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Intermountain Journal of Sciences

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

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

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

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

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

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

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Intermountain Journal of Sciences

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	Balance 01/01/14		**$1,683.47**
Income:			
	Subscriptions:		
	Regular Member	$75.00	
	Library Subscriptions	$225.00	
	Life Member	150.00	
	International Member	$25.00	
	Subscriptions Total		**$475.00**
	Page Charges		$4,400.00
	Reprints		$250.00
	Refund		$50.00
	Total Income		**$5,175.00**
Expenses:			
	Design and Printing		$2,695.87
	Postage		$154.20
	P. O. Box Rent		$128.00
	Administrative and Bank Fees		$83.75
	Reprints and Layout		$150.00
	Storage		$373.00
	Refunds		880.00
	Total Expenses		**$4,464.82**
	Balance 12/31/14		**$2,393.65**

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Editorial Review Policy

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

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

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

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

Acceptance

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

Rejection

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

Reviewer Anonymity

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

Manuscripts Submitted by Editors

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

Abstracts

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

Commentary

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

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

Literature Cited

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

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Age Estimation of Burbot Using Pectoral Fin Rays, Branchiostegal Rays and Otoliths

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Abstract

Throughout much of its native distribution, burbot (*Lota lota*) is a species of conservation concern. Understanding dynamic rate functions is critical for the effective management of sensitive burbot populations, which necessitates accurate and precise age estimates. Managing sensitive burbot populations requires an accurate and precise non-lethal alternative. In an effort to identify a non-lethal ageing structure, we compared the precision of age estimates obtained from otoliths, pectoral fin rays, dorsal fin rays and branchiostegal rays from 208 burbot collected from the Green River drainage, Wyoming. Additionally, we compared the accuracy of age estimates from pectoral fin rays, dorsal fin rays and branchiostegal rays to those of otoliths. Dorsal fin rays were immediately deemed a poor ageing structure and removed from further analysis. Age-bias plots of consensus ages derived from branchiostegal rays and pectoral fin rays were appreciably different from those obtained from otoliths. Exact agreement between readers and reader confidence was highest for otoliths and lowest for branchiostegal rays. Age-bias plots indicated that age estimates obtained from branchiostegal rays and pectoral fin rays were substantially different from age estimates obtained from otoliths. Our results indicate that otoliths provide the most precise age estimates for burbot.

Key words: Burbot, Age and growth, Precision, Age estimation, Otoliths, Wyoming

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Introduction

Burbot (*Lota lota*) is the only freshwater member of the family Gadidae (McPhail and Paragamian 2000). It has a circumpolar distribution rarely extending south of the 40th parallel N and occupies diverse lentic and lotic habitats throughout Europe, Asia and North America. Secure burbot populations exist in Alaska, much of Canada and several Eurasian countries (Latvia, Lithuania, Switzerland, Russia; Stapanian et al. 2010). However, across much of its native distribution, burbot populations are declining or completely extirpated as in many Eurasian countries (Tammi et al. 1999, Dillen et al. 2008, Stapanian et al. 2010), the United States and Canada (McPhail and Paragamian 2000, Stapanian et al. 2008, 2010). Therefore, the conservation of burbot is a major management focus of numerous natural resource agencies worldwide.

Effective management of fish populations requires knowledge about the most influential functions controlling productivity: recruitment, growth and mortality (Ricker 1975). Recruitment, often defined as the age a fish is recruited to a population or fishery, has obvious implications for fisheries management. Back calculations are ubiquitous in fisheries research and allow for estimates of growth given age and length data (Quist et al. 2012). Similarly, catch curves are essentially an age distribution by which inferences about mortality can be established (Chapman and Robson 1960). Regardless of the method used to evaluate population dynamics, accurate calculations of rate functions rely on precise and accurate age estimates.

Sagittal otoliths are the primary structure used to estimate the age of burbot. A number of studies have evaluated the precision and (or) accuracy of otoliths for estimating the age of burbot (McCrimmon and Devitt 1954, Guinn and Hallberg 1990, Stuby 2000, Edwards et al. 2011). Stuby (2000) validated age estimates of otoliths from burbot in the Fish Creek drainage, Alaska using oxytetracycline (OTC) and reported 100 percent accuracy in age estimates beyond the OTC mark. Unfortunately, the use of otoliths requires sacrificing fish. In areas where burbot conservation is a concern, managers are often unwilling to sacrifice burbot. Therefore, a non-lethal method for accurately and precisely estimating the age of burbot is highly desirable.

Few studies have evaluated the viability of non-lethal structures for estimating the age of burbot. Scales of burbot are generally disregarded for age estimation due to their small size, difficulty in reading and misrepresentation of annuli (McCrimmon and Devitt 1954, Guinn and Hallberg 1990). Pectoral fin rays have also been used to assess the age of burbot (McCrimmon and Devitt 1954, Giroux 2005). However, previous research suggests pectoral fin rays of burbot are difficult to read and consistently underestimate the age of burbot. To acknowledge declining burbot populations and conservation efforts around the world, non-lethal options for ageing burbot requires further research.

The goal of this study was to assess the precision of age estimates of burbot obtained from all structures while evaluating the accuracy of pectoral fin rays, dorsal fin rays and branchiostegal rays compared to otoliths.

Study Area

The Green River is the largest tributary of the Colorado River and drains portions of Wyoming, Utah and Colorado (Wyoming Game and Fish Department 2010). The Green River originates in the Wind River Range of western Wyoming and flows for approximately 235 km before entering Fontenelle Reservoir (Wyoming Game and Fish Department 2010). From Fontenelle Reservoir, the Green River flows for about 150 km until it enters Flaming Gorge Reservoir at the Wyoming-Utah border. Flaming Gorge Dam was completed in 1962 impounding approximately 17,000 hectares of water with a maximum depth of 34 m (Teuscher and Luecke 1996). Flaming Gorge Reservoir is approximately 145 km long and encompasses portions of western Wyoming and northeastern Utah.

Methods and Materials

Burbot were sampled from the Green River using electrofishing in the summer and autumn of 2013. Electrofishing was conducted at night using a drift boat equipped with a 5,000 W generator and Smith-Root VVP-15B electrofisher (Smith-Root, Vancouver, WA). Electrofishing power output was standardized to 2,750 – 3,200 W (Miranda 2009). Burbot were sampled from Flaming Gorge Reservoir using trammel nets in the autumn of 2013. Trammel nets were 48.8 m long and 1.8 m wide, with 25.4-cm outer bar mesh and 2.5-cm inner bar mesh. Nine nets were set perpendicular to shore and fished for approximately 24 hours.

All burbot sampled were enumerated and measured to the nearest millimeter (total length). Up to ten burbot from each 10 mm length group were euthanized with an overdose of tricaine methanesulfonate (MS-222; Western Chemical, Ferndale, Washington). Sagittal otoliths, pectoral fin rays, dorsal fin rays and branchiostegal rays were removed from each fish in the field. Otoliths were accessed from the ventral surface and removed following Schneidervin and Hubert (1986). The left leading pectoral fin ray was removed by cutting at the insertion of the articulating process (Koch et al. 2008). The anterior-most dorsal fin ray was removed by cutting into the surrounding tissue and rotating the dorsal fin ray until it was pulled free. The ventral-most branchiostegal ray (largest) was removed by rotating the structure until it pulled free from the hyoid complex. Otoliths, pectoral fin rays, dorsal fin rays and branchiostegal rays were cleaned of tissue and stored in numbered scale envelopes and allowed to air dry.

Structures were mounted in epoxy and sectioned using a low speed saw (Buehler, Lake Bluff, Illinois; Koch and Quist 2007). Fin rays and branchiostegal rays were mounted in epoxy with the proximal end down in 2 ml centrifuge tubes following Koch and Quist (2007). Fin rays were cross-sectioned at the base of the structure. Upon initial examination, branchiostegal rays had a small protrusion near the proximal end of the structure which interfered with annuli identification. Therefore, branchiostegal rays were cross-sectioned immediately distal to the protrusion. Cross-sections of fin rays and branchiostegal rays measured approximately 0.7 mm in thickness. Otoliths were mounted in epoxy in 2 ml centrifuge tubes and transversely sectioned about the nucleus (Edwards et al. 2011). Otolith cross-sections measured approximately 0.5 mm in thickness. Cross-sections were examined using a dissecting microscope with transmitted light and an image analysis system (Image-Pro Plus; Media Cybernetics, Silver Springs, Maryland).

Annuli were enumerated independently by two readers without knowledge of fish length, sampling location, or prior age estimates. Both readers had experience enumerating annuli of various structures prior to the study. After each reader assigned an age, each age estimate was compared. If discrepancies existed between age estimates, the structure was re-aged by both readers and discussed in a mutual reading. If a consensus age could not be reached, the structure was removed from further analysis.

In addition to an age estimate, readers assigned a rating indicating their confidence in their age estimate (Fitzgerald et al. 1997, Koch et al. 2008, Spiegel et al. 2010). Following the rating criteria suggested by Spiegel et al. (2010), readers assigned a confidence rating that varied from 0 to 3. A confidence rating of 0 indicated the reader had no confidence in their age estimate; whereas, a rating of 3 corresponded to near absolute confidence in the reader's age estimate.

Reader bias was evaluated by plotting age estimates from reader one against reader two (Campana et al. 1995). Differences in confidence ratings by structure were evaluated using a Kruskal-Wallis test. A Tukey's honest significant difference post-hoc procedure was used to determine if confidence ratings between pairs of structures were significantly different. All statistical tests used a type I error rate at $\alpha = 0.05$. Between-reader precision for each structure was evaluated by calculating the coefficient of variation (CV; Campana et al. 1995). The CV was calculated as:

$$CV_j = 100 \times \frac{\sqrt{\sum_{i=1}^{R} \frac{(X_{ij} - X_j)^2}{R-1}}}{X_j},$$

where X_{ij} is the ith age determination for the *j*th fish, X_j is the mean age of the *j*th fish and *R* is the number of times each fish was aged (Campana et al. 1995). The accuracy of age estimates for fin rays and branchiostegal rays was evaluated by comparing the consensus age estimates from each structure to the consensus age estimates from otoliths using age-bias plots. A CV was calculated for consensus age estimates of pectoral fin rays, dorsal fin rays and branchiostegal rays as an additional measure of accuracy. Concordance between consensus ages and reader bias was interpreted in reference to the equivalence line. In addition, variation in age estimates between readers and structure was assessed by calculating the percent agreement [exact (PA-0), within-1 year (PA-1)].

Results

Two readers estimated the age of 208 burbot from the Green River drainage, Wyoming (Table 1). Burbot averaged 418 mm in length and had a length distribution of 116 – 898 mm. Consensus age estimates varied from 0 – 11 for otoliths and branchiostegal rays and 0 – 10 for pectoral

Table 1. Sample size (*n*), and total length (mm) statistics of burbot sampled for age estimation from the Green River drainage, Wyoming (2013). Mean, standard deviation (SD), minimum (min), and maximum (max) lengths are provided (mm).

	Total Length				
Location	*n*	Mean	SD	Min	Max
Green River	128	422	138	116	686
Flaming Gorge Reservoir	80	411	127	285	898

fin rays (Fig. 1). A subset of 100 dorsal fin rays was independently read by both readers, but annuli were largely indiscernible. Therefore, dorsal fin rays were deemed a poor structure for estimating the age of burbot and removed from further analysis.

Readers were most confident in the age estimates for otoliths and least confident in the age estimates for branchiostegal rays (Table 2). Mean reader confidence was 2.9 (SD = 0.40) for otoliths, 1.6 (SD = 0.94) for pectoral fin rays and 1.3 (SD = 0.68) for branchiostegal rays. Confidence ratings of branchiostegal rays and pectoral fin rays were significantly different when compared to confidence ratings of otoliths ($P = 0.00$). Readers consistently reported lower confidence ratings for older fish (≥ 5 years old) using branchiostegal rays and pectoral fin rays than for younger fish. However, age estimates for otoliths were generally assigned high confidence rating by both readers regardless of the individual fish's presumptive age. For example, the mean confidence rating for branchiostegal rays was 1.27 (SD = 0.59) for fish with a consensus age ≥ five years; whereas, the mean confidence rating for otoliths was 2.81 (SD = 0.42) for fish with age estimates five years or older.

Exact agreement between age estimates of both readers (PA-0) was highest for otoliths and lowest for branchiostegal rays. Exact agreement between reader's age estimates was 90.4 percent for otoliths, 68.3 percent for pectoral fin rays and 58.4 percent for branchiostegal rays. Percent agreement between estimated ages within-1 year was 100.0 percent for otoliths, 93.3 percent for pectoral fin rays and 88.0 percent for branchiostegal rays. Between-reader CV was lowest for otoliths and highest for pectoral fin rays (Fig. 2). Age-bias plots indicated that concordance was highest between the age estimates of readers one and two for otoliths (Fig. 2). Age estimates using pectoral fin rays and branchiostegal rays showed high concordance between readers for fish less than 5 years old (i.e., consensus age). Relative to reader one, reader two tended to underestimate the age of older fish (> 5 years) using pectoral fin rays and branchiostegal rays.

Consensus age estimates from branchiostegal rays and pectoral fin rays tended to disagree with sectioned otoliths (Fig. 3). Branchiostegal rays and otoliths showed high concordance up to age 5. After age 5, branchiostegal rays tended to underestimate fish age when compared to age estimates obtained from otoliths. Age estimates from pectoral fin rays displayed little agreement with otoliths and consistently underestimated fish age. When compared to otoliths, exact agreement between consensus ages was 27.9 percent for branchiostegal rays and 11 percent for pectoral fin rays. Agreement within-1 year was 69.7 percent for branchiostegal rays and 39.0 percent for pectoral fin rays when compared to age estimates obtained from otoliths.

Discussion

Our findings support previous research suggesting sectioned otoliths provide precise age estimates for burbot. Stuby (2000) compared the readability of whole and sectioned burbot otoliths and observed higher readability in sectioned burbot otoliths.

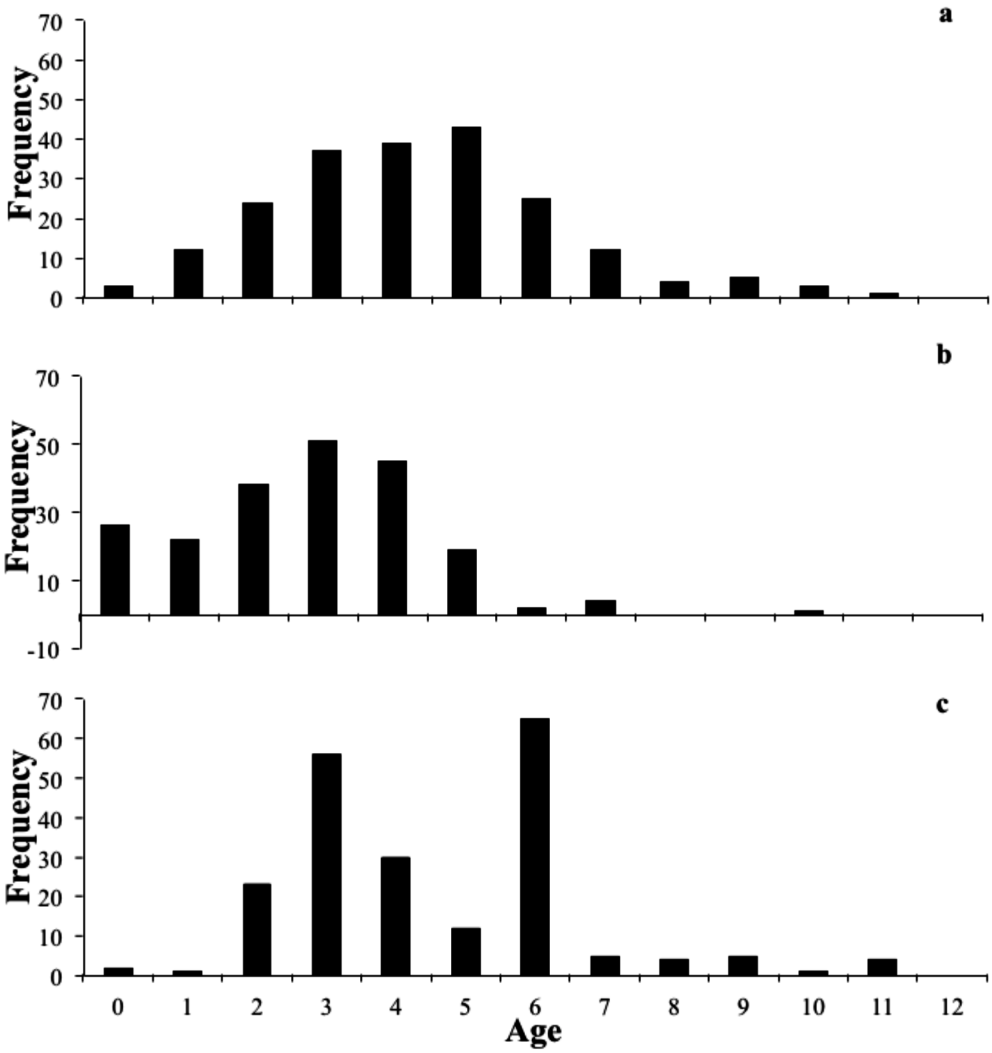

Figure 1. Age-frequency distributions for branchiostegal rays (a), pectoral fin rays (b), and otoliths (c) from burbot collected from the Green River drainage, Wyoming (2013).

Table 2. Percent confidence rating for reader one and two by structure for burbot collected from the Green River drainage, Wyoming (2013). Each structure represents the same individual fish with the sample size included in parenthesis.

