocated individuals were fitted with GPS-radiocollars and tissue-sampled for DNA analysis. Subsequently, we captured and processed Missouri-born calves, took calf tissue samples for paternity analysis, and monitored calf survival. Results indicated increasing levels of polygeny in the face of advancing sire age structure across years following translocation. We found a positive effect of sire age on male reproductive success, but observed a significant year interaction signifying a decreasing effect of age across years following translocation as the population both aged and expanded. While we found increased calf mortality associated with later birth dates, we found limited evidence for increased calf mortality hazard associated with younger aged sires. Change in breeding structure is a little considered aspect of wildlife translocation that holds potential population genetic and demographic ramifications. Understanding how wildlife populations respond to translocation events across varied ecological metrics is crucial for increasing project success, improving subsequent management, and, ultimately, ensuring persistence of translocation populations.

Predator Avoidance by Partially Migratory Mule Deer **

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Teagan Hayes, Wildlife Biology, University of Montana , Missoula

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Within partially migratory ungulate populations, selection of forage and security may vary greatly between migrants versus residents, and with spatial scale. Predation risk and forage limitation may be limiting the growth of mule deer (*Odocoileus hemionus*) populations in northwest Montana, which appear to be in decline. We asked how avoidance of mountain lions (*Puma concolor*) and wolves (*Canis lupus*) varies between migrant versus resident deer in 3 partially migratory populations throughout western Montana. We used GPS collar locations of 113 mule deer collared from summers 2017-2019 and developed resource selection functions (RSFs) to assess the effect of predation risk (estimated using mountain lion and wolf RSFs) on home range (2nd order) and within-home range (3rd order) selection by mule deer. Across study areas and migratory strategies, mule deer avoided wolves more

strongly at the 3rd order than at the 2nd order. Migrants were indifferent to wolves at the 2nd order, whereas 2nd order selection by residents was more variable. Mule deer in each study area and strategy avoided lion risk at at least one scale, though lion avoidance strategies were highly variable. We hypothesize that mule deer's indifference to predation risk at a given scales was a result of prioritization of forage at that scale. Our findings highlight the ability of partially migratory ungulates to adjust scale-specific predator avoidance strategies based on local conditions. By incorporating forage quality estimates, we may be able to understand how scale-specific forage/risk tradeoffs vary between migrant and resident mule deer in different ecotypes.

CRP and FWP: the Past, Present and Future of FWP Collaboration with the Conservation Reserve Program

Kenneth Plourde*, Upland Game Bird Enhancement Program, Montana Fish, Wildlife and Parks, Flaxville

The Conservation Reserve Program (CRP) is the largest private farmland conservation program in the US, with over 22 million acres currently enrolled nationwide and about $1.8 billion spent in annual rental payments. Since the program's inception in 1985 the positive impacts of CRP on many wildlife species have been documented in Montana and across the country. Montana Fish, Wildlife and Parks has partnered with CRP since 1990 by providing additional cost-share and lease programs specifically for private landowners enrolled in CRP, with the goal of increasing landowner participation and the resulting wildlife benefits of the program. However, over the last 30 years changing rules and implementation of both CRP and FWP programs have led to varying landowner enrollment and fewer benefits to wildlife over time. Discussion of the challenges and successes of both CRP and FWP programs in Montana may provide insight into improving future FWP programs to help keep CRP providing strong positive impacts on Montana's wildlife and private landowners.

To Beaver or not to Beaver, Strategies for Beaver Management on Private Lands

Torrey Ritter*, Montana Fish, Wildlife and Parks, State of Montana, Missoula

The activity of beavers (*Castor canadensis*) on streams in the western United States can lead to landscape-scale benefits for natural water storage and fish and wildlife habitat. There is increasing interest in using beavers and beaver mimicry as stream and riparian habitat restoration tools, and to mitigate the impacts of drought and rapidly changing annual water regimes on rangelands. Private landowners may benefit from beaver activity through increased water availability and greater production of green vegetation in floodplains during dry portions of the year. However, beavers can also cause rapid and significant damage to human infrastructure and desired streamside vegetation when they settle down in an inappropriate area. The purpose of this presentation is to outline strategies for evaluating situations where landowners want beavers to colonize their property, as well as situations where landowners want to thwart or preclude beaver-related property damage. Strategies for encouraging colonization include GIS and field-based habitat evaluations, habitat modification to encourage settlement, evaluating the local beaver population for dispersal potential, and communicating realistic expectations of colonization potential and expected benefits based on stream conditions. Strategies for discouraging beavers include tree fencing and painting, culvert fencing, pond levelers, dam destruction, translocation, and lethal trapping. Beaver management on private lands will be a key issue in the coming decades as private landowners

are faced with challenges related to long-term environmental changes, and biologists, land managers, and other entities are uniquely situated to help private landowners navigate the complexities of beaver colonization and associated impacts.

Assessment of Sympatric Turtle Populations and Movements in Relation to an Irrigation Barrier on Pryor Creek **

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Habitat loss and fragmentation due to dams is one of the most significant threats to turtles worldwide. Barriers can isolate populations and reduce gene flow, increasing vulnerability to extinction-level events. Pryor Creek (Huntley, Montana) features a sympatric population of spiny softshell turtles (*Apalone spinifera*) and snapping turtles (*Chelydra serpentina*), and a 3-meter tall irrigation barrier. Populations of both species live on either side of the barrier, but connectivity between these populations is unknown. We hypothesized that movements of both species would be restricted by the barrier. We also expected possible differences in population demographic structures of each species above and below the barrier due to habitat differences and population isolation. Mark-recapture and radio-telemetry techniques were used to gather movement data on 150 individual turtles over four years. To date no snapping turtles have been documented bypassing the barrier, but four spiny softshell turtles have passed the barrier. Demographics of both species were found to be significantly different above and below the barrier. No female snapping turtles were caught below the barrier, and no juvenile spiny softshell turtles were caught above the barrier. Mean weight of spiny softshell turtles above and below the dam were significantly different. These differences may indicate differences in survival, reproduction, and possibly food availability. This is the first study looking at the ability of turtles to navigate around an aquatic barrier, which has significant long-term implications for population health and management efforts.

Seeking Snow and Breathing Hard: Behavioral Tactics in Mountain Goats to Combat Warming Temperatures

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Mark Biel, Natural Resources, Glacier National Park, West Glacier, MT

Joel Berger, Fish, Wildlife and Conservation Biology, Colorado State University, Fort Collins, CO

The world glaciers and persistent summer snowpack are being lost due to warming temperatures. For cold-adapted species, habitat features may offer opportunities for cooling during summer heat yet the loss of snow and ice may compromise derived thermoregulatory benefits. Herein we offer insights about habitat selection for snow and the extent to which other behavioral adjustments reduce thermal debt among high elevation mammals. Specifically, we concentrate on mountain goats (*Oreamnos americanus*), a species whose native distribution is tied areas where large patches of persistent summer snow are declining, and which became extinct during geologically warmer epochs. To examine sensitivity to possible thermal stressors and use of summer snow cover, we tracked marked and unmarked mountain goats in Glacier National Park, Montana, USA, to test hypotheses about selection for cold microclimates including shade and snow during periods of relatively high temperature. To understand functional responses of habitat choices, we measured microhabitat temperatures and a component of goat physiology “breaths per minute“ as an index for metabolic expenditure. Individuals 1) selected areas closer to snow on warmer summer days, and 2) on snow had a 15% mean reduction in respiration when accounting for other factors, which suggests remnant snow plays an important role in mediating effects of air temperature.

The use of shade was not as an important variable in models explaining respiration. Despite the loss of 85% of glaciers in in Glacier National Park, summer's remnant snow patches are an important reservoir by which animals reduce heat stress and potential hyperthermia.

Mount Dean Stone: Planning for Growth and Balancing Use at the Edge of the City

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Pelah Hoyt, Lands Director, Five Valleys Land Trust, Missoula, MT

Missoula's Mount Dean Stone community open space project is a 4,200 acre proposed complex located on the wildland-urban interface of the city's fast growing south side. The Mount Dean Stone Committee, comprised of community partners including organizations, agencies, businesses and individuals, have worked together since the inception of the overall proposed complex in 2016 to help understand how to best meet the recreation needs of a growing Missoula area and to leverage these recreational opportunities into broad and engaged community support for conservation of community open space and wildlife habitat. This session aims to share about the role of a community land trust in private lands conservation to meet the conservation values of publicly accessible community open space and protection of wildlife habitat along the wildland-urban interface.

Mechanisms Influencing Pack Size in Gray Wolves

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Estimates of the abundance of gray wolves (*Canis lupus*) are important to the Montana Fish, Wildlife and Parks (MFWP) Wolf Program. MFWP uses a Patch Occupancy Model (POM) to estimate area occupied, from which they estimate abundance based on average territory and pack size. Accordingly, abundance estimates depend on intensive field monitoring to estimate pack sizes. Pack size is driven by births, deaths, and the social decisions of group members, including if and when to disperse. Like many cooperatively breeding canids, gray wolves exhibit flexible and diverse dispersal behaviors. We aimed to better understand mechanisms influencing pack size and dispersal, and to develop a predictive tool for estimating pack size for wolves in Montana, absent data directly related to births and dispersals because these data will be unavailable to wildlife managers. We hypothesized that group sizes of cooperatively-breeding canids would be influenced by conditions related to prey, competition, and mortality risk. We found that wolf pack sizes in Montana were positively related to local densities of prey and packs, and negatively related to terrain ruggedness, local mortalities, and intensity of harvest management. A predictive model for pack sizes reliably estimated the mean annual pack sizes observed from 2005-2018 (adjusted R-squared = 0.58, $P < 0.002$) and illuminated possible underlying mechanisms influencing variation in pack sizes over space and time. Alongside a mechanistic territory model we developed for POM, our pack size model will help keep abundance estimates from POM calibrated into the future, absent intensive monitoring effort.

