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IJS

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.

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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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Fred Nelson, Business Manager

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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)

Hard Structure Aging Precision and Length-At-Age Data from Two Northern Leatherside Chub Populations

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Abstract

Northern leatherside chub *Lepidomeda copei* are an imperiled cyprinid fish native to the upper Snake River and upper Bear River basins in Utah and Wyoming. Age and growth rates have been documented for only a few populations and the precision of scale and otolith age estimates have never been described for the species. In this study, we describe the precision of scale and otolith derived age estimates for the northern leatherside chub. We also document scale-derived estimates of age and growth rates of two populations, Ham's Fork, Wyoming and Yellow Creek, Utah. Ages determined using scales agreed with those determined using otoliths in 70.8% of fish and agreement declined with age. Scale derived age estimates were on average younger than otolith derived estimates. The maximum age of the fish collected from Ham's Fork and Yellow Creek was three years. At the end of the growing season, captured age 1, 2, and 3 fish had an average (range) total length of 86 (73-100), 105 (99-115), and 124 (100-135) mm, in Yellow Creek and 86 (63-96), 99 (89-117), and 112 (100-123) mm in Ham's Fork. Growth rates did not differ between sexes in Ham's Fork, but females in Yellow Creek tended to grow faster than males. The data from our study increases our understanding of age and growth rates in northern leatherside chub and how these parameters vary among populations.

Key Words: Northern Leatherside Chub, Otolith, scale aging, back-calculation, Ham's Fork, Yellow Creek.

Introduction

Northern leatherside chub *Lepidomeda* (syn. *Gila, Snyderichthys*) copei, are increasingly rare cyprinids, native to the upper Snake River and upper Bear River in the Bonneville Basin of Utah and Wyoming (Sigler and Sigler 1987; Wheeler 1997; Blakney et al. 2014). Based on molecular (Johnson and Jordan 2000), morphological, and life history differences (Belk et al. 2005), northern leatherside chub were taxonomically separated from the southern Bonneville Basin ecotype by Johnson et al. (2004), who separated the southern leatherside chub into a new species, *Lepidomeda aliciae*. Relative to historic distributions, northern leatherside chub are declining due to introduction of non-native fish, habitat alterations, and dewatering of historical habitats (Walser et al. 1999; Wilson and Belk 2001; Belk and Johnson 2007). From a state and federal wildlife management perspective, northern leatherside chub are considered a species of special concern and are at risk of becoming threatened or endangered.

The biology and life history of northern leatherside chub had not been well studied until the 1990's. Sigler and Sigler (1996) noted that leatherside chub spawn from June to August in waters from 15 to 20°C. Johnson et al. (1995) found that gonadosomatic indices peaked in May for *L. aliciae* and fecundity, based on ova counts, averaged 1,813 eggs/female. Fecundity was correlated with the size of the female, ranging from 938 eggs for a 67 mm (standard length) female to 2,573 eggs for a 92 mm female that weighed 14.6 g (Johnson et al. 1995). Females may begin

spawning at age 2 at 65-85 mm standard length and multiple spawns per year may occur (Johnson et al. 1995; Bartley et al. 2012). Johnson et al. (1995) determined that southern leatherside chub can reach a maximum age of 8 years. Maximum length is about 152 mm (Sigler and Sigler 1996). Females prefer small cobble as a spawning substrate (Billman et al. 2008a). Early life history characteristics, e.g., egg size, time to hatch and swim-up, have been described by Billman et al. (2008a). Temperatures of 26.8°C led to significant egg mortality compared to 18.4-24.6°C (Bartley et al. 2012). For juvenile northern leatherside chub, critical thermal maximum (CTM) and upper incipient lethal temperature (UILT) tests indicated CTM values were 29.6 to 35.0°C and UILT was 26.5 to 30.2°C (Billman et al. 2008b) and optimal temperature for growth was about 23°C (Billman et al. 2008b). Field observations have noted preferred velocities of 2.5-4.5 cm sec-1 and water depths of 25-65 cm (Wilson and Belk 2001). Lateral habitats such as off-channel pools and backwaters are important refuges from main channel predators (Walser et al. 1999). A diet study (Bell and Belk 2004) sampling adult fish >65 mm indicated that a broad array of prey were consumed; aquatic and terrestrial insects were especially favored, but crustaceans (Amphipoda and Isopoda) and gastropods were also consumed at some sites.

Length-at-age data are useful for understanding the general life history of fish, obtaining information about growth rates, and leading to an understanding of annual recruitment, mortality rates of age cohorts, and of the age structure of fish populations (Summerfelt and Hall 1987). Age of fishes can be estimated using a number of hard structures including scales, otoliths, fin rays, cleithra, and opercular bones (DeVries and Frie 1996). Otoliths provide the most accurate estimate of age for most species (DeVries and Frie 1996), but one disadvantage to the use of otoliths is that they require fish to be sacrificed whereas the use of scales is non-lethal. Quist et al. (2007) compared the precision of hard structures used to estimate cyprinid age in the Upper Colorado River Basin and found ~45% agreement between estimates derived using scales and otoliths. Agreement varied with species and was up to 92% for the two chub species included in their study (creek chub *Semotilus atromaculatus* and rountail chub *Gila robusta*). Previous studies with leatherside chub have used otoliths (Johnson et al. 1995) and no studies have evaluated the agreement between scales and otoliths for the species. Limited age and growth rate information is available for leatherside chub. Johnson et al. (1995) noted that the standard lengths for *L. aliciae* ranged from 38-100 mm for 1- to 8-year-old fish and that age- 2 fish were about 58 mm. Belk et al. (2005) noted that northern leatherside chub from one population were about 15% shorter than individuals from a southern leatherside population. The objectives of this paper are to first summarize the scale/otolith aging agreement from a sample of 24 northern leatherside chub and summarize length-at-age data obtained from two northern leatherside chub populations, one from Wyoming, and the other from Utah.

Methods

Aging Agreement Study

Backpack electroshockers (Smith-Root LR-24, Vancouver, Washington) were used to collect northern leatherside chub from two streams; Hayden Fork (Summit County, Utah; 40°51'24" N, 110°50'24"W; collected August 2, 2009) and Deadman Creek (Summit County, Utah; 40°53'35" N, 110°46'54"W; collected June 25, 2010). These fish were used as part of a captive breeding program and individuals from both populations were mixed in indoor holding tanks where temperature and photoperiod were manipulated seasonally to mimic natural conditions. Mortalities (N = 29) among these brood fish were collected and frozen between 2011 and 2013. No necropsies were performed to determine the cause of death. Frozen fish were later thawed, weighed, measured, and saggital otoliths and scales were removed. The

scales and otoliths were stored dry. Scales were taken from the left-side of the fish in the region directly below the dorsal fin but above the lateral line. Otoliths were mounted to microscope slides and ground to a thin section that included the nucleus using fine-grit sandpaper. During grinding, the otoliths were regularly viewed under a microscope to ensure that no annuli were lost. The otolith with the most visible annuli from each fish was retained for this study and the other otolith was discarded. Each structure (scale vs. otolith) was aged either two or three times by an experienced reader by viewing the otoliths under a microscope at 100X magnification or by projecting scale images using a microfiche reader (Micro Design 175A). A third reading was only performed when the ages from the first two readings on a structure did not agree.

Age and Growth Rate Determintion from Ham's Fork and Yellow Creek

Leatherside chub were collected using backpack electrofishing units (Smith-Root LR-24, Vancouver, Washington) from a variety of habitats (i.e., pools, riffles, and runs) from two populations; Ham's Fork (Lincoln County, Wyoming; 42° 8'55" N, 110°44'44"W) and Yellow Creek (Summit County, Utah; 40° 59'31" N, 111°1'34"W; collection location downstream of where fish for aging agreement study were collected). The Ham's Fork fish were collected on September 19, 2014 and the Yellow Creek fish were collected on October 7, 2014. The fish were transported to the Fisheries Experiment Station (FES; Utah Division of Wildlife Resources, Logan, Utah) in a 100 L cooler filled with 50-60 L of FES water. An air bubbler was placed into the cooler and oxygen was provided to the fish at 1-2 L/min.

The leatherside chub were originally collected for a captive breeding program, but high mortality occurred both in transit (Yellow Creek only; likely due to chemical disinfectant residuals) and after arrival (both populations; due to "ich" *Ichthyophthirius multifiliis* outbreak) to FES. Dead fish were collected for the first 28 d after arrival and were frozen for later examination. We decided to opportunistically use the dead fish to derive length-at-age data from each population. The total length, weight, and sex of each fish was determined. Scales were also removed and aged using the same procedures described previously for the aging precision study. Scales were selected in favor of otoliths for aging because time and funding constraints prevented us from being able to mount and section otoliths. Measurements to each annulus (based on the consensus age from the 2 or 3 scale readings) were made using a ruler and fish length at the time of formation of each annulus was made through back-calculation via the Fraser-Lee Method (DeVries and Frie 1996). The intercept parameter was estimated as 6.5 mm based on total length measurements made on the day of hatch for captive reared northern leatherside chub (Wagner, personal observation). A fish was removed from analysis if two of the age estimates did not agree after three readings (5.7% of fish removed). In total, 31 fish from Ham's Fork and 37 fish from Yellow Creek were retained for analysis. Growth rates (mm/day) were estimated using these data for each fish by age group (0 to 1, 1 to 2, 2 to 3 yrs) by calculating the difference in back-calculated length between years and dividing by 365 days.

The mortality of fish from the Yellow Creek population was non-selective and the average weights (total length not measured) of surviving fish was similar to the dead fish evaluated in the study ($P = 0.78$, $t = 0.78$, $df = 13$). The mortality of Ham's Fork fish was size selective towards larger individuals ($P < 0.05$ for both total length and weight comparisons with surviving fish). Even though larger fish are over-represented in our sample from Ham's Fork we have chosen to include the data because the leatherside chub is a species that has been considered for listing as either Threatened or Endangered. In our opinion, the presentation of the data from this population could be beneficial for the conservation of the species. The fish fed poorly after the

ich outbreak, and it is assumed minimal growth occurred after the fish were brought to FES. Weight data was excluded from analysis because it is probable that the fish lost weight after collection and that weights at the time of death were not representative of the time of collection.

Results

Aging Agreement Study

The scales and otoliths collected from each fish (n =29) were read twice and a third reading was used to determine a consensus age from each aging structure when the first two age estimates were not the same. The first two readings agreed for 18 fish (62%) when scales were read and 26 fish (90%) when otoliths were read. These data indicate that for northern leatherside chub that otoliths are easier to age and provide greater inter-reading precision than scales.

We could not derive a consensus age estimate (i.e., the same age was estimated twice after three readings) from the scales from five fish whereas we were able to derive consensus age estimates for all fish using otoliths. The five fish where we could not derive a consensus age estimate using scales were removed from analyses comparing age estimates derived using scales with those derived using otoliths. The ages derived using scales and otoliths were the same for 17 out of the 24 fish (70.8%) included in this analysis and the median age for both aging structures was 4 yrs. There was a tendency, however, for scale derived ages to be younger than those derived using otoliths and for agreement to decrease with age (Table 1). The oldest scale-derived age estimate was 5 yrs but ages up to 7 yrs were estimated using otoliths. The otolith derived age was older in every case where the ages from the two structures did not agree.

Age and Growth Rate Determination from Ham's Fork and Yellow Creek

From Ham's Fork we collected a total of 19 females (63%), 10 males (34%), and two small fish (3%) that had undeveloped gonads (Table 2). We collected 13 females (35%), 23 males (63%), and 1 undeveloped fish (3%) from Yellow Creek (Table 2). Length-

Table 1. Two-way table showing the number of northern leatherside chub that were aged to a particular age using scales when the otolith derived ages for the same fish are as given in the left-hand column. For example, there were 10 fish that had an otolith derived age estimate of 4 yrs. When scales were used to age the same fish, three of the fish were determined to be age-3 and the remaining seven individuals were estimated to be age-4.

	Scale Age Estimate (Yrs)								
Age Derived Using Otolith (Yrs)	0	1	2	3	4	5	6	7	Total
0	1								1
1		4							4
2									0
3				1					1
4				3	7				10
5					2	4			6
6						1			1
7						1			1
Total	1	4	0	4	9	6	0	0	24

Table 2. Mean total length at capture (mm) of northern leatherside chub collected from Yellow Creek and Ham's Fork from each of three age classes that were determined using scale samples. Annulus formation occurs in the spring and fish were collected in the fall; the fish had one additional growing season than suggested by the age (indicated by the "+"). Data are separated by sex (undetermined represents fish whose sex could not be determined using visual gonad examination). The number of fish collected (N) and range of total lengths for each category are reported.

		All Fish			Male			Female			Undetermined		
Source	Age	N	Mean (mm)		N	Mean (mm)	Range (mm)	N	Mean (mm)	Range (mm)	N	Mean(mm)	Range (mm)
Yellow Creek	1+	20	86	73-100	16	87	73-100	4	83	74-95			
	2+	12	105	99-115	6	102	99-105	6	109	102-115			
	3+	3	124	110-135	1	110		2	131	127-135			
Ham's Fork	1+	5	86	63-96	1	87		3	93	87-96	1	63	
	2+	17	99	89-117	9	98	91-104	7	102	95-117	1	89	
	3+	6	112	100-123				6	112	100-123			

at-age computed via back-calculation did not vary between sexes in Ham's Fork ($F_{1,52} = 1.24$, $P = 0.27$) but females in Yellow Creek had significantly longer lengths-at-age ($F_{1,47} = 5.04$, $P = 0.03$) than males (Fig. 1). Daily growth rates in both populations ranged from 0.061 to 0.125 mm/d among 1 to 3 year-old fish (Table 3). Growth rates decreased with age (both populations, $P < 0.01$), but did not vary between sexes (both $P > 0.11$), and there was no significant sex × age interaction (both $P > 0.89$).

Discussion

Information on age and growth rates can help provide information that is needed to help conserve imperiled species such as the northern leatherside chub. Various hard structures can be used to derive these parameters and it is often desirable to use structures that can be collected non-lethally. Similar to other studies (e.g., Marwitz and Hubert 1995; Isermann et al. 2003; Quist et al. 2007), we found that estimates derived using both scales and otoliths are precise in younger fish, but that scale derived ages are younger than otolith derived ages in older fish (DeVries and Frie 1996). The aging agreement that we observed for scales and otoliths was similar to what has been observed in other species including white crappie *Pomoxis annularus* (Hammers and Miranda 1991), creek chub and roundtail chub (Quist et al. 2007), and bluegill *Lepomis macrochirus* (Hoxmeier et al. 2001). No information comparing the precision of scale and otolith age estimates for leatherside chub is available in the literature and other studies that have aged the leatherside chub (e.g., Johnson et al. 1995) used otoliths. The actual age of the fish included in our sample is not known; thus, the accuracy of the use of scales and otoliths for estimating the age of northern leatherside chub is not known. Based on data available for

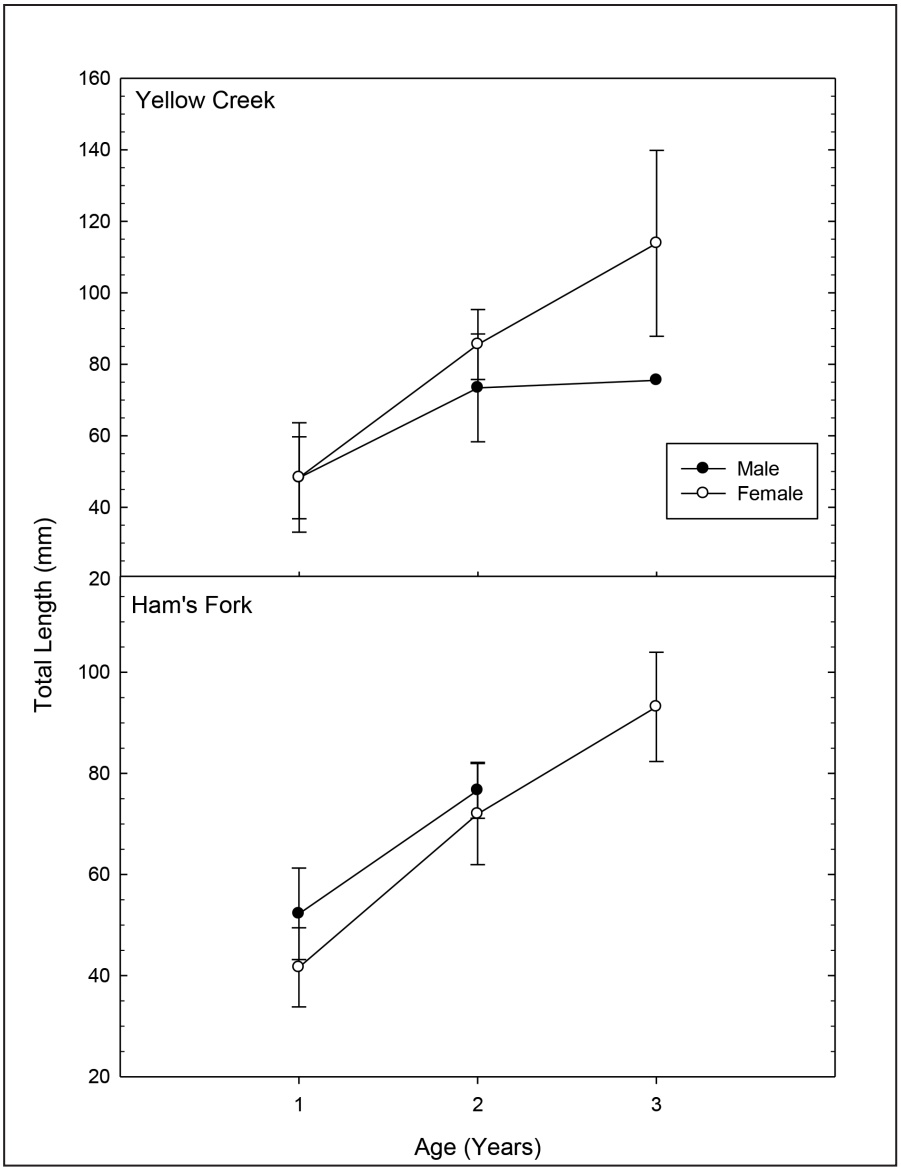

Figure 1. Average back-calculated lengths-at-age for male (closed circles) and female (open circles) northern leatherside chub collected from Yellow Creek (top panel) and Ham's Fork (bottom panel). Error bars represent ± 1 SD of the mean.

other species (DeVries and Frie 1996), it is likely that otoliths are more accurate than scales for the leatherside chub but our data suggests that scales are good substitutes when fish cannot be sacrificed.

Our study is the first to document the length-at-age and growth rates of northern leatherside chub in Ham's Fork and Yellow Creek. On average, the length at the time of capture was approximately 40 mm longer than back-calculated lengths-at-age and this difference can be attributed to the lengths being back-calculated to the beginning of the growing season (DeVries and Frie 1996) whereas the fish were collected at the end of the growing season. The growth rates we calculated were greater than those reported by Belk et al. (2005) based on common garden experiments for both northern leatherside chub from Sulfur Creek,

Table 3. Average daily growth rates (mm/d; with SD in parentheses) for northern leatherside chub from Yellow Creek and Ham's Fork. Data are based on back-calculation performed using scale samples.

Source	Age	All Fish (mm/d)	Male (mm/d)	Female (mm/d)	Undetermined (mm/d)
Yellow Creek	1	0.111 (0.040)	0.114 (0.032)	0.115 (0.042)	
	2	0.080 (0.015)	0.074 (0.012)	0.085 (0.017)	
	3	0.069 (0.008)	0.061	0.074 (0.004)	
Ham's Fork	1	0.106 (0.026)	0.125 (0.025)	0.096 (0.021)	0.096 (0.021)
	2	0.080 (0.023)	0.070 (0.022)	0.088 (0.021)	0.065
	3	0.0740 (0.028)		0.074 (0.030)	

Wyoming and southern leatherside chub from East Fork of the Sevier River, Utah (about 0.0045 mm/day for both populations). The growth rates that we calculated are less than those reported for young-of -the-year northern leatherside chub reared in captivity (0.2952 mm/day; Bartley et al. 2012). Belk et al. (2005) documented the occurrence of individuals that were up to four years-old from both populations and found that the length-at-age of southern leatherside chub was approximately 15% greater than found in northern leatherside chub.

In a separate study, Johnson et al. (1995) documented the age-structure and growth rates from southern leatherside chub from two tributaries to Utah Lake, Utah. The maximum age of the leatherside collected by Johnson et al. (1995) was 8 yrs. The ages reported by Johnson et al. (1995) were based on otoliths whereas we report ages that were derived using scales, which can have the tendency to underestimate age (DeVries and Frie 1996). No studies have reported aging agreement between scales and otoliths for leatherside chub but data from chub species from other genera indicate that agreement may be greater for chub than other species (Quist et al. 2007). Johnson et al. (1995) back-calculated growth rates using standard lengths rather than total lengths; thus, it is difficult to compare the growth rates in the populations they assessed against our populations. The oldest individuals collected in our study were age-3. Given a maximum age of about 8 years (Johnson et al. 1995), the data suggests that older age classes that should be present were not. So, this maximum age in both Yellow Creek and Ham's Fork suggests that most northern leatherside chub in these populations spawn only once or twice in their lifetimes. Further research would be needed to determine what factors (e.g., predation, disease, overwinter mortality) may be contributing to poor recruitment to the older age classes.

Our data from these two populations contributes additional knowledge concerning the growth rate and age structure of northern leatherside chub. We acknowledge that our sample size is small, but the northern leatherside chub is an imperiled species and our sample size is similar to other studies on the species (e.g., Johnson et al. 1995; Bell and Belk 2004; Belk et al. 2005). Our data from Ham's Fork indicates that fish from that population grow at a similar rate to other populations whereas fish from Yellow Creek appear to grow faster than individuals from other populations. Future studies should address why individuals from Yellow Creek grow faster than other populations and why older age classes of northern leatherside chub are not found in either population.

Acknowledgments

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First Records of the Fish Assemblage on Turnbull National Wildlife Refuge, Spokane County, Washington, 2013

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Abstract

We present the first documentation of the fish assemblage on Turnbull National Wildlife Refuge (TNWR) in Spokane County, Washington. Using various methods, we collected fishes inhabiting the wetlands of TNWR in 2013. A total of 15,921 fish was collected, and included, recorded by relative abundance (RA); brook stickleback (RA = 81%), pumpkinseed (RA = 18%), speckled dace (RA = <1%), redside shiner (RA = <1%), and brown bullhead (RA = <1%). This paper describes the 2013 fish assemblage at Turnbull National Wildlife Refuge.

Key words: brook stickleback; Turnbull National Wildlife Refuge; fish assemblage; wetlands

Introduction

A previous fish investigation by Scholz et al. (2003) in 1999 reported the first occurrence of the nonindigenous brook stickleback (*Culaea inconstans*) in the headwaters of Rock Creek on the Turnbull National Wildlife Refuge (TNWR). This discovery prompted us to conduct more comprehensive fish surveys in all of the water bodies on the refuge in 2013. This paper presents the first record of the assemblage of the fish species on TNWR. The data presented here could serve as a baseline for future studies on the refuge. A cursory study conducted in 2002 revealed that brook stickleback, brown bullhead (*Ameiurus nebulosus*), kokanee salmon (*Oncorhynchus nerka*), pumpkinseed (*Lepomis gibbosus*), rainbow trout (*O. mykiss*), redside shiner (*Richardsonius balteatus*), and speckled dace (*Rhinicthys osculus*) were present on the refuge (Nine and Scholz, unpublished data).

TNWR is located 32 km southwest of Spokane, Washington (Fig. 1) and was established for the protection of migratory birds in 1937 by Franklin D. Roosevelt. TNWR is 6,475 hectares in size with 2,023 hectares of lakes, wetlands, and marshes. The Cheney/Plaza road divides the refuge into east and west sides (Fig.1). The native fish community, comprised of speckled dace and redside shiner, was present only in water bodies on the east side of the road (unpublished data). There were likely no native fishes on the west side of the road, but nonindigenous pumpkinseed had established self-sustaining populations in most water bodies on both the east and west sides and nonindigenous brook stickleback had established self-sustaining populations in most water bodies on the east side of the refuge by 2002.

Methods

The sample locations consisted of 17 lakes, ponds, streams, and sloughs on the refuge (Fig. 1). Fish were collected at randomly selected sites by using a combination of baited minnow traps

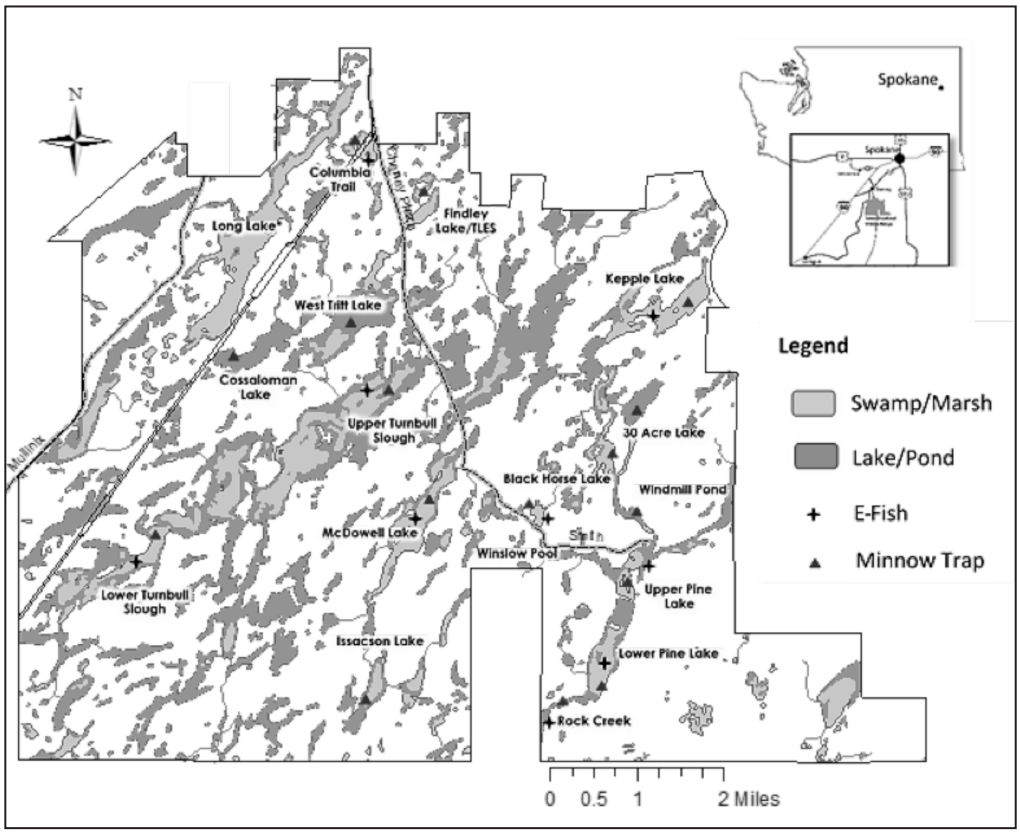

Figure 1. Map of Turnbull National Wildlife Refuge, Spokane County, Washington, with the method of sampling in each waterbody in 2013.

(n = 508 total) or electrofishing transects (n = 23 total) from April to August – 2013 (Table 1). Each minnow trap was set for 24-hours (1 trap night). Electrofishing transects of 10 minutes duration, were conducted using either a Smith Root electrofishing boat or Smith Root backpack electrofisher (Model LR20B), dependent on the presence of a boat launch. Each site was sampled in accordance with the guidelines set forth by the American Fisheries Society (Jenkins et al. 2004), United States Fish and Wildlife Service (USFWS; Brennan-Dubbs 2012), and the Washington Department of Fish and Wildlife (WDFW; Bonar et al. 2000). After collection, fish were identified to species using taxonomic keys (Wydoski and Whitney 1979, 2003; Scholz and McLellan 2009, 2010). Data for each water body sampled was compiled and catch per unit effort (CPUE) by each method for each water body was recorded.

Results

A total of 15,921 fish was collected in 2013. The fish community consisted of [number (n), relative abundance (RA)]) brook stickleback (n = 12355, RA = 81%), pumpkinseed (n = 2730, RA = 18%), redside shiner (n = 61, RA = <1%), speckled dace (n = 13, RA = <1%), and brown bullhead (n = 1, RA = <1%). The CPUE at each water body for each method of collection is summarized in Table 1. We observed two brook sticklebacks on the west side of the Cheney/Plaza Road in 2013 (Fig. 1). These were the first observations of brook stickleback on the west side of the refuge.

Discussion

TNWR was established as habitat for waterfowl and is one of the last quality breeding habitats available to waterfowl in Eastern Washington. Brook stickleback

Table 1. Summary of the effort to collect fish [Catch per unit effort (CPUE) and standard deviation (SD)] on Turnbull National Wildlife Refuge in 2013 by minnow trapping and electrofishing. TLES = Turnbull Laboratory for Ecological Studies, BBH = brown bullhead, BS = brook stickleback, PS = pumpkinseed, RSS = redside shiner, SPD = speckled dace.

	Minnow Trap				Electrofishing				
Site	Traps	Species	# of fish	CPUE (fish per trap night) (±SD)	Minutes E-fish	Transects	Species	# of fish	CPUE (fish/min) (±SD)
30 Acre Lake	7	BS	197	50 (28)	-	-	-	-	-
Black Horse Lake	38	BS	878	40 (47)	10	1	BS	19	2
		PS	475	30 (27)			PS	12	1
Columbia Trail Pond	5	BS	1	0.2 (0.44)	10	1	BS	16	2
Cossaloman Lake	5	-	-	-	-	-	-	-	-
Findley Lake	43	PS	534	12 (35)	-	-	-	-	-
Issacson Lake	7	-	-	-	-	-	-	-	-
Kepple Lake	32	BS	403	13 (12)	20	2	BS	1	<1
							SPD	3	<1
Lower Turnbull Slough	110	PS	530	5 (13)	57	6	PS	52	0.9
McDowell Lake	11	PS	275	25 (32)	10	1	PS	3	<1
Pine Lake	61	BS	3904	64 (105)	34	4	BS	3801	112
		PS	2	<1			RSS	60	1.8
		BBH	1	<1			PS	3	<1
							SPD	6	<1
Rock Creek	26	BS	1231	54 (50)	30	3	BS	90	3
		PS	1	<1			PS	5	<1
		RSS	1	<1					
TLES Ponds 1 & 2	14	-	-	-	-	-	-	-	-
Upper Pine Creek	18	BS	800	44 (70)	-	-	-	-	-
Upper Turnbull Slough	57	PS	174	3 (10	50	5	PS	41	<1
		BS	1	<1					
West Tritt Lake	25	PS	623	25 (25)	-	-	-	-	-
		BS	2	<1					
Windmill Pond	24	BS	96	4 (7)	-	-	-	-	-
		SPD	4	<1					
Winslow Pool	25	BS	915	37 (90)	-	-	-	-	-
TOTAL	508		11048		221	23		4112	

can potentially compete with water birds that rely on the same invertebrates (e.g., *Chironomus* larvae and cladocerans) for prey items (McParland and Paszkowski 2006). Brook stickleback have reduced invertebrate densities within aquatic systems (Zimmer et al. 2000); consequently, they can potentially impact prey items for waterfowl populations (McParland and Paszkowski 2006). Bridges (2011) examined the diets of brook

stickleback on TNWR and found that ~50% of their diet overlapped with prey consumed by waterfowl. Brook stickleback has the potential to impact not only native minnows, but also indirectly effect waterfowl through food limitation.

During a cursory fish survey of TNWR conducted in 2002 (Nine and Scholz, unpublished data), the same species were collected as in this study with the addition of two species, rainbow trout and kokanee salmon. In this study 12,928 fish were collected and were comprised of [number (n), relative abundance (RA)]): brook stickleback (n = 8,946, RA = 69%), pumpkinseed (n = 3,562, RA = 28%), rainbow trout (n = 245, RA = 2%), redside shiner (n = 84, RA = <1%), speckled dace (n = 69, RA = <1%), brown bullhead (n = 21, RA = <1%), and kokanee (n = 1, RA = <1%).

Rainbow trout (n=245) and kokanee salmon (n=1) were observed in Rock Creek between Lower Pine Lake and Chapman Lake in 2002, but not in 2013. The WDFW formerly stocked both species in Chapman Lake and it is likely that a few individuals migrated upstream into Rock Creek in 2002. WDFW discontinued stocking Rainbow Trout in 2009 because the land owner denied public access to the lake (John Whalen, WDFW, Spokane, WA, personal communication), so it is not surprising that we did not catch any in 2013.

Because the non-native brook stickleback was the most commonly collected fish in the 2013 study posing potential competitive food interactions with native fish and waterfowl, future studies should quantify populations and biomass of brook stickleback at TNWR and propose possible eradication measures.

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Breeding Season Occupancy of Long-Billed Curlews and Sandhill Cranes in Grazed Habitats at Red Rock Lakes National Wildlife Refuge, Montana

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Abstract

Long-billed curlew (*Numenius americanus*) and sandhill crane (*Grus canadensis*) are species of concern at state and federal levels. The concern is largely due to declines in population resulting from loss and degradation of wetland and grassland habitats that have reduced the amount of available breeding habitat for both species. Red Rock Lakes National Wildlife Refuge (RRLNWR) in southwestern Montana encompasses one of the largest wetland complexes in the Intermountain West, providing important breeding habitat for cranes and curlews in the region. We explored landscape- and plot-scale drivers of curlew and crane breeding-season occupancy (ψ) in grazed grassland and wet meadow habitats at RRLNWR. Distance to palustrine emergent marsh was the best landscape-scale predictor of curlew and crane occupancy. Mean breeding season occupancy of curlews across sites was 0.68 (95% CI = 0.39–0.87) and increased with distance from emergent marsh, ranging from 0.37 (95% CI = 0.24–0.52) to 0.80 (95% CI = 0.56–0.93) as distance to emergent marsh went from 64 m to 629 m. Conversely, crane mean breeding season occupancy was 0.38 (95% CI = 0.17–0.64) and decreased as distance from emergent marsh increased, ranging from 0.58 (95% CI = 0.27–0.58) to 0.28 (95% CI = 0.11–0.56) as distance to emergent marsh went from 64 m to 629 m. Plot-scale vegetation characteristics available from a reduced data set indicated curlew occupancy was positively related to the ratio of vegetation 5–15 cm tall to vegetation >15cm ($\hat{\beta}$ = 4.92, SE = 2.53).

Key Words: cattle grazing, grassland, *Grus canadensis*, *Numenius americanus*, wetland, wet meadow, habitat management

Introduction

Grazing is an important disturbance in many grassland systems from arid savannah to wetlands. Grazing affects the structure of a grassland proximately, through consumption and trampling of vegetation, and ultimately by altering plant community composition (Augustine and McNaughton 1998). Grazing-related disturbance can result in decreased vegetation height, increased soil water infiltration (Abdel-Magid et al. 1987), redistribution of litter, and improved grass production (Austin et al. 2007, Watts et al. 1987). Additionally, ungulate hoof action disturbs the soil, altering seedbeds and aiding in the transportation of seeds (Vavra et al. 2007). Wild ungulates such as elk (*Cervus elaphus*) and American bison (*Bison bison*) have evolved symbiotically with grassland ecosystems (Vavra et al. 2007). They

contribute to the nitrogen cycle by fertilizing grassland plant species with their feces and urine. Grazing also interacts with fire, another key grassland disturbance, affecting fire frequency, intensity, and distribution on the landscape (Coppedge et al. 2008). Where native herbivory no longer provides these grassland disturbances, domestic livestock are commonly used as a primary tool in grassland management.

Grasslands provide nesting, foraging, and brooding habitat for a diverse group of avian species. Long-billed curlew (*Numenius americanus*) (hereafter, curlew) and sandhill crane (*Grus canadensis*) (hereafter, crane) are two species that preferentially select grazed grasslands during the breeding season (Pampush and Anthony 1993, Gerber et al. 2014). The Long-billed curlew is an upland nesting shorebird species of management concern at international, national, regional, and state levels (Brown et al. 2001). For example, curlew has been extirpated from five states and is a species of concern in at least eighteen states, including Montana (Fellows and Jones 2009).

Like many other grassland birds, curlew numbers have declined significantly across their range (Fellows and Jones 2009). Vegetation type and height play an important role in breeding territory selection of curlews (Saalfeld et al. 2010). Curlews preferentially select grazed native grasslands for nesting (Saalfeld et al. 2010). Redmond and Jenni (1986) observed that curlews chose nesting sites that had been grazed within the previous year and selected nesting territories based on structural attributes of vegetation over the availability of forage items. Grassland structural attributes selected by breeding curlews include grassland swards relatively homogenous in vertical height (Pampush and Anthony 1993), and with vegetation heights measuring 4–15 cm (Saalfeld et al. 2010).

Sandhill cranes prefer open grasslands and freshwater marshes (Gerber et al. 2014). Cranes differ from curlews in their utilization of wet meadow habitat for nesting and brooding. Cranes prefer to nest in shallowly flooded wetlands and meadows (Drewien and Bizeau 1974), returning annually in monogamous pairs to nest (Baker et al. 1995; Drewien et al.1999). Cranes tend to nest in habitat that is isolated from human activity (Drewien 1973), has standing water with adjacent emergent aquatic vegetation (Gerber et al. 2014), and includes tracts of intact adjacent upland habitat (Austin and Pyle 2004). Grassland and wet meadow habitats adjacent to nesting territories are utilized during brood rearing (Bennett 1978; Downs 2004). Downs (2004) observed that cranes nested in marshy areas ≤100 m from grasslands that were used extensively for brood rearing, forage and cover. Grassland habitats, including wet meadows, contain macroinvertebrates and other protein and lipid rich foods (e.g., rodents, frogs, eggs and nestlings) that provide forage items for cranes during the breeding season (Walkinshaw 1973; Armbruster 1987).

We undertook the current study to explore the relative contribution of local-scale habitat attributes influenced by grazing and broader-scale landscape attributes (e.g., distance to palustrine emergent marsh) on breeding season occupancy of long-billed curlews and sandhill cranes. This is in contrast to other studies on these species that considered local- and landscape-scale attributes in isolation. Moreover, this study examined occupancy of both species simultaneously, providing insight into how these two species with potentially conflicting breeding season habitat needs could be used to dynamically manage disturbance of wet meadow and grassland habitat with cattle grazing.

Study Area

Red Rock Lakes National Wildlife Refuge (RRLNWR) (19,334 ha) is located in the Centennial Valley of southwestern Montana. The elevation ranges between 2,013 m above mean sea level (msl) to 2,926 m msl. The average annual precipitation is 49.5 cm, as recorded at refuge headquarters at 2,039 m msl. Twenty-seven percent of the precipitation received annually occurs in the

months of May and June. The annual mean temperature is 1.7°C; mean maximum July and mean minimum January temperatures are 24.8°C and -17.9°C, respectively.

Grassland habitat comprises >800 ha of RRLNWR. Dominant grasses include Idaho fescue (*Festuca idahoensis*), needle and thread grass (*Hesperostipa comata*), tufted hairgrass (*Deschampsia caespitosa*), and basin wildrye (*Leymus cinereus*). Non-native grasses smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*) are also present in the grassland habitat (USFWS 2009).

Wet meadow habitat comprises ~2,869 ha of RRLNWR and is the most commonly grazed habitat on the refuge (USFWS 2009). This habitat is seasonally flooded during most springs and sub-irrigated by groundwater during the summer, resulting in a highly productive habitat. Sedge (*Carex* spp.) and rush (*Juncus* spp.) dominate wet meadow habitat, which also includes common forbs such as lupine (*Lupinus* spp.), fleabane (*Erigeron* spp.), phlox (*Phlox* spp.), and cinquefoil (*Potentilla* spp.) (USFWS 2009). Vegetation height is highly dependent upon moisture gradients and can range from <30 cm to >60 cm in height.

RRLNWR contains 21 active grazing units varying in size from 123 to 1,327 ha. With few exceptions, late-season (i.e., after 10 July) grazing treatments are followed by two full growing seasons of rest. Stocking rates (Animal Units per Month [AUM]) were determined and implemented for each grazing unit by a Natural Resources Conservation Service (NRCS) range condition survey conducted in 1987 (USFWS, unpubl. data).

Methods

Avian Surveys

Sample plots (n = 102) within wet meadow and grassland habitats on RRLNWR were randomly selected using ArcGIS 9.3 Geographic Information System (GIS) software (ESRI, Redlands, California). Plots were 16 ha in size, which was determined based on published estimates of crane and curlew breeding territory sizes; 6–14 ha for curlews (Stanley and Skagen 2007) and 10–23 ha for cranes (Gerber et al. 2014).

Plots were surveyed three times during the nesting and early brood rearing periods for both species to allow estimation of ψ (MacKenzie et al. 2004). For logistical reasons, plots were grouped and the order that groups were surveyed was randomly selected. Surveys were conducted from sunrise to 4 hours after sunrise and from 4 hours before sunset to sunset. Each plot was surveyed at least once during a morning survey and once during an afternoon/early evening survey.

Plots were surveyed by a single observer following an 800-m U-shaped transect that began and ended at a plot boundary and ran parallel to, and 100-m inside of, the remaining three boundary edges. Surveys were not conducted during periods of high winds or heavy rain. For each observation species, detection type (call, flyover, flew into plot, visual, visual/call), social status (lone, paired, group, nest, brood), and numbers of individuals were recorded. Auditory only detections were also recorded (Tipton et al. 2008).

Habitat Characteristics

We quantified vegetation characteristics in each avian survey plot using the point-line intercept method (Bonham 1989) along two randomly placed 50-m transects. A transect was placed along a random bearing from a random point within the plot. Bearings that resulted in the transect crossing a road, extending into open water, or exiting the plot were eliminated and another random bearing selected. A 5-mm diameter, 1-m long dowel marked in 5-cm increments was used to record physiognomic class in 5-cm height categories every other meter along each transect. Vegetation physiognomic classes included: bunchgrass, rhizomatous grass, sedge/rush, and forb. Ground cover class (plant physiognomic class, bare soil, rock, moss, cow pie, water) was recorded at each point along each transect where the dowel contacted the ground. Mean plot percent

ground cover by class was calculated as the number of hits per class divided by 50 (2 transects × 25 samples per transect). Litter depth was measured (± 1.0 cm) every fourth meter along each transect for a total of 12 measurements per transect and used to calculate mean litter depth for a plot (n = 24). We calculated the ratio of preferred height vegetation (5–15 cm) to vegetation >15 cm as a predictor of curlew ψ, and the sum of vegetation hits >15 cm as predictors of crane ψ. Lastly, the ratio of sedge/rush hits to grass hits (rhizomatous and bunchgrass hits combined) was calculated as a proxy measure of within-plot sub-irrigated wet meadow habitat. We believe this metric was sensitive to subtle hydrological gradients within areas classified as wet meadow by remotely sensed wetland data (Cowardin et al. 1979, Richards 2012). Moreover, we considered the sedge/rush to grass ratio a measure of plant productivity; the ratio should decline with the hydrological gradient from mesic wet meadow to xeric grassland. The vegetation height ratio was included as a proxy for plant biomass, and resultantly crane forage availability; invertebrate diversity and abundance (Morris 2000, Kruess and Tscharntke 2002), and small mammal biomass (Grant et al. 1982) are generally positively correlated with plant height and biomass.

Other habitat characteristics hypothesized to affect curlew and crane ψ recorded for each sample plot included: years since last grazed, proportion of palustrine emergent marsh, distance from palustrine emergent marsh, and distance to road. The latter two covariates were estimated using GIS software as the distance (± 1 m) from the plot centroid to the nearest emergent wetland edge or road, respectively. Proportion of palustrine emergent marsh within each plot was quantified using palustrine emergent marsh as classified by the National Wetlands Inventory (Cowardin et al. 1979).

Data Analysis

We modeled variation in ψ using plot-scale vegetation characteristics (e.g., litter depth) and landscape-scale habitat attributes (e.g., distance to emergent marsh) using Program PRESENCE version 2.3 (MacKenzie 2002). Based on a review of pertinent literature, we created two a priori model suites for each species – one comprising all plots surveyed (n = 102) and a reduced set (n = 47) that included covariates for plot-scale vegetation structure. For the former, distance to emergent marsh (DEM), distance from road (DRD), proportion of palustrine emergent marsh (PEM), and years since last grazed (YLG) were covariates considered. For the latter, plot- scale vegetation characteristic covariates included the ratio of preferred-height vegetation (6–15 cm) to taller vegetation (>15cm) (HeightRatio), mean litter depth (LitDpth), sum of vegetation hits >15 cm (Sum15cm) and the ratio of sedge/rush to grass (both rhizomatous and bunch grass) (SRGrRatio). The distance to emergent marsh habitat (DEM) was also included in these model suites as it was the best predictor of curlew and crane ψ from the full model suites. Detection probability, p, was held constant (p(.)) or allowed to vary among survey periods (p(t)) for each ψ model structure described above.

We employed methods developed by MacKenzie et al. (2002) to estimate single-season occupancy rates based on presence-absence data when detection probabilities were <1. A key assumption of occupancy modeling is that the occupancy state of a site is constant within the season surveyed (e.g., breeding season). The territoriality of cranes and curlews during the breeding season should lead to minimal violation of this assumption.

We tested model goodness-of-fit for each model suite using the parametric bootstrap procedure (n = 1,000 simulations) in Program PRESENCE. We used Akaike's Information Criterion corrected for small sample size (AICc) to evaluate the amount of support for each model in each suite. Where overdispersion was evident (i.e., $\hat{c} > 1.0$) we accounted for this by using quasi-likelihood AIC_c ($QAIC_c$). We calculated ΔAIC_c (the difference in AIC_c values between a candidate model and the most supported

model) to determine strength of support for each model. Models within 2 ΔAIC_c units of the best model (i.e., that with the lowest AIC_c score) were well supported (Burnham and Anderson 2002), assuming models differ by more than an uninformative parameter (Arnold 2010).

Results

A total of 102 plots were surveyed for ψ of curlews and cranes during 14 May–18 June 2009; 86 plots were surveyed three times, 15 twice, and a single plot was only surveyed once. Vegetation transects (n = 94) were completed on 47 plots from 25 June–28 July 2009, providing data on plot-level vegetation characteristics. Plots varied considerably in the four habitat attributes used to model the full data set (n = 102 plots); distance to palustrine emergent marsh, distance to road, proportion of palustrine emergent marsh and years since last grazed (Table 1).

Mean litter depth was variable within grazing units (Table 1) and not dependent upon years since last grazed. The estimated slope of the relationship between litter depth and YLG was -0.054 (SE = 0.185, P = 0.77). Other plot-scale attributes quantified were similarly variable, providing strong gradients to assess curlew and crane breeding season occupancy within grazed grassland and wet meadow habitat (Table 1).

Avian Surveys

We detected curlews and cranes on 62 and 23 plots, respectively. There were 135 recorded observations of curlews; 63% (n = 85) were of lone birds, 31% (n = 42) pairs, and 6% (n = 8) were groups ranging from 3–10 birds. Of the 38 total observations of cranes, 53% (n = 20) were lone birds, 45% (n = 17) pairs, and 3% were groups (a single group of 5 birds). Based on models from the full data set, breeding season ψ of curlews and cranes was best predicted by a plot's distance to emergent marsh, and the nature of the response differed between species. The importance of distance to emergent marsh in crane ψ was corroborated with the plot-scale model suite. However, the proportion of preferred vegetation height in a plot was the best predictor of curlew ψ in the plot-scale model suite. Goodness-of-fit tests demonstrated a modest level of over-dispersion in the full curlew model

Table 1. Summary of predictor variables used to model breeding season occupancy of long-billed curlew and sandhill crane at Red Rock Lakes National Wildlife Refuge, 2009. Variables are distance to emergent marsh (DEM), distance to road (DRD), proportion emergent marsh (PEM), years since last grazed (YLG), litter depth (LitDpth), sedge/rush to grass ratio (SRGrRatio), preferred height (6–15 cm) vegetation to taller (>15 cm) vegetation ratio (HeightRatio), and the sum of vegetation hits >15 cm (Sum>15cm). HeightRatio was only used to model curlew occupancy; Sum15cm was used exclusively to model crane occupancy.

Variable	$\bar{x}$	SE	Range
DEM (m)	0	51	0 – 1985
DRD (m)	438	95	0 – 4144
PEM	0.08	0.01	0.0 – 0.47
YLG	3[a]	—	1 – 17
LitDpth (cm)	8.1	0.61	0.5 – 19
SRGrRatio	8.3	5.42	0 – 256
HeightRatio[b]	1.8	0.33	0 – 13.5
Sum15cm[c]	123	13.61	2 – 474

[a] Most frequent number of years since last grazing.
[b] Curlew analysis only.
[c] Crane analysis only.

suite only ($\hat{c}$= 1.85); results presented for that model suite were adjusted accordingly using $QAIC_c$. As there was no evidence of over-dispersion in the crane data sets we used only AIC_c.

Landscape-scale Models

Long-billed Curlew—The most parsimonious model in our a priori suite of landscape-scale models indicated that curlew ψ increased with increasing distance from palustrine emergent marsh (DEM) habitat (Tables 2 and 3). There was considerable support for the top model ψ(DEM) , p(.), with a model weight of 0.58 and nearly 2 QAICc units between this model and the second-best model (Table 2). Moreover, DEM was in each of the top three models. For example, based on the top model, $\hat{\psi}$ for a plot at a distance of 64 m (1st quartile) from the nearest emergent marsh was 0.37 (95% CI = 0.24–0.52), which increased to 0.80 (95% CI = 0.56–0.93) for a plot 629 m (3rd quartile) from an emergent marsh (Table 3; Fig. 1). Detection probability, p, was constant among surveys in the top model ($\hat{p}$ = 0.52, 95% CI = 0.43–0.61). The second best model differed from the best model only by inclusion of years since last grazed (YLG). However, YLG was an uninformative parameter (Arnold 2010) with a confidence interval that broadly overlapped zero ($\hat{\beta}$ = 0.03, SE = 0.080).

Table 2. Model results from the long-billed curlew landscape-scale model suite (n = 102 plots) with covariates distance to emergent marsh (DEM), distance to road (DRD), proportion emergent marsh (PEM), and years since last grazed (YLG). Model rankings were corrected for over dispersed data ($\hat{c}$ =1.85). Detection probability is p, occupancy is ψ, Red Rock Lakes National Wildlife Refuge, 2009.

Model	K[a]	w[b]	$\Delta QAIC_c$
ψ (DEM),p(.)	3	0.58	0.00
ψ (DEM+YLG),p(.)	4	0.22	1.93
ψ (DEM),p(t)	5	0.16	2.64
ψ (DRD),p(.)	3	0.02	6.86
ψ (PEM),p(.)	3	0.01	8.86
ψ (.),p(.)	2	<0.01	8.90
ψ (YLG),p(.)	3	<0.01	10.87
ψ (.PEM),p(t)	5	<0.01	11.63
ψ (YLG),p(t)	5	<0.01	13.60

[a]Number of parameters

[b]Normalized relative weight likelihood

[c]Difference between model's quasi-likelihood Akaike's Information Criterion corrected for small sample size and the lowest $QAIC_c$ value

Table 3. Coefficient estimates, standard errors (SE), and 95% confidence intervals (CI) for the most parsimonious long-billed curlew breeding season occupancy model from the landscape-scale model suite, Red Rock Lakes National Wildlife Refuge, 2009.

			95% CI	
Model Parameter	$\hat{\beta}$	SE	LCI	UCI
Occupancy (ψ; intercept)	0.74	0.41	-0.06	1.54
Distance to emergent marsh (m)	1.75	0.61	0.55	2.94
Detection probability (p)	0.08	0.18	-0.27	0.43

Note: Coefficients are presented based on a logit link to the real parameter.

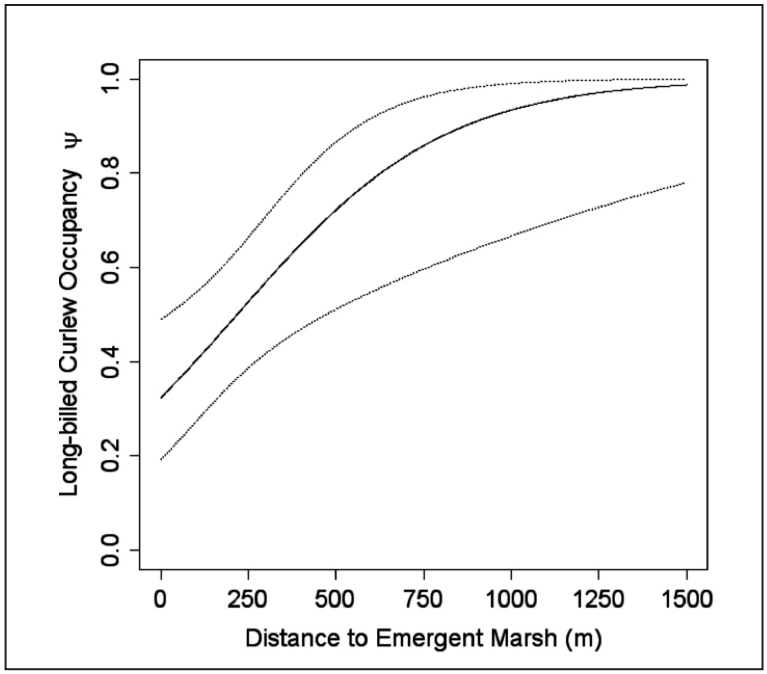

Figure 1. Predicted long-billed curlew occupancy rate, ψ (solid line), and 95% confidence intervals (dotted lines), in relation to distance to emergent marsh habitat on Red Rock Lakes National Wildlife Refuge, 2009.

The high QAICc score for the YLG-only model further demonstrated no support for this attribute.

Sandhill Crane.—We found support for the hypothesis that crane ψ in grassland habitats would increase with proximity to palustrine emergent marsh habitats preferred for nesting. Landscape-scale-models containing distance to palustrine emergent marsh (DEM) were strongly supported, with the covariate occurring in the top three models (Tables 4 and 5). For example, $\hat{\psi}$ for a plot at a distance of 64 m (1st quartile) from the nearest emergent marsh was 0.58 (95% CI = 0.27-0.58), whereas $\hat{\psi}$ for a plot 629 m (3rd quartile) from an emergent marsh was 0.28 (95% CI = 0.11-0.56) (Fig. 2). Detection probability, p, was constant among surveys in the top model ($\hat{p}$ = 0.24, 95% CI = 0.13– 0.41). The second-best model provided weak support for the hypothesis that crane ψ would be positively related to number of years a unit had been rested from grazing, but the effect of rest from grazing was imprecisely estimated ($\hat{\beta}$ = 1.30, SE = 1.17).

The hypothesis that distance to road (DRD) would be positively related to crane ψ was clearly not supported by the data (Table 4). Similarly, a hypothesized positive relationship between crane ψ and the proportion of palustrine emergent marsh in a plot was not supported (Table 4).

Plot-Scale Models

Long-billed Curlew.—Results from models investigating curlew ψ relative to plot-scale vegetation characteristics (Table 6) supported our hypothesis of preference for habitats with vegetation heights between 5 and 15 cm. For curlew, ψ was positively related to the proportion of vegetation 5–15 cm in height in a plot. For example, on a plot with a relatively low proportion of preferred-height vegetation (1st quartile vegetation height ratio of 0.70), ψ was estimated to be 0.47 (95% CI = 0.26–0.69) (Fig. 3).

Table 4. Model results from the full sandhill crane landscape-scale model suite (n = 102 plots) with covariates distance to emergent marsh (DEM), distance to road (DRD), proportion emergent marsh (PEM), and years since last grazed (YLG). Detection probability is p, occupancy is ψ, Red Rock Lakes National Wildlife Refuge, 2009.

Mode	k[a]	w[b]	ΔAIC_c
ψ (DEM),p(.)	3	0.36	0
ψ (DEM+YLG),p(.)	4	0.29	0.38
ψ (DEM),p(t)	5	0.16	1.65
ψ (YLG),p(t)	6	0.12	2.12
ψ (YLG),p(.)	3	0.02	5.71
ψ (.),p(.)	2	0.01	6.42
ψ (YLG),p(t)	5	<0.01	7.58
ψ (PEM),p(.)	3	<0.01	8.29
ψ (DRD),p(.)	3	<0.01	8.42
ψ (PEM),p(t)	5	<0.01	10.11
ψ (DRD),p(t)	5	<0.01	10.23

[a]Number of parameters
[b]Normalized relative weight likelihood
[c]Difference between model's quasi-likelihood Akaike's Information Criterion corrected for small sample size and the lowest AIC value

Table 5. Coefficient estimates, standard errors (SE), and 95% confidence intervals (CI) for the most parsimonious sandhill crane breeding season occupancy model from the landscape-scale model suite, Red Rock Lakes National Wildlife Refuge, 2009.

			95% CI	
Model Parameter	$\hat{\beta}$	**SE**	**LCI**	**UCI**
Occupancy (ψ)	-0.51	0.56	-1.61	0.59
Distance to emergent marsh (m)	-1.18	0.53	-2.22	-0.14
Detection probability (p)	-1.14	0.41	-1.94	-0.34

Note: Coefficients are presented based on a logit link to the real parameter.

Estimated occupancy rate increased twofold to 0.94 (95% CI = 0.50–1.00) for a plot with a high proportion of preferred-height vegetation (3rd quartile vegetation height ratio of 2.0). The model including vegetation height was a better predictor of curlew ψ than distance to emergent marsh (Table 5). Detection probability, p, was constant among surveys in the top model ($\hat{p}$ = 0.51, 95% CI = 0.39–0.63), and similar to the estimate from the landscape scale model suite top model.

Sandhill Crane.—We did not find strong support for the hypothesis that crane ψ was positively related to vegetation height (i.e., vegetation hits >15 cm), amount of wet meadow (i.e., ratio of sedge/rush hits to grass hits), or litter depth within a plot (Table 7). Models including litter depth failed to converge and therefore were not presented in table 7. Results from the plot-scale model suite corroborated results from the landscape scale model suite, with distance to palustrine emergent

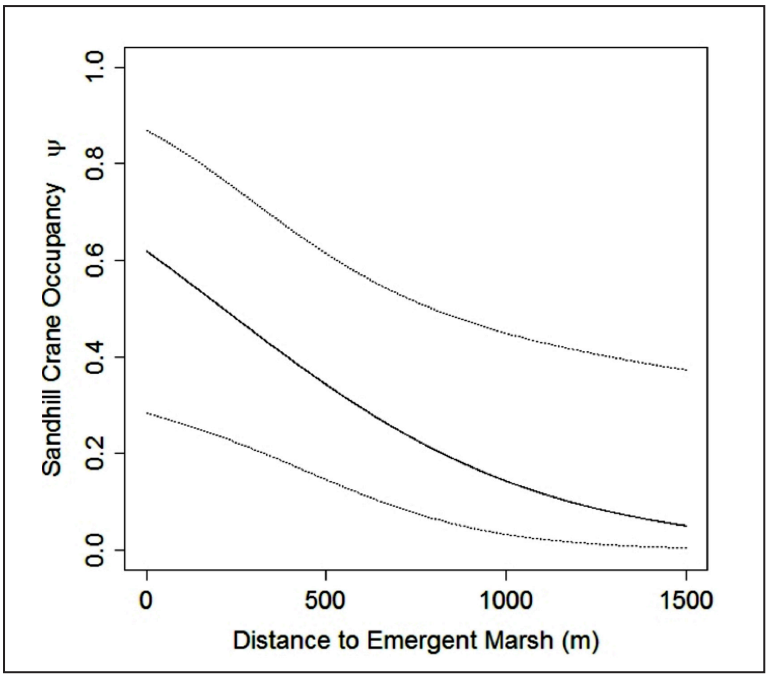

Figure 2. Predicted sandhill crane occupancy rate, ψ (solid line), and 95% confidence intervals (dotted lines), in relation to distance to emergent marsh habitat on Red Rock Lakes National Wildlife Refuge, 2009.

Table 6. Model selection results investigating the relationship between long-billed curlew breeding season occupancy and plot-scale vegetation characteristics (n = 47 plots). Covariates included the ratio of preferred-height vegetation (6–15 cm) to taller vegetation (>15cm) (HeightRatio), mean litter depth (LitDpth), and the ratio of sedge/rush to grass (both rhizomatous and bunch grass) (SRGrRatio). The distance to emergent marsh habitat (DEM) was also included as it was the best predictor of curlew occupancy from the landscape-scale suite, Red Rock Lakes National Wildlife Refuge, 2009.

Model	K[a]	w[b]	ΔAIC_c
ψ HeightRatio, p(.)	3	0.49	0.00
ψ (DEM),p(.)	3	0.29	1.06
ψ (HeightRatio),p(t)	5	0.13	2.66
ψ (DEM),p(t)	5	0.08	3.71
ψ (LitDpth),p(.)	3	0.01	7.28
ψ (.),p(.)	2	<0.01	9.10
ψ (LitDepth),p(t)	5	<0.01	10.04
ψ (SRGrRatio),p(.)	3	<0.01	10.08
ψ (SRGrRatio),p(t)	5	<0.01	12.85

[a]Number of parameters
[b]Normalized relative weight likelihood
[c]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value

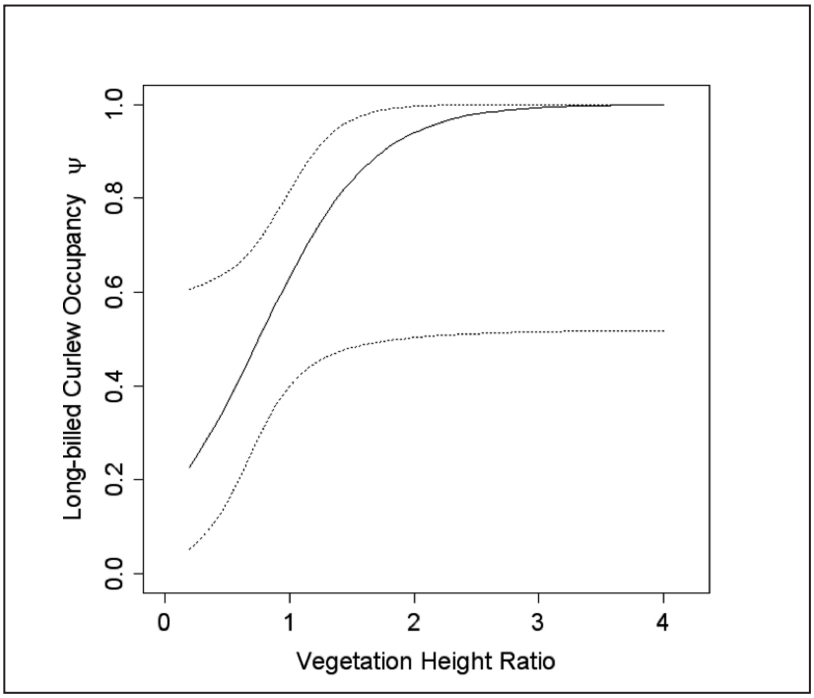

Figure 3. Predicted relationship between long-billed curlew occupancy rate, ψ (solid line), and 95% confidence intervals (dotted lines), in relation to vegetation height ratio during the breeding season, Red Rock Lakes National Wildlife Refuge, 2009. Height ratio was calculated as the ratio of transect hits of preferred height vegetation (6-15 cm) to taller vegetation (>15 cm).

Table 7. Model results from the sandhill crane and plot-scale vegetation characteristics (n = 47 plots). Covariates included the number of vegetation hits above 15 cm (Sum15cm), mean litter depth (Mean), and the ratio of sedge/rush hits to grass (both rhizomatous and bunch grass) hits (SRGrRatio). The distance to emergent marsh habitat (DEM) was also included as it was the best predictor of crane occupancy from the landscape-scale suite. Detection probability is p, occupancy is ψ on Red Rock Lakes National Wildlife Refuge.

Model	K[a]	w[b]	ΔAIC_c
ψ (DEM),p(.)	3	0.41	0.00
ψ (.),p(.)	2	0.25	0.99
ψ (Sum15cm),p(.)	3	0.12	2.44
ψ (DEM),p(t)	5	0.08	3.41
ψ (SRGgRatio),p(.)	3	0.05	4.11
ψ (.),p(t)	4	0.04	4.45
ψ (Sum15cm),p(t)	5	0.02	5.90
ψ (SRGrRatio),p(t)	5	0.02	6.27

[a]Number of parameters

[b]Normalized relative weight likelihood

[c]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value

marsh appearing in the top model (Table 7). Plot vegetation height was the most-supported vegetation-characteristic model with a ΔAICc score of 2.44 (Table 7). The small sample size of the reduced data set, coupled with the relatively low number of crane observations, likely limited our ability to detect relationships between crane ψ and habitat characteristics.

Discussion

Our results provide insights into the relative role of plot- and landscape-scale attributes of grazed grasslands and wet meadows on breeding season occupancy of long-billed curlews and sandhill cranes, and how those responses differed between species. For example, curlew ψ increased with increasing distance to palustrine emergent marsh, whereas for crane ψ, estimates decreased as distance to palustrine emergent marsh increased. Moreover, for curlew, estimates of ψ responded positively to vegetation heights demonstrated in other studies to be preferred nesting habitat (Pampush and Anthony 1993, and Saalfeld et al. 2010). We did not find support for models in which crane ψ was related to plot-scale vegetation characteristics, although the number of crane observations in the reduced data set used in the plot-scale model suite was small, and therefore limited this analysis. Alternatively, our selection of sedge/rush to grass ratio may not have been a suitable metric for predicting crane ψ, although we believe it was a relatively sensitive measure of hydrological gradient in more mesic wet meadow habitat, where we predicted higher crane occupancy due to greater foraging opportunities, compared to drier adjacent grassland habitat.

Long-billed curlews preferentially select grazed grassland habitat for nesting. Redmond and Jenni (1986) observed that curlews chose nesting sites that had been grazed within the previous year. For curlew, estimates of ψ during this study increased with increasing amounts of preferred height vegetation, corroborating earlier work that found curlews preferred nesting in vegetation 4–15 cm in height (Saalfeld et al. 2010). However, our results for curlew did not demonstrate a strong relationship between how recently a grazing unit was grazed and ψ. This may be due to the inconsistency of vegetation and litter in grazing units post-grazing treatment. Current grazing levels are relatively light, resulting in high sward heterogeneity with respect to vegetation structure and height due to localized grazing patterns within a unit. For example, we did not find a relationship between years since last grazed and mean litter depth at the grazing unit scale during this study. Moreover, variation in litter depth within grazing units was high, with standard deviations ranging from 2.9 – 8.5 cm during 2009. This structural heterogeneity could benefit curlews. Having taller grass habitat juxtaposed with more recently grazed nesting habitat supports both nesting and brooding activities of curlews (Redmond and Jenni 1982).

Sandhill cranes prefer to nest over water in shallowly flooded wetlands and meadows (Austin et al. 2007). Our results consistently demonstrated a positive relationship between crane ψ and proximity to palustrine emergent marsh habitat. These results corroborate those of Downs et al. (2008) who found that cranes nested in marshy areas ≤100 m from grasslands that were used extensively for brood rearing, foraging, and cover. Grassland and wet meadow habitats adjacent to nesting territories are preferred by cranes during brood rearing (Gerber et al. 2014). Our results for crane provided only weak support for a relationship between ψ and vegetation structure, i.e., years since last grazed in the landscape-scale model suite, and sum of vegetation hits >15 cm and the ratio of sedge/rush to grass in the plot-scale model suite.

This study underscores the differences of habitat needs for nesting and brood-rearing cranes and curlews. Large tracts of grassland and wet meadow habitats are necessary for both species' nesting, brood rearing, forage and cover needs (Gerber et al. 2014). Curlews and cranes similarly utilize grasslands in conjunction with emergent wetlands for nesting and foraging

(Austin et al. 2007, Saalfeld et al. 2010). Curlews utilize sparse grassland, preferably grazed within the previous year, for nesting (Stanley and Skagen 2007). Conversely, cranes prefer to nest on or near water where vegetation density is high (Gerber et al. 2014, McWethy and Austin 2009).

The current grazing plan for RRLNWR creates disturbance that provides the vegetation structure preferred by nesting curlews within a matrix of taller vegetation that may benefit broods. The rotational aspect of the current grazing plan also provides areas with taller vegetation preferred by nesting, foraging and brood-rearing cranes. This illustrates how prescriptive livestock grazing can be used to provide structurally diverse grassland and wet meadow habitats for species with seemingly disparate structural preferences within the same habitat type. Managing grassland and wet meadow habitat for species that exist on opposite ends of a disturbance preference gradient presumably incorporates the needs of species with intermediate preferences.

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Decadal Growth of Traffic Volume on US Highway 2 in Northwestern Montana

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Abstract

We measured vehicle traffic volume at two locations on US Highway 2 along the southern boundary of Glacier National Park during 2012 and 2013 and then compared results to those collected during 1999 through 2001. We show that traffic volumes have increased substantially in the 11 years between counts and that the increases are most dramatic during the hours in which grizzly bears (*Ursus arctos*) are most likely to cross the highway. Over the preceding decade, grizzly bears have lost two hours of suitable crossing opportunity and will, should observed growth rates and traffic continue, lose an additional three hours within five years.

Key words: connectivity, grizzly bear, habitat fragmentation, highways, Montana, roads, traffic volume, *Ursus arctos*

Introduction

The purpose of this study was to examine current traffic patterns on US Highway 2 (US2), compare them to patterns measured 10 years earlier in Waller and Servheen (2005) and then discuss our findings and their implications for grizzly bear (*Ursus arctos*) conservation.

Highway systems are key elements of human progress, development and economic growth (Bhatta and Drennan 2003), but can also be agents of environmental degradation (Hamilton and Harrison 1991). Highways can divert water-ways and create large areas of impermeable surfaces, interrupting and altering hydrologic systems (Wheeler et al. 2005). They can be sources of many forms of pollution, including noise, lighting and chemical runoff (Hamilton and Harrison 1991). They can become impassable barriers to movement for many forms of wildlife, thus fragmenting habitat and populations (Forman and Alexander 1998). Highways can also cause direct wildlife mortality through vehicle collisions and may further threaten endangered species (Lode 2000). Over the past 20 years, the conservation science community has been challenged to find ways to understand, eliminate, or mitigate the detrimental impacts of road systems (Van der Ree et al. 2011). Such efforts require detailed information on how road systems affect wildlife and ecological systems. It is also useful for planning mitigation efforts as road systems change through time with respect to the surrounding environment.

From 1998 through 2001, Waller and Servheen (2005) studied how traffic on US2, affected the local grizzly bear population. They systematically captured grizzly bears within the US2 corridor between East Glacier and West Glacier, Montana, USA and fitted them with GPS telemetry collars that recorded their position hourly. Beginning in 1999, they measured highway traffic volumes and related them to observed concurrent patterns of grizzly bear movement. They found that, while about half the sampled population of grizzly bears crossed US2 frequently and successfully, there were some effects on bear behavior. Grizzly bears avoided the highway corridor and also crossed the highway less than expected. Most crossings were by young males. Grizzly bears crossed US2 most often at night and when they crossed, they moved faster and farther than expected. Crossing frequency was strongly and negatively correlated with traffic

volume, reaching zero when traffic volume exceeded 100 vehicles per hour (VPH). They concluded that the primary attribute allowing continued grizzly bear population connectivity across the highway was very low observed traffic volumes during evening and night hours. Based on the observed increase in traffic volume between 1984 and 2001, Waller and Servheen (2005) hypothesized that US2 would become a complete barrier to grizzly bear movement in about 30 years.

Study Area

The northern most highway in the contiguous United States, US2, is a two-lane highway separating Glacier National Park to the north from the Bob Marshall Wilderness complex to the south (Fig. 1). The western portion of the highway lies in the valley bottom of the Middle Fork of the Flathead River, from West Glacier (elevation 974 m) to its confluence with Bear Creek at the southern tip of Glacier National Park. Here the highway continues to follow the Bear Creek valley in a northeasterly direction until it crosses the Continental Divide at Marias Pass (elevation 1,610 m). East of Marias Pass, US2 parallels the Two Medicine River and crosses the western boundary of the Blackfeet Indian Reservation (elevation 1,462 m). A major railroad line parallels US2 for its entire length within the study area. This railroad line is a primary freight corridor between Chicago, Illinois and Seattle, Washington. Small concentrations of seasonal homes, businesses, ranches and small communities exist within the US2 corridor in the study area, but the majority of the area is undeveloped federal land. Topography associated with US2 varies from flat valley bottoms to steep mountainsides, up to 2,653 m elevation. Dominant vegetation is primarily spruce/fir forest (*Picea englemmanii/ Abies lasiocarpa*) in the western portions of the study area with open grass/forb/aspen (*Populus tremuloides*) communities in the eastern portions. Riparian areas associated with the Middle Fork Flathead River and Bear Creek parallel the highway for much of its length within the study area. Avalanche chutes, preferred grizzly bear foraging areas (Waller and Mace 1997, McLellan and Hovey 2001), occur in numerous locations, often close to the highway.