	Confidence Rating			
	0	1	2	3
Branchiostegal rays				
Reader 1	5% (11)	62% (129)	29% (61)	4% (7)
Reader 2	10% (21)	54% (113)	29% (61)	7% (13)
Pectoral fin rays				
Reader 1	11% (23)	45% (94)	32% (67)	12% (24)
Reader 2	14% (28)	32% (67)	27% (56)	27% (57)
Otoliths				
Reader 1	0% (0)	2% (4)	13% (28)	85% (176)
Reader 2	0% (0)	1% (2)	11% (24)	88% (182)

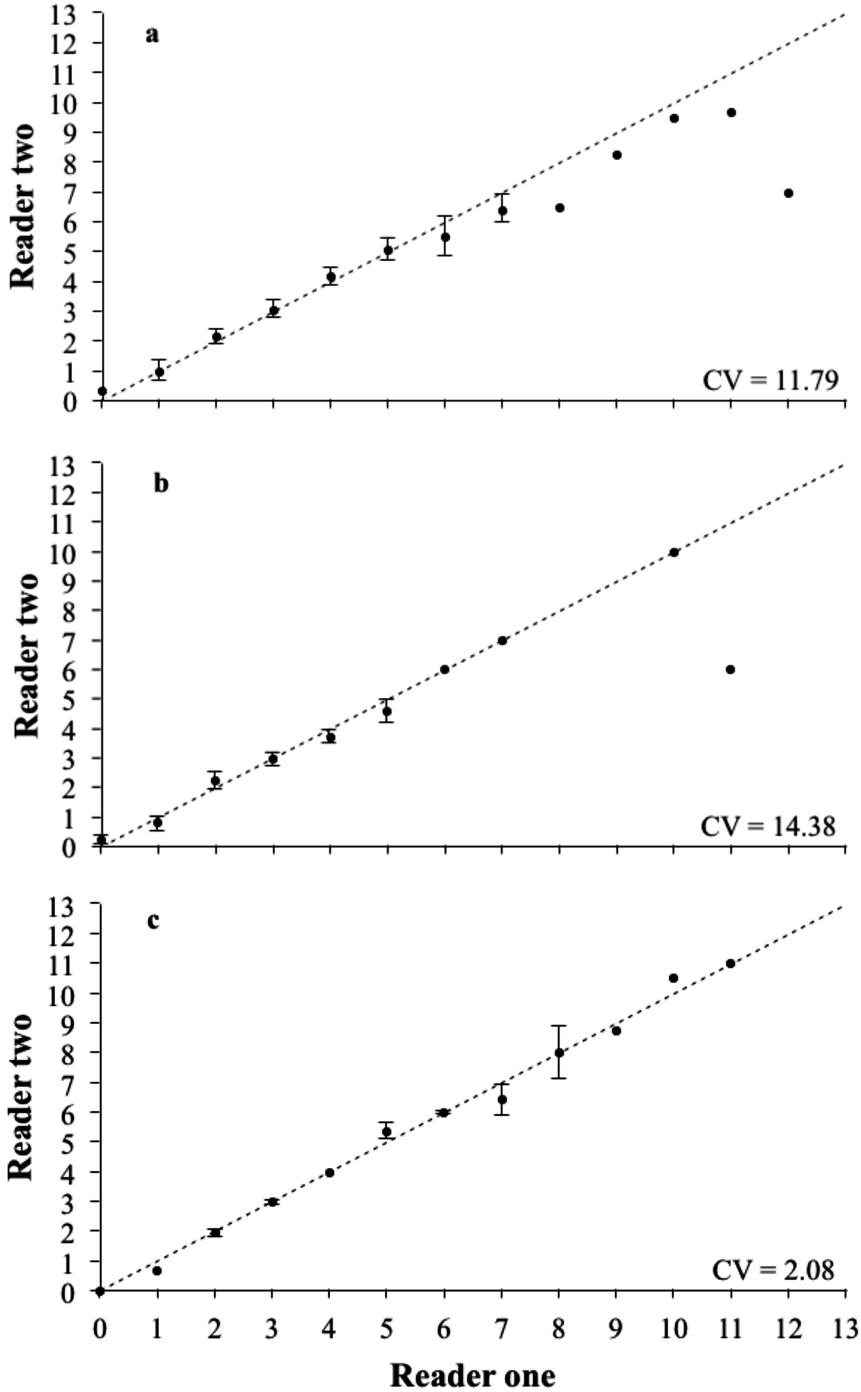

Figure 2. Assigned ages of reader one and two for branchiostegal rays (a), pectoral fin rays (b), and otoliths (c) from burbot collected from the Green River drainage, Wyoming (2013). Dashed lines represent exact agreement and error bars represent 95% confidence intervals. The mean coefficient of variation (CV) for each structure is provided.

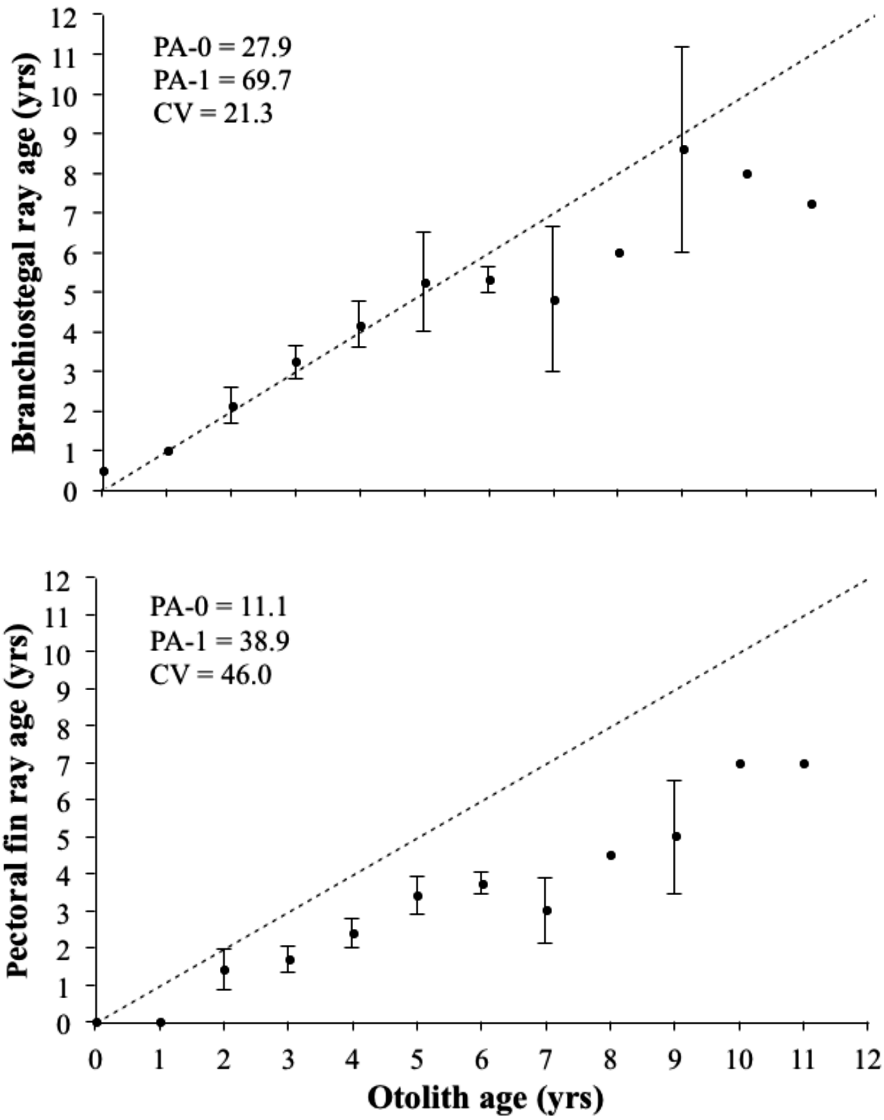

Figure 3. Age-bias plots for consensus ages assigned to branchiostegal rays and pectoral fin rays compared to otoliths for burbot collected from the Green River drainage, Wyoming (2013). Dashed lines represent exact agreement and error bars represent 95% confidence intervals. Precision between structures is indicated as exact (PA-0) and within-1 year (PA-1) agreement and mean coefficient of variation (CV).

More recently, Edwards et al. (2011) compared precision in age estimates using whole, cracked and sectioned otoliths and reported sectioned otoliths provided the most precise age estimates. Although we did not specifically address the precision of sectioned otoliths compared to other preparation techniques, otoliths appear to be a precise structure for ageing burbot regardless of the processing methodology. The relative ease of use and precision of otoliths will likely cement their use as the primary ageing structure for estimating the age of burbot.

Branchiostegal rays are routinely used to estimate the age of certain species and families of fish, e.g. gar (*Lepisosteidae* spp.; Love 2004, Glass et al. 2011, Buckmeier et al. 2012.) However, outside of select families of fish, limited knowledge exists regarding the use and practicality of estimating the age of fishes using branchiostegal rays. Bulkley (1960) evaluated the accuracy of age estimates obtained from whole branchiostegal rays of lake trout (*Salvelinus namaycush*) from Lake Michigan and reported 81 percent exact agreement between the known age and presumptive age estimates of branchiostegal rays. In the current study, age estimates obtained from branchiostegal rays of burbot were relatively inaccurate with only 27.9 percent exact agreement and 69.7 percent agreement within-1 year between branchiostegal and otolith age estimates. The discrepancy between burbot and lake trout in precision using branchiostegal rays is likely due to differences in species-specific morphology and processing methodology. Previous research generally used the largest pair of branchiostegal rays and estimated age using whole branchiostegal rays (Bulkley 1960, Netch and Witt 1962, Love 2004, Murie et al. 2009, Glass et al. 2011, Buckmeier et al. 2012). The majority of branchiostegal rays used in previous research exhibited thin, translucent distal ends which allowed for easy identification of annuli on whole branchiostegal rays (Netch and Witt 1962). The branchiostegal rays of burbot were relatively uniform in shape and annuli were not discernible under transmitted or reflected light using whole branchiostegal rays. As such, cross-sectioned branchiostegal rays were used in our study because they exhibited discernible annuli. Due to the paucity of information surrounding the use of branchiostegal rays for age estimation, it is difficult to know if another processing method (e.g., staining, clearing) might result in increased precision. Additionally, it is unclear if branchiostegal rays are truly a non-lethal ageing structure. To our knowledge, no research has evaluated the lethality of branchiostegal removal. Glass et al. (2011) posited that the removal of branchiostegal rays was lethal to spotted gar (*Lepisosteus oculatus*). Bulkley (1960) did not specifically assess survival of lake trout from which branchiostegal rays had been removed, but mentioned the potential for decreased survival for non-lethal removal of a single branchiostegal ray. Branchiostegal rays were easily removed from burbot, suggesting that a single branchiostegal ray could be carefully removed from anesthetized burbot without lethal repercussions. Further research to assess the potential use of branchiostegal rays as a non-lethal ageing structure for burbot may be warranted.

Fin rays are a common non-lethal structure used for estimating the age of fishes. Zymonas and McMahon (2009) reported that pelvic fin rays provided precise age estimates and were a viable non-lethal alternative to otoliths when estimating the age of bull trout (*Salvelinus confluentus*). Similarly, Quist et al. (2007) reported nearly identical age estimates between fin rays and otoliths for five catostomid species from the Little Snake River drainage, Wyoming. However, results regarding the accuracy and precision of age estimates obtained from fin rays are variable and tend to be species-specific. For instance, fin rays collected from pallid sturgeon (*Scaphirhynchus albus*) and white sturgeon (*Acipenser transmontanus*) provided inaccurate and imprecise age estimates (Rien and Beamesderfer 1994, Hurley et al. 2004). Results from our study support previous research suggesting age estimates obtained from burbot fin rays are relatively inaccurate when compared to age estimates obtained from otoliths. Giroux (2005) reported consistent underestimation of age using pectoral fin rays when compared to otoliths for burbot collected from British Columbia lakes. Additionally, pectoral fin ray age estimates obtained from burbot in our study had a mean CV of 14.38 indicating relatively imprecise age estimates. Campana (2001) suggested a CV ≤ 8 as an acceptable level of precision for most age estimation studies. Thus, the imprecision and inaccuracy of age estimates obtained from pectoral fin rays likely preclude their use as a valuable ageing structure for burbot.

The successful management of burbot relies on ageing structures that provide precise and accurate age estimates. To date, no non-lethal structures have been identified for estimating the age of burbot. In areas where managers are unwilling to sacrifice burbot, other age estimation methods will need to be used. Unfortunately, alternative age estimation methods rely on repeated sampling events and large sample sizes (e.g., mark-recapture of known aged fish, length-frequency analysis; Quist et al. 2012). Most management agencies will likely be unwilling or unable to bear the financial cost associated with repeatedly targeting a single species as in a mark-recapture study. Furthermore, low relative abundance in systems focused on burbot conservation will largely preclude the use of length-frequency analysis due to low sample sizes. Until future research identifies a viable non-lethal option, accurate and precise age estimates of burbot will likely rely on otoliths. Therefore, managers will need to weigh the loss of fish from a system to the relative importance of information gained from accurate and precise age data.

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Western Range Expansion of the Black Sandshell Mussel in Montana

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Abstract

Newly discovered populations of the black sandshell mussel (*Ligumia recta*) from the Missouri and Marias Rivers in east-central Montana extend the species known range to its farthest western point in the United States and North America (west of 110° longitude). The black sandshell is an introduced mussel in Montana and has become common and abundant in the Missouri River drainage since its establishment in Fort Peck Reservoir in the 1940's. Despite the increased distribution of the black sandshell westward across the prairie rivers of Montana, elsewhere in their native range, the species is declining. This is a species of conservation concern in 21 states. Habitat conditions and host fish abundances that are allowing this species to thrive in Montana's rivers might provide valuable information for the conservation needs of this species in native states where it is now in decline.

Keywords: *Ligumia recta*, Black Sandshell, Freshwater Mussels, Unionidae, Montana

Introduction

The decline of freshwater mussels (Unionidae) in North America and worldwide has caused this family to be listed as one of the most imperiled on the planet (Williams et al. 1993, Allen and Flecker 1993, Stein et al. 2000). The conservation status of the black sandshell mussel, *Ligumia recta* (Lamarck, 1819) is listed as G4G5 "apparently secure" globally (G5 is globally common), because declines appear to be localized and the species maintains a wide distribution with many stable populations (Nature Serve 2013). The black sandshell is a wide-ranging species native to the eastern and central U.S. and Canada, occurring from the Great Lakes basin south into Mississippi River drainages to Louisiana and in some Gulf Coast drainages (Cummins and Meyer 1992). However, throughout much of its native distribution, the black sandshell is a species of conservation concern in 21 of the 24 states (two states [Nebraska and Georgia] report this species as possibly extirpated) in the United States and two of the four provinces in Canada (Nature Serve 2013). The American Fisheries Society also classifies the black sandshell as a North American species of special concern (Williams et al. 1993). Lately, many states are reporting that the black sandshell is becoming increasingly more difficult to find with occurrences represented by fewer individuals, and often without evidence of recruitment (Angelo and Cringan 2003, NatureServe 2013).

The black sandshell is an introduced species in Montana and has become common and abundant in the Missouri River drainage since its dispersal from glochidia (mussel propagules) attached on the gills of game fish introduced into Fort Peck Reservoir in the 1940's, as postulated by Gangloff and Gustafson (2000). Prior to the 1940's, the presence of this large (up to 20 cm) distinctive mussel was not mentioned in the extensive Missouri River collections of Henderson (1924, 1936) across Montana where there are now currently known populations. Nor have they been reported in the Missouri River downstream of Fort Peck Reservoir in North Dakota (Cvancara 1983) or in the lower Yellowstone River (Gangloff and Gustafson 2000, Stagliano 2010) (Fig. 1).

In the case of the black sandshell, suitable habitat and the presence of multiple host fish species (Percidae) in Montana's Missouri River reaches are likely two

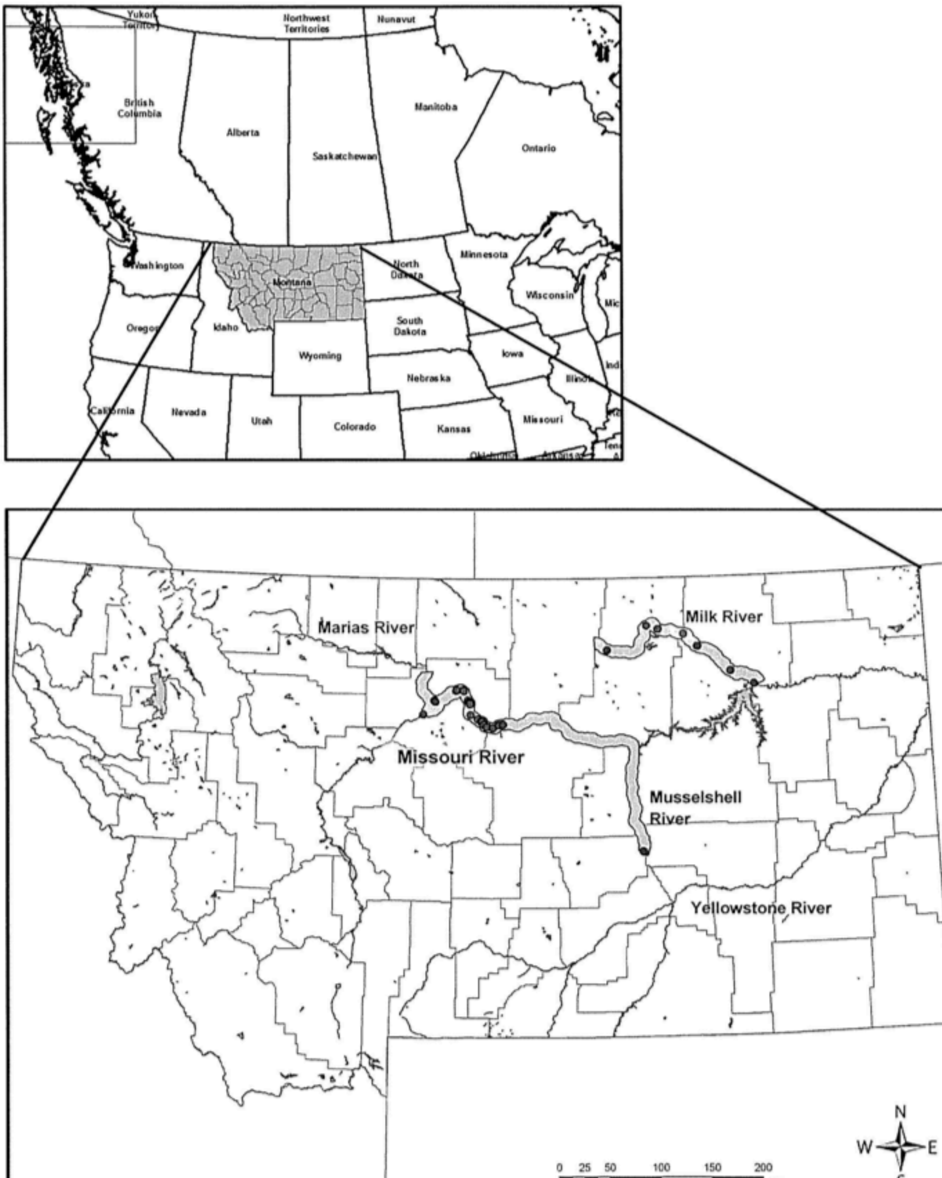

Figure 1. Black sandshell mussel records (dots) and distribution (shading) in Montana's rivers.

conditions responsible for supporting more robust and viable populations than in its native sections of the Missouri River hundreds of miles downstream in South Dakota and Iowa where it is listed as imperiled (S1) (Nature Serve 2013). Three of the known host fish species (walleye, sauger and yellow perch) (Cummins and Mayer 1992, Khym and Layzer 2000) for this mussel occur in the Missouri and Marias Rivers (MFISH 2013) which is a contributing factor to the mussel's persistence. Gangloff and Gustafson (2000) proposed that large portions of Montana's warm-water river reaches may serve as nursery refuges for non-native mussel species that are imperiled elsewhere. More recently, a newly discovered black sandshell

Table 1. Location and collection information for the westernmost black sandshell records in Montana.