Gray Wolves Select Territories Economically

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Estimating wolf (*Canis lupus*) abundance is a key component of wolf management in Montana. Montana Fish, Wildlife and Parks uses a Patch Occupancy Model (POM) to estimate area occupied, from which they estimate abundance based on average territory and pack size. Abundance estimates thus depend on assumptions that territory size is fixed and consistent statewide. In reality, territories vary spatiotemporally, which will affect precision and accuracy of abundance estimates. We developed a mechanistic model of territory selection to better understand territorial behavior and improve abundance estimates from POM. We hypothesized that wolves select territories economically based on the benefits of food resources and costs of competition, travel, and predation risk. Using only simple behavioral rules and limited, readily-available data for food resources, terrain ruggedness, and human density, the model predicted wolf distribution in Montana and the territory sizes and locations for specific packs. It accomplished this without using empirical data for wolves. The model provided evidence for the mechanisms driving empirically-observed patterns in space use by wolves. It demonstrated, for example, how economical behavior will cause territory size to decrease and overlap to increase with greater densities of prey and competitors. Results are consistent with the hypothesis that wolves select territories economically based on the benefits and costs of territory ownership. The mechanistic nature of the model makes it reliable for predicting territorial behavior under a full range of conditions wolves might encounter. This information will help keep abundance estimates from POM calibrated, absent intensive monitoring effort.

By Thinking Outside the Box, Mitigation Conserves Working Private Lands Intermingled With Public Lands in Key Sagebrush-Grassland Areas

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Montana's efforts to conserve Greater Sage-grouse (GRSG) and GRSG habitats have been long-standing and significant. Most of Montana's highest priority GRSG habitats are found on working private lands managed for livestock. BLM lands comprise 30% of the total, but addressing all threats across a checkerboard ownership in ecologically meaningful ways and at a landscape scale requires outside-the-box tools. Alongside voluntary private land stewardship, developers must mitigate direct and indirect impacts on state, federal, and private

lands in designated GRSG habitats for which state or federal permits are required. Mitigation motivates developers to avoid, minimize, reclaim, and compensate for impacts by siting and implementing projects in ways that are least impactful and keep mitigation obligations/costs low. Mitigation motivates private landowners to continue stewarding their lands through the overt acknowledgment and explicit rewards reaped by providing ecosystem services that sustain a host of wildlife species. Developers can satisfy obligations through permittee-responsible projects implemented on state, federal, or private land or by contributing to Montana's Stewardship Account. The Account funds grants to implement projects offsetting development, similar to an in-lieu fee approach. The state will have spent almost $6.8 million to conserve 77,233 acres through perpetual easements and term leases targeted at private lands from 2016-2020. These projects are strategically located adjacent to and intermingled with BLM lands. State funds were matched with at least $6.86 million in NRCS and private funds. Developers themselves placed a perpetual easement on private land, permanently plugged and abandoned an oil and gas field on BLM land, and removed and buried overhead electrical distribution lines crossing private and BLM lands. Montana's approach to implementing mitigation across all lands is a novel way to conserve remaining habitats using market forces.

Sage-Grouse: Fine-Scale Specialist or Shrub-Steppe Generalist?

Joseph Smith*, Wildlife Biology, University of Montana, Missoula

Sage-grouse (*Centrocercus spp.*) are driving rapidly-evolving land management policy in the western United States. Management objectives for fine-scale vegetation characteristics have been widely adopted by land management agencies based on resource selection or relationships with fitness proxies reported among numerous habitat studies. However, some managers have questioned the appropriateness of these objectives. Moreover, it remains untested whether habitat-fitness relationships documented at fine scales (i.e., among individual nests within a study area) also apply at scales of management units (e.g., pastures or grazing allotments), which are many orders of magnitude larger. We employ meta-analyses to help resolve the role of fine-scale vegetation structure in nest site selection and nest success across the geographic range of greater sage-grouse (*C. urophasianus*) and evaluate the validity of established habitat management objectives. Importantly, our approach tests habitat relationships at a range-wide extent and a grain size closely matching scales at which agencies make management decisions. We found moderate, but context-dependent, effects of shrub characteristics and weak effects of herbaceous vegetation on nest site selection. None of the tested vegetation characteristics were related to variation in nest success, suggesting nesting habitat-fitness relationships have been inappropriately extrapolated in developing range-wide habitat management objectives. Our findings reveal surprising flexibility in fine-scale habitat use for a species often depicted as having very particular fine-scale habitat requirements, and cast doubt on the practice of adopting precise management objectives for vegetation structure based on findings of individual small-scale field studies.

An Interactive Web Tool for Deciding Between Possible Occupancy Study Designs for Rare and Cryptic Species

Hannah Specht*, Montana Cooperative Wildlife Research Unit AND UM Boone & Crockett Wildlife Conservation Program, University of Montana, Missoula

Occupancy-based monitoring has become a valuable tool for studying rare and cryptic wildlife species. The growth of popularity of occupancy studies has been accompanied by

the development of many adaptations to the original standard occupancy design, aiming to improve efficiency and to address cases where model assumptions cannot be met. For example, removal & conditional designs were developed for efficient distribution of effort between initial site visits versus repeat surveys based on how common a species is. The robust design is another adaptation that accounts for cases where the focal species may leave the study site between survey occasions. Given many options, it is not always clear which survey design will be most effective for the multiple constraints of a specific case. Yet, choosing an effective study design is critical, particularly when seeking to obtain information for rare and cryptic species, for which standard approaches are often less effective. We used case studies of Montana non-game "Species of Greatest Inventory Need" to guide development of an interactive, web-based tool that provides recommendations on occupancy study design based on study objectives and focal species characteristics. These recommendations are based on a synthesis of existing research into occupancy study design and accompanying power analyses. Simple power analyses provide users a visual sense of the effort required to obtain information related to covariates or detect trends when using an occupancy study approach under different circumstances. We will demonstrate the app using Montana Species of Greatest Inventory Need as an example.