Methods

Beginning in May 2012, we placed two Unicorn Limited pneumatic tube-type traffic counters (Diamond Traffic Products, Oakridge, OR) on US2 at the identical two locations used in 1999–2001; mile marker (MM) 184 near Java Creek and MM 202 near Coonsa Creek. We configured the counters to tally the number of vehicles passing over the counter sensors each hour of the day in each lane (east- and west-bound lanes). The counters used a rubber tube stretched across the road surface to detect the passage of each axle by registering the number of air bursts transmitted through the tube by tire compression. Having counters at each end of the study area provided system redundancy should one of the counters become inoperative and allowed calculation of local vs. through traffic by comparing same-lane counts within concurrent time intervals. Because the counters actually tallied axles, we developed a correction factor for multi-axle vehicles by having an observer count axles and classify vehicle types during nine 30–60 minute observation periods, conducted at or near peak traffic periods. We then compared these actual counts to those collected by the counters to derive a ratio estimate of the true number of vehicles. Vehicle types categorized were cars (includes motorcycles and light trucks), heavy trucks (straight and combination units of 3 to 10 axles), busses, recreational vehicles (motorhomes, pickup campers, house trailers) and cars pulling various types of trailers (boats, horse trailers and utility trailers). We monitored the counters biweekly and downloaded the stored data to a laptop computer. We removed the counters with the onset of snow in October, then redeployed them in May 2013, where again they remained in place until October. We

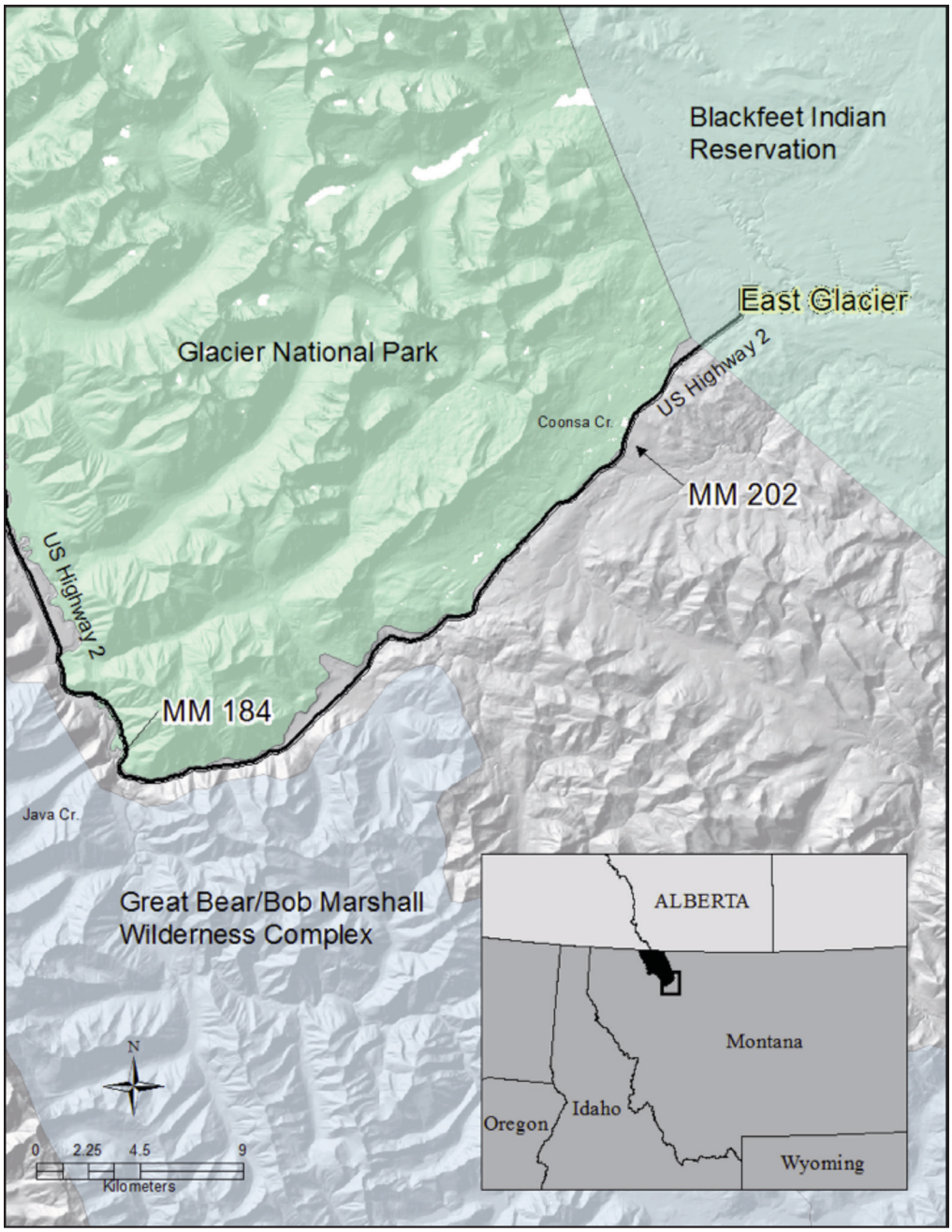

Figure 1. US Highway 2 study area and traffic counter locations in northwest Montana, USA. 1999–2001 and 2012–2013.

pooled the data collected during and within each time period, 1999 through 2001 and 2012 through 2013, to obtain mean values by hour, day and month. We performed all statistical analyses using the software Statistica (Statsoft Inc., Tulsa, OK 74104).

We estimated exponential growth rates using the formula $N_{(t)}=N_{(0)}e^{rt}$, where $N_{(t)}$ is the traffic volume at the end of the period of interest, $N_{(0)}$ is the traffic volume at the start of the period of interest, e is Euler's constant and r is the growth rate.

Results

The traffic counters recorded over 4,000 hours of highway traffic between May and October 2012 and 2013. Based on our correction factor, we estimated the actual number of vehicles to be 84 percent of the recorded number. Overall average hourly traffic volume was 112 (range 0–455) vehicles per hour (VPH)at MM 184 and 104 (range 0–390) VPH at MM 202. This was an increase from 77 (range 0–318) VPH at MM 184 and 87 (range 0–398) VPH at MM 202 from the 1999–2001 study (Waller and Servheen, 2005) (Fig. 2). Mean total vehicles per day (VPD) increased from 1806 to 2775 VPD at MM 184 and from 2066 to 2377 VPD at MM 202. Traffic volume continued to show strong daily and seasonal fluctuation (Fig. 3). As was the case in the 1999 through 2001 study period, traffic peaked at 1600 hours, but mean traffic volumes at that time of day increased in the 2012 through 2013 study period from 158 to 222 VPH at MM 184 (Fig. 4) and from 178 to 212 VPH at MM 202. Similarly, traffic volume continued to reach its minimum at 0400 hours, but mean traffic volumes at that time of day increased from 4-5 VPH to 8-9 VPH at both locations. Traffic also had a pronounced weekly pattern that did not vary between time periods, although its magnitude did; traffic volume was generally higher Friday through Sunday than Monday through Thursday (Fig. 5). The distribution of traffic types was unchanged; approximately 24 percent of traffic was local and 82 percent of the traffic consisted of cars, 4 percent was heavy trucks and 7 percent was recreational vehicles.

Overall traffic volume increased significantly between the two study periods; growth in mean hourly traffic volume was 45 percent at MM 184 and 19 percent at MM 202. Total daily traffic increased 54 percent and 15 percent at MM 184 and MM 202, respectively. However, the growth rate varied considerably by time of day. Peak hourly traffic volumes at 1600

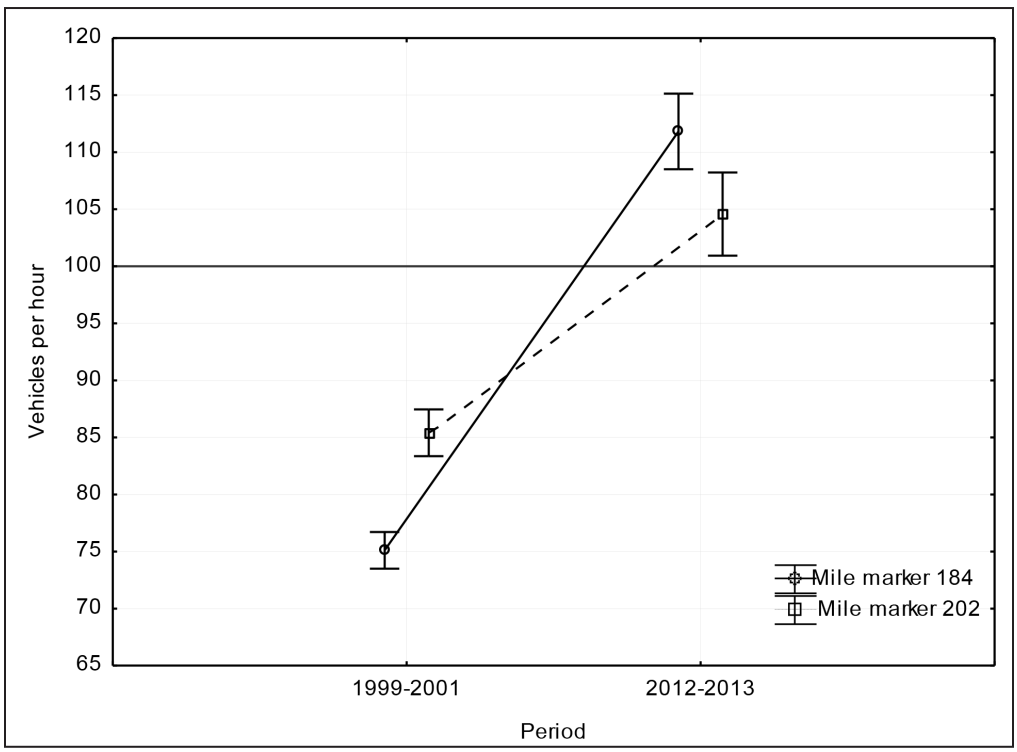

Figure 2. Change in mean bidirectional hourly traffic volume at two traffic counters on US Highway 2 in Western Montana during 1999–2001 and 2012–2013.

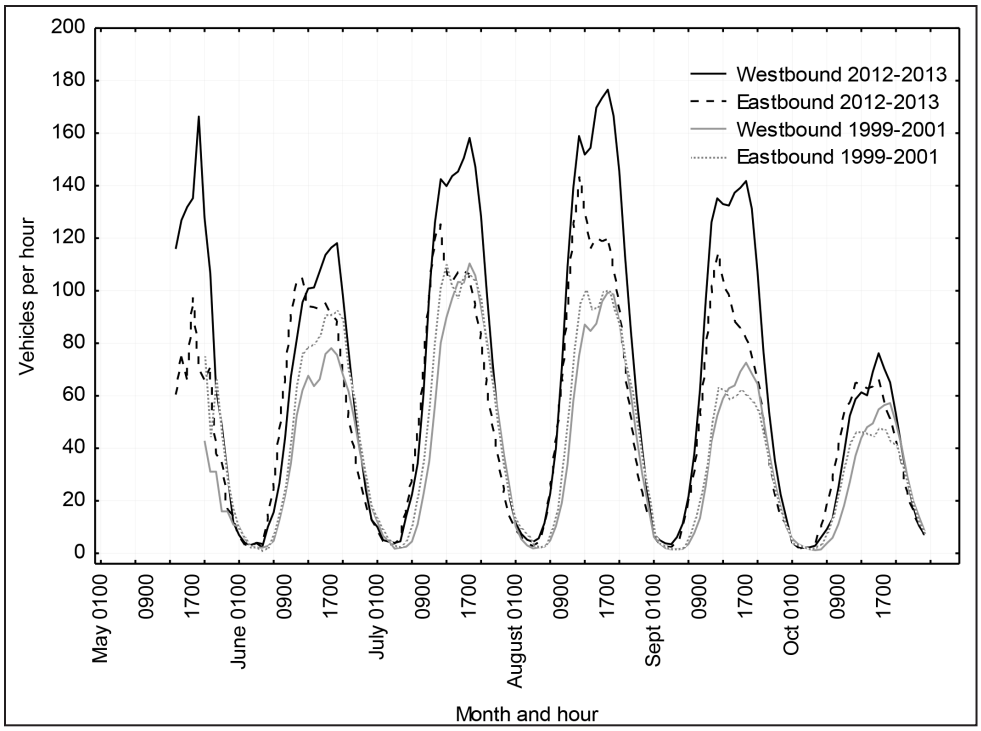

Figure 3. Mean hourly unidirectional traffic volume by month at US Highway 2 in Western Montana, mile marker 184, during; 1999–2001 and 2012–2013.

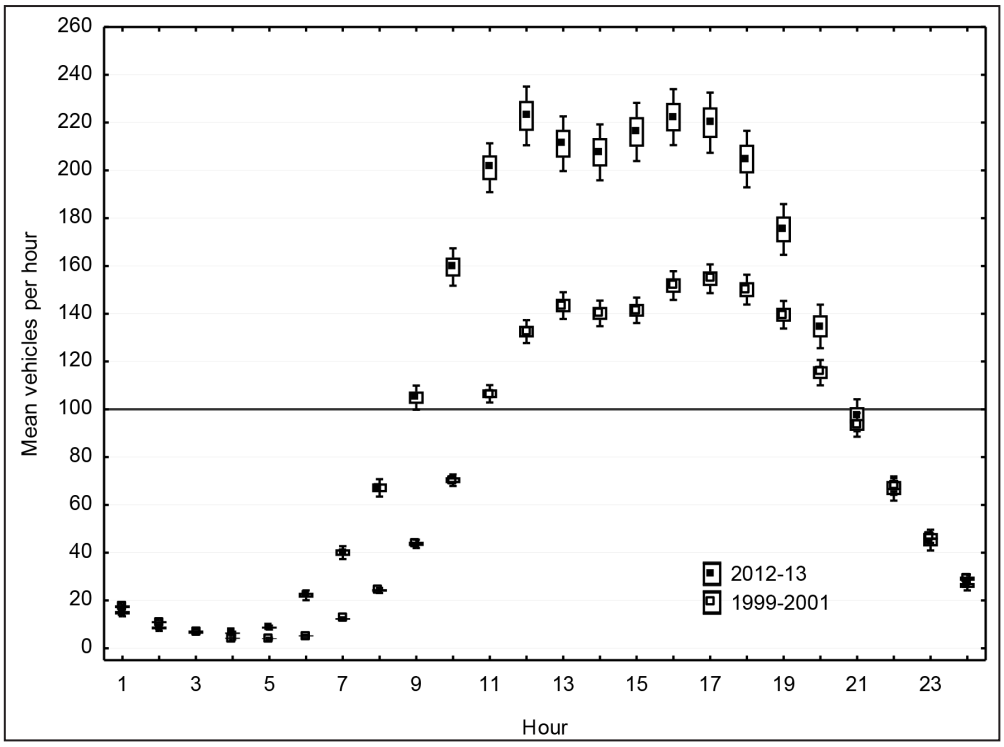

Figure 4. Mean traffic volume by hour at US Highway 2 mile marker 184 in western Montana during; 1999–2001 and 2012–2013.

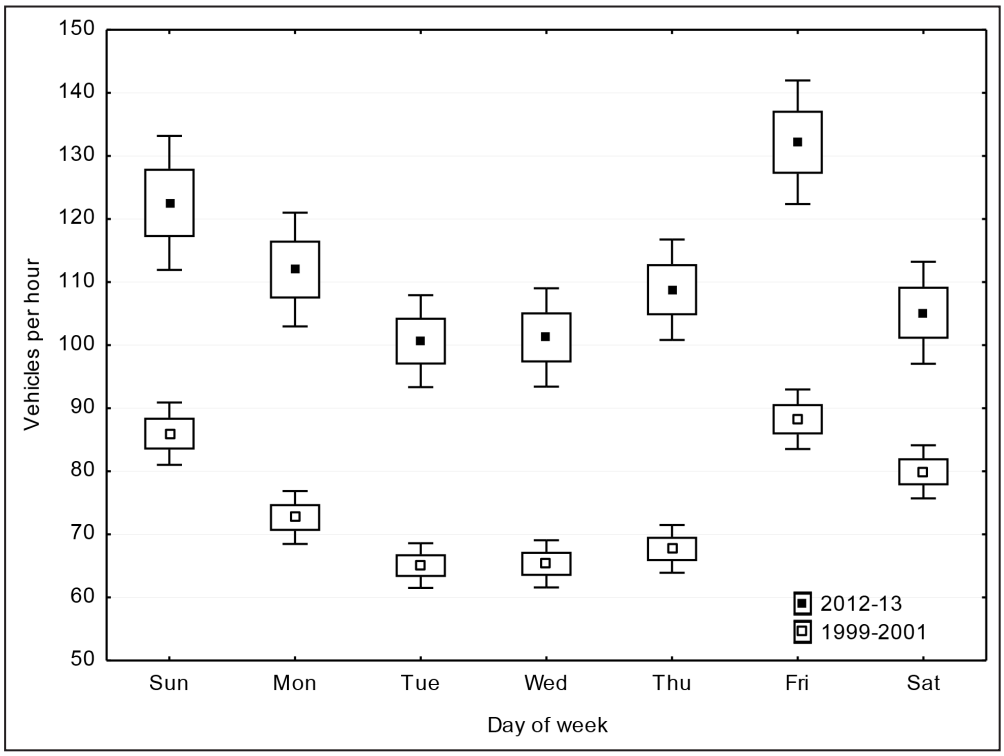

Figure 5. Mean hourly traffic by day of the week, US Highway 2, mile marker 184, in western Montana.

hours increased 40 percent and 21 percent respectively and minimum traffic volumes at 0400 hours increased 100 percent and 80 percent, respectively. Mean VPH at MM 184 and MM 202 declined between 2200 and 0300, then increased from 0400 to 2100 (Fig. 6).

Discussion

In the wildlife literature, traffic volumes are often expressed as average daily traffic (ADT; expressed here as VPD), or annual average daily traffic (AADT). These are the measurements commonly collected at automated vehicle counters and reported by state departments of transportation. While sufficient for transportation planners, they lack the resolution necessary to understand the true environmental impact of traffic (Bissonette and Kassar 2008). Important daily, weekly and seasonal patterns of traffic flow are masked through averaging. For example, strong daily fluctuations in traffic volume can have vastly different effects on species if they are diurnal or nocturnal. Reporting ADT for our study area would suggest lower traffic volumes than what is observed during the day and higher traffic than what we observed at night. Further, US2 is the primary western access for Glacier National Park, a major summer tourist destination. Visitors to the park create high traffic volumes during the summer months, followed by relatively low counts during the winter. These low winter counts offset high summer counts in AADT calculations, thus masking important traffic impacts during the seasons when grizzly bears are not in winter dens.

In 2005, Waller and Servheen (2005) estimated that US2 would become a complete barrier to grizzly bears in 30 years, when minimum traffic levels exceeded 100 VPH. This estimate was based on an observed 35 percent exponential growth rate in mean VPH between 1984 and 2001. Although mean VPH again increased exponentially between 1999 through 2001

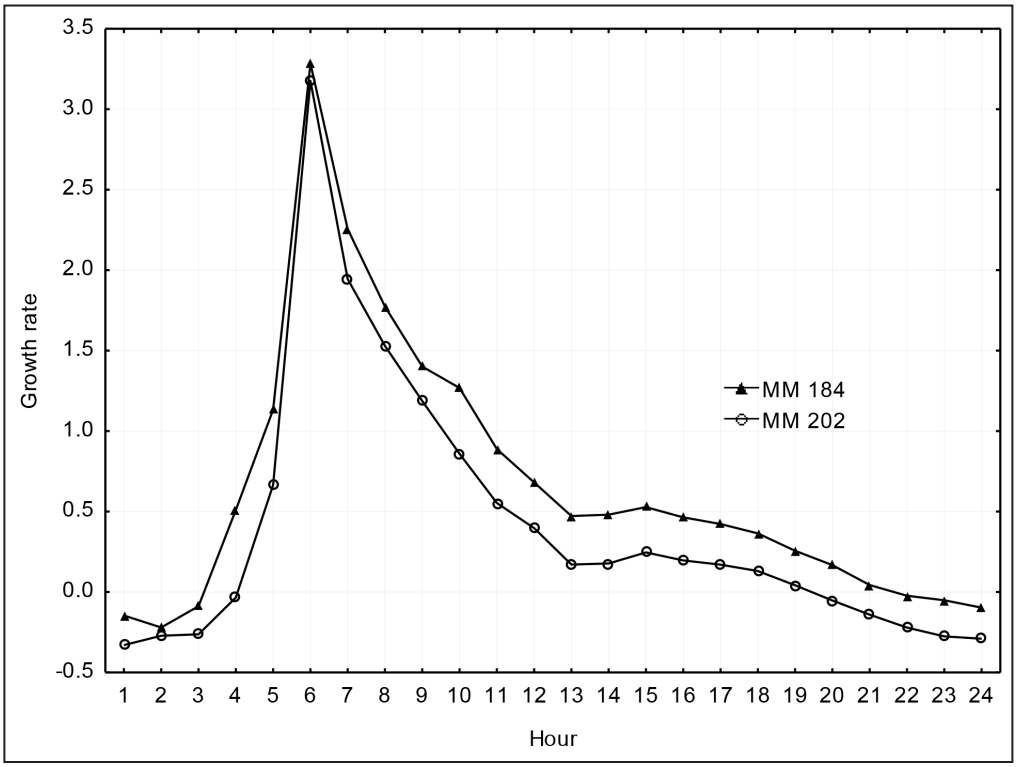

Figure 6. Growth rate in mean vehicles per hour between 1999–2001 and 2012–2013 at two locations on US Highway 2, in western Montana.

and 2012 through 2013, given the observed variation in growth rates during the day, we wondered if this estimate would hold true for those hours when grizzly bears were most likely to cross the highway (2300–0700). Applying a 35 percent growth rate to the low traffic volumes observed during these hours suggests that traffic might not reach 100 VPH for 80 years or more. Unfortunately, the mean observed exponential growth rates for these hours was much higher; 73 percent at MM 184 and 48 percent at MM 202. These averages were driven primarily by large increases in traffic between 0500 and 0700 hours. At these rates, the 100 VPH point during those hours will be reached in 22 years and 35 years at MM 184 and 202, while some crossing opportunity may remain 2300 through 0300 hours.

Since we last monitored traffic in 2001, mean VPH has surpassed 100 in the 0900 and 1000 hours. Mean VPH remained over 100 from 1100–2000. In other words, out of a 24-hour day, 12 hours now have traffic volumes above that threshold where grizzly bears were observed to stop crossing the highway. Based on the traffic growth rates observed here, bears will lose an additional three hours over the next five years. The hours 2200 to 0300 will likely remain below 100 VPH for much longer. Unfortunately, Waller and Servheen (2005) showed that rail traffic was significantly higher during these hours. If that remains the case, then grizzly bears will continue to have to choose between high risk of vehicle strike or high risk of train strike.

It is important to recognize that grizzly bear behavior is affected at traffic volumes well below 100 VPH. Northrup et al. (2012) documented strong avoidance of roads by grizzly bears where traffic volume exceeded 20 VPD, (as did Waller and Servheen (2005)), and showed that traffic volume is a strong behavioral determinant independent of any habitat covariates. Proctor et al. (2012) documented continental scale

fragmentation of grizzly bear populations in the USA and Canada and related it to increasing human development and highway traffic. Within our study area, Kendall et al. (2009) discovered incipient genetic population fragmentation along the western portions of US2 south of Glacier National Park.

The intervening decade between these two traffic samples encompassed broad societal upheavals at the national and local levels, including the 11 September 2001 terrorist bombing of the World Trade Center in New York City, US military actions in Afghanistan and Iraq, the boom in the national housing market followed by economic recession in 2008 and development of large oil fields in Alberta and North Dakota. These events are reflected to some extent in the observed changes in traffic volumes on US2 by changing the distribution of economic activity centers and the movement of people to and from those centers. Interest in widening US2 by local chambers of commerce was a hot topic in the early 2000's (Missoulian 2001), but died down during the economic recession and development of eastern oilfields. We do not know if an improving economy will renew calls for widening the highway, but interest in the transportation corridor from business groups is increasing (Great Falls Tribune 2014). Regardless, it seems likely that traffic will continue to increase, with commensurate impacts to grizzly bears and other species.

Habitat connectivity is a national issue. In 2007, the Western Governors Association launched an ambitious plan to support wildlife corridor protection efforts (Western Governors Association 2008). This initiative fostered a diversity of GIS mapping and corridor modeling efforts, many of which identify locations within our study area as important locations for regional wildlife connectivity (Cushman et al. 2013, Ament et al. 2014, McClure and Ament 2014, Weaver 2014). Given the growth in traffic volume observed here, we recommend that efforts to identify locations for crossing structures transition from landscape modeling to field validation. Empirical documentation of wildlife movement patterns is essential to inform placement of highway crossing structures. Highway planners should recognize that mitigation should be in place within 20 years to minimize detrimental impacts to grizzly bears.

Acknowledgements

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Effects of a Beaver Pond in Southwestern Montana on Metals Concentrations and Loads

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Abstract

A 400-m^2 beaver pond on Cabbage Gulch (Deer Lodge County, MT) was investigated for its retention of total recoverable (TR) and dissolved arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn), and total suspended solids (TSS) during three storm water runoff events in the summer of 2013. Water samples were collected and flow rates were measured at monitoring stations above and below the pond. Decreases in TR metals concentrations were -17 percent for As (that is, As concentrations increased), 10 percent for Cu, 7 percent for Pb, and 27 percent for Zn. Total recoverable metals retained in the pond, on a mass basis, were 24 percent for As, 47 percent for Cu, 45 percent for Pb, and 55 percent for Zn. The average retention was 49 percent (by mass) for TR Cu, Pb, and Zn. Twenty-four percent of the influent TR Cu and TR Zn loads were retained because the metals were suspended in the pond with stored storm water. An additional 27 percent of the influent TR Cu and TR Zn loads settled out of the water during the sampling periods. Arsenic retention was low because all of the As was in the dissolved phase and no As could settle out. Total suspended solids concentrations decreased by 2 percent and TSS mass retention was 41 percent.

Keywords: beaver pond, sedimentation, metals, arsenic, cadmium, copper, lead, zinc, suspended solids, Montana

Introduction

Historic smelting activity in Anaconda, Montana, released contaminants of concern (COCs) into the air with the flue gas from the smelter stack. The COCs were then deposited on the land downwind from the smelter. The COCs spread across the Mill Creek (Deer Lodge County, Montana) drainage. Storm water runoff contains these COCs and contaminates streams when the runoff enters the streams. Beaver ponds improve water quality because they retain storm water runoff (Naiman et al. 1988, Beedle 1991, Pollock et al. 2003) and increase particle removal by sedimentation of some of the solid particles and particulate phase COCs in the water (Maret et al. 1987, Naiman et al. 1988, Gurnell 1998, Butler and Malanson 1995, 2005). Beaver ponds may reduce maximum daily loads by reducing stream flow rates because they store water during floods and release the stored water slowly, which may spread the release of loads over more than one day.

This study had four objectives: (1) to measure stream flow rates and COC concentrations above and below a beaver pond in the Mill Creek drainage during storm water runoff, (2) to compare the COC concentrations to Montana DEQ-7 surface water quality standards and determine if the pond reduced COC concentrations to below surface water quality standards, (3) to quantify COC retention by a beaver pond during the first-flush of storm water runoff, and (4) to quantify how much of the COC retention was due to particle sedimentation compared to dissolved and suspended COCs that were retained in stored pond water during the sampling periods.

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Study Area

The beaver pond studied in this project was located at 46.074°N latitude and 112.924°W longitude, and was in Cabbage Gulch, a tributary to Mill Creek. Cabbage Gulch is ~ 4.5 km south of the decommissioned Anaconda Company smelter smokestack. The pond was 39 m wide and 11 m long; its dam lay on an approximate east-west line (Fig. 1). Global positioning system coordinates taken around the pond periphery were used to calculate a pond surface area of 400 m^2 (Lorenzo 2014). Cabbage Gulch entered the pond in its southeast corner and left through a hole in the dam near its eastern end. The water surface was about 0.5 m below the dam crest during this study, and the hole in the dam was below the pond surface at all times. The dam contained a significant hole because beavers did not inhabit the pond in 2013 and the dam was not being maintained. A dead tree lay along the west side of the inlet, with its trunk roughly parallel to the direction of inlet flow. The flow pattern relative to the inlet, outlet and dead tree divided the pond into a hydraulically active zone (40 m^2) east of the dead tree and a stagnant zone west of the dead tree.

Methods and Materials

Two monitoring sites were established to collect stream samples above and below the beaver pond. Teledyne ISCO Model 3700 automated samplers activated by liquid level sampler actuators collected samples at each site. The sampler actuators started the samplers when the water stage reached a depth indicating that a storm runoff event had started. Both sites had Solinist Model 3001 Edge F15 series pressure transducers that recorded the stream stage at 15-min intervals. The lower station had a 23-cm H-flume while the upper station had a 7.6 cm Parshall flume. Stream stages were calculated from pressures measured by the two pressure transducers, and flow rates were calculated from these stream stages (Lorenzo 2014).

Samples were collected at both sites during each storm runoff event. Six individual samples were taken 1 hr apart during a sampling period. The number of samples was determined from the

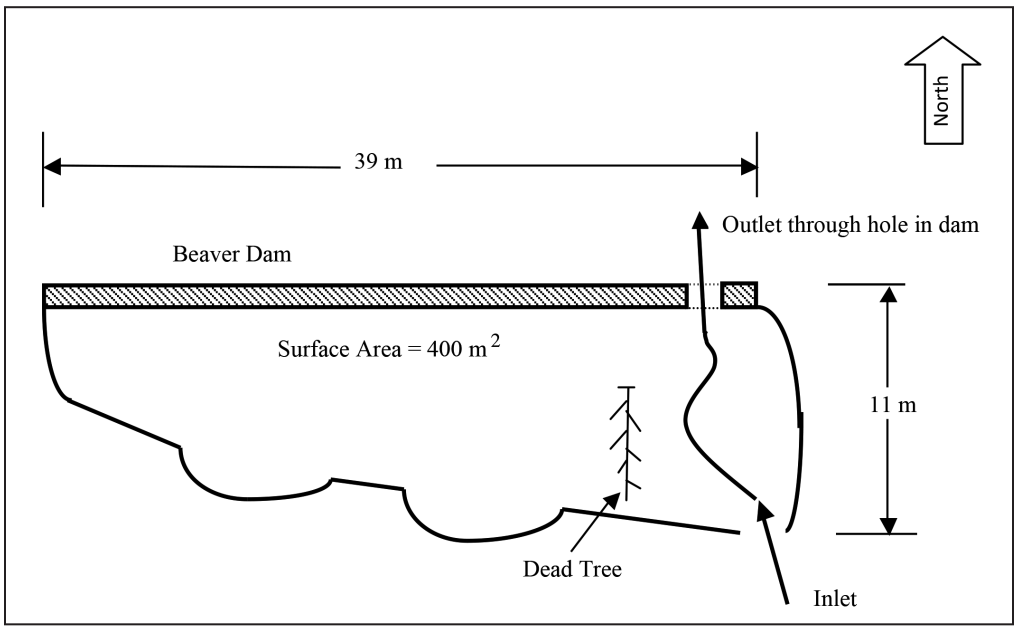

Figure 1. Plan view and dimensions of a beaver pond on Cabbage Gulch in southwestern Montana. Measurements taken in June 2013.

capacity of the ISCO samplers and the sample volume required for all specified analyses on individual samples. Samples were collected during the rising limbs of the storm hydrographs because the water quality below the pond was to be assessed for compliance with Montana DEQ-7 acute toxicity water quality standards (Tucci 2014). Water quality standards are most likely to be exceeded when a storm hydrograph is rising (the "first flush") because that is when water quality is the worst (Stenstrom and Kayhanian 2005). Thus, samples were taken only during a portion of the rising limb of a storm hydrograph.

Arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) were analyzed for both total recoverable (TR) and dissolved concentrations in all samples. Total suspended solids (TSS) were measured in one sample taken at each monitoring site per storm event. All analyses were performed by the Montana Bureau of Mines and Geology (MBMG) Analytical Laboratory. Metals analyses followed EPA Methods 200.2, 200.7 and 200.8. Total suspended solids (TSS) analyses followed Standard Methods Method 2540D (APHA 2005).

Mass loads were calculated by multiplying concentrations times flow rates. Flow rate data was obtained every 15 min, but COC concentrations were sampled hourly. Flow rates were averaged from 30 min before to 30 min after sampling, resulting in a 6-hr sampling period. The average flow rate for each of the 6 hrs was multiplied by the COC concentrations in the sample from that hour. The 1 August 2013 event was an exception, where the flow rate associated with the first of the six samples was averaged from 15 min before the sample was taken to 30 min after the sample was taken because the 1 August storm hydrograph did not start until l5 min before the first sample was taken.

Results

Storm runoff events were sampled on 1 August 2013, 17 September 2013, and 24 September 2013. The samplers were activated manually on 1 August and 24 September to assure that samples were taken during those storm events.

Storm Hydrographs

Hydrographs show that the rising limbs of the upper site hydrograph preceded the rising limbs of the lower site hydrograph (Figs. 2 and 3). The hydrographs for the 1 August storm and the 17 September storm were similar (Fig. 2) with the upper site having a rising limb and a falling limb that preceded these limbs at the lower site. The storm hydrographs for 24 September (Fig. 3) were different in that the falling limb at the upper site occurred after the falling limb at the lower site.

Water Quality

Copper, Pb, and Zn had TR metals concentrations were greater than dissolved metal concentrations for all but one analysis (Fig. 4). Dissolved As metal concentrations equaled TR As metal concentrations. Nearly all Cd TR and dissolved metals concentrations were below the minimum reportable limit, so no analysis of Cd concentrations was possible.

Most COC concentrations were less than the Montana DEQ-7 acute toxicity surface water quality standards (Table 1). Copper was the only COC that exceeded the DEQ-7 standard, and this occurred at both monitoring sites. All As, Pb, and Zn concentrations were below surface water quality standards.

The effect of the beaver pond on concentrations and mass loads varied with each COC (Table 2). Zinc had the greatest decreases in both TR and dissolved metal concentrations, followed by Cu and Pb. Decreases in TSS concentrations were negligible. Total recoverable and dissolved As concentrations increased as water flowed through the pond. Total recoverable metals masses retained in the pond (as a percent of upper site loads) were greater than were decreases in TR metal concentrations, and averaged 49 percent for Cu, Pb, and Zn (Table 2). Zinc had the greatest mass retained in the pond, and As had the lowest mass retained in the pond. Concentration

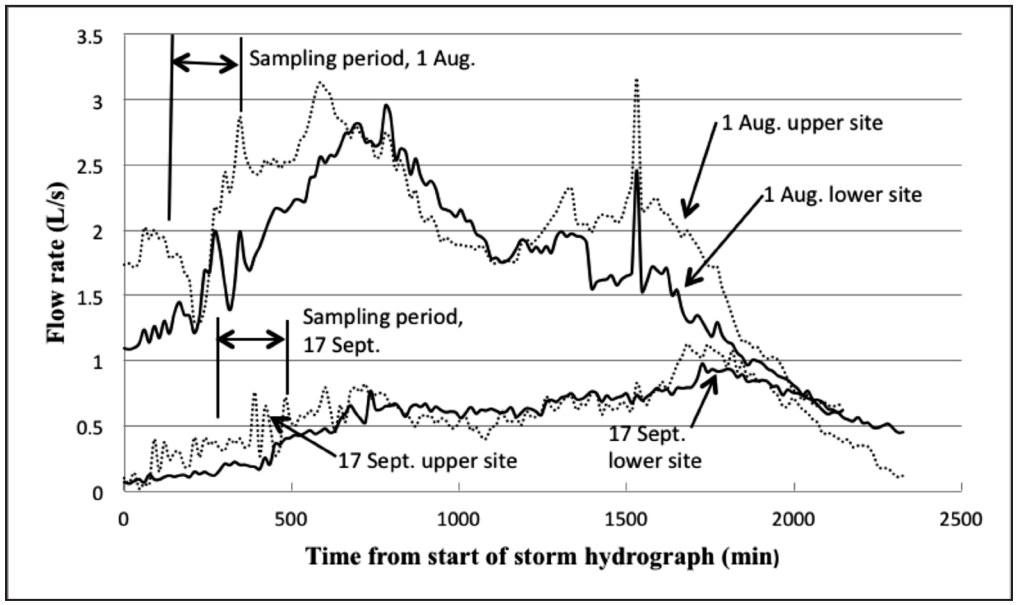

Figure 2. Hydrographs above and below a beaver pond in southwestern Montana for the 1 August 2013 and 17 September 2013 storm events.