Stream	4th Code HUC	Latitude	Longitude	County	Date	Observer	Site Location
Marias River	10030203	47.9442	-110.5197	Liberty	19-Aug-09	Stagliano, David	Marias River, 0.7 km upstream of Loma Bridge
Marias River	10030203	47.9323	-110.5092	Liberty	19-Aug-09	Stagliano, David	Marias River, 0.25 km upstream of Loma Bridge
Missouri River	10040101	47.7626	-110.8689	Fergus	19-Aug-09	Stagliano, David	Missouri River downstream of Carter Ferry Crossing
Missouri River	10040101	47.7633	-110.8700	Fergus	07-Sep-11	Leathe, Steven	Missouri River downstream of Carter Ferry Crossing

population in Canada has extended its range further north and west in the province of Saskatchewan (latitude 53°4 N, longitude 106°00W) (Phillips et al. 2009), but the authors do not speculate if this is an introduced population or undetected in prior surveys. Here, we report collections of the black sandshell from three locations on the Missouri (latitude 47°7 N, longitude 110°8 W) and Marias Rivers (latitude 47°9 N, longitude 110°5 W), that are approximately 26 river kilometers west (upstream) of any previously documented Missouri River occurrences and newly reported for the Marias River watershed (Table 1, Fig. 1).

Methods

From 2007-2010 the Montana Natural Heritage Program (MNHP) lead a statewide mussel survey to update historic records and determine population and distributional status of the six mussel species reported in the state (Stagliano 2010). The survey was not randomized. We targeted rivers within watersheds that had prior documented mussel records (Gangloff and Gustafson 2000) or incidental reports from anglers or biologists. We sampled at publically accessible river locations, usually highway bridges, BLM owned land or Montana Fish Wildlife and Parks Fishing Access Sites (FAS) within drainages where mussels were documented in previous reports. We used aquascopes (glass-bottomed buckets) and snorkeling along longitudinal transects moving in an upstream direction within preferred habitats of streams and rivers (Young et al. 2001). We recorded initial transect survey start and end points with a Garmin 60S GPS handheld unit, so site location and distance effort could be replicated. Time per search was recorded so that numbers of mussels could be represented as catch per unit effort (CPUE) in man-hours, as well as in mussels per unit distance (meters). Typically, we devoted at least one man-hour of search time to a site, while transect distance was determined by habitat suitability. We identified, measured and photographed live individual mussels encountered during survey transects. We placed live mussels back into the substrate as close as possible to where they were extracted. Empty shells encountered during the surveys were kept for vouchers and represented a record of species presence at the site, if live individuals were not found. Specimens of black sandshell were identified with keys (Clarke 1973, Clarke 1981, Cummings and Mayer 1992) and empty shells were sent for verification by outside malacologists. We deposited voucher specimens in the malacology collections of North Carolina State

University (Durham, NC) and the Montana Natural Heritage Program Voucher Series (Helena, MT).

Results

This study documented 32 new occurrences of the black sandshell across Montana (Fig. 1). We revisited eight of the nine previously known populations and found them viable and persisting. We found the highest black sandshell catch rates (averaging 4 individuals per hour, n = 14 sites) in the Missouri River Designated Wild and Scenic reach between Coal Banks Landing and the Judith River (3237-3163 River kilometers, rkm). In the expanding edge of the population in the Marias River (2 rkm) we found 1.5 individuals per hour of search (n = 2 sites). The identification of black sandshell mussels from Carter Ferry Crossing on the Missouri River (3282 rkm) in 2009 and 2011 increased the known distribution in that river approximately 26 kilometers further upstream than previously known from 2006 (Table 1). We also found robust populations in the Milk River, a tributary to the Missouri River whose confluence with the Missouri River is below Fort Peck Dam. These populations were from near Dodson, MT (437 rkm) downstream to Malta, MT (376 rkm), and also represent an upstream (westward) expansion of this species (Stagliano 2010) (Figure 1). The black sandshell population on the Musselshell River reported in 1998 (Gangloff and Gustafson 2000, Figure 1) was not revisited, but other Musselshell River sites upstream have been surveyed without finding black sandshell.

We collected six paired valves (shells) of the black sandshell along the stream margins of the Missouri and Marias River sites. We found four live specimens which we measured, photographed and returned to the Marias River (Table 1, Figure 1).

Montana Collections include: *Ligumia recta* (Lamarck, 1819): Marias River upstream of Loma Bridge: (47.9442 N, -110.5197 W), 19.viii.2009, D.M. Stagliano (2 live individuals, 95-100 mm). Marias River upstream of Loma Bridge: (47.93233 N, -110.50923 W), 19.viii.2009, D.M. Stagliano (2 live individuals, 100-105mm; 2 recent shells, 75 and 110 mm). Missouri River at Carter Ferry Crossing: (47.76329 N, -110.87001 W), 19.viii.2009, D.M. Stagliano (0 live individuals; 4 recent shells 90-120mm) and 7.ix.2011, S. Leathe (0 live individuals; 8 recent shells 90-140 mm). Other mussels collected in the Marias River reach were the giant floater (*Pyganodon grandis* [Say]) and the fatmucket (*Lampsilis siliquoidea* [Barnes]); while just the fatmucket was found at the Missouri River reach. The Marias River in this survey area flows through river bottom gallery forest dominated by cottonwoods, green ash and boxelders. At the time of our survey, turbidity was 8 NTUs, water temperature was 20.5°C, specific conductivity was 563µS, maximum depth was 1.5 m, and wetted width averaged 45 m. The 300m riffle, run, pool survey reach was dominated by gravels and pebbles (75%), with cobble beds in the riffle (15%) and silt depositional areas (10%). The Missouri River at Carters Ferry Crossing is a wide shallow channel (~100 m wetted width) dominated by run/glide habitat flowing through a dry valley bottom, with sparse riparian forest dominated by shrubs, green ash and few cottonwoods. At the time of our surveys, turbidity was 5 NTUs, water temperature was 21.0°C, specific conductivity was 565µS, and maximum depth in the thalwag was 2.0 m. The study reach was dominated by large cobbles (60%), with smaller sections of gravel and pebbles (25%) and silt depositional areas (15%).

Discussion

Prior to this study, only nine black sandshell occurrence records were in the MNHP database and none were reported from the Marias River (Gangloff and Gustafson 2000). The current study added 32 population records extending the range further west (upstream in the Missouri River) and north (upstream into the Marias) into east-central Montana. Including this 26 km expansion, the black sandshell currently occupies approximately 218 river kilometers of the Missouri River and 2 km of the Marias River. This upstream expansion may be even larger as we only found empty shells at the Missouri River Carter Ferry Site, no live individuals. The next Missouri River site that surveys produced no evidence of the black sandshell was 20 km further upstream.

To understand what river conditions are allowing the black sandshell to expand in Montana while the species is significantly reducing its river occupancy in native states, we evaluated two population expansion sites (Marias and Missouri Rivers). The Marias and Missouri Rivers are both large, warm-water prairie rivers that flow through sparsely and undeveloped rural ranching country of central and eastern Montana. Though largely undeveloped, both river systems experience dam-mediated, hydrologic effects from upstream reservoirs, and can be substantially affected by agricultural activities, especially irrigation. Habitat disturbance, increased siltation and environmental stresses induced by low-flow discharge and dam-flow fluctuations are cited by Pip (2000) as major causes of mussel population declines in western Canada. Dams and channelization have been casually linked to black sandshell declines in Kansas (Angelo and Cringan 2003) and Alabama (Williams et al. 1992).

Combes and Edds (2005) found mussel species richness and densities upstream of reservoirs in Kansas significantly higher than those found below the dam due to benthic habitat differences. Another indirect dam-effect occurs as mussels inhabiting shallow side channel areas in the Missouri River are left stranded during dam repair draw-down operations (author, personal observations, 2012) leaving them vulnerable to desiccation and predation. Fortunately, the Missouri River retains more natural channel characteristics and appears less impacted by dam-related effects as the river approaches the Designated Wild and Scenic Reach below Coal Banks Landing, a reach with the highest reported density of black sandshells. Preferred stable sand and gravel mussel habitats and abundant host fish populations in these Missouri River reaches are conditions that support Montana's expanding robust and viable introduced black sandshell populations compared to its native sections of the Missouri River downstream in both South Dakota and Iowa where it is state listed as imperiled (S1) (Nature Serve 2013). The main stem Missouri River flowing through southeast South Dakota and Iowa has been so severely altered by dams, diking and channelization (Funk and Robinson 1974) that few reaches retain the natural river geomorphology with stable sand and gravel runs preferred by the black sandshell (Cummins and Mayer 1992). Additionally, fish communities inhabiting these "between-the-dam" reaches of the Missouri have lost many of the native or introduced lithophilic spawners, such as walleye and sauger (Hughes et al. 2005), host fish of the black sandshell (Cummins and Mayer 1992, Khym and Layzer 2000). The presumed extirpation of the black sandshell in Kansas was partially blamed on the loss of sauger as their host fish in two watersheds where sandshells were historically abundant (Angelo and Cringan 2003). Therefore, although dams are present in Montana and can have hydrologic effects on the Missouri and Marias Rivers, natural geomorphology and abundant populations of sauger and walleye in these reaches (MFISH 2013) are overarching factors contributing to the successful colonization and expansion of the black sandshell.

The black sandshell presently occupies approximately 218 kilometers of the Missouri River with the possibility of expansion upstream by another 73 km based on habitat and host fish, while the population in the Marias River could potentially expand upstream 140 km. Thus, Montana's introduced black sandshell populations are robust and have even more potential habitat to expand into, while their distribution continues to decline in most of other states in its native range. It may, in fact, come to fruition as predicted by Gangloff and Gustafson (2000) that large portions of Montana's warm water river reaches with suitable habitat and host fish serve as viable conservation refuges for non-native mussel species that are imperiled elsewhere.

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Small Mammal Inventory of a Remediated Portion of Silver Bow Creek, Montana

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Abstract

Silver Bow Creek in southwestern Montana has been heavily impacted by past mining and smelting activities resulting in a floodplain largely devoid of vegetation and wildlife. Much of the creek has been remediated by removal of mine tailings, reconstruction of the stream channel, and floodplain re-vegetation. We gathered data on small terrestrial mammals and bat species following remediation of a portion of the creek. Small mammals were live trapped and bats were monitored using ultrasonic detectors. We determined the presence of four species of small mammals (rodents and insectivores) and four species of bats utilizing this remediated portion of Silver Bow Creek. Both capture rates of small mammals and bat activity were low compared to other studies in this part of Montana.

Key words: Small mammals, Chiroptera, bats, Montana, riparian, remediation

Introduction

Silver Bow Creek, part of the largest contiguous Environmental Protection Agency (EPA) Superfund Site in the United States, is a headwater tributary of the Clark Fork River (Gammons et al. 2006). The approximately 37- km creek passes through a historic mining area between Butte and Anaconda, Montana. Various mining and smeltering activities beginning in the late 1870s resulted in tailings, and other heavy metal contaminated mine wastes, being either discharged directly into Silver Bow Creek or into adjacent impoundments (Davis et al. 1999). In addition, several large flood events in the early 1900s washed enormous amounts of tailings from these impoundments directly into and down Silver Bow Creek and the Upper Clark Fork River (Gammons et al. 2006). The end result was a creek with little aquatic life and a floodplain largely devoid of vegetation and wildlife (NRDP 2005).

In 1983 the state of Montana filed a natural resource damage lawsuit against the Atlantic Richfield company for damages to the water, soils, vegetation, fish, and wildlife in the Upper Clark Fork River Basin including the Silver Bow Creek flood plain corridor (NRDP 2005). This lawsuit was settled in 1999 and $130 million were earmarked for remediation of these watersheds. Remediation along Silver Bow creek included excavation of tailings and impacted soil, reconstruction of the stream channel, and floodplain re-vegetation (NRDP 2005). Watershed remediation efforts have traditionally focused on re-vegetating impacted areas with the assumption that once vegetation is established, vertebrates will colonize the area (Morrison 2002).

While some monitoring work has been done on aquatic invertebrates in Silver Bow Creek, no studies have examined how other animals have responded to the remediation efforts, specifically how re-vegetation of riparian areas has influenced species present. Riparian zones are important areas for birds and mammals including bats. It has been estimated that close to 70 percent of vertebrate species in an area will use riparian corridors in some significant way during their life cycle (Raedeke 1989). The primary objective of this study was to determine small mammal and bat use of a recently re-vegetated portion of Silver Bow Creek in southwestern Montana. The specific objectives of the study were to (1) inventory terrestrial small mammals, estimate small mammal abundance, bat species composition, and bat activity in restored areas of Silver Bow Creek, (2) to determine the amount and type of vegetative cover currently in the area, and (3) to set up long-term monitoring stations that can be used to examine change in these populations over time as vegetative cover in this area increases and matures.

Methods

Study area

Our inventory was conducted along a 2-km stretch of Silver-Bow creek located between Butte and Rocker, Silver Bow County, Montana. This portion of the creek was part of subarea 1 of the streamside tailings operable unit within the Butte superfund site (NRDP 2005). The remediation in this area was completed in 2003. The study area is now part of the Montana Greenway Corridor and includes a paved path that starts at Whiskey Gulch Station and ends at Rocker Depot.

Small Terrestrial Mammal Surveys— We established 15 live-trapping grids in the remediated areas adjacent to the creek and north of the paved pathway. Each grid contained a series of trapping stations, 10 m apart. The number of trapping stations/grid depended on the size of the land between the creek and the paved pathway but ranged from 24 to 50. Universal Transverse Mercator (UTM) Coordinates were recorded at each corner of the grids and in each grid's center for future reference.

Non-folding aluminum Sherman live traps (8 × 9 × 23 cm; H.B. Sherman Trap Co), baited with peanut butter and oatmeal, were placed at each trapping station per grid. We trapped each grid for five consecutive days in July – August 2011, and we generally trapped three grids concurrently. Traps were checked each morning and again in the late afternoon during the course of the 5 days. All captured mammals were identified to species. Body mass, sex, and reproductive condition (males: testes scrotal or abdominal; females: non-perforate, perforate, pregnant, and/or lactating) were also recorded. All individuals were marked with model #1005-1 ear-tags (National Band and Tag Co., Newport, KY) for identification on subsequent captures. Each grid was surveyed once during the course of the study. Capture data on each grid were standardized to the number of individuals/100 trap night effort, where a trap night was one trap set for one night.

Vegetation Sampling.— We sampled vegetation and substrate including bare ground, along 20-m transects centered on the middle of each grid using an adaptation of the point-intercept method (Karr 1968). The direction of the first transect was chosen randomly and remaining transect directions were placed at compass increments of 45 degrees for a total of eight transect lines radiating from each trapping grid's center. We sampled points every meter along each transect for a total of 80 points/ grid.

At each sampling point, we recorded the presence of plant species/type in each of four height categories: 0.0 to 0.1 m (ground level); 0.1 -0.5 m; 0.5 – 1.0 m; > 1 m. We calculated percent cover for the plant species/types and substrates by dividing the frequency of occurrence by the total number of sampling points.

Bat Surveys.— We established 10 monitoring points along Silver Bow Creek to survey for bats. Monitoring points were located ≥500 m from one another and were adjacent to slow moving areas of the creek because bats prefer these spots for foraging and drinking (von Frenckell and Barclay 1987, Mackey and Barclay 1989). Each point was surveyed once during the study (Jul-Aug 2011).

During each survey, acoustic bat echolocation calls were monitored using a heterodyne detector (Petterson Electronic Ultrasonic Detector (Model D100,) set at

40 kHz, beginning at sunset, and continuing for 1-2 hrs depending on bat activity. If no echolocation calls were detected during the first hour the survey was stopped after that hour. An index of bat activity was determined by counting bat passes, a sequence of a bat's echolocation call from beginning to end, during 15- min periods during each night's survey. The number of bat passes during these 15-min periods was averaged to get a mean index of bat activity for that night. In addition to the heterodyne detector, we also used a Petterson D240X full spectrum bat detector (Petterson Electronics, Sweden) and an iRiver digital recorder (iRiver ifp, Reigncom Ltd., Korea) to record full spectrum echolocation calls of bats. The Petterson D240X detector was mounted on a tripod that elevated the detector about 4 feet off the ground. Recorded sound files from each night were analyzed using Sonobat 2.5 sound analysis software (Sonobat, 315 Park Ave, Arcata, California) to determine species present.