Straight from the Horse's Mouth

Kate Stone*, Ecology, MPG Ranch, Florence, MT

Eric Rasmussen, Ecology, MPG Ranch, Florence, MT

What prompts a private landowner to decide that "opening the gate" for scientists or wildlife managers is a good idea? In this presentation, we will hear from several private landowners in the Bitterroot Valley who've embraced research and inventory projects. Why do they participate? What have they learned? How do they see these types of collaborations supporting conservation efforts in the Bitterroot Valley and elsewhere? Please join us in celebrating a few people brave enough to venture to Butte to visit with you. We'll allow ample time for discussion.

Bring Me a Carcass! The Gift of Reciprocal Giving on Private Lands in the Bitterroot Valley

Kate Stone*, Ecology, MPG Ranch, Florence, MT

Eric Rasmussen, Ecology, MPG Ranch, Florence, MT

Debbie Leick, Ecology, MPG Ranch, Florence, MT

William Blake, Ecology, MPG Ranch, Florence, MT

The Bitterroot Valley contains diverse stakeholders. We've experienced rapid growth in recent years, but agricultural activities and private parcels with minimal development still dominate much of the landscape. Conservation groups work on voluntary efforts to protect wildlife, working lands, and water in our community. However, like agricultural communities in many areas, our working lands and their stewards are often under-appreciated for the habitat services they provide to all community members. Our neighbors and friends host some of the best habitats for non-game wildlife, from Long-billed Curlews to Lewis's Woodpeckers. The decision to let scientists come on your land and collect data or record observations could instigate fear, skepticism, or hesitancy. Over the past ten years, the bird scientists at MPG Ranch have alleviated some of these reactions, expanding their research area to include thousands of acres of private land, blanketing the landscape with hundreds of thousands of observation points. What kind of data have we collected? How do we apply it? From moth nights to carcass-camera traps to the peeps of millions of passerine migrants, we've expanded our knowledge of ecosystems, engaged the general public, and leveraged information for positive conservation outcomes. Come hear some tales from the field.

Scavengers Of Southwest Montana And Their Potential Impact On Brucellosis Transmission

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

Brucellosis, a bacterial disease caused by *Brucella abortus*, is a major concern in the Greater Yellowstone Ecosystem due to potential transmission from elk (*Cervus elaphus*) to livestock. B. abortus can lead to abortion in infected animals and is primarily transmitted between elk and livestock when individuals contact infected abortion materials. Therefore, the risk of transmission is likely a function of how long abortion materials remain on the landscape. To investigate removal rates of abortion materials by scavengers in southwest Montana, we placed bovine fetuses and placentas at 266 sites within suitable elk habitat during the brucellosis transmission risk period from February-June, 2017 and 2018. We used remote cameras to quantify the removal rate and conducted parametric survival analysis to test for covariate effects. Abortion materials were removed by scavengers at an average rate of 84 hours (± 8.5 SE) across all study sites. The top model suggested time to removal decreased in grassland habitats in comparison to sagebrush steppe and forest. Additionally, preliminary analyses suggest that mammalian predator removal practices on private ranches are correlated with time to removal. Abortion materials were consumed by a variety of avian and terrestrial scavengers with golden and bald eagles, coyotes, foxes, and turkey vultures being responsible for scavenging most of the abortion materials. Our results suggest scavengers play a vital role in reducing the persistence of B. abortus on the landscape, and that the rate of fetus removal varies across habitat and management types.

The Flathead River to Lake Initiative - Diverse Partners Effectively Collaborating to Save a River Corridor

Kris Tempel*, Montana Fish, Wildlife and Parks, Kalispell

Twenty years ago, agencies, NGOs, tribes, and landowners came together to protect the natural heritage of Flathead River and Lake: excellent water quality, abundant fish and wildlife and their habitat, outstanding scenic and recreation values, and prime farmland. In the early 2000s, the Flathead Valley was experiencing rapid growth and development. Farms throughout the valley, but especially along the river and lake, were being sold and subdivided threatening this important natural heritage. Using the power of partnerships and leveraging multiple funding sources, the River to Lake Initiative has successfully knitted together a patchwork of relatively small private ownerships into an ecologically functional unit. Landscape-scale habitat protection is often the focus of conservation efforts, but small-scale, focused conservation can also play a critical role preventing wildlife conflicts and providing for movement corridors. This presentation highlights how long-term, collaborative partnerships can achieve meaningful conservation and are essential to weathering the ups and downs inherent in any conservation effort.

Stress Hormones Mediate Tradeoffs Between Survival and Growth for Amphibians Exposed to Increased Salinity **

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Creagh Breuner, Organismal Biology, Ecology, and Evolution, University of Montana, Missoula
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Salinity has increased in many freshwater ecosystems in the last century. Despite this, limited information exists on its effects on freshwater vertebrates. Amphibians are sensitive to salinity because of their porous skin and primarily-aquatic lifecycle. Wildlife managers often seek biomarkers to gauge the influence of contaminants on population health; one marker may be changes in stress hormones (e.g., corticosterone; CORT). We investigated the influence of increased salinity on growth, CORT, and survival of larval leopard frogs (*Rana pipiens*) in a controlled experiment. We exposed larvae to one of three environmentally-relevant salt concentrations, and compared them against controls. For half of the larvae, we also blocked actions of CORT (using RU486) to determine if it mediates effects of salinity. We used novel, noninvasive techniques to collect waterborne CORT samples from larvae every 4 d for 24 d (baseline and stress-induced). Larval size, development, and survival decreased with exposure to increasing salinity. Survival decreased faster when CORT was also blocked. However, size and development did not decrease compared to controls when CORT was blocked. Baseline and stress-induced CORT were positively related to survival. Our results demonstrate that CORT may mediate life history tradeoffs of larvae exposed to increased salinity by diverting energy from growth and development towards survival. However, by blocking CORT, the opposite occurred. We detected some differences in CORT among treatments during the experiment, but CORT responses were not different after 3 weeks of exposure. Therefore, CORT may not be a suitable biomarker for monitoring influences of salinity on amphibians.

Looking Back at 19 Years of Mule Deer Adaptive Harvest Management in MFWP Region 6

Ryan M Williamson*, Montana Fish, Wildlife and Parks, Outlook

The FWP adapted the Mule Deer (*Odocoileus hemionus*) Adaptative Harvest Management plan in 2001 and since then, mule deer densities within FWP Administrative Region 6 have increased significantly over the last two decades, as estimated through 11 deer trend areas across the region. Due to increasing densities, increased hunting pressure, new disease threats and potential game damage concerns on private lands, the FWP has steadily increased harvest through available antlerless b-licenses. The majority of the region is either-sex, general hunting opportunity for both deer species with liberal b-licenses but available b-licenses have fluctuated in the last 19 years, as low as no b-licenses available for two years, to over 6,000 offered across the region in 2019. In recent years, the demand from both landowners and sportsman for increased harvest opportunity and the need to reduce higher concentrations of deer has also increased. Mule deer numbers have thrived under AHM since its inception and the FWP's objective to maintain deer densities at a more tolerable and closer to average level provides mostly liberal hunting seasons across the region while minimizing landowner conflicts with mule deer and maintaining a healthy population.

Learning From your Mistakes - A New Approach to Conservation Partnerships

Alan Wood*, Wildlife Division, Montana Fish, Wildlife & Parks, Kalispell, MT

Wildlife habitat conservation projects are often complicated, and they become increasingly so when working with a variety of funding partners. In addition, these projects can be politically charged when government agencies are involved. Montana Fish, Wildlife & Parks has a variety of funding sources that are dedicated to wildlife habitat conservation, including the funding for mitigating wildlife impacts caused by construction of Libby and Hungry Horse dams in northwest Montana. After years of struggling to complete conservation projects, we developed a new approach relying on partners to help us achieve our goals. This new focus on partnerships had unexpected and very positive results. This presentation will tell the story of how this partnership-based focus came to be and how $750,000 has leveraged more than $200 million dollars resulting in conservation of 260,000 acres of wildlife habitat in northwest Montana.

Quantifying Elk Aggregation From GPS, Satellite, and UAS Data on the National Elk Refuge

Michael Yarnall*, Northern Rocky Mountain Science Center, U.S. Geological Survey, Bozeman, MT

The transmission and prevalence of CWD and other wildlife diseases likely depend on the density of animals on the landscape, which can have important implications for the frequency of animal contacts and the potential for environmental transmission. Amid increasing concern regarding the spread of CWD, new tools are needed to characterize the degree to which animals are aggregated on the landscape so that managers can assess the effectiveness of actions intended to reduce aggregation and disease transmission. Ideally, the type of data used to measure aggregation would a) provide precise and accurate information on how aggregation changes through time, b) yield additional information on the number and distribution of animals, and c) be inexpensive. We evaluated 7 aggregation metrics calculated using elk (*Cervus canadensis nelsoni*) locations on the National Elk Refuge derived from GPS collars, satellite, and UAS imagery. We assessed 1) the accuracy of these methods relative to traditional aerial and ground counts, 2) which approaches adequately identify changes in aggregation across time periods relevant for disease management action, and 3) whether aggregation metrics from different data sources can be compared directly to enable comparisons across multiple populations. We discuss potential pitfalls and benefits presented by new approaches to quantifying elk aggregations. We found that satellite and GPS data were most valuable for comparing elk aggregations across time and in relation to feeding activities. Inter-elk distance distributions and kernel density estimates represent easily interpretable metrics that are sensitive to changes in elk aggregation.

Poster Abstracts

Alphabetical By Presenter's Name
*** Denotes Presenter**
**** Indicates Student Presentation**

Montana BRAT: an Online Tool For Assessing Beaver Dam Capacity and Suitability in Montana Streams (Poster)

Heidi Anderson*, Montana Natural Heritage Program, Spatial Analysis Lab, University of Montana, Missoula

Braden Burkholder, Montana Natural Heritage Program, University of Montana, Helena

Claudine Tobalske, Montana Natural Heritage Program, Spatial Analysis Lab, University of Montana, Missoula

Linda Vance, Montana Natural Heritage Program, University of Montana, Missoula

The Beaver (*Castor canadensis*) Restoration Assessment Tool, originally developed by the Wheaton Lab at Utah State University, is a planning tool designed to evaluate a stream's potential to support beaver dams, whether build by beavers or by humans in the form of beaver dam analogs (BDAs). It operates at a drainage network level to assess dam capacity and the potential risks that dams might pose to infrastructure (e.g., roads, bridges) or natural and human resources. The Montana Natural Heritage Program has adapted the USU BRAT model to run with Montana-specific data sets, and has turned it into an ArcGIS Onlone interactive tool for easy use by managers and planners. The poster presents the background and assumptions of BRAT, and demonstrates how it can be used to identify opportunities and risks associated with beaver conservation and restoration or BDA installation.

Experimental Mapping of Great Blue Heron Colonies in Important Bird Areas using Satellite Imagery (Poster)

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Bryce Maxell, Montana Natural Heritage Program, 1515 6th Ave., Helena

The great blue heron (*Ardea Herodias*) is a species of concern in Montana that has seen significant population decline of 2.2% per year between 1966 and 2010 and is vulnerable to human disturbance and habitat loss. They are an important indicator species as they rely on healthy productive riparian systems for foraging and nesting. Great blue herons are colonial nesters that typically nest in mature cottonwood galleries along major river and stream corridors. They prefer to nest in areas with little human disturbance and low road density, and often abandon colonies when disturbed during the egg laying and incubation stages. Colonies are also sometimes abandoned as a result of tree mortality. Since great blue herons establish nesting colonies in relatively remote areas, often dozens of miles apart, it can be logistically challenging and costly to survey them. We wanted to determine whether it is possible to effectively survey colonies in Montana using high-resolution satellite imagery. We used Google Earth to systematically survey for important burn areas and found that many colonies are clearly visible and relatively easy to detect using this method. To assess search efficacy, we conducted a "blind" search and then compared the findings to non-colony locations. In a short time, we were able to identify nearly all known colonies. Additionally, we documented

several unreported colonies using this simple, accessible method. This demonstrates that using imagery to survey remotely may be a viable or alternative to costly aerial surveys in a reliable way to monitor long-term population trends.

Evaluating Two Monitoring Methods During Autumn Songbird Migration (Poster)

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Margaret M. Blake, Bird Ecology Lab, University of Montana, Missoula
Debbie S. Leick, Avian Sciences Dept., MPG Ranch, Florence, MT
Tricia M. Rodriguez, Bird Ecology Lab, University of Montana, Missoula
Kate R. Stone, Avian Sciences Dept., MPG Ranch, Florence, MT

Migration is an important part of avian life cycles that is not well understood, particularly in the West. Understanding how factors like climate change and habitat condition are affecting migrating populations is limited by our ability to monitor them. We compared two widely used migration monitoring tools to see if they are comparable for detecting apparent abundance. This study evaluated how standard effort mist-netting detections compared to automated recording unit detections. For the 24 species that were detected by both methods, relative abundance was correlated ($r = 0.60$; SE 0.17). While there is some ability to estimate apparent abundance based on the correlative nature of one method, the target species or project goal may dictate which monitoring method should be applied. Ideally, combining these methods will provide a better and more complementary representation of trends in migrating songbirds.

Snapping Turtle Nesting Habitat On A Tributary Of The Yellowstone River** (Poster)

Miranda Gallagher*, Environmental Science, Rocky Mountian College, Billings, MT

Snapping turtles (*Chelydra serpentina*) are considered a “Species Of Concern” in Montana due to the lack of knowledge of their life history and distribution. Information on turtle home ranges, adult survival, and female nesting locations are critical for understanding the viability of snapping turtle populations. We used geospatial data about snapping turtle movement along Razor Creek (a tributary of the Yellowstone River) and environmental factors (slope, aspect, land use, proximity to water) to map linear home ranges and identify suitable nesting habitat. The study area is at the northwestern-most range edge of the species distribution, where no previous studies have occurred.Snapping turtle location data and attributes were collected with standardized trapping to document movements, and randomly selected turtles of both sexes were fitted with radio-telemetry tags to facilitate a more comprehensive analysis of habitat use and linear home range sizes. For nest habitat modeling we selected adult female locations during the nesting season (May - June). The resulting datasets were processed using ArcMap 10.5 GIS software. Geoprocessing workflows were then used to identify potential nesting areas based on the following factors known to influence nesting habitat: distance from water, land use, aspect, and slope.Average linear home ranges were longer for females (3,079 m) ($n = 6$) when compared to males (2,914 m) ($n = 6$) but not significantly different. Of the total accessible nesting habitat in our study area, 40% was deemed as “suitable nesting habitat”. Of the total “suitable nesting habitat” area , 58% was located on private lands. This refined area will guide nest searches next spring and hopefully lead to the documentation of the first snapping turtle nests in Montana, a better understanding of nesting habitat, and improved efforts to conserve this species.