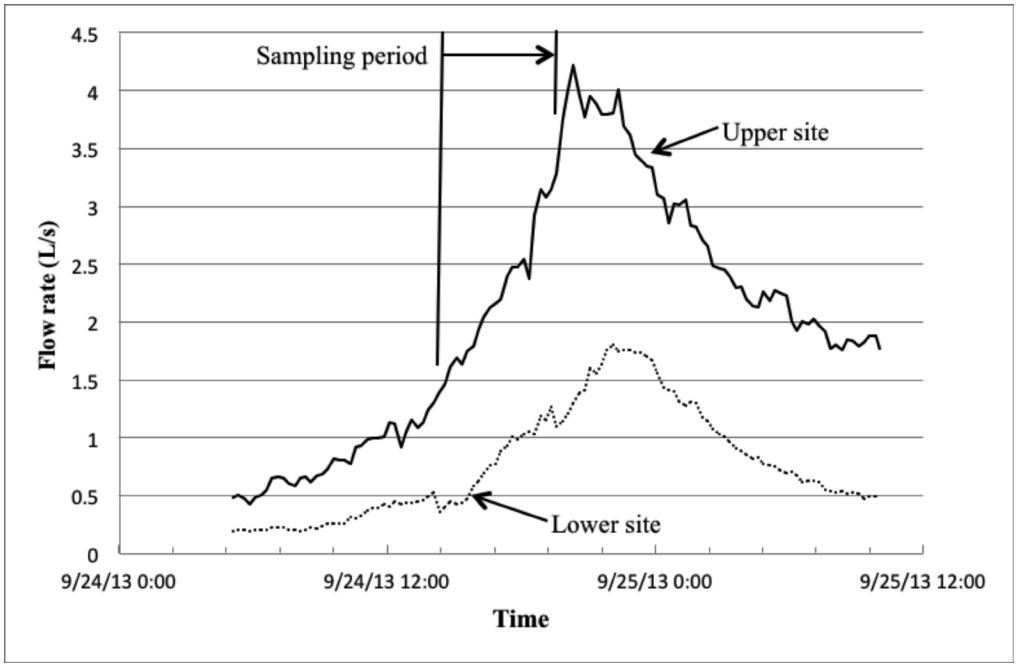

Figure 3. Hydrographs above and below a beaver pond in southwestern Montana for the 24 September 2013 storm event.

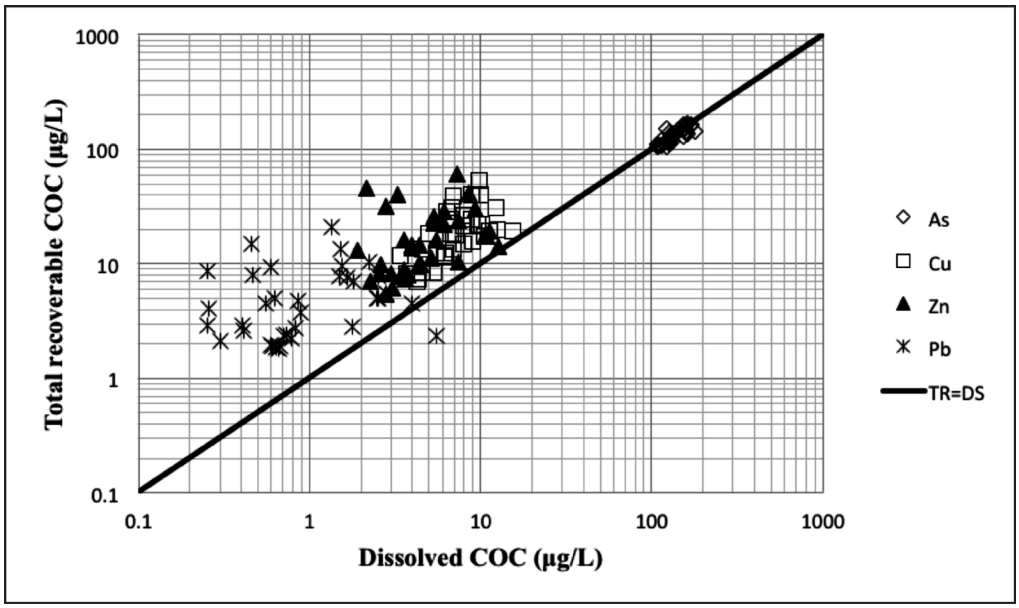

Figure 4. Total recoverable COC concentrations vs. dissolved COC concentrations.

Table 1. Total recoverable COC concentrations (µg/L) above and below a beaver pond in southwestern Montana during storm events in August and September 2013. The concentrations are the averages of the six samples per event. The acute toxicity standards for Cu, Pb, and Zn were calculated with the average hardness values from both sites.

Date	Upper site	Lower site	Acute toxicity standard
	Arsenic		
1 Aug	142	162	340
17 Sept	119	142	340
24 Sept	110	128	340
	Copper		
1 Aug	33.6	29.3	6.7
17 Sept	13.9	8.6	6.7
24 Sept	19.2	16.0	6.7
	Lead		
1 Aug	11.7	8.8	30.3
17 Sept	2.2	2.4	30.3
24 Sept	4.9	3.9	30.3
	Zinc		
1 Aug	37.8	27.0	61.9
17 Sept	10.4	7.9	61.9
24 Sept	17.7	11.7	61.9

Table 2. Effect on concentrations and mass loads from a beaver pond in southwestern Montana during storm runoff events in August and September 2013. The reported values are averages from the three storm events.

Contaminant of Concern	Average TR concentration decreases (%)	Average TR mass retained (%)	Average dissolved concentration decreases (%)
As	-17	+24	-20
Cu	+10	+47	+12
Pb	+7	+45	+6
Zn	+27	+55	+20
TSS	+2	+41	--

differences of TR COCs (percent of upper site concentrations) were < 50 percent of the mass retention of TR COCs.

Discussion

This beaver pond did not reduce TR Cu concentrations leaving the pond to below the Montana DEQ-7 acute toxicity surface water quality standard. Other beaver ponds in neighboring drainages studied by the MBMG had identical results (Tucci 2013, Tucci 2014). In the drainages studied, beaver ponds alone improve water quality but do not provide sufficient treatment to meet Montana DEQ-7 standards.

The fraction of storm water stored in the pond was determined as part of the calculation of COC retention. The storm water volume stored in each 15 min time increment was calculated with Equation 1:

$$Volume = \left(\frac{Q_{u,1} + Q_{u,2}}{2} - \frac{Q_{l,1} + Q_{l,2}}{2}\right) x\ 15\ min\ x\ 60\ s/min \quad (1)$$

where Q represents flow rate (L/s), the subscripts u and l represent the upper and lower monitoring sites, respectively, and the subscripts 1 and 2 represent the beginning and end of a time increment, respectively. The incremental storage volumes were then summed over a sampling period. The fraction of storm water stored equaled the storm water volume stored divided by the water volume that passed through the upper monitoring site. The fraction of water stored was 19 percent for the 1 August storm, 23 percent for the 17 September storm, and 26 percent for the 24 September storm, with an average storage of 23 percent. The fractions of the COC mass loads that were retained were positively correlated with the water volumes stored (Fig. 5). Lead is not shown in Figure 5 because its concentrations were scattered such that an analysis was not meaningful.

Contaminant of concern masses stored in the pond were the suspended and dissolved (not settled) COCs that entered but did not leave the pond during a sampling period. Mass stored was calculated by multiplying the water stored in each 15 minute time increment by the COC concentrations at the lower site. The incremental values were then averaged. We assumed the hydraulically active zone in the pond was completely mixed, which is reasonable considering its small volume. Thus, pond water COC concentrations equaled COC effluent concentrations.

Mass balances around the beaver pond were used to estimate the COC masses that settled out of the water in each 15 minute time increment (Equation 2):

$$mass\ settled = mass\ in - mass\ out - mass\ stored \quad (2)$$

Settled mass incremental values were then averaged for all three storm events. Twenty-four percent of the influent TR Cu and TR Zn mass loads were stored in the pond water while another 27 percent settled out of the water (Table 3). The fraction of influent TR Cu and TR Zn mass stored was

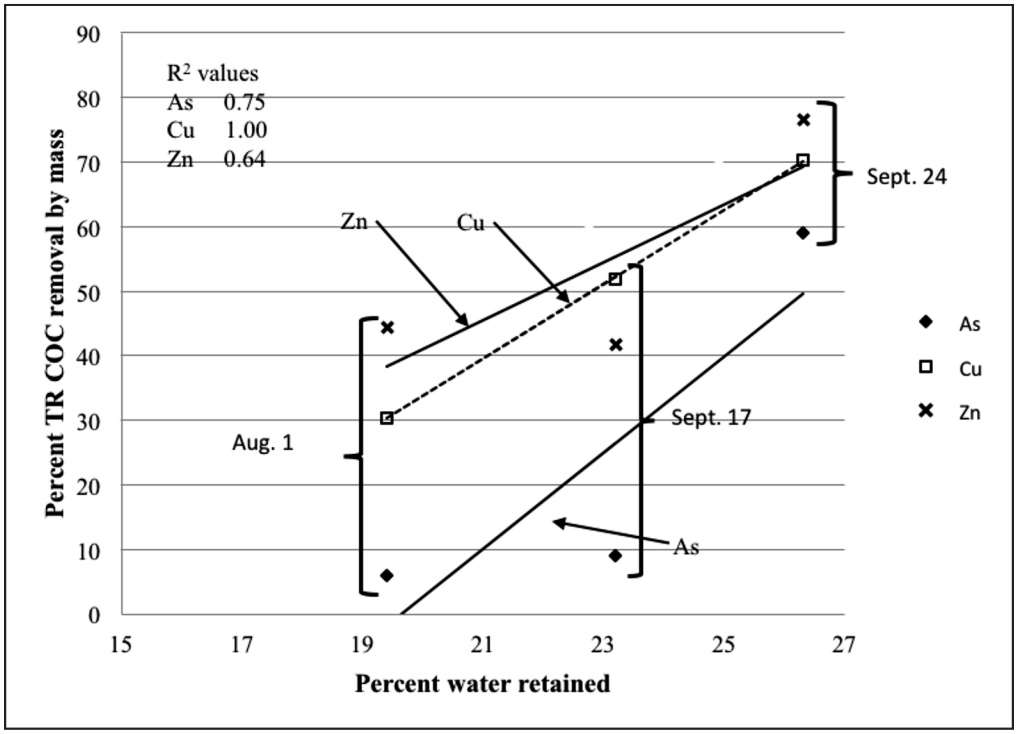

Figure 5. Percent TR COC retained vs. percent water retained. The lines are linear regression lines.

Table 3. Average TR Cu and TR Zn masses calculated to have settled out of the water during the three storm events.

	TR Cu				TR Zn			
	Mass in	Mass out	Mass stored	Mass settled	Mass in	Mass out	Mass stored	Mass settled
Average mass (mg)	937	500	260	176	972	434	201	336
Percent of mass in	--	53	28	19	--	45	21	35

	Mass in	Mass out	Mass stored	Mass settled
Average of Cu + Zn (mg)	955	467	231	256
Percent of Cu + Zn mass in	--	49	24	27

consistent with the fraction of storm water retained in the pond (23 percent) and the reduction in As mass loads (24 percent). The decrease in the TR As mass loads must be attributed solely to storage, because all of the As was in the dissolved phase and dissolved solids do not settle.

Contaminant of concern masses that settled out or were stored in the pond were most likely different for the entire storm hydrograph periods than those measured during the sampling periods. The sampling periods were short compared to the hydrograph lengths (Figs. 2 and 3). Some particulate-phase COCs suspended in the pond water should have settled out after the sampling periods ended, so the COC masses removed by sedimentation were most likely larger than the values shown in these data. Some of the particulate and dissolved COCs

stored in the pond water would have left in the pond outflow after the sampling periods ended as the pond volume returned to its base flow volume. Therefore, storages of suspended and dissolved COC masses for entire hydrographs were likely less than storages reported in the Results.

Arsenic retention on a mass basis was positive only because the flow rates at the upper site were higher than the flow rates at the lower site during the sampling periods. Arsenic was dissolved (Fig. 4) so there was no particulate As to settle out. Arsenic concentrations at the lower site were greater than those at the upper site (Table 1), which may have occurred because of the mobility of As in the sediment column, flux diffusion, and sediment re-suspension into the pond water (Cornett et al. 1992).

Total suspended solids concentrations varied significantly from runoff event to runoff event. Total suspended solids masses retained were sometimes high (24 Sep; 84% on a mass basis) and sometimes low (1 Aug; 17% on a mass basis). A reason why TSS retention was highly variable was that few TSS analyses were performed.

Conclusions

- The masses of TR COCs retained (either by sedimentation or by being suspended or dissolved in stored pond water) by a beaver pond on Cabbage Gulch in southwestern Montana during three storm water runoff events were 24 percent for As, 47 percent for Cu, 45 percent for Pb, 55 percent for Zn, and 41 percent for TSS.
- Concentrations of TR COCs decreased by -17 percent for As (that is, As concentrations increased), 10 percent for Cu, 7 percent for Pb, 27 percent for Zn and 2 percent for TSS.
- Cadmium concentrations were almost all below the minimum reportable limit.
- Arsenic was entirely in the dissolved phase.
- Upper monitoring site flow rates were higher than lower monitoring site flow rates during all storm events.
- Contaminant of concern retention on a mass basis was greater than decreases in COC concentrations.
- Total recoverable Cu and Zn retention in the stored storm water (24% of the inflow mass quantity) was approximately the same as mass retention due to sedimentation (27%).

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Effects of Three Swim Strokes Over 25 Yards in Labor-Wear with a Personal Flotation Device

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Abstract

We determined how three different swim strokes (breast, back, and American crawl) were affected by standard labor-wear while wearing a personal flotation device (PFD) over 22.8 meters (25 yards). The main research questions were, (1) which stroke would yield the fastest times over 22.8 meters and (2) Would there be a difference in the swim times between male and female subjects? We addressed these questions with three hypotheses addressing whether or not there would be a statistically significant difference among the three strokes, and whether or not gender would have an effect on performance of the different strokes. The mean 22.8-m elementary back stroke swim time for all subjects (n = 51) was 59.98 sec; for the breast stroke it was 46.05 sec and for the crawl stroke it was 46.48 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 1 in favor of research hypothesis 1 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke for all subjects, with breast stroke being the fastest and the elementary back stroke being the slowest. The mean 22.8-m elementary back stroke swim time for male subjects (n = 26) was 51.04 sec; for the breast stroke it was 41.41 sec and for the crawl stroke it was 34.73 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 2 in favor of research hypothesis 2 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke, with the crawl stroke being the fastest and the elementary back stroke being the slowest. The mean 22.8-m elementary back stroke swim time for female subjects (n = 25) was 69.28 sec; for the breast stroke it was 50.87 sec and for the crawl stroke it was 58.71 sec. An ANOVA generated a P-value of .001. Thus, we rejected null hypothesis 3 in favor of research hypothesis 3 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke, with the breast stroke being the fastest and the elementary back stroke being the slowest.

Keywords: swim strokes, labor-wear, swim times, personal flotation device, life vest

Introduction

In March 2011, a train derailment along the Kootenai River in Northwest Montana required railway workers to be transported to the derailment site via jet boat and to work on an inclined embankment along the river. The ensuing clean-up effort lasted 4 months and involved over 1000 people. Many of the laborers were transported on jet-boats to islands, and worked in close proximity to the flooding river. During this time, the air temperature fluctuated between -1-12 ◦C (30-54 ◦F), the Kootenai River was flowing at about 566.34 m3/ sec (20,000 ft3/ sec), and the temperature of the water was about 3.8 ◦C (39 ◦F) (U.S. Geological Survey 2011).

A common question of the laborers during transport was, “If we fall into the drink [while working], how long would we be able to stay up before you guys are able to rescue us?” The average worker transported to the worksite was wearing standard labor-wear: a hard hat with a liner, a heavy canvas jacket with insulation under

the jacket, canvas bib coveralls, and heavy leather work-boots with steel-toe protection. We tested the hypothesis that occupational clothing would impair performance during swimming and treading water (Amtmann et al. 2012).

Our research provided evidence that standard labor-wear had adverse effects on 11.4-m swim time, water treading time, and rate of perceived exertion (RPE) on the Borg Scale (1998) during water treading. The mean swim time more than doubled when the subjects wore standard labor-wear and their average rate of perceived exertion increased from 11.6 in standard swimwear to 17.1 in standard labor-wear. Because the trials excluded the use of a personal flotation device (PFD), the authors' recommendations for future research included comparing the effectiveness of different strokes with and without a PFD over 11.4 meters/12.5 yards. (Amtmann et al. 2012).

Subsequent research examined the effects of standard labor-wear with and without use of PFDs for three strokes: elementary back stroke, breast stroke and American crawl. Statistical analysis showed statistically significant differences between PFD and no PFD for the American crawl (no PFD 23.29 sec, PFD 18.29 sec, P = 0.0010), and back stroke (no PFD 36.96 sec, PFD 31.00 sec, P = 0.0223); these strokes showed shorter swim times with the PFD. We detected no statistical evidence (P = 0.2086) for the mean swim time (22.61 sec) for the breast stroke with PFD and the mean swim time (23.00 sec) for breast stroke without a PFD.

Swim time between swimmers with and without a PFD differed. The mean swim time for all swimmers with a PFD (24.17sec) was faster than the mean swim time for all swimmers without a PFD (27.75 sec, P = 0.0153). We concluded that swimming was not adversely affected by wearing a PFD over 11.4m, and that wearing a PFD would be beneficial in water emergencies requiring self-rescue. Also, we were able to determine that the American crawl produced the fastest times over 11.4 m. The recommendations for future research were to examine the effects of swimming those same strokes over a longer distance while wearing a PFD (Amtmann et al 2014).

The current research included (1) what effects would standard labor-wear have on the American crawl, elementary back stroke, and breast stroke while wearing a PFD over 22.8 m (25 yards)? (2) Would there be a difference in the swim times between male and female subjects?

Null Hypothesis 1: There will be no statistically significant ($p > .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for all subjects.

Research Hypothesis 1: There will be a statistically significant ($p < .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for all subjects.

Null Hypothesis 2: There will be no statistically significant ($p > .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for male subjects.

Research Hypothesis 2: There will be a statistically significant ($p < .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for male subjects.

Null Hypothesis 3: There will be no statistically significant ($p > .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for female subjects.

Research Hypothesis 3: There will be a statistically significant ($p < .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for female subjects.

Methods

We tested the hypotheses in a controlled indoor pool environment. Each subject swam one trial each of the three strokes. Each trial was performed wearing standard labor-wear, including coveralls and boots,

and a PFD. The PFD used was a United States Coast Guard Approved Type V PFD that provides about 20 lb. of buoyancy (United States Coast Guard 2013). The labor-wear consisted of canvas coveralls worn over the subjects' swim-suit and steel-toed work-boots.

Fifty one volunteer subjects were chosen based on current or previous experience and credentials. The exclusion criteria were guided by the American College of Sports Medicine risk stratification process. American College of Sports Medicine (ACSM) guidelines suggest a pre-participation screening that identifies current medical conditions that would exclude those who are at risk for adverse cardiovascular, pulmonary, metabolic, as well as other conditions that would cause adverse responses to exercise (ACSM 2009). The list of conditions that excluded a subject included:

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

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

Safety of the subjects for the swim was ensured in two ways. First, the swim was conducted in water that was 4 ft. deep, in which all of the subjects were able to stand. The subjects were instructed to simply stand up if they were in distress. The subjects were surrounded by a lifeguard in the water and a lifeguard on the deck with appropriate rescue equipment as back-up measures. Additionally, each subject was wearing the aforementioned PFD.

The subjects read an informed consent form that emphasized the voluntary nature of this study, and that if they were uncomfortable doing anything related to this study they had the option to not participate. The decision to take part in this research study was entirely voluntary, and the subject could withdraw from the study at any time. Additionally, all procedures were presented to, and authorized by, an institutional review board.

After the subjects read the informed consent form, they were informed of the order of the randomly selected trials. Each subject would swim each stroke with a PFD; we randomly assigned the order in which testing was conducted. Resting heart rate and blood pressure was measured on each subject prior to the start of testing, and each subject was allowed to rest following each trial until their heart rate and blood pressures reached resting states. The subject's heart rate was recorded by palpation of the radial artery immediately following completion of each trial. Additionally, each subject's rating of perceived exertion was recorded. The subjects performed the next time trial when their heart rate returned to their resting norms.

Results

The mean 22.8-m elementary back stroke swim time for all subjects (n = 51) was 59.98 sec; for the breast stroke it was 46.05 sec and for the crawl stroke it was 46.48 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 1 in favor of research hypothesis 1 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke for all subjects, with the crawl stroke being the fastest and the elementary back stroke being the slowest.

The mean 22.8-m elementary back stroke swim time for male subjects (n = 26) was 51.04 sec; for the breast stroke it was 41.41 sec and for the crawl stroke it was

34.73 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 2 in favor of research hypothesis 2 at a significance level of 0.05. There was a difference in swim times over 22.8-m among strokes, with the crawl stroke being the fastest and the elementary back stroke being the slowest.

The mean 22.8-m elementary back stroke swim time for female subjects (n = 25) was 69.28 sec; for the breast stroke it was 50.87 sec and for the crawl stroke it was 58.71 sec (=0.001). Thus, we rejected null hypothesis 3 in favor of research hypothesis 3 at a significance level of 0.05. There was a difference in swim times over 22.8-m among strokes for females, with the breast stroke being the fastest and the elementary back stroke being the slowest.

Discussion

In our previous studies, we established the fact that self-rescue in labor-wear may be physically exhausting, and that wearing a PFD improves swim times (Amtmann et al. 2012 & 2014). When a person treads water and/or swims, it takes energy to stay on the surface of the water and to propel themselves forward (McArdle 2010). Labor-wear adds drag making swimming more difficult. Although wearing a PFD will add more surface area creating extra drag (Parsons and Day 1986, Benjanuvatra et al. 2002, Vennell et al. 2006), the PFD keeps the person on the surface so there is no need to expend energy to stay afloat. The person can use that energy to propel themselves forward, making the swim faster.

In our previous study, we found that there was no statistically significant difference in swim times between the breast stroke and the crawl stroke at a distance of 11.4 yards (Amtmann et al. 2014). The results of this study suggest that there is a difference in which stroke produces faster results over a longer distance, 22.8-m, for each gender. For men the crawl stroke produced the fastest results, but for women the breast stroke was the fastest stroke. Why is there a difference between the male and female subjects? Upper body strength may be the reason. Beyond a certain distance it may be more prudent to make efficiency and endurance a priority over speed. If that is the case, then everyone, males and females, will have a point where the focus will change from choosing to move as swiftly as possible to a safe area to moving as efficiently as possible over a greater distance to a safe area. It is important for the victim to be able to assess the distance they need to swim for self-rescue to be successful, and use the appropriate stroke for the situation.

Over shorter distances, it appears the crawl stroke will be the best choice, but for longer distances, it may be some other more efficient stroke. In water rescue situations it may be important for the victim to be able to decide whether to sprint a shorter distance using a more exhausting stroke, or cruise a longer distance with a more efficient stroke. Essentially, it means having the mind-set of being prepared to survive the marathon if you can't win the sprint.

The limitations to this study included lack of objective fitness data and lack of our ability to classify the subjects according to swimming skill. Most of the subjects were young, ranging from 18 - 30 years, with only eight subjects being older than 30 years of age. This age distribution may not accurately reflect the age of the work-force. The subjects were relatively fit with some being collegiate athletes and firefighters, this degree of fitness also may not be a true representation of the work-force. Also, the labor-wear only consisted of boots and coveralls; no inner layers were worn. Insulation layers may have a further impact on the measurements. The environment was controlled; the water was warm, clear and non-moving when, in reality, many water incidents occur in cold, dark moving water.

Suggestions for Future Research

To gather more information, conducting fitness assessments on each subject would be beneficial. Also, adding the insulation layers that are normally worn may more accurately reflect a laborer's physiological response in water. Monitoring heart rates and oxygen consumptions and comparing the

different strokes would provide information on energy expenditure. It would also be important to compare the effect of different water temperatures and environments on swim times and strokes.

Practical Application

When recreating or working on or near water where there is a drowning hazard, wearing a PFD will ensure an easier self-rescue. The Occupational Safety and Health Administration requires workers to wear a PFD when working near a drowning hazard, and we recommend that employers strictly follow that requirement. Simply wearing a personal flotation device will improve the efficiency of self-rescue, making swimming easier. However this rule is not always followed and wearing a PFD will not always prevent the loss of a life. If there is a need for self-rescue we recommend using the stroke with which the person is most comfortable. The breast stroke was the fastest stroke for women over 22.8-m. The American crawl was the fastest for men. The crawl stroke appeared to be the most exhausting, so distance to safety may need to be considered during self-rescue. If the distance is great enough that exhaustion will set in prior to reaching the safe zone, the victim must be able to recognize the situation and choose an efficient stroke that will conserve energy while moving toward the safe zone.

We also recommend that any company requiring their employees to work on or near water consider implementing water safety plans that may include swift water rescue professionals to conduct training and to be on-site to help prevent water injury and death. Finally, we recommend training that allows in-water experiences so employees develop an understanding of their abilities and limitations over varying distances, and practice the different strokes in the water to find out which stroke they are most comfortable with if water-based self-rescue is required.

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Montana Chapter of the Wildlife Society

53nd Annual Meeting

Wildlife Disease: Challenges for Research & Management in the 21st Century

February 24-27, 2015

Helena, Montana

Brent Lonner, President 2015-16
Montana Chapter of The Wildlife Society

Introduction

Wildlife disease management is arguably one of the greatest challenges of contemporary wildlife management. Wildlife disease has significant impacts not only on wildlife health and population status, but also with regard to human social and economic impacts. Additionally, zoonotic diseases have routinely played significant roles with respect to human health concerns for centuries. And alternatively, human and/or domestic livestock born pathogens can also have significant impacts on particular susceptible wildlife. Although occurrence of disease in wildlife can be a natural phenomenon, there appears to be increasing trends toward the appearance of novel or introduced diseases with severe consequences for wildlife populations. As is stated in a The Wildlife Society position statement from July, 2012:

> "Understanding transmission, pathophysiology, epidemiology, and ecology of pathogens and how they interact with wildlife hosts is essential for developing effective strategies to prevent or manage disease in wildlife. Better understanding of these concepts will enable wildlife managers and scientists to address disease challenges."

The 53rd annual meeting contained a total of 62 oral presentations, many of which focused on various aspects of local and national wildlife disease management and research. These presenters (wildlife managers, researchers, students, and others engaged in various forms of wildlife/habitat resource management) bettered our knowledge and understanding of how pathogens and disease events, large or small, impact living species at multiple levels. This year's banquet speaker was biologist and author Dr. Bruce Smith. Dr. Smith provided some valuable firsthand experience and perspectives related to working with diseases such as Brucellosis and Chronic Wasting Disease in the Greater Yellowstone Area. Just as important, Dr. Smith reminded us of the value of field biologists, wildlife managers and researchers having a working understanding of disease ecology along the way emphasizing the importance of good communication between wildlife professionals and the public on these topics

Hopefully the following presentation and poster abstracts will provide not only a better understanding of the importance and consequences of disease ecology and management, but wildlife research and management in general as we continue to progress into the 21st century.

Plenary Session Abstracts

In Order of Presenting Author
(* Denotes Presenter)

Hemorrhagic Disease in Montana

*Neil Anderson, Montana Fish, Wildlife and Parks, 1400 South 19th Ave., Bozeman, MT 59718
Jennifer Ramsey, Montana Fish, Wildlife and Parks, 1400 South 19th Ave., Bozeman, MT 59718
Keri Carson, Montana Fish, Wildlife and Parks, 1400 South 19th Ave., Bozeman, MT 59718

Hemorrhagic Disease (HD) is caused by two groups of orbiviruses, bluetongue (BT) and epizootic hemorrhagic disease (EHD). Both BT and EHD are capable of causing large scale mortalities in white-tailed deer. Although both are capable of causing disease in other species, BT typically causes clinical symptoms and mortality in a larger range of species, including pronghorn and domestic sheep. Three subtypes of EHD and five subtypes of BT are known to exist in North America. Only EHD subtype 2 and BT subtype 17 have been identified in Montana. Both BT and EHD are transmitted by a biting midge and the onset of disease typically occurring in late summer/early fall with mortality cases decreasing rapidly after the first killing frost. HD was first documented in Montana in 1961. Montana Fish, Wildlife and Parks has participated in a national survey documenting HD occurrence since that time. Outbreaks within Montana appear to be becoming more frequent and the area affected has increased. Until 2013 HD had been limited to the east side of the Rocky Mountain front. However, in 2013 several counties in western Montana experience their first recorded EHD die-off in white-tailed deer. The history and potential future ramifications of HD outbreaks in MT are discussed.

An Overview of Some Emergent Infectious Diseases of Concern to Montana's Nongame Species

*Bryce Maxell, Montana Natural Heritage Program, 1515 E. 6th Ave., Helena, MT 59620

Virulent infectious diseases in a variety of wildlife populations have increased over the past couple of decades in both natural and managed landscapes. Fungal and viral pathogens, aided by human disturbance of habitats and human, wildlife, and domestic animal derived transport, are playing an increasingly dominant role in wildlife disease epidemics. State and federal agencies and professional organizations such as this chapter need to do a better job of keeping wildlife professionals fully informed of all emerging infectious diseases in order to facilitate detection and a potential response at the earliest possible time. I will provide overviews of: 1) White-Nose Syndrome which is caused by a cold-adapted fungus that, since 2006, has killed more than 6 million bats in eastern North America and has continued to spread westward; 2) two chytrid fungi which have caused mass mortalities and extinctions of amphibians worldwide, including near extinction of the Northern Leopard Frog (Lithobates pipiens) and decline of the Western Toad (Anaxyrus boreas) in western Montana; 3) Tiger Salamander Ranavirus, an iridovirus which is the most likely cause of mass mortality events in larval Western Tiger Salamander (Ambystoma mavortium) populations that have been recorded across Montana; and 4) Snake Fungal Disease, which has emerged as a threat to some snake populations in eastern and midwestern North America since 2006 and may be spreading westward. In general, wildlife professionals in Montana should report observations of unhealthy wildlife and wildlife mortality events that may involve these and other emerging infectious diseases to the Montana Fish, Wildlife, and Parks Wildlife Laboratory in Bozeman in order to facilitate coordinated diagnoses and responses with other state and federal agencies.

A Historical Perspective of Bighorn Sheep Disease in Montana

*Jennifer Ramsey, Montana Fish, Wildlife & Parks, 1400 South 19th Ave., Bozeman, MT 59718

A historical overview of bighorn sheep disease in the state of Montana will be discussed by summarizing causes of morbidity and mortality experienced by various Montana bighorn herds. Changes in our understanding of bighorn sheep diseases, their impacts on herd health, and management strategies that may be directed at reducing risk of disease outbreaks in bighorn will be discussed. Additional information and updates on current health testing protocols and a multi-state effort to standardize testing protocols for bighorn sheep will also be presented.

Critters, Cooties and Congress: Managing Health at the Wildlife-Livestock Interface

*Lee C. Jones, U.S. Fish and Wildlife Service, Wildlife Health Office, 10 E. Babcock, Rm 105, Bozeman, MT 59715

Wildlife disease processes can be described as the interaction between the three principles of the epidemiologic triad model: host, agent and environment. Increasing human populations decrease the size and quality of the environment, and increase the complexity of the wildlife - domestic animal disease interface. Additional levels of complexity are added by regulatory, political and socioeconomic perspectives. Diseases such as brucellosis, hemorrhagic disease, avian influenza, malignant catarrhal fever and Mycoplasma bovis disease are making big headlines during an era of small budgets. The "One Health" concept challenges wildlife managers to think critically, think outside the boundaries and to actively integrate animal health into wildlife management at the landscape level.

Towards Proactive Wildlife Health – Global Insights on Conservation from the Wildlife Conservations Society's Wildlife Health & Health Policy Program

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The Wildlife Conservation Society's Wildlife Health & Health Policy Program, the first of its kind, evolved from the Field Veterinary Program begun in 1989. We work at the interface of wildlife health, domestic animal health, and human health and livelihoods, all as underpinned by the state of environmental stewardship. It is at this interface where the opportunities for infectious disease spread, environmental pollution and other disruptions to critical ecosystems are greatest, and where proactive approaches to ecosystem health can optimize benefits for all. Our program has grown to address important conservation issues impacting landscapes, seascapes and species around the world, including those related to Ebola virus disease, avian influenza, foot and mouth disease as it relates to cross-sectoral land-use planning, lead poisoning up food chains, canine distemper in Amur tigers, emerging zoonotic disease threats to human health, and policy-relevant quantification of relationships between environmental degradation and impacts on public health. As we try to work 'upstream' to address health-related challenges that limit conservation success, our toolbox includes research, training, education and outreach, the creation of enabling environments for addressing intersectoral conflicts, and sociopolitical engagement at a range of scales.

Presentation Abstracts

Alphabetical By First Authors Last Name
***Denotes Presenter**
****Denotes Student Presenter**

Social Living Mitigates the Costs of a Chronic Illness in a Cooperative Carnivore

Emily S. Almberg**, Department of Biology, Huck Institutes of the Life Sciences, Pennsylvania State University, University Park, PA

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Andrew P. Dobson, Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ

Douglas W. Smith, Yellowstone Wolf Project, Yellowstone National Park, WY

Matthew C. Metz, Yellowstone Wolf Project, Yellowstone National Park, WY and College of Forestry and Conservation, University of Montana, Missoula, MT

Daniel R. Stahler, Yellowstone Wolf Project, Yellowstone National Park, WY

Peter J. Hudson, Department of Biology, Huck Institutes of the Life Sciences, Pennsylvania State University, University Park, PA

Infection risk is assumed to increase with social group size, and thus be a cost of group living. We assess infection risk and costs with respect to group size using data from an epidemic of sarcoptic mange (*Sarcoptes scabiei*) among gray wolves (*Canis lupus*). We demonstrate that group size does not predict infection risk and that large individual costs of infection, in terms of reduced survival, can be entirely offset by having sufficient numbers of pack-mates. Infected individuals also increase the mortality risk of their pack-mates, but the magnitude of this burden is comparatively small. The mechanisms by which pack-size offsets survival costs of infection remain unknown and we speculate that it is mediated through enhanced food acquisition and territory defense. This is likely a common phenomenon among other social species and parasites, although it is difficult to detect in systems where infection status cannot be measured continuously over time.

How does Montana do Fish and Wildlife Conservation?

Kurt L. Alt*, retired FWP, International Wildlife Consultant

This presentation may provoke thoughts within our professional society on how to build a more effective fish and wildlife conservation voice in Montana. Like most other State and Provincial fish and wildlife agencies, Montana too is in a transformative period. Implementing change will be counterproductive if the agency minimizes those interests that continue to pay the bills, both financially and politically, for conservation efforts at the State level. Montana can lead the country, by example, in changing the approach of effective hunter and angler engagement with the non-hunting, non-angling community.

Survival and Recruitment of Gray Wolf Pups Before and after Harvest

David E. Ausband*, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT
Carisa R. Stansbury, University of Idaho, Department of Fish and Wildlife Sciences, Moscow, ID
Jennifer L. Stenglein, Wisconsin Department of Natural Resources, Madison, WI
Jennifer L. Struthers, Idaho Department of Fish and Game, Nampa, ID
Lisette P. Waits, University of Idaho, Department of Fish and Wildlife Sciences, Moscow, ID

Knowledge about recruitment in a population can be critical when making conservation decisions, particularly for harvested species. Harvest can affect population demography in complex ways and this may be particularly true for species whose successful reproduction is linked with complex social dynamics. We used noninvasive genetic sampling and a natural experiment to estimate recruitment in gray wolves (Canis lupus) before and after harvest in the northern Rocky Mountains, Idaho USA (2008-2013). We hypothesized that recruitment would decline after hunting and trapping began and that the decline in recruitment would be attributable to the harvest of pups and not subtler mechanisms associated with group dynamics and reduced reproductive success. We collected fecal samples from wolves in 10 packs for 6 consecutive years, extracted DNA, and genotyped 154 individual pups across 18 microsatellite loci. Population harvest rates averaged 23.8% (SD = 9.2). Our hypothesis that recruitment would decline was supported; survival from 3 – 15 months of age decreased from 0.60 (95% CI: 0.48-0.72) without harvest to 0.38 (95% CI: 0.28-0.48) with harvest and recruitment declined from 3.2 (95% CI: 2.1-4.3) to 1.6 (95% CI: 1.1-2.1) pups per pack after harvest was initiated. We attributed just 18-38% of pup mortality directly to harvest and suggest that there are indirect effects of harvest on recruitment that may be associated with changes in group size and structure. Models that do not include both direct and indirect effects of harvest on recruitment may underestimate the potential impact of harvest on population growth in social species.