Results

Small Terrestrial Mammal Surveys

In 2492 trap nights we captured 39 individuals of four different species for an overall capture rate of 1.6 individuals/100 trap nights (Table 1). Capture rates on a trapping grid ranged from 0.5 individuals/100 trap nights to 5.5 individuals/100 trap nights. Deer mice (*Peromyscus maniculatus*) and meadow voles (*Microtus pennsylvanicus*) were the most commonly captured species. Deer mice were captured on 67 percent (10/15) of the trapping grids, while meadow voles were captured on 53 percent (8/15) of the grids. Masked shrews (*Sorex cinereus*) were captured on four of the trapping grids and one juvenile northern pocket gopher (*Thomomys talpoides*) was captured on one grid. On girds where deer mice were captured, their capture rates ranged from 0.5 to 2.0 individuals/100 trap nights, with an average of 1.13 ± 0.66 individuals/100 trap nights. On the eight grids where meadow voles were captured, their capture rate varied from 0.5 to 5.5 individuals/100 trap nights, with an average of 1.4 ± 1.7 individuals/100 trap nights.

Vegetation Sampling

At ground level (0-0.1m) all of the trapping grids contained some type of vegetative cover (Table 2). Percent occurrence of bare ground was ≤ 10 percent on the majority of grids (10/15). On all of the trapping grids, grass was the most common form of vegetation at ground level ranging from 22.5 to 96.25 percent. Unidentified forb species and clover (*Trifolium* spp.) were also present at ground level on approximately half of the grids. Dead vegetation (litter) was found at ground level on all grids and ranged from 2.5 to 33.75 percent occurrence. Above ground level (> 0.1m) grass continued to be the most common form of vegetation on all grids (Table 2). Shrubs were not abundant on the trapping grids, but some grids did contain small numbers of rubber rabbitbrush (*Ericameria nauseosa*) and willows (*Salix* spp.). While sagebrush (*Artemisia* spp.) was also present in some areas it was not detected during our vegetation surveys.

Bat Surveys

Average bat activity in the first 2 hrs after sunset ranged from 0 bat passes/15 min to 3.0 passes/15 min (Table 3). We recorded echolocation calls that were of sufficient quality to determine species based on sonograms at five of the 10 monitoring points (Table 4). Based on analyses of these calls, we determined that at least four species utilized this re-vegetated portion of Silver Bow creek. These species were silver-haired bats (*Lasionycteris noctivagans*), long legged myotis (*Myotis volans*), big brown bats (*Eptesicus fuscus*), and little brown bats (*Myotis lucifugus*).

Discussion

Re-vegetation efforts along Silver Bow Creek from Whiskey Gulch Station to Rocker Depot have resulted in vegetative cover in areas that were previously devoid of vegetation. On our trapping grids, grass

Table 1. Number of small mammals captured July-August 2011in re-vegetated areas along Silver-Bow creek from Whiskey Gulch Station to Rocker Depot, Butte Superfund Site, Silver Bow County, Montana.

Grid #	Location[1]	Number of trap nights	Total number individuals Captured	Number Captured/ 100 Trap nights	Number of Species	Number of *Peromyscus maniculatus*	Number of *Microtus pensylvanicus*	Number of *Sorex cinereus*	Number of *Thomomys talpoides*
1	E0376008 N5095446	108	6	5.5	1	0	6	0	0
2	E0376249 N5095342	140	2	1.4	1	2	0	0	0
3	E0376159 N5095415	144	1	0.7	1	0	1	0	0
4	E0376276 N5095393	200	1	0.5	1	1	0	0	0
5	E0376399 N5095388	200	2	1.0	2	1	1	0	0
6	E0376532 N5095371	200	2	1.0	1	2	0	0	0
7	E0376632 N5095358	200	4	4.0	2	2	2	0	0
8	E0376732 N5095373	200	1	0.5	1	0	1	0	0
9	E0376830 N5095373	200	2	1.0	2	1	1	0	0
10	E0376919 N5095341	200	5	2.5	2	4	1	0	0
11	E0376984 N5095383	200	3	1.5	2	0	2	1	0
12	E0377006 N5095330	100	2	2.0	1	1	0	1	0
13	E0377257 N5095380	120	4	3.3	2	0	0	3	1
14	E0377391 N5095312	120	1	0.8	1	1	0	0	0
15	E0377457 N5095357	160	3	1.9	2	1	0	2	0
All grids combined		2492	39	1.6	4	16	15	7	1

[1]Universal Transverse Mercator (UTM) Coordinates recorded in NAD 83 from the grid center.

Table 2. Vegetation data collected July – August 2011 from trapping grids in re-vegetated areas along Silver-Bow creek from Whiskey Gulch Station to Rocker Depot, Butte Superfund Site, Silver Bow County, Montana.

Percent Occurrence (0-0.1 meters)[1]									
Grid #	BG	MO	DL	CL	YA	GR	FO	RB	WI
1	5.00	0.00	11.25	16.25	42.50	67.50	0.00	0.00	0.00
2	41.25	5.00	33.75	0.00	0.00	22.50	0.00	0.00	0.00
3	0.00	5.00	15.00	12.50	8.75	78.75	0.00	0.00	0.00
4	2.50	5.00	15.00	8.75	0.00	81.25	3.75	1.25	0.00
5	10.00	8.75	10.00	2.50	0.00	78.75	0.00	0.00	0.00
6	5.00	12.50	17.50	1.25	0.00	77.50	2.50	0.00	0.00
7	1.25	3.75	11.25	5.00	1.25	82.50	1.25	0.00	0.00
8	16.25	12.50	12.50	0.00	0.00	63.75	7.50	0.00	0.00
9	3.75	3.75	3.75	0.00	2.50	92.50	0.00	0.00	0.00
10	3.75	0.00	7.50	0.00	0.00	87.50	2.50	0.00	0.00
11	6.25	5.00	12.50	1.25	1.25	76.25	1.25	0.00	0.00
12	12.50	0.00	2.50	0.00	0.00	78.75	0.00	0.00	0.00
13	0.00	0.00	3.75	0.00	0.00	96.25	5.00	0.00	0.00
14	18.75	0.00	18.75	0.00	1.25	62.50	2.50	0.00	0.00
15	11.25	0.00	7.50	0.00	0.00	77.50	6.25	0.00	0.00

Percent Occurrence (0.1-0.5 meters)						
Grid #	CL	YA	GR	FO	RB	WI
1	21.25	27.50	77.50	1.25	0.00	0.00
2	0.00	0.00	67.50	0.00	0.00	0.00
3	30.00	6.25	88.75	7.50	0.00	5.00
4	15.00	1.25	92.50	7.50	1.25	0.00
5	5.00	0.00	86.25	0.00	1.25	0.00
6	2.50	0.00	87.50	5.00	2.50	0.00
7	13.75	5.00	93.75	8.75	0.00	0.00
8	0.00	0.00	92.50	36.25	0.00	0.00
9	0.00	1.25	95.00	2.50	0.00	1.25
10	0.00	0.00	90.00	3.75	0.00	1.25
11	1.25	1.25	88.75	3.75	22.50	0.00
12	0.00	0.00	91.25	0.00	0.00	0.00
13	0.00	0.00	98.75	5.00	0.00	0.00
14	0.00	2.50	81.25	8.75	0.00	0.00
15	1.25	0.00	86.25	23.75	0.00	0.00

	Percent Occurrence (0.5-1.0 meters)				Percent Occurrence (>1 meters)			
Grid #	GR	FO	RB	WI	GR	FO	RB	WI
1	43.75	1.25	0.00	0.00	2.50	0.00	0.00	0.00
2	12.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	33.75	0.00	0.00	11.25	1.25	0.00	0.00	6.25
4	27.50	5.00	1.25	0.00	1.25	0.00	1.25	0.00
5	18.75	0.00	0.00	0.00	2.50	0.00	0.00	0.00
6	28.75	0.00	0.00	0.00	2.50	0.00	0.00	0.00
7	56.25	0.00	0.00	0.00	12.50	0.00	0.00	0.00
8	10.00	7.50	0.00	0.00	2.50	0.00	0.00	0.00
9	25.00	0.00	0.00	1.25	3.75	0.00	0.00	0.00
10	25.00	1.25	0.00	3.75	1.25	0.00	0.00	6.25
11	26.25	1.25	18.75	0.00	2.50	0.00	0.00	0.00
12	58.75	0.00	0.00	0.00	25.00	0.00	0.00	0.00
13	51.25	1.25	0.00	0.00	7.50	0.00	0.00	0.00
14	26.25	0.00	0.00	0.00	5.00	0.00	0.00	0.00
15	50.00	16.25	0.00	0.00	10.00	2.50	0.00	0.00

[1]DL= dead litter, CL= clover (*Trifolium* spp.), YA= common yarrow (*Achillea millefolium*), GR= grass, FO= forbs, RB= Rabbitbrush (*Ericameria nauseosa*), WI= willow (*Salix* spp.), BG= bare ground, MO= Moss.

Table 3. Bat activity along Silver-Bow creek from Whiskey Gulch Station to Rocker Depot, Butte Superfund Site, Silver Bow County, Montana, July - August 2011.

Location	Date surveyed	Average number of passes per 15 minutes + standard deviation (N)
E0376079 N5095442	7/10/2011	1.17 + 1.94 (6)
E0375995 N5095436	7/13/2011	1.40 + 1.94 (5)
E0376298 N5095416	7/19/2011	0.00 + 0.00 (4)
E0376376 N5095436	7/21/2011	1.33 + 1.03 (6)
E0377824 N5095222	7/26/2011	2.17 + 1.94 (6)
E0377284 N5095339	7/28/2011	2.00 + 1.41 (6)
E0377681 N5095246	8/3/2011	0.83 + 1.17 (6)
E0377822 N5095221	8/4/2011	1.00 + 0.63 (6)
E0377310 N5095369	8/12/2011	3.00 + 1.26 (6)
E0377222 N5095394	8/20/2011	0.00 + 0.00 (4)

Table 4. Bat species present along Silver-Bow creek from Whiskey Gulch Station to Rocker Depot, Butte Superfund Site, Silver Bow County, Montana, July - August 2011.

Location	Date surveyed	Species present
E0377824 N5095222	7/26/2011	*Lasionycteris noctivagans* *Myotis lucifugus* *Myotis volans*
E0377284 N5095339	7/28/2011	*Lasionycteris noctivagans* *Myotis lucifugus*
E0377681 N5095246	8/3/2011	*Lasionycteris noctivagans* *Myotis lucifugus*
E0377822 N5095221	8/4/2011	*Lasionycteris noctivagans* *Myotis lucifugus*
E0377310 N5095369	8/12/2011	*Eptesicus fuscus*

was the most common type of vegetation at both ground level and above. Although we did not differentiate among grass species, this area was planted with a drought tolerant seed mix that consisted of equal parts indian rice grass (*Achnatherum hymenoides*), bluebunch wheatgrass (*Pseudoroegneria spicata inermis*), prairie sandreed (*Calamovilfa longifolia*), and lesser quantities of Canada wildrye (*Elymus canadensis*) and prairie Junegrass (*Koeleria macrantha*).

Deer mice and meadow voles were the most common species captured in the re-vegetated areas adjacent to Silver Bow creek. These species are widely distributed throughout the state (Foresman 2012), and both were the two most common species captured at other study sites in southwestern Montana (Kuenzi et al. 2001, Douglass et al. 2001). Capture rates were low on all grids, averaging ~ 1 individual/100 trap nights. These are lower than previous studies in southwestern Montana. Waltee et al. (2009)

reported summer capture rates of deer mice over a three year period as between 1.8 – 4.9 individuals/100 trap nights at one study site and between 18-22 individuals per 100 trap nights at another. Both deer mice and meadow vole populations in the state have been found to fluctuate widely over time and space, with peaks approximately five times higher than the lows (Douglass et al. 2001).

Bat activity was low during the course of this study compared to a nearby more established riparian area, Blacktail Creek, where average activity in July was 21.67 passes/15 min (Kuenzi unpublished data). Bat activity is highly variable both spatially (Ober and Hayes 2007) and temporally (Kuenzi and Morrison 2003) and is influenced by many environmental factors including insect abundance (Hagen and Sabo 2014). High levels of bat activity along waterways have been found to be correlated with the emergence of aquatic insects (Hagen and Sabo 2012) which varies temporally (Corbet 1964). The low level of bat activity we detected may be due to low insect abundance. Future work in the area should take this variable into consideration.

Even though bat activity was low, we detected presence of four bat species utilizing this portion of Silver Bow Creek. All four species have been found to be fairly common in other riparian areas in Silver Bow County as well as other counties in southwestern Montana (Lamarr and Kuenzi 2011).

The main objective of this study was to inventory small mammals using a remediated portion of Silver Bow creek. Prior to remediation, this area was devoid of vegetation. While we were unable to conduct a pre-restoration inventory, it is likely that small mammals were not present due to the lack of vegetative cover. Our inventory is limited by its short duration and small data set but it provides a baseline for future inventories and/or monitoring efforts.

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Biological Sciences – Terrestrial

Presentation Abstracts

Montana Chapter of the Wildlife Society 52nd Annual Meeting

Splitting the Baby? Public Trust, Multiple Use and Current Policy in Wildlife Management

March 4 - March 7, 2014

Bozeman, Montana

Kristina Boyd, President 2014-15
Montana Chapter of The Wildlife Society

I gape at the complex tapestry of wildlife policy that has been woven over the past century in our state, and the concepts that color it from much further back and wider in history. Whether considering the interplay of Native American hunting rights with state game management regulations and private land rights during my Master's research, working on NEPA analyses for the Forest Service, or interpreting ESA wording for wolf depredation response during my time with MFWP, I always felt uneasy when it came to understanding where I fit into the policy picture as a wildlife biologist.

When I had to come up with a conference theme, it was those experiences that boiled to the top and left me with this raft of disquietude to examine for clues. Underneath it all I wondered whether the concept we work toward as management biologists, essentially the orchestration of human activity for the perpetuity of wildlife and its habitat, ultimately works in the favor of wildlife. Or, will wildlife and its habitat, so beloved by so many people for so many reasons, ultimately be torn asunder in the gaping maw of clashing policy?

I pictured the tale of King Solomon facing two women both desperately bereaving a lost infant and a living one. As he raised his hand to split the living infant in two - a fair compromise – the true mother, as the tale goes, reneged her claim on the child in order to save its life. As biologists and citizens, we strain to influence wildlife and habitat constituencies through both the concepts of public trust and multiple use; to redirect a most basic human desire to hold something, use something, own something that fulfills them and channel it productively. But we are constantly pushed and pulled by forces beyond our control that are also driven by this same desire. In the face of this, can we even hope to split the baby, to manage wildlife, like sagacious Solomon? What do we need to know about ourselves, our constituencies, our political history and current surroundings in order to be successful in our work? I don't have answers, just questions. I hope that our presenters will offer a long perspective as well as inspire a creative inquisitiveness in us that will help us navigate our work world with humble sagacity and abundant enthusiasm.

Alphabetical by First Author's Last Name
(* Denotes Presenter)
(Indicates Student Presentation or Poster)**

Brucellosis in Montana Elk: Factors that Influence Disease Prevalence and the Social And Political Influences and Issues Associated with Managing a Disease of Concern for Livestock in a Free-Ranging Elk Population

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Brucellosis is a bacterial disease that affects elk (*Cervus elaphus*), bison (*Bison bison*) and domestic cattle. Transmitted primarily through contact with birth tissues, the disease is a significant livestock disease resulting in significant costs to producers and is a USDA eradication program disease. Brucellosis was first documented in wildlife in the Greater Yellowstone Area (GYA) in the early 1900s and was brought into the region by livestock producers. The disease has since been eradicated in livestock, but persists in elk and bison populations of the GYA. Recently the seroprevalence of brucellosis in free-ranging elk populations of Montana has increased and its range has likely expanded resulting in increased pressure on Montana Fish, Wildlife and Parks (MFWP) to manage the disease in elk. We evaluated factors that potentially influence elk aggregation behaviors and the consequences of these factors on seroprevalence. We used a Bayesian spatial model to estimate seroprevalence across the designated surveillance area. This research approach allowed seroprevalence to be estimated for the first time in areas with limited surveillance data. The socio-political influences associated with managing wildlife potentially infected with a disease that threatens the cattle industry of Montana, the available tools for managing the disease in elk, and MFWP's current strategy for managing brucellosis in one of Montana greatest public trusts is discussed.

**Indirect Effects of Nonnative Brome Grasses on Small Mammals in Sagebrush Steppe Ecosystems

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Nonnative plants can affect habitat quality for native animals directly, by altering available resources like cover or food, and indirectly, by changing access to these resources and altering species interactions. Understanding these diverse effects is crucial to develop management techniques and maintain ecosystem processes. In sagebrush steppe, brome grasses such as cheatgrass (*Bromus tectorum*) and smooth brome (*Bromus inermis*) can invade and form dense stands, increasing the depth and persistence of litter, as well as the density of standing

vegetation. These structural changes alter abundance and composition of the small mammal community. We used a series of experiments to explore whether changes in vegetation structure associated with the invasion of brome grasses would alter foraging and predation risk for small mammals. In the first experiment, we placed a known amount of grain at stations with increased litter or stem density and measured how much grain was removed overnight. Increased litter impeded foraging; rodents removed 2.8 g (95% CI = 2.09 to 3.05) less grain from these stations. In the second experiment, we timed animals fleeing a simulated predator through various densities of litter or stems and found that dense stems impeded movement more than litter. Based on these experiments, dense monocultures of brome grasses may reduce habitat quality for small mammals by making foraging less efficient and increasing vulnerability to predators. Management techniques for brome grasses should focus on reducing stem density where predation limits small mammal populations and litter where small mammals are food-limited.

The Future Of American Bison: Domesticated Or Wild? (Oral Presentation & Poster)

James A. Bailey, Wildlife Biologist Retired, Belgrade, Montana 59714

I proceed from 3 assumptions: (1) Natural selection is necessary to maintain wild bison (Bison bison). (2) We don't leave bison to future generations; we leave the bison genome. (3) Wildness is the opposite, in a continuum, from domestication. South of Canada, more than 200,000 bison are being domesticated in about 4500 private, commercial herds. In contrast, there are about 44 conservation herds owned by government agencies, the Nature Conservancy and American Prairie Reserve. In these conservation herds, natural selection is weakened or replaced by synergistic actions of (1) cattle-gene introgression; (2) founder effects; (3) inbreeding; (4) genetic drift; and (5) artificial selection. I review the prevalence of 12 management practices diminishing natural selection in these conservation herds, and promote a broader understanding and appreciation of the needs and values of wildness in American bison.