Estimating Population Size of Grand Canyon Bighorn Sheep With SCR (Poster)

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Tabitha A. Graves, Northern Rocky Mountain Science Center, U.S. Geological Survey, West Glacier, MT

Brandon Holton, Grand Canyon National Park, National Park Service, Grand Canyon, AZ

Clinton Epps, Department of Fisheries and Wildlife, Oregon State University , Corvallis, OR

Rachel Crowhurst, Department of Fisheries and Wildlife, Corvallis, OR

Ryan Monello, Pacific Island Network, National Park Service Inventory and Monitoring Network, Hawaii Volcanoes National Park, HI

Desert bighorn sheep (*Ovis canadensis nelsoni*) are a species of conservation concern and management importance for their symbolism, role as the only ungulate in the desert nutrient cycle, and as a prey and carrion source. The bighorn population in the Grand Canyon (GRCA) represents the largest population managed by the National Park Service on the largest protected habitat on the Colorado Plateau. Bighorn sheep are highly susceptible to pneumonia from contacts with domestic sheep and the first documented occurrence of pneumonia in the GRCA caused a significant decline in survey counts between 2011 and 2014. The disease outbreak occurred during a large-scale, multi-year study of bighorn sheep movement and connectivity by sampling fecal pellets. This created an opportunity to conduct the first estimate of bighorn abundance and disease impacts for the entire GRCA. Thirteen hundred samples from five years were genotyped and analyzed with spatial capture-recapture models to estimate abundance while modeling detection and incorporating environmental constraints. We will discuss top models for detection and density, and describe our approaches for accounting for a linear sample design in this population, reducing the size of confidence intervals with auxiliary data, and estimating movement through the system.

Nest Attentiveness in North America's Largest Grouse** (Poster)

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Aaron Pratt, Department of Ecosystem Science and Management, University of Wyoming, Laramie

Jeffrey Beck, Department of Ecosystem Science and Management, University of Wyoming, Laramie

Understanding nest attentiveness (i.e., amount of time spent incubating) of North America's largest grouse, greater sage-grouse (*Centrocercus urophasianus*), hereafter "sage-grouse"), can be important for conserving populations, as reproductive costs can reduce survival of parents and nest attentiveness can influence nest success. When nesting, parents must allocate their time between incubating and maintenance activities, such as foraging to meet their nutritional demands. Previous research has shown female sage-grouse sustain long stretches of incubation interrupted by relatively short recesses from their nests, but incubation patterns likely differ among females. We initiated our study in 2018 with two objectives: 1) to evaluate what factors influence nest attentiveness, and 2) how nest attentiveness influences nest success by examining duration, number, and timing of recesses, and time spent incubating for successful and unsuccessful nests. We monitored female sage-grouse with GPS transmitters collecting locations every 5 minutes from 0300-2300 MST in Carbon

County, Montana in 2018 and 2019 and in Carbon County, Wyoming in 2019. In Montana, we monitored 40 sage-grouse nests (17 hatched, 23 failed) in 2018, and 46 nests (21 hatched, 25 failed) in 2019. In Wyoming, we monitored 50 nests (12 hatched, 38 failed) in 2019. We measured microhabitat vegetation at 81 nests in Montana and 50 nests in Wyoming to determine habitat influences on nest attentiveness. Understanding factors that influence nest attentiveness throughout the incubation period and therefore nest success will add important and novel information to basic sage-grouse nesting ecology.

Mammal Community Response to Cattle Grazing** (Poster)

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Roland Kays, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh

The impacts of cattle (*Bos taurus*) grazing on the environment are complex. Chronic overgrazing may inhibit primary productivity and alter vegetation structure and composition, while moderate grazing may increase the quality of vegetation by stimulating new growth and net primary productivity. Numerous studies have estimated the effects of grazing on wildlife demography and behavior, but few have evaluated the effects of grazing on multitrophic communities. Our objective is to identify how squirrel-sized and larger mammals interact with cattle at varying grazing intensities and how cattle affect the structure of the mammal community. Specifically, we aim to determine whether species richness, occurrence, and behavior of mammal species is influenced by the number of cattle, and whether these potential influences cause changes in interspecific interactions among sympatric mammal species. To answer these questions, we set trail cameras 40-50 cm high, unbaited, at random sites within cattle ranches in western Montana representative of the variation in grazing management practices. Throughout spring, summer, and fall, we set trail cameras for at least 21 days at 75 sites per ranch. We will estimate co-occurrence of all potentially interacting mammal species, using a multispecies occupancy model that accounts for imperfect detection, and evaluate how the presence of cattle affects these interactions. We will also monitor species changes in temporal activity patterns in the presence of cattle. Results will identify how mammal communities respond to cattle grazing, which may offer insight into sustainable coexistence among wild and domestic species.

Help Wanted: Volunteer Observers Needed for Mountain Grouse** Population Study (Poster)

Elizabeth Leipold*, Department of Animal and Range Sciences, Montana State University, Bozeman

Claire Gower, Montana Department of Fish, Wildlife, and Parks, Montana Department of Fish, Wildlife, and Parks, Bozeman

Lance McNew, Department of Animal and Range Sciences, Montana State University, Bozeman

Montana State University in conjunction with Montana, Fish, Wildlife, and Parks is developing a population monitoring program for mountain grouse. Species of interest include dusky and ruffed grouse, which are found in montane conifer forests throughout western Montana. Males of both species engage in courtship displays during spring that increase the probability of detecting an individual. Dusky grouse produce a hooting noise that can be heard within 50-100 meters and ruffed grouse produce a drumming noise that is audible up to 200 meters. We are looking for volunteers interested in assisting with surveys during the sampling period. Surveys will occur between 25 April-25 May during early morning hours. Survey methods may include point counts and walking transect routes that occur along forest service roads or trails. Point counts will consist of going to multiple locations (5) along a survey route and recording all grouse detections within a 4 minute time period. If interested in spending a few mornings this spring hiking and looking or listening for mountain grouse, please let us know!

The Bitterroot Valley Winter Eagle Project (Poster)

Mary Scofield*, Avian Science, MPG Ranch, Missoula, MT
Kate Stone, Avian Science, MPG Ranch, Missoula, MT

Golden (*Aquila chrysaetos*) and bald (*Haliaeetus leucocephalus*) Eagles commonly scavenge on carrion while overwintering in Montana. This behavior may expose them to conflict with other scavengers, including other eagles. The availability of carrion is generally ephemeral, suggesting overwintering eagles must possess behavioral adaptations to successfully find food and potentially compete with other scavengers. We documented the occurrence and behavior of marked eagles at camera traps set on roadkill deer on private lands in the Bitterroot Valley of western Montana. Our re-sightings included over 25 eagles individually identifiable by wing tag, colored and numbered leg band, or satellite transmitter. We also had re-sightings of at least 10 eagles with metal USGS leg bands, allowing us to look at visitation length and behavior without individual identification. With few exceptions, most eagles visited a carcass just one day and over half of these eagles fed on the carcass once that day. The length of time a bald eagle feeds at the carcass increases with the number of other bald eagles present and reduces when golden eagles are present. Golden eagles have more consistent feeding lengths regardless of the other eagles present. We also compared eagle re-sightings to movement data from eagles with transmitters to investigate whether or not persistent food availability influences the movements or behavior of bald or golden eagles. Our results suggest that even with a consistent food resource, eagles generally feed then move on. This behavior may result from an adaptation to ephemeral winter food resources.

Evaluating Habitat Suitability for Lesser Prairie-Chicken** Reintroduction (Poster)

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Lance B. McNew, Animal and Range Sciences, Montana State University, Bozeman

Large-scale patterns of land-use and habitat fragmentation have significantly reduced the range and numbers of lesser prairie-chickens in the southern Great Plains. Because lesser prairie-chickens are generally a residential species with limited dispersal abilities, increasing the size and connectivity of sub-populations and restoring habitat in areas previously occupied is essential for species' recovery. To guide future management practices for lesser prairie-chicken recovery, we will use locations of stable leks collected from lek survey data from 2010 -2019 to develop resource selection models for the species' current distribution in the mixed-grass prairie ecoregion. We will extrapolate our best resource selection model to the historic range of lesser prairie-chickens to identify and quantify potential habitat patches for reintroduction, as well as to evaluate the relative connectivity of potential habitat patches to existing lesser prairie-chicken populations using a least-cost path analysis. We will then use our resource selection model with habitat-based ratio estimators to estimate population sizes at potential habitat patches. Habitat patches will be prioritized for lesser prairie-chicken reintroduction based on habitat patch size, total available lesser prairie-chicken habitat, and relative connectivity of potential habitat patches to existing populations. Finally, we will use

our resource selection model to quantify the relative improvement in available lesser prairie-chicken habitat for areas that recently participated in restorative management actions by comparing current habitat conditions to habitat conditions prior to management actions. Our resource selection models will assist future reintroduction and habitat restoration plans by identifying habitat conditions that predict the presence of stable lesser prairie-chicken leks, and the highest quality, most connected habitat patches in the mixed-grass prairie ecoregion.

Sticking Their Noses in it…. Ungulates Investigating Carrion in a CWD World (Poster)

Katharine Stone*, Bird Ecology , MPG Ranch, Florence, MT
Eric Rasmussen, Bird Ecology , MPG Ranch, Florence, MT
Mike McTee, Environmental Science, MPG Ranch, Florence, MT
Erik Samsoe, Technology Transfer, MPG Ranch, Florence, MT

The recent arrival and spread of chronic wasting disease (CWD) in Montana permeates the thoughts of the hunting public and wildlife managers. Both communities share a concern for how hunters might play a role in either facilitating or limiting disease spread; live ungulates may contact infected carrion, either in the field post harvest or after transport and disposal by a hunter. We operate two camera-trap projects involving dead ungulates to study scavenger ecology. From winter of 2015 to present we have placed cameras on over 400 road kill deer on private lands in the Bitterroot Valley to document marked eagles and other scavengers. We've also worked with hunters for two years placing cameras on gut piles in the field in many parts of Montana as well as Colorado and Wyoming. In addition to scavengers, we incidentally noticed a surprising number of ungulates investigating the carrion involved in both projects. This poster will share camera footage and documentation of how often this behavior occurs. We'll discuss our results in the context of potential CWD transmission and spread and managing hunter behavior in disposal of gut piles, carcasses, and butchering scraps.

Footnote:

- *The annual meeting of The Montana Chapter of The Wildlife Society was held before the spread of the Covid-19 virus was declared a pandemic.*
- *No abstracts were submitted in 2020 by the Montana Academy of Sciences, since their 2020 annual conference was canceled due to the Covid-19 pandemic.*
- *The Montana Chapter of The American Fisheries Society opted out of submitting their annual meeting abstracts to IJS beginning in 2011 with Volume 17.*

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