Developing a Monitoring Framework to Estimate Wolf Distribution and Abundance in Southwest Alberta

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Dave E. Ausband, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT
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Greg Hale, Fish & Wildlife, Alberta Environmental & Sustainable Resource Development, Blairmore, Alberta, Canada

Gray wolf (*Canis lupus*) populations are difficult to monitor because wolves can be elusive and occur in low densities. Traditional radiotelemetry-based monitoring methods have limited application when turnover is high within the wolf population and resources to maintain long-term collaring programs are limited. We worked collaboratively with Alberta Environmental Sustainable Resource Development between 2012 and 2014 to develop techniques for monitoring gray wolf populations in the absence of radiotelemetry in southwest Alberta. We surveyed potential rendezvous sites and collected DNA samples from wolf scats for genetic analysis and surveyed hunters for wolf sightings made during the hunting seasons.

We fit false-positive occupancy models to annual detection data derived from genetic results and hunter surveys with Program PRESENCE. We found percent forest cover and human density positively influenced pack occupancy whereas detection probabilities varied by survey method, sampling effort, and sampling season. The model predicted wolf pack occupancy well and distribution and abundance estimates were consistent with agency predictions. While developing the monitoring framework, questions arose regarding pack turnover and population growth under widespread human harvest. Previous studies have focused on population recovery following wolf control actions but little emphasis is put on populations that exist under regular harvest. We will use genetic data to determine how immigration contributes to wolf population trends under a long-term harvest regime and tie this into pack occupancy through colonization and local extinction probabilities. This will expand the application of our occupancy model and will further clarify how wolf populations respond to long-term regulated harvest.

Examining Seasonal Anthrax Risk in Wildlife: Comparing Home Ranges and Site Fidelity in Sero-Positive and Sero-Negative Ungulates

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Anthrax is frequently reported from wildlife and livestock in the US. While useful in reducing risk in livestock, vaccination, the primary method of prevention, is untenable for free-ranging wildlife. Because of this, accurate surveillance and carcass clean-up are the most efficacious control measures for wildlife. However, surveillance is expensive and requires significant personnel across large landscapes. Likewise, the transmission pathways are poorly understood in most species. Wildlife telemetry improves our understanding of movement patterns during risk periods. At the same time, serological surveys provide data on host exposure. Such data allow us to test hypotheses about host/pathogen interactions on the landscape. Starting in 2010, we initiated GPS telemetry and sero-prevalence studies for managed bison, *Bison bison bison*, and free-range elk (*Cervus elaphus*) in Montana. Here we will evaluate summertime home ranges in bulls from both species in western Montana. We compared home ranges and site fidelity metrics in sero-positive and sero-negative animals. Serological tests indicated that ~30% of bull elk and ~27% of unvaccinated bison were sero-positive for anthrax exposure, suggesting that low-level exposure is frequent on this landscape. Seasonal ranges can be useful for defining areas where animals may have increased likelihood of anthrax, comparing ranges to niche-based estimates of *B. anthracis*. Fidelity metrics suggest both species spent considerable time in niche-based high risk areas. Inter-annual data from elk suggest long-term range fidelity and overlap with high risk areas. These

data can be used to prioritize surveillance efforts in those areas to maximize disease control, while managing search costs.

Can Montana Shrews be Identified using Morphology of Dorsal Guard Hairs?

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Several species of shrews present in Montana are considered species of concern by state and federal agencies, primarily due to a lack of information. Current methods for identifying shrew species can be costly, potentially inaccurate, and logistically challenging. We sought to validate a novel methodology developed in the United Kingdom that uses morphological characteristics of dorsal guard hairs for identification of shrew species. Utilizing museum collections at Montana State University and the University of Montana, we sampled dorsal guard hairs from specimens of Montana shrews with known identities. We measured four length and width characteristics for each hair sample and used a discriminate function analysis to calculate the probability of correctly identify a specimen to species. We achieved >80% confidence identifying the pygmy shrew (*Sorex hoyi*), which is a species of concern in Montana, and >70% confidence identifying the Northern short-tailed shrew (*Blarina brevicauda*). To increase our ability to discriminate between species we analyzed subsets of species found within discrete ecoregions and habitats. Within these subsets we achieved >80% confidence identifying the masked shrew (*S. cinereus*), and >60% confidence identifying the dwarf shrew (*S. nanus*). These findings suggest that this new methodology is viable for some species and can provide a simple, affordable research tool for the targeted study of shrews in Montana.

Wolf-Cougar Co-occurrence in the Central Canadian Rocky Mountains

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Cougars and wolves are top predators that can influence the dynamics of an ecosystem, including prey behavior, dynamics, and interspecific competition. I am examining co-occurrence between wolves and cougars in the Central Alberta Rockies using occupancy modeling. I hypothesize that cougars will have lower occupancy of higher quality habitat in the presence of wolves; cougars will be restricted to higher elevations, more rugged terrain, and areas with lower NPP than the areas occupied by wolves. To test this overall hypothesis, we collected data from 167 remote wildlife cameras in Banff, Jasper, and Yoho National Parks and use co-occurrence models to explicitly test the effects of wolves on cougars. We examined co-occurrence between seasons, summer (May 1 – October 31) and winter (Nov 1 – April 30), in seven-day intervals. From naïve occupancy models, summer cougar occupancy was 0.35 with a detection probability of 0.202 and winter occupancy was 0.157 with a detection probability of 0.065. Summer wolf occupancy was 0.625 with a detection probability of 0.209, while winter occupancy was 0.435 with a detection probability of 0.134.

The larger proportional, seasonal decline in cougar occupancy in winter is intriguing because prey density is higher during the winter, meaning cougar-wolf competition may increase during winter; wolf presence may impact both cougar detection and occupancy. Preliminary co-occurrence models support our hypothesis that wolves can potentially outcompete cougars in our system. This study is important because the literature about wolf-cougar co-occurrence provides mixed results: mostly cougars are secondary predators to wolves, but occasionally, cougars are unaffected by wolf presence.

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

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Montana's bat species face a wide array of conservation issues that threaten the long-term viability of these populations. The potential arrival of White-Nose Syndrome (WNS) may be the single greatest threat as mortality has exceeded 95% for some bat populations in eastern North America. A collaborative effort was initiated in 2011 to document year-round spatial and temporal activity patterns of Montana's bats prior to WNS arrival. In the last 4 years, we have deployed a network of over 60 Song Meter ultrasonic acoustic detector/recorder stations programmed to record bat passes from sunset to sunrise year-round. Through late December of 2014, these recording stations have resulted in more than 3.9 million full spectrum sound files containing more than 12.5 terabytes of information. Processing and automated analyses have been completed for all sound files and over 30,000 bat passes have been reviewed by hand using an updated Montana bat call characteristics key to definitively confirm the presence of species during each month of the year, identify the lowest temperatures at which individual bat species are active, and track overall bat activity, regardless of species, at each station. Highlights to-date include: 1421 new records of monthly species presence throughout the state, numerous first records of species' activity during the fall, winter, and spring months, numerous first records of species in regions with previously limited bat survey effort, documentation of nightly activity patterns throughout the year and regular winter activity for a few resident species, and the year-round presence of species previously considered migratory.

One-Year Progress Report for the Montana Statewide Bighorn Sheep Research Project

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Kelly Proffitt, Montana Fish, Wildlife and Parks, Bozeman, MT
Jay Rotella, Ecology Department, Montana State University, Bozeman, MT

Restoration and conservation of bighorn sheep has been a challenge. Despite strong conservation efforts, bighorn sheep have not recovered to historic range and numbers as most other ungulates have. The Montana Statewide Bighorn Sheep Research Project, a collaborative effort between Montana Department of Fish Wildlife & Parks and Montana State University, began operations in winter 2013/2014 in order to provide information to

help guide future management and conservation of bighorn sheep. Seven bighorn sheep populations were scheduled to be sampled in the first year of the study and this presentation will outline the accomplishments, challenges, and findings from the first year of the research effort. Research objectives are to quantify and compare exposure to and prevalence of pneumonia pathogens, body condition, habitat use and demographic rates in multiple bighorn sheep populations with varying histories and characteristics across Montana. Study plans and initial findings relevant to these objectives will be presented.

Wolf Disease Summary 2004-2014

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Neil Anderson, Montana Fish, Wildlife and Parks, Bozeman, MT

Canine distemper virus (CDV), canine parvovirus (CPV), canine adenovirus (CAV), canine herpesvirus (CHV), neosporosis, leptospirosis, *Brucella abortus* and *B. canis* are diseases that have wolf health or wildlife management implications. Blood serum samples from wolves captured and collared for management purposes between 2004-2014 were screened for these pathogens. Serologic tests for leptospirosis, *B. abortus*, and *B. canis* were completed by the Montana Department of Livestock Diagnostic Laboratory with the remaining tests performed by Cornell University Animal Health Diagnostic Center (Cornell University, AHDC). Samples were assigned as being collected in the Northwest or Southwest region of the state based on capture location and the region designation provided by Montana Fish, Wildlife and Parks wolf specialists. We evaluated and compared pathogen presence and prevalence within Northwest and Southwest Montana. Each disease and its potential implications in the Northwest and Southwest region is discussed.

Pneumonia in Bighorn Sheep: Testing the Super-Spreader Hypothesis

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Peter J. Hudson, Penn State University, Center for Infectious Disease Dynamics, University Park, PA

Following introduction of pneumonia, disease can persist in bighorn sheep (*Ovis canadensis*) populations for decades as annual or sporadic pneumonia epidemics in lambs. Recurring years of depressed recruitment due to high rates of pneumonia-induced mortality

in juveniles is a major obstacle to population recovery. Management strategies for resolving this problem have so far been elusive. We are investigating the feasibility of removing individual "super-spreaders" to improve lamb survival. Individual variation in infection and transmission is well documented in human diseases (e.g. "Typhoid Mary"). We are testing the hypothesis that pneumonia epidemics in lambs are initiated by transmission of pathogens from a few "chronic-shedder" ewes. We have completed the first year of a 5-year project in the Hells Canyon region of Idaho, Oregon, and Washington, and in a captive population at South Dakota State University. Through repeated testing of free-ranging individuals in Hells Canyon, we have identified individual differences in shedding of *Mycoplasma ovipneumoniae*, a primary pathogen in the bighorn sheep respiratory disease complex. We also found that when penned separately in captivity, lambs of ewes that consistently tested positive (chronic shedders) were infected and died of pneumonia, whereas lambs born to ewes from an infected population that tested negative (non-shedders), were not infected and survived. Over the next 4 years we plan to 1) continue and expand testing of free-ranging and captive animals, 2) determine whether removal of chronic-shedder ewes improves lamb survival in free-ranging populations, 3) expand and replicate chronic-shedder commingling experiments in captivity, and 4) establish and monitor a new population founded with non-shedders from an infected population.

Audubon's Birds and Climate Study: From Bioclimatic Envelopes to Implications for Montana

Amy Cilimburg, Director of Bird Conservation and Climate Policy, Montana Audubon, Missoula, MT

This past fall National Audubon Society released an extensive "Birds and Climate" report which modeled future climatic distribution for over 500 North American bird species. In sum, 314 bird species were shown to be significantly imperiled as we move through this century. In Montana, over 230 bird species are at risk. This Birds and Climate report, similar to other recent published studies, uses bioclimatic models to predict future climate envelopes for each species. This presentation will describe what these models predict, how they are used, and how they can be combined and overlain with ecologically sensitive habitat maps. We would like to begin a discussion about their usefulness in bird prioritization and conservation. Can peering into the future with bioclimatic modeling help us plan our habitat projects and efforts toward protecting priority species? Let's start the conversation about their applicability and usefulness to Montana biologists and conservationists.

Updates from the Transportation and Wildlife Front

Patricia Cramer*, Independent Researcher, Logan, UT
Robert Hamlin, Independent Researcher, Logan, UT

Multiple western states are researching how to best mitigate roads for wildlife. We will present updates to ongoing projects in Montana and Utah and several other states. Lessons learned from these projects can be applied to Montana wildlife mitigation. Recent research is learning of mule deer, white-tailed deer, elk, pronghorn, big horn sheep, moose and other wildlife preferences for types of crossing structures. The results show support for the idea that the length of wildlife crossing structures is the most important structural dimension for mule deer success. Results also show a willingness of white-tailed deer to use bridged structures that are under 5 feet high to pass beneath roads. Elk are the "problem child" of wildlife crossing structures in several places, and are very hesitant to use any structures. Pronghorn and bighorn sheep are successfully using wildlife overpasses in three states. The efficacy of the use of double cattle guards and wildlife guards to prevent wildlife access to roads is being

examined in a Utah study. Results will be presented on the effectiveness of these and electric mats at preventing wildlife access and will help elucidate which types of guards would work for various situations. Recommendations for future mitigation types and concerns will be presented at the end of our presentation.

A Review of Parasites and Disease Impacting Moose in North America

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Jennifer M. Ramsey, Montana Fish, Wildlife & Parks, Bozeman, MT

Moose (*Alces alces*) are relative newcomers to North America, believed to have crossed the Beringian land bridge during the late Pleistocene, 10,000–15,000 years ago. Their evolution in Asia may have left them relatively ill-prepared to cope with a suite of North American parasites that have proportionately greater impacts on moose than other cervids. We review the current state of knowledge regarding impacts of parasites on North American moose populations, including brainworm (*Parelaphostrongylus tenuis*), arterial worm (*Elaeophora schneideri*), giant liver fluke (*Fascioloides magna*), winter tick (*Dermacentor albipictus*), and others. We then pay specific attention to recent research and monitoring of moose, parasites, and disease, in the context of potentially declining moose populations in Montana and elsewhere. Notably we have preliminary evidence suggesting minimal impacts of winter ticks in Montana relative to the eastern US, but also a separate and poorly understood parasite- or disease-induced reduction of adult female moose survival in a southwest Montana population. These results are preliminary and we discuss them as yielding more questions than answers thus far.

Summer Habitat Selection and Range Expansion of Non-Native Mountain Goats in the Greater Yellowstone Area

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Jay J. Rotella, Ecology Department, Montana State University, Bozeman, MT
Stuart Challender, Department of Earth Sciences, Montana State University, Bozeman, MT
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The ongoing expansion of non-native mountain goat populations throughout the mountainous regions of the greater Yellowstone area (GYA) may pose a threat to species native to this ecosystem, particularly native and restored bighorn sheep populations with a history of vulnerability to overexploitation, habitat loss, and disease die-offs. To inform future management actions and policy on the breadth of mountain goat expansion, we used unique occupancy methodologies to rigorously survey two study areas with established bighorn sheep and mountain goat populations over three summer field seasons (2011-2013), modeled patterns of scale-specific habitat selection, and predicted the ultimate distribution of suitable habitat and abundance of mountain goats for the entire GYA. We recorded 505 mountain goat detections for 53,098 sampling units. Mountain goat occupancy was most strongly related to slope, slope variance, canopy cover, heat load, and NDVI. We predicted extensive suitable habitat for the GYA covering 10,745 km2 and extending throughout the South Absaroka, Teton, Gros Ventre, Wind River, and Wyoming Ranges. We estimated the GYA to support 5,372-8,918 total mountain goats, or about 2.5-4.2 times the current abundance estimate of 2,104. The potential implications to management and conservation of bighorn sheep and mountain goats are addressed.

Estimating Natal Origins of Migratory Juvenile Golden Eagles Using Stable Hydrogen Isotopes

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Tim Pitz, Raptor View Research Institute, Missoula, MT
Kathy Gray, Department of Mathematics and Statistics, California State University, Chico, CA
Melanie Smith, Audubon Alaska, Anchorage, AK

We used stable hydrogen isotope analysis to estimate the natal origins of juvenile Golden Eagles (*Aquila chrysaetos*) captured during fall migration along the Rocky Mountain Front in Montana, U.S.A. We collected feather samples from 50 hatch-year (juvenile) Golden Eagles at several fall migration sites from 2004 – 2007. We analyzed feathers for their ratio of deuterium (δ^2H_f) described in parts per thousand [‰]. A simple linear regression model was used to calibrate our isotope ratios of migrating eagles to a raptor-specific deuterium base map. This enabled us to make inferences about the natal origins of juvenile Golden Eagles captured during fall migration. Our analysis indicated natal origins ranged from the Brooks Range in Alaska to northern Montana. However, 66% (range 50-76%) of the individuals we sampled likely originated from natal areas located in the Yukon and Northwest Territories, Canada, and a small portion of eastern Alaska ($\leq$ -140 δ^2H_f). We did not observe any passage date differences regarding gender or natal latitudinal origins. Our study supports that stable isotope analysis is effective in aiding researchers to understand natal origins of migratory, juvenile Golden Eagles captured during fall migration, or found as mortalities on wintering grounds. It may also be a useful tool for linking Golden Eagle migration count and trend data with population status when utilized among multiple migration sites and wintering areas throughout North America.

Elk Calf Survival and Elk Population Dynamics in the Southern Bitterroot Valley

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Mark Hebblewhite, Wildlife Biology Program, University of Montana, Missoula, MT
Ben Jimenez, Montana Department of Fish, Wildlife, and Parks, Missoula, MT
Justin Gude, Montana Department of Fish, Wildlife, and Parks, Helena, MT
Mike Thompson, Montana Department of Fish, Wildlife, and Parks, Missoula, MT

In response to declining elk calf recruitment in the southern Bitterroot Valley of Montana, we initiated a 3-year study to determine the importance of bottom-up and top-down factors for elk calf survival and elk population dynamics. We monitored the survival of 286 elk calves during 2011-2014 in order to estimate cause-specific mortality and calf survival to age 1.We used continuous-time survival modeling to evaluate the effect of risk covariates and estimate calf survival and cause-specific mortality rates. Annual elk calf survival was 0.32 in 2011, 0.43 in 2012, and 0.45 in 2013. We found that mountain lions (20%) were the most important mortality source for elk calves, followed by unknown causes (17%), unknown predation (9%), bear predation (5%), natural, non-predation (4%), wolf predation (3%), and human-related mortality (1%). Male elk calves were at 63% higher risk of mortality than females ($P = 0.01$), and elk calves in the West Fork area were at 42% higher risk of mortality compared to the East Fork ($P = 0.07$) during their first year. Also, we detected a significant positive effect of estimated birth date on summer mortality risk for elk calves ($P = 0.07$). We will use integrated population modeling to combine elk calf and adult female survival, nutrition, and carnivore population data, allowing us to forecast the effect of habitat and carnivore densities on elk population trends. These tools may help managers balance carnivore and ungulate population objectives and is applicable to all areas experiencing carnivore recovery.

The Influence of Snow on Ground Temperatures

Phil Farnes, Snowcap Hydrology, Bozeman, MT

Snow influences temperatures within the snowpack and soil temperatures. Air temperatures may be well below freezing but temperatures within the snowpack and at soil surface will be near 0 ^{0}C (32 ^{0}F). When there is fall green-up and snow covers the vegetation before cold temperatures occur (less than – 5 ^{0}C or 23 ^{0}F), the native forage may stay green into January. With soil surface temperatures near freezing under snow packs that exceed about one meter, organisms can survive extremely cold winter air temperatures. Air temperatures can affect snow consistency as the seasons snowpack is being deposited which can affect foraging and animal movement. Relationships between air temperature, snow temperature and soil temperatures will be presented.

Distribution of Breeding Ducks Relative to Habitat Characteristics in the Prairie Pothole Region of North Central Montana

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Jay J. Rotella, Department of Ecology, Montana State University, Bozeman, MT
Terry L. Shaffer, Northern Prairie Wildlife Research Center, USGS, Jamestown, ND

Continental waterfowl population declines in the early 1980s led to the development and implementation of the North American Waterfowl Management Plan. The plan identified wetland and grassland losses in the Prairie Pothole Region (PPR) of Canada and the United States as the major causes of low continental duck populations. Until 2008, north central Montana was the only remaining PPR area in the United States without a ground-based annual survey to monitor breeding duck populations and quantify breeding duck habitat. The purpose of this study was to establish an annual breeding duck survey in north central Montana to 1) develop species-specific breeding pair predictive models, and 2) apply the models to estimate the distribution of breeding ducks and identify priority areas for conservation. We observed 10539 indicated breeding duck pairs on approximately 675 wetland basins surveyed annually from 2008-2014. A competing models analysis was used to identify local- and landscape-scale habitat characteristics to predict breeding duck pair abundance on wetland basins. The five most commonly observed species were modeled separately; those species were mallard (*Anas platyrhynchos*), northern pintail (*A. acuta*), gadwall (*A. strepera*), northern shoveler (*A. clypeata*) and blue-winged teal (*A. discors*). At the local scale, wetland basin area, the square root transformation of wetland basin area, and wetland basin class were important predictors for all species. Important model predictors varied by species at the landscape scale. We applied the models in a GIS to develop a decision support tool for conservation actions funded by the Migratory Bird Conservation Fund.

Partners of the Americas Montana-Patagonia Chapter: Challenges, Directions, and Successes

Melissa A. Foster, Secretary/Treasurer, Montana Chapter of Partners of the Americas

From the steppe to the Andes, the small towns to the big ranches, outdoor tourism to oil and gas development, Patagonia has a lot in common with Montana. Partners of the Americas (POA) is a nonprofit organization that pairs regions in North and South America to share culture, foster understanding, identify common ground, and develop unique solutions

to local challenges. The projects undertaken by various POA chapters are as diverse as their membership and range from exchanges of professionals (e.g., doctors, lawyers, teachers, law enforcement) to charity activities (e.g., school building, clean water) to language learning. The Montana-Patagonia chapter of POA is comprised mostly of biologists and the majority of exchanges over the past 25 years have been related to wildlife management. Last fall, I traveled to Junín, San Martín, and Bariloche, Argentina and met with over 20 biologists from state and federal agencies, universities, and nonprofits to fortify the Montana-Patagonia partnership and help illuminate a path for the future. I'll discuss the history of the Montana-Patagonia partnership, and highlight important biological challenges in Patagonia such as problems with exotic species—especially red deer, mink, trout, and a variety of plants—and declining native species such as the huemul and pudú (deer) and huillín (otter). Other challenges include conflicts between ranchers and wild felids like the Andean cat, the lack of a public trust doctrine, habitat loss, and poaching. Finally I'll talk about where Partners is headed and how to get involved in this exciting partnership.

Approaches Initiated to Gain Insight into Respiratory Disease in Montana's Bighorn Sheep Herds

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Respiratory disease is a major limiting factor in the restoration, conservation, and management of bighorn sheep in Montana and throughout western North America. Despite many decades of research there is a limited understanding of the disease process, with proactive management to minimize disease primarily limited to establishing policies to minimize exposure of bighorn sheep to domestic sheep. In the past decade, however, there have been significant advances in understanding the pathogens involved in bighorn sheep pneumonia that have resulted in the development of new sampling and testing methodologies that promise to advance our understanding of the disease. This presentation will review the general ideas regarding the pathogens and the disease process advanced by leading researchers of bighorn sheep pneumonia and describe how these ideas are being combined with recent sampling and testing advances and incorporated into Montana's state-wide bighorn sheep research program. We will also describe the collaborations developed between our research team and other research teams addressing the same questions in neighboring states. These collaborations are an attempt to build a regional initiative that combines the resources, expertise, and unique management histories of bighorn herds in other states. We think such open communication and coordination of research activities will help us advance our understanding of bighorn sheep pneumonia and develop management strategies that can enhance restoration of the species.

Monitoring Responses of Bear Foods to Climate Change Evaluating Adaptive Monitoring Designs for Occupancy Studies

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Methods for assessing site occupancy while accounting for imperfect detection have quickly become important for ecologists wishing to study the distribution and prevalence of species across landscapes. Occupancy data are convenient to collect because, while they do require repeated sampling efforts, they do not require the marking of individual organisms. Some guidance on monitoring for occupancy studies has been provided for conventional settings. However, coupling the data collection and analysis components via an optimal adaptive sampling design may improve precision of estimates and save money. Optimal adaptive sampling designs have not been applied to occupancy models previously. We present a design criterion that facilitates adaptive monitoring for occupancy studies and illustrate its advantages and disadvantages through the use of simulations and real-data scenarios. Our findings indicate that, depending on the focus of the study in question, monitoring designs can be improved substantially by considering adaptive sampling schemes.

Assessing Integrated Carnivore-Ungulate Management in the Bitterroot Valley

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Whether increasing large carnivore harvest can increase ungulate populations is uncertain for several reasons. One primary ecological uncertainty is whether carnivores limit ungulate population dynamics. A second results from partial controllability of large carnivore populations; whether large carnivore hunting seasons will reduce carnivores to the extent that ungulates increase. We first review cases of 'integrated carnivore-ungulate' management from western North America, highlighting where key uncertainties were addressed. Then, using the Bitterroot valley of MT as a case study, we present results from a research project designed to provide quantitative measurements of (1) elk population dynamics and limiting factors, (2) mountain lion densities, (3) the effect of harvest on mountain lion densities under a management plan designed to differentially affect lion density across western Montana, and (4) the ultimate effect of changes in mountain lion seasons on elk population dynamics. During the first phase of research, mountain lions caused 6-8 times more mortality than wolves, limiting elk populations via calf survival and recruitment. We estimated mountain lion densities in the Bitterroot and Granite County to help address scientific uncertainty, the effect of lion hunting on lion densities and ultimately elk recruitment and populations. In 2016, following implementation of 4 years of mountain lion seasons intended to reduce lion density in the Bitterroot and stabilize lion density in Granite county, we plan to return to the Bitterroot to monitor both lion and ungulate populations to quantify the effects of this integrated carnivore-elk management strategy. This research will provide objective information to inform public decision-making processes about carnivore and elk management, but it cannot provide direction regarding what strategy for carnivore or elk management should be pursued. Balancing the input and desires of divergent stakeholders is perhaps the most challenging facet surrounding integrated carnivore-elk management.

Habitat Quality Influences Migratory Strategy of Female White Tailed Deer

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Partial migration is a life history strategy that is common for ungulate species living in seasonal environments. One factor that influences the decision to migrate by ungulates is access to high quality habitat. We evaluated the influence of access to winter habitat of high quality on the probability of an individual migrating, seasonal habitat use between and within migratory and resident classes of deer, and the effects of this decision on the survival of female white-tailed deer. We radio-collared 67 female white-tailed deer (*Odocoileus virginianus*) in 2012 and 2013. The odds of being a migrant increased as home range size increased and decreased as proportion of cropland within home range in winter increased. The habitat with the highest relative probability of use in winter for residents was pasture (1.00, SD = 0.01) and for migrants was riparian (0.73, SD = 0.39). In summer both groups had the highest relative probability of using pasture (resident = 0.96, SD = 0.15; migrant = 0.99, SD = 0.08). We integrated the migration probability and survival models to estimate annual and seasonal survival rates of migrants and residents. We found no difference between the annual and seasonal rates of survival for the different migration strategies. Our results indicate that access to habitat of high quality may be a strong influence on a female white-tailed deer's decision to migrate. We suggest the presence of partial migration in a population may be a response to competition for high quality habitat.

Habitat Selection by Chiricahua Leopard Frogs During Summer Monsoons

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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, the Chiricahua leopard frog is restricted to anthropogenic sources of water, including tanks maintained for livestock, throughout most of its range. Movement habits of this frog and patterns of dispersal between disjunct water sources are not well understood. We attached radio transmitters to 44 total frogs on the Ladder Ranch in southern New Mexico during summer 2014 and located each frog daily for up to 8 weeks (mean = 29 days). We quantified habitat characteristics at each frog location and a random location 5 meters away. We assessed fine-scale habitat selection using conditional logistic regression and also explored the degree of variation in selection among individual frogs. Frogs chose areas with more low-lying cover (especially aquatic vegetation and woody debris), less overstory cover, and a mud substrate. Whether the location was far from or close to water and the amount of overstory cover did not appear to be important for selection, suggesting that frogs are able to find areas that provide habitat away from water

bodies. The variation among individuals was low, suggesting that tracked were selecting similar habitat characteristics. The findings of this study will inform active management of amphibians in anthropogenic settings, where managers can enhance amphibian habitat characteristics between occupied sites to improve population connectivity.

Assessing Brucellosis Seroprevalence and Transmission Risk in a Free-Ranging Elk Population: The Targetted Brucellosis Surveillance Project in Montana

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Brucellosis is a bacterial disease that affects elk, bison and domestic cattle. Recently the seroprevalence of brucellosis in free-ranging elk populations of Montana has increased and its' range has expanded, resulting in increased pressure on Montana Fish, Wildlife and Parks (MFWP) to manage the disease in elk. In 2010 MFWP and the Montana Department of Livestock initiated a targeted surveillance program to delineate the current geographic distribution of brucellosis, document spatio-temporal habitat selection and movement patterns, and to quantify potential transmission risk from elk to cattle. Since 2010, we have targeted 11 different winter ranges from 9 hunt districts, both within and outside of the Designated Surveillance Area used to manage cattle. During each capture operation we tested approximately 100 adult female elk for exposure to brucellosis. We deployed GPS radiocollars on a subsample of adult female elk on each winter range. An epidemiological summary of the first five years, including seroprevalence, movement and implications for transmission vectors will be presented. Current brucellosis exposure in domestic herds, future surveillance areas, evaluation of various management actions on transmission risk, and the creation of a spatio-temporal risk model are discussed.

Home-Range Size of White-Headed Woodpeckers in West-Central Idaho

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The white-headed woodpecker (*Picoides albolarvatus*) is a species of management concern in dry-conifer forests of the Inland Northwest, where forest restoration and fuels reduction treatments are increasingly common. This species may be vulnerable to forest management treatments because it occupies a limited distribution and has narrow habitat requirements. Forest treatments could negatively affect this species if foraging and nesting resources are removed or could benefit the species through creation of more heterogeneity across the landscape. Studies of other woodpecker species have identified resource availability and habitat composition as a key influence on the variation of home range size within a population. We examined home range size of white-headed woodpeckers in a

landscape historically managed for timber harvest and is currently receiving extensive forest restoration treatments. In our first field season, we obtained relocations on 7 radio-tagged woodpeckers (5 males and 2 females, all from different breeding pairs), from late nesting through fledgling periods (late June to early September). We obtained direct foraging observations at the radio locations. Estimated home range sizes were quite variable(24 - 180 ha), based on the minimum convex polygon (MCP) method. We will also estimate home range sizes using the fixed-kernel method. Identifying habitat spatial attributes that account for variation in home range size will contribute towards effective management decisions for the persistence of white-headed woodpecker populations.

Mountain Plover Population Trends in 3 Montana Areas

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Permanent point count transects were established in 1992 in central, northeastern and southwestern Montana to monitor mountain plover population trends in these areas. At the time, these were considered to be Montana's 2nd, 3rd and 4th largest mountain plover populations. During the 23 year period from 1992 to 2014, these transects were surveyed during 10 different years with the last counts for the Central and Northeastern Montana Study Areas occurring in 2014, and the last count for the Southwestern Montana Study area occurring in 2004. The count of adult mountain plovers in the Central Study Area declined from 103 adult birds in 1992 to 13 birds in 2014. In the Northeastern Study Area, mountain plover started at 17 in 1992, peaked at 36 in 1996, dipped to 12 in 2004, and ended with a final count of 17 in 2014. Mountain plover numbers in the Southwestern Study Area progressively declined from a high of 33 adult birds in 1992 to no birds found in the Study Area in 2004. Cause of mountain plover decline in the Central Study Area was attributed to conversion of native grasslands to cultivated cropland and introduced grasses, a drastic decline in domestic sheep numbers, and an overall reduction in livestock grazing. In the Southwestern study area, the collapse of the mountain plover population was attributed to a housing development, a log home factory, prairie dog poisoning, and the lack of livestock grazing. The Northeastern Study Area was almost entirely public lands with relatively stable habitat conditions.

Effects of Oil and Gas Development on Mule Deer Populations in Western North Dakota and Eastern Montana

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Oil and gas production are becoming a significant part of the economy and landscape of western North Dakota and eastern Montana. Much of the areas being developed overlap with mule deer ranges. Our ongoing research aims to identify and quantify the direct and indirect effects of oil and gas energy development on mule deer abundance, survival, recruitment, movements and resource selection. Since February, 2013, we have deployed 240 GPS collars in three main areas of breaks habitat: 1) in North Dakota along the Little Missouri River; 2) the east side of the Yellowstone River; and 3) just south of Culbertson, MT. These collars are being used to collect spatial data about mule deer distributions and monitor survival across areas of low, medium, high energy development. We will also use digitized aerial survey data to estimate abundance and recruitment across various levels of development. To date we

have collared 99 adult females and 110 fawns, gathering more than 300,000 deer locations, conducted 39 lab necropsies on full and partial carcasses, and conducted biannual aerial surveys in North Dakota (2 years) and Montana (1 year). Our research will address potential impacts to mule deer populations, but will also provide mitigation strategies to help minimize disturbances from further development.

Impacts of Aspen and Conifer Vegetation on Predation Risk and Distributions of Bird Species

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Aspen forests are in decline around the globe and are largely being replaced by conifers. Associated with this shift in forest composition, we document an increase in nest predation risk and decrease in abundance of bird species that breed in aspens. These observational data from 5 years across 19 forest stands in western Montana were verified with an adaptive management experiment removing all conifers from three large aspen stands in the Mt. Haggin WMA. This landscape-scale approach strongly supports the active management of aspen stands, by such methods as removing conifers, to improve breeding bird habitat. Our results also suggest that vegetation-mediated effects of predation are associated with avian distributions and species turnover.

Identifying Potential Breeding Areas of Short-Eared Owls Prior to Nesting Using Roadside Surveys to Detect Courtship and Territoriality Behavior: A Comparison of Visual and Audio Techniques

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We piloted a roadside survey technique for detecting Short-eared Owls during the courtship period in western Montana. Thirty-five surveys were conducted between 2009 and 2012 and were timed to coincide with pair-formation and courtship behavior. Short-eared Owls perform courtship flights and vocalizations which can be observed and heard during the crepuscular period. Surveys were designed to compare visual and audio survey techniques. Visual surveys occurred during the crepuscular period at the end of civil twilight and were immediately followed by a nocturnal audio survey. Visual survey techniques accounted for over 91% (N=240) of all detections. Detections associated with audio survey techniques were almost always associated with survey points where at least one owl was detected during visual survey. Nearly three-quarters of visual detections (N=220) occurred between 30 and 70 min before the end of civil twilight. Over 75% of visual detections and 90% of nocturnal detections occurred in areas where vegetation was uncut and ungrazed and most frequently associated with vegetation heights greater than approximately 60cm. Short-eared Owls were never detected in areas where livestock was present. We recommend visual surveys during the courtship to identify potential breeding areas prior to the onset of incubation.

Two Out of Three Ain't Bad: 3 Year Progress Report of Multi-Species Non-Invasive Montioring of Forest Carnivores in the Southwest Crown of the Continent

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The Southwestern Crown of the Continent is a 1.5 million acre landscape in western Montana that has been the focus of collaborative forest restoration since 2010. Monitoring the effects on forest carnivores of forest restoration efforts can aid land management decisions significantly. A multi-party working group initiated field work to collect baseline information regarding the distribution and relative abundance of forest carnivores across the Southwestern Crown. In the winters of 2012-2014, we employed non-invasive detection methods, including systematic grid-based snowtrack surveys (with backtracking to obtain genetic samples), combined with baited DNA snares and camera traps, to detect target species, including lynx (*Lynx canadensis*), wolverine (*Gulo gulo*), and fisher (*Pekania pennanti*). We surveyed 82 of the 129 5 x 5 mile grid cells in the study area, resulting in 3,366 miles of track surveys, and 274+ bait stations. We detected lynx in 35 cells and wolverine in 38 cells. The number of cells where lynx were detected was consistent between survey years, while the number of wolverine detection cells increased each survey year. We did not detect any fisher in the study area. Genetics have identified at least 18 individual lynx (13 M, 5 F) and 15 individual wolverines (6 M, 9 F). The combination of two detection methods improved our ability to detect species, including non-target species, compared with either method alone. Our methods could be deployed more widely in Montana.

Wildlife Health Surveillance on the National Bison Range – Monitoring for M. Paratuberculosis in Bison

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Lee C. Jones, USFWS-Wildlife Health Office, Bozeman, MT

The wildlife health surveillance program on the National Bison Range was designed to assess the presence and prevalence of diseases in wildlife populations. Annual sampling and disease testing has been conducted at the range for decades. Starting in 2000, a statistically derived disease detection model for bison was designed and implemented to enhance detection of several diseases, including M. paratuberculosis. This disease, commonly known as Johne's disease, is a bacterial intestinal disease that causes diarrhea, severe weight loss, and eventual death in bison and cattle. Targeting analysis of both populations as a whole and the status of individual animals, the program includes; (1) year-round direct observations aimed at detecting acute injuries, chronic conditions, mortalities, and emerging disease, and (2) regular diagnostic laboratory testing for a suite of diseases of particular concern and to evaluate exposure to several viral, parasitic and bacterial diseases common in the cattle industry. Information from direct observation is documented and shared with staff experienced in dealing with injuries, mortalities, and necropsies. Diagnostic analysis depends on routine

coordination with our wildlife health office in Bozeman, Montana, by providing guidance concerning disease or other life-threatening conditions, and annual summary analysis of data. This is a long term adaptive process that includes periodically assessing local and regional wildlife threats, updating protocols according to sample results and providing management with necessary information to maintain healthy wildlife populations within a fenced boundary.

**An Initial Inquiry Into Mountain Ungulate Space Use Within the Greater Yellowstone Area

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The expansion of mountain goats (*Oreamnos americanus*) throughout the Greater Yellowstone Area (GYA) has continued since their initial introduction in the 1940's. Mountain goats occupy similar habitats as native bighorn sheep (*Ovis canadensis*) and harbor pathogens known to be detrimental to bighorn sheep recovery efforts. In 2006 the Greater Yellowstone Area Mountain Ungulate Project initiated a large-scale collaring effort to enhance our understanding of the spatial dynamics of both species and the potential impacts of mountain goat range expansion on regional bighorn sheep. The research is unique in spatial scale and encompasses ten study areas with examples of both sympatric and allopatric mountain ungulate populations. To date we have instrumented 122 individuals (76 BHS and 46 MTGs) with GPS collars and have recovered 45 collars (22 BHS and 23 MTGs) from the field. Initial inquiries into space use across species and study areas with respect to seasonal migrations and elevational changes will be discussed. An early investigation of the heterogeneity in mountain ungulate space use and movement strategies throughout the GYA will help to inform future capture efforts and provide insights into mountain ungulate competition across space and time.

Hantavirus Outbreaks in Deer Mice in Montana May Be Predictable Based on Mouse Population Dynamics

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Sin Nombre hantavirus (SNV) is a rodent-borne virus that causes hantavirus pulmonary syndrome in humans, which has a 37% mortality rate. There is no vaccine or cure, therefore the best strategy is to prevent spillover from rodent hosts. Understanding the ecological drivers of infection in rodent populations can lead to better predictive models of disease dynamics in the reservoir and consequent risk to humans. Using an epidemiological model parameterized and cross-validated using a long term dataset from Montana, I show how environmental variation and fluctuating mouse density affects hantavirus prevalence. I provide evidence for a critical host density necessary to sustain transmission and show how there can be long delays between peaks in density and subsequent peaks in infection prevalence. The lengths of these delays vary with density but are predictable. This means that outbreaks may sometimes be predictable many months in advance. These same principles should also apply to many other disease systems in wildlife with fluctuating populations, and may help predict and mitigate wildlife disease.

Use of an Electro-Optic/Infrared Imaging System for Grizzly Bear Management in Northwest Montana

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Aerial monitoring of grizzly bears in the dense forests and shrub fields of northwest Montana can be difficult. It is important to get visuals on grizzly bears to count cubs, locate dens, and to find injured or dead bears. Even from the air, radio-collared grizzly bears can be difficult to observe. During 2013 and 2014, we had the opportunity to use the services of the Two Bear Air Bell 429 Helicopter and their L-3 WESCAM MX-10 Electro-Optic/Infrared (EO/IR) imaging system. Two Bear Air provides philanthropic aviation support for search and rescue teams in Flathead County and other agencies. We partnered with Two Bear Air to help provide targeted training for their camera operator and they provided us with the opportunity to locate and monitor grizzly bears. During flights we located and observed radio-collared and non-collared grizzly bears and their offspring, pinpointed den sites, and found grizzly bears that had been shot. The advantages of the EO/IR camera system allowed us to locate and monitor grizzly bears from a long distance, record locations, switch between daylight and infrared camera mode to locate bears under the forest canopy. We were able to locate a dead female grizzly bear almost 24 hours after she had been shot. In one case, we were able to look into a grizzly bear den with the infrared camera and see both the female one cub. In addition to grizzly bears, the EO/IR system could be used for monitoring and recording many other species of wildlife.

2014 Statewide Winter Owl Surveys (Oral Presentation and Poster)

Bryce Maxell*, Montana Natural Heritage Program, Helena, MT
Lauri Hanauska-Brown, Montana Fish, Wildlife, and Parks, Helena, MT

Localized winter owl surveys have been conducted in Montana in the past, but a coordinated statewide effort had never been undertaken. Eleven owl species were, therefore, listed as Species of Highest Inventory Need by Montana Fish, Wildlife, and Parks and the Montana Natural Heritage Program. We coordinated statewide winter owl call surveys in 180 of the 185 quarter latitude/longitude (QLL) blocks that encompass Montana. Call transects each consisted of 10 call stations spaced at 1-mile intervals along a 9-mile long road transect within a QLL block. At each call station, observers alternately silently listened for owl calls and played owl calls for species likely to occur in the surrounding habitat. A total of 1,829 call stations were surveyed and a total of 511 owls across 11 owl species were detected. Detections during the 2014 surveys nearly, or more than, doubled the number of records with indirect evidence for breeding that have been gathered in Montana across all time for Eastern Screech-Owl, Great Horned Owl, Long-eared Owl, and Short-eared Owl. We recommend that these species and the Northern Saw-whet Owl be removed from the Montana Species of Highest Inventory Need as a result of the information gathered during these surveys.

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

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Shannon Hilty, Montana Natural Heritage Program, Helena, MT
Lauri Hanauska-Brown, Montana Fish, Wildlife, and Parks, Helena, MT

Amie Shovlain, Beaverhead-Deerlodge National Forest, Dillon, MT
Jake Chaffin, Montana/Dakotas State BLM Office, Billings, MT
Chris Servheen, U.S. Fish and Wildlife Service, Missoula, MT
Bigfork High School Cave Club, http://bigforkhighschoolcaveclub.weebly.com
Northern Rocky Mountain Grotto, http://nrmg.cavesofmontana.org

White-Nose Syndrome (WNS), caused by the cold-adapted soil fungus *Pseudogymnoascus destructans*, has killed an estimated 5.7 to 6.7 million bats in eastern North America since 2006 and has spread westward to states along the Mississippi River corridor as well as the province of Ontario. With at least 9 of Montana's 15 known bat species facing potentially devastating increases in mortality from WNS, a collaborative effort was initiated in the fall of 2011 to document the species composition, number, degree of clustering, and roost temperatures and humidities of bats winter roosting in caves and mines. To-date, collaborators have surveyed over 50 caves and mines, deploying over 30 temperature and relative humidity data loggers near winter roosting bats; most known bat hibernacula in Montana are now being monitored. Most caves and mines surveyed to date support only small numbers of winter roosting bats; typically less than ten roosting in isolation or clusters of two to three. A handful of caves have 50-1750 winter roosting bats with clusters of up to 40 individuals. Many of the caves that have been surveyed have temperatures and humidities that appear to be capable of supporting *P. destructans*, but PCR-based testing of bat and substrate swabs have tested negative for its presence so far. The majority of Montana bats apparently winter roost away from mines or caves that are accessible to, or known by, humans and these roosts need to be located and assessed for their ability to support *P. destructans*.

Field Trials to Determine the Efficacy of an Oral Plague Vaccine for Prairie Dogs

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North American prairie dogs (*Cynomys* spp.) and black-footed ferrets (*Mustela nigripes*) have been severely affected by plague, an exotic zoonotic disease caused by the bacterium Yersinia pestis during the last 100 years. Plague has contributed to population declines of prairie dogs, near extinction of black-footed ferrets, and has caused human illness and fatalities. An oral sylvatic plague vaccine (SPV) developed and tested jointly by the U.S. Geological Survey, National Wildlife Health Center and University of Wisconsin (Madison, WI) shows great promise as an effective, pre-emptive method for controlling plague in prairie dogs. Field trials to evaluate the efficacy of SPV were initiated in 2013 and include 4 species of prairie dogs on study areas in 7 states, including Montana. This presentation is a status report after the second year of a planned 4 year study. The primary objectives are to measure vaccine/bait uptake and to assess prairie dog survival rates at paired study sites, with and without vaccine application. At the north-central Montana study site, about 8,000 baits, half with SPV and half placebos, were distributed across 5 pairs of study sites (totaling 81 ha) in 2013 and over 13,000 in 2014 on the same 5 pairs of study sites (totaling 107 ha). In addition to ear tagging and microchip-marking each individual, flea, hair, whisker and blood samples were collected each year. A total of 584 individual prairie dogs were marked during 929 capture events in 2013 and 814 individuals during 1,293 capture events in 2014.

Attitudes Toward Brucellosis Management Tools Among Montana Hunters, Landowners, and Residents

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Justin Gude, Montana Fish, Wildlife, and Parks, Helena, MT

Wildlife management agencies often balance the effectiveness of management actions with their public acceptability. We measured the acceptability and level of agreement among different stakeholder groups for elk (*Cervus Canadensis*) management in MT. The area of highest concern for Brucellosis in MT is known as the Designated Surveillance Area (DSA). MT Fish, Wildlife, and Parks (FWP) has considered several management actions within the DSA and in more targeted geographic locations (e.g., specific valleys) including fencing to prevent comingling of cattle and elk, hazing elk off private property, kill permits issued to landowners, disease management hunts, and others. To understand the acceptability of these management actions we conducted a survey of landowners, hunters, and the general public across MT; the sample was stratified to include respondents in these groups from inside and outside the DSA. The Potential for Conflict Index (PCI) was used to explore differences of acceptability of different management actions under eight scenarios. Scenarios varied based on the status of elk infection; status of cattle infection; comingling of elk and cattle; status of elk population size (i.e., below or above objective); and public hunting access provided by private landowners. Results indicated acceptability of management tools varied by group. Increasing risk of infection also affected acceptability. Understanding the acceptability of these management tools and how acceptability varied based on context informed agency decision making with regard to elk management. Demonstrating contrasts in acceptability among stakeholder groups helped identify areas of disagreement and focus conflict resolution efforts.

Raptor Electrocutions on Power Lines

Sam Milodragovich, Environmental Department, NorthWestern Energy, Butte, MT

Raptors commonly perch on power poles across Montana. Occasionally this results in the electrocution of a raptor. Electric Utilities, Electric Cooperatives, agencies and NGO's are working together to share information and reduce risks to raptors and other birds on electric systems across Montana. This presentation will discuss why raptors use power poles, what the risk factors are, what electric utilities can do to prevent electrocutions and what we as biologists can do when we encounter a dead bird under a power pole.

Elk, Cervus Elaphus, Resource Selection and Implications for Anthrax Management in Southwest Montana

Lillian R. Morris**, University of Florida, Department of Geography, Emerging Pathogens Institute, Gainesville, FL
Kelly M. Proffitt , Montana Fish Wildlife and Parks, Bozeman, MT
Valpa Asher, Turner Enterprises, Inc., Bozeman, MT
Jason K. Blackburn, University of Florida, Department of Geography, Emerging Pathogens Institute, Gainesville, FL

Anthrax, caused by the spore forming bacterium *Bacillus anthracis*, is a zoonotic disease that affects humans and animals throughout the world. In North America, anthrax outbreaks occur in livestock and increasingly wildlife species. Vaccine administration in wildlife is untenable, and the most effective form of management in wildlife is surveillance and decontamination of carcasses. Successful management is critical, as untreated carcasses can create infectious zones increasing risk for other susceptible hosts. This study focused on informing management in a re-emerging anthrax zone in southwest Montana. In 2008, a large anthrax epizootic primarily affected a domestic bison, *Bison bison*, herd and the bull segment of a free ranging elk, *Cervus elephus*, herd in southwestern Montana. Following the outbreak, we initiated a telemetry study on elk to evaluate resource selection during the anthrax season in an effort to inform anthrax management. A mixed effects generalized linear model (GLM) was used to estimate resource selection by bull elk, and habitat preferences were mapped across the landscape. Preferred habitats were overlaid on ecological niche model-based estimates of B. anthracis presence. We found significant overlap between areas with a high predicted probability of bull elk use and *B. anthracis* potential. These potentially risky areas of elk and *B. anthracis* overlap are broadly spread over both public and private lands. Future outbreaks in the region are probable, and this analysis identified the spatial extent of the risk area in the region, which can be used to prioritize anthrax surveillance.

A Forty Year Odyssey with Montana Wolves: Beginnings Through Five Years of State Management

Robert R. Ream*, College Of Forestry And Conservation, University Of Montana, Missoula, Mt
Justin Gude, Montana Fish, Wildlife And Parks, Helena, Mt

This study traces wolf population growth in Montana from initial searches for wolves in 1973, through the first wolf radio-collared in the North Fork Flathead in 1979 up to the 2014 population. Reintroduction of wolves to Yellowstone NP and Central Idaho in 1995 and 1996 resulted in two “non-essential experimental” Montana recovery areas in addition to the Northwest Montana “endangered” recovery area. From early in wolf recovery to present, livestock depredation control actions have removed individuals or packs from the population. The first public harvest of wolves began in 2009, was stopped by legal action in 2010 and resumed in 2011 to present. The Montana population appears to have leveled off at approximately 700-900 wolves. Minimum counts peaked at 653 in 2011 and have been approximately 625 wolves for the last two years. Approximately 60% of Montana’s wolves occupy the Northwest Montana recovery area. Through the 5 years state harvests have been conducted, harvest quotas and restrictions on methods of take have been gradually relaxed. However, those changes have resulted in relatively little change in harvest or in Montana’s wolf population. Wolf depredation control actions have decreased since the advent of public harvests. Wolves are here to stay at about the current population level, assuming no drastic changes in public harvests or wolf control actions.

Montana Climate Change and Big Game: Things Were Better When They Were Worse

Robert R. Ream, Professor Emeritus, College of Forestry and Conservation, University of Montana, Missoula, MT

Climate change may influence wildlife populations more than any management challenge in recent history. Within the past year numerous reports and papers have come out relative to wildlife and climate change. Now is the time to start addressing the impacts of these changes in Montana. This paper discusses some of the ways climate change may impact big game populations relative to recent climate data sets for Montana. 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. 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. We must be proactive in assessing the impacts of climate change on Montana wildlife populations in order to apply adaptive management.

Identifying Priority Areas for Chronic Wasting Disease Surveillance in Montana

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Neil J. Anderson, Montana Fish, Wildlife, and Parks, Bozeman, MT
Jennifer M. Ramsey, Montana Fish, Wildlife, and Parks, Bozeman, MT

Chronic Wasting Disease is a fatal prion disease affecting ungulate species throughout North America. As of 2013, no CWD positive deer have been found in the state of Montana, however, several surrounding states and provinces have identified multiple cases of the disease. We used information on mule deer habitat selection, abundance, and locations of CWD cases in surrounding states to identify priority areas in Montana for CWD surveillance. The habitat selection models were based on over 10000 VHF and GPS locations collected from mule deer from 1975-2011, and predicted resource selection function (RSF) values for winter and summer in 5 of the 7 wildlife management regions in the state of Montana. We estimated mule deer density using the aerial survey counts weighted by the value of the RSF for each pixel. High priority areas were those that contained the highest densities of mule deer and were closest to locations with CWD positive deer. This information can be used to inform Montana's CWD surveillance program for mule deer. We concluded that based on mule deer distribution and movement patterns several mule deer herds in Montana were at risk of coming into contact with deer from known infected herds.

Bat Activity Patterns and Roost Selection in Managed Forests

Nathan A. Schwab *, ABR, Inc., Missoula, MT
Lorin L. Hicks, Plum Creek Timber Company, Columbia Falls, MT

The recent introduction and subsequent westward spread of white-nose syndrome (WNS) has decimated hibernating bat populations in eastern North America and created an urgent need for scientists to understand basic information about bat ecology, especially during the winter season. White-nose syndrome has killed between 5 and 7 million bats and continues to

spread westward from the eastern U.S. and southern Canada, primarily affecting bats during hibernation. Acoustic monitoring has been suggested as a potential surveillance tool for detecting WNS; however, baseline information must first be collected to test this technique. We initiated a pilot project in June 2014 by deploying 2 remote acoustic monitoring stations in western Montana's managed forests collecting baseline acoustic information. We also conducted radio telemetry to determine characteristics of roosts used by bats during the fall season. Thus far we have recorded 11 of Montana's 15 bat species, and observed extremely high activity levels during the summer. We radio-tagged 5 bats of 3 different species (California myotis, Western small-footed myotis, Silver-haired bat) and tracked them in late October and early November. Identifying the characteristics of roost sites used during the pre-hibernation period, and the annual activity patterns determined from acoustic monitoring, begin to form the foundation for understanding basic aspects of bat ecology during the season when Montana bats will be most susceptible to WNS.

Modeling Proactive Decisions to Manage Pneumonia Epizootics in Bighorn Sheep

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Pneumonia epizootics in bighorn sheep (*Ovis canadensis*) are a major challenge for wildlife agencies due to the complexity of the disease, long-term impacts, and lack of tools to manage risk. We developed a decision model to facilitate proactive management of pneumonia epizootics in bighorn sheep in Montana. Our decision model integrates a risk model to predict probability of pneumonia epizootics based on identified risk factors. It uses a structured decision making (SDM) approach to analyze potential decisions based on predictions from the risk model, herd-specific management objectives, and predicted consequences and trade-offs. We demonstrated our model's use with an analysis of representative herds and analyzed the recommended decisions to understand them clearly. We learned that proactive management for each herd was expected to outperform in meeting multiple, competing management objectives compared to ongoing status quo management. Based on sensitivity analyses, we also learned that the recommended decisions were relatively robust with limited sensitivity to variations in model inputs and uncertainties; we expect this to be the case in future analyses as well. Our decision model addressed the challenges of uncertainty, risk tolerance, and the multi-objective nature of management of bighorn sheep while providing a consistent, transparent, and deliberative approach for making decisions for each herd. It is a unique tool for managing pneumonia epizootics using an accessible framework for biologists and managers. Our work also provides a case study for developing similar SDM-based decision models, particularly for other wildlife diseases, to address challenges of making complex decisions.

Elk Movements and Harvest Across Public and Private Lands in the Sapphire Mountains

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Kelly Proffitt, Montana Fish, Wildlife and Parks, Bozeman, MT
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Hunting access issues have become increasingly contentious as changes in land ownership and use have influenced elk distributions in some areas. In the Sapphire Mountains of western Montana, hunters have voiced concerns regarding elk aggregations on privately-owned lands that restrict hunter access. To address these concerns, we initiated a survey of landowners and hunters to determine satisfaction with elk management. We also radiocollared 65 elk (45 cows, 20 bulls) to better understand elk distributions across public and private lands. In all seasons, bull elk locations were more likely to occur in publicly accessible areas than cow elk locations. During archery season, 61% of bull locations and 41% of cow locations occurred in publicly accessible areas. These numbers dropped to 48% of bull locations and 14% of cow locations in publicly accessible areas during rifle season. During archery and rifle seasons combined, 1 of 39 radiocollared cows (2.4%) was harvested on private land, and 5 of 19 radiocollared bulls (26.3%) were harvested: 3 on publicly accessible land and 2 on private land. Although hunters reported a lack of elk on public lands as a concern, our radiocollar and harvest data confirm that at least a segment of the bull population was accessible to public hunters, but female elk were aggregated in areas that restricted hunter access. A lack of hunter access to female elk during the hunting season may result in management challenges, including game damage issues, and increases in the population beyond objective levels.

Dietary Overlap of American Barn Owl and Short-Eared Owl in the Mission Valley, Montana

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Victoria Dreitz, Wildlife Biology Program and Avian Science Center, University of Montana Missoula, MT
Denver W. Holt, Owl Research Institute, Charlo, MT

The Mission Valley is home to many species of wildlife, including the Short-eared owl. Over the last decade Barn Owl sightings have increased in the valley and nests have been discovered. We analyzed food-niche overlap between American Barn Owls (*Tyto furnata*) and Short-eared Owls (*Asio flammeus*) over one year to determine whether prey competition from the local Barn Owl population will affect the Short-eared Owl population. A total of 325 prey items (11 different species) were identified from 152 pellets; 79 Barn Owl and 73 Short-eared Owl. Diets of both species consisted primarily of *Microtus* species, although traces of additional food resources were present. Using Pianka's index the food-niche overlap was 0.658, where Pianka's index determines what proportion of the two owl species' diets overlap with a value of 0 representing total separation and a value of 1 representing total overlap. The results of this study showed a food niche overlap between the two owl species. We suggest, however, that the current population of Barn Owl in the Mission Valley is not directly competing with the established Short-eared Owl population in the Mission Valley, given the

availability of alternative food resources. The consequence of small mammal population dynamics in this study is also addressed.

Mapping the Future of Oil and Gas Development in Relation to the Conservation of Greater Sage Grouse

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Frederick, Robert B., Department of Biology, Eastern Kentucky University, Richmond, KY
Matthew Heller, Great Northern Landscape Conservation Cooperative, USDI – Fish and Wildlife Service, Bozeman, MT
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The effects of oil and gas development on the conservation of greater sage grouse (*Centrocercus urophasianus*) is of concern in the Northeastern portion of their current range that coincides partially with grouse Management Zones I, II, and IV. Although some research has reported on these effects, much remains uncertain. This is often the case with ecological studies where cause-effect relationships are complex, multivariate, and involve landscape perspectives. Gaining an understanding of the effects of the development on grouse requires predicting where that development is expected to occur on a landscape level. We gathered the "reasonable foreseeable development" spatial data from the USDI's Bureau of Land Management that were available for Montana, North Dakota, South Dakota, Wyoming, and Northwestern Colorado. These data were disparate across the study area, and we standardized them across mapping units to establish consistent and quantitative categories. We describe the GIS processes used to accomplish that and to display the number of wells per township as projected in the BLM data. The data were then overlain with the priority areas for conservation for greater sage grouse. Our data, metadata, and data processing (standardization) documentation will be made available on the web via the Landscape Conservation Management and Analysis Portal (LCMAP— https://www.sciencebase.gov/ catalog/?community=LC+MAP+-+Landscape+Conservation+Management+and+Analysis+Portal). Companion research to model the risk to greater sage grouse from oil and gas development has also begun. This uses artificial intelligence and Bayesian belief network software to represent knowledge and its uncertainty as presented in the scientific literature, and we present our conceptual model.

Movements and Habitat Use of Northern Saw-Whet Owls During Fall Migration

Katharine R. Stone*, Ecologist, MPG Ranch, Florence, MT
William Blake, Biologist, MPG Ranch, Florence, MT

We used radio telemetry to track the movements and habitat use of Northern Saw-whet Owls (*Aegolius acadicus*) as they traveled south through the Bitterroot Valley during fall migration. We deployed 38 units over the course of 3 weeks in late September and early October 2014. We hypothesized that owls would use the Bitterroot River floodplain as a travel route, because this landscape feature offers continuous vegetative cover the whole length of the Bitterroot Valley. Instead, many owls traveled along the periphery of the valley, through the forested foothills of both the Bitterroot and Sapphire Mountains. In many cases, their locations suggested that they crossed over landscapes offering little vegetative cover. Our greatest nightly distance moved was 26 miles. We tracked one owl a distance of approximately 60 miles from the banding station. Many owls exhibited stopover behavior, staying in the same general area for several days between movements. Some owls did not

migrate; we do not know if these individuals were year-round residents or overwintering owls arriving from other areas. Our ability to document roost-site characteristics of both migratory and resident owls was constrained by the common use of tall ponderosa pines for roosting, limiting our ability to precisely locate owls, even with telemetry equipment. This result suggests that methods relying on passive observation to detect owls and/or roost sites likely miss the majority of roost sites, at least during migration. We documented one communal roost containing at least three individuals.

Montana Pergrine Falcon Survey: 2014

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The release of 617 captive-bred young during the 1980's and 1990's sparked the recovery of the Peregrine Falcon (*Falco peregrinus*) in Montana. By 1994, a mix of state, federal, and private biologists (Montana Peregrine Falcon Working Group) documented 13 known active Peregrine Falcon territories. For the following four years, the number of known territories averaged about 16, but then intensive survey efforts in 1999 documented a total of 28 territories. The number of active Peregrine Falcon territories discovered in Montana has increased yearly. Montana had a record number of 108 active Peregrine Falcon territories recorded during the 2012 field season. By the end of the 2014 field season, we have recorded 166 active Peregrine Falcon territories. Montana Peregrine Falcon surveys are conducted in conjunction with the USFWS national surveys scheduled every three years, beginning in 2002 and ending in 2015. Annual survey objectives include the establishment of a citizens group (Project Peregrine Watch) to monitor individual Peregrine territories throughout the state, determine status and trends of Montana's Peregrine Falcon population, study all known historic Peregrine Falcon eyries, record occupancy and productivity at all active territories, locate new Peregrine Falcon territories, seek confirm and consolidate information from all public and private sources, record activity and locations of neighboring cliff-nesting raptors Prairie Falcon (*Falco mexicanus*), Golden Eagle (*Aquila chrysaetos*), and the Red-tailed Hawk (*Buteo jamaicensis*), and develop , a long-term and cost-effective monitoring program for determining annual status and population trends of the State's Peregrine Falcon population.

MT Legislature and Wildlife 101

Robert R. Ream, former Chair of Montana Fish, Wildlife and Parks Commission
Amy Seaman, Bird Conservation Associate & Lobbyist MT Audubon Society, Helena, MT

Bob Ream and Jake Troyer will lead an educational discussion about the Montana Legislature. The discussion will center on the best ways to engage with legislators, critical wildlife legislation introduced in the 2015 Montana Legislature, and how you can get involved as a citizen advocate on the issues that are most important to you.

Investigating Habitat Characteristics Important to Hoary Marmots in Montana

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Andrea R. Litt, Department of Ecology, Montana State University, Bozeman, MT
John Vore, Montana Fish, Wildlife and Parks, Helena, MT
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Steven Kalinowski, Department of Ecology, Montana State University, Bozeman, MT

Alpine ecosystems will be impacted by climate change, which will shift distributions of alpine species on the landscape. Understanding which habitat characteristics are important to alpine species will be necessary to predict changes in distribution reliably. The hoary marmot (*Marmota caligata*) is an alpine obligate whose range extends from Alaska into western Montana. Although hoary marmots are relatively abundant, they are a potential species of concern in Montana because we lack information on their distribution and habitat requirements. We initiated a project to investigate the genetic connectivity and habitat characteristics that promote occupancy of marmots. Between June and August 2014, we visited five mountain ranges in search of hoary marmots. At two to three sites per mountain range, we trapped marmots for genetic samples and surveyed areas visually to quantify occupancy. We sampled 47 sites during 79 surveys; at least one marmot was detected by at least one observer in 12 of these surveys (15%). Marmots were more likely to occupy sites with increased cover of boulders and wet meadow and less likely to occupy sites with increased cover of shrubs and grasses. Overall, the probability of detecting a marmot was 0.59 (SE = 0.10) and the probability of occupancy across all sites was 0.27 (SE = 0.10). Our work will provide information about non-game species in alpine environments and inform the design of monitoring programs that can aid managers as they begin to understand where hoary marmots are on the landscape and where they could be in the future.

Bat Use of Bridges in Missoula, Ravalli, and Mineral Counties in Western Montana (Oral Presentation and Poster)

Ellen Whittle**, Wildlife Biology Program, U. of Montana, Missoula, MT

Bryce A. Maxell, Montana Natural Heritage Program, Helena, MT

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Many North American bat species are declining as populations face increasing pressure from disease and degradation or loss of habitat. Bats roost in natural and artificial structures with adequate crevices. It is important to document the structural and thermal characteristics of these roosts across the landscape in order to provide natural resource managers with tools to protect and conserve these species. Bat use of bridges has been well documented in the southwest United States, but bridges in northwest Montana were not surveyed because temperatures were thought to be insufficient for bats. This lack of knowledge was the basis for our survey of roadway bridges in Missoula, Ravalli, and Mineral Counties. In May-October 2014 we visited 412 bridges and categorized them as day roost, night roost, maternity colony, or no detectable use. We detected widespread use of bridges (45.9%) as night roosts used between foraging flights. Bats were detected in day roosts at a smaller number of bridges (2.7%) with use ranging from solitary bats to hundreds of females and offspring. Bridge type and structure appear to be significant in predicting bat use, and initial temperature data indicate that day roosts have a slightly higher temperature regime than unoccupied bridges. Survey and bat detection information is available to resource managers via the Montana Natural Heritage Program's MapViewer web application (http://mtnhp.org/mapviewer). In consideration of the potential importance of these artificial roosts to bat species, we encourage the evaluation of roadway bridges for bat use prior to maintenance or replacement activities.

Thirty Years Of Wetland Conservation In Montana

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James L. Hansen, Montana Fish, Wildlife and Parks, Billings, MT
Mark G. Sullivan, Montana Fish, Wildlife and Parks, Glasgow, MT
Rick D. Northrup, Montana Fish, Wildlife and Parks, Helena, MT

In 1985 the Montana Legislature authorized the Department of Fish, Wildlife and Parks (FWP) to use funds from migratory bird hunting licenses "…for the protection, conservation, and development of wetlands in Montana", thereby creating the Migratory Bird Wetland Program (a.k.a. State Duck Stamp Program). Wetlands and their associated uplands provide critical nesting, foraging, brood-rearing, and migration habitat for waterfowl and other wetland-associated wildlife. Wetlands also provide critical ecosystem functions important for our communities and wildlife, including water purification, flood control, and groundwater recharge. FWP's Migratory Bird Wetland Program is dedicated to conserving wetlands and associated uplands to benefit Montana's wildlife, especially migratory birds, to enhance consumptive and non-consumptive recreational opportunities, and to maintain wetland systems for Montana's citizens. Since many of the opportunities were on private land, it was essential for FWP personnel to learn how best to work with farmers and ranchers to benefit their operations as well as wildlife and wetland values. In addition to the partnership of private landowners, many other agencies and organizations have been partners in habitat projects. The program has adapted to changing opportunities and conservation needs over time. We will chronicle the past 30 years of program implementation, showcase successes, and discuss a philosophy for continued wetland conservation into the future.

Is Science Meeting the Needs of Land Management? A Case Study of the USFS and the Fisher

Dave Wrobleski, Wildlife Biologist, USFS, Lolo National Forest

Laws including the National Environmental Policy Act, National Forest Management Act and Endangered Species Act require both knowledge of potential effects on wildlife species and specify what effects may or may not occur to species. In the context of land management agencies such as the U.S. Forest Service, before a timber harvest, prescribed fire, or wildlife habitat improvement project occurs, these laws require a wildlife biologist to disclose the effects of the project on wildlife species and propose options to reduce potential negative effects. Decision-makers are then required to consider these effects and prevent jeopardizing listed species or impacting viability of "sensitive" species. These legal requirements result in biologists producing a report called a Biological Evaluation and Assessment specifying how a project would affect sensitive and federally listed species. Wildlife research is used to answer the following questions about each species of interest including, status, trend, habitat, applicable survey data, and mechanisms of effects on species. The key piece of information needed is the effect on the individual and population as a whole. However, the less research is available, the more logic and reasoned speculation are used to estimate these potential effects. Discerning the effect on the individual and population as a whole is usually based on little science because the science rarely reaches this point. Thus, the most critical pieces of the analysis – *what are the effects? And how important are they?* are based upon a logic string, and of course subject to judicial review. The fisher (*Pekania pennanti*) was used as an example by comparing recent research with conclusions reached in land management

documentation. As land managers we recommend that research 1) work closely with management to insure research is as applicable as possible, and 2) that research focus on how changes in a home range may affect the individual and population and to what degree.

Poster Abstracts

Alphabetical By First Authors Last Name
***Denotes Presenter**
****Denotes Student Presenter**

Assessing the Effect of Social Information on Cerulean Warbler Settlement in South-Central Indiana (Poster)

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Kamal Islam, Department of Biology, Ball State University, Muncie, IN
Sasha A. Auer, Department of Biology, Ball State University, Muncie, IN

Breeding bird settlement cues are typically defined by correlating occupancy to habitat related variables; however, social cues can influence breeding bird distributions and confound habitat modeling studies. The cerulean warbler (*Setophaga cerulea*) is one of the fastest declining songbirds in North America and conservation efforts would improve through a holistic understanding of breeding site selection. I assessed the influence of three forms of social information on male cerulean warbler breeding site selection: 1) pre-breeding cues, 2) post-breeding cues, and 3) clustered locational cues. The experiment was conducted by broadcasting conspecific vocalizations within plots that contain mature deciduous forests and have not contained a breeding territory over the past six years. Song was broadcasted in 2013 from the settlement to the post-fledging period. Song was broadcasted during the settlement period in another location in 2014 using a clustered speaker arrangement to mimic a breeding aggregation. Point counts were conducted every 3-6 days within treatment and control plots (no vocalizations broadcasted). Three males were detected in treatment plots during this study; however, no territories were established in treatment or control plots. Territories were not established in response to pre-breeding locational cues, post-breeding locational cues, or clustered locational cues, despite visitation by a male during these periods. These results suggest that conspecific social information does not have a strong influence on male cerulean warbler settlement. However, this experiment would be more conclusive if conducted in a part of its range where abundance is greater.

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

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Shannon Hilty, Montana Natural Heritage Program, Helena, MT
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Lauri Hanauska-Brown, Montana Fish, Wildlife, and Parks, Helena, MT
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Jake Chaffin, Montana/Dakotas State BLM Office, Billings, MT

Montana's bat species face a wide array of conservation issues that threaten the long-term viability of these populations. The potential arrival of White-Nose Syndrome (WNS) may be

the single greatest threat as mortality has exceeded 95% for some bat populations in eastern North America. A collaborative effort was initiated in 2011 to document year-round spatial and temporal activity patterns of Montana's bats prior to WNS arrival. In the last 4 years, we have deployed a network of over 60 Song Meter ultrasonic acoustic detector/recorder stations programmed to record bat passes from sunset to sunrise year-round. Through late December of 2014, these recording stations have resulted in more than 3.9 million full spectrum sound files containing more than 12.5 terabytes of information. Processing and automated analyses have been completed for all sound files and over 30,000 bat passes have been reviewed by hand using an updated Montana bat call characteristics key to definitively confirm the presence of species during each month of the year, identify the lowest temperatures at which individual bat species are active, and track overall bat activity, regardless of species, at each station. Highlights to-date include: 1421 new records of monthly species presence throughout the state, numerous first records of species' activity during the fall, winter, and spring months, numerous first records of species in regions with previously limited bat survey effort, documentation of nightly activity patterns throughout the year and regular winter activity for a few resident species, and the year-round presence of species previously considered migratory.

Blood-Lead Levels of Wintering Golden and Bald Eagles of the Bitterroot Valley Montana (Poster)

Robert Domenech*, Raptor View Research Institute, Missoula, MT
Adam Shreading, Raptor View Research Institute, Missoula, MT

Lead has long been documented as a serious environmental hazard to eagles and other predatory, opportunistic and scavenging avian species. The use of lead shotgun pellets for waterfowl hunting on federal and state lands was banned in 1991 due to lead poisoning in Bald Eagles (*Haliaeetus leucocephalus*), Golden Eagles (*Aquila chrysaetos*) and numerous waterfowl species. At that time, this was thought to be the major source of the lead exposure. More recently, lead poisoning from ingested lead-bullet fragments and shotgun pellets has been identified as the leading cause of death in California Condors (*Gymnogyps californianus*), leading to a ban of lead ammunition within the "California Condor Recovery Zone." Another on-going study on Common Ravens (*Corvus corax*) and Bald Eagles in Wyoming has shown a direct correlation between very high blood-lead levels and the on-set of rifle hunting season. Indeed, there is overwhelming evidence showing that lead toxicity is still prevalent in the environment and mounting data points to fragmented rifle bullets as the source. We sampled blood from 32 Golden Eagles and 11 Bald Eagles captured on wintering grounds in the Bitterroot Valley from 2011 - Present. Eighty-six percent of eagles tested showed blood-lead concentrations higher than natural background levels. These preliminary results suggest exposure to lead is prevalent among eagles from northern latitudes wintering in the Bitterroot Valley.

Wing-Tagged Encounters of Goldens Eagles Captured in Montana (Poster)

Robert Domenech*, Raptor View Research Institute, Missoula, MT
Adam Shreading, Raptor View Research Institute, Missoula, MT

Recently, there has been an increase in concern for Golden Eagle (*Aquila chrysaetos*) populations in the western United States. The concern stems from a marked decrease in the number of migrants and concern over an increase in future threats from a variety of anthropogenic factors including, but not limited to, energy development. Thus, there is a need

for more information on Golden Eagles including: where they winter, longevity, causes of mortality and critical habit needs. Standard banding offers low encounter rates (<7%) and satellite telemetry is cost prohibitive. We began auxiliary marking Golden Eagles with vinyl wing-tag markers as a cost effective means to gather information on the species. Since 2004, we have wing-tagged over 214 eagles, and re-encountered 46 individuals, giving us a 21% encounter rate. This technique is proving considerably more effective than banding alone as a means of identifying individuals and receiving re-encounter information. We attribute this success, in part to internet information sharing and the increasing use of remote cameras set up on carcasses to view scavenger activity.

Bighorn Sheep Movements and Mineral Lick Use in Waterton-Glacier International Peace Park (Poster)

Elizabeth P. Flesch*, University of Montana, USGS Glacier Field Station, West Glacier, MT
Tabitha A. Graves, Northern Rocky Mountain Science Center, USGS, West Glacier, MT
Mark J. Biel, Glacier National Park Science Center, NPS, West Glacier, MT

This study used bighorn sheep telemetry data collected in Glacier National Park, Waterton Lakes National Park, and the Blackfeet Reservation to examine bighorn sheep movements and use of known mineral licks. Over 168,400 GPS locations were collected between 2002 and 2011 on 97 bighorn sheep individuals from 17 different social groups. We examined the proximity of bighorn sheep telemetry data to 32 known mineral lick locations to describe timing and frequency of mineral lick use. Fifty individuals had locations near known mineral licks, and most mineral lick visits took place between May and August. We compared movements towards known mineral lick locations with general bighorn sheep movements. After estimating bighorn sheep kernel home ranges, we evaluated how movement towards the lick, timing, and frequency of use varied depending on location of the lick relative to sheep home ranges. We conducted a k-means cluster analysis of movement characteristics to identify potential locations of unknown mineral licks and movement pinch points. We will discuss options for using these locations to monitor bighorn sheep health and population size.

Spatiotemporal Variability in Biomass and Forage Quality Across a Temperate Landscape with Heterogeneous Phenology Patterns (Poster)

Erica L. Garroutte*, Ecology Department, Montana State University, Bozeman, MT
Andrew Hansen, Ecology Department, Montana State University, Bozeman, MT
Scott Creel, Ecology Department, Ecology Department, Montana State University, Bozeman, MT
Rick Lawrence, Land Resources and Environmental Science, Montana State University, Bozeman, MT
Jim Robison-Cox, Department of Mathematical Sciences, Montana State University, Bozeman, MT

Although spatial and temporal heterogeneity in grassland biomass and forage quality is well-recognized to play an important role in migratory ungulate population dynamics, attempts to directly quantify biomass and forage quality across temperate landscapes throughout the growing season are limited. It is generally recognized that biomass and forage quality are directly related to phenology, but little is known about how seasonal biomass and forage quality differs across land use and biophysical gradients with varying phenology patterns. This study uses field estimates of biomass, chlorophyll concentration, crude protein, and in vitro dry matter digestibility collected from 20, 250m^2 grassland plots throughout the

summers of 2013 and 2014 to quantify how biomass and forage quality differ across land uses and biophysical gradients in the migratory elk (*Cervus elaphus*) range in the Upper Yellowstone River Basin. Key findings were that irrigated agriculture had overall greater and longer available biomass and forage quality throughout the growing season compared to private and public grasslands with natural phenology patterns. And that areas that begin growth later in the season had overall greater biomass and forage quality than areas with mid and early phenology characteristics, but availability was shorter. These results suggest that seasonal patterns of biomass and forage quality differ with phenological characteristics across temperate landscapes. This information should be incorporated in our understanding of spatiotemporal patterns of vegetation important for studying migratory ungulate ecology and predicting the effects of climate change and human land use on vegetation dynamics in temperate landscapes.

Through Citizen Science (Poster)

Tabitha A. Graves*, Northern Rocky Mountain Science Center, USGS, West Glacier, MT
Jami Belt, Glacier National Park, West Glacier, MT
Kristina Boyd, Yaak Valley Forest Council, Troy MT

The spatial and temporal availability of grizzly bear foods influences bear health and reproduction and is likely to change with the changing climate. Even short-term shortages of bear foods may increase bear movements into human settlements and the potential for conflicts, which may lead to increased bear mortality. However, climate drivers of bear food availability are poorly understood and few resources are available for long-term monitoring at a spatial scale to adequately connect food availability to climate. We are proposing to evaluate citizen science as a potential mechanism for researching and monitoring relationships of multiple bear food sources with climate change. We have several questions and are seeking input: 1) How much interest is there among various groups (e.g., Glacier National Park visitors, Salish tribal members, Blackfeet tribal members, backcountry horsemen, naturalists, conservation group members) in collecting these kinds of data? 2) What are the best protocols for citizen scientists to measure bear food availability across the ecosystem? 3) What would the ongoing costs be for coordinating a citizen science program? We will discuss several ideas for which we are seeking pilot project funding that will help to answer these questions, including 1) a geocaching app that would initially target park visitors and school programs to collect huckleberry phenology and berry abundance data, and 2) multiple ways to engage citizens in using National Phenology Network protocols.

A GIS Tool for Applying Habitat Suitability Models to Inform Management (Poster)

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Victoria A. Saab, Rocky Mountain Research Station, U.S. Forest Service, Bozeman, MT
Jessica R. Haas, Rocky Mountain Research Station, U.S. Forest Service, Missoula, MT
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Habitat suitability models are used to guide habitat management for species of conservation concern. Models quantify relationships between known species locations and environmental attributes, which are used to identify and map areas most likely to support species of concern. Managers can then restrict human activities with negative impacts on habitat suitability in these areas. Application of habitat suitability models, however, typically requires technical expertise not available to most land managers. We developed a prototype

GIS tool that facilitates application of habitat suitability models to guide management of habitat for woodpecker species of conservation concern. The tool operates within an ArcGIS environment, which is readily available to most managers, and will be capable of generating habitat suitability maps for several species of concern (i.e., Black-backed Woodpecker [*Picoides arcticus*], Three-toed Woodpecker [*P. dorsalis*], Lewis's Woodpecker [*Melanerpes lewis*], and White-headed Woodpeckers [*P. albolvartus*]). The tool also automates much of the model application process, reducing requisite technical expertise, and making habitat suitability models widely available. The tool will be accompanied by a manual describing implementation and interpretation of resulting habitat suitability maps. The tool will be especially helpful for informing management of post-disturbance forests (i.e. after wildfire and beetle infestations) to identify suitable habitat for disturbance specialists (e.g., Black-backed, Three-toed, and Lewis's Woodpeckers). Identification of suitable habitat is necessary to effectively develop management plans that incorporate the needs of habitat specialists in post-disturbance landscapes. Our prototype is currently being tested by U.S. Forest Service biologists.

Acoustic Monitoring of Nocturnal Migrants in the Bitterroot Valley, Montana (Poster)

Debbie Leick*, MPG Ranch, Florence, MT
Kate Stone, MPG Ranch, Florence, MT

Many avian species migrate under the cover of darkness, limiting our ability to study migration phenomena. Some migrants emit nocturnal flight calls (NFCs) to presumably echolocate and maintain communication with other birds. NFC monitoring provides a reliable, passive, and unbiased way to document species composition and spatial and temporal components of nocturnal migration. During spring and fall migration of 2013 and 2014, we installed autonomous recording units (ARUs) at low-, mid-, and high-elevation sites. ARUs record NFCs and allow spectrogram generation, followed by species-level identification. From the recordings, we extracted and analyzed over 6000 NFCs from sparrows, warblers, and thrush-like species. Our data show that we can track annual, seasonal, weekly, and nightly trends as well as patterns between monitoring sites. We found more NFCs in 2014 compared to 2013, substantially more NFCs in fall than in spring, and saw differences in nightly detections times between different bird groups. Across the three monitoring sites, the mid-elevation site continued to record the most NFCs during fall migration. In 2015, we plan to finish the species-level classification and compare the results to other survey methods (e.g., bird banding and visual surveys). We also plan to monitor NFCs for a third year to confirm these patterns persist. An additional year of monitoring will provide a good baseline to monitor future population trends and migration pathways.

2014 Statewide Winter Owl Surveys (Oral Presentation and Poster)

Bryce Maxell*, Montana Natural Heritage Program, Helena, MT
Lauri Hanauska-Brown, Montana Fish, Wildlife, and Parks, Helena, MT

Localized winter owl surveys have been conducted in Montana in the past, but a coordinated statewide effort had never been undertaken. Eleven owl species were, therefore, listed as Species of Highest Inventory Need by Montana Fish, Wildlife, and Parks and the Montana Natural Heritage Program. We coordinated statewide winter owl call surveys in 180 of the 185 quarter latitude/longitude (QLL) blocks that encompass Montana. Call transects each consisted of 10 call stations spaced at 1-mile intervals along a 9-mile long road transect

within a QLL block. At each call station, observers alternately silently listened for owl calls and played owl calls for species likely to occur in the surrounding habitat. A total of 1,829 call stations were surveyed and a total of 511 owls across 11 owl species were detected. Detections during the 2014 surveys nearly, or more than, doubled the number of records with indirect evidence for breeding that have been gathered in Montana across all time for Eastern Screech-Owl, Great Horned Owl, Long-eared Owl, and Short-eared Owl. We recommend that these species and the Northern Saw-whet Owl be removed from the Montana Species of Highest Inventory Need as a result of the information gathered during these surveys.

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

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Shannon Hilty, Montana Natural Heritage Program, Helena, MT
Lauri Hanauska-Brown, Montana Fish, Wildlife, and Parks, Helena, MT
Amie Shovlain, Beaverhead-Deerlodge National Forest, Dillon, MT
Jake Chaffin, Montana/Dakotas State BLM Office, Billings, MT
Chris Servheen, U.S. Fish and Wildlife Service, Missoula, MT
Bigfork High School Cave Club, http://bigforkhighschoolcaveclub.weebly.com
Northern Rocky Mountain Grotto, http://nrmg.cavesofmontana.org

White-Nose Syndrome (WNS), caused by the cold-adapted soil fungus *Pseudogymnoascus destructans*, has killed an estimated 5.7 to 6.7 million bats in eastern North America since 2006 and has spread westward to states along the Mississippi River corridor as well as the province of Ontario. With at least 9 of Montana's 15 known bat species facing potentially devastating increases in mortality from WNS, a collaborative effort was initiated in the fall of 2011 to document the species composition, number, degree of clustering, and roost temperatures and humidities of bats winter roosting in caves and mines. To-date, collaborators have surveyed over 50 caves and mines, deploying over 30 temperature and relative humidity data loggers near winter roosting bats; most known bat hibernacula in Montana are now being monitored. Most caves and mines surveyed to date support only small numbers of winter roosting bats; typically less than ten roosting in isolation or clusters of two to three. A handful of caves have 50-1750 winter roosting bats with clusters of up to 40 individuals. Many of the caves that have been surveyed have temperatures and humidities that appear to be capable of supporting *P. destructans*, but PCR-based testing of bat and substrate swabs have tested negative for its presence so far. The majority of Montana bats apparently winter roost away from mines or caves that are accessible to, or known by, humans and these roosts need to be located and assessed for their ability to support *P. destructans*.

Monitoring Huckleberries for Invasive Fruit Flies and Climate Change Impacts on the Flathead Indian Reservation (Poster)

Joel A. Smith*, Wildlife and Fisheries, Salish Kootenai College, Pablo MT
Tabitha A Graves, USGS Northern Rocky Mountain Science Center, West Glacier, MT
Janene Lichtenberg, Natural Resources, Salish Kootenai College, Pablo, MT

The huckleberry (*Vaccinium spp.*) has been important to both bears and the Salish people for hundreds of years. With predicted climate changes including increasing temperature, increasing variability in weather, and unknown changes in precipitation it is important to understand effects on huckleberry plants on the Flathead Reservation. In this project, we

are proposing to extend huckleberry phenology research in Glacier National Park led by Dr. Tabitha Graves to the Flathead Reservation. The USGS project aims to understand potential climate change impacts on grizzly bear food sources, a research need identified in a workshop evaluating climate change impacts to grizzly bears (Servheen and Cross 2010). Two potential impacts include 1) changes in phenology that could impact pollination rates and thus productivity and 2) the possible presence of an invasive fruit fly, the spotted wing drosophila that lays eggs in ripe fruit, and can cause the fruit to drop off early. I will use remote cameras that record pictures every day to measure the length of time individual flowers bloom and individual berries are present. This will be used to evaluate how flowering time and duration and ripe berry time and duration varies with temperature across sites that range in precipitation and solar radiation. Productivity metrics will be recorded at the peak of the berry season. All findings and conclusions will be a part of my senior thesis and will be provided to the Confederated Salish and Kootenai Tribes.

Bat Use of Bridges in Missoula, Ravalli, and Mineral Counties in Western Montana (Oral Presentation and Poster)

Ellen Whittle**, Wildlife Biology Program, U. of Montana, Missoula, MT

Bryce A. Maxell, Montana Natural Heritage Program, Helena, MT

Creagh W. Breuner, Division of Biological Sciences, U. of Montana, Missoula, MT

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

Paul Hendricks, Division of Biological Sciences, U. of Montana, Missoula, MT

Many North American bat species are declining as populations face increasing pressure from disease and degradation or loss of habitat. Bats roost in natural and artificial structures with adequate crevices. It is important to document the structural and thermal characteristics of these roosts across the landscape in order to provide natural resource managers with tools to protect and conserve these species. Bat use of bridges has been well documented in the southwest United States, but bridges in northwest Montana were not surveyed because temperatures were thought to be insufficient for bats. This lack of knowledge was the basis for our survey of roadway bridges in Missoula, Ravalli, and Mineral Counties. In May-October 2014 we visited 412 bridges and categorized them as day roost, night roost, maternity colony, or no detectable use. We detected widespread use of bridges (45.9%) as night roosts used between foraging flights. Bats were detected in day roosts at a smaller number of bridges (2.7%) with use ranging from solitary bats to hundreds of females and offspring. Bridge type and structure appear to be significant in predicting bat use, and initial temperature data indicate that day roosts have a slightly higher temperature regime than unoccupied bridges. Survey and bat detection information is available to resource managers via the Montana Natural Heritage Program's MapViewer web application (http://mtnhp.org/mapviewer). In consideration of the potential importance of these artificial roosts to bat species, we encourage the evaluation of roadway bridges for bat use prior to maintenance or replacement activities.

Montana Academy of Sciences

2015 Annual Meeting

April 20 - 11, 2015

Montana Tech of the University of Montana - Butte, Montana

Phil Jensen, President, Montana Academy of Sciences
James Barron, Executive Director, Montana Academy of Sciences

INTRODUCTION

The Montana Academy of Sciences (MAS) was incorporated on the 20th day of March, 1961, as a non-profit, educational organization. The objectives of the Montana Academy of Sciences are to encourage interest and participation in the sciences and to promote public understanding of science and its contribution to society. The Academy accomplishes its objectives by conducting meetings of those interested in sciences and the education of scientists, by publishing contributions to scientific knowledge, by supporting research, by making awards to recognize accomplishments in science, by administering gifts and contributions to accomplish these aims, by assigning and cooperating with affiliated and other organizations with similar objectives, and by engaging in such other activities as deemed necessary to accomplish its objectives.

We held our 2015 Annual Meeting at Montana Tech in Butte, MT. on April 10 and 11. Over 100 registrants participated, viewing 29 contributed oral presentations and 20 poster presentations over the day and a half meeting. The abstracts from this meeting are included in this issue of the Intermountain Journal of Sciences for archival and reference purposes. The Board of Directors of MAS would like to thank the sponsors of our 2015 Annual Meeting:

Dr. Bob Wilmouth, President, Rocky Mountain College

Dr. Doug Coe, Dean, College of Letters, Sciences and Professional Studies, Montana Tech

Dr. Beverly Hartline, Vice Chancellor for Research, Montana Tech

Dr. Renee Reijo Pera, VP for Research, Montana State University

Dr. Beth Weatherby, Chancellor, University of Montana-Western

Department of Biological and Physical Sciences, Montana State University Billings

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Presentation Abstracts

Alphabetical by First Author's Last Name

Composition Operators on Weighted Bergman and S^P Spaces

Waleed Al-Rawashdeh, Montana Tech of the University of Montana, Butte MT. 59701

Let $varphi$ be an analytic self-map of open unit disk $mathbb{D}$. The operator given by $(C_{varphi}f)(z)=f(varphi(z))$, for $z in mathbb{D}$ and f analytic on $mathbb{D}$ is called composition operator. For each $pgeq 1$, let S^p be the space of analytic functions on $mathbb{D}$ whose derivatives belong to the Hardy space H^p. For $alpha > -1$ and $p > 0$ the weighted Bergman space A^{p}_{alpha} consists of all analytic functions in $L^{p}(mathbb{D}, dA_{alpha})$, where dA_{alpha} is the normalized weighted area measure. In this presentation, we characterize boundedness and compactness of composition operators act between weighted Bergman A_{alpha}^{p} and S^q spaces, $1leq p, q<infty$. Moreover, we give a lower bound for the essential norm of composition operator from A_{alpha}^{p} into S^q spaces, $1leq pleq q$.

Identification of Heavy Metal Hyper-Accumulating Fauna in the Butte Montana Region through the use of ICP Analysis

Olivia Coguill, Montana Tech-Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

In many parts of the country human activity has contaminated soils through mining operations. One of the major contaminates from mining are heavy metals like Lead, Cadmium, Copper, and Zinc in concentrations that exceed safe human exposure. Consequently, remediation of the contaminated soil is now needed in these areas. Remediation of contaminated soils can be expensive, labor intensive, and disruptive to the native habitat. Phytoremediation is a method of remediating soils by the use of plants that accumulate high levels of contaminates from the soil into the plant's tissue. Plants that are used for the removal of soil contaminates are known as hyper-accumulators; meaning plants that can accumulate metal levels exceeding that of the soil in which they reside. Ideally native plants are to be used in the phytoremediation to reduce the risk of introducing invasive species to the area. The list of known hyper-accumulators native to Montana, or accumulators that can grow in Montana, specifically the Butte-Silver Bow area is limited. Research was done on tissue samples collected from plants growing in the un-reclaimed Butte Priority Operative Soil Unit (BPOSU) that were analyzed by means of inductively coupled plasma mass spectrometry (ICP-MS) for the levels of heavy metals in the tissue, so the plant may be determined a hyper-accumulator or not. Parameter tests included analyzing the soil at the location of the each plant, and site evaluation of the plants location.

Determining Nitrate and Phosphate Levels in Blacktail Creek

Garrett Craig, Montana Tech- Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Nitrates (NO3-) are nitrogen-oxygen chemical units which combine with various organic and inorganic compounds that are commonly used in fertilizers. Phosphates (PO43-) are inorganic chemicals that are important in biochemistry and ecology. In small quantities, both nitrates and phosphates are essential for the health of aquatic ecosystem. However, even a small increase in either nutrient can lead to an accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals.

Blacktail Creek in Butte has previously had high levels on contaminants, including the nitrates and phosphates that were evaluated. Blacktail Creek is approximately nine miles long and empties into Silver Bow Creek west of Butte. The sampling plan included an approximately 1.5 mile reach along Blacktail Creek's most contaminated section, with eight sites being analyzed. During field sampling, grab samples and water flow data were taken to obtain concentrations and to calculate Total Maximum Daily Loads for the nutrients of interest. The data was compared to previous analyzed data, and similar conclusions were reached. The majority of the sites had elevated nitrate and phosphate loading, with the phosphates being the most highly elevated contaminant. The lower four sites on the sampling reach had the highest nutrient loading levels, and all four of these sites have the similarity in being located below the mouth of Grove Gulch that flows into Blacktail Creek. This finding supports the conclusion that the Grove Gulch inlet contributes a significant level of nutrient loading to Blacktail Creek.

Analysis of Urban Humans and Their Spatial Allowance for Predators

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This research addresses varying degrees of social tolerance to wildlife within the urban environment. Rapid growth of the urban environment is thought to create new interactions between humans and wildlife. These new interactions are made unique by the modern urbanite's perspective of wildlife. In the summer of 2013, the occurrence of a mountain lion (*Puma concolor*) in a Butte, Montana neighborhood incited a variety of comments regarding public opinion of urban-wildlife. Research and wildlife managers suggest that to develop a strong, effective urban wildlife management strategy we must first have a comprehensive understanding of the local urbanites' disposition towards urban wildlife (Patterson, Montag, & Williams, 2003). A survey was developed using the tripartite model of attitude assessment to measure Butte residents' attitude towards urban –wildlife. The tripartite model assumes that an attitude is equally influenced by three factors, cognitive, behavioral, and affective. The survey asked respondents questions alluding to their wildlife-education, experiences, and past behaviors. Respondents were then scored according to the amount of influential factors involved in developing their attitude towards urban-wildlife. Respondents were also asked to rank wildlife based on the amount of tolerance afforded to an individual species within an urban setting. The respondents' attitude score was compared with their urban-wildlife tolerance ratings. This research suggests that the cognitive and behavioral attitude influences have the largest bearing on a Butte resident's attitude toward urban-wildlife.

Examining Antibodyto Sin Nombre Virus in Rodents Associated with Peridomestic Habitats in North East Montana.

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Dr. Amy Kuenzi, Department of Biological Sciences, Montana Tech of the University of Montana, Butte, MT. 59701

Hantaviruses are rodent-borne pathogens that produce chronic persistent infections in their reservoir hosts. Sin Nombre virus (SNV) is a type of hantavirus carried by deer mice (*Peromyscus maniculatus*). Infected deer mice shed virus in urine, saliva, or feces, and human contact with the virus can lead to a serious illness called hantavirus cardiopulmonary syndrome. Most studies examining SNV in the rodent host have been conducted in natural settings where human contact with the virus is unlikely. This study, performed in a peridomestic setting (in and around buildings), where contact with the virus is more likely, adds data to a previous study in west central Montana. Mice were live trapped for 3 consecutive nights every two weeks from May to August 2014, at 2 sites in NE Montana. Captured individuals were ear tagged,and species, body mass, sex, reproductive condition, presence of scars or wounds, and location of capture were recorded into a field journal. Blood samples were collected from the retro-orbital sinus of each captured animal. These blood samples were frozen until they could be analyzed. Blood samples were analyzed for antibodies (IgM) to SNV. Deer mice were the most common species captured at both study sites and antibody positive deer mice were detected at both study sites. Antibody prevalence was found to be variable both spatially and temporally with highest prevalence in the middle of the summer.

Chronic Fatigue Syndrome: A Study of Southwestern Montana Health Care Providers Diagnosis Criteria and the Treatment Plan

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This study is a way to qualitatively gauge the knowledge of Southwestern Montana Health Care Providers in regards to Chronic Fatigue Syndrome. CFS is “a debilitating and complex disorder characterized by profound fatigue that is not improved by bed rest and may be worsened by physical or mental activity” (CDC 2015). Additionally this study is used to better understand what diagnosis criteria is being used to determine and differentiate this difficult and controversial syndrome, and also the treatments which are being used to help in the healing process of patients suffering from CFS. This study will discuss the common practices in use in the Southwestern Montana region.

An Investigation of yhe Common Loon, (*Gavia Immer*), on Spencer Lake and Blanchard Lake, Montana: Identifying Populations of Banded and Non-Banded Birds of the Common Loon.

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Common Loon (*Gavia immer*) studies were conducted between May and August, 2014 at known loon territories in the Whitefish, Montana area. Data were collected on nesting pairs at Spencer Lake and Blanchard Lake, both of which are a few miles of Whitefish. Loon pairs were observed and behaviors recorded as well as leg-band identifications, foraging habits, territorial behaviors, chick stages, and nesting success. The study covered 46 hours of observational study. Based on prior data provided by the Montana Common Loon Working Group and the Flathead National Forest Service, it is possible to identify pairs that are returning to the same locations and remaining with the same breeding pair. This summer research provided valuable data including identification of nesting pairs on both Blanchard and Spencer Lake, adult band data from both of these lakes, and both lakes had chick hatch dates allowing for a comparison between both lakes of study noting their differences as possible causes for differing nest success and hatch dates between Spencer Lake and Blanchard Lake.

Metabolites, Metabolic Hormones, and Hematological Profiles in Mountain Goats (*Oreamnos Americanus*) Before the Breeding Season and During the First Trimester of Pregnancy

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Objectives were to evaluate the relationships among energy-related metabolites, hormones, and hematological variables in mountain goats (MG) before the breeding season and during the 1st trimester of pregnancy. Does were from herds in the Palisades (PAL) and NE Yellowstone (NEY) areas. Samples were collected from July to Aug. (before breeding season) and mid-Jan. (1st trimester of pregnancy). Sera was assayed for insulin (I), thyroxine (T4), triiodothyronine (T3), b-OH-butyrate (bOHB), blood urea nitrogen (BUN), and total protein (TP). Concentrations of TP did not differ ($P > 0.05$) between pregnant (P) and non-breeding season (NB) does. bOHB, I, BUN, and T3 concentrations, and the T3:T4 ratios were greater ($P < 0.05$) in NB does than in P does. Whereas, T4 concentrations were greater ($P < 0.05$) in P does than in NB does. Obviously, NB does have a different profiles of metabolites, metabolic hormones and select hematological variables compared to P does. In conclusion, these differences may be related to P does utilizing and partitioning nutrients to support placental and fetal growth and development. These differences may also be related to the effect of season, since there were no non-pregnant does were sampled in Jan. Another factor that may be important for interpretation of these differences is location. All NB does were sampled in the PAL, while all P does were sampled in the NEY.

BH3I-1 Derivatives Inhibit The Filamentous Growth of The Cea10 Strain of *Aspergillus Fumigatus*

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David K. Butler, Department of Biological & Physical Sciences, Montana State University-Billings, Billings, MT. 59101

Kurt A. Toenjes, Department of Biological & Physical Sciences, Montana State University-Billings, Billings, MT. 59101

Recent and exciting advances in medical therapies for cancer and organ failures have greatly extended the life span of afflicted patients. However, these therapies often place the patient at risk for potentially lethal fungal infections. As the number of immunocompromised patients continues to rise, there has been an increase in associated opportunistic fungal infections. Treatment options for invasive mycoses caused by *Candida albicans* and *Aspergillus fumigatus* are surprisingly limited. *A. fumigatus* is the most common *Aspergillus* species associated with invasive pulmonary aspergillosis, accounting for over 60% of cases. *Aspergillus* grows as a filamentous mold with true hyphae originating from the germination of asexual conidia. *A. fumigatus* is not a dimorphic fungi as is the case with *C. albicans*, however, as both grow in hyphal form it seems possible that small molecules that inhibit the transition of *C. albicans* budded cells to hyphal growth (often referred to as the germination of blastoconidia) may also inhibit the germination of *Aspergillus* conidia. We tested BH3I-1 and derivatives against *A. fumigatus* strain CEA10 in YPD media. BH3I-1 and five of the derivatives inhibited at a 200μM concentration based on general observation via microscopy as well as eleven showing promising inhibition at possible different concentrations. Out of these inhibiting molecules, seven also shown inhibition within the prior *C. albicans* assay. We are currently employing a micro-plate reader to obtain quantitative levels of inhibition with increasing concentrations of molecule. Molecule 54 at the 300μM concentration showed similar inhibition to that of BH3I-1 at the same concentration.

Design And Development of Large Scale Data Collection for Eyes Free Text Entry

Rochelle Johnson, Montana Tech-Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Entering text on a touchscreen is challenging when users are unable to receive visual feedback due to their situation or disability. We are working on a recognition-based approach that attempts to infer the user's intended text from a sequence of noisy tap data. We need to gather large amounts of such eyes-free data to develop and test our recognizer. We first interviewed users in the low vision and blind community to explore the best ways to engage users in our data collection effort. With the information gathered in the interviews, we are developing a cross-platform data collection interface that will enable us to reach a large population of users who are visually-impaired. We will describe our current progress in the development of our eyes-free data collector.

Developing Reproducible Antibacterial Surfaces Using Thermal Imprint Technology

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Staphylococcus aureus is a naturally occurring bacterium carried in human respiratory systems and on skin. Dangerous *Staphylococcus* infections in hospitals are of specific concern due to the high traffic and open wounds that exist in such facilities. One way these facilities can prevent on-site contraction of *Staphylococcus* infections is through rigorous disinfection of surfaces exposed to human contact. While disinfection with cleaning solutions can be effective, this method provides only a temporary solution. In contrast to temporary disinfection of surfaces, another approach may be to prevent the spread of *Staphylococcus* infections by engineering surfaces that are inherently antibacterial. Physicochemical properties of bacteria and the surfaces on which they live can influence bacterial adhesion to a surface. Recently, studies have been conducted which examine the effect of nanoscale features on biological specimens. Researchers have found that particular patterns naturally dissuade bacteria from attaching to and contaminating surfaces.

To build on this research, further work to create a reliable, cost-efficient, and reproducible antibacterial surface is needed. In this project, potentially antibacterial surfaces will be developed using thermal imprinting. A non-pathogenic form of *Staphylococcus aureus* will be used as a model *Staphylococcus* organism to test and quantify bacterial health on such surfaces. Although medical facilities present an obvious market for such surfaces, these patterning techniques can be used on other surfaces such as door knobs and toilet seats. Because of the inexpensive fabrication methods and materials, this research could lead to antibacterial surfaces being made readily available to populations no matter their socioeconomic backgrounds.

Indigenous Community Impacts of Large Corporations in Arctic Communities: Specific Focus on Social Justice and Sustainability for the Swedish Sami.

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Sonja H. Bickford, University of Great Falls, Great Falls, MT. 59405
Nate Bickford, University of Great Falls, Great Falls, MT. 59405

In recent decades more global attention has focused on the Arctic. This can be seen in the both the development of industries as well as the expansion of the Arctic Council's membership. Countries with at least some part located above the Arctic Circle are; Norway, Greenland, Canada, United States, Russia, Finland, and Sweden. The focus on the indigenous people, specifically the Sami of Sweden, presents a good case for assessing impacts of development on northern, Arctic, communities. Population density in Sweden is recorded as 21.4 people per square kilometer, with a higher population density in southern Sweden. The majority of the Sami people live in small to medium-sized communities, in remote regions, resulting in a disconnect with the modern world. One industry that is already present in the Swedish Arctic is mining, especially for ore and carbon. However, now other industries, including multinational enterprises (MNE's), such as Facebook, which recently built a new five acre data center near the Arctic Circle, are beginning to realize the opportunities the Arctic region and its environment have to offer. The question of how sustainable business can be conducted in the Arctic will be answered by analyzing the impacts on the

Sami communities and how people react and should react to these changes within their communities. This study analyzed current events through literature review and interviews of representatives from the impacted Arctic regions. The increased development has resulted in both negative and positive impacts such as reduction of land use, but increased employment opportunities.

Preparation For Using Fiber Optic Cables To Monitor Distributed Strain And Temperature Profiles In An Underground Mine Setting

Hannah Kuchinsky, Montana Tech-Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Early detection of rock movement signaling imminent underground space or pit wall collapse in mines has the potential to prevent loss of life and serious injuries from mine disasters. Unlike most traditional instrumentation that provides data at a single point, fiber optic cables can be deployed in a network that allows continuous monitoring of distributed profiles of ground movement and temperature variations.

Researchers at Montana Tech and UW-Madison are collaborating to demonstrate that this fiber optic-based Distributed Strain and Temperature (DST) technology can be employed in an underground mine to reliably and accurately detect ground deformation of different characters, and fluctuating temperature profiles. The focus of the research is a field experiment that will be conducted at Montana Tech's Underground Mining Education Center (UMEC). In order to demonstrate the field performance of the technology under a variety of conditions, strain-sensing cables will be attached to the rock faces with grout and epoxy, and grouted into boreholes, and a temperature-sensing cable will be submerged to significant depths in two flooded shafts, allowing continuous monitoring of the water in the shafts and the air in the drift between. Data will compared to that collected using traditional geotechnical instrumentation and to predictions made using numerical models. Laboratory experiments and tests will be conducted to support the field deployment and modeling aspects.

This presentation summarizes the preliminary work done to support the field deployment, focusing on preparation/calibration of the cables, design and implementation of the laboratory experiments, and development of the field instrumentation plans.

Using Click Chemistry to Modulate the Aggregation of the Parkinson's Disease Protein

Tyann Kuehn, Montana Tech-Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Parkinson's disease (PD) is a neurodegenerative disorder characterized by the presence of protein aggregates called Lewy bodies. These plaques are primarily composed of oligomers of the protein α-synuclein (αS), which is a small protein of 140 amino acids that is natively unfolded, however the folding of this protein has been found to be accelerated in the presence of metal ions, particularly copper. One ideology that has been used for therapeutic removal of endogenous metal ions is chelation therapy. Click chemistry, or the Copper-Catalyzed Azide-Alkyne Cycloaddition (CuAAC), involves the reaction of an alkyne and an azide, resulting in the formation of a 1,2,3-substituted triazole. This reaction is well known for being extremely versatile, accommodating a wide variety of functionalized alkynes and azides. Recently,

click chemistry was used to successfully generate a copper chelator in situ where copper ions within protein deposits acted as both the catalyst and target of the reaction. We are looking to extend this ideology to PD therapy, by preparing a small library of click reagents that will be selectively activated in the Cu-containing aggregates of αS. Following the click reaction, the newly formed products will act as a Cu-chelator, removing the Cu from the protein thus aiding in the degradation of the Lewy bodies.

Seasonal Differences in Hantavirus Prevalencein Deer Mice Captured in Ranch Buildings in Southwestern Montana

Richard McEwen, Montana Tech- Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Hantaviruses are widespread emergent zoonotic agents that cause unapparent or limited disease in their rodent hosts, yet cause acute, often fatal pulmonary or renal infections in humans (Bagamian et al., 2013). In the United States one rodent species, the deer mice (*Peromyscus maniculatus*) are the principal host of Sin Nombre virus (SNV), which causes Hantavirus Pulmonary Syndrome (Childs et al. 1994, Nichol et al. 1993). Mice spread the virus to each other when they come in direct contact. Males spread the disease more because they are more aggressive and bite each other when they fight (Bagamian et al. 2013). A previous study (Kuenzi et al. 2001) has shown that mice that live inside of ranch buildings in western Montana have a higher prevalence of antibodies to SNV than outside populations. This study also found that male mice were more likely to be infected than female mice.

A similar study was conducted in southwestern Montana testing seasonal effects instead of location. Knowing that indoor mice have higher antibody prevalence to SNV, mice were trapped in two ranch buildings during the summer and fall to examine seasonal differences in SNV prevalence in these populations.

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Isolation of Essential Oils from Indigenous Montana Flora and Their Antimicrobial Effectiveness as a Non-Toxic Sterilizing Reagent Against Bacteria That Cause Food Borne Illness.

Samantha Miner, Montana Tech- Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Bacterial resistance and the negative effects of chemicals used to kill them have become a growing worldwide public health concern. The widespread use of antibiotics in medicine and Animal husbandry have caused bacteria adaptation to antibiotics. New drug discovery has become vital in fighting the war against drug-resistant bacteria such as *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella epidermis*, which have posed considerable medical problems. Essential oils are a safe, generally non-toxic and relatively inexpensive alternative to synthetic chemical based antibiotics. Essential oils hydro-distilled from indigenous Montana flora will be explored for their antimicrobial effectiveness as a non-toxic sterilizing reagent against bacteria. We hypothesis that the oils of *Lomatium dissectum*, *Arctostaphylos uva-ursi* (L.), *Chimaphila umbellate* (L.), W. Bart *Prunella vulgaris* L , *Artemisia dracunculus* L, Spreng *Medicago lupulina* L., and *Balsamorhiza sagittata* will have significant anti-bacterial properties and variability that works to reduce bacterium's resistance.

Use of Fiber Optic Cables to Monitor Strain and Temperature in A Borehole, and Temperature Profile in A Flooded Shaft

Kaitlyn O'Connell, Montana Tech-Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Researchers at Montana Tech are investigating the use of fiber optic cables for distributed monitoring of ground movement and temperature profiles. The highlights of Montana Tech's research with this Distributed Strain and Temperature (DST) sensing technology are:

- Deployment of special strain-sensing cable in a 300' deep borehole at a nearby mine in January, 2013. The cable was installed along with traditional inclinometer and time domain reflectometry (TDR) instrumentation to allow direct comparison of these technologies. Monitoring scans conducted after installation show that the fiber optic system detected ground deformation more than a month earlier than the inclinometer (the TDR data were inconclusive) and provided a more definitive determination of the depth of the movement, suggesting that its sensitivity and precision are higher than those of the other types of instrumentation.
- More recent deployment (fall 2013/winter 2014) of two cables to depths of 20' and 300' in a flooded shaft in Montana Tech's Underground Mining Education Center. Periodic monitoring of the water temperature profiles suggests fluctuations down to a depth of about 200' that could be seasonal, and/or could be related to the geothermal heat exchanger present in the shaft. Also, differences in the readings made using the two cables suggest that they do not provide the same data accuracy.

Although preliminary inspection of the data from these two field experiments provided some insight, a thorough analysis was not performed. This presentation will summarize the field deployment and data collection activities, along with interpretations based on comprehensive data analysis.

Designing an Edna Assay for River Otter (*Lontra canadensis*) Detection in Streams

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Environmental DNA (eDNA) is a highly promising field of survey science that hasn't been fully explored on mammalian species. The river otter species (*Lontra canadensis*), is a prime candidate for testing eDNA's uses and limitations with mammals. An eDNA primer was therefore designed that fully amplifies river otter DNA, but does not amplify any other species, including closely related ones . Candidate primer sets were generated using the computer programs BioEdit 7.2.5 , Mega6 , eprimer3 , and Life Technologies. Once primer set possibilities were identified, those with the most base pair differences in non-target species were selected and purchased. Then, using qPCR techniques, two primer sets (OTTER_2 and OTTER_3) were tested against thirteen target DNA samples and seventeen varying non-targets. The primers were effective in amplifying all target species, but also amplified many non-target species in later PCR cycles. Hence, an internal probe was additionally designed to add specificity for the OTTER_2 primer set. The probe was not as effective as decreasing non-target amplification as hypothesized, which lead to the prediction that the samples themselves may have been contaminated with river otter DNA. To test this, the non-targets that amplified despite the additional probe were re-extracted and run through qPCR with the OTTER_2 primer set. Any amplified results will be sequenced. If sequenced results produces otter DNA, the samples are contaminated and not indicative of assay specificity, if it produces non-target DNA, then the assay must be redesigned. It is the eventual goal to use this assay in management scenarios.

Evaluation of Differences in Body Composition and Carcass Characteristics in Lambs Divergent in Residual Feed Intake

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The objective of this study was to evaluate differences in growth performance, carcass characteristics and quality, and body composition in lambs selected for divergent residual feed intake (RFI). Mixed-breed 4-mo-old wether lambs (n = 65) were placed on a 47 d feeding trial in September, 2014 to obtain an estimate of individual intake. Residual feed intake, an efficiency measurement based upon the difference in actual and expected feed intake, was calculated for each lamb. Wethers with an RFI of one standard deviation greater (HIGH; less efficient; n = 6) or lower (LOW; more efficient; n = 6) than the mean RFI (approximately 0) of the 65 wethers were used in the present study. Lambs were processed, and organ weights and carcass data were collected in December, 2014. Performance measures were not affected ($P > 0.05$) by RFI class. Back fat thickness (BF) and yield grade (YG) were greater ($P < 0.03$) in HIGH lamb carcasses, while rumen weight ($P<0.005$), total GIT and viscera weights ($P<0.03$), and lung and trachea weights ($P<0.03$) were greater in LOW lamb carcasses. Regression of lung weight on hot carcass weight (HCW) indicated that lighter carcasses had

heavier lungs ($P < 0.02$, $R2=0.45$); this relationship was observed in both RFI classes (HIGH: $P < 0.04$; $R2 = 0.68$; LOW: $P < 0.04$; $R2 = 0.68$). In growing lambs, selection for RFI seems to affect fat deposition and visceral organ weights, although more research is necessary to understand the relationship between lung weight, RFI, and HCW.

Analysis of Craniofacial Skeletal and Soft Tissue Anatomy of the Eye in Relation to Reduced Visual Acuity in Humans

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Despite nearly 100 years of research, the etiology of juvenile-onset myopia is still unknown. However, given that millions of years of brain expansion and reduced facial prognathism have brought the frontal lobes to rest directly above the eyes, while the face has become situated directly beneath them, it is likely that these adjacent craniofacial characteristics are associated with functional constraints of the visual system. As a result, this study examined to what extent the myopic eye is associated with circumscribing hard and soft tissues of the skull.

This was carried out using magnetic resonance images and associated de-identified clinical data for 112 subjects. Linear and volumetric measurements of the eye, orbit, and craniofacial anatomy were obtained using AMIRA, and linear regression analysis and ANOVA were used to test for relationships between variables, and differences among vision groups.

Results showed that increased eye ($F = 2.93$, $p = 0.05$), orbital ($F = 7.28$, $p = 0.00$), and to a lesser extent ocular fat volumes ($F = 2.26$, $p = 0.109$), were associated with reduced visual acuity across the study sample. A larger eye relative to orbital volume was also associated with diminished vision ($F = 2.55$, $p = 0.083$) though at slightly above $\alpha = 0.05$. However, this relationship became statistically significant ($F = 3.13$, $p = 0.048$) when ocular fat was also considered (eye/fat+orbit). Outside of these eye, ocular fat, and orbital relationships, no other skeletal trait of the face or cranium were found to be associated with visual acuity.

Utilization of Electrospinning Technique to Decorate Nanofibers for Biomedical Applications

Heidi Reid, Montana Tech- Undergraduate Research Program, Montana Tech of the University of Montana, Butte MT. 59701

Hydroxyapatite has long been recognized for its biocompatible properties. Because a modified form of this substance is found in up to 80% of human bone, the human immune system does not recognize it as foreign and therefore does not initiate an immune system attack. Hydroxyapatite has been used as scaffolding for bone repair, as well as for coating metallic implants. Additionally, hydroxyapatite has the ability to promote bone growth without dissolving in the human system. This substance presents great potential for treatment and repair applications in a physiological system.

Although hydroxyapatite has been demonstrated to have great biological applications, these applications all require a substrate for administration. Electrospinning technique provides technology for creating such a substrate. Electrospinning has been used to create drug delivery systems and scaffolds for tissue regeneration. The electrospinner manufactures tiny nano- or micro-sized fibers and when these nanofibers are layered, a thick nanofiber mesh results. This nanofiber mesh provides a surface for hydroxyapatite nanoparticle attachment.

In addition to electrospinning technique, the electrospinner also has the capabilities to "electrospray," or to create individual nanoparticles laid down on a metal collector plate. In

my research, I intend to electrospin a fiber mesh, and then use electrospraying to decorate the mesh with iron-doped hydroxyapatite nanoparticles. This endeavor involves the development and characterization of fabrication techniques for biomedical applications.

The Fantastic and the Modern Experience

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The genre of Fantastic literature deals with intersections of the natural and supernatural worlds. The fantastic experience is one of doubt, felt both by reader and protagonists as they attempt to reconcile a possible supernatural occurrence with the rules of the natural world. Cocteau's Les Enfants Terribles, examines the fantastic's role in the divide between childhood and adulthood, in which the fantastic and the natural worlds become the spheres of childhood and adulthood, respectively. Creative play allows children to fully experience the fantastic. However, the fantastic, like childhood, is fleeting and attempts to maintain it result in ostracism; the fantastic violates the accepted norms of the natural adult world. This research broadened the scope of research on the fantastic as a genre. Theories of the fantastic have been applied to literary texts written in the late 18th and 19th century, but have not been previously applied to modern texts, which go beyond the conventional fantastic experiences detailed in the works of Tzvetan Todorov and Rosemary Jackson. Todorov's definition of the fantastic classifies fantastic experiences themselves as brief, while Jackson's list of recurrent fantastic themes are best suited to works written before the establishment of the prevailing scientific paradigm. Modern literary perspective is rooted in psychological explanations for what was previously classified as fantastic. In modern literature, the fantastic's place as the divide between the "marvelous" and the "uncanny" is unsustainable and must be redefined so that modern fantastic experiences may occupy the spaces between freewheeling creativity and abnormal psychology.

Blogging and Tweeting about Teaching: Teachers' Perceptions of Informal Online Professional Networks

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This is a case study of teachers that use blogs and/or Twitter to connect with other teachers online. This purpose of the study was to examine the perceived benefits of teachers who use blogs and/or Twitter to connect with other teachers. Social media has the potential to create a connected network of professional colleagues beyond the constraints of face-to-face meetings. In this study bloggers were contacted and interviewed in regards to the benefits to participating in online interactions. Interview data were analyzed to determine perceptions about the benefits of blogging and/or Twittering. Preliminary analysis suggests that participants identified of potential benefits such as one that creates some emotional distance that it is more convenient to interact on their own time schedule, and that they are able to learn from these interactions. The results of the study indicate that online networks can help to overcome many barriers that prevent teachers from interacting face-to-face. Although these networks may not fit into traditional professional development schema, it is clear that teachers feel that they benefit professionally from their participation in these professional networks. However, the type of interactions that participants preferred (e.g. Skype, Twitter, blogs) were influenced by the specific barriers faced by the participant in building their face-to-face professional network.

Touchless Thermal Respiratory Monitor

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The ability to track a person's respiratory rate is a vital technology that has applications in medical procedures, sleep studies, and patient monitoring. Safety devices used to track breathing today, however, often require the use of wires and sensors that can create obvious restrictions in the patient's motion, ability to maneuver, or even sleep. The long-term objective of this research project is to build a system that can monitor breathing without coming into contact with the patient. The Touchless Respiratory Thermal Monitor will be built using a 1 pixel thermal sensor, 3-D printed parts, and a laser. The thermal sensor will be programmed to simply read temperature. In a later project improvements will be made to look for a temperature differential between the air that has been exhaled by the patient and the room temperature while the laser allows for proper alignment on the upper lip of the subject. A lack of this temperature difference would indicate that the patient has stopped breathing. Though the design is rather simple, complications are expected on replicating the respiratory pattern of a human. This design will incorporate a 3-D printed mouth and nose attached to a ventilator, a flow rate monitor, and a temperature-controlled bucket of water kept at 100°F. This will be compared to a human's respiratory pattern to ensure proper replication.

Life History Traits of Solitary Bees as Mediators of Responses to Climate-Warming: Phenological Shifts, Body Size, and Life Span

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Climate change threatens pollinators and plants due to temperature-sensitive species traits that affect pollinator-plant interactions. For example, climate-warming is causing shifts in seasonal pollinator activity and flowering periods (i.e. phenologies) that are species-specific in magnitude and direction, which has uncoupled pollinator-plant interactions. Additionally, environmental temperature during development may affect pollinator body size and life span, with implications for pollinator-plant interactions and pollinator fecundity. Species-specific responses to climate-warming indicate that certain pollinator and plant species may be more vulnerable to the negative effects of climate-warming than others. The goal of this study was to help pinpoint species of concern by experimentally determining the role of solitary bee overwintering life stage (adult vs. prepupae) as a mediator of responses to climate-warming. Using multiple bee species and temperature-controlled chambers, I subjected bees to eight manipulations, i.e. factorial combinations of two temperatures (warm vs. cool) and two durations of fall and winter (i.e. short and long). Bee emergence date, weight (before and after manipulations), and longevity following emergence were recorded. Results suggest that increased temperature may cause bees that overwinter as prepupae to advance their phenology more than bees that overwinter as adults, while bees that overwinter as adults showed a greater reduction in body size and life span compared to bees that overwinter as prepupae. These results indicate the potential for overwintering life stage to mediate bee responses to climate-warming and suggests that certain species may be more prone to either phenological responses or altered body size and life span.

Knee Joint Prosthesis: Mechanical Properties Evaluation of a Titanium Based Biomedical Alloy

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Although the technology behind biomedical implantations has grown vastly in the past few years many complications still exist. One of the most difficult of these complications to overcome is the difference in the mechanical properties of human bone and of current prosthetic implants. The research completed in this study investigated the change in mechanical properties, induced via heat treatment, of Ti-6Al-2Sn-4Zr-2Mo (Ti-6-2-4-2); a titanium based alloy containing: 6% aluminum, 2% tin, 4% zirconium, and 2% molybdenum. Ti-6-2-4-2 is a near alpha titanium alloy containing both alpha and beta phase stabilizers. These phase stabilizers allow for the formation of the material in two different crystal structures. The ratio of the crystal structures present in the final material induces a variety of changes in the mechanical properties of the material. A various range of heat treatments was carried out as to effect the amount of alpha and beta phase present in the material, and the tensile strength and microstructure of the material was then examined. From these two pieces of data many mechanical properties can be investigated and explained. Experimental research such this provides important preliminary information about the tested alloy's usefulness in the field of biomedical implantations.

Concurrency in a Real-Time Multi-User Simulation

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Current methods of Real-Time simulation involving multiple users are non-scalable, difficult to develop, difficult to maintain, and expensive. Concurrent computer usage is exploding. The ability to edit documents, 3D models, and interact with multi-user simulations by users who are remote from one another is an emerging technology. Current techniques do not scale well and require a large infrastructure investment. This research addressed issues in which existing infrastructure of the clients' PCs can be leveraged to the computational demands of distributed interaction. In this research, I investigated the feasibility, of a thin server – peer client architecture for real-time multi-user simulation. This project involved a number of issues in simulating a shared environment on multiple computers, with multiple users in real-time. These issues included: latency, synchronization of state, events, clients coming into or leaving the simulation, security, and privacy. Solutions for data conflict resolution that were investigated included distributed state verification (peer voting) and master-client (one or more clients are designated as arbiters of truth).

Macroinvertebrate Community Assemblage from Canyon Ferry to Great Falls Along the Missouri River

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The Missouri River represents a major resource for the state of Montana, both environmentally and economically. Understanding macroinvertebrate community assemblage provides insight into food web structure, helping to construct a biological foundation from

which water quality can be monitored now and in the future. A comprehensive description of macroinvertebrate assemblage between Canyon Ferry Dam and the mouth of the Sun River near Great Falls also serves as a marker for comparison of biologically similar reaches. In order to examine macroinvertebrate community structure between these locations, we used samples previously collected by Montana Fish, Wildlife, and Parks for a walleye larval study. After fish larvae were removed from samples, we sorted the macroinvertebrates as well as casings from debris and daphnia. Debris and daphnia were dried and weighed to obtain a comparative biomass, and macroinvertebrates were sorted and identified to the lowest taxonomic level (order or family, species dependent). They were also sorted into functional feeding groups for further analysis of community structure between these locations. Daphniidae were determined to be predominant in Canyon Ferry, Hauser, and Holter samples, while Ephemerellidae and Baetidae were also very common across all sample locations.

Poster Abstracts

Late Summer-Early Fall Photosynthesis in Cottonwood (*Populus deltoides*)

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Photosynthesis was investigated during late summer and early fall in a population of mature cottonwood (*Populus deltoides*) trees growing on the campus of MSU-Billings in southcentral Montana. Parameters related to photosynthesis were measured in situ with a Licor 6400XT Photosynthesis system. A diurnal fluctuation in assimilation was observed with a peak value of 17.0 uM m-2 s-1 CO2 fixed during mid-day. We examined the capacity for assimilation at a PAR of 4000 uM m-2 s-1 (approx. 200% full sunlight) and observed assimilation values as high as 17.6 uM CO2 m-2 s-1 with no indication of photoinhibition. *P.deltoides* also responded to high ambient CO2 (1600 umol M-1) where assimilation increased to 31.5 umol CO2 m-2 s-1 under 1000 uM m-2 s-1 PAR. We used an ACi curve fitting utility to obtain values of 104 mmol m-2 s-1, 117 mmol m-2 s-1 and 8.6 mmol m-2 s-1 for rubisco Vcmax, electron flow rate and triose phosphate utilization, respectively. Transpiration was 0.1-6.1 mmol m-2 s-1 and correlated with assimilation. Assimilation declined 37% from the earliest measurements on 23Sep to those taken on 15Oct. We conclude that photosynthesis continues in leaves of *P.deltoides* well into autumn despite shorter days and cooler temperatures, but with an adaptive response resulting in less CO2 fixation. Leaves can photosynthetically fix carbon, presumably stored as reserve carbohydrates well into late fall before the onset of autumnal leaf senescence.

Analysis of Human Versus Machine Translation Accuracy

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The purpose of this study was to determine whether significant differences exist in Chinese-to-English translation accuracy between moderate to higher-level human translators and commonly employed freely available machine translation tools. A Chinese-to-English language proficiency structure test and a Chinese-to-English phrase and sentence translation

test were given to a large sample of machine (n=10) and human translators (n=133) who are native Chinese speakers with at least 15 years of familiarity with the English language. Results demonstrated that native Chinese speakers with this minimum level of English proficiency were significantly better at translating sentences and phrases from Chinese to English, compared to the ten freely available online machine translation applications, which unexpectedly showed a considerable degree of variation in translation accuracy among them. These results indicate that humans with at least a moderate level of exposure to a non-native language make far fewer translation errors compared to machine translation tools. This outcome is understandable, given the unique human ability to take into account subtle linguistic variants, context, and capricious meaning associated with the language and culture of different groups.

Isolation and Characterization of an Allelochemical from Russian Olive, Elaeagnus Angustifolia.

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Plants excrete compounds that can be beneficial or detrimental to the receiving organism. The detrimental compounds are referred to as allelochemicals and typically inhibit growth, delay germination, and may result in death. Previous unpublished work at Rocky Mountain College has indicated that leaves of the invasive tree species, Russian olive, contain a substance that causes delayed germination and stunted root growth in radish bioassays. The main goal of this study is to extract, isolate, and characterize the compounds causing this delayed germination via bioassays and analytical chemistry techniques. Our current results indicate that extractions of leaves using polar solvents may contain an allelochemical. Future work will include separation of the extract with chromatography and the characterization of the compound. Implications off this research include better infestation management practices and potential applications in agriculture.

Pain Tolerance: Differences According to Sex and Sport

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Numerous studies have independently examined gender differences in experimental pain, but few have examined the different surfaces of play that may influence an athlete's pain tolerance. The present experiment examined the effects of race, gender, and sport on experimental pain tolerance and threshold.

Forty (10 female basketball, 10 male basketball, 10 female soccer, 10 male soccer) collegiate athletes were given two pain tolerance tests consisting of a cold water intolerance test (CWIT) and a tourniquet pain test (TPT). The CWIT measured the maximum length of time that each athlete could place his/her hand in an ice cold bucket of water (2°C). The TPT measured the maximum length of time that each athlete could repeatedly squeeze a hand grip dynamometer while blood was occluded from the arm. A series of ANOVA tests determined if there were significant differences in pain tolerances between race, gender, and sport.

Based on the results, there are no differences in pain tolerance when comparing sport;

however, there is a significance difference ($p < 0.05$) in pain tolerance when comparing race and gender. The CWIT shows that white females have a significantly higher pain tolerance than non-white females; however, there is no significant data that shows that white males have a higher pain tolerance than non-white males.

This data is beneficial for physicians, trainers, coaches, etc. because they now know to treat injuries of both males and females of indoor and outdoor sports equally because sport has no effect on pain tolerance.

Measuring Algal Growth in Agar for use on the International Space Station

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Through a NASA Hunch grant, we are attempting to grow algae in a semi-solid agar media for oxygen production on the International Space Station (ISS). Novel growing conditions are necessary to sustain algal cultures in the microgravity environment of space. The results show that algae can be grown on earth, embedded in agar, with a uniform growth pattern. A 3% agar growth media is cooled to 47OC and inoculated using a saturated liquid culture. The inoculated agar is poured into impact-resistant Nalgene® containers. Once solidified, the agar is exposed to near-IR (infrared) and near-UV (ultraviolet) lights for 13 hour light / 11 hour dark cycles. Within a Nanoracks one unit aluminum box, we are able to fit 3 Nalgene® containers, two of which have algae and one does not. An exact duplicate of this experiment will be launched to the ISS in July 2015 to compare algal growth in microgravity with algal growth in the lab. The long-term goal of this project addresses the use of algae to produce oxygen from carbon dioxide on the ISS.

An Entomological Study of the Transfer of Melatonin, Nicotine, and Zeranol from Tissue to Maggot

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Throughout daily life humans consume substances that are metabolized by the body and eventually secreted. When death occurs metabolism stops and substances are trapped inside the body for a limited amount of time. If the body is left out, eventually flies and other bugs will make their way to it and lay eggs. When the eggs hatch, maggots begin to eat the tissue of the body. Since the tissue contains the consumed substances they should be transferred to the maggots. This is important in forensics because any substances that have dissipated from the tissue of the body may still be found in the maggots. If the maggots are collected they can be analyzed to determine what substances they contain. Knowing what can and cannot be transferred is important, as well as knowledge of how long it will take different substances to dissipate from the body. To imitate dead human tissue, skinned pig muscle was soaked in solutions of melatonin, nicotine, and zeranol (an animal steroid). Maggots were introduced and allowed to feed on the tissue for 72 hours. Samples of maggots were collected

every 12 hours, as well as a sample of tissue at the beginning and end of the experiment. All samples were digested in nitric acid. Analysis on the GC-MS of each sample was compared to standards to identify the substances they contained.

Mycobacterium Tuberculosis Resistance to PZA

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The aim of this project is to understand the mechanism of horizontal gene transfer and, more specifically, how resistance arises via mutations in *Mycobacterium tuberculosis* (TB). In particular, its resistance to the drug Pyrazinamide (PZA) will be examined. I will conduct two phases of this research. The first will be to observe horizontal gene transfer in everyday bacteria. The second phase will be to insert the mutant pncA gene that confers PZA resistance to a competent, non-virulent bacteria, *E. coli,* and study the rate of transfer in PZA-resistant TB. By doing this, it will be possible to better understand the mechanisms by which PZA-resistant bacteria transfer resistance and learn more about the mutations of this disease.

Spatiotemporal Variationin Grassland Biomass and Forage Quality Across the Upper Yellowstone River Basin

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Spatial and temporal heterogeneity in the abundance of high quality forage is known to play an important role in migratory ungulate ecology. While many studies have documented how variations in the timing of start of growth and land use affect the availability of high quality forage across temperate landscapes, few studies have quantified how the abundance of high quality forage varies across these gradients. In this study we quantified how aboveground biomass, crude protein, and digestibility varied throughout the growing season in (1) grasslands that start growth early, mid, and late in the season and (2) in irrigated agriculture, private grasslands, and public grasslands and then used these estimates to (3)assess how the seasonal abundance of high quality forage differed in these start of season and land use classes in the Upper Yellowstone River Basin. We found that grasslands that start growth late in the season had up to 150% greater aboveground biomass, 20% greater crude protein, and 15% greater digestibility at its seasonal peak than grasslands that start growth mid and early in the season. Irrigated agriculture had up to 500% greater aboveground biomass, 90% greater crude protein, and 10% greater digestibility at its seasonal peak than private and public grasslands. Overall, the abundance of high quality forage was greater in the late start of season and irrigated agriculture grasslands. Understanding these landscape-scale variations in the abundance of high quality forage may provide important information for migratory ungulate research and management.

Online Professional Learning Networks

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As technological advancements are made in the social media world, more people are connecting for professional development this way. This study served as an update to a 2011 study conducted by Dr. Hilary Risser. The previous study established a base network of teachers that used blogs to communicate educational practices. The purpose of this investigation is to analyze the differences, similarities, and benefits of online versus face-to-face communication. Interviews with multiple math and science teachers were conducted first with an online survey, and followed up via Skype. Their blogs were examined to identify connections between these teachers so that a new network of communication could be established. Preliminary results show that since 2011, networks have grown. Moving forward, the contents of each blog will be assessed. One future goal is that the conclusion of this study could lead to better equipped online social media for education professionals to grow.

An Investigation of the Common Loon, (*Gavia immer*), on Spencer Lake and Blanchard Lake, Montana: Identifying Populations of Banded and Non-Banded Birds of the Common Loon.

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Common Loon (*Gavia immer*) studies were conducted between May and August, 2014 at known loon territories in the Whitefish, Montana area. Data were collected on nesting pairs at Spencer Lake and Blanchard Lake, both of which are a few miles of Whitefish. Loon pairs were observed and behaviors recorded as well as leg-band identifications, foraging habits, territorial behaviors, chick stages, and nesting success. The study covered 46 hours of observational study. Based on prior data provided by the Montana Common Loon Working Group and the Flathead National Forest Service, it is possible to identify pairs that are returning to the same locations and remaining with the same breeding pair. This summer research provided valuable data including identification of nesting pairs on both Blanchard and Spencer Lake, adult band data from both of these lakes, and both lakes had chick hatch dates allowing for a comparison between both lakes of study noting their differences as possible causes for differing nest success and hatch dates between Spencer Lake and Blanchard Lake.

In-Vitro Reconstitution of Sulfite Reductase from *Pseudomonas aeruginosa*

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Recent work has established a link between a ferredoxin:NAD(P)H oxidoreductase (FprA) and sulfite assimilation in members of the genus *Pseudomonas*. This suggested that FprA is a component of a novel sulfite reductase enzyme. That hypothesis is consistent with the fact that only one component of the well-characterized E. coli a8β4 sulfite reductase has been identified in *Pseudomonas* genomes; i.e the β siroheme subunit CysI is present but not the a flavoprotein subunit CysJ. This led to the hypothesis that FprA is a component of a novel sulfite reductase enzyme. Our aim is to test that hypothesis by in-vitro reconstitution using the purified proteins CysI and FprA. We have successfully overexpressed and purified FprA from *Pseudomonas aeruginosa*. The strategy for production of purified CysI has been complicated by the requirement for concomitant expression of CysG (siroheme synthase). We are also investigating the possibility that a downstream, overlapping reading frame (PA1837) may also be necessary for functional CysI production.

Forensic Application of Larvae Analysis to Detect Chemicals in Muscle Tissue

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Past events cannot be observed, that is where forensic toxicology comes into play regarding the detection of toxic amounts of chemicals. This is useful in the forensic science field because it allows death investigators to deduce if the body at the scene had been under the influence of any chemicals before death. The purpose of this research is to determine if maggots can uptake trace amounts of chemicals from muscle and to determine if this uptake can be detected and quantified. This research will specifically examine the toxicology of three common chemicals (alcohol, caffeine, and penicillin) as absorbed by fetal pig muscle. To do such, fetal pig thighs were removed and skinned then placed in individual solutions of alcohol, caffeine, or penicillin to soak for 24 hours. Once all the liquid was removed, maggots were placed on the muscle. Samples of maggots were collected every 12 hours for a total of 72 hours. The maggots were then frozen and later placed in a nitric acid digestion to create a liquid solution that was later analyzed using the GC-MS.

Biochemical and Functional Characterization of a Potential 2', 3'-Cyclic-Nucleotide 3'-Phosphodiesterase (CNPase) Found in Tumorigenic Fish Retroviruses

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Tumorigenic retroviruses cause seasonal cancer in fish. Many of these retroviruses contain an interesting unknown gene of cellular origin. Computational programs predict that this gene encodes a CNPase (2',3'-Cyclic-nucleotide 3'-phosphodiesterase). In mammals, the natural function of CNPase is unknown. The purpose of the experiment is to isolate and characterize the potential viral CNPase. Utilizing a vector from zebrafish endogenous retrovirus (ZFERV), the potential CNPase genetic sequence will be isolated and analyzed. Thereafter, the potential CNPase protein will be expressed and purified, and characterization will include enzymatic activity assays, inhibition activity studies, and NMR studies. Future studies involve functional characterization of the potential CNPase, including binding and transformation studies. Potential CNPase is predicted to function as an oncogene that promotes tumorigenesis in fish. Exploring this potential CNPase may aide in the treatment of affected fish as well as provide insight into the function of this enzyme in humans.

Identification of Potential Targets of the Grr1p SCF Ubiquitin Ligase in Fungi

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The opportunistic human pathogen *Candida albicans* causes both superficial and life-threatening systemic infections and is a leading cause of fungal disease in immunocompromised individuals. *C. albicans* can grow in different cell shapes, or morphologies, including yeast-like cells and a variety of filamentous forms, such as true hyphae and pseudohyphae. Yeast, hyphae and pseudohyphae have been observed at the sites of *Candida* infection and there is strong evidence that morphogenesis, the transition between yeast and filamentous growth forms, is essential for virulence. Several studies have implicated ubiquitin-dependent proteolysis in the regulation of morphogenesis, yet the mechanism by which this pathway does so is largely unknown. Previously, we have shown that deletion of the GRR1 gene results in the constitutive formation of filamentous growth forms. The Grr1 protein is a component of an SCF ubiquitin ligase system that selectively targets proteins for degradation. Thus, the loss of Grr1-mediated proteolysis presumably leads to the aberrant accumulation, and inappropriate activity, of a protein or proteins that induce filamentous growth. The spectrum of proteins targeted for degradation by Grr1 is not known. The goal of this project is to identify Grr1 targets in *Saccharomyces cerevisiae*, an experimentally tractable model system for pathogenic fungi. We are using a novel proteomics-based approach to isolate and characterize proteins that are ubiquitinated in a Grr1-dependent fashion. The successful identification of Grr1p targets will be important for developing a

working model of the pathways involved in the yeast to filamentous growth transition in pathogenic fungi.

Analysis of TacA Overexpression on Phenotypic Characteristics of *Sinorhizobium meliloti*

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Sinorhizobium meliloti is a nitrogen-fixing bacterium that forms a symbiosis with legumes. These bacteria colonize plant roots within nodules and undergo a novel cell cycle as a symbiont. Free-living in soil, it undergoes asymmetrical cell division with one round of DNA replication per cell cycle. We are interested in identifying cell cycle regulators and understanding their function during free-living growth and symbiosis. We hypothesize that TacA is a cell cycle regulator since deletion of the TacA ortholog in *Caulobacter crescentus* shows morphology, motility, and cell membrane defects. To test this, we examined IPTG-induced overexpression of tacA for exopolysaccharide, membrane, and motility defects. Our results show low IPTG levels decrease motility of wild type and ΔcbrA strains. Surprisingly, higher amounts of IPTG restore motility to each strain's original level. Additionally, tacA overexpression causes a membrane defect in WT that is similar to ΔcbrA, while tacA does not appear to regulate exopolysaccharide production. In conclusion, tacA overexpression has several cell cycle phenotypes, which makes it a good candidate for further investigation. *S. meliloti* is an important model organism, not only for its potential to replace synthetic nitrogen fertilizers, but also because it is related to bacteria that cause brucellosis and plant tumors.

The Role of Zic1 in Cranial Suture Formation

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The zic1 gene plays an important role in embryonic development, in part by regulating the expression of many other genes including the engrailed gene. Previous investigators have reported that abnormal engrailed expression shifts the location of cranial suture formation and affects gene expression in the developing sutures (Deckelbaum et al. 2012). Such defects may cause a premature fusion of cranial sutures, leading to a serious birth defect known as craniosynostosis. Dr. Andrew Wilkie (Oxford University) has found that mutations in the human ZIC1 gene cause craniosynostosis. He hypothesizes that the engrailed gene is abnormally regulated in patients with these ZIC1 mutations. In collaboration with the Wilkie lab, we are testing this hypothesis by injecting RNA derived from the human ZIC1 mutants into *Xenopus* frog embryos. The goal of our experiments is to observe whether the mutated human ZIC1 genes affect the expression of the engrailed gene in frog embryos, which we were able to show by in situ hybridization. The degree of abnormality of engrailed expression caused by the various human ZIC1 mutations corresponds to the severity of the patients' phenotypes. These findings provide a better understanding of the molecular mechanisms underlying craniosynostosis and suggest possible gene regulatory pathways.

A Bioassay of Montana Grassland Plant Resistance to Catechin: an Exudate of Spotted Knapweed, *Centaurea maculosa*

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Centaurea maculosa, or Spotted knapweed, is considered an invasive species in the Western United States, including Montana. It has established sizeable populations and displaced native plant communities through what is believed to be a result of the plant's exudate, catechin. Catechin is an allelochemical documented to have phytotoxic, antimicrobial, and chelating properties. Current methods of remediation (biological, mechanical, and chemical) have demonstrated limited degrees of success. It is hypothesized that the degree of resistance to catechin of neighboring plant species determines the degree of knapweed invasiveness. The goal of this research is to test Montana native grassland species for resistance to catechin. Assembling a bioassay on agar plates, Montana grassland seeds will be grown in the presence and absence of catechin. The degree of resistance for each respective grassland species will be assessed through percent germination, root length, and shoot length. In identifying a Montana native grassland species with catechin resistance, the species could provide potential means of remediation and prevention.

Rescuing Convergent Extension after Inhibition of an Aquaporin

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Much is known about the function of aquaporins within individual cells. Aquaporins are membrane protein channels that are permeable to water and a subset, the aquaglyceroporins, are also permeable to glycerol. Little research has been conducted on how they contribute to larger processes such as gastrulation. Gastrulation organizes embryos into germ layers, which will later form different body tissues. Convergent extension cell movements are critical for driving gastrulation. During convergent extension, cells fold into the embryo at the dorsal lip of the blastopore and then merge to help form the long body axis. An aquaglyceroporin, aqp3b, is expressed during convergent extension. When it is inhibited using a morpholino oligonucleotide, convergent extension does not occur properly. Since this process is difficult to manipulate in whole embryos, I explant and culture the dorsal lip of the blastopore region of embryos, which then undergoes convergent extension by growing long and narrow protrusions. When aqp3b is inhibited, these protrusions do not develop. My project focuses on rescuing the convergent extension defects caused by inhibiting. If rescue methods are successful, explants will form a long and narrow protrusion as observed in control embryos. For these experiments, 4-cell embryos are injected into the dorsal blastomeres and explants are cut at early gastrula stage. So far, I have achieved 25-35% convergent extension in control explants. I plan to achieve 80% convergent extension and will then begin the rescue experiments.

Riverine Dissolved Organic Matter Decomposition and Dynamics

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Aquatic and terrestrial ecosystems are intimately linked through the transfer of energy and materials. A common example of ecosystem linkage is the input of terrestrial dissolved organic matter (DOM) to rivers and streams. DOM can play a variety of roles in stream ecosystem function by fueling local food webs, influencing trophic state, and affecting the dissolved nutrient availability. Microorganisms utilize, transform, and produce DOM during microbial metabolism, a relationship that links microbes to DOM quality and quantity. Chemical and physical properties are known to vary with DOM source, and thus the type of terrestrial input may dictate how DOM is processed in a stream. Using laboratory microcosms, and added terrestrial organic matter substrates, we carried out a leaching experiment over forty-five days. We employed a suite of complementary techniques to determine the effect of leaching DOM sources on microorganisms, DOM processing, and ecosystem function. Microbial community composition changed from the original stream water inoculum and depended on DOM source. Cell abundances for all DOM sources spiked after two days, after which abundances dropped and remained relatively steady until the end of the experiment. DOM concentrations decreased exponentially with the maximum amount of carbon utilization taking place within the first five days. The DOM fluorescent signature, initially influenced by amino acid-like fluorescence shifts to more humic-like character over the course of the experiment, indicating DOM humification over time. Our results showcase the advantages of interdisciplinary tools to elucidate the connection of microbial processing, DOM chemistry, and ecosystem function.

Sequencing and Characterization of Canine Viral Genomes

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Some viruses, like canine parvoviruses, are known to infect both human and canine hosts. Currently there is a significant lack of information about canine viruses, as a result there is no conclusive way to evaluate whether a virus is capable of cross species infection. Another problem that stems from this lack of information is that screening for viruses in sick canines is rarely practiced and instead antibiotics are almost exclusively the choice remedy. Improper use of antibiotics will not stop viral infection and may create antibiotic resistance as well as cause further discomfort to sick dogs. The goal of this research project is to isolate and sequence viral strains, to drastically improve the genome databases for other scientists to use, and conduct phylogenetic analysis to characterize found viruses. To accomplish these goals, fecal samples will be taken from sick and healthy canines noting in detail any symptoms the dog is exhibiting. The viral DNA/RNA is extracted and purified using a specially designed kit. After extraction the viral DNA/RNA is amplified and the products are sequenced.

The newly sequenced viruses will be compared to each other as well as known strains to aid in characterizing their type. Using the information that corresponds to each sample, characterized viruses will be correlated to symptoms found in canines. By expanding the known information about viruses, it may be used later to determine more viruses that infect both human and canine hosts as well as a way to better diagnose sick dogs.

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