Livestock Management for Coexistence with Large Carnivores, Healthy Land And Productive Ranches: A Viewpoint

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The livestock – large carnivore coexistence field can be more effective by expanding from a direct focus on carnivores and predation-prevention tools to the context of livestock management and the broader social-ecological systems of ranches and rural communities. Ranchers may be able to apply many of the same approaches that work for rangeland health and livestock production to reduce conflicts with large carnivores. Generally, in the presence of their predators, wild grazing animals tend to form large, dense herds that then move around the landscape to seek fresh forage, avoid fouled areas, and escape predators. They also tend to have their young in short, synchronized birthing seasons (predator satiation). Grazing management involving high stocking density and frequent movement, such as rotational grazing and herding with low-stress livestock handling, can improve rangeland health and livestock production, by managing the distribution of grazing across time, space, and plant species. Short calving seasons can increase livestock production and reduce labor inputs, especially when timed to coincide with peak availability of forage quality.

Livestock management, including grazing management and calving in short seasons that correspond with those of wild ungulates, may directly and synergistically reduce predation risk, while simultaneously establishing a management context in which other predation-prevention practices and tools can be used more effectively. Pilot projects on summer cattle range in western Montana involving increased stocking density through intensification of existing grazing rotations with herding suggest methods that can be used to improve grazing distribution and prevent depredations.

Black Swifts in Montana: Finding New Nesting Sites and What's Next for This Elusive Bird

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Until a few years ago, Black Swifts (*Cypseloides niger*) were only known to nest at three sites in Montana. With concerted efforts over the last few years by Montana Fish Wildlife and Parks, Glacier National Park, and intrepid volunteers, we have now added to our known nesting sites in Montana. Black Swifts nest behind waterfalls, often in remote and challenging terrain. Through these recent efforts, we have learned how best to successfully identify possible nesting sites, increasing our understanding of where this rarest of birds breeds in Montana. Black Swifts are a Montana Species of Concern because of their small population size, restricted breeding range, lack of monitoring, and threats from a changing climate. We explore these issues and share plans for a collaborative research and outreach effort for 2014 and beyond. We also examine how Montana's findings fit into a broader, regional effort to better understand and conserve this species.

Glacier National Park Bat Inventory and Monitoring Project

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Prior to 2011, no formal bat surveys had been conducted in Glacier National Park (GNP). Given concerns about high bat mortalities due to the continual spread of white-nose syndrome (WNS) and placement of wind energy facilities, it was critical to learn about GNP's bat diversity, abundance, and distributions before these risks could potentially impact our populations. Of the 11 potential species in GNP, six are Montana (or potential) species of concern. Three years of surveys have now been completed. Survey techniques included mist-netting, acoustic surveys, bridge, building, and cave inspections. To date, we have mist-netted bats over 44 nights in 24 sample units (grid cells-each unit 10 km^2) in GNP, processing a total of 700 individuals. Results indicated no sign of WNS. In addition, we conducted nighttime acoustic surveys at 97 different locations within 31 grid cells. Thus far, we have confirmed nine different bat species throughout the park and added three new bat species to the mammals list for GNP. Acoustic surveys have also confirmed the presence of hibernating bats in the winter. The two most commonly captured bats were the little brown myotis (*Myotis lucifugus*) and the hoary bat (*Lasiurus cinereus*). GNP may be one of the most substantial migratory routes for hoary bats across North America. Plans include continuing with the inventory phase by surveying additional grid cells using both acoustic and visual techniques, and focusing on long-term monitoring using acoustic sampling and systematic and repeatable counts of little brown bat maternity roosts.

Kootenai River Operational Loss Assessment Methodology and its Application to Habitat Restoration

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Libby dam regulates in-stream flow of the Kootenai River through Montana, Idaho, and into Canada. The floodplain and associated biotic communities are strongly influenced by riverine system alterations. In order to assist with habitat restoration work, an assessment tool was developed that defines ecologically functional impacts to the Kootenai River floodplain and its vegetative, aquatic, and wildlife communities. This assessment tool includes; hydrologic models for historic flows, anthropomorphic floodplain alterations, post-dam flows, and sturgeon flow releases; an Index of Biological Integrity for insect and avian communities; vegetative cover estimates within sample plots; and an index of human disturbance. In addition, summary indices of ecological integrity were compiled. This assessment tool is being used to identify areas on the Kootenai River for habitat restoration and/or protection. Some of the tool's uses and implications are identified.

Grizzly Bear Abundance and Density in The Cabinet-Yaak Ecosystem

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Cabinet-Yaak Grizzly Bear DNA Project Study Team[1]

We use genetic detection data from concurrent hair corral and bear rub sampling to provide abundance and density estimates for the threatened grizzly bear (*Ursus arctos*) populations in the Cabinet Mountain and Yaak regions in northwestern Montana and northern Idaho collectively known as the Cabinet-Yaak Ecosystem (CYE). We used Huggins models in Program MARK and model averaging to generate region- and sex-specific abundance estimates. To estimate the average number of bears present, we estimated mean bear residency on our sampling grid from telemetry data and used it to correct our super population estimates for lack of geographic closure. Total grizzly bear abundance in the CYE in 2012 was 49 (95% CI: 44-62) with an average of 45 (95% CI: 42-65) present at any one time. Population size in the Cabinet and Yaak regions was equal: Cabinet: 22 (95% CI: 20-36); Yaak: 22 (95% CI: 22-39). Grizzly bear density in the CYE was 4.5 (95% CI: 3.7-5.3) grizzly bears/1000 km^2. With parentage analysis, we document the first natural migrants to the critically low and interbred Cabinet population and the Yaak population by bears born to parents in neighboring populations. These events support data from other sources suggesting that the expansion of neighboring populations may eventually help sustain the CYE populations.

[1] The Cabinet-Yaak Grizzly Bear DNA Project Study Team provides interagency oversight to this study and facilitates communication among project partners. Members are: K. Kendall-Leader (US Geological Survey (USGS)), L. Allen (US Forest Service (USFS)-Idaho Panhandle NF), K. Annis

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New GIS Tools for Implementing Broad-Scale Wildlife Connectivity Models in Land Use Planning and Management

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Wildlife habitat connectivity at regional scales is necessary for the conservation of wide-ranging species and to provide opportunities for species to respond to a changing climate. Conservation planning and wildlife management must incorporate a broad-scale perspective to provide the best chance for long-term persistence of complete species assemblages. Much of the crucial linkage habitat in the U.S. Northern Rockies occurs on private lands at lower elevations. Therefore, land use decisions that ultimate influence broad-scale connectivity occur at fine (parcel level) scales. The ability to integrate broad-scale conservation planning that wildlife need with the scales where decisions are made has been difficult. New GIS tools provide advances in multi-scale conservation planning. These tools assist decision makers in identifying opportunities, setting priorities, and targeting actions at very fine scales but within the context of regional planning. These tools also facilitate scenario analysis to allow practitioners to as "what if" questions and help them understand potential outcomes of proposed actions.

Habitat Characteristics of a Southern Fringe Greater Sage Grouse Population: Implications For Range-Wide Management

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Range-wide declines in Greater Sage-Grouse (*Centrocercus urophasianus*) populations have prompted extensive research on sage grouse habitat use. However, habitat use information for fringe populations is limited. We examined nest, brood-rearing, and summer habitat use in a fringe sage-grouse population in southern Utah. We tracked 66 birds (17 females, 49 males) via VHF telemetry and surveyed vegetation plots at nest (n = 9), brood-rearing (n = 13), summer (n = 53), and random (n = 75) locations in 2011 and 2012. Although hens did not select for measured habitat characteristics (shrub, forb, grass, and bare ground) at nest sites, they did select for higher forb cover at brood-rearing sites as compared with random sites. The canopy cover of forbs and grasses at nest and brood-rearing sites was lower than range-wide habitat recommendations, while the shrub cover was greater. Non-reproductive sage grouse selected for lower shrub but higher forb and grass cover as compared with random sites. Their roost sites were characterized by higher shrub and lower forb and grass cover than range-wide recommendations for productive habitat. Discrepancies between sage-grouse habitat use in this population and range-wide recommendations may be explained by differing ecosystem dynamics in southern Utah, as well as unique habitat use patterns observed in fringe populations. The use of agricultural fields for summer habitat exemplifies a local adaptation to the absence of productive habitat that has unique

management implications. This study highlights the importance of adaptive management techniques that address unique habitat preferences in local populations, particularly for a sensitive species.

**Correlates of Recruitment in Montana Bighorn Sheep Populations

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Relatively little is known about bighorn sheep (*Ovis canadensis*)population dynamics across Montana. In an effort to improve understanding of bighorn recruitment, we summarized demographic data collected by Montana Fish, Wildlife and Parks for 48 bighorn populations in five ecological regions (eco-regions) across Montana. For 22 bighorn populations, data were adequate for use in multiple linear regression estimation of baseline recruitment rates (indexed by lamb:ewe ratios) and to evaluate relationships between recruitment rates and annual variation in weather conditions and all-age disease die-off events. After accounting for all-age disease die-off events, recruitment rates of populations in three eco-regions were very similar, one had lower recruitment rates than all others in the state, and one had recruitment rates that were not comparable to others due to timing of data collection. There was substantial variation in baseline recruitment rates of populations within eco-regions. After all-age disease die-off events, recruitment rates were typically severely reduced for multiple years. Recruitment rates of individual populations were related to the average number of animals counted in a population, with small populations having lower baseline recruitment rates than those for larger populations. We failed to detect consistent correlations between recruitment and annual weather conditions across populations. We suspect that the small size of many bighorn populations in Montana limits biological insight that can be gained, as accurate demographic data are difficult to collect from small populations, and small populations can be strongly influenced by unpredictable, chance events.

USDA Forest Service and Montana Fish Wildlife and Parks Collaborative Overview and Recommendations for Elk Habitat Management on the Custer, Gallatin, Helena and Lewis and Clark National Forests

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A group of wildlife biologists from the USDA Forest Service (FS) and Montana Fish, Wildlife, and Parks (MFWP) have compiled recommendations for elk (*Cervus elaphus*) habitat management. While we focus on elk habitat considerations in this effort, we do not advocate for single species management. We advocate for ecologically appropriate habitat management under an umbrella of landscape scale ecosystem management, which focuses on providing a range of habitats to support all fauna native to the landscape, including elk.

The recommendations are based on the most current available information and the collective experiences of these biologists. They considered contemporary issues and circumstances such as increases in recreation of all types on these National Forests, changes in the numbers and distribution of elk, the restoration of large predators, the current mountain pine beetle epidemic, and small and large fires on the Custer, Helena, Lewis and Clark, and Gallatin National Forests in the Northern Region of the FS. The shared goal of the two agencies is to provide for elk and other big game on National Forest System (NFS) lands throughout the year, recognizing that with the multiple use mandate of the FS, management for elk will be one of many considerations on NFS lands. The overview and recommendations address an appropriate elk analysis unit, management of cover and recreation on winter ranges, security during the archery and rifle hunting seasons, motorized route management relative to habitat effectiveness, cover on spring-summer-fall ranges, cover patch size, and forage considerations.

BLM Planning and Implementation: Successes, Challenges and Opportunities

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This presentation discusses/illustrates the USDI Bureau of Land Management (BLM) multiple use issue analysis and resolution at two different scales: the Resource Management Plan (RMP) policy scale and the applied project scale. BLM RMPs will be discussed with specific examples of how RMPs guide future management decisions. Greater sage grouse (*Centrocercus urophasianus*) will be used as a primary example. Seven RMPs in the Montana/Dakotas had drafts for RMP revisions or Greater sage grouse RMP amendments in 2013. Guidance contained in the RMP establishes sideboards for project alternatives and what may be considered. The Crooked Creek Project in the Lewistown Field Office will be covered to illustrate how projects are planned within the framework of an RMP to achieve specific conditions on the ground and the tools, information, and experience used to develop these actions. Finally, examples of applied efforts to improve wildlife habitat across BLM lands in the Montana/Dakotas will be demonstrated.

Montana Audubon's Riparian Bird Research and Conservation: What's New, What's Next?

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Audubon's Important Bird Area (IBA) program is a data-driven, science-based approach for on-the-ground conservation projects. We will describe how our current IBA program is working: how we collect bird data, use these data to map key riparian areas, connect with our partners and volunteers, work toward habitat protection and enhancement, and use our knowledge to affect policy. We report on recent data collection efforts on key species, including Lewis's woodpeckers (*Melanerpes lewis*), red-headed woodpeckers (*Melanerpes erythrocephalus*), and Black-billed Cuckoos (*Coccyzus erythropthalmus*). We will also share various educational products and stories that resonate with those who care about birds, own and manage the land, and who advocate for wildlife conservation—from Best Management

Practice brochures to multi-media films. Finally, we outline how we are prioritizing our IBA work and plans for the future.

Influence of Whitebark Pine Decline on Fall Habitat Use and Movements of Grizzly Bears in the Greater Yellowstone Ecosystem

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Seeds of whitebark pine (WBP; *Pinus albicaulis*) are a major food item for grizzly bears (*Ursus arctos*) in the greater Yellowstone ecosystem. Higher rates of bear mortality and bear-human conflicts are linked with low WBP productivity. Recently, infestations of mountain pine beetle (Dendroctonus ponderosae) have killed many mature, cone-bearing WBP trees. We investigated whether this decline caused bears to reduce their use of WBP and increase use of areas near humans. We used 52,332 GPS locations of 72 individuals (89 bear-years) monitored during fall (15 Aug–30 Sep) to examine temporal changes in habitat use and movements during 2000–2011. We calculated a Manley-Chesson (MC) index for selectivity of mapped WBP habitats for each individual within its 100% local convex hull home range, and determined dates of WBP use. One third of sampled grizzly bears had fall ranges with little or no mapped WBP habitat. Most other bears (72%) had a MC index > 0.5, indicating selection for WBP habitats. Over the study period, mean MC index decreased and median date of WBP use shifted about 1 week later. We detected no trends in movement indices over time. Outside of national parks, 78 percent of bears selected for secure habitat (areas ≥ 500 m from roads), but mean MC index decreased over the study period during years of good WBP productivity. The foraging plasticity of grizzly bears likely allowed them to adjust to declining WBP. However, the reduction in mortality risk associated with use of WBP habitat may be diminishing for bears in multiple-use areas.

Annual Timing of Elk Abortions and Potential Brucellosis Risk

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The transmission of *Brucella abortus*, the bacteria causing brucellosis, occurs through abortion events. In this study, we investigated the timing of those abortion events using

vaginal implant transmitters (VITs) in pregnant elk (*Cervus elaphus*) from the Jackson and Pinedale regions of Wyoming. From 2006 to 2013, we captured 463 pregnant female elk and 136 of those were seropositive (29%, 95% CI = [25, 34]). We had a total of 29 abortion events with 20 percent (95%CI = [13, 29]) of seropositive elk aborting compared to 2.2 percent (95% CI =[0.8, 4.5]) of seronegative elk aborting. VIT data are left-truncated, right and interval censored. We analyzed these data in a Bayesian framework borrowing from the survival analysis literature to estimate the baseline hazard and how it changes during the year. When we conducted a joint analysis of both abortions and births our preliminary results indicated that elk abortions are concentrated in March and April. Only three abortions occurred after 20 May and one may have occurred as late as 10 July. These results are relevant to mitigating the risk of transmission between elk and cattle. Future work can build upon these results to assess the amount of brucellosis transmission risk during the winter on private land compared to public grazing allotments, which are used later in the year.

Bighorn Sheep Translocation: Two Case Studies from the Ground

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Bighorn sheep (*Ovis Canadensis*) translocation is a major tool towards meeting bighorn population recovery goals statewide. However, finding and establishing release sites requires navigating a complex series of biological, political, and social evaluations. Here, we present two case studies of bighorn sheep relocation proposals in southwestern Montana followed from the idea phase through (near) resolution: the Bridger Mountains and the Madison Mountains. Both historic bighorn winter ranges, these two proposed locations differed in their biological, political, and social considerations. We discuss the model and timeline we used to meet biological criteria (defined by Montana's Bighorn Sheep Conservation Strategy), political checks proposed in Montana's Senate Bill 83 (mandatory criteria for bighorn sheep transplantation), and the social needs of landowners, Montana's sportsmen and the Fish, Wildlife and Parks commission. This involved defining the proposed habitat (or affected area), contacting all landowners within or near the expected habitat, involving all stakeholders (county commissioners, sportsmen, Montana Woolgrowers, USDA Forest Service, and others), identifying domestic sheep herds nearby to quantify disease risk (and determining how to mitigate such risk if possible), assessing other major issues (highways, predators, subdivisions), developing the Environmental Assessment, employing landowner agreements, and finalizing the project. These case studies provide information to other biologists seeking to release bighorn in their areas. Recognition of non-biological needs and careful a *priori* evaluation can save time and effort and maximize the chance of biological success.

**Modeling Summer Habitat Selection of Sympatric Bighorn Sheep and Mountain Goats in the Greater Yellowstone Area

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With introduced mountain goat (*Oreamnos americanus*) populations continuing to expand throughout the mountainous regions of the greater Yellowstone area (GYA), wildlife managers

have expressed a need for reliable information to understand mountain goat ecology specific to this region as well as any potential impacts to native species and communities, especially to native and restored bighorn sheep populations. In response to this need for ecological knowledge, we developed and implemented rigorous occupancy survey methodologies in two study areas for three field seasons (2011-2013). A total of 611 surveys were performed over 550 observer-days, capturing spatially-precise locations of 128 bighorn sheep groups and 286 mountain goat groups. These data are being used to develop fine-scale summer habitat-selection models for both mountain goats and bighorn sheep that account for imperfect detection. This presentation reports on the accomplishments from the three field seasons, including what we have learned from preliminary analyses and the next steps to completing a full analysis of the data. Products from this research will provide insight into the potential for resource competition between bighorn sheep and mountain goats. Development of a mountain goat habitat-selection model will also allow prediction of range expansion of mountain goats into the extensive ranges of bighorn sheep in the eastern mountains of the GYA where small numbers of colonizing mountain goats have recently been observed.

**Compensatory Mortality in a Multiple Carnivore System: Consequences for Elk Calf Survival and Elk Population Dynamics in the Southern Bitterroot Valley

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The recent expansion of large carnivores in North America may dramatically alter the population dynamics of their primary ungulate prey species. In response to declining elk (*Cervus elaphus*) calf recruitment in the southern Bitterroot Valley of Montana, we initiated a 3-yr study to determine the relative importance of top-down and bottom-up processes in explaining elk recruitment rates. We predicted that forage quality would interact with predation risk across the landscape, causing predation on elk calves to become more compensatory in areas of higher forage quality. Continuous-time survival modeling will be used to estimate the relative importance of bottom-up and top-down processes in explaining calf survival, and test the interaction of predation risk and forage quality. Overall, male elk calves have a 62.7-percent higher risk of mortality than females, and annual survival rates have significantly varied among years, with estimates of 0.27 in 2011, 0.42 in 2012, and 0.55 thus far in 2013. Mountain lions (*Puma concolor*) are the most important mortality source for elk calves, with cause-specific mortality rates of 0.17 for lions; 0.04 for black bears (*Ursus americana*); 0.03 for wolves (*Canis lupus*); 0.08 for unknown predators; 0.10 for unknown; 0.04 for natural, non-predation; and 0.008 for human-related events. Calf survival data, together with adult survival, nutrition, and carnivore population data, will be used to develop an integrated population model to forecast the effect of habitat and carnivore densities on elk population trends. This tool may help managers balance carnivore and ungulate population objectives and is applicable across all areas experiencing carnivore recovery.

**ESTIMATING GRIZZLY BEAR USE OF LARGE UNGULATE CARCASSES WITH GPS TELEMETRY DATA

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Ungulate meat is among the most calorie-rich food sources available to grizzly bears (*Ursus arctos*) in the greater Yellowstone ecosystem (GYE). However, the ephemeral and unpredictable nature of carcasses makes them difficult to study and their influence on grizzly bear foraging and spatial ecology is poorly understood. We developed a spatial-clustering technique specifically for detecting grizzly bear use of large ungulate carcasses using Global Positioning System (GPS) telemetry locations (n = 54 bear years). We used the DBScan algorithm to identify GPS clusters of individual bears (n = 2,038) and intersected these clusters with an independent dataset of site visits to recent bear movement paths based from randomly selected days (n = 732 site visits; 2004–2011) resulting in 174 clusters associated with field measured bear behavior. Using a suite of predictor variables derived from GPS telemetry locations, e.g., duration of cluster, area used, activity sensor values, re-visitation rate, we used multinomial logistic regression to predict the probability of belonging to each of the five response classes (resting, multiple-use, low-biomass carcass, high-biomass carcass, old carcass). Focusing on the high-biomass carcass category, for which our top model correctly classified 88 percent of the carcasses correctly, we applied our approach to a larger dataset of GPS data to examine trends in large-ungulate carcass using of grizzly bears in the GYE from 2002-2011. We found quantitative support for a positive effect of year and mortality adjusted white bark pine cone counts on the carcass-use index during the fall months (Sep and Oct) from 2002-2011.

MULTIPLE USE ON MOUNT JUMBO IN MISSOULA, MONTANA — BALANCING WILDLIFE RESOURCE VALUES, PUBLIC RECREATIONAL OPPORTUNITIES AND LAND MANAGEMENT

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Between 1996 and 1998, the City of Missoula, Montana Fish, Wildlife and Parks (MFWP), and the USDA Forest Service acquired 1650 acres on Mount Jumbo in the northern Missoula Valley to protect winter range for elk (*Cervus elaphus*) and other wildlife, to preserve the viewshed and its associated habitats, and to provide public recreational access

and opportunities. Multi-governmental management of the mountain has included establishing a public lands advisory committee, implementing a conservation lands management plan, establishing a bighorn sheep/domestic sheep interaction policy, and instituting a seasonal public closure and educational program to protect wintering ungulates. Over time, the need and political pressures to manage forested habitats on these lands in the wildland-urban interface have pushed land management and conservation efforts to the next level, especially on the City's conservation lands. To ensure that additional forest management treatments do not negatively affect the Jumbo elk herd and other wildlife, the City of Missoula and MFWP personnel have increased elk survey and inventory efforts on the mountain and incorporated a citizen scientist-based program to not only gather important management data, but also to expand public involvement, awareness and education of the overall resource values of the area. This presentation will include discussions on the cooperative management strategies implemented to conserve the wildlife resources of Mount Jumbo, while balancing public recreational opportunities and forest and other habitat management prescriptions.

Relating Climate Data to Whitebark Pine Cone Production in South-Central Montana

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Whitebark pine (*Pinus albicaulis*) is a critical species for grizzly (*Ursus arctos*) and black bears (*Ursus americana*)in the Greater Yellowstone Area. Being able to predict the number of cones that will be produced in a year or two would help with the management of these species. There is a strong correlation between cone production and Black Bear harvest. Climatic variables from SNOTEL stations can provide an insight into cone production. If there are not enough growing degree days to start fall cones, there will be no cones produced in year three. Critical parameters that reduce cone production include poor soil moisture during year two and three and number of days with rain during pollination in year two. Cold spring temperatures can also reduce cone production. Within whitebark pine transects, individual trees may produce a different number of cones. These can be related to tree age and/or increased moisture from upslope areas. Cone production from ten Whitebark Pine transects in the Rock Creek-Stillwater-Boulder area of south central Montana observed by Montana Department of Fish, Wildlife and Parks has been compared to climatic data from three NRCS SNOTEL stations in the vicinity. The effects of various parameters on cone production and results of estimating the cone crop will be presented.

After 70 Years of Data: What Do We Know and What Do We Think We Know About Elk Habitat and Vegetation in the Gallatin Canyon?

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Many agency biologists use wildlife exclosures to draw inferences about wildlife habitat relative to herbivore population densities and the effect of soil and vegetation manipulation on plant community recovery. When herbivore density is high, vegetative suppression is expected, and even erosion and soil loss may be suggested. As herbivore populations decrease, cascading trophic effects on trees, shrubs, and grasses may be hypothesized. In a case study using nearly 100 years of elk (*Cervus elaphus*) data and 70 yrs of vegetation data from wildlife exclosures in the Gallatin Canyon, we present qualitative and quantitative assessments of a series of hypotheses about elk relationships to the landscape. When elk numbers were high, USDA Forest Service and Montana Fish, Wildlife and Parks performed experimental vegetative treatments to improve range conditions: red fescue seeding, planting caragena, contour plowing to limit soil loss, sagebrush removal, and testing snow fences to trap snow to retain moisture. Several exclosures were equipped with soil traps to monitor soil erosion, hypothesized to come from range overuse by elk. After the 1990s, multiple landscape-level changes, including wolf reintroduction, resulted in substantial elk population declines. Wintering elk numbers decreased from a long-term average of 1600 to fewer than 500. Given elk numbers declined by 2/3, biologists hypothesized a trophic cascade would release to later vegetation series or climax communities. We examined the results of the early habitat manipulations and discuss their implications. We describe how several of the hypotheses were not borne out in the data when examining the entire ecological picture.

Montana's New State-Wide Bighorn Sheep Research Initiative

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Bighorn sheep (*Ovis canadensis*) conservation and management in Montana has been, and continues to be, a challenge. The majority of Montana's bighorn sheep populations are patchily distributed across the state and are relatively small, with many populations static or periodically experiencing dramatic declines despite the fact that adequate habitat seems to be abundant. Wildlife managers and biologists are routinely making decisions on bighorn sheep population augmentation and restoration, harvest, habitat management, disease prevention and response, and other conservation actions without adequate knowledge of the drivers of demographic processes that inform management of many of Montana's more successfully restored ungulate species. Field studies of bighorn sheep in Montana have been limited primarily to short-term, master's thesis projects focused on a specific herd. A 6-yr research program has been designed and funded on the premise that research insights that are broadly applicable for management and conservation are best obtained by addressing the same questions in multiple populations representing differing demographic characteristics, ecological settings, and management histories that capture the range of variation realized by the species of interest. The research program will involve field studies of seven bighorn sheep herds in Montana, with data on each herd collected over a 5-yr period. Herds were selected to capture a wide range of variability in disease outbreak history, habitat types, and herd attributes in an effort to maximize our ability to partition and quantify the potential relative effects of these factors on lamb and adult survival, recruitment, and population dynamics.

Counting Bears, P's And Q's: An Efficient Sample Design for a Spatial Capture Recapture Hair Snag Study of Grizzly Bears

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Accurate assessment of abundance can be expensive and managers often seek to minimize costs. Because spatial capture recapture (SCR) methods explicitly account for variation in trap effort in space and time and permit the use of covariates to explain abundance, substantial flexibility in design and thus reduction in costs may be possible. Estimates of grizzly bear (*Usus arctos*) densities and abundances in 4 management units in Alberta were very low (superpopulation n = 47-133) in the latest studies occurring from 2004-2008. Since these first provincial population estimates were obtained, management, landscape, and habitat conditions have changed. Managers would like updated abundance information but also seek to reduce the costs of acquiring these data. We assessed 1) the behavior of SCR models across several general sample designs and 2) whether we could eliminate sampling in helicopter-access-only areas in the Yellowhead management unit while maintaining accurate estimates. We used a combination of retrospective subsampling of existing data from a 2004 sampling effort and simulations to evaluate several designs. Placing sampling arrays in areas with high densities of bears decreased variance, while the fine-scale configuration of traps did not greatly influence estimates. Simulations of designs for Alberta with more intensive sampling of only the areas accessible by road and no sampling of more expensive helicopter-access-only areas provided robust estimates with little loss in precision. We will describe the framework and assumptions of SCR models with covariates for abundance in comparison with traditional capture recapture models.

Reproductive Biology of Breeding Harlequin Ducks in Glacier National Park

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Glacier National Park and The University of Montana partnered up in 2011-2013 to study the reproductive biology of Harlequin Ducks (*Histrionicus histrionicus*) breeding on Upper McDonald Creek (UMC) in Glacier National Park. The Harlequin Duck exhibits unusual migratory patterns compared to other ducks, moving east to west, rather than north to south; these birds winter along North America's Pacific coast, then move inland to breed on alpine streams. The objectives of this study were to understand the environmental, physiological, and anthropogenic influences on reproduction. During the course of this study, 138 Harlequin Ducks were trapped and banded. We also attached radio transmitters to breeding females (n = 43) to enable daily tracking, behavioral observations, and nest discovery. Over the course of the study our team discovered 11 nests, tracked two broods, and located four females on their wintering grounds. With the use of radio telemetry, we documented novel habitat use and nesting habitat. Human presence along UMC is widespread. We used occupancy and presence/absence techniques to analyze these influences. To validate assumptions of stream flow on reproductive success, we used a 23-yr data set collected by park personnel and citizen scientists to confirm these assumptions. We found a strong relationship between unpredictable stream flow and reduced reproductive success. To further understand reproductive dynamics, we measured corticosterone concentrations in feathers, which significantly predicted reproductive decision. We address the management implications from this study for future Harlequin Duck conservation.

Trends in Causes and Distribution, and Effects of Whitebark Pine Decline on Grizzly Bear Mortality in the Greater Yellowstone Ecosystem

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Documented grizzly bear (*Ursus arctos*) mortalities have been increasing in recent years in the Greater Yellowstone Ecosystem (GYE), due, in part, to increases in bear numbers and range expansion. Previous research has documented that variable seed production of whitebark pine (WBP; *Pinus albicaulis*), an important fall food, is inversely related to grizzly bear fall mortality. However, WBP has experienced widespread mortality during the last decade because of mountain pine beetle (*Dendroctonus ponderosae*) infestations. We investigated trends in causes and distribution of human-caused mortalities for independent-aged (≥ 2 yrs old) grizzly bears in the GYE during 1975–2012, and the effect of WBP cone production on numbers of fall (> 1 August) mortalities (n = 172) during the period of WBP decline (2000-2012) using Poisson regression. During 1975–1982, 91 percent of mortalities occurred within the Grizzly Bear Recovery Zone and primary causes were poaching/malicious killings and losses related to conflicts with livestock. During the two most recent decades most mortalities were associated with ungulate hunting, usually involving self-defense kills, or anthropogenic sites, and an increasing percentage of mortalities occurred outside the recovery zone. Using predictor variables of cone production, sex, location in or out of the Recovery Zone, and year suggests: 1) annual cone production was still predictive of human-caused fall mortalities, 2) no evidence of a difference in annual numbers of fall mortalities between males and females, and 3) an increase in annual mortalities over the study period, with most of this increase outside the Recovery Zone.

Developing Priorities for Metapopulation Conservation at the Landscape Scale: Wolverines in the Western United States

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Wildlife populations are often influenced by multiple political jurisdictions. This is particularly true for wide-ranging, low-density carnivores whose populations have often contracted and remain threatened, heightening the need for geographically coordinated priorities at the landscape scale. Yet even as modern policies facilitate species recoveries, gaps in knowledge of historical distributions, population capacities, and potential for genetic exchange inhibit development of population-level conservation priorities. Wolverines (*Gulo gulo*) are an 8–18 kg terrestrial weasel (*Mustelidae*) that naturally exist at low densities (5/1000 km^2) in cold, often snow-covered areas. Wolverines were extirpated, or nearly so, from the contiguous United States by 1930. We used a resource selection function to (1) predict habitat suitable for survival, reproduction and dispersal of wolverines across the western US, (2) make a rough estimate of population capacity, and (3) develop conservation priorities at the metapopulation scale. Primary wolverine habitat (survival) existed in island-like fashion across the western US, and we estimated capacity to be 644 wolverines (95% CI = 506–1881). We estimated current population size to be approximately half of capacity. Areas we predicted suitable for male dispersal linked all patches, but some potential core areas appear to be relatively isolated for females. Reintroduction of wolverines to the Southern Rockies and Sierra- Nevadas has the potential to increase population size by >50% and these regions may be robust to climate change. The Central Linkage Region is an area of great importance for metapopulation function, thus warranting collaborative strategies for maintaining high survival rates, high reproductive rates, and dispersal capabilities. Our analysis can help identify dispersal corridors, release locations for reintroductions, and monitoring targets. The process we used can serve as an example for developing collaborative, landscape scale, conservation priorities for data-sparse metapopulations.

Genomics of Brucellosis in Wildlife and Livestock of the Greater Yellowstone Ecosystem

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Brucellosis, a disease caused by the bacterium Brucella abortus, has recently been expanding its distribution in the Greater Yellowstone Ecosystem (GYE), with increased outbreaks in cattle and rising seroprevalence in elk (*Cervus elaphus*) over the past decade. Genetic studies suggest elk are a primary source of recent transmission to cattle. However, these studies are based on Variable Number Tandem Repeat (VNTR) data, which are limited in assessing and quantifying transmission among species. The goal of this study was to (*i*) investigate the introduction history of *B. abortus* in the GYE, (*ii*) identify *B. abortus* lineages associated with host species and/or geographic localities, and (*iii*) quantify transmission across wildlife and livestock host species and populations. We sequenced *B. abortus* whole genomes (*n*= 207) derived from isolates collected from three host species (bison, elk, cattle) over the past 30 years, throughout the GYE. We identified genetic variation among isolates, and applied a spatial diffusion phylogeographic modeling approach that incorporated temporal information from sampling. Based on these data, our results suggest four divergent *Brucella* lineages, with a time to most recent common ancestor of ~130 years ago, possibly representing a minimum of four brucellosis introductions into the GYE. Two *Brucella* lineages were generally clustered by geography. Evidence for cross-species transmission was detected among all species, though most events occur within species and herds. Understanding transmission dynamics is imperative for implementing effective control measures and may assist in identifying source populations responsible for past and future brucellosis infections in wildlife and outbreaks in livestock.

**Investigating Coexistence Between Trout and Long-Toed Salamanders and the Indirect Effects of Fish Predators

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In many, formerly fishless lakes in western North America, trout have been introduced for recreational fishing, replacing native amphibians as top predators. Trout are associated with reducing the abundance of amphibians and have extirpated populations of long-toed salamanders (*Ambystoma macrodactylum*). Salamanders and trout may coexist in some lakes, as larvae often are able to alter foraging behavior, use of open water, and time in refugia in response to predatory cues. However, salamanders are still subject to attacks and may have different body morphology in environments with fish. We sought to estimate minimum population sizes of long-toed salamanders, as well as investigate indirect effects of fish on salamander morphology. We sampled lakes with and without fish in northwestern Montana during the summers of 2012 and 2013. We caught salamander larvae using minnow traps, took several body measurements, and compared capture rates and morphological measurements between lakes with and without fish. Preliminary results suggest that more salamanders were captured per trap in lakes with fish (1.8 salamanders/trap, 95% CI = 1.3-2.4), compared to lakes without fish (0.58 salamanders/trap, 0.36-0.81), which could reflect higher population sizes or increased use of traps as refugia. However, salamanders in lakes with fish were smaller: they weighed less, had shorter snout-vent lengths, and had shorter and narrower tails. Even if salamanders are more abundant in lakes with fish, growth may be reduced. Further research into the coexistence of long-toed salamanders and trout may aid in developing conservation strategies for these and other amphibians affected by novel predators.

Investigations of the Breeding Ecology of the Northern Hawk Owl in Western Montana

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In North America, the Northern Hawk Owl (*Surnia ulula*) primarily breeds in the boreal regions of Alaska and Canada. It also can move southward into the contiguous lower 48 United States, occasionally breeding in states of northern latitude. In the contiguous states, Northern Hawk Owl nests are primarily documented in Montana and Minnesota. This study describes nest-site characteristics, habitat associations, breeding diet, and distribution of 15 Northern Hawk Owl nests from Glacier National Park and surrounding areas in northwestern Montana.

Natural Nest-Site Characteristics of Two Small Forest Owls with Implications for Conservation and Management

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Natural nest cavities of the Northern Saw-whet Owl (*Aegolius acadicus*) and the Northern Pygmy-Owl (*Glacidium gnoma*) were characterized using several variables measured from 79 nests. Northern Saw-whet Owls appear to prefer larger diameter trees, with larger cavity openings, and deeper cavities compared to the Northern Pygmy-Owls. Pygmy-owls also

use a higher proportion of living trees with natural, i.e., not excavated, cavities compared to saw-whet owls. Tree height, nest height, and the number of cavities located on a snag were consistent between the two species. Internal examination of hundreds of cavities within owl territories shows that many cavities which appear appropriate for nesting owls are unusable. Leaving dead or dying trees for cavity nesting species is a common practice for forest managers in the West. However, criteria for "wildlife habitat" trees often adhere to a one-size-fits-all approach; retained cavities are selected based on external assessment alone. The dissimilarity in nest-site selection by these two species, and the fact that cavities show great variability in internal condition, underscore the need for forest managers to select a diverse array of trees for cavity nesting birds in western forests.

Avian Community Changes in Relationto Different Forest Fire Conditions in Central Idaho

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Wildfire is an important driver of forest bird communities in western North America. To fully understand wildfire effects, more studies comparing species-specific responses across space, time, and a range of burn severities are needed. We analyzed point count data (n = 809 point × year survey occasions; 2002–2010) from central Idaho to examine forest bird community responses to fire. Using community occupancy models, we analyzed changes in point occupancy before and after prescribed burning and wildfire, and along a post-wildfire burn-severity gradient. Occupancy patterns were largely consistent with those expected from species life histories. Cavity nesters and aerial insectivores (mountain bluebird [*Sialia currucoides*; n = 37 survey occasions detected], house wren [*Troglodytes aedon*; n = 15], Olive-sided Flycatcher [*Contopus cooperi*; n = 15]) responded positively to fire consistent with increases in nesting substrate and foraging opportunities expected for these species. Shrub-nesting species (lazuli bunting [*Passerina amoena*; n = 75], Black-headed Grosbeak [*Pheucticus melanocephalus*; n = 29]) exhibited lagged positive responses with the expected lag in shrub development after wildfire. In contrast, canopy-nesting foliage gleaners and pine-seed consumers (Clark's nutcracker [*Nucifraga Columbiana*; n = 50], Townsend's warbler [*Setophaga townsendi*; n = 133]) responded negatively to wildfire. More species responded positively than negatively to fire, and responses to high-severity wildfire were stronger than to prescribed burning. Consequently, species richness increased by approximately 3 species from low- to high-severity burned points and pre- to post-wildfire years. Our results suggest high-severity wildfires generate important habitat for many species, contributing positively to avian diversity.

**Acoustic Monitoring of Nocturnal Migrants in the Bitterroot Valley, Montana

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Acoustic monitoring of passerine nocturnal migration represents a unique and passive way to study bird movements. As migrant songbirds pass over the landscape, many emit nocturnal flight calls (NFCs) to presumably echolocate and maintain communication with other birds. Capture of these calls with autonomous recording units (ARUs) allows generation of spectrograms, and species-level identification. In September 2012, MPG Ranch began an

NFC monitoring project that now includes the fall 2012, spring 2013 and fall 2013 migrations. Each season, we installed three ARUs at low-, mid-, and high-elevation sites, and extracted over 2700 NFCs from the recordings. Analyses indicate spatial and temporal trends between sites and between seasons. We detected substantially fewer NFCs during the spring migration compared to the fall seasons. Spring migrant NFC detections were consistent throughout the season at the low-elevation site, but only occurred later in the season at the higher elevation sites. During fall migration 2013, peak migration occurred in late August to mid-September when the mid-elevation site consistently saw higher numbers of NFCs than the low- and high-elevation sites. The low-elevation site continues to detect previously undocumented species on the property, including the Barn Owl and Virginia Rail. In 2014, we plan to monitor fall and spring migration to determine if spatial and temporal trends persist.

**Contact Networks and Mortality Patterns Suggest Pneumonia-Causing Pathogens may Persist in Wild Bighorn Sheep

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Efficacy of disease control efforts is often contingent on whether the disease persists locally in the host population or is repeatedly introduced from an alternative host species. Local persistence is partially determined by the interaction between host contact structure and disease transmission rates: relatively isolated host groups facilitate pathogen persistence by slowing the rate at which highly transmissible pathogens access new susceptibles; alternatively, isolated host groups impede persistence for pathogens with low transmission rates by limiting the number of available hosts and forcing premature fade-out. Here, we use long-term data from the Hells Canyon region to investigate whether variable host contact patterns are associated with survival outcomes for 46 cohorts of bighorn sheep (*Ovis canadensis*) lambs subject to recurrent pneumonia outbreaks. We build social contact networks for each lamb cohort, and quantify variation in lamb mortality attributable to populations, years, and groups. We then refine estimates of chronic carriage rates in ewes, and disease-induced mortality rates in lambs, by finding parameters for the disease process that produce lamb morality rates similar to those observed when simulated on the observed host contact networks. Our results suggest that summer lamb hazards are spatially structured at the subpopulation level: 92.5 percent of the variation in lamb hazards during pneumonia outbreak years was attributable to sub-population-level groups, whereas 1.7 percent and 5.6 percent were attributable to year and population, respectively. Additionally, the posterior distribution generated by our disease transmission model suggests that pneumonia-causing pathogens may persist locally in bighorn sheep populations, even during apparently healthy years.

Montana's Bat And White-Nose Syndrome Surveillance Efforts (Oral Presentation & Poster)

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Montana's bat populations face a wide array of conservation issues, including loss of roosting sites, collision and drowning hazards at sites where they forage and drink, barotrauma and collision hazards at wind farms, and the potential arrival of *Pseudogymnoascus destructans*, the cold-adapted soil fungus that causes White-Nose Syndrome and has decimated bat populations in eastern North America. These conservation issues, and the low reproductive output of bats, highlight the need to gather baseline information that can be used to mitigate impacts to populations. Beginning in the fall of 2011, a collaborative effort was initiated to document roost habitat characteristics and year-round spatial and temporal activity patterns of Montana's bats. To-date, collaborators have deployed over 30 temperature and relative humidity data loggers near known winter bat roosts; most known bat hibernacula in Montana are now being monitored. Collaborators have also established a statewide array of 50 passive ultrasonic detector/recorder stations that are deployed year-round and powered by solar panels and deep cycle batteries. Through January 2014, these recording stations have resulted in more than 2.35 million sound files containing more than 7.5 terabytes of information. Highlights to-date include numerous first records of species in regions with previously limited bat survey effort, numerous first records of bat activity during the fall, winter, and spring months, documentation of temperatures at which bats are active year-round, documentation of winter bat roost temperatures, documentation of nightly activity patterns throughout the year, and the potential year-round presence of species previously considered migratory.

Montana's Mapviewer Web Application: Direct Access to 1.4 Million Animal Observations, Wetland and Land Cover Mapping, Land Management and Georeferenced Photos (Oral Presentation & Poster)

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The Montana Natural Heritage Program (MTNHP) was established by the Montana State Legislature in 1983 and charged with statutory responsibility for the acquisition, storage, and retrieval of information documenting Montana's flora, fauna and biological communities (Montana Code Annotated 90-15). In order to track the distribution and status of species, MTNHP has developed databases containing nearly 1.5 million animal observation records and over 160,000 locations where a formally structured animal survey protocol has been followed. This information is used to create a variety of other data products, including, range maps, species occurrence areas used in environmental review processes, and predicted distribution models. Agency biologists and resource managers have direct access to this information as well as more than 2.2 million acres of mapped wetland and riparian areas, statewide landcover mapping, land management information, and georeferenced photos on MTNHP's new MAPVIEWER web application. MAPVIEWER is compatible with Internet Explorer, Mozilla Firefox, and Google Chrome and will eventually be compatible with touch screen devices. Users can submit animal observations, search for a place names and map coordinates, get summaries of land cover and land management within preselected areas, select different wetland types for viewing, overlay a variety of information layers, create a variety of customized queries, and generate image, pdf, and excel reports through the application.

Western Montanan Rancher's, Hunter's and Trapper's Wolf Tolerance in Light of Public Hunting and Trapping

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The Public Trust Doctrine placed wildlife in trust, via state control and regulation, for the benefit of the people. Managing agencies that lose sight of the importance of public acceptance of predator policies and management actions may find themselves legislatively or judicially subverted. This study examines how the Montana public wolf hunting and trapping seasons have affected tolerance of gray wolves (*Canis lupus*) among rural resident ranchers, hunters, and trappers. Twenty residents from the Blackfoot, Bitterroot, and Ninemile Valleys were qualitatively interviewed over the summer and fall of 2013. Potential participants were initially identified using purposive sampling, with subsequent interviewees located through snowball sampling. Preliminary results show that the hunting and trapping seasons have not yet caused changes in attitudes towards wolves in these groups; however losing the hunting and trapping seasons would have a negative impact. The majority of interviewees stated a desire for some avenue of management and control of the Montana wolf population. One apparent theme was that residents are more likely to accept hunting as a means of lethal control over trapping due to concerns of indiscriminate, inhumane take. Wolf presence conjures up a mixture of both awe and fear in these groups. Ranchers are primarily concerned with the threat to livestock and livelihood, while hunters and trappers are uneasy about predator and big game balance on the landscape. As intended, the public wolf hunting and trapping seasons allow ranchers, hunters, and trappers to feel some measure of control over the perceived threat of wolf presence.

Montana Prairie Pothole Joint Venture Breeding Shorebird Project

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Populations of several shorebird species in the Prairie Pothole Region (PPR) appear to be declining, largely because of loss of grasslands and wetlands. Marbled godwit (*Limosa fedoa*), long-billed curlew (*Numenius americanus*), willet (*Tringa semipalmata*), Wilson's phalarope (*Phalaropus tricolor*), upland sandpiper (*Bartramia longicauda*), American avocet (*Recurvirostra americana*) and Wilson's snipe (*Gallinago delicata*) are listed as priority species by Partners in Flight or the U.S. Shorebird Plan. In 2012, the USDI Fish and Wildlife Service's Habitat and Population Evaluation Team began conducting breeding shorebird surveys in the western portion of the Montana PPR to complement existing surveys for partners of the Prairie Pothole Joint Venture in North Dakota, South Dakota, and northeast Montana. The purpose of these surveys is to provide data for development of habitat models identifying priority conservation areas where habitat needs overlap for breeding shorebirds and breeding waterfowl. Results will allow land managers to integrate breeding shorebird conservation with ongoing waterfowl conservation actions in the Montana PPR. This is a long-term adaptive process that includes updating models with annually collected survey data to inform and improve model performance. We summarize the objectives and field design of the project and report results of preliminary modeling from our 2012/2013 efforts.

Predicting Abundance of Gray Wolves in Montana Using Hunter Observations and Field Monitoring

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From the early 1980s to present, wolf (*Canis lupus*) numbers in Montana have been documented by attempting to locate and count all individuals. These counts represented minimums with unknown error. We describe a method using observations by hunters, in conjunction with field monitoring to estimate wolf population size and distribution in a more systematic way. Our method consists of three general steps: 1) use a multi-season occupancy model to estimate the area occupied by wolves in packs using locations reported by a random sample of hunters, 2) estimate the numbers of wolf packs by dividing area occupied by average territory size from field monitoring, then 3) estimate the numbers of wolves by multiplying the number of estimated packs by average pack size from field monitoring. Estimated area occupied by packs increased between 2007 and 2012. From 2007 to 2009, mean estimated territory size from 38 closely monitored packs was 599.83 km^2.

Dividing estimated area occupied by mean territory size resulted in an increase in estimated packs between 2007 and 2012, exceeding minimum counts. From 1994 to 2011, complete counts were obtained from 413 packs within or bordering Montana, and mean pack size was estimated at 6.32 animals. Multiplying estimated packs by mean pack size resulted in an increase in estimated population size between 2007 and 2012, exceeding minimum counts. MFWP's method to estimate the wolf population is cost effective and incorporates public participation with field monitoring. Future application will test the effects of harvest and removals on occupancy, colonization, and local extinction.

Applying New Research Methods to Inform Mountain Lion Harvest Management in Western Montana

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The lack of reliable methods to accurately estimate mountain lion abundance has made lion (*Puma concolor*) management one of the most contentious wildlife issues in western Montana over the last 20 years. Lion harvest prescriptions and hunting season structure varied widely during that period because social factors drove management decisions in the absence of objective population data. During winter 2012-2013, we used a DNA-based spatial capture-recapture (SCR) approach to estimate mountain lion abundance in hunting districts 250 and 270 in the southern Bitterroot Watershed of western Montana. Mountain lion hair, scat, and muscle samples were collected for genetic analysis to identify individuals. We developed extensions to standard SCR models to accommodate simultaneous sampling and harvest events and incorporate existing information regarding mountain lion habitat quality. We estimated the abundance of 85 (95% CI = 54, 141) independent mountain lions in hunting district 250 and 82 (95% CI = 51, 137) in hunting district 270. These results are 2 - 3 times higher than previously reported mountain lion abundance in this area and correspond to density estimates of 4.6 and 5.4 lions per 100 km^2. Because current harvest regulations in western Montana were developed under the assumption of lower population abundance, lion management objectives are unlikely to be met unless harvest prescriptions are adjusted to account for this new understanding of lion population status. More broadly, the analytic improvements in SCR methods will enhance the ability of wildlife managers to reliably and economically estimate abundance of harvested species.

Montana Climate Variability: a Challenge for Big Game Management

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In recent decades changes in climate have influenced wildlife populations worldwide. This paper presents recent climate data sets for Montana with an emphasis on some ways changes in climate have impacted big game populations and management in our state. Length

of growing season, winter severity, time of spring green-up, summer heat, drought, all may have direct or indirect impacts on wildlife populations. Indirect impacts include disease and disease vectors. These changes have implications for how we manage hunting and fishing opportunities. Recent declines in some of our big game species may be attributed in part to climate change. Hunting quotas and seasons have been modified to ameliorate some of the population changes. Further modifications in hunting season structure may be required to maintain hunting opportunities and sustain big game populations.

**A Risk Model for Proactive Management of Pneumonia Epizootics in Bighorn Sheep

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Pneumonia epizootics are a major challenge for management of bighorn sheep (*Ovis canadensis*). Risk factors associated with the disease are poorly understood, making pneumonia epizootics hard to predict; such epizootics are thus managed reactively rather than proactively. We developed a model that identifies risk factors and addresses biological questions about risk. Using Bayesian logistic regression with repeated measures, we found that private land, weed control using domestic sheep or goats, pneumonia history, and herd density were associated with risk of pneumonia in 43 herds in Montana that experienced 22 epizootics out of 637 herd years from 1979–2013. Within high-risk areas occupied by herds, risk increased with greater amounts of private land and use of domestic sheep or goats for weed control. Herds had >10 times greater odds of having a pneumonia epizootic if they or neighboring herds within high-risk areas had a history of pneumonia. Risk greatly increased when herds were at high density, with nearly 15 times greater odds of pneumonia compared to herds at low density. Number of federal sheep and goat allotments, proximity to nearest herds, ram:ewe ratios, normality of winter and spring precipitation, and herds with native versus mixed or reintroduced origin were not associated with increased risk. We conclude that factors associated with risk of pneumonia are complex and may not always be from the most obvious sources. The ability to identify high risk herds will help determine where to focus management efforts and what risk factors most affect each herd, facilitating more effective, proactive management.

Satellite Telemetry Provides Insight into Where Western Montana Osprey Spend the Winter

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During a long-term study of Osprey (*Pandion haliaetus*) in western Montana on demography and ecotoxicology, migratory information on several birds was collected. It is

important to know where these birds migrate and spend the winter because 2/3 of their lives are spent outside Montana. Since virtually nothing was known about where these birds go when they leave the state, in 2012 and 2013 we put satellite transmitters on two families of Osprey (adults and chicks) from nests near Florence, Montana. Telemetry data show that these birds migrate south through a fairly narrow corridor to Arizona and New Mexico, but then go in different directions: some individuals spend the winter in Texas, and others migrate to Mexico and as far south as the Nicaragua-Costa Rica border on both the Atlantic and Pacific coasts. Migration pathways of the adults were very similar for both south-bound and north-bound migrations across multiple years.

A Demonstration of using Partnerships and Private Lands Conservation to Evaluate Livestock Grazing as a Management Tool for Greater Sage Grouse in Central Montana.

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Partnerships across agencies and land ownerships established to maintain wildlife-compatible "working landscapes" are critical for conserving and managing wildlife in the West. Preliminary results from the first three years of a 10-yr study in central Montana demonstrate this management approach. We are evaluating prescribed grazing systems implemented by NRCS's Sage Grouse Initiative (SGI) that are designed to improve hiding cover and food availability for Greater sage grouse (*Centrocercus urophasianus*) during critical life stages via voluntary, incentive-based modifications of livestock grazing management. Extensive vegetation sampling across 8 SGI-enrolled ranches and 20 non-enrolled ranches in 2013 revealed significant increases in residual grass height, live grass height, and herbaceous vegetation cover on SGI-enrolled lands. In 2011-2013, we monitored adult female sage-grouse and chicks with radiotelemetry to measure vital rates and habitat use. Annual hen survival ranged from 57-74 percent, nest success ranged from 12-61 percent, and chick survival ranged from 9-23 percent. Using an information theoretic approach in program MARK, the top-ranked nest success model showed that grass height was positively correlated with nest success. During late nesting to early brood rearing periods of 2012 and 2013 we used pitfall traps to collected ground-dwelling arthropods from cattle grazed and rest-rotation phase pastures enrolled in the SGI program. Collected arthropods were identified and appropriate specimens were classified as sage grouse chick food items. During both years of study, food item catches were greatest ($P < 0.03$) in rested versus grazed pastures indicating that strategic pasture rest may increase the availability of sage grouse chick food resources.

Using Citizen Scientists to Monitor Bald Eagle and Osprey Nests in Western Montana

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Montana has witnessed a remarkable recovery of Bald Eagles (*Haliaeetus leucocephalus*) following Endangered Species Act protection. With over 600 territories to monitor, managing agencies currently struggle to collect data on territory occupancy, productivity, and range expansion. In 2013, the Bitterroot Audubon Society initiated a Citizen Science effort to assist Montana Fish, Wildlife, and Parks in Bald Eagle monitoring efforts. Because of an overwhelming public interest, we also used volunteers to collect information on Osprey (*Pandion haliaetus*) nests. Volunteers ranged in age from 8 to 80. Most had little or no birding experience prior to project participation. Volunteers collected information on 35 Bald Eagle territories, documenting nest occupancy, phenology, cause and timing of failures, and productivity. Volunteers mapped and observed behavior at over 100 Osprey nests throughout western Montana. Bitterroot Audubon plans to continue and expand this project during the 2014 breeding season.

Raptor Use of Water Sources as Documented via a Remote Camera Network

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The MPG Ranch maintains a large network of over 200 remote cameras on two properties in western Montana. We use these cameras to document the occurrence of rare or unusual wildlife, the phenology of life history activities, and wildlife use of areas of interest. Over the course of 3 yrs, our cameras have documented raptors frequently visiting natural and man-made water sources. Most of our common, resident raptors visit water sources for activities such as bathing, preening, drinking, and hunting. Camera stations at natural water sources near breeding territories of Cooper's hawks (*Accipiter cooperii*), northern goshawks (*Accipiter gentilis*), Northern saw-whet owls (*Aegolius acadicus*), and western screech owls (*Megascops kennicottii*) recorded routine visits to water during the breeding season. These behaviors are difficult for observers to see in the field, and their documentation adds insight into our overall understanding of the life history and habitat needs of raptor species. Frequent use of stock tanks underscores the importance of providing escape structures to reduce mortality risk.

Density Dependence, Whitebark Pine Decline and Vital Rates of Grizzly Bears in The Greater Yellowstone Ecosystem

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Recent evidence suggests annual population growth of the grizzly bear (*Ursus arctos*) population in the Greater Yellowstone Ecosystem has slowed from 4.1–7.6 percent during 1983–2001 to 0.3–2.2 percent during 2002–2011. Substantial changes in availability of an important fall food has occurred over the past decade. Whitebark pine (*Pinus albicaulis*), a highly variable but important fall food source for grizzly bears, has experienced substantial mortality due to a mountain pine beetle (*Dendroctonus ponderosae*) outbreak that started in the early 2000s. Concurrent with changes in food resources, the grizzly bear population has reached high densities in some areas and has continued to expand, now occupying >50,000 km^2. We tested research hypotheses to examine if changes in vital rates detected during the past decade were more associated with grizzly bear density versus a whitebark pine decline. We focused our assessment on known-fate data to estimate survival of cubs-of-the-year, yearlings, and independent bears (≥ 2 yrs) and reproductive transition of females from having no offspring to having cubs. We observed a change in survival of independent bears between the periods of 1983–2001 and 2002–2012, which was mostly a function of increased male survival; female survival did not change. Cub survival and reproductive transition declined during the last decade and were associated with an index of grizzly bear density, which indicated increasing density over time. We found no support that the decline in these vital rates was associated with the index of whitebark decline.

Decadal Growth of Traffic Volumes on Us Highway 2 and Implications for Grizzly Bear Habitat Connectivity

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I monitored traffic volumes on US Highway 2 between East and West Glacier, Montana, 1998-2001 as part of a study of the effects of transportation infrastructure on grizzly bears (*Ursus arctos*). I found that traffic volumes were below that where connectivity was impeded, but that some impacts to grizzly bear movement patterns could be measured. During the summers of 2012 and 2013 I replicated the traffic volume monitoring last conducted in 2001. I found that traffic volumes had increased dramatically, nearly doubling in some instances, and that some characteristics of traffic flow had changed. I discuss the implications of this growth in traffic to grizzly bear habitat connectivity.

Density and Abundance of Wolverines in Glacier National Park, Montana, Usa

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Wolverines (*Gulo gulo*) are a rare mustelid carnivore inhabiting the northern US Rocky Mountains. Because they may be closely tied to areas with persistent snow pack, and because these areas may diminish due to climate change, wolverines are a candidate for listing under the U.S. Endangered Species Act. Glacier National Park (GNP) contains over 4,000 km^2 of rugged mountain terrain straddling the Continental Divide immediately south of the U.S./Canada border. Much of this terrain is considered wolverine habitat, and GNP may contain a significant portion of the U.S. wolverine population. GNP, in collaboration with the USDA Forest Service Rocky Mountain Research Station, and following on the heels of a telemetry-based research project conducted in GNP 2003-2008, began a non-invasive DNA-based wolverine population monitoring program in 2009. The objectives of the program were

to identify effective methods of non-invasive monitoring and then use these to estimate population size and density. Using primarily volunteer labor, we began by placing baited hair-snag stations along lakeshores where we felt we might intercept wolverines during winter 2009. This evolved into a systematic survey of the park using a 10 x 10 km sampling grid over putative wolverine habitat during the winters of 2011 and 2012. We then applied a multi-faceted mark-recapture analysis to the accumulated data. Here, we present the findings from this effort, including estimates of population size, density, and trend, and insights concerning wolverine population monitoring.

Poster Abstracts

The Future of American Bison: Domesticated or Wild? (Oral Presentation & Poster)

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I proceed from 3 assumptions: (1) Natural selection is necessary to maintain wild bison (Bison bison). (2) We don't leave bison to future generations; we leave the bison genome. (3) Wildness is the opposite, in a continuum, from domestication. South of Canada, more than 200,000 bison are being domesticated in about 4500 private, commercial herds. In contrast, there are about 44 conservation herds owned by government agencies, the Nature Conservancy and American Prairie Reserve. In these conservation herds, natural selection is weakened or replaced by synergistic actions of (1) cattle-gene introgression; (2) founder effects; (3) inbreeding; (4) genetic drift; and (5) artificial selection. I review the prevalence of 12 management practices diminishing natural selection in these conservation herds, and promote a broader understanding and appreciation of the needs and values of wildness in American bison.

Monitoring Huckleberry in Northwest Montana to Investigate Response to Vegetative Treatments

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The remote and ecologically rich forests of northwest Montana are home to an endangered population of grizzly bears (*Ursus arctos*). Within the Cabinet/Yaak ecosystem, recent research suggests an average population estimate of 45 bears. While grizzly bear core-areas and security requirements have been identified in the Cabinet/Yaak ecosystem, figuring out how to best manage the lush vegetation that provides foraging opportunities within that defined habitat has yet to occur. Large portions of this designated habitat are in need of ecological restoration. Since a high percentage of the Cabinet/Yaak grizzly bear's diet is supplied through berries, grasses, and forbs, it is crucial to develop the knowledge today that can transform portions of the forest back into the edible landscapes that were once historically abundant. Because huckleberries (*Vaccinium* spp.) comprise a substantial amount of the annual diet volume for Cabinet/Yaak grizzly bears, land managers are beginning to design projects with the intention of increasing the amount of huckleberry foraging opportunities on the forest. Strong anecdotal evidence suggests that huckleberry prefers minimal overstory, yet few studies have been undertaken that document the plant's response to management. Addressed is a partnership that has formed between the Yaak Valley Forest Council, USDA Forest Service, and the USDI Fish and Wildlife Service to monitor and document the effects the vegetative treatments have on huckleberry abundance.

**Beaver in the Upper Madison Beaver Management Area Outside Of West Yellowstone, Montana

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Through the late 1960s and early 1970s, trappers harvested most of the beaver in the Hebgen Lake watershed outside of West Yellowstone, Montana. In an attempt to bring back the beaver, Montana Fish, Wildlife, and Parks and the Forest Service established the Upper Madison Beaver Management Area (UMBMA) to regulate the number of the licenses made available to trappers. Both agencies wanted beaver on the landscape because of the important role beaver play in watershed ecology. By building dams, beavers raise water levels which improve wetland habitat for birds, fish, moose, and other animal species. My project included surveying one kilometer of good beaver habitat in the major drainages throughout the Hebgen lake watershed while looking for different beaver signs. These signs include recent beaver clippings in the willow, caches (piles of willow where beaver store there winter food supply), slides (folded down grass where beaver enter river), active lodges, and active dams. The objective of my paper was to evaluate the status of the beaver population by looking at the indices of presence to help FWP decide whether reintroductions and/or changes in the trapping season regulations are necessary.

**Modeling Daily Nest Survival of Five Woodpecker Species in Relation to a Mountain Pine Beetle Epidemic Near Helena, MT

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Forested ecosystems of Western North America have experienced increased periodicity and severity of disturbances in recent years. Large-scale mountain pine beetle (*Dendroctonus ponderosae*) epidemics affecting hundreds of thousands of forested hectares in the American and Canadian Rockies have been attributed to favorable climatic conditions. Ecosystem processes of these forested landscapes are potentially becoming altered. Wildlife responses, however, to beetle disturbance are not yet well understood. Because of their sensitivity to changes in forest conditions, as well as their ability to create valuable habitat for several other forest-dwelling species, our study focused on woodpeckers as disturbance specialists. Owing to differences among life history characteristics, we grouped 5 focal woodpecker species into three assemblages based on feeding and habitat requirements and predicted responses to beetle epidemic conditions. Based on a *priori* hypotheses, we modeled daily nest survival (DSR) of each assemblage as a function of several temporal and spatial covariates, including remotely sensed data, abiotic factors, and beetle epidemic conditions at two spatial scales. To rank the support for each candidate model, we used Akaike's Information Criterion corrected for small sample size (AICc) and used the principle of parsimony to arrive at a final inferential model. Results suggest that abiotic weather and local habitat features were important to include in models of DSR, whereas a number of other covariates containing information about the timing and nature of the beetle epidemic were not useful. Our results will inform management activities for post-beetle forests that will help maintain habitat of disturbance specialist species.

Status Update for Common Loons in Montana and Implications for Restoring Loons to Their Former Breeding Range

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The majority of the western United States' breeding Common Loons (*Gavia immer*) breed on lakes located in northwestern Montana (72 pairs, 68.6%) with Washington, Wyoming, and Idaho having only 17 (16.2%), 14 (13.3%) and 2 (2.0%) territorial pairs, respectively. Recently, there have been enough continuous years of sustainable chick production in Montana (ranging between 0.66 and 0.70 chicks fledged/territorial pair) that an increase in territorial pairs is expected. Territorial pair numbers, however, have increased only slightly. Another possibility, despite loons being poor dispersers with strong breeding site fidelity, is that loons have colonized lakes south of their known breeding locations (and north of Wyoming's breeding population). To address this possibility, in 2013, the Biodiversity Research Institute (BRI) surveyed 28 suitable lakes in southwestern Montana. No loon pairs were found on any of these lakes, suggesting loons have not expanded their range. Therefore, Montana Department of Fish, Wildlife and Parks, the Montana Common Loon Working Group, the Ricketts Conservation Foundation, and BRI are working cooperatively to investigate reasons for this finding. BRI has initiated a large-scale conservation study for the Common Loon across North America, with MT, WY, ID, and WA as a focus area. Together, these organizations hope to: further investigate these questions in the western US, to create solutions that strengthen current populations, and to one day restore loons to their former breeding range.

**Understanding Movement Patterns of Chiricahua Leopard Frogs to Promote Species Persistence in Desert Ecosystems

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One-third of the described species of amphibians worldwide are threatened with extinction, including the Chiricahua leopard frog (*Lithobates chiricahuensis*). This frog is highly aquatic, found in portions of Arizona and New Mexico, and listed as threatened under the Endangered Species Act. Currently, habitat for the Chiricahua leopard frog generally is restricted to anthropogenic sources of water, including tanks maintained for livestock. Movement habits of this frog and patterns of dispersal between disjunct water sources are not well understood. On the Ladder Ranch, a working bison ranch in southern New Mexico, we constructed pitfall traps to capture frogs leaving stock tanks. We attached radio transmitters to 14 individuals during the summer of 2013 to study the potential for movement between widely-spaced tanks. Individuals captured in stock tanks (n = 11) showed very high site fidelity, never leaving their source location while carrying transmitters up to 18 days. Individuals captured in a nearby creek (n = 3) moved as much as 2800 m over a 17-day period. Daily movements of these individuals varied greatly (mean = 121 m, SD = 249) and do not appear to be related to temperature or precipitation. During the 2014 field season, we will attempt to track a larger number of animals moving along the creek corridor and to nearby tanks. Quantifying movement abilities of native amphibians will allow biologists to manage anthropogenic water sources to support movement between habitat patches and maintain functioning metapopulations, while preserving important features of the Ranch for livestock use.

Montana's Bat and White-Nose Syndrome Surveillance Efforts (Oral Presentation & Poster)

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Montana's bat populations face a wide array of conservation issues, including loss of roosting sites, collision and drowning hazards at sites where they forage and drink, barotrauma and collision hazards at wind farms, and the potential arrival of *Pseudogymnoascus destructans*, the cold-adapted soil fungus that causes White-Nose Syndrome and has decimated bat populations in eastern North America. These conservation issues, and the low reproductive output of bats, highlight the need to gather baseline information that can be used to mitigate impacts to populations. Beginning in the fall of 2011, a collaborative effort was initiated to document roost habitat characteristics and year-round spatial and temporal activity patterns of Montana's bats. To-date, collaborators have deployed over 30 temperature and relative humidity data loggers near known winter bat roosts; most known bat hibernacula in Montana are now being monitored. Collaborators have also established a statewide array of 50 passive ultrasonic detector/recorder stations that are deployed year-round and powered by solar panels and deep cycle batteries. Through January 2014, these recording stations have resulted in more than 2.35 million sound files containing more than 7.5 terabytes of information. Highlights to-date include numerous first records of species in regions with previously limited bat survey effort, numerous first records of bat activity during the fall, winter, and spring months, documentation of temperatures at which bats are active year-round, documentation of winter bat roost temperatures, documentation of nightly activity patterns throughout the year, and the potential year-round presence of species previously considered migratory.

Montana's Mapviewer Web Application: Direct Access to 1.4 Million Animal Observations, Wetland and Land Cover Mapping, Land Management and Georeferenced Photos (Oral Presentation & Poster)

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The Montana Natural Heritage Program (MTNHP) was established by the Montana State Legislature in 1983 and charged with statutory responsibility for the acquisition, storage, and retrieval of information documenting Montana's flora, fauna and biological communities (Montana Code Annotated 90-15). In order to track the distribution and status of species, MTNHP has developed databases containing nearly 1.5 million animal observation records

and over 160,000 locations where a formally structured animal survey protocol has been followed. This information is used to create a variety of other data products, including, range maps, species occurrence areas used in environmental review processes, and predicted distribution models. Agency biologists and resource managers have direct access to this information as well as more than 2.2 million acres of mapped wetland and riparian areas, statewide landcover mapping, land management information, and georeferenced photos on MTNHP's new MAPVIEWER web application. MAPVIEWER is compatible with Internet Explorer, Mozilla Firefox, and Google Chrome and will eventually be compatible with touch screen devices. Users can submit animal observations, search for a place names and map coordinates, get summaries of land cover and land management within preselected areas, select different wetland types for viewing, overlay a variety of information layers, create a variety of customized queries, and generate image, pdf, and excel reports through the application.

Western Painted Turtle Distribution at MPG Ranch

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This study seeks to understand western painted turtle (*Chrysemys picta*) distribution at MPG Ranch, a 9500-acre conservation property in the Northern Sapphires. The recent completion of a large pond in our Clubhouse Floodplain provided a larger habitat for western painted turtles. Prior to the pond's completion no more than 16 turtles basked at any one time in the smaller pools of this floodplain. After the completion of the pond in early 2012, 57 turtles concurrently basked on a sunny spring day. MPG staff sought to better understand western painted turtle distribution after the completion of the pond. How many turtles live at the pond? Are these turtles now able to remain in the pond throughout their life cycle? What specific advantages does this pond provide for a resident population? How can we further promote turtle habitat in the Clubhouse Floodplain? In order to begin answering these questions staff set up multiple basking traps in the Clubhouse Pond. For two years we marked and measured 90 adult and sub-adult turtles caught in the traps during the summer months. Our initial findings should help us begin to answer these questions.

Sod-Busting and Sage Grouse: Estimating Historical Impacts and Planning for the Future

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A conservation strategy for Greater sage grouse (*Centrocercus urophasianus*) in the Great Plains, where conversion of native rangeland to cropland is an accelerating agent of land use change, must anticipate impacts of future sod-busting on populations. We use resource selection functions (RSF) to estimate the scale and magnitude of the effect of sod-busting on the distribution of sage-grouse leks in the Great Plains Management Zone and estimate impacts of future cropland expansion. Active leks were used to develop a distribution envelope based on topographic and climatic variables from which random pseudo-absences were drawn to fit a used-available RSF. Models with proportion cropland at scales from 800 m to 8.5 km were compared using AICc to determine the most supported scale at which cropland influences lek occurrence. Finally, we develop a buildout scenario based on a cropland suitability model to estimate potential impacts of future sod-busting on known leks. Negative effects of cropland on lek occurrence were evident at all scales tested. The 6.4 km scale was most supported, and impacts were severe, with the relative probability of lek occurrence falling by 50% when about 20 percent of the landscape within 6.4 km was in cropland. These results, which highlight the large scale and magnitude of impacts of cropland on sage grouse populations, are needed to evaluate the potential contribution of conservation easements and land-use policy to local and range-wide sage-grouse conservation goals. Population-level benefits of targeted conservation implementation are explored.

**Landscape Heterogeneity at White-Headed Woodpecker Nest Sites in West-Central Idaho

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The white-headed woodpecker (*Picoides albolarvatus*) is a regional endemic species of dry conifer forests in the Inland Pacific Northwest, where forest restoration activities are increasingly common. Recent efforts to mitigate severe fire effects and restore ecological function in these forests have prompted land managers to consider the implications of forest management actions on a range of resources, including wildlife. Identifying the associations of sensitive wildlife species with the structure and distribution of resources across landscapes is necessary for scientifically-sound management decisions. We examined the heterogeneity and proportion of open- and closed- canopy forest patches surrounding white-headed woodpecker nest sites during 2012 and 2013. We used logistic regression to compare differences between nest (n = 34) and non-nest (n = 184) sites. We found a stronger positive relationship with low canopy closure within 1-ha of nest sites compared with non-nest sites (nests: $\overline{x}$ = 0.49, SD = 0.43; non-nests: $\overline{x}$ = 0.06, SD = 0.16; $P < 0.001$). We also measured a stronger positive relationship with the edge density between low and moderate canopy patches within a 1-km radius of nest sites compared with non-nest sites (nests: $\overline{x}$ = 30.0 meters/ha, SD = 14.6; non-nests: $\overline{x}$ = 18.4 m/ha, SD = 14.9; $P < 0.001$). Our results are consistent with studies of nesting white-headed woodpeckers in Oregon. These data will help further validate and refine habitat suitability models across their northern range and contribute towards effective management decisions that will benefit the white-headed woodpecker.

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