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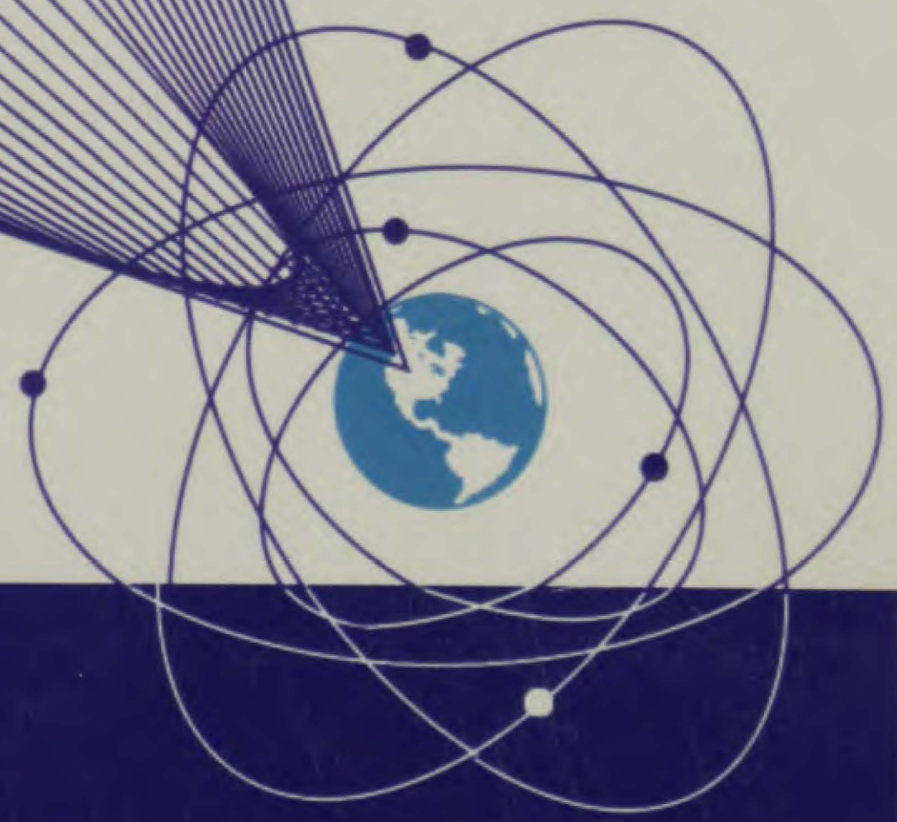

INTERMOUNTAIN JOURNAL OF SCIENCES

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

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

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

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

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

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

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Financial Statement (01/01/05-12/31/05)

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International Member	25.00
Subscription Total	$1,528.00
Page Charges	5,940.00
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P.O. Box Rent	76.00
Fees	15.00
Reprints and Layout	379.28
Website Maintenance	194.40
Refund	5.00
Total Expenses	**$6,286.71**
Balance 12/31/05	**$1,970.00**

Fred Nelson, Business Manager

Editorial Review Policy

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

Manuscripts are submitted to the Editor-in-Chief (EIC) for initial consideration for publication in the IJS. This review shall include, but not be limited to, appropriateness for publication in this journal, correct formatting, and inclusion of a letter of submittal by the author with information about the manuscript as stated in the "Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*" (Dusek 1995). 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 cop ' of the manuscript containing comments thereon and other comments are returned to the corresponding author. Revised manu cripts are to be returned to the EIC in hard cop four copies if further review i required or one hard copy plus the computer disk if onl minor revision or formatting i n c ' ry. The revised manuscript shall be returned tc the EIC within 14 days of the notification. Review of the revised manuscript b the Associate Editor and reviewers hall completed and returned to the EIC within 14 days. An accepted manuscript will th n b 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 A o ymity

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, key or scan them onto a 3.5" diskette, and submit the diskette and hard copy of each abstract to the EIC 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. Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*. Int. J. Sci. 1(1):61-70.

Send all manuscripts to: Editor-in-Chief, P.O. Box 3014, Bozeman, MT 59772-3014

Evidence Of Relationships Between Tubifex Habitat And *Myxobolus Cerebralis* Across A Mountain Watershed

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Abstract

We tested the hypothesis that the proportions of age-0 salmonids infected by *Myxobolus cerebralis*, the causative agent of whirling disease, and histologic evidence of whirling disease in stream reaches across a watershed are related to measures of suitable habitat for Tubifex tubifex, the oligochaete host for M. cerebralis. We assumed habitat quality for *T. tubifex* increased with the amount of fine sediment, aquatic macrophytes, or low-gradient mesohabitat, i.e., pools and glides, and decrease with increasing channel slope in stream reaches. The highest rates of infection and tissue damage were observed among age-0 salmonids sampled from a cluster of spring streams in the upstream portion of the valley with low channel slopes or modifications to enhance deep-pool cover for adult salmonids, side channels of the main stem river with large amounts of sediment deposition, and mountain streams downstream from beaver (*Castor canadensis*) ponds with accumulations of fine sediment.

Key words: *Myxobolus cerebralis*, Salmonids, trout, *Tubifex tubifex*, stream, watershed

Introduction

Myxobolus cerebralis, the myxozoan parasite that causes whirling disease, is recognized as a threat to wild salmonid populations (Vincent 1996, Nehring and Walker 1996). The life cycle of *M. cerebralis* is complex because it has two alternating spore-forming phases. One phase involves formation of single-celled spores in salmonids that are released from the fish and consumed by the oligochaete, *Tubifex tubifex* (Rognlie and Knapp 1988). While in the gut of *T. tubifex*, *M. cerebralis* produces a multicellular spore known as a triactinomyxon (TAM, Wolf et al. 1986). Triactinomyxons are released into the water column and infect fish through epithelial contact. The parasite migrates to the cartilage of the skull and vertebral column where damage to the upper spinal cord and compression of the brain stem causes behavioral changes and clinical signs of disease (Schisler et al. 1997, Rose et al. 2000).

Physical characteristics of streams conducive to *T. tubifex* may lead to high infection rates in fish and manifest as whirling disease (Hiner and Moffit 2001, de la Hoz Franco and Budy 2004). *Tubifex tubifex* flourishes in areas with accumulations of fine sediment rich in organic matter (Lazim and Learner 1987, Sauter and Gude 1996, Lampert and Sommer 1997, Zendt and Bergersen 2000, Arndt et al. 2002). Stream substrate composition is largely a function of channel slope in mountain streams with low-gradient reaches typically having finer particles rich in organic matter, ideal habitat for *T. tubifex*.

Our goal was to evaluate the relationships of age-0 salmonids infected with *M. cerebralis*, occurrence of histologic evidence of tissue damage, and physical habitat features conducive to *T. tubifex*. We chose age-0 salmonids to minimize probable bias due to mortality associated with *M. cerebralis* infection in older salmonids. We tested the hypothesis that proportions of age-0 salmonids infected by *M. cerebralis* or with histologic evidence of whirling disease

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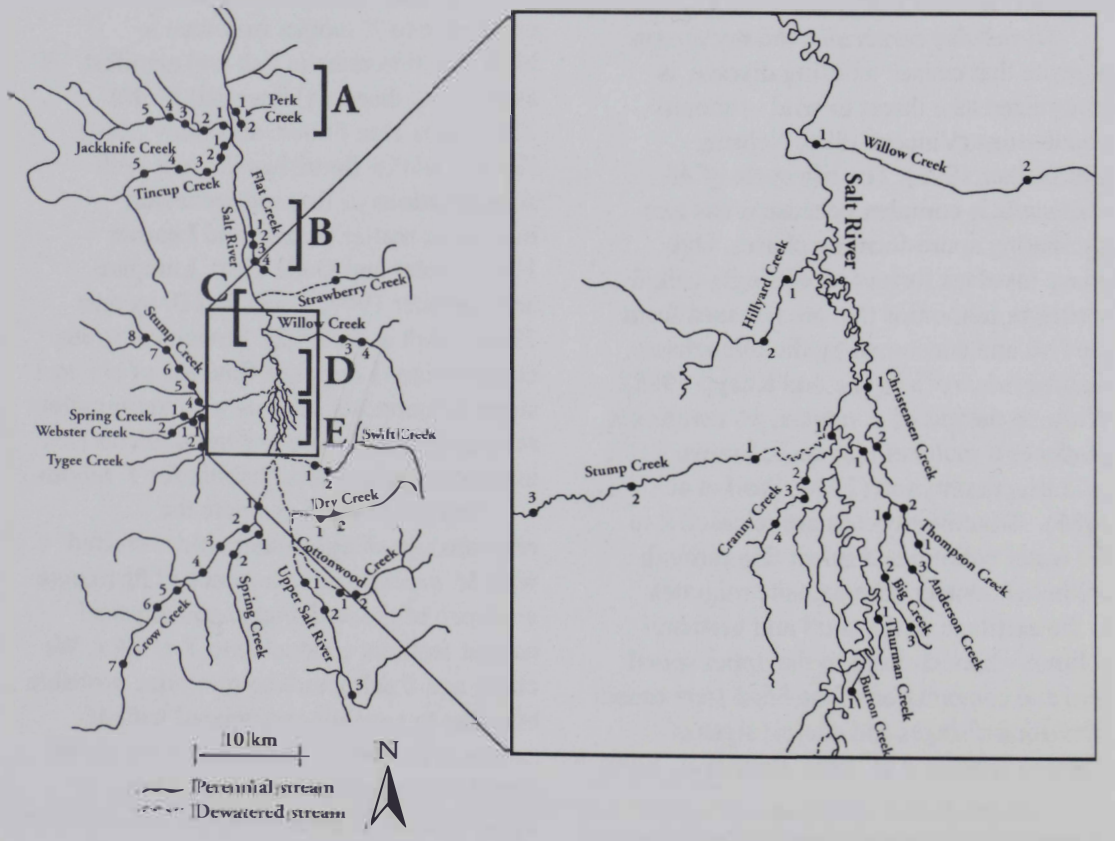
in reaches across a watershed are correlated with measures of suitable habitat for *T. tubifex*. We also hypothesized that infection rates and histologic evidence of disease would be positively related to the amount of fine sediments, aquatic macrophytes, and low-gradient mesohabitat, i.e., pools and glides, but negatively related to channel slope among reaches.

Study Area

The Salt River is a fifth-order (after Strahler 1957) stream with a 2150-km^2 watershed near the Wyoming-Idaho border that has a mean annual discharge of 22.5 m^3/s into the Snake River. The Salt River Range to the east, Gannet Hills to the south, and Caribou and Webster ranges to the west border the watershed. Mountain tributaries and the headwaters of the Salt River have steep channels with the highest slopes among tributaries in the Salt River Range. Numerous streams formed by springs occur on the valley floor and flow short distances to the Salt River (Kennington and Hamblin 1989, Isaak 2001). The mainstem of the Salt River flows through a broad alluvial valley for 45 km with several high-gradient, highly braided reaches.

Native salmonids in the Salt River watershed included the fine-spotted form of Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) and mountain whitefish (*Prosopium williamsoni*). Rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*) have been introduced and become naturalized in the watershed. *Myxobolus cerebralis* was first detected in the Salt River in 1995 (Money and Wanner 1997) and has spread within the watershed (Gelwicks et al. 2000, Hubert et al. 2002).

Figure 1. Location of reaches sampled in mountain and spring streams that are tributaries to the Salt River and identification of the four segments of the Salt River where reaches in side channels were sampled.



Methods

We selected sample sites of 100-m reaches to represent the array of stream habitats across the watershed. From one to eight reaches were systematically selected in each of nine mountain tributaries and the Salt River headwater. Mountain tributaries were sampled with an upstream progression that included one reach above the most upstream barrier to fish passage for streams in which barriers occurred (Fig. 1). One to four reaches were systematically selected in each of 11 spring streams progressing from the mouth of the spring stream to the headwater spring(s). We sampled from four to 17 reaches in side channels among four segments of the Salt River. Side channels were sampled because they had potential spawning and nursery habitat for salmonids.

Four features were measured over each 100-m reach during summer and fall 2000: (1) fine sediment, (2) aquatic macrophytes, (3) channel slope, and (4) low-gradient mesohabitat. Patches of fine sediment (<1 mm diameter), > 2 cm deep, were measured and recorded as the percentage of the water surface area of non-riffle mesohabitats covered. Similarly, we measured aquatic macrophytes as the percentage of the water surface area with aquatic vascular plants covering the streambed. Measurement of channel slope within a reach followed Isaak et al. (1999) using a surveyor's rod and Abney level. Pools were scoured or dammed areas with water surface slopes near zero. Glides consisted of areas with generally uniform depth and no surface turbulence with water surface slopes ≤ 1 percent. Our measure of low-gradient mesohabitat included the percentage of water surface area of a reach comprised of pools and glides.

Age-0 salmonids were sampled by electrofishing during habitat sampling in the summer and fall of 2000. We sampled up to 200 m of stream encompassing each 100-m reach in an effort to obtain up to 25 age-0 fish of each species present at a site. Fish were identified to species, with the exception that *Oncorhynchus* were pooled due to difficulty in discerning age-0 rainbow trout, cutthroat trout, and rainbow trout x cutthroat trout hybrids in the field. Each fish was placed in an individual plastic bag and stored on dry ice. In the laboratory their heads were removed and laterally dissected along the dorsal midline with half preserved in ethanol for DNA extraction and half preserved in 10-percent buffered formalin for histologic assessment. The occurrence of *M. cerebralis* was determined by nested polymerase chain reaction (PCR) following Andree et al. (1998). Histologic assessment was conducted on those fish that tested positive for *M. cerebralis* to determine the extent of tissue damage. Individual fish were graded 0 (no abnormalities noted) to 4 (severely affected) following the grading protocol of Baldwin et al. (2000). The Washington Animal Disease Diagnostic Laboratory, Pullman, conducted all histologic assessments.

Infection rates and histologic grades of different salmonid species were assessed using a paired-*t* test to detect evidence of differences between species when two species occurred in the same reach. We used linear regression analysis to assess relationships between the extent of infection (% fish in samples with *M. cerebralis*), mean histologic scores of tissue damage, and habitat features among reaches. Dependent variable proportions were transformed with an arcsine square-root transformation before analysis to improve homoscedascity. All trout species were pooled for regression analysis. Regressions were computed for all reaches combined and for reaches in each of three stream types: (1) mountain tributaries and headwater of the Salt River, (2) spring streams, and (3) side channels along the mainstem of the Salt River.

Regression analyses were also conducted to account for spatial autocorrelation, i.e., the spatial independence of sample sites. We used a geographic information system (GIS) to map the locations of sampled sites and measure distances between them. The residuals derived from the conducted regressions were tested for spatial autocorrelation using Moran's I (Moran 1948) and a row-standardized spatial

weights matrix based on linear distances between sample locations obtained from the GIS. A correlogram was used to assess the influence of the distance between sampled reaches on the regression analysis.

We used one-way analysis of variance to assess differences in physical habitat features, infection rates, and histologic scores of tissue damage among the three stream types and among reaches of the Salt River. Significance was determined at $P < 0.05$ for all tests.

Results

In 2000, we sampled 46 reaches on nine mountain tributaries and the headwater of the Salt River, 24 reaches on 11 spring streams, and 37 reaches in side channels over four segments of the Salt River (Fig. 1, Appendix A). Measured habitat features differed among the three types of streams (Table 1). Reaches in mountain tributaries tended to have less fine sediment and higher channel slopes than reaches in spring streams or side channels of the Salt River. Spring streams had the lowest channel slopes, were dominated by low-gradient mesohabitats, i.e., pools and glides, had substantial aquatic vegetation, and contained high amounts of fine sediment.

Age-0 salmonids were found in 99 of 107 reaches sampled in the Salt River watershed (Appendix A). *Myxobolus cerebralis* was detected in age-0 salmonids at all but four reaches where they were collected. Reaches where age-0 salmonids occurred but did not test positive for *M. cerebralis* included the headwater areas of Cottonwood (2 sites) and Dry (1 site) creeks upstream from barriers to fish passage, and the most upstream reach on Willow Creek. The reach on Willow Creek was upstream of a long series of cascades that may inhibit upstream movement of fish. We found fish with *M. cerebralis* upstream of major barriers to upstream movement by fish on Swift Creek (see Reach 2, Appendix A).

We compared the percentages of *Oncorhynchus* spp. and brown trout from which we detected *M. cerebralis* at 14 reaches where at least five individuals of each species were collected and observed no difference ($P = 0.16$) between species. Similarly, when mean histologic grades were compared at the 14 reaches, we detected no difference ($P = 0.99$) between species. Five or more brook trout and brown trout were collected in only three reaches, five or more *Oncorhynchus* spp. and brook trout were collected in only two reaches, so we made no statistical comparisons of these species.

The proportions of fish with *M. cerebralis* detected in their heads varied widely among sampled reaches. The highest rates of infection by *M. cerebralis* were observed among fish from side channels of the Salt River followed by fish from spring streams (Table 1). Mean histologic scores followed a similar pattern (Table 1). Infection rate was related ($r^2 = 0.29$, $P = 0.006$) to mean histologic grade:

$$HG = -0.194 + 0.521\ IR$$

where HG is the mean histologic score among all fish in a reach and IR is the arcsine square-root transformation of the percentage of fish in a reach with *M. cerebralis* detected in their head among the 99 reaches where age-0 salmonids were found. In many instances the highly sensitive PCR technique detected the presence of the parasite in fish with no histologic evidence of infection.

We rarely encountered clinical signs of whirling disease, i.e., black tail, shortened opercula, and spinal or cranial deformities. Clinical signs of whirling disease were most common in reaches with high infection rates. High histologic grades of tissue damage occurred in a cluster of spring streams in the upper valley, in side channels of the Salt River adjacent to and immediately downstream of the cluster of springs in the upper valley, and in mountain tributaries on the west side of the valley downstream from beaver ponds.

Comparisons of habitat features, rates of infection by *M. cerebralis*, and histologic grades of tissue damage among the four segments of the Salt River indicated no significant differences in habitat features or mean histologic grades (Table 2). However, a highly significant ($P < 0.001$) difference

Table 1. Means and standard errors (in parentheses) of measured habitat features, infections rates by *M. cerebralis*, and histologic scores of tissue damage among the three stream types in the Salt River watershed measured during 2000. *P*-values are from one-way analysis of variance comparing the three stream types. Included in the analysis were 99 reaches where both age-0 salmonids and infection by *M. cerebralis* were observed.

	Stream type					
Variable	Mountain streams (41 reaches)		Spring streams (22 reaches)		Salt River side channels (36 reaches)		*P*
Fine sediment (%)	30.0[bc]	(4.1)	70.0[a]	(5.3)	66.4[a]	(5.0)	<0.001
Aquatic macrophytes (%)	4.4[b]	(1.3)	37.3[ac]	(5.5)	5.3[b]	(2.1)	<0.001
Channel slope (%)	1.02[b]	(0.12)	0.32[a]	(0.09)	0.62	(0.09)	<0.001
Low-velocity mesohabitat (%)	47.2[b]	(4.2)	73.8[a]	(5.4)	63.2	(5.5)	0.002
Infection rate (%)	39.0[bc]	(4.7)	63.0[a]	(5.4)	77.5[a]	(3.7)	<0.001
Mean histologic score	0.08[c]	(0.03)	0.25	(0.07)	0.33[a]	(0.06)	0.001

[a] significantly different from mountain streams
[b] significantly different from spring streams
[c] significantly different from Salt River side channels

in rates of infection was observed among segments. A mean infection rate of 92 percent was observed in the two most upstream segments (Segments C and D), whereas mean infection rates of 54 percent (Segment B) and 62 percent (Segment A) were observed in the two most downstream segments.

The four habitat features were significantly correlated among the 99 reaches where age-0 salmonids were collected (Table 3). Abundance of low-velocity mesohabitat was positively correlated with the abundance of fine sediment and aquatic macrophytes, and negatively correlated with channel slope.

Linear regression identified several significant relationships between infection rate and physical habitat features (Table 4). Among all of the sampled reaches, infection rate was positively related to abundance of fine sediment, aquatic macrophytes, and low-velocity mesohabitat, but negatively related to channel slope. Infection rate was positively related to abundance of fine sediment and low-velocity mesohabitat but negatively related to channel slope among reaches in mountain streams. Infection rate was positively related to the abundance of fine sediment among reaches in spring streams. We observed no significant relationships among reaches in the Salt River.

Mean histologic grade of tissue damage was positively correlated to abundance of fine sediment, aquatic macrophytes, and low-velocity mesohabitat among all sampled reaches where age-0 salmonids were found (Table 4). Mean histologic grade was positively related to the abundance of fine sediment among reaches in mountain streams and the abundance of aquatic macrophyptes among reaches in spring streams. We again observed no significant relationships among reaches in the Salt River.

Spatial autocorrelation was evident in all of the significant linear regressions. The range of spatial correlation, i.e., the inter-plot distance beyond which the data from two sample sites were essentially uncorrelated, varied from 9 to 14 km. Many sampled reaches were within 9-14 km of each other suggesting our sampling reaches were not spatially independent (see Fig. 1). Adjusting regression models for spatial autocorrelation resulted in no statistically significant relationships between physical habitat features and infection rates or histologic grades of tissue damage.

Discussion

Results from this study partially supported our hypothesis, i.e., the proportions of age-0 salmonids infected by *M. cerebralis* and with histologic evidence

Table 2. Means and standard errors (in parentheses) of measured habitat features, infections rates by *M. cerebralis*, and histologic scores of tissue damage among the four segments of the Salt River watershed measured during 2000. *P*-values are from one-way analysis of variance comparing the four segments. Included in the analysis were 36 reaches where both age-0 salmonids and infection by *M. cerebralis* were observed in side channels.

Variable	Reach				
	A (6 reaches)	B (9 reaches)	C (17 reaches)	D (4 reaches)	*P*
Fine sediment (%)	70 (14)	68 (8	60 (8	84 (10	0.546
Aquatic macrophytes (%)	1.2 (1.2)	0	8.5 (3.7)	10.0 (10.0)	0.280
Channel slope (%)	0.89 (0.12)	0.31 (0.14)	0.68 (0.16)	0.63 (0.13)	0.179
Low-velocity mesohabitat (%)	62 (13)	60 (7)	58 (9)	93 (7)	0.283
Infection rate (%)	62[cd] (8)	54[cd] (7)	92[ab] (2)	92[ab] (3)	< 0.001
Mean histologic score	0.22 (0.12)	0.22 (0.07)	0.37 (0.08)	0.57 (0.28)	0.286

[a] significantly different from A Reaches.
[b] significantly different from B Reaches.
[c] significantly different from C Reaches.
[d] significantly different from D Reaches.

of whirling disease in reaches across a watershed are related to measures of suitable habitat for *T. tubifex*. We found that infection rates and histologic scores of tissue damage tended to be positively correlated to the amount of fine sediments, aquatic macrophytes, and low-gradient mesohabitat, i.e., pools and glides, but negatively correlated to channel slope among reaches throughout the Salt River watershed when spatial autocorrelation was not considered. However, these physical habitat features accounted for relatively small amounts of variation, and statistically significant relationships were not observed when we accounted for spatial autocorrelation. Nonetheless, our data provide insight into locations with high rates of infection or tissue damage and the habitat features at those locations. Sampled reaches with high infection rates and high histologic grades of tissue damage occurred in a cluster of spring streams in the upper valley, in side channels of the Salt River adjacent to and immediately downstream of the cluster of springs in the upper valley, and in mountain tributaries on the west side of the valley downstream from beaver ponds.

Our findings suggest linkages among land use, high sediment deposition, occurrence of *M. cerebralis* infection, and tissue damage in age-0 salmonids. We found high rates of infection in most of the spring streams sampled in the upstream portion of the valley. The sampled reaches in the spring streams with high rates of infection typically had high (> 75%) amounts of fine sediments and low (< 0.2%) channel slopes. Livestock grazing had deteriorated riparian vegetation and accentuated bank erosion in many of the reaches on spring streams, thereby increasing fine sediment accumulation. Sediment loading can lead to stream segments with high *T. tubifex* densities and TAM production (Lampert and Sommer 1997, Zendt and Bergersen 2000).

A few of the spring streams in the upstream portion of the valley had modifications to enhance deep-pool habitat for adult salmonids that created silt-laden pools with abundant aquatic macrophytes. Additionally, spawning habitat had been enhanced by the construction of riffles between pools. The highest rates of infection (> 97%) and highest mean histologic scores of tissue damage (> 0.9) were observed in one of these spring streams with extensive habitat modification. High densities of adult brown trout and cutthroat trout, substantial spawning, and abundant age-0 fish have

Table 3. Pearson correlation coefficients among the four physical habitat variables measured at 99 reaches where age-0 salminids infected by *M. cerebralis* were found in the Salt River watershed during 2000. Correlations coefficients greater than 0.195 are significant at $\alpha = 0.05$.

Variable	Fine sediment	Aquatic macrophytes	Channel slope
Aquatic macrophytes	0.3689		
Channel slope	- 0.4181	- 0.3258	
Low-velocity mesohabitat	0.5967	0.4450	- 0.6170

been observed in modified spring streams compared to unmodified spring streams in the Salt River watershed (Joyce and Hubert 2004). The combination of good habitat for both *T. tubifex* and salmonids possibly makes these reaches in spring streams point sources of TAMs that infect age-0 fish in the spring streams and downstream in the mainstem of the Salt River.

Dams constructed by beaver (*Castor canadensis*) were common among mountain tributaries that flowed from the Caribou and Webster ranges on the west side of the Salt River valley. Several reaches immediately downstream from beaver dams on Jackknife (Reach 2), Tincup (Reach 1), Webster (Reaches 1 and 2), and Crow (Reaches 2, 3, and 6) creeks had higher infection rates than reaches with similar physical habitat characteristics elsewhere in the watershed (Appendix A). A common feature among these reaches was the presence of beaver ponds with substantial fine-sediment deposition in the ponds a short (< 1 km) distance upstream. We did not include the presence of upstream beaver dams as an independent variable in our analysis because we did not search the entire length of all tributary streams for presence of beaver dams. However, beaver dams trap sediment and organic material (Naiman et al. 1988), and the activity of bacteria on organic matter in beaver ponds can consume oxygen allowing *T. tubifex* to flourish due to lack of competition from other invertebrate species (Hynes 1966, Hart and Fuller 1974). Hiner and Moffitt (2002) found that salmonids downstream from beaver dams with high accumulations of organic matter had higher histologic grades of tissue damage than fish in other locations.

The poor predictive abilities of our models were likely due to complex interactions of pathogen, hosts, and environmental features. Numerous factors were not accounted for in this study, including fish density, contact rate with the pathogen, immunity, natural survival rates of both fish and *T. tubifex* populations, and parasite development within *T. tubifex* (Reno 1998). *M. cerebralis* colonization throughout the Salt River watershed also may not have been complete so that maximum *M. cerebralis* density had occurred throughout the watershed (Kennedy 1976).

Spatial autocorrelation of the sampled reaches indicated that the dependent variables, e.g., infection rates and histologic scores, were similar among reaches in close proximity to each other. Additionally, measuring habitat features at the reach scale did not reflect habitat conditions upstream of the sampled reaches. These insights contribute to interpretation of the data. For example, high rates of infection were observed in side-channel reaches of the Salt River with the highest of these rates immediately downstream from the cluster of spring streams in the upper valley. High rates of *M. cerebralis* infection in the side-channel reaches likely were due to high densities of TAMs drifting from the upstream cluster of spring streams (Hubert et al. 2002).

Management implications may be drawn from our observations of physical habitat features, *M.cerebralis* infection rates, and histologic evidence of disease. We found the highest rates of infection and tissue damage in reaches with substantial accumulation of fine sediment in the reach due to habitat degradation or efforts to

Table 4. Significant ($P < 0.05$) linear regressions accounting for variation in infection rates (IR) by *M. cerebralis* and histologic scores (HS) of tissues in age-0 salmonids from the Salt River watershed during 2000. Infection rates were arcsine square-root transformed. Independent variables were expressed as percentages.

Dependent variable	Independent variable	Slope	Intercept	Adjusted r^2	P
		All sites (99 reaches)			
IR	Fine sediment	0.0044	0.547	0.201	<0.001
	Aquatic macrophytes	0.0032	0.740	0.031	0.045
	Channel slope	-0.1838	0.309	0.144	<0.001
	Low-velocity mesohabitat	0.0033	0.584	0.091	0.001
HS	Fine sediment	0.0029	0.061	0.084	0.002
	Aquatic macrophytes	0.0034	0.170	0.041	0.025
	Low-velocity mesohabitat	0.0020	0.094	0.029	0.049
		Mountain streams (41 reaches)			
IR	Fine sediment	0.425	26.3	0.118	0.016
	Channel slope	-17.7	57.0	0.209	0.003
	Low-velocity mesohabitat	0.390	20.6	0.104	0.023
HS	Fine sediment	0.0026	0.0023	0.097	0.027
		Spring streams (22 reaches)			
IR	Fine sediment	0.0040	0.546	0.167	0.034
HS	Aquatic macrophytes	0.0065	0.005	0.215	0.017

improve habitat for adult salmonids, or upstream from the reach due to the presence of beaver ponds with substantial amounts of fine-sediment deposited in them. Zendt and Bergersen (2000) proposed that habitats rich in organic matter may serve as point sources of TAM production, and that management of riparian habitats could reduce *T. tubifex* and effects of *M. cerebralis* on salmonids. Our study suggested that not only the management of riparian habitats, but also the management of beaver in mountain streams and habitats modified for adult salmonids in spring streams, may be important in the control of *T. tubifex*, *M. cerebralis*, and the impacts of whirling disease on salmonids across a watershed.

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Literature Cited

Andree, K. B., E. MacConnell, and R. P. Hedrick. 1998. A nested polymerase chain reaction for the detection of genomic DNA for *Myxobolus cerebralis* in rainbow trout (*Oncorhynchus mykiss*). Diseases of Aquatic Organisms 34:145-154.

Arndt, R. E., E. J. Wagner, Q. Cannon, and M. Smith. 2002. Triactinomyxon production as related to rearing substrate and diel light cycle. Pp. 87-91 *in* J. L. Bartholomew and J. C. Wilson, editors. Whirling disease: review and current topics. American Fisheries Society, Symposium 29, Bethesda, MD. 262 pp.

Baldwin, T. J., E. R. Vincent, R. M. Silflow, and D. Stanek. 2000. *Myxobolus cerebralis* infection in rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta* exposed under natural stream conditions. Journal of Veterinary Diagnostic Investigation 12:312-321

de la Franco, E., and P. Budy. 2004. Linking environmental heterogeneity to the distribution and prevalence of *Myxobolus cerebralis*: a comparison across sites in a northern Utah watershed. Transactions of the American Fisheries Society 113.1176-1189.

Gelwicks, K., D. Zafft, and R. Gipson. 2000. Effects of *Myxobolus cerebralis* on salmonids in the mainstem Salt River, Wyoming. Pp. 95-97 *in* Proceedings of the Whirling Disease Symposium "Solutions to whirling disease: putting the pieces together." Coer d'Alene, Idaho, February 3 and 4, 2000. Whirling Disease Foundation, Bozeman, MT.

Hart, C. W. Jr., and S. L. H. Fuller, editors. 1974. Pollution ecology of freshwater invertebrates. Academic Press, New York, NY. 389 pp.

Hiner, M., and C. M. Moffitt. 2001. Variation in infections of *Myxobolus cerebralis* in field exposed cutthroat and rainbow trout in Idaho. Journal of Aquaatic Animal Health 13:124-132.

Hiner, M., and C. M. Moffitt. 2002. Modeling *Myxobolus cerebralis* infections in trout. associations with habitat variables. Pp. 167-179 *in* J. Bartholomew and C. Wilson, editors. Whirling disease. reviews and current topics. American Fisheries Society Symposium 26, Bethesda, MD. 262 pp.

Hubert, W. A., M. P. Joyce, R. Gipson, D. Zafft, D. Money, D. Hawk, and B. Taro. 2002. Whirling disease among Snake River cutthroat trout in two spring streams in Wyoming. Pp. 181-193 *in* J. Bartholomew and C. Wilson, editors. Whirling disease. reviews and current topics. American Fisheries Society Symposium 26, Bethesda, MD. 262 pp.

Hynes, H. B. N. 1966. The biology of polluted waters. Liverpool University Press, Liverpool, England. 555 pp.

Isaak, D. J., W. A. Hubert, and K. L. Krueger. 1999. Accuracy and precision of stream reach water surface slopes estimated in the field and from maps. North American Journal of Fisheries Management 19:141-14 .

Isaak, D. J. 2001. A landscape ecological view of trout populations across a Rocky Mountain watershed Doctoral dissertation. niversity of Wyoming, Laramie. 148 pp.

Joyce, M. P., and W. A. Hubert. 2004 Spawning ecology of finespotted nake River cutthroat trout in spring streams of the Salt River Valley, Wyoming. Western orth American aturalist 64:78-85.

Kennedy, . R., editor. 1976. Ecological aspects of parasitology orth Holland Publishing Company, Amsterdam, Holland. 474 pp.

Kennington, F. W., and K. K Hamblin. 1989. A history of the Star Valley 1800-1900. Valley Graphics, Salt Lake City, UT. 289 pp.

Lampert, W., and U. Sommer. 1997. Limnoecology: the ecology of lakes and streams. Oxford University Press, ew York, Y. 382 pp.

Lazim, M. ., and M. A. Learner. 1987. The influence of sediment composition and leaf litter on the distribution of tubificid worms (Oligochaeta). Oecologia 72:131-136.

Money, D., and S. Wanner. 1997. ew findings and current tatus of whirling di ease in Wyoming. Pp. 35-38 *in* Whirling disease sympo ium, expanding the databa e: 1996 research progress reports, Logan, tah, March 6-8, 1997. Whirling Disease Foundation, Bozeman, MT.

Moran, P. 1948. The interpretation of statistical maps. Journal of the Royal tatistical Society B 10:243-251.

aiman, R., C. Johnston, and J. Ke ley. 1988. A teration of orth American treams by beaver. Bio: cience 38:753-761.

ehring, B. R , and P. G. Wa.ker. 1996. Whirl ng di ease n the wild: the new rea ty in the Intermountain West. Fisheries 21(6) 29-30.

Reno, P. W. 1998. Factors involved in the dissemination of disease in fish populations. Journal of Aquatic Animal Health 10:160-171.

Rognlie, M. C., and S. E. Knapp. 1998. *Myxobolus cerebralis* in *Tubifex tubifex* from a whirling disease epizootic in Montana. Journal of Parasitology 84:711-713.

Rose, J. D., G. S. Marrs, C. Lewis, and G. Schisler. 2000. Whirling disease behavior and its relation to pathology of brain stem and spinal cord in rainbow trout. Journal of Aquatic Animal Health 12:107-118.

Sauter, G., and H. Gude. 1996. Influence of grain size on the distribution of tubificid oligochaete species. Hydrobiologia 333:97-101.

Schilser, G. L., R. B. Nehring, P. G. Walker, K. G. Thompson, and E. P. Bergersen. 1997. Assessment of the distribution of clinical signs of whirling disease among rainbow and brown trout fingerlings *in* the Upper Colorado River. Pp. 103-106 *in* Whirling disease symposium. Expanding the database: 1996 research progress reports. Whirling Disease Foundation, Bozeman, MT.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Transactions of American Geophysical Union 38:913-920.Vincent, E. R. 1996. Whirling disease and wild trout: the Montana experience. Fisheries 21(6):32-33.

Wolf, K., M. E. Markiw, and J. K. Hiltunen. 1986. Salmonid whirling disease: Tubifex tubifes (Muller) identified as the essential oligochaete in the protozoan life cycle. Journal of Fish Diseases 9:83-85.

Zendt, J. S., and E. P. Bergersen. 2000. Distribution and abundance of the aquatic oligochaete host *Tubifex tubifex* for the salmonid whirling disease parasite *Myxobolus cerebralis* in the Upper Colorado River Basin. North American Journal of Fisheries Management 20:502-512

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Appendix A. Measurements of habitat feature , number of age-0 salmonids collected, rate of infection by *Myxobolus cerebralis*, and mean histologic scores of tissue damage for 107 reaches sampled across the Salt River watershed during 2000.

Stream	Reach	Fine sediment (%)	Aquatic macrophytes (%)	Channel slope (%)	Low-velocity mesohabitat (%)	Fish collected	Infection rate (%)	Histologic score
				MOUNTAIN TRIBUTARIES				
Cottonwood Creek	1	1	0	2.78	18	6	0	0.00
	2	0	0	1.29	0	30	0	0.00
Crow Creek	1	0	0	0.38	0	6	50	0 00
	2	40	24	0.44	52	3	67	0.00
	3	23	7	0.28	50	25	60	0 16
	4	40	8	0.12	70	16	38	0 00
	5	55	19	0.28	43	9	44	0.00
	6	27	12	0.63	46	27	63	0.04
	7	46	7	1.34	32	36	3	0.00
Spring Creek (tributary to Crow Creek)	1	88	6	0.68	52	26	8	0.00
	2	55	3	0.40	65	36	25	0.03
Dry Creek	1	0	0	2.53	26	5	20	0.00
	2	0	0	.50	11	8	0	0.00
Jackknife Creek	1	63	90	0.38	72	0		
	2	63	10	0.79	78	4	75	0.25
	3	33	11	0.94	68	13	8	0 23
	4	38	0	0.82	57	18	33	0.00
	5	55	0	1.02	76	26	4	0.00
Upper Salt River	1	19	0	0.96	52	14	29	0.00
	2	12	0	1.37	34	14	50	0.07
	3	6	0	1.57	28	25	8	0.00
Strawberry Creek		0	0	1.80	5	0		
Stump Creek	1	14	0	0.01	100	3	67	0.33
	2	15	0	0.55	53	2	100	0.00
	3	8	3	1.08	23	20	50	0.00
	4	54	13	0.16	81	25	60	0 04
	5	38	2	0.42	40	27	48	0.00
	6	32	4	0.34	77	16	25	0 00
	7	22	2	0.62	46	28	25	0.04
	8	6	0	1.71	19	18	11	0.06
Spring Creek (tributary to Tygee Creek)	1	26	73	0.63	94	0		
Tygee Creek	1	68	41	0.26	71	4	50	0.25
	2	63	8	1.08	61	7	71	0.00
Webster Creek	1	0	0	2.12	0	25	80	0.40
	2	85	0	1.51	46	25	100	1.08
Swift Creek	1	0	0	2.82	24	0		
	2	60	1	0 01	100	25	92	0.00

Appendix A (cont.)

Stream	Reach	Fine sediment (%)	Aquatic macrophytes (%)	Channel slope (%)	Low-velocity mesohabitat (%)	Fish collected	Infection rate (%)	Histologic score
Tincup Creek	1	70	2	0.14	87	24	75	0.33
	2	57	1	0.87	86	6	50	0.00
	3	95	0	0.23	100	0		
	4	9	0	.60	37	8	50	0.00
	5	10	0	1.08	0	26	35	0.00
Willow Creek	1	7	0	1.33	40	26	19	0.00
	2	13	0	1.08	58	0	3	0.00
	3	1	0	2.57	32	17	6	0.00
	4	0	0	3.01	23	25	0	0.00
SPRING STREAMS								
Anderson Creek	1	90	60	0.09	100	51	76	0.24
	2	95	1	0.13	76	26	85	0.23
	3	61	23	0.33	32	25	36	0.00
Big Creek	1	46	24	0.02	60	29	79	0.39
	2	80	76	0.13	100	21	57	0.43
	3	67	20	0.21	67	28	64	0.04
Burton Creek	1	89	31	0.14	100	30	73	0.03
Christensen Creek	1	95	70	0.14	88	30	97	0.93
	2	79	66	0.39	90	51	98	1.22
Cranny Creek	1	67	24	0.01	58	25	88	0.44
	2	100	90	0.01	100	0		
	3	100	75	0.14	97	4	75	0.25
	4	37	11	0.14	80	0		
Dave Creek	1	86	4	0.16	64	16	38	0.06
Flat Creek	1	19	3	0.12	81	35	11	0.00
	2	10	0	0.17	7	51	29	0.00
	3	75	47	0.37	92	25	32	0.00
	4	67	1	1.13	33	25	80	0.00
Hillyard Creek	1	64	40	0.25	65	14	93	0.07
	2	67	45	0.05	64	26	62	0.85
Perk Creek	1	69	36	1.94	73	36	33	0.00
	2	90	53	0.17	96	35	37	0.06
Thompson Creek	1	93	58	0.50	80	37	76	0.08
Thurman Creek	1	29	61	0.36	100	26	65	0.23
SALT RIVER SIDE CHANNELS								
Reach A	1	83	0	0.88	90	16	56	0.06
	2	90	0	1.34	18	23	87	0.13
	3	95	7	0.64	69	21	48	0.38

Appendix A (cont.)

Stream	Reach	Fine sediment (%)	Aquatic macrophytes (%)	Channel slope (%)	Low-velocity mesohabitat (%)	Fish collected	Infection rate (%)	Histologic score
Reach A (cont.)								
	5	10	0	1.00	28	4	75	0.75
	6	51	0	1.00	66	8	75	0.00
Reach B								
	1	49	0	0.09	65	22	82	0.27
	2	85	0	0.57	57	29	38	0.14
	3	68	0	0.22	37	29	38	0.07
	4	60	0	0.05	79	13	23	0 00
	5	64	0	0.17	69	27	63	0 30
	6	94	0	0.01	93	11	64	0 45
	7	75	0	0.21	68	28	82	0.57
	8	22	0	0.18	29	34	38	0 16
	9	90	0	1.30	46	22	59	0.00
Reach C								
	1	65	0	1.11	70	14	86	0.36
	2	90	60	0.01	100	6	83	0.00
	3	6	0	0.99	31	0		
	4	96	11	0.63	55	5	100	0.00
	5	99	0	0.01	100	2	100	1.50
	6	36	11	0.01	35	29	90	0.31
	7	98	5	0.01	100	26	96	0.20
	8	97	25	0.08	92	25	96	0.20
	9	39	0	0.03	95	26	100	0.42
	10	60	0	1.49	2	33	88	0.70
	11	60	0	1.50	11	26	96	0.38
	12	92	14	0.39	72	27	85	0.24
	13	70	0	0.52	85	26	92	0.12
	14	20	0	1.50	46	7	100	0.29
	15	74	0	0.34	100	19	84	0.37
	16	0	5	1.00	0	28	75	0.21
	17	0	0	1.50	0	16	100	0.56
	18	30	13	1.50	25	24	92	0.38
Reach D								
	1	95	0	0.50	100	15	87	0.20
	2	95	40	0.50	100	8	100	1.38
	3	55	0	0.50	74	25	88	0.20
	4	92	0	1.00	100	23	91	0.48

Forage Use By White-tailed Deer In Northwest Montana From An Historical Perspective

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Abstract

We evaluated forage use by white-tailed deer (*Odocoileus virginianus*) that occupy montane forests of northwest Montana over a period spanning the 1940s through the 1990s. Several studies provided food habit information, but most came from the Thompson River, Swan Valley, Kootenai River, and Salish Mountains. Use of Douglas-fir (*Pseudotsuga menziesii*) and Oregon grape (*Berberis repens*) by deer during winter was consistent over the 60-year period despite habitat alteration or loss due to construction of large hydroelectric facilities, logging and other silvicultural treatments, and fire suppression. The relative importance of conifer browse and low-growing species such as Oregon grape probably varied with amount of winter snowpack. Douglas-fir and Oregon grape probably have not represented emergency or starvation forage as traditionally believed but rather a very important dietary component on deer winter ranges in northwest Montana. Availability and use of arboreal lichens by deer might also increase digestibility and importance of browse available to deer during winter. Further, the observed pattern of forage use over time was consistent with a strategy of overwinter survival that favors energy conservation whereby value of overhead cover might override that of forage in winter resource selection.

Key words: forage use, northwest Montana, *Odocoileus virginianus*, white-tailed deer

Introduction

White-tailed deer in the northern Rocky Mountains occupy winter ranges consisting of cutover stands of Douglas-fir along lower valleys and foothills. Human manipulation of these lower-valley montane forests by fire dates back some 6-10 thousand years before Euro-American settlement (Arno 1980, Barrett and Arno 1982). However, a combination of logging and fire from the 1880s to the 1930s altered a large portion of these stands to a mixture of remnant old conifers and second-growth timber dominated by shade tolerant species such as Douglas-fir and shrublands (Pengelly 1963). Additionally, increasingly effective fire suppression through the 1990s probably influenced structure and composition of traditional winter ranges used by white-tailed deer.

Timber harvest with associated road construction has been a primary use of public and corporate timberlands in northwest Montana. From the mid-1940s through the mid-1950s, private and public resource managers maintained that whitetails had exceeded forage carrying capacity on many of these ranges (e.g., Cole 1959) and cited heavy use of conifers as a symptom of overbrowsing (e.g., Adams 1949, Neils et al. 1955). During the 1960s, a common belief held that opening up the forest canopy across the northern tier of the species' range would increase winter browse for white-tailed deer by increasing abundance of shade-intolerant seral shrubs (Krefting 1962, Pengelly 1963). However, short- and long-term effects that logging might have on deer distribution and resource selection were left largely to speculation and an assumption that white-tailed deer depended heavily on early seral communities to meet yearlong forage needs. For example, efforts to mitigate habitat loss resulting from construction of Libby Dam in the early 1970s (Campbell 1971, 1972, Campbell and Knoche 1973) included treating alternative winter ranges to

stimulate growth of deciduous shrubs such as serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginianus*), and bitterbrush (*Purshia tridentata*) to make these sites more attractive to both white-tailed and mule deer (*O. hemionus*).

Hildebrand (1971), Leach (1982), and Mundinger (1984) in the Swan River Valley in northwest Montana and Baumeister (1992) in north-central Idaho reported a close relationship between white-tailed deer and mature, late seral forest. All these studies essentially challenged a concept that categorized white-tailed deer as an animal primarily associated with early succession; these studies and that of Morgan (1993) on summer range in the Salish Mountains suggested that deer preferred mature forests that provided both cover and forage to those that provided either forage or cover alone. In contrast, Hicks (1990) reported that deer preferentially used younger pole-sized timber stands under severe winter conditions in the Thompson River Valley in northwest Montana.

This paper documents forage use by white-tailed deer throughout northwest Montana to determine if such use might have changed in the past 60 years related to (1) a combination of forest management practices and fire suppression policies, and (2) a perceived upward trend in white-tailed deer populations in northwest Montana.

Study Area And Methods

Descriptions of the respective areas and food habit information were previously reported for the Swan-Clearwater by Hildebrand (1971), Janke (1977), and Mundinger (1980) and for the Kootenai in the vicinity of Libby Dam by Campbell (1972). Dusek et al. (2005) described two winter ranges in the Salish Moutains for which Morgan (1993) reported food habits of deer on one of the associated summer ranges.

The early work from the Thompson River included examination of rumen contents of deer found dead in the field, and forage composition was based on weight of consumed material (Montana Fish and Game Department, unpublished). Later analyses of forage use by white-tailed deer, except those for winter in the Salish Mountains, were based on rumen samples collected incidental to the various studies; relative abundance of individual items was determined by an aggregate volume method (Martin et al. 1946).

Winter food habits of white-tailed deer from the Salish Mountains were evaluated from microhistological analysis of fecal composite (Department of Natural Resource Sciences, Washington State University, Pullman) collected on the Bowser and Murphy winter ranges (Dusek et al. 2005) during 1998 and 1999. A sample consisted of three pellets from each of 20 pellet groups. Eight samples were collected, one each during January and February, during 1998 and 1999, from both winter ranges.

Results

The 1940s and 1950s

The earliest known documentation of forage use by white-tailed deer in northwest Montana came from the Thompson River in the early 1940s (Montana Department of Fish and Game, unpubl. data). Douglas-fir occurred in all four rumens examined from the Thompson River during February and March 1942 and was the most abundant item in the diet by average weight (21%). An interpretation of these data hinted at overbrowsing of deciduous shrubs, such as bitterbrush and serviceberry, which managers at that time typically expected to be available to deer during periods of deep snow; this work also reported heavy use of "black lichen" as it became available through blow-down and cuttings. Browsing of conifers by deer was widely documented in northwest Montana by the late 1940s, and managers widely regarded such a foraging pattern indicative of degraded deer range (Adams 1949).

Weckworth (1959) reported consistent use of conifer browse in the Swan Valley from October 1957 through April 1958; among conifer species, deer used Douglas-fir most consistently and most prominently during January and February. He noted that

Oregon grape was the most abundant item in the diet (Table 1) and attributed this to mild winter conditions with relatively light snowfall.

The 1960s and 1970s

Douglas-fir and Oregon grape were major items in the winter diet during the period (Table 1) as reported from rumen analyses of white-tailed deer in the Kootenai drainage following construction of Libby Dam (Campbell 1972) and in the Swan Valley (Mundinger 1980). The relative volume of Douglas-fir in rumens was greatest during periods of heavy snowpack, whereas Oregon grape received its greatest use during years when winter and spring were relatively snow-free.

Managers believed that deer would respond favorably to an increase in shrub production following large-scale timber harvests, but undesirable shrubs would begin to reduce production of "good" browse species within 10-15 years following logging (Pengelly 1961). Treatment of forested communities to stimulate increased abundance and nutritional quality of seral shrubs considered to be important to deer dominated early efforts to mitigate loss of winter range along the Kootenai although Campbell (1972) noted that deer continued to rely primarily on Douglas-fir, other conifers, and other taxa that retained chorophyll through winter, e.g., Oregon grape and horsetail (*Equisetum* spp.).

The 1980s and 1990s

Winter.—Foods used by white-tailed deer on the Bowser and Murphy winter ranges during the relatively mild winters of 1998 and 1999 (determined from micro-histological analysis) are summarized in Table 2. Browse, including both conifers and deciduous species, accounted for about 91 percent of the winter diet (Table 2). Oregon grape and Douglas-fir were by far the most abundant items occurring among samples across both areas during both years. Their combined use accounted for an average of 79 percent among all winter samples (Table 2). Abundance of other browse species was low although willow (*Salix* spp.) and lodgepole pine (*Pinus contorta*) consistently occurred in the diet both spatially and temporally. Grasses and grass-like plants accounted for about 5 percent of the winter diet. Lichens occurred among samples for both years and from both winter ranges. These most likely represented two genera of lichens occurring in the *Pseudotsuga menziesii* Series (Eversman, personal communication 2004): *Bryoria* spp. and *Usnea* spp. Project personnel observed deer using Bryoria either from camera surveys or by direct observation. Periodic winds seemingly increased availability of this taxon through blow down.

Spring/summer/autumn.—Food habits of white-tailed deer for spring-autumn 1989 and 1990 were previously reported by Morgan (1993) for a portion of the Salish Mountains that included the Tally Lake District of the Flathead National Forest (Fig. 1). These findings offer additional evidence that browse dominated the yearlong diet of white-tailed deer in northwest Montana. Based on forage items used by deer during this period, these data further emphasized that deer foraged consistently under the forest canopy even during spring-autumn and probably made less use of early seral deciduous shrubs than one might expect.

Browse received less use during spring than in other seasons but still accounted for nearly half of the spring diet. During spring, grasses received their only significant use and accounted for most of the remaining volume among rumen samples (Fig. 1). The average volume of forbs among rumens increased from spring to summer and then declined from summer to autumn. Rumen samples for the autumn period were taken prior to 15 October; as such, these data reflect forage use only during early autumn and not that of late autumn when deer would probably increase their use of taxa that typically occur in the winter diet.

Among shrubs that contributed to the spring-autumn diet of deer in the Salish Mountains (Morgan 1993), pachistima (*Pachistima myrsintes*) accounted for $\geq$ 21 percent by volume among rumen samples collected during spring, summer, and autumn.

Table 1. Summary of winter food habits of white-tailed deer in Northwestern Montana from rumen analysis.

Study	Forage Class Composition (% of diet)				Top 5 species in the diet ranked by volume				
	Browse	Grasses	Forbs	Nonvascular	1	2	3	4	5
MDF&G 1942 (n = 3)[1]	71	9	0	13	Kinnikinnick	Douglas-fir	Lichen	Lodgepole pine	Other conifers
Weckwerth 1959 (n = 23)	91	2	7	0	Oregon grape	Twin -flower	Douglas-fir	Kinnikinnick	Pachistima
MDF&G 1950-70 (n = 62)	78	9	10	1	Oregon grape	Douglas-fir	Serviceberry	Equisitium	Lodgepole pine
Hildebrand 1971 (n = 23)	84	7	7	1	Oregon grape	Douglas -fir	Lodgepole pine	Ponderosa pine	Snowbrush ceanothus
Campbell 1972 (n = 16)	72	18	9	1	Douglas-fir	Oregon grape	Ponderosa pine	Cottonwood	Western larch
MDF&G 1970-75 (n = 91)	48	37	10	1	Equisitium	Douglas-fir	Oregon grape	Ponderosa pine	Serviceberry
Mundinger 1980 (n = 106)	91	2	5	2	Douglas-fir	Oregon grape	Lodgepole pine	Spruce	Common juniper
This Study[2]	91	5	2	2	Oregon grape	Douglas-fir	Willow	Lodgepole pine	Lichen

[1] Number of rumen samples collected
[2] Winter food habits from this study were from microhistological analysis (see Table 2).

Its use increased during spring through mid autumn. Other browse species used consistently throughout the spring-autumn period but accounted for ≤ 1 percent of the average volume for each season included huckleberry (*Vaccinium* spp.), Douglas-fir, princes-pine (*Chimaphila umbellata*), and serviceberry. Princes-pine and huckleberry received their greatest use during summer compared to spring and autumn.

Discussion

Our examination of forage use by white-tailed deer throughout northwest Montana over the past six decades leaves little doubt that second growth Douglas-fir in the foothills and lower drainages has provided key winter range for white-tailed deer in western Montana as suggested early on by Pengelly (1963). It is important to note that the predominance of Douglas-fir and Oregon grape in the winter diets of white-tailed deer was consistent in food habit studies from the 1940s through the 1990s (Tables 1 and 2). This time frame transcends a period of significant change in the forests of northwestern Montana including marked habitat loss resulting from construction of several large hydroelectric dams. Harvest patterns and fire exclusion have converted much of the late-seral forest communities to mid-seral forest communities, while invasion of noxious weeds has rapidly displaced native species throughout the

Table 2. Winter foods of white-tailed deer in the Salish Mountains, 1998-1999, from microhistological analysis of pellets from four sites across each winter range.

Deer Diets	BTWR	BTWR	MDWR	MDWR	Overall	
Plant species[1]	1998	1999	1998	1999	Mean	Rank
Berberis repens (leaf)	58.10	33.43	52.23	53.28	47.29	1
Pseudotsuga menziesii	26.18	43.89	30.45	22.13	31.44	2
Salix spp. (stem)	0.85	2.30	0.83	2.23	1.79	3
Pinus contorta	0.83	1.45	3.80	1.23	1.66	4
Lichen	1.85	1.88	1.83	1.00	1.57	5
Poa spp.	0.63	1.73	0.08	2.40	1.49	6
Amelanchier alnifolia (stem)	0.00	1.01	0.75	1.60	1.00	7
Shepherdia canadensis	0.00	1.60	0.75	0.99	0.99	8
Vaccinium spp. (leaf)	0.28	0.40	0.48	1.83	0.87	9
Carex spp.	0.75	0.73	0.20	1.40	0.87	9
Salix spp. (leaf)	1.50	0.14	0.23	1.29	0.76	11
Moss	0.55	0.70	0.00	1.21	0.73	12
Juniperus spp.	0.98	1.23	0.08	0.33	0.69	13
Cornus stolonifera (leaf)	0.45	0.19	1.05	0.98	0.64	14
Other Shrub (stem)	0.08	0.98	0.63	0.55	0.63	15
Other grasses	0.83	0.83	0.23	0.29	0.55	16
Other forbs	0.60	0.36	0.78	0.51	0.52	17
Total	100.00	100.00	100.00	100.00	100.00	
Forage Class						
Total Conifers	28.60	48.38	34.55	23.74	34.56	
Total Shrub	61.78	42.53	60.78	64.85	56.22	
Total Grass	4.43	4.93	0.50	5.18	4.19	
Total Sedge/Rush	0.75	0.83	0.20	1.40	0.90	
Total Forb	1.75	0.73	1.63	2.09	1.50	
Total Ferns	0.10	0.00	0.43	0.04	0.10	
Nonvascular plants	2.40	2.58	1.83	2.21	2.30	

[1]Includes only those plants that comprise ≥ 0.5 % of the overall winter diet.

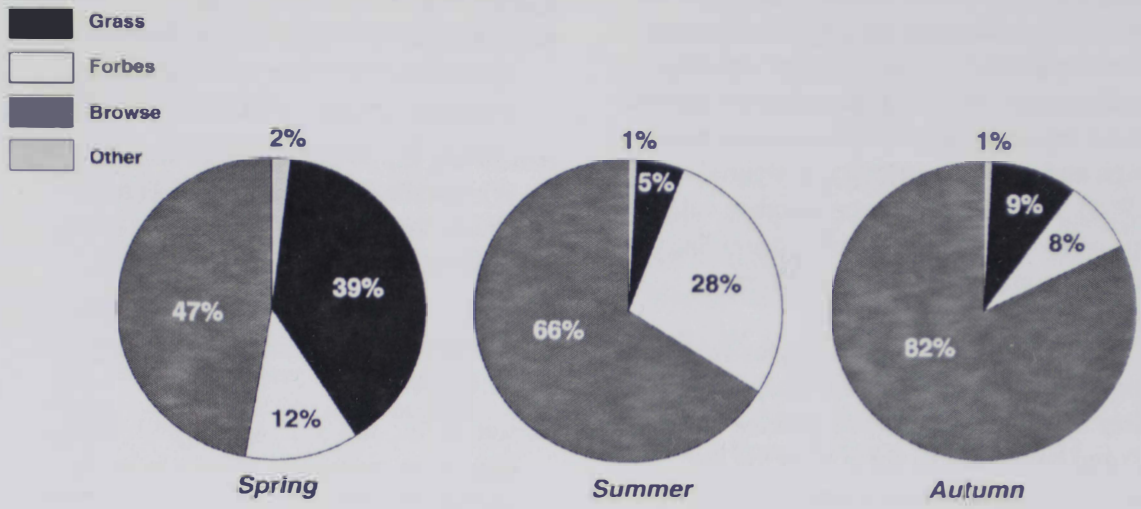

Figure 1. Use among forage classes by white-tailed deer in the Tally Lake District during Spring-Autumn based on data reported by Morgan (1993). Relative use of each forage class is expressed as a percent of the average total volume.

Pacific northwest (USDA Forest Service 1996). Douglas-fir and Oregon grape continue to dominate winter diets of deer, despite the extensive changes in forest structure and composition over the last 60 years. This, together with an upward trend in deer harvests (Dusek et al. 2005) over the same period suggests that these forage species do not and probably never represented emergency or starvation rations, but probably represented an important dietary component available to deer on winter ranges in this region.

Although early efforts to increase browse production through timber harvest, low-intensity burns, or other silvicultural treatments were based on a premise that deer would respond favorably to fragmenting continuity of forest canopy on winter ranges, such practices may have only reduced the shelter value of the habitat. For example, in Ontario deer did not noticeably respond to increased availability of browse following opening the canopy to develop cottage sites suggesting that shelter quality probably outweighed browse availability (Armstrong et al. 1983). Pauley et al. (1993) explained and predicted winter habitat selection in the context of energy budget for white-tailed deer in northern Idaho. Thus, when snow depth was < 30 cm deer strongly selected for lodgepole pine and Douglas-fir pole stands that provide relatively minimal snow interception and an abundance of 'preferred' forage (Pauley et al. 1993); however, during mid winter when snow depths often exceeded 40 cm, deer avoided openings and early successional stands and selected advanced forest age classes that provided more optimal snow conditions. Under such conditions we would expect white-tailed deer to increase their use of Douglas-fir and other browse that was readily available.

Although lichens occurred only as a small proportion of the total winter diet, they were a disproportionately important component of the winter food supply because of the synergistic effect they have on rumen function. High levels of digestible energy found in lichens increases the concentration of rumen protozoa many-fold, which results in an increased net utilization of nitrogen from other forage species (Ullrey et al. 1971). Studies of penned deer also found that a combination of energy and nitrogen supplements to a browse diet, although not changing overall digestibility of native forage species, significantly increased total forage intake when the supplement comprised as low as 10 percent of total dry matter intake (Ullrey et al. 1975). Thus, consumption of

lichen likely increases nutritional status of wintering deer by increasing overall rumen function. Lichens also might be typically under-represented in dietary studies such as those reported in Table 1 because of their high and rapid digestibility (Bergerud et al. 1964). They are of disproportionate value in the winter diet of white-tailed deer relative to their composition in overall forage consumption.

Oregon grape and/or Douglas-fir are major winter food items for white-tailed deer in northwest Montana (Tables 1 and 2) and have been so for at least the last 60 years. Similar dietary patterns have been documented in the lower Clearwater-Blackfoot drainages of western Montana (Janke 1977, Slott 1980). Campbell (1972), Janke (1977) and Mundinger (1980) reported predominance of Oregon grape in the diet of deer in the Kootenai and Swan valleys during either mild winters with below-average snowfall or the portion of individual winters in which snowpack was minimal or absent; Douglas-fir dominated deer diets during periods of heavier snow accumulation. Thus, we conclude that the effect of winter snowpack on availability of Oregon grape determines forage selection between two primary forage species. These studies all point to a strategy of overwinter survival of white-tailed deer in northwest Montana that favors energy conservation whereby deer tend to be habitat specialists and forage generalists.

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Literature Cited

Adams, L. 1949. The effects of deer on conifer reproduction in northwestern Montana. Journal of Forestry 47:909-9.

Armstrong E., D. Euler, and G. Racey. 1983. White-tailed deer habitat and cottage development in central Ontario. Journal of Wildlife Management 47:605-612.

Arno, S. F. 1980. Forest fire history in the northern Rockies. Journal of Forestry 78:460-465.

Barrett, S. W., and S. F. Arno. 1982. Indian fires as an ecological influence in the northern Rockies. Journal of Forestry 80:647-651.

Baumeister, T. R. 1992. Ecology of white-tailed deer on summer-fall range in northcentral Idaho. Masters Thesis, Montana State University, Bozeman. 81 pp.

Bergerud, A. T., and L. Russell. 1964. Evaluation of rumen food analysis for Newfoundland caribou. Journal of Wildlife Management 28:809-814.

Campbell, R. B. 1971. Evaluation of big game habitat improvement. Job Progress Report, Game Division, Montana Department of Fish and Game, Helena.

Campbell, R. B. 1972. Evaluation of big game habitat improvement. Job Progress Report, Game Division, Montana Department of Fish and Game, Helena. 22 pp.

Campbell R. B., and K. G. Knoche. 1973. Evaluation of big game habitat improvement. Job Progress Report, Game Management Division, Montana Department of Fish and Game, Helena. 45 pp.

Cole, G. F. 1959. Game management based on facts. Montana Wildlife (June):22-30.

Dusek, G. L., A. K. Wood, and C. A. Sime. 2005. Population ecology of white-tailed deer in northwest Montana. Montana Fish, Wildlife and Parks, Wildlife Division, Federal Aid Completion Report, Project W-100-R-4, Helena.

Hicks, L. L. 1990. Habitat use by white-tailed deer in relation to winter range

silvicultural treatments in the Thompson River Drainage, northwestern Montana. Ph.D. dissertation, University of Montana, Missoula. 79 pp.

Hildebrand, P. R. 1971. Biology of white-tailed deer on winter ranges in the Swan Valley, Montana. Masters Thesis, University of Montana, Missoula. 91 pp.

Janke, D. 1977. White-tailed deer population characteristics, movements, and winter site selection in western Montana. Masters Thesis, University of Montana, Missoula. 92 pp.

Krefting, L. W. 1962. Use of silvicultural techniques for improving deer habitat in the Lake States. Journal of Forestry 60:40-42.

Leach, R. H. 1982. Summer range ecology of white-tailed deer in the coniferous forests of northwestern Montana. Masters Thesis, University of Montana, Missoula. 79 pp.

Martin, A. D., R. H. Gensch, and C. P. Brown. 1946. Alternative methods in upland game bird food analysis. Journal of Wildlife Management 10:8-12.

Morgan, J. T. 1993. Summer habitat use of white-tailed deer on the Tally Lake Ranger District, Flathead National Forest. Ph.D dissertation, Montana State University, Bozeman. 102 pp.

Mundinger, J. G. 1980. Population ecology and habitat relationships of white-tailed deer in coniferous forests of northwestern Montana. Pp. 8-92 in Montana Deer Studies. Job Progress Report, Federal Aid Project W-120-R-11, Montana Fish, Wildlife and Parks, Helena.

Mundinger, J. G. 1984. Biology of the white-tailed deer in the coniferous forest of northwestern Montana. Pp. 275-284 *in* W. R. Meehan, T. R. Merrell, Jr., and T. A. Hanley, eds. Proceedings of fish and wildlife relationships in old-growth forests: Proceedings of a symposium held in Juneau, AK, 12-15 April 1982. American Institute of Fisheries Research Biologists.

Neils, G., L. Adams, and R. M. Blair. 1955. Management of white-tailed deer and ponderosa pine. Transactions of the North American Wildlife Conference 20:539-551.

Pauley, G. R., J. M. Peek, and P. Zager. 1993. Predicting white-tailed deer habitat use in northern Idaho. Journal of Wildlife Management 57:904-913.

Pengelly, W. L. 1961. Factors influencing production of white-tailed deer on the Coeur d' Alene National Forest, Idaho. USDA Forest Service, Missoula, MT. 190 pp.

Pengelly, W. L. 1963. Timberlands and deer in the northern Rockies. Journal of Forestry 61:734-740.

Slott, B. J. 1980. White-tailed deer movements, survival, and population characteristics in the Clearwater River drainage, Montana. Masters Thesis, University of Montana, Missoula. 62 pp.

Ullrey, D. E., W. G. Youatt, H. E. Johnson, L. D. Fay, D. B. Purser, B. L. Schoepke, and W. T. Magee 1971. Limitations of winter aspen browse for the white-tailed deer. Journal of Wildlife Management 35:732-743.

Ullrey, D. E., W.G. Youatt, H. E. Johnson, L. D. Fay, R. L. Covert, and W. T. Magee 1975. Consumption of artificial browse supplements by penned white-tailed deer. Journal of Wildlife Management 39:699-704.

USDA Forest Service. 1996. Status of the interior Columbia basin: summary of scientific findings. Gen. Tech. Rep. PNW-GTR-385. Portland, OR. 144 pp.

Weckworth, R. 1959. Big game surveys and investigations – Swan Unit. Job Prog. Rept., Montana Department of Fish and Game, Helena. Fed. Aid Proj. W-71-R-3. 21 pp.

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Ear Tags Versus Passive Integrated Transponder (PIT) Tags For Effectively Marking Deer Mice

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Abstract

We examined whether passive integrated transponder (PIT) tags were a more effective marking technique for a long-term population study of deer mice (*Peromyscus maniculatus*) than ear tags. We compared the number of PIT tags lost to ear tags lost in a population of individuals that received both types of markers. A total of 194 deer mice received both PIT and ear tags and 56.7 percent of these animals were recaptured at least once during the study. We found that PIT tags performed poorly as a marking technique for a mark-recapture study of deer mice using our methods of implantation. The percentage of recaptured individuals that lost PIT tags (31.8%) was significantly higher than the percentage that lost ear tags (8.2%). We recommend further study to determine if alternative tag placement techniques may increase PIT tag retention in this species.

Key words: ear tags, marking techniques, *Peromyscus maniculatus*, passive integrated transponders, tag loss and retention

Introduction

Many studies of animal population biology require repeated, accurate identification of individuals (Schooley et al. 1993). Numerous marking techniques are available for different groups of animals. Attaching small metal or plastic ear tags stamped with a unique number to the lower inner region of the ear is a commonly used method to mark small mammals. Although ear tagging is relatively easy and inexpensive, tags can be lost as a result of infection, wear, grooming, or fighting (Hubert et al. 1976, Alt et al. 1985), and numbers on ear tags may be misread because of their small size.

Passive integrated transponder (PIT) tags offer a relatively new animal-marking device. PIT tags consist of an electromagnetic coil and a microchip that emits a signal when excited by electromagnetic energy. The transponder chip is programmed with a unique alpha or numeric code and only activated when energized, which makes the life of the marker virtually indefinite (Nietfeld et al. 1994). PIT tags are implanted subcutaneously using a modified syringe applicator. They have been used on a variety of small mammal species with a generally high rate of tag retention (> 90%). Species include ground squirrels (*Spermophilus townsendii*) (Schooley et al. 1993), voles (*Microtus* sp.) (Harper and Batzli 1996), big brown bats (*Eptesicus fuscus*) (Barnard 1989), ferrets (*Mustela* sp.) (Fagerstone and Johns 1987, Morley 2002), and house mice (*Mus musculus*) (Rao and Edmondson 1990). The use of PIT tags might also reduce the frequency of misreading tags especially when using a PIT tag reader with data memory. The primary disadvantage of PIT tags is their high cost; currently (2005) PIT tags cost ~ $5/unit.

We attempt to determine the mo t effective marking technique for a long-term population study of deer mice (*Peromyscus maniculatus*) by comparing the number of lost PIT tags versus ear tags in a population of deer mice that had received both types of tags. Although deer mice are among the most widely distributed mammals in North

America (Baker 1968), we could find no published data on the field use and retention of PIT tags in this species. This study was part of a larger study of deer mouse behavior in peridomestic populations and hantavirus transmission within those populations.

Methods

Our study was conducted from May 2002 through September 2003 near Gregson, Silver Bow County, Montana. Vegetation at the study site was mainly big sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*) with scattered willows (*Salix* spp.) and Douglas-fir (*Pseudotsuga menziesii*).

We live trapped deer mice on a 100- x 100-m grid containing 100 trap stations with trap stations located 10 m apart. At each trap station we placed a non-folding aluminum Sherman trap (8 x 9x 23 cm, H.B. Sherman Trap Co.) baited with oatmeal and peanut butter and provided each trap with polyester bedding. Traps were set for three consecutive nights twice/month from May through August, and for three consecutive nights/month from September through April.

Traps were opened each evening and promptly checked the following morning. Traps containing animals were transported to a central location for processing. We recorded species, body mass, sex, age, reproductive condition, and location of capture. Deer mice were then ear-tagged with monel #1005-1 tags (National Band and Tag Co., Newport, KY). After ear tagging, we implanted subcutaneously a 12-mm, 134.2-kHz PIT tag (Biomark, Inc., Meridian, ID) between the shoulders of each deer mouse. We used a 12-ga needle attached to a plastic syringe to implant each tag. Tags, needles, and syringes were sterilized with Nolvasan solution (Fort Dodge Laboratories, Fort Dodge, IA) prior to use. We used a hand held reader to verify that PIT tags were functioning after implantation, recorded ear-tag and PIT-tag numbers, and released each animal at the point of capture.

We determined loss of ear tags by looking for ripped pinna on all animals captured and estimated both PIT tag and ear tag loss as the percent of mice known to have lost tags. We used a hand-held reader to determine if previously implanted PIT tags were still present in recaptured animals. Recaptured individuals that gave no response to the hand held reader were palpated to determine if tags were present but not functional. We could not determine the exact time of loss of tags because not all animals were captured during every session of trapping. Instead we determined the range of time of retention for each lost tag bounded by the last day the tag was known to be present (minimum) and the 1st day we discovered the loss of a tag (maximum). All recaptured animals that lost tags were retagged. A sign test (Zar 1984) was used to compare the number of lost pit tags versus the number of lost ear tags among males, females and all animals combined.

Results

A total of 194 animals received both PIT and ear tags, and we recaptured 110 of these animals at least once during the study (Table 1). Three animals (2 females, 1 male) could not be identified positively because they lost both PIT and ear tags. Loss of PIT tags was higher ($P < 0.05$) than loss of ear tags for males, females, and all animals combined (Table 1). The mean minimum and mean maximum length of time that individuals retained PIT tags before loss ranged from ~ 8-35 days in females and 3 - 26 days in males.

We retagged individuals that lost either a PIT or ear tag. Nine individuals were given new ear tags of which four were recaptured; one secondary ear tag was lost (25%, not included in Table 1). Thirty-five individuals were given new PIT tags of which 25 were recaptured; five secondary PIT tags were lost (20%, not included in Table 1). Four of five individuals given a third PIT tag also lost the tag.

Our rate of ear tag loss (8.2%) was comparable to those reported for other small mammal species (Table 2), i.e., a reported average loss rate of 9.9 percent (range 2.2-15.0%). Our PIT tag loss rate of 31.8 percent was considerably higher than those reported

Table 1. Number (percent) of deer mice tagged and recaptured in Montana from May 2002 through September 2003, losses of pas ive integrated transponders (PIT) and ear tags, and minimum and maximum number of days (X ± 1 SE) PIT tags were retained before loss. *P* values are given for sign tests of PIT vs. ear tag losses.

			No. Tags Lost				Days retained before loss	
Sex	*Tagged*	*Recaptured*	*PIT*	*Ear*	*Both*	*p*	*Minimum*	*Maximum*
Female	89	52	16 (30.8)	5 (9.6)	2 (3.8)	0.026	8.3 + 3.9	34.9 + 14.4
Male	105	58	19 (32.8)	4 (6.9)	1 (1.7)	0.003	3.4 + 2.1	25.8 + 7.7
Total	194	110	35 (31.8)	9 (8.2)	3 (2.7)	< 0.001	5.6 + 2.1	29.8 + 7.5

for other small mammal species (Table 2). The average PIT tag loss rate in other small mammal studies was 4.6 percent (range 2.6-8.7%).

Discussion

In our study, ear tags provided a better long term marking technique for deer mice than PIT tagging. Ear tag loss was much lower than PIT tag loss for both male and female deer mice. In addition, ear tags are inexpensive and relatively easy to apply, and application requires minimal training of personnel. However, ear tags can be misread due to their small size, and one can expect difficulty in restraining mice in order to read tag numbers (Nietfeld et al. 1994). To limit misreading tags, animals can be tagged in both ears with unique tag numbers, forming a cross-reference to check for errors. However, the additional time and handling of animals may not be justified in some studies. For example, studies involving threatened or endangered species may require minimal handling to reduce the chance of induced stress or mortality.

PIT tagging may reduce or eliminate handling time as they can be read remotely or quickly when animal is captured and the equipment used is functioning properly. Morley (2002) found that the time required to read ear tags of wild ferrets (*Mustella furo*) averaged 43 sec, whereas scanning an animals PIT tag required <5 sec. Stoneberg (1996) developed methods to read implanted black-footed ferrets (*Mustella nigripes*) remotely. However, we do not feel that reduction in handling time outweighs the high rate of tag loss that we experienced.

PIT tags injected with a 12-ga needle left a relatively large injection site through which the tag could slip back out suggesting some of our PIT tag loss likely occurred before the implant wound healed. Schooley et al. (1993) and Harper and Batzli (1996) also found that tags with short retention times might have been lost through fresh implant wounds. Although they did not try it, Williams et al. (1997) thought that applying liquid suture to the wound left by the needle might increase tag retention. Williams et al. (1997) also recommended squeezing the injection site for several seconds after withdrawing the needle to reduce tag loss.

Although we encountered a high rate of PIT tag loss, all PIT tags retained by deer mice remained operable. Other studies have reported high failure rates for retained PIT tags. In a study of wild badgers, Rogers et al. (2002) reported a PIT tag failure rate of 6.9 percent. Fagerstone and Johns (1987) reported a 30.4-percent failure rate in their work with domestic ferrets (*Mustela putoris furo*) although this included lost PIT tags as well as tags that remained in place but had become inoperative; they identified a design problem in their PIT tags that caused the tags to short circuit and fail prematurely, which was subsequently addressed and eliminated most tag failures.

In conclusion, we found that PIT tags performed poorly as a marking technique for a long-term mark-recapture study of deer mice using our methods of implantation. We are currently examining if use of topical tissue adhesive to suture the implantation wound might increase PIT tag retention. Placement of PIT tags between the shoulder

Table 2. A summary of the percentage of PIT tag and ear tag loss in this study compared to published small mammal studies by species

Author(s)	Species	% tag loss	
		PIT	Ear
This study	*P. maniculatus*	31.8	8.2
Harper and Batzli (1996)	*Microtus ochrogaster*	4.8	11 6
Harper and Batzli (1996)	*M. pennsylvanicus*	5.1	9.6
Krebs et al. (1969)	*M. ochrogaster*		2.2
Krebs et al. (1969)	*M. pennsylvanicus*		5 1
Wood and Slade (1990)	*M. ochrogaster*		16.0
Williams et al. (1997)	*Dipodomys ingens*	2.9	9.1
Williams et al. (1997)	*D. heermanni*	2 6	11.1
Williams et al. (1997)	*D. nitratoides*	8.7	15.0
Schooley et al. (1993)	*Spermophilus townsendii*	3.4*	
Rao and Edmondson (1990)	*Mus musculus*	5.0*	
Bias et al. (1992)	*M. musculus*		9.5

* Includes losses and retained tags that stopped functioning.

blades is common and often recommended because the skin of head and neck is loose allowing easy insertion of the transponder and nerves are not prevalent. However, tag retention has been affected by site of implantation (Gibbons and Andrews 2004). Thus, we are also considering other implantation locations, such as the abdomen.

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Literature Cited

Alt, G. L., C. R. McLaughlin, and K. H. Pollock. 1985. Ear tag loss by black bears in Pennsylvania. Journal of Wildlife Management 49:316-320.

Baker, R. H. 1968. Habitats and distribution. Pp. 98-126 *in* J. A. King, editor. Biology of *Peromyscus* (Rodentia). Special Publication of the American Society of Mammalogists 2

Bias, M. A., N. L. Breuner, and M.L. Morrison. 1992. House mice as indicators of potential marking effects on salt marsh harvest mice. Transactions of the Western Section of the Wildlife Society 28:34-37

Barnard, S. M. 1989. The use of microchip implantation for identifying big brown bats (*Eptesicus fuscus*). Animal Keepers Forum16:50-52

Fagerstone, K. A., and B. E. Johns. 1987. Transponders as permanent identification markers for domestic ferrets, black-footed ferrets, and other wildlife. Journal of Wildlife Management 51:294-297

Gibbons, J. W., and K. M. Andrews. 2004. PIT tagging: simple technology at its best. Bioscience 54:447-454

Harper, S. J. , and G. O. Batzli. 1996. Monitoring use of runways by voles with passive integrated transponders. Journal of Mammalogy 77:364-369

Hubert, G. F., Jr., G. L. Storm, R. L. Phillips and R. D. Andrews. 1976. Ear tag loss in red foxes. Journal of Wildlife Management 40:164-167

Krebs, C. J., B. L. Keller, and R.H. Tamarin. 1969. *Microtus* population biology:

demographic changes in fluctuation populations of *Microtus ochrogaster* and *M. pennsylvanicus* in southern Indiana. Ecology 50:587-607

Morley, C. G. 2002. Evaluating the performance of PIT tags and ear tags in a capture-recapture experiment. New Zealand Journal of Zoology 29:143-148

Nietfeld, M. T., M. W. Barrett, and N. Silvy. 1994. Wildlife marking techniques. Pages 140-168 *in* T. A. Bookhout, ed. Research and management techniques for wildlife and habitat. The Wildlife Society, Bethesda, Maryland

Rao, G. N., and J. Edmondson. 1990. Tissue reaction to an implantable identification device in mice. Toxicologic Pathology. 18:412-416

Rogers, L. M., T. D. Hounsome, and C. L. Cheeseman. 2002. An evaluation of passive integrated transponders (PITs) as a means of permanently marking badgers (*Meles meles*). Mammal Review 32:63-65

Schooley, R. L., B. Van Horne, and K. P. Burnham. 1993. Passive integrated transponders for marking free-ranging Townsend's ground squirrels. Journal of Mammalogy 74: 480-484.

Stoneberg, R. 1996. Implanted microchips used to individually identify black-footed ferrets in Montana. Prairie Naturalist 28:163-168.

Willams, D. F., W. Tordoff III, and D. J. Germano. 1997. Evaluation of methods for permanently marking kangaroo rats (*Dipodomys*: Heteromyidae). Pp. 259-271 *in* T. L. Yates, W. L. Gannon, and D. E. Wilson, eds. Life among the Muses: papers in honor of James S. Findley, Museum of Southwestern Biology, University of New Mexico, Albuquerque.

Wood, M. D., and N. A. Slade. 1990. Comparison of ear-tagging and toe-clipping in prairie voles, *Microtus ochrogaster*. Journal of Mammalogy 71:252-255.

Zar, J. H. 1984. Biostatistical analysis. Second Edition. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

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Case Study Of A Children's Judo Class: Musculoskeletal Fitness Changes

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Abstract

We evaluated the musculoskeletal fitness changes in 18 children enrolled in the Montana Tech Fall Judo Camp (test sample) and 12 children from a 3rd grade class at a local elementary school in Butte, Montana (control sample). The musculoskeletal fitness tests included push-up test, pull-up test, and one-minute timed sit-ups for the test sample and push-ups and one minute timed sit-ups for the control sample, with five minutes of rest between each test. The test sample increased their performances in pull-ups, sit-ups, and push-ups by 0.7, 3.7, and 6.6 repetitions, respectively. The control sample decreased in their sit-up performance by 1.3 repetitions, and improved their push-up performance by 0.2 repetitions. These results show that the test sample improved their musculoskeletal fitness as measured by these tests.

Key words: grappling, martial arts, cardiovascular, children, adults

Introduction

Judo is a system of self-defense, and can take many forms. As a grappling sport like wrestling, judo requires a high level of physical fitness although some participants have no interest in competing in judo tournaments and practice judo in a recreational manner. Judo coaches believe that this activity offers an excellent systematic method for improving physical fitness. Judo is even recommended as an activity for developing fitness for other sports (Richards 1982) although our review of pertinent literature yielded only one study showing how judo affects child participants.

Amtmann et al. (2004) studied the effects of a judo class on average heart rates on six children and 15 adults and concluded that beginning judo classes effectively elevated heart rates to a level that can improve overall health and fitness. They also recommended further study to determine changes in musculoskeletal fitness.

The research question guiding this study was, 'What kinds of musculoskeletal fitness changes will occur during a 7-week judo camp?' The 18 children in the experimental group averaged 8 years of age, and we used a first grade class at a local elementary school as a comparison group. We used the case study format to describe the results of this study because the assumption of meeting the central limit theorem was not met.

A comprehensive literature review yielded no studies on musculoskeletal fitness effects from judo. Max VO_2 as influenced by cardio-respiratory fitness is the amount of oxygen that can be utilized by the body. Cipriano (1993) measured max VO_2 of elite wrestlers and reported values between 60 and 70 $mlkg^{-1}min^{-1}$. Horswill (2000) reported a range of 50-62 $mlkg^{-1}min^{-1}$ for scholastic age to Olympic level wrestlers. Grappling sports also require a high degree of musculoskeletal fitness. Those athletes whose cardiovascular and musculoskeletal systems perform efficiently have a clear advantage.

Combat sports, including judo, wrestling, boxing, and karate, are physically demanding, and developing overall physical fitness clearly is a prerequisite for successful

participation in these sports. Most of the research in this area has focused on sport-specific requirements, physiological effects of training methods, and physiological profiles of high-level athletes rather than child participants. Our study sought the answer to this question, 'Will improvements in musculoskeletal fitness occur as a by-product of participating in a 7-wk judo camp?'

Methods

Our case study used a quasi-experimental nonequivalent control group design. Eighteen children of ages 5-12 years who participated in a fall judo camp at Montana Tech of the University of Montana served as subjects for the test sample. The control sample consisted of 12 third grade students at a local elementary school in Butte, Montana, all of ages 8-9 yrs. The university approved all procedures, and each subject and a parent/guardian signed an informed consent document. All participants volunteered for the project of which all completed a physical activity readiness questionnaire.

On the first day of the camp, each participant completed a push-up test to failure, a pull-up test to failure, and a one-minute timed sit-up test with a five-minute rest between tests. This same test procedure was used on the last day of the seven week camp. The coaches were instructed to maintain normal class procedures during the seven weeks. A typical judo class consists of the following phases (Dewey 2003): (1) warm-up; (2) instruction; (3) drills; (4) randori (freestyle practice); (5) fitness/judo exercises; and (6) cool-down.

The duration of each phase varied and depended on factors such as age, experience, and objectives of participants. For a beginner class, phases may last from 5-20 min, and for a children's class there's considerably more time devoted to games.

The frequency of the Montana Tech Judo Camp sessions were only one day/wk, and instructors encouraged child participants to continue the physical fitness exercises during the rest of the week. Coaches instructed the children to perform the sit-ups, pull-ups and push-ups, as well as other fitness exercises two other days/wk on their own.

Following the Fall Judo Camp, we administered the push-up test and, following a 5-min rest, a 1-min timed sit-up test to the control sample. The school did not have a pull-up bar to test for pull-ups. Following an additional 7 weeks, students were given the same test.

Results

The test sample increased average performances in pull-ups, sit-ups, and push-ups by 0.7, 3.7, and 6.6 repetitions, respectively (Table 1). The control sample decreased their average sit-up performance by 1.3 repetitions, and improved their average push-up performance by 0.2 repetitions (Table 2).

Discussion

Although many judo coaches state that their art is effective in improving overall physical fitness, a comprehensive literature search found no research on this topic as it pertains to musculoskeletal fitness. The results show that the children involved in the Fall Judo Camp at Montana Tech improved musculoskeletal fitness as measured by a 1-min timed sit-up test, pull-up test to exhaustion and push-up test to exhaustion. These results are more important in light of the minimal changes seen by the school kids.

However, there were limitations in our experimental design of which one included small non-representative samples. The age range of 5-12 was quite large from which subjects from the two groups were not age, height or weight matched. This possibly may have affected children's physiological response to exercises they participated in and/or their performance on tests. Also, we did not obtain information on extracurricular activities each child participated in, which also may have affected their performance.

So, we acknowledge two threats to internal validity. First, there was a selection bias because samples were nonprobability convenience samples. This selection effect also threatens the external validity.

Table 1. Test sample performance results.

Subject	Sit-up 1	Sit-up 2	Pull-up 1	Pull-up 2	Push-up 1	Push-up 2
1	19	18	0	0	14	16
2	29	38	4	5	30	14
3	16	17	0	0	14	21
4	27	34	0	0	1	3
5	23	29	1	2	6	23
6	28	36	0	1	1	13
7	32	34	4	5	24	40
8	29	35	1	3	2	17
9	41	46	5	7	22	23
10	37	32	4	8	18	30
11	44	46	1	1	16	20
12	30	36	0	0	2	7
13	29	37	5	5	19	30
14	23	30	0	0	19	21
15	23	27	0	0	3	10
16	28	24	1	1	8	18
17	15	21	0	0	0	3
18	40	43	5	7	12	21
Average	**28.5**	**32.4**	**1.7**	**2.5**	**11.7**	**18.3**

The second included a maturation threat because, as mentioned earlier, we did not match samples by specific developmental or growth stage.

At the time of the study, we were unaware that the elementary school where the school kids (control group) were tested did not have a pull-up bar. We could have done a pull up test outside, but weather did not favor doing so. Also, we were unable to quantify exactly how many days each week the judo kids exercised outside of judo class although judo coaches encouraged the test sample to continue their exercises two other days each week.

Motivation is an important factor in tests to exhaustion. Some children are naturally more competitive than others and have the inner desire to do their best, whereas others are more complacent in their approach to this kind of testing. As a result, subjects in both groups could have done better or worse based on individual personalities.

Studies show that American children are becoming increasingly overweight, which may lead to chronic lifestyle diseases at an accelerated pace (Strauss and Pollack 2001, Troiano and Flegal 1998). Children should be encouraged to participate in a variety of activities that exercise all major muscle groups. Identifying activities such as judo that are healthy although somewhat non-traditional are important because they may in part offer a solution for many American adults and children.

According to the American College of Sports Medicine (2000:220), benefits for children participating in regular physical activity are great, and include (1) greater strength and endurance, (2) enhanced bone formation, (3) weight management, (4) reduced anxiety and stress, (5) improved self-esteem and self-efficacy, (6) minimization of heart disease risk factors, (7) fun and/or enjoyment, (8) social interaction, and (9) skill development.

This project also raised the question of whether school physical education courses effectively provide opportunities for children to improve physical fitness. Reputable organizations recommend daily physical education classes at each grade level (American College of Sports Medicine 2000, United States Department of Health and Human Services 2005). Our control sample attended physical education classes twice weekly, and other students only have physical education once/week. This is a common situation throughout the country according to the ational Association for Sport and Physical Education's (2001) most

Table 2. Control sample performance results.

Subject	Sit-up 1	Sit-up 2	Push-up 1	Push-up 2
1	0	0	2	1
2	44	39	4	2
3	19	20	3	5
4	40	39	30	33
5	43	42	18	15
6	27	22	3	2
7	33	33	12	13
8	42	41	7	10
9	36	36	8	6
10	18	14	10	10
11	32	35	5	5
12	36	33	10	12
Average	**30.8**	**29.5**	**9.3**	**9.5**

recent survey. Only Illinois among all states mandates daily physical education for all grades K-12.

Some teachers and administrators fear that a daily physical education requirement will reduce time allowed for more important academic activities. The Accountability clause of the No Child Left Behind Act signed into action in January of 2002 requires schools to demonstrate adequate yearly progress, which might perpetuate a desire of educators to sacrifice time devoted to physical education. Based on achievement tests, however, Sallis et al (1999) reported that students in a health-related physical education program did as well academically as students who spent half as much time each week in physical education. Further research should focus on changes in fitness over greater periods of time and changes in musculoskeletal fitness from one judo camp to the next.

Practical Applications

Although this is a descriptive study, and no causal relationships can be derived, our results imply that judo can be an effective method for improving musculoskeletal fitness. However, benefits that may be derived from training with a judo club, or any athletic club for that matter, may vary depending on a variety of factors, including but not limited to overall mission of the club and coaching quality.

Acknowledgments

The authors would like to thank Mrs. McWhorter and her third grade class!

Literature Cited

American College of Sports Medicine. 2000. ACSM's Guidelines for Exercise Testing and Prescription. Sixth Edition. Franklin, B., Editor. Philadelphia, Pennsylvania: Lippincott, Williams and Wilkins.

Amtmann, J., S. Berry, and W. Spath. 2004. Effects of a Beginning Judo Class on Heart Rate. Intermountain Journal of Sciences 10:20-24.

Cipriano, N. 1993. Technical-tactical Analysis of Free-style Wrestling. Journal of Strength and Conditioning Research 7:133-140.

Dewey, C. 2003. Coach Education Manual: Level III. United States Judo Association, Colorado Springs, CO.

Horswill, C. 2000. Physiology of Wrestling. Pp. 955-964 *in* W. Garret and D. Kirkendall, Editors. Exercise and Sport Science.

National Association for Sport and Physical Education. 2001. Shape of the Nation Report, http://www.aahperd.org/naspe/pdf_files/shape_nation.pdf.

Ogasawara, N. 1988. Textbook of Judo. Kokushi Dojo, Inc., Montvale, NJ.

Pulkkinen, W. 2001. The Sport Science of Elite Judo Athletes: A Review & Application for Training. Pulkinetics, Inc., Guelph, Ontario, Canada.

Richards, J. 1982. Conditioning for Judo and Judo as a Conditioner for Other Sports. Pp. 32-34 *in* NSCA Journal, Feb-Mar.

Sallis, J., T. McKenzie, B. Kolody, M. Lewis, S. Marshall, and P. Rosengard. 1999. Effects of Health-Related Physical Education on Academic Achievement: Project Spark. Research Quarterly *in* Exercise and Sport 70:127-234.

Strauss, R., and H. Pollack. 2001. Epidemic increase in childhood overweight, 1986-1998. Journal of the American Medical Association 286:2845-2848.

Troiano, P., and K. Flegal. 1998. Overweight children and adolescents: description, epidemiology, and demographics. Pediatrics 101:497-505.

United States Department of Health and Human Services. 2005. Physical activity and health: adolescents and young adults. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion. Internet Available: http://www.cdc.gov/nccdphp/sgr/adoles.htm. Date of Download: April 15.

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ABSTRACTS

BIOLOGICAL SCIENCES – AQUATIC

ABSTRACTS OF THE 2005 ANNUAL MEETING OF THE MONTANA CHAPTER OF THE AMERICAN FISHERIES SOCIETY

Kate Walker, President, Montana Chapter AFS

INTRODUCTION

The Montana Chapter of the American Fisheries Society is an organization of professional fisheries scientists and students from agencies, universities, and the private sector across Montana. Our objectives are: conservation, development and wise utilization of Montana's fisheries; promotion of educational, scientific and technological development; advancement of fisheries science and practice; and exchange and dissemination of knowledge about fish, fisheries and related subjects.

Our chapter is growing!

We had over 275 professionals attend our session this year!

- First, over 50 people attended the continuing education workshop Aquatic Nuisance Species: Identification, Status and Management. The workshop was an impressive mix of specialists in pathogens, plants and fish. The information was a blend of lecture and hands on—with very positive feedback from the attendees. The demand for the class was greater than what we could accommodate, a sure sign that this issue is of great interest to our professionals in Montana.
- Next, we had the pleasure of a thought provoking presentation by Dr. Bruce Rieman to kick off our meeting. Titled: Practical Solutions in Fish Conservation: A Reflection and Revision, Dr. Rieman challenged us all to rethink some of the assumptions we make as biologists, and to continue to look at the information and allow our hypotheses to change as the information bases develop.
- Keep an open mind—continue to learn and adapt!
- The meeting then continued with 10 sessions packed with amazing presentations on the practical approaches to addressing the needs of inland fisheries. I am continually awed by the caliber of professionals working in the state of Montana. We are incredibly fortunate to have these folks working on issues in the state!

The Montana Chapter of the American Fisheries Society offers the abstracts of its 2005 Annual Meeting to the readers of the Intermountain Journal of Sciences in the spirit of

Title footnote indicates organization, location and date presentation was made:

AFS Montana Chapter of the American Fisheries Society Annual Meeting, Missoula, MT, February 8-11, 2005

TWS Montana Chapter of the Wildlife Society Annual Meeting, Helena, MT, March 1-3, 2005

exchanging ideas and information regarding the aquatic sciences. Many of these abstracts reference ongoing research and management projects, and may include data that are not comprehensive or fully analyzed. Thus, these abstracts should not be cited in other works without permission of the author(s), whose contact information is provided. We hope that you enjoy our proceedings, and urge readers to attend and participate in our next meeting to be held in conjunction with the Western Division AFS meeting on May 15-18, 2006 in Bozeman, Montana.

Barriers To Prevent Non-Native Fish Movement: A Review[AFS]

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Barriers to non-native fish movement are important tools in the conservation of native fish species. Natural and manmade barriers provide protection to some of the last populations of native fish, and barriers are frequently used to help restore a species to a larger portion of its native range. We surveyed barriers being used to prevent non-native fish movement in an effort to make a wide variety of barrier designs available to managers and researchers. Barrier design, longevity, cost, and functionality vary, and there is some indication that those designing barriers lack the information necessary to build the best barrier to meet their management needs. A wide variety of materials are used to build barriers and each has associated advantages and disadvantages. We review the major types of barrier construction, as well as noteworthy innovative designs, and discuss the advantages and disadvantages of each. The falls barrier was found to be the most common type of barrier currently used to exclude non-native fish. Results of this survey have provided an array of barrier designs and have helped to highlight gaps in the knowledge base necessary to construct effective barriers. Other types of barriers included mesh, perched culverts and velocity barriers. Knowledge gaps in the design of barriers include, the jumping performance of wild fish, proper barrier siting, and barrier designs that can accommodate both high and low discharges. A comprehensive manual on barrier design and an understanding of the jumping ability of wild fish are necessary before barrier designers can be expected to consistently build effective barriers. focused on species of special concern, non-native species introductions, impacts of fire on fish and aquatic ecosystems, and hydroelectric development.

Basis Of Design For A Fish Barrier In German Gulch near Anaconda, Montana[AFS]

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German Gulch supports a population of genetically pure westslope cutthroat trout, physically isolated from rainbow trout due to historic mining activities near Butte, Montana. The ongoing restoration of Silver Bow Creek, into which German Gulch flows, will eventually reconnect these populations. This project involved the development of design criteria and the design of a fish barrier. Design criteria included conditions that would prevent fish from swimming or leaping over the barrier. Due to a lack of published data on rainbow trout, the swimming and leaping capabilities for pink and chum salmon were used. The barrier design consisted of rock configured to create a weir and downstream apron in a reach of channel confined by generally vertical exposed bedrock. A hydraulic model of a stylized

barrier was used to determine water velocities and depths, and the location and configuration of the hydraulic jump. Four different barrier heights were evaluated (4 to 7 ft). A 6-ft high structure was selected as it satisfied the swim and leap criteria at the 2-year through 100-yr flows. As swimming over the structure at lower flows was also a consideration, the model was run at flows of 10 cfs (considered baseflow), 20 cfs, 40 cfs and 80 cfs. While water velocities at these lower flows did not satisfy the swim impedance criterion, shallow water and a compound weir surface probably would nonetheless limit fish passage at low flows.

Efficacy Of Fish Screens On Irrigation Diversion Canals At Skalkaho Creek, Montana[AFS]

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Tom McMahon, Department of Ecology, Montana State University, Bozeman, MT 59717

Chris Clancy, Montana Department of Fish, Wildlife, and Parks, 316 North 3rd Street, Hamilton, MT 59840

Post-spawn adult and downstream migrant juvenile westslope cutthroat trout are entrained, become trapped, and die in the seven irrigation canals on Skalkaho Creek, a tributary of the Bitterroot River. We quantified entrainment rates into the canals using telemetry and trapping before (2003) and after (2004) installation of fish screens at three of the canals (Highline, Ward, and Hughes). No telemetered adults were entrained in 2003, because most were residents and did not migrate past the canals. Fifteen telemetered adults were entrained in 2004; three were entrained, bypassed, and entrained again further downstream. Nine telemetered adults were entrained at screened canals and all nine were successfully bypassed. Five telemetered age-1 juveniles were entrained at the Highline ditch in 2003; three were entrained there in 2004, but only one was bypassed. We estimated that 33,722 age-0 westslope cutthroat trout (95% CI, 12,044-161,799) moved downstream from 16 July to 20 September in 2003; 8964 (95% CI, 2840-72,141) or about 27 percent were entrained at the Highline ditch. In 2004 all three screens bypassed 7840 fish of which 6041 were westslope cutthroat trout. Fish screens effectively precluded entrainment and effectively bypassed adult, age-1 juvenile, and age-0 westslope cutthroat trout. Fish screens offer an effective management tool to eliminate entrainment of westslope cutthroat trout at Skalkaho Creek.

Stream Simulation Culvert Design And Installation On The Clearwater National Forest[AFS]

Anne Hall Connor, Clearwater National Forest, USDA Forest Service, 12730 Highway 12, Orofino, ID 83544, aconnor@fs.fed.us

The Clearwater National Forest, in partnership with the Nez Perce Tribe, has been identifying and replacing culverts that are migration barriers to fish and other aquatic species. We have embraced the concept of designing replacement structures to mimic stream conditions. Since 2000, in we have replaced 23 barrier culverts and opened 64 mi of habitat to steelhead, bull trout, chinook salmon, and westslope cutthroat trout. The majority (83%) of the replacement structures have been embedded pipe arches. A pipe arch can be a cost effective alternative for stream simulation for streams with a bankfull width of less than approximately 12 ft and with fill depths of less than approximately 20 ft. The drawback may be difficulty in holding substrate in the culvert for the full length of the culvert to the desired depth.

Removing Roads To Restore Watersheds O The Clearwater Natio al Forest A Nez Perce Tribe—Clearwater Natio al Forest Part ership[AFS]

Rebecca A. Lloyd, Nez Perce Tribe, Department of Fisheries and Resource Management, Powell Ranger Station, Highway 12, Lolo, MT 59847, rebecca lloyd@hotmail.com

Over the last eight years, the Nez Perce Tribe and the Clearwater National Forest have worked in partnership to protect and restore watersheds. Restoration projects follow aquatic resource priorities. The Lochsa River Drainage, an important fishery, has been a focal point for restoration projects, especially road removal. The Lochsa River and its tributaries provide critical habitat to populations of spring chinook salmon, E A listed nake River steelhead, ESA listed bull trout, westslope cutthroat trout, and rainbow trout. In addition to providing critical fisheries habitat, the Lochsa has been an important part of the learwater National Forest's timber production program. Among the legacies of intensive timber harvest are roads. Over the last 50 yrs, management priorities and harvest systems changed, leaving many of the roads in the Lochsa redundant to management needs. These abandoned roads on the steep, failure prone slopes of the Lochsa have proved deleterious to aquatic resources. The Nez Perce Tribe and Clearwater National Forest have successfully removed over 400 mi of failing roads. Over the years we have learned many lessons about how to effectively implement road removal projects (road removal is referred to as road decommissioning and/or road obliteration) to restore watershed function and protect aquatic resources. Successful road removal projects involve multiple steps including planning, public outreach, mapping, earthwork, erosion control, and monitoring.

Assessment Of Road Decommissioning On Stream Habitat In The Flathead National Forest[AFS]

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The Flathead National Forest has almost 4000 miles of roads and a mandate to decommission nearly a quarter of the road infrastructure for grizzly bear security. In addition to this area being valuable for grizzlies, it is important for bull trout and westslope cutthroat trout. Although there are multiple studies demonstrating negative impacts of roads on fish populations (including bull trout), there is relatively little research examining which technique (e.g., gating, berming and revegetating) and what degree of decommissioning is necessary to improve stream habitat. The Flathead National Forest has decommissioned over 300 mi of roads, but has few watersheds where the entire area was decommissioned. We sampled 12 streams in the Hungry Horse and Spotted Bear Ranger Districts with four different watershed types (1) wilderness, (2) roads in use, (3) exclusively decommissioned roads, and (4) a mix of decommissioning (gated, decommissioned spurs, very little road use). Our goal was to address two questions. First, do forest roads have measurable impacts on stream habitat in our study site? If so, do streams with watersheds containing decommissioned roads demonstrate recovery and how important is decommissioning at the watershed scale? We performed habitat surveys, Wolman pebble counts, visual embeddedne s estimates, and substrate coring in the summer and fall of 2004. There was high variability across streams regardless of

treatment. We found no differences in habitat measures (temperature, pool size and number, and LWD) between treatments, but there were differences in sedimentation.

Fire Suppression And Post-fire Rehabilitation On The Bitterroot National Forest—What Did And Didn't Work For Aquatics[AFS]

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Over 320,000 ac of the Bitterroot National Forest burned in 2000 and 2003. Resource advisors monitored protection of aquatic resources during suppression and post-fire rehabilitation activities. Forest fisheries biologists, hydrologists, and other specialists served as resource advisors and worked closely with the fire and burned area emergency recovery teams. During suppression, resource advisors provided guidance to fire leadership, monitored compliance with standards, communicated their findings to the fire teams, and developed rehabilitation plans. Following suppression, resource advisors supervised the re-contouring of dozer lines (165 mi) and contour felling (1000 ac). Biologists and hydrologists were instrumental in the replacement of fish barrier culverts (21) and road obliteration (35 mi). The most effective post-fire rehabilitation actions for aquatic resources were replacing fish culvert barriers, upgrading undersized culverts, obliterating roads, and re-contouring dozer lines. Effectiveness of other actions such as contour felling, aerial seeding, and straw mulching was limited. During fire, biologists and hydrologists are most effective in protecting aquatic resources if they participate at several levels. Ideally, they should be involved in development of resource protection standards, know the inner working of the fire bureaucracy, be in the field near equipment and crews during the operational period, and stay with the same fire until rehabilitation is finished. This level of participation provides consistency to limit damage during suppression, irreplaceable knowledge of the site, and efficient follow through on complex rehabilitation plans.

Comparison And Use Of Streambank Alteration Assessment Methods[AFS]

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The potential impacts of livestock grazing on streambanks and riparian areas have received considerable attention in recent years. The percent of the streambank trampled is one tool used by range managers as a "trigger" to determine when livestock should be moved. Over the last two years the USDA Forest Service has been developing a standardized sampling method for Region 1. As part of this process, we have compared different streambank alteration assessment methods used on federal lands in the Western U.S. Our objectives were to 1) define observer variability for each method, 2) determine whether the methods yield similar estimates, and 3) determine importance of training and 4) discuss recommendations for improving methods. We summarize the results from these studies, implications for using alteration as a grazing management tool, and current Forest Service direction for sampling alteration.

barrier was used to determine water velocities and depths, and the location and configuration of the hydraulic jump. Four different barrier heights were evaluated (4 to 7 ft). A 6-ft high structure was selected as it satisfied the swim and leap criteria at the 2-year through 100-yr flows. As swimming over the structure at lower flows was also a consideration, the model was run at flows of 10 cfs (considered baseflow), 20 cfs, 40 cfs and 80 cfs. While water velocities at these lower flows did not satisfy the swim impedance criterion, shallow water and a compound weir surface probably would nonetheless limit fish passage at low flows.

Efficacy Of Fish Screens On Irrigation Diversion Canals At Skalkaho Creek, Montana[AFS]

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Post-spawn adult and downstream migrant juvenile westslope cutthroat trout are entrained, become trapped, and die in the seven irrigation canals on Skalkaho Creek, a tributary of the Bitterroot River. We quantified entrainment rates into the canals using telemetry and trapping before (2003) and after (2004) installation of fish screens at three of the canals (Highline, Ward, and Hughes). No telemetered adults were entrained in 2003, because most were residents and did not migrate past the canals. Fifteen telemetered adults were entrained in 2004; three were entrained, bypassed, and entrained again further downstream. Nine telemetered adults were entrained at screened canals and all nine were successfully bypassed. Five telemetered age-1 juveniles were entrained at the Highline ditch in 2003; three were entrained there in 2004, but only one was bypassed. We estimated that 33,722 age-0 westslope cutthroat trout (95% CI, 12,044-161,799) moved downstream from 16 July to 20 September in 2003; 8964 (95% CI, 2840-72,141) or about 27 percent were entrained at the Highline ditch. In 2004 all three screens bypassed 7840 fish of which 6041 were westslope cutthroat trout. Fish screens effectively precluded entrainment and effectively bypassed adult, age-1 juvenile, and age-0 westslope cutthroat trout. Fish screens offer an effective management tool to eliminate entrainment of westslope cutthroat trout at Skalkaho Creek.

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Anne Hall Connor, Clearwater National Forest, USDA Forest Service, 12730 Highway 12, Orofino, ID 83544, aconnor@fs.fed.us

The Clearwater National Forest, in partnership with the Nez Perce Tribe, has been identifying and replacing culverts that are migration barriers to fish and other aquatic species. We have embraced the concept of designing replacement structures to mimic stream conditions. Since 2000, in we have replaced 23 barrier culverts and opened 64 mi of habitat to steelhead, bull trout, chinook salmon, and westslope cutthroat trout. The majority (83%) of the replacement structures have been embedded pipe arches. A pipe arch can be a cost effective alternative for stream simulation for streams with a bankfull width of less than approximately 12 ft and with fill depths of less than approximately 20 ft. The drawback may be difficulty in holding substrate in the culvert for the full length of the culvert to the desired depth.

Challenges In Developing And Implementing Ecological Standards For Aquatic Restoration Projects: A Practitioner View[AFS]

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While the stated or implied goal of most aquatic restoration projects is to be ecologically effective, many in the restoration community question if these goals are being consistently achieved. In response, some in the academic community have proposed the establishment of ecological standards to evaluate projects. In this presentation, these standards are introduced and placed in context to the subset of restoration projects that principally involve the alteration of existing channel geomorphology. From the lessons of practice it is argued that a number of cultural and institutional factors impede ecologically effective restoration including (1) misuse of the term "restoration," (2) failure to create sound, ecologically-based guiding images at project inception and the related phenomenon of *image drift*, (3) a lack of risk tolerance leading to unnatural project hardening, (4) practitioner/sponsor inexperience and inflexibility, and (5) lack of commitment to monitoring. It is also suggested that more interaction needs to take place between practitioners and the academic community so that the lessons of practice are communicated and integrated into the emerging science of restoration. Although this interaction will advance the common goal of implementing more ecologically effective projects, it is noted that project participants outside the scientific community must also appreciate the challenges a project faces meeting higher standards. These challenges are not insignificant and include convincing project sponsors, practitioners and regulators of the need for standards in project generation, implementation, and monitoring on a project-by-project basis.

Jocko River Floodplain Restoration Planning Using Suitability Analysis[AFS]

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The Confederated Salish and Kootenai Tribes are restoring the Jocko River watershed, located on the Flathead Indian Reservation in western Montana. Restoration efforts focused on restoring (1) the watershed for bull trout, and (2) ecological processes impacted along the river corridor. To support these efforts, we identified areas with high potential for restoring native riparian and wetland plant communities along the lower main-stem Jocko River floodplain using a suitability analysis approach. This analysis used a GIS system to combine variables (layers) according to a set of decision rules to ultimately determine restoration categories for revegetation potential along the river. Four main geographic variables were used to determine suitability classes for native plant community restoration: soil texture in the surface layer; hydric soil status, presence of woody vegetation in 1937 and HGM (hydrogeomorphic) cover type. These variables were selected as the best available information for predicting restoration potential across the entire ecological floodplain area. Fine-resolution topographic data will be used as it becomes available, to refine the analysi to include elevation classes relative to known hydrologic features. Based on this analysis, three combinations of variables (suitability classes) were identified that indicate high restoration potential for restoring native plant communities along the Jocko River. This type of analysis

is a useful tool that should be incorporated into watershed restoration planning to increase the success of restoration efforts of rivers, floodplain, wetlands and ultimately native fisheries.

A Watershed-based Approach To Restoring Wetland-riparian Resources And Bull Ttrout On The Flathead Indian Reservation[AFS]

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The Confederated Salish and Kootenai Tribes (CS&KT) are undertaking a comprehensive watershed restoration effort on the Flathead Indian Reservation. In 1998, as part of a legal settlement, the Atlantic Richfield Company agreed to pay the CS&KT for mining-related damages to treaty-protected resources in the Upper Clark Fork River Basin. Under the terms of the settlement, the CS&KT were to replace, restore, and/or acquire the equivalent of the injured resources, which included wetland-riparian resources and bull trout. Rather than using a piece-meal approach to mitigation, the CS&KT decided to commit to a more holistic resource management approach in one focus area, the Jocko Watershed. The basic goal of the restoration is to maintain or reestablish natural processes to the greatest degree possible, while recognizing limitations imposed by past and ongoing watershed disturbances. The watershed restoration process the CS&KT chose involved four key actions: 1) assessment to determine environmental history and identify restoration potential; 2) protection to identify and maintain the best remaining habitats; 3) passive restoration to modify activities that are disturbing or preventing recovery; and, 4) active restoration to reestablish functions where the ecosystem would otherwise remain degraded indefinitely. In this talk we presented a broad overview of the settlement and of the planning and implementation of the watershed restoration effort.

Native Species Habitat Restoration In The Upper Klamath Basin, Oregon[AFS]

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Aquatic ecosystems in the Upper Klamath Basin have been significantly altered by historical and contemporary land use practices. Modified watershed hydrology, riparian communities, channel morphology, and aquatic habitat conditions have profoundly impacted the native fish community in the Upper Klamath Basin, including bull trout, Lost River and shortnose suckers, and Klamath redband trout. Preliminary efforts to restore riparian and stream habitats in the Sprague River watershed near Beatty, Oregon, offer promising opportunities to rehabilitate considerably degraded aquatic environments. Target project streams including multiple spring creeks and the mainstem Sprague and Sycan rivers, were prioritized in the *Master Plan for the Restoration of the Sycan and Sprague Rivers near Beatty, Oregon*, a guidance document for focusing restoration efforts in the middle Sprague River watershed. River Design Group is collaborating with local agencies and landowners to identify and achieve multiple land management and endangered species recovery goals through the application of passive and active restoration techniques. Restoration projects completed in 2004 included one spring creek and two off-channel pond complexes that provide important spawning and rearing habitat for the focus species. Techniques included channel reconstruction and passive techniques including artificial beaver dam construction for channel grade control. Final restoration design plans were completed in 2004 for a

2-mi section of the main Sprague River, which is scheduled for construction in 2005. Once completed, the reconstructed streams and off-channel habitats are expected to provide cold water refugia and improved spawning, rearing, and migratory corridor conditions for the focus sucker species, Klamath redband trout, and bull trout.

Build It And They Will Come: Early Monitoring Results From The Nevada Spring Creek Restoration Project[AFS]

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Nevada Spring Creek is a tributary to Nevada Creek, an impaired tributary of the Blackfoot River. Nevada Spring Creek has been the focus of several restoration projects from 1990-2004. The goal of restoration work was to restore habitat conditions suitable for native trout, specifically westslope cutthroat trout and to improve downstream water quality and reduce thermal stress in Nevada Creek and the Blackfoot River. Restoration of four miles of Nevada Spring Creek took place in several stages, and utilized a variety of methods including complete channel reconstruction, instream wood placement, gravel addition, shrub plantings, sod mat stacking, and riparian grazing management changes. Pre- and post-project monitoring indicates that original project objectives are being met. Temperatures have been moderated throughout the entire length of the spring creek (decreased 10-15 °F) to provide the preferred range for trout. Initial fisheries surveys indicate community shifts in the upper and lower portions of the spring creek. Surveys in the upper section, a section previously dominated by brown trout, have found continued increased densities of brown trout and early signs of increased westslope cutthroat trout densities. A dramatic community shift was also detected in the lower spring creek as species diversity increased from three to six species, and a pre-project non-salmonid community shifted completely to an assemblage dominated by 85 percent salmonids (brown trout, westslope cutthroat and whitefish). In addition, a single bull trout was also collected, the first documented bull trout in the evada Creek watershed in the last 15 years.

Rainbow Trout And Brown Trout Populations Before And After A Stream Restoration Project On Big Spring Creek, Montana[AFS]

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A high profile stream restoration project was completed on a 2600-ft reach of Big Spring Creek at the Brewery Flats Fishing Access Site from 1998 to 2001. This project replaced an entrenched reach with a meandering riffle pool stream channel and floodplain. Stream length was increased by 1400 ft. Initial findings indicated the project was successful. The restored reach successfully passed a flood event in 2003 and trout numbers appear to have increased. Big Spring Creek is a 100-cfs (base flow) trout stream that originates from a 52 F spring south of Lewistown, Montana. Population data were collected with mobile electrofishing on the restored section and two other reaches of Big Spring Creek from 1995 to 2004. Mean number of combined rainbow trout and brown trout (≥ 10 inches) ranged from 500 to 2200/ mi depending on the section. Total trout/mi (≥ 10 in) averaged 36 percent higher during the 4 yrs immediately after the project in the restored section, compared to increases of 22 and 0.9

percent in the other two sections. The 1400-foot increase in length at Brewery Flats meant trout numbers ($\geq$ 10 inches) in the section increased by 90 percent after restoration. From 2002 to 2004 Brewery Flats showed a 66-percent increase in trout/mi compared to declines of 36 and 23 percent in the other two sections. Small rainbow trout declined to 33 percent of the pre-project numbers at Brewery Flats but were 42 percent of the pre-project average at the section 3 mi upstream.

Responses Of Yellowstone Cutthroat Trout Populations In The Upper Yellowstone River To In-Stream Flow Restoration[AFS]

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Yellowstone cutthroat trout (YCT) in the upper Yellowstone River rely on quality spawning habitat in tributaries for most of their reproduction. For over 20 years, research and conservation efforts for this mixed-stock of pure and hybridized YCT focused on restoring minimum flows and habitat in spawning tributaries. FWP has leased irrigation water in six tributaries of the Yellowstone River since the mid-1990s. Intermittent monitoring of water leases demonstrated localized benefits such as increases in fry production and spawner and redd counts, but the efficacy of these efforts relative to the greater Yellowstone River population is not clear. YCT population estimates dating back to the 1970s provide a means of analyzing population trends relative to limiting factors. Earlier researchers documented a relationship between mid-summer streamflows and YCT reproductive success. In the Corwin Springs section, age-2 YCT abundance is correlated to mean September flow at the Livingston gage. In low flow years, year class strength is weak. However, since water leases were implemented, year classes have been strong, even during record drought years. The YCT population has been well above long-term median since leases have been in place. In the Springdale Section, YCT populations continue to fluctuate around the long-term median. The only lease affecting this reach was implemented in 2002, so no response is expected for a few years. Apparently water leases and habitat restoration efforts are successfully mitigating a primary factor limiting recruitment of YCT to the Yellowstone River.

The Cherry Creek Native Fish Introduction Project: Successes And Problems After Two Years Of Piscicide Treatment[AFS]

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The Cherry Creek Native Fish Introduction Project is a cooperative effort between Montana Fish, Wildlife, and Parks, the Gallatin National Forest, and Turner Enterprises, Inc. to establish westslope cutthroat trout in a large (> 50 connected stream mi) tributary of the Madison River, as prescribed in the 1999 Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana. The project was initiation in 2003 after four years of delay by administrative and legal challenges. *In situ* bioassays were conducted to determine travel time and lethal concentration of Fintrol (i.e., antimycin). To remove non-native fish, Fintrol was applied to Cherry Lake (105 ac-ft, 35-ft max depth) from a raft, and to 11 mi of stream in two forks of upper Cherry Creek using constant flow stations at

specific points along the stream. Backpack sprayers were used to treat shallow lake margin and off channel areas. A total of 11.3 gal of Fintrol was used in 2003 and 2004. xposed fish succumbed readily to Fintrol, but fish persist in the lake. Gillnets are being used to continue removal from the lake. Natural waterfall barriers on each of the forks prevent fish from invading treated areas, and an existing irrigation weir was dammed to isolate the next portion of the drainage scheduled for treatment in 2005 and 2006.

Selective Electrofishing Removal Strategies For Non-Native Brook Trout To Facilitate Persistence Of Native Cutthroat Trout[AFS]

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Inland cutthroat trout presently occupy a fraction of their historic ranges, and existing populations are often found as isolates in small headwater streams. Displacement by non-native brook trout is among the greatest threats to existing populations. Cutthroat trout restoration projects often utilize electrofishing to suppress brook trout, but these operations are labor intensive and costly. Information on the effectiveness of different removal electrofishing scenarios would help managers prioritize restoration efforts given limited resources. To address this, we constructed matrix population models for Colorado River cutthroat trout and brook trout using demographic data from a field experiment whereby we modeled survival of juvenile (ages-0 and -1) cutthroat trout as a function of brook trout density. Population responses to brook trout suppression were modeled as a function of electrofishing effort, defined by the number of visits over 50 yrs, the temporal distribution of those visits and the number of passes per visit. Stochastic simulations suggested an increased probability of cutthroat trout persistence with increasing electrofishing effort. However for a given effort level, persistence was strongly affected by the temporal distribution of visits. Model scenarios with three years of consecutive brook trout suppression repeated at regular intervals provided the greatest benefits to cutthroat trout by providing the periodic infusion of a strong cohort into the population. Model results may inform managers as they prioritize efforts to sustain existing cutthroat trout populations where complete brook trout eradication and/or isolation of cutthroat trout is not feasible.

Conservation Of Westslope Cutthroat Trout By Removal Of Brook Trout Using Electrofishing[AFS]

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We evaluated removal and relocation of non-native brook trout from about 14 km of stream in Cottonwood, Craver, Muskrat, Spring, and Staubach creeks to conserve sympatric populations of native westslope cutthroat trout. We successfully eliminated brook trout from treatment reaches in Cottonwood, Muskrat, and Staubach creeks. While we successfully suppressed brook trout in Spring and Craver creeks, we were unable to eradicate them due to dense riparian vegetation, beaver dams, and abundant woody debris in these channels.

Eradication cost about $3000-$4000 ($US)/ km. Electrofishing eradication costs were similar to estimated costs for two antimycin piscicide treatments, but slightly more than estimated costs for two rotenone treatments. However, electrofishing eradication is preferred in locations where native fish are in sympatry with non-native fish because more native fish can be saved during removal efforts. It took at least six removal treatments of two to three passes/ treatment to effectively eliminate brook trout from most treatment reaches. We recommend conducting: 1) six removal treatments within three years; 2) the first two removal treatments prior to spawning by nonnative fish and removing mature adults; 3) one removal treatment during spawning and trampling nonnative fish redds; and 4) some removal treatments in the late fall or early winter. It is important to realize that smaller, younger nonnative fish (age-0 and age-1) will be more difficult to capture, so plan on eradicating these fish after adults have been eliminated. Our data, and other studies, have shown that native cutthroat trout populations will respond positively to removal of nonnative brook trout. This response may take two to three years and appears related to elimination of competition and/or predation that occurs when cutthroat trout are age-0 to age-1.

Predicting Cutthroat Trout Abundance In High-Elevation Streams: Revisiting A Model Of Translocation Success[AFS]

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Assessing viability of stream populations of cutthroat trout and identifying streams suitable for establishing populations are priorities in the U.S. central Rocky Mountains. We reevaluated a model of translocation success developed for cutthroat trout by examining the relation between electrofishing-based abundance estimates (n = 31) and mean July water temperature, pool bankfull width, counts of deep pools, and occupied stream length. The preferred model was $\sqrt{}$(population size) = 0.00508 (stream length, in m) + 5.148 (R^2_a = 0.81; $P < 0.001$). An independently developed model based on visual counts broadly supported this finding. Additional habitat coupled with increased habitat complexity may account for the abundance-stream length relation because abundance lacked a consistent longitudinal trend within streams. Model-derived estimates and prediction intervals imply that many Rocky Mountain populations of cutthroat trout fail to meet thresholds associated with reduced risk of extinction. We believe that this model can reduce uncertainty about projected population sizes when selecting streams for reintroductions of cutthroat trout or evaluating unsampled streams.

Behavior And Characteristics Of Anglers In Bull Trout Recovery Areas Within The Upper Clark Fork Watershed[AFS]

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Recent radio-telemetry studies in the upper Clark Fork Basin (1999-2004) indicated ≤ 10-15 percent annual angler-caused mortality for adult fluvial bull trout. Because of extremely low population abundance (1-5 adults/river mi), increasing fishing pressure, concentration of fishing pressure in key bull trout habitats, vulnerability of bull trout to

angling, etc., angling is still suspected to be a significant source of mortality. With this in mind, we interviewed 544 anglers (Jun-Oct 2004) in 33 known bull trout staging and spawning areas to a sess regulation compliance, fish identification skills, angling methods and angler demographics. Anglers surveyed were primarily unguided bank anglers, although guided anglers (13%) and float anglers (25%) were represented in our sample of Montana residents (47%) and nonresidents (53%). Angling methods included fishing with flies (75%), bait (9%), hardware (10%) or some combination of these (6%). Most anglers (79%) were aware of special regulations for bull trout and overall regulation compliance was very high (>99%). However, trout identification skills were poor and the angler group that we were most concerned about (those intending to keep fish) was particularly deficient. Anglers planning to keep fish exhibited lower regulation compliance (94%) and success in identifying the five common trout species (15%) relative to catch and release anglers (46% success). These data do not provide conclusive answers to the question of angling impacts on depressed bull trout populations, but do suggest the need for education targeting specific angler groups and concerted river recreation planning efforts in order for native fish recovery to be successful.

Ground Water Pumping And Streamflow Depletion In Montana[AFS]

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Stream dewatering poses a major threat to aquatic ecosystems in Montana. To prevent further dewatering in overappropriated basins, the Montana legislature and the Department of Natural Resources and Conservation have closed the upper Clark Fork, Musselshell, upper Missouri, Milk, and Teton Rivers and their tributaries to new water rights. Closures, however, do not apply to new ground-water appropriations. In response to the closures and prompted by the recent drought, agricultural water users have turned increasingly to ground-water wells and sprinkler systems as more reliable and efficient irrigation methods than traditional flood irrigation from surface-water diversions. The increased crop production made possible by these changes increases water consumption from the basins. New residential and commercial water users likewise may withdraw additional ground water from aquifers in the basin Because ground water naturally discharges into stream channels, this increased consumption of ground water ultimately decreases streamflow. Conjunctive stream-aquifer models can help planners maximize ground-water withdrawals while minimizing streamflow depletion at critical times of the year. Water-right transfers provide an alternative means to develop new water projects without increasing overall water consumption. Concurrent enforcement of the basin closures for all water, whether from surface or subsurface sources, would prevent further stream dewatering and protect existing water rights.

Trammel Net Efficiency For Sturgeon Sampled In The Missouri River: Implications For Sampling Design[AFS]

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To accurately document the continued decline or recovery of sturgeon, efficiency of sampling these species needs to be evaluated. Drifted trammel nets are considered an important tool for sampling sturgeon in lotic systems. Thus, our objectives were to evaluate efficiency of drifting trammel nets for sampling juvenile sturgeon [pallid sturgeon and shovelnose sturgeon] using known fish locations, and to determine the abiotic factors that influence whether a sturgeon is sampled or not sampled. During the summers of 2003 and 2004, we attempted to recapture radio-tagged juvenile pallid sturgeon and shovelnose sturgeon at 69 locations in the Missouri River above Fort Peck Reservoir, Montana. Drifting trammel net efficiency was 32 percent, and first drift efficiency was 36 percent. Sixty-nine percent of the sampled sturgeon were captured on the first drift and subsequent drifts were less efficient and often unsuccessful. A multiple analysis of variance was not significant and all pair-wise comparisons for abiotic variables between successful and unsuccessful captures were non-significant. Stepwise logistic regression was used to model the probability that a drift would not capture a sturgeon. However, none of the abiotic variables we measured were useful in the model. These results suggest that drifted trammel nets were a moderately effective sampling gear for juvenile sturgeon in lotic systems. When considering sampling design, our results suggest that it was most efficient to conduct single drifts at multiple sampling locations, rather than drifting multiple times at one location, if a large sample size is the objective.

HAbitat U e, Diet, And Growth Of Hatchery-reared Juvenile Pallid Sturgeon And Indigenous Juvenile Shovelnose Sturgeon In The Missouri River Above Fort Peck Reservoir[AFS]

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Natural recruitment of pallid sturgeon has not been observed in the Missouri River above Fort Peck Reservoir, Montana, for at least 30 years. In an effort to recover the species, 736 hatchery-reared juvenile pallid sturgeon (HRJPS) were released as yearlings in 1998. Evaluation of these HRJPS is necessary to determine their performance in a natural lotic environment. A set of habitat variables was measured at each location for 29 HRJPS and 22 indigenous juvenile shovelnose sturgeon (JSNS) implanted with radio transmitters during the spring, summer, and autumn in 2003 and 2004. Significant interactions among species, season, and year existed for mean relative depth, column velocity, and bottom velocity. However, no significant interactions existed for mean fish depth, which was significantly higher for HRJPS than JSNS. Hatchery-reared juvenile pallid sturgeon frequently used lotic habitat created by receding reservoir water levels, indicating that Fort Peck Reservoir influences the amount of available habitat for juvenile pallid sturgeon. We also examined the

diets of all HRJPS and JSNS sampled. Fish composed the majority of the diet of HRJPS, while JSNS primarily consumed aquatic invertebrates. There was no significant difference in relative growth rate between recaptured HRJPS and JSNS from May to October in 2003 and 2004. This study indicated that HRJPS in the Missouri River above Fort Peck Reservoir are capable of living in a natural lotic environment. Therefore, we believe that stocking HRJP can successfully augment wild pallid sturgeon populations, which is crucial to the long-term recovery of the species.

Distribution And Status Of Montana Prairie Stream Fishes [AFS]

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During 1999-2004, we took 820 samples for fish in 561 prairie streams in Montana. The streams ranged in size from the Powder River down to ephemeral headwater streams. Of the 820 samples, 480 (56 %) were from sites with fish present, whereas fish were absent at 340 (44 %) of sites. We captured over 176,000 individual fish representing 48 species and 11 families. Thirty of the fish species and 89 percent of individuals captured were native to Montana, whereas 18 species and 11 percent of individuals were introduced species. At sites with fish present, native species richness averaged 4.5 and ranged from 1 to 14 species per sample, whereas introduced species richness averaged 1.9 and ranged from 1 to 8. Only two species, fathead minnow and white sucker were captured at more than 50 percent of sites with fish present. Twelve native and 3 introduced species were captured in 10-50 percent of samples with fish present, and 15 native species and 16 introduced species were captured in < 10% of samples with fish present. Of the 30 native species, 13 species were found in close proximity to large rivers or in larger streams, 13 species were found primarily in smaller streams, and 4 species were in coolwater streams in proximity to higher elevations. We documented the distribution of four species of special concern and 6 potential species of concern.

Spatial Partitioning Of Two Sculpin Species In West Central Montana[AFS]

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Although sculpin are often important components of fish communities in coldwater streams, their ecology, movements and population structure are poorly understood. To understand how sculpin are distributed within the upper Clark Fork drainage of Montana, we investigated phylogenic relationships, species differentiation and movement patterns of sculpin in eight tributaries. We determined phylogenetic relationships and identified patterns of genetic differentiation using morphometric measurements, meristic element counts and genetic sequence data from the mitochondrial control region. In each stream, we collected sculpin from two locations; typically from one site as far upstream as they were

distributed and another site close to the mouth. In three streams, anthropogenic barriers limited movements between sample sites. Morphometric measurements, meristic counts, and genetic analyses confirmed the presence of two sculpin species in each stream (*Cottus cognatus* and, the previously undocumented, *C. sp. cf. bairdi*). Furthermore, sculpin were distributed similarly among streams regardless of passage barriers. In general, we found only *C. cognatus* in the upper sites and *C. sp. cf. bairdi* in the lower sites. Movement studies revealed that *C. sp. cf. bairdi* was highly mobile (moving frequently, and up to 200 m) whereas *C. cognatus* was immobile during the 5-wk study, despite similar densities of sculpin in both sites. These data suggest that two allopatric species of sculpin are apparently widely distributed in the upper Clark Fork watershed and that behavioral mechanisms, e.g., life history tactics, may be responsible for isolating these two species.

Prairie Fish Community Assessments: Scientific Uses With Implications For Conservation[AFS]

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Aquatic ecosystems of Montana's prairie region have only recently been intensively inventoried for fish and macroinvertebrate communities. Recent surveys from Montana Fish, Wildlife and Parks, USDI Bureau of Land Management, Montana State University, and Montana Natural Heritage Program have identified Montana SOC fish species within these communities, as well as "species on review" that need additional information. Since comprehensive data on these prairie aquatic communities remains limited, the Montana Natural Heritage's goal is to compile reliable information on the distribution and diversity of these assemblages with the ultimate goal of tracking unique communities across watersheds and predicting additional locations of these communities containing SOC fish and other aquatic organisms. We began by documenting the stream types where the characteristic aquatic community clusters with indicator species occur in the landscape, and overlay these on TNC's Stream Classification System to determine if they consistently and predicatively align with similar classified stream reaches. Eight statistically valid prairie fish community groups were identified from the data. These were linked on NHD reach codes in a GIS to produce maps of occurrences and potential reach habitat for the fish community types considered potential conservation targets or priorities.

Environmental And Biological Factors Contributing To *Salmincola* Sp. Infections In Missouri River Rainbow Trout[AFS]

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During the summer and late fall of 2002, Montana Fish, Wildlife and Parks personnel received reports of Missouri River rainbow trout infected with *Salmincola sp.* gill parasites. During June and July of 2003 and 2004, sampling was conducted to determine the extent and severity of the parasite in Missouri River rainbow trout. Rainbow trout were sampled by nighttime electrofishing in two sections of the Missouri River. Length and weight were recorded on all sampled fish, and all fish were examined for the presence of the parasite. Infected fish were classified into 3 categories: 1 (mild), 2 (moderate), and 3 (severe)

infections. In 2003, 79.3 percent (n = 63) and 31.8 percent (n = 66) of sampled rainbow trout were infected with the parasite in the Craig and Pelican Point sections, respectively. Most (78%) of the infections observed in the Craig area were classified as grade 1 or 2; however, 22 percent were severely (grade 3) infected. In the Pelican Point area, all infected rainbow trout had mild infections. In 2004, 52 percent (n = 50) and 9 percent (n = 64) of sampled rainbow trout were infected with the parasite in the Craig and Pelican Point sections, respectively; however, all infected fish had mild infections. The infection rates observed throughout this study are considerably higher than those reported in literature for wild fish. We hypothesize that the severity of the infection was related to environmental conditions (low flows and high water temperatures) coupled with a rainbow trout population with an abnormally high proportion of large (and old) fish.

Using An Index Of Biotic Integrity As A Surrogate Indicator In The TMDL Process For Prairie Streams[AFS]

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The State of Montana is determining total maximum daily loads (TMDLs) for pollutants in streams, rivers, and lakes identified as water quality impaired. Common impairments listed for eastern Montana prairie streams include sediment loads, salinity, and temperature. However, numeric water quality standards either have not been developed for these impariments, or criteria have been based on data from western Montana streams. As part of the TMDL process Garcia and Associates (GANDA) sampled fish populations at 11 sites on three streams within the Flatwillow and Box Elder watersheds near Winnett. We then analyzed the results from each site using an index of biotic integrity (IBI) for prairie fish communities. The IBI ratings were used to support water quality information collected, and to determine level of impairment for sites on each stream. We are applying a similar approach to the Redwater River planning area near Circle. No new fish collections have been made, but existing collections made by Montana Fish, Wildlife and Parks and Montana State University were used to calculate IBI scores. We then used the IBI scores to assess whether total suspended solids (TSS) and salinity levels negatively impact native fish communities. TSS and salinity levels from less impaired reaches are also being used to support "background levels" of these parameters in eastern Montana streams. The goal is to develop fish-based monitoring plans to assess whether water quality restoration plans are effective within prairie streams.

Monitoring The Biological, Physical, And Chemical Integrity Of The Powder River: ImplicationS For The Sustainable Development Of Coalbed Natural Gas [AFS]

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Coalbed natural gas (CBNG) is an emerging energy source with significant development slated for the Powder River basin in Montana and Wyoming. Water is the principal by-product of CBNG extraction and wastewater disposal strategies have an unknown effect on fish and aquatic life. The objective of this investigation was to document the existing biological, chemical, and physical integrity of the Powder River in Wyoming, upstream and

downstream of areas with CBNG development. The investigation included assessments of fish, periphyton, macroinvertebrates, water chemistry, riparian vegetation, and instream habitat. Comparing results with existing data provided a means to evaluate temporal trends associated with current levels of CBNG development. Factors influencing macroinvertebrate and periphyton results included the difficulties related to sampling this sand bed river. Fish populations reflected habitat availability and emphasized the importance of large woody debris in forming pools. The scarcity of sturgeon chub, especially compared to its distribution in the early 1990s, emerged as major concern, although the cause of the decline is unknown. Water samples collected downstream of CBNG wastewater discharges had anomalously high concentrations of salts. Invasion of salt cedar and the potential for increased salt loading from CBNG to give this nonnative species a competitive advantage over cottonwood may have long-term implications for fish habitat. Recommendations for sustainable development of CBNG included incorporation of the river's ability to assimilate wastewater given its unique hydrology and integration life history strategies and movements of native fishes.

Toxicity Of Coalbed Methane Discharge Water To Prairie Stream Fishes[AFS]

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Acute (96 hr) and chronic (60-day) toxicity tests were conducted on various fish species in order to better understand the sensitivities to major ions in surface waters, particularly those present in coalbed methane discharge water of the Powder and Tongue River basins. Discharge water in portions of the basins is high in $NaHCO_3$, which when combined with reconstituted Tongue or Powder River water can be toxic to fish at environmentally relevant levels. A general discussion of the sensitivity of different lifestages and the mechanisms of toxicity was also provided.

Consulting 101: A View From Both Sides Of The Fence[AFS]

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This presentation addressed the role of consultants in the fishery profession from two perspectives. It provided information for people who may want to become consultants, and for people who may want to hire consultants. I will discuss what consultants can do, when to hire them, how to hire them, and the big question—why do they cost so much. I also gave some insight into what a career in consulting is like for people who might be considering a career change.

Risk-based Viable Population Monitoring[AFS]

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We describe risk-based viable population monitoring in which the monitoring indicator is a yearly prediction of the probability that, within a given timeframe, the population abundance will decline below a pre-specified level. Common abundance-based monitoring strategies usually have low power to detect declines in threatened and endangered species and are largely reactive to declines. Comparisons of the population's estimated risk of decline over time will help determine status in a more defensible manner than current monitoring methods. Monitoring risk is a more proactive approach; critical changes in the population's status are more likely to be demonstrated before a devastating decline than with abundance-based monitoring methods. In this framework, recovery is defined not as a single evaluation of long-term viability, but as maintaining low risk of decline for the next several generations. Effects of errors in risk prediction techniques are mitigated through shorter prediction intervals, setting threshold abundances near current abundance, and explicitly incorporating uncertainty in risk estimates. Viable population monitoring also intrinsically adjusts monitoring effort relative to the population's true status and exhibits considerable robustness to model misspecification. We present simulations showing risk predictions made with a simple exponential growth model can be effective monitoring indicators for population dynamics ranging from random walk to density dependence with stable, decreasing, or increasing equilibrium. In analyses of time-series data for five species, risk-based monitoring warned of future declines and demonstrated secure status more effectively than statistical tests for trend. We presented more detailed risk-analyses for Flathead bull trout populations.

Trophic Position, Habitat Use, And Mercury In Flathead Lake Fish: Insights From Stable Isotopes[AFS]

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We measured $\delta^{13}C$ and $\delta^{15}N$ in lake trout, lake whitefish, and their major prey items to quantify foraging depth and trophic position of individual fish in Flathead Lake, Montana. We subsequently applied our isotopic quantification of foraging depth and trophic position to investigate mercury contamination at the individual fish level. δ^{15} of chironomids increased with site depth, and $\delta^{13}C$ generally declined. In contrast, *Mysis relicta* showed no relationship between its isotope ratios and site depth. The isotope ratios in the pooled fish sample were related to fish capture depth, growth rate, and total length. We found no relationship between mercury contamination and our isotopic assessment of foraging depth in the fish. A significant relationship between existed between fish mercury contamination and our i otopic assessment of trophic position, suggesting that fish that feed deeper and/or higher up the food web are more contaminated.

Seasonal movement And Habitat Use By Sub-Adult Bull Trout In The Upper Flathead River System, Montana[AFS]

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Despite the importance of large-scale habitat connectivity to the threatened bull trout, little is known about the life history characteristics and processes influencing natural dispersal of migratory populations. We used radiotelemetry to investigate the seasonal movements and habitat use by subadult bull trout (e.g., fish that emigrated from natal streams to the river system) tracked for varying periods from 1999 to 2002 in the upper Flathead River system in northwestern Montana. Telemetry data revealed migratory (n = 32 fish) and nonmigratory (n = 35) behavior, indicating variable movement patterns in the subadult phase of their life history. Most migrating subadults (84%) made rapid or incremental downriver movements (mean distance, 33 km; range, 6-129 km) to lower portions of the river system and to Flathead Lake during high spring flows and as temperatures declined in the fall (to below 12 °C) and winter (to below 4 °C). Conversely, some migrants (16%) moved upriver (mean distance, 22 km; range, 6-46 km) as flows subsided following spring runoff and as mean daily temperatures gradually rose above 7 °C. Bull trout subadults used complex daytime habitat throughout the upper river system, including deep runs that contained unembedded boulder and cobble substrates, pools with large woody debris, and deep lake-influenced areas of the lower river. Our data indicate that bull trout exhibited variable movement patterns in the subadult phase of their life history, and that water temperature and river discharge appeared to influence movement. Results elucidated importance of maintaining natural connections and a diversity of complex habitats over a large spatial scale to conserve the full expression of life history traits and processes influencing natural dispersal of bull trout populations. Managers should seek to restore and enhance critical river corridor habitat and remove migration barriers, where possible, for recovery and management programs.

Age And Growth Of Bull Trout In The Lower Clark Fork River System And Factors Affecting The Relative Abundance Of Migratory And Resident Life History Forms[AFS]

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Bull trout exhibit resident, fluvial, and adfluvial forms, sometimes in sympatry. The mechanisms driving bull trout life history variation are poorly understood but important to management of this threatened species. In this study, we characterize the age structure of 17 bull trout populations, including age at outmigration and age at maturity. We compare age structures and growth rates between and among resident and migratory populations and discuss patterns across the study area. We examine relationships among life history form, age characteristics, and environmental variables including temperature, productivity, stream size, fish densities, population structure, species composition, and presence of migratory barriers. These findings will enable managers to better determine whether life history variation in bull trout populations can be directed to favor production of resident or migratory forms.

Adult Bull Trout Response To Release Above A Dam On The Clark Fork River, Montana[AFS]

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Electofishing and a fish ladder/trap were used to capture 129 adult bull trout in the Clark Fork River downstream of Cabinet Gorge Dam, Idaho, from 2001 through 2004. A portion of these fish were presumed to have migrated downstream as juveniles from Montana tributaries through or over the dam and reared in Lake Pend Orielle, Idaho (16 km downstream of Cabinet Gorge Dam). Captured adult bull trout were surgically implanted with radio transmitters, transported upstream by fish tank truck, and released at two sites in Cabinet Gorge Reservoir, Montana (13 and 20 km upstream of the dam). Of the 129 bull trout successfully released in Montana, 78 were detected in tributaries to cabinet Gorge Reservoir during the spawning season, September and October. A total of 26 bull trout transported from Idaho were recaptured in spawning tributaries, transported downstream, and released in the Clark Fork River, Idaho. Another 37 bull trout were documented to have volitionally passed downstream through turbines or over Cabinet Gorge Dam, a minimum of 23 of those that likely survived turbine passage. Genetic assignments to tributaries of origin were accomplished for most fish captured over the 4-yr study. Of the 112 viable genetic samples collected below Cabinet Gorge Dam, 90 percent were assigned to upstream tributaries. Radio receivers at Noxon Rapids Dam (31 km upstream from Cabinet Gorge Dam) detected 40 of the 129 bull trout in the dam tailrace area, 70 percent of these fish originated upstream of the second dam on the Clark Fork River. In 2004 a "Rapid Response Genetic Analysis" was employed to determine natal tributary of origin of captured fish prior to transport above Cabinet Gorge Dam.

Thermal Requirements Of Westslope Cutthroat Trout[AFS]

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Westslope cutthroat trout have declined throughout their native range in the orthern Rockies and were considered for listing under the federal Endangered Species Act. Water temperature is widely regarded as playing a key role in determining their persistence, but specific thermal optima and lethal levels for this cutthroat trout subspecies have not been precisely defined. This laboratory study used the acclimated chronic exposure method to determine thermal optima and tolerances for westslope cutthroat trout and for rainbow trout a potential nonnative competitor now occupying much of the former range of westslope cutthroat trout. Optimum growth temperature for westslope cutthroat trout (13.6° C; 95% CI, 10.3-17.0 °C) over the 60-d test period was, unexpectedly, similar to that of rainbow trout (13.1 °C; 95% CI, 6.8-18.2 °C). However, rainbow trout grew significantly better at temperatures below 6.8 °C and above 20.8 °C. Increased growth by rainbow trout at these temperatures could be the mechanism by which rainbow trout are out-competing westslope cutthroat trout. In addition, the ultimate upper incipient lethal temperature (temperature at which 50% of the population can survive for 60-d) for rainbow trout (24.2 °C; 95% CI, 22.9

– 25.4 °C) was 4 °C higher than that for westslope cutthroat trout (19.7 °C; 95% CI, 19.1-20.3 °C). The higher upper temperature tolerance of rainbow trout may account for its increased occurrence at lower elevations than cutthroat trout. The thermal requirements established in this study can help guide protection and restoration efforts for this unique cutthroat trout subspecies.

Status Of Burbot In Montana[AFS]

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In Montana, burbot are native to the Kootenai, Missouri, and Saskatchewan drainages. To assess the distribution and status of burbot in Montana, we requested population characteristic data (e.g., length-weight data, catch per effort, population estimates) from fisheries biologists throughout the state. In addition, we surveyed biologists regarding their opinions about the status of burbot in their area. We were able to obtain and analyze trend data from several populations throughout Montana, but most of these data were from incidental catches while biologists were sampling for other species. Thus, low sample size was a common problem with these data and made any conclusions regarding population trends relatively unreliable. Fisheries biologists throughout the state also agreed that data was limiting to make any recommendations regarding the status of burbot in Montana. Where standardized long-term data sets existed, burbot population abundance was highly variable and likely related to discharge. We recommend that standardized sampling be incorporated for monitoring burbot populations and that sampling for burbot be specifically targeted in areas that are identified as potential spawning and rearing habitat. Despite that burbot are native to much of Montana, little is known about their overall status, usefulness as an indicator species, and function in fish assemblages.

Seasonal And Diel Distribution Of Lake Trout In Lake Mcdonald, Glacier National Park[AFS]

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Bull trout have suffered a dramatic population decline since the establishment of non-native lake trout in Lake McDonald, Glacier National Park (GNP). In an attempt to prevent further decline of this population, GNP is considering implementing a lake trout suppression program. We used ultrasonic telemetry to examine the spatial and temporal distribution of lake trout, thus providing information critical to developing a successful suppression program. We relocated 36 lake trout 1137 times from June through November 2003 and March through November 2004. Tracking was conducted at all times during a 24-h period. Lake trout total length varied from 508-859 mm and averaged 629 mm (SE = 13.1). Mean depth of lake trout was shallowest (14.0 m, SE = 2.2) in May and deepest (25.2 m, SE = 1.03) in September.

Mean depth increased from May through September as thermal stratification became more pronounced. During stratification, lake trout occupied depths in the thermocline and upper hypolimnion where temperatures varied from 6-12 C and dissolved oxygen levels were ~9-12 mg/L. Additionally, lake trout were found in the pelagic zone more frequently during stratification than in spring and autumn. Spawning commenced in late-October (water temperature <11 C), and lake trout aggregated in shoreline habitats with clean cobble and rubble substrates. Mean fish depth during spawning was 16.1 m (SE = 1.4). These data illustrate patterns in the spatial and temporal distribution of lake trout and will be useful for developing methods to reduce lake trout abundance in Lake McDonald.

A Spatially Explicit Approach For Evaluating Relationships Among Coastal Cutthroat Trout, Habitat, And Disturbance In Headwater Streams[AFS]

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Headwater stream systems are complex networks that form a physicochemical template governing the persistence of aquatic species such as coastal cutthroat trout. Individual portions of the network can function as conduits or receptacles for sediments, wood, and nutrients from terrestrial areas. Temporal and spatial changes in the delivery of these constituents can substantially alter the habitat template and its ability to support this native fish. Our study of 40 mid-sized watersheds (500-1500 hectares) in western Oregon is providing new insights into the factors affecting the distribution of coastal cutthroat trout within, and among, headwater stream networks. For example, data suggest that coastal cutthroat trout move throughout the accessible portions of headwater streams for reproductive, feeding, and refuge purposes. Fish congregate in these areas and form local populations that may exhibit unique phenotypic and genetic attributes. At times, coastal cutthroat trout move into larger downstream portions of the network where they may contribute to the persistence and genetic character of anadromous or local potamodromous assemblages. Variations in distribution patterns among watersheds reflect diverse environments and selective factors, such as geology, geomorphology, climate, and land-management history. According to our research findings, human activities that impede movement among suitable habitat patches can have lasting consequences for local assemblages of coastal cutthroat trout and may ultimately affect persistence.

Biological Sciences – Terrestrial

Beaver Effects On Watershed Structure And Gene Flow For Columbia Spotted Frog Populations In Southwestern Montana[TWS]

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Beaver have long been recognized as animals with a unique ability to strongly alter their environment. In southwestern Montana, historical pressure on beaver populations has altered the hydrology of many watersheds. At the same time, amphibian populations that depend on lentic habitat might be declining. Whereas multiple factors are clearly behind these declines, habitat fragmentation due to the loss of beaver-created habitat may be one of them. Although research has shown a link between diversity of aquatic fauna and beaver activity, a landscape comparison of population connectivity for a species using beaver-created habitat has not been attempted. This study contrasts watersheds with and without beavers to investigate possible differences in habitat composition and configuration for pond breeding amphibians. We queried a database consisting of hundreds of randomly selected watersheds developed for monitoring lentic amphibian distribution to examine the type, number, and distances between water bodies serving as potential breeding sites for Columbia spotted frogs. To test the relative importance of beaver-created lentic habitat for gene flow within and between populations of Columbia spotted frogs, we selected three pairs (beaver and non beaver) of watersheds, and genetic and habitat data from all known breeding sites were collected. Individual samples were analyzed at six microsatellite loci and estimates of population connectivity were inferred based on the number of shared alleles.

Veterinary Interventions, Management, And Conservation Of The Black Rhinoceros In Zimbabwe[TWS]

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Wild populations of black rhinoceros (*Diceros bicornis*) in Africa have suffered catastrophic declines over the past 3 decades as a result of illegal hunting for horn. The black rhino received CITES Appendix I listing in 1977. However, between 1970 and 1992, 96 percent (~63,000 animals) of the wild population was killed. Since the late 1990s certain populations have been showing signs of recovery with a total estimated wild population of 3610 in 2005. The Zimbabwean population suffered a correspondingly precipitous decline reaching a low of ~300 animals by 1992. A 2004 survey, however, revealed a population of 536. Conservation measures responsible for the current increasing trend, detailed in the Zimbabwe Black Rhino Conservation Strategy and instituted in 1992, include outreach and education, capture and translocation, dehorning, creation of Intensive Protection Zones, increased law enforcement, improved monitoring techniques, and establishment of a viable ex-situ population. Improved capture techniques and judicious use of long-acting neuroleptics have greatly improved the success of these programs, reflected in overall mortality rates associated with capture of < 1 percent. Some approaches have been controversial and

expensive and dehorning as a conservation technique was discontinued in 1996. The threat of poaching remains, however, and current conservation efforts remain at a low level due to political instability, lack of government support, and inadequate operating funds. It is proposed that sustainable utilization of the black rhinoceros through live sales and sport hunting would contribute significantly to rhino conservation by generating revenue suitable for reinvestment in conservation programs.

Relative Contributions Of Prey, Physical Condition, And Habitat Structure To Predation By Cougars And Wolves In Southwest Montana[tws]

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Vulnerability to predation resulting from direct or indirect effects of physical condition allegedly is a widespread phenomenon in predator-prey systems. Yet there is a paucity of empirical support for the putative linkage between predator detection and avoidance behaviors and relative or absolute body condition. We examined patterns of prey selection by sympatric cougars (*Puma concolor*) and wolves (*Canis lupus*) to determine (i) if prey killed by wolves were in poorer absolute physical condition relative to prey killed by cougars and (ii) if declining relative physical condition resulted in prey becoming risk-insensitive, thus making them more vulnerable to predation. Additionally, we assessed the role of vegetative structure in facilitating predation. Since 2003, we have documented prey characteristics and kill site attributes in the northern Madison range of southwest Montana. Mule deer (*Odocoileus hemionus*) were the primary prey for cougars, whereas elk (*Cervus elaphus*) were the primary prey for wolves. Wolves selected prey in relatively poor absolute physical condition compared to prey selected by cougars. However, declining relative condition in mule deer may have contributed to vulnerability to predation by cougars. Wolf kills occurred in habitat that was more reflective of the study area than cougar kills. These disparities suggest that patterns in species-specific hunting behavior and prey selection differ considerably, and prey likely forage in a risk-prone manner as physical condition declines.

Looking Back To See Our Future: Managing Bison In The Greater Yellowstone Ecosystem[tws]

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Bison management within and near Yellowstone National Park (YNP) has been a source of public controversy since the park was established in 1872. An early census in 1880 indicated that about 600 wild bison remained in YNP, and sport hunting became illegal in the park by 1883. Because of an intractable bison-poaching problem, the U.S. army managed Yellowstone from 1886 until 1918. By 1902 only 40-50 bison remained within YNP, so the herd was augmented with 21 bison from Texas and Montana herds. Introduced bison were carefully husbanded at holding facilities in Mammoth and the Lamar Buffalo Ranch. Until 1967 YNP's bison were intensively managed, which frequently included herding or transporting among various habitats within YNP to enhance genetics, distribution, and

demographics. When brucellosis was identified in bison in 1917, various attempts were made to eradicate the disease: (1) bison testing positive for brucellosis for several decades were sent to slaughter; (2) in the early 1960s bison testing negative for the disease were vaccinated; and (3) various culling measure were implemented that included transplanting bison testing negative for brucellosis to habitats outside of YNP or to commercial bison ranches. After 1967, when the National Park Service emphasized managing free-ranging bison through natural population regulation, all of these activities ceased. Despite 50 years of intensive manipulation and 30 subsequent years of minimal management that coincided with periodic culling outside the park, YNP's bison herd continues to thrive and now numbers > 4200 animals. Management applied to YNP bison over ~100 years has significantly impacted genetics, distribution, movements, and numbers of the present population. We thoroughly examined management history of YNP bison to identify future management tools. The robust nature of YNP's bison herd and its diverse genetic make-up offer an appropriate source for future restoration projects. Chronic presence of brucellosis is the only significant factor inhibiting use of YNP herds for restoration. We propose that modern testing and rigorous monitoring protocols be developed and tested to explore the feasibility of extracting brucellosis free bison from YNP. Removing bison from this robust population through quarantine procedures to establish new conservation herds is consistent with historical models of wildlife conservation, the history of restoration projects using bison and other wildlife from YNP, and a need to regulate numbers and distribution of bison in this system.

Assessing The Success Of Swift Fox Reintroductions On The Blackfeet Indian Reservation: Project Update[TWS]

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From 1998 to 2002, the Blackfeet Indian Nation and Defenders of Wildlife reintroduced 123 captive-reared swift fox on the Blackfeet Indian Reservation in Montana. Our current research project is directed at determining whether these reintroductions have established a self-sustaining population of swift fox on tribal lands. To obtain matrix-based growth rates for the fox population, we radio-collared > 60 animals and to date have known fates for 23 individual foxes. From 2003 to 2004 the fox population on the Reservation grew at a rate of 7 percent and projected growth for 2004-2005 was approximately 15 percent. Most swift fox mortality can be attributed to coyotes (57%) and raptors (22%). Also, because we thought that more releases might possibly be needed, we implemented a small mammal survey across the Reservation in an effort to estimate relative abundance of prey. During summer 2004, we placed 20 trap grids at random locations and captured 169 animals with deer mice (61%) and Richardson's ground squirrels (21%) comprising the majority of captures. This research project will be completed in autumn 2005.

West Side Story: Genetic Population Structure Of Elk Gangs In The Northern Rocky Mountains[TWS]

Jocelyn L. Aycrigg and Edward O. Garton, Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844-1136

Managing and conserving wildlife populations over large spatial areas challenge wildlife and conservation biologists to take new approaches. Large mammals, such as Rocky Mountain elk (*Cervus elaphus nelsoni*), exemplify this challenge because they have seasonal and annual ranges that cover areas the size of watersheds or sub-basins, respectively. To meet

this challenge of managing elk, we performed spatial analysis of populations at the landscape level using the metapopulation concept and a genetic analysis approach. We collected tissue samples of individual elk from across the northern Rocky Mountains and genotyped each individual using microsatellites at multiple loci. We examined genetic population structure with 5 approaches. Individuals were assigned to local populations based on their relative similarity or dissimilarity to each local population using genotypes and geographical location. Our results indicated little genetic differentiation between specific regions. Understanding the genetic population structure of elk from a metapopulation perspective provides both theoretical and practical benefits for managing and sustaining this species.

Assessing The Roles Of Nutrition And Habitat Selection In The Decline Of A Bighorn Sheep Population [TWS]

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Reintroduced populations often face the hazard of insufficient or inadequate habitat in their new range. Bighorn sheep herds in the Jacks Creek area of Owyhee County, Idaho, increased steadily from initial releases in the late 1960s until the early 1990s but have recently exhibited a precipitous decline. Habitat deficiencies, specifically inadequate forage or escape terrain, have been implicated as potential causes for this decline. We assessed the extent to which variation in use and availability of habitat resources across three drainages in the study area were correlated with variation in lamb production and ewe and lamb survival. Radio-telemetry indicated that females in each drainage represented distinct herds. Sheep in the herd exhibiting the highest lamb survival were more often located feeding at sites dominated by cliffs and shrubs, whereas sheep in the herd exhibiting the lowest lamb survival fed at sites dominated by loose rock and grass. Availability of rugged terrain did not differ between the two drainages. In 2003, fecal nitrogen content also differed significantly among herds; we obtained the highest mean value from the herd exhibiting the highest lamb survival. Analyses of arrangement, size, and interspersion of habitat patches are currently underway. Preliminary results suggest that selection of habitat features was related to lamb survival, and therefore

may have played a role in this population's decline.

Distribution Of Pygmy Rabbit On Public Lands In Southwest Montana[TWS]

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Pygmy rabbit (*Brachylagis idahoensis*) records in southwest Montana date back to 1918 with the majority of the historical range occurring in Beaverhead County. Current distribution in Montana does not vary from hi torical distribution, but rabbits occupy different sagebrush habitat types than previously documented. Past studies focused on basin big sagebrush (*Artemisia tridentata tridentata*) habitat in drainages and swales that provide taller sagebrush structure and on deeper, friable soils at elevations of 4500 to 6700 ft. Recent survey efforts in Dillon Field Office (DFO) have documented pygmy rabbits ≤ 8000 ft in mixed agebrush habitat types of mountain big sagebrush (*A. t. vaseyana*), three tip sagebrush (*A. tripartita tripartite*), and Wyoming big sagebrush (*A. t. wyomingensis*) across the landscape in a variety of soils suitable for burrowing. Pygmy rabbit. We noted burrows and pellets while doing sage grouse habitat surveys during summers 2003 and 2004. In 2004 we began inventorying

habitat for which few records existed, or pygmy rabbits had not been documented in the past, to refine distribution maps. These inventories indicated a more widespread and common occurrence than was previously noted from surveys of the mid-1990s. Daubenmire and line intercept methods were used to characterize habitat for sage grouse and pygmy rabbits and determine shrub canopy cover and vertical structure. Pygmy rabbit occurrence in this area appeared more dependent on sagebrush structure and patchiness rather than on species composition.

The Montana Challenge: Remaining The Last Best Place For Fish And Wildlife In A Changing West[TWS]

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Montanan's relationship to fish and wildlife, and their ties to the natural landscape, are defining characteristics of the state and its people. From our long-time ranchers in their sturdy pick-up trucks to today's emergency-room nurses riding titanium-framed bicycles, we all seem to know times are changing. To better understand the shifts and changes in Montana's cultural and economic landscape, 30 years of disparate economic, social, demographic, recreational, political, and legal information was compiled. The information shows that a new and important economic engine is operating along side the state's established commodity-based industries. For today's Montanans, who are fueling the state's growth and economic vitality, the West's natural landscapes and fish and wildlife resources are proving to be a key consideration in where to live and how to make a living. The challenge for wildlife managers is to recognize the opportunities this new social and economic sector represents to conservation while maintaining, restoring, and conserving the natural landscapes that create it.

Spatial Dynamics Of The Central Yellowstone Bison Herd: Use Of A Road System And Travel Network[TWS]

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The topic of winter recreation in Yellowstone National Park (YNP) has presented many controversial wildlife management issues. At the forefront of the debate is the effect of road grooming—done to facilitate over-snow vehicle travel—on bison (*Bison bison*) ecology. Bjornlie and Garrott (2001) conducted a two-year study from 1997-1999 on YNP's central bison herd and concluded that groomed road use by bison on the Madison-Gibbon-Firehole (MGF) winter range is neither sought out nor avoided and that roads are not a major influence on bison ecology—results contrary to popular belief. As an extension of Bjornlie and Garrott's (2001) research, data were collected from November to May from 1999-2004 on bison movements, road travel, distribution, and behavior in the MGF. In addition, daily snow water equivalent (SWE) estimates and related covariates were modeled at 28.5-m spatial resolution from 1997 to 2004. We assessed causes of temporal variation in bison travel—both

on-and off-road—by evaluating competing hypotheses to determine the relative contributions of snowpack, road grooming, density-dependence, and forage accessibility on magnitude of travel. Using multiple linear regression output and model comparison techniques, the best-supported models indicated that road travel is positively affected by SWE and the number of bison in the MGF but negatively influenced by road grooming. Likewise, bison density-dependence and SWE variability positively affect the magnitude of off-road travel. Our finding coincide with Bjornlie and Garrott (2001) that suggest that a suite of abiotic and biotic factors positively affected bison travel rather than road grooming.

Canada Lynx And Wolverine: Five Years Of Conservation [TWS]

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Canada lynx (*Lynx canadensis*) were listed under the Endangered Species Act (ESA) in March 2000 as threatened. Wolverine (*Gulo gulo*) were petitioned and determined to be not warranted for federal listing in August 2003. Independent of these different legal histories, national interagency conservation programs for these 2 species have been handled in a similar fashion by state and federal agencies with management responsibility. The Lynx and Wolverine Steering Committee, consisting of state and federal members, continues to provide oversight for the conservation of these 2 carnivores. For Canada lynx, a nationwide management document entitled, Canada Lynx Conservation Assessment and Strategy (LCA , August 2000) provides guidance for project design in mapped lynx habitat. Conservation Agreements among USDI Fish and Wildlife Service, USDA Forest Service, and USDI Bureau of Land Management provide guidance for the interim period between the LCAS and its incorporation into agency management plans. Lynx have been surveyed across their historic range in the lower 48 states and found to exist in 5 primary areas. For wolverine, there are 2 teams developing a conservation strategy and science report. Research is underway in selected areas of historic wolverine range. We summarized conservation programs and status of both species on public lands in the contiguous United States in relation to species status, ongoing management programs, and research. Potential threats and future conservation needs for both species and habitats were presented.

Natal Dispersal Of Juvenile Pygmy Rabbits: Preliminary Results[TWS]

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Natal dispersal is an important aspect in maintaining wildlife populations. Habitat fragmentation and a tendency for populations to exhibit local extinctions make knowledge of dispersal capabilities of pygmy rabbits (*Brachylagus idahoensis*) critical for conservation planning. However, due to logistical constraints, natal dispersal has not been studied in pygmy rabbits. We studied movements of juveniles from shortly after emergence from

natal burrows (May-July 2004) through early January 2005 as part of an ongoing study of juvenile dispersal. We trapped 12 males and 14 females at approximately 0 to 4 weeks post emergence. We attached 1-g glue-on radio transmitters to fur between the shoulder blades. Glue-on transmitters were replaced with 5-g radio collars after juveniles reached body mass of ~300 g. Individuals were radio-tracked twice/week until mid August, after which rabbits were tracked once every two weeks. Preliminary data suggested that both male and female juveniles tended to be relatively sedentary until about 6-8.5 wks of age when many made rapid long-distance movements ranging from 0.8 to 6.2 km for males and 2.9 to11.8 km for females. However, movements of several juveniles of both sexes during that time period were ≤ 200 m. Median natal dispersal distances for males and females >8.5 weeks of age were 1.1 and 4.8 km, respectively. Mortality rates for males and females through January 2005 were 67 and 64 percent, respectively. Although preliminary, these results indicated that pygmy rabbits regularly disperse farther than previous movement data suggest, increasing the potential for connections among populations.

Chronic Wasting Disease: National And State Implications[tws]

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Chronic wasting disease (CWD) has affected wildlife management programs nationwide. In some states, allocation of expenditures for CWD management has been detrimental to funding other important wildlife management programs. The presence of CWD in a state may also reduce hunter participation thereby reducing the effectiveness of one of wildlife management's most effective tools, the big game hunter. The long-term effect of CWD on wildlife populations is still being evaluated. While Montana has not found CWD in its free ranging wildlife populations, we expect surveillance efforts at some point to identify the disease within our borders due to our proximity to states and provinces where CWD has been diagnosed. What is the current state of knowledge about CWD: its distribution, pathology, epidemiology, transmission, management, and control? What is Montana FWP doing to prevent CWD or to prepare to manage it when it is found within our borders? Current results from national and state surveillance programs as well as considerations for management of CWD were presented.

Bison Demography In Yellowstone National Park 1902 To Present[tws]

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Once nearly extirpated across its range, the population of American bison (*Bison bison*) in Yellowstone National Park (YNP) has increased from just 22 animals in 1902 to > 3000 in modern times. This conservation success came about as a result of shifting management paradigms to correspond with population size of the bison herds. Park managers initially used intense animal husbandry practices to foster herd growth. As herd size increased, the USDI National Park Service implemented a free-range system of management known as natural regulation. Most recently, several agencies employ periodic removals when bison leave park boundaries and come into conflict with local livestock operations. Today, we have over a century of bison population information on the Northern and Central herds. We analyzed 47 years of ground count data together with 51 years of aerial count data to investigate changes in population growth rates. We used piecewise log-linear analysis of count data to estimate

the population growth parameter λ during periods of uninterrupted growth, and we used a series of ratio estimators to estimate λ during periods in which frequent removal occurred. We also examined effects of snowfall, summer precipitation, and elk population numbers on population growth rates of bison. Our research provides a context to interpret controversial bison movements outside the park and demographic evidence that bison have changed their spatial use patterns within YNP.

Identification Of Functional Corridors With Movement Characteristics Of Brown Bears On The Kenai Peninsula TWS

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We describe a technique to identify functional corridors using animal movement characteristics across a landscape. We use GPS locations from brown bears (*Ursus arctos*) on the Kenai Peninsula to illustrate the technique. We derived movement density, movement speed, and angular deviation of movement from paths drawn between locations and use a cluster analysis to classify the landscape into non-habitat, primary habitat, and corridors. We examined differences among landscape types with a classification tree. We assess the influence of frequency of locations and scale on the number and size of corridors identified. This corridor identification technique will help managers move beyond the theoretical discussion of corridors and linkage zones to management of landscape features to preserve connectivity.

Why Did The Turtle Cross The Road? Consequence Of Habitat Fragmentation On A Painted Turtle Population TWS

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Human-induced fragmentation of landscapes is a major threat to species conservation. Highways and other road systems can affect wildlife populations directly through highway mortality and indirectly through habitat loss and decreasing habitat connectivity. Semi-aquatic turtles are especially vulnerable to this type of fragmentation because they use terrestrial landscapes for nesting and seasonal movements but have limited abilities to move effectively across the landscape. Although it is widely believed that freshwater turtles have declined in abundance due to habitat loss and fragmentation, few quantitative studies have documented such a relationship. I'm studying the effect of human-induced fragmentation on a population of western painted turtles (*Chrysemys picta bellii*) in a wetland ecosystem in the Mission Valley, Montana. Fragmentation is likely to increase given pending reconstruction of U.S. Highway 93, which bisects this network of wetlands. Current effects of the highway on turtle population demography and connectivity are unknown. I characterized demographics of the turtle population by estimating pond-specific abundance, sex ratios, and stage-class structure. To gain an understanding of the level of connectivity, movement patterns and road mortality rates will also be examined. Summarizing all 3 yrs of fieldwork (2002-2004), I marked a total of 2302 individuals and have recorded >10,200 captures. All individuals were

measured, weighed, tagged, and released into the original pond of capture. I've recorded 841 males, 783 females, and 678 juveniles (sex undetermined). Preliminary results of the road mortality data indicated 1043 turtles were killed during the study.

Impacts Of Tourism On Behavior And Demography Of Olympic Marmots[TWS]

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Relatively little is known about the impacts of hiking and other recreation on small mammals, whose size and life-history may constrain their responses to disturbance. We tested for effects of recreation pressure on survival and reproduction in Olympic marmots (*Marmota olympus*), a large ground-squirrel that has disappeared from several areas of high human activity levels. We assessed the degree to which anti-predator and foraging behavior and demographic rates differed between heavily visited and unvisited sites. Marmots at heavily visited sites displayed behavioral signs of habituation; they allowed hikers to approach significantly closer before retreating to their burrows, and remained in their burrows for less time after disappearance of hikers. During two-minute focal observation periods, heavily visited marmots looked up more often while foraging although length of each look was the same as that seen in unvisited marmots. By foraging longer, visited marmots did not appear to compensate for this difference. In support of the assumption that energy intake is not limited by human disturbance, marmots at both types of sites had comparable reproductive rates and were in similar body condition as measured by seasonally adjusted body mass. Survival rate estimates for radio-tagged marmots appeared only slightly higher at the low-visitation sites. All these results are consistent with the hypothesis that marmots adjust their behavior to accommodate current levels of tourism without incurring a demographic penalty; however, the possibility that high visitation may decrease marmot survival rates should be investigated further.

Bat Use Of Highway Bridges In South-Central Montana[TWS]

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Bat use was evident at 78 of 130 highway structures examined during summer 2003 in Carbon, Stillwater, and Yellowstone counties, Montana; 66 were used apparently exclusively for night roosting, and 12 were day roosts. Use of highway structures was widespread among highway categories (Interstate: 73.2%, Primary: 47.2%, Secondary: 57.1%, Local/State Maintained: 60.0%). Day roosts were found in all system categories, but relatively more so in the Local/State Maintained category, and all maternity colonies (4) were in this category. Use of bridges and intensity of use at night roosts were generally unrelated to landscapes within 3 km (1.86 mi) of structures. Only mean percent forest cover was significantly greater around day roost structures, but substantial overlap among unused, night roost, and day roost categories indicated the pattern was a trend and not the major influence on structure use by bats. All day roosts were found within 8 km (5 miles) of riparian corridors. Bats used 75.9 percent of concrete structures, 37.5 percent of steel structures, and 31.6 percent of wooden

ones. Day roosts were not found in steel structures; three of four maternity colonies were in wood bridges. Slab bridges were the least preferred concrete spans. Day roosting site in concrete bridges included accessible expansion joints between cast-in-place and T-beam bridge sections, the longitudinal slots on the underdeck of parallel box-beam structures, and the space between two abutting bridge lanes. Day roosts in wood bridges included the narrow space between parallel girders, and spaces between wood supports under the deck where railing posts were anchored.

Development And Application Of A Mass Estimation Method: Weddell Seals As A Case Study[TWS]

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In contrast to terrestrial systems where abundance of food resources of large predators is generally easily monitored, food resources of large marine predators are difficult to monitor. As a surrogate measure of marine predator food availability, researchers have used both direct and estimated measurements of body morphometrics and mass. However, subsequent uses of estimated mass measurements have failed to explicitly incorporate error variance around estimated values. Using the Weddell seal (*Leptonychotes weddellii*) population in Erebus Bay, Antarctica, we present development of a mass estimation method and techniques that incorporate prediction error variance around mass estimates. The equipment and procedures were developed for estimating mass of Weddell seals by taking morphometric measurements from digital photographs. Mass measurements were collected following initial photographic sampling so that regression models correlating known mass with photogrammetric measurements could be built. To select the model with the narrowest prediction intervals, we used predicted sum of squares (PRESS) as the model selection criteria. Resulting regression models predict mass of adult female seals to within ±13.8 percent of estimated mass, and ± 25.9 percent of estimated mass for pups. Differences in mass transfer between 7 experienced and 3 inexperienced maternal females and their pups were successfully tested using explicit incorporation of prediction error variance around mass estimates. We suggest that future use of mass estimations should include prediction error variance and that these techniques be used to explore links between variation in population parameters of the McMurdo Sound Weddell seal population and environmental variation.

Evaluation Of Hunter Management Strategies Utilized By Montana's Block Management Program[TWS]

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The Block Management Program, initiated in 1985, was implemented to encourage private landowners to provide free public hunting acce s. Currently, the program is very successful with >1200 landowners enrolling >8.7 million acres, and providing > 400.000 hunter days of free public hunting. Surveys were sent to 423 landowners (303 returned) and

1636 hunters (976 returned) to evaluate current perceptions of block management area (BMA) users. Preferences, expectations, and satisfaction levels were determined by calculating frequencies and means using SAS 8.2. Landowners were satisfied with permission methods used, numbers of hunters received annually, and hunter limit and travel restriction rules utilized, but satisfaction levels differ when comparing relative game abundance and harvest success between geographic regions. Hunters are very successful in gaining permission to BMAs and are satisfied with travel restrictions encountered, but satisfaction levels differ when comparing amounts of other hunters seen, game abundance, and harvest success between BMA types and geographic regions. Program success is evident by levels of satisfaction with various hunter management tools evaluated by this study, but some areas need improvement. This study identified management strategies that should be continued and strategies that can be improved on existing BMAs. It also provided insight for designing strategies that meet specific preferences and expectations of program users when developing new BMAs. Implementing these findings will allow the Block Management Program to become an even greater success in providing free public hunting access to private land than it is today.

Developing A 4-H Wildlife Program In Montana[TWS]

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There is no existing wildlife habitat educational program offered to Montana youth. Montana 4-H'ers excel in livestock raising and judging, sewing, foods, demonstrations, and even skateboarding. Unfortunately, the state with the greatest wildlife diversity in the lower 48 has a very under-developed wildlife program. Nationally, 30 states have participated in the 4-H Wildlife Habitat Evaluation Program (WHEP), a program currently unavailable to Montana youth. The MSU Extension Wildlife Program has received a number of e-mails and telephone calls indicating a need for a well-developed wildlife program offered through the framework of Montana 4-H. In June 2004, a state committee was formed to address this concern, and the result is the Montana 4-H Wildlife and Habitat Education Program. Montana 4-H WHEP will help youth strengthen self-concepts and character through interaction with other young people. It will teach essential life skills such as oral and written communication, critical thinking, teamwork and decision-making. Montana 4-H WHEP will foster relationships between professional wildlife and fisheries biologists, volunteers, parents, youth, teachers, farmers and ranchers. The mission of Montana 4-H WHEP is *...to foster critical thinking and development of life skills through exposure of various concepts of wildlife management, including: wildlife biology, population management and habitat requirements and enhancement.*

Wildlife Abundance In Reponse To Leafy Spurge Control With Sheep[TWS]

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Although much research has been completed on impacts of cattle grazing on wildlife habitat, available information documenting effects of sheep grazing on wildlife habitat is limited. In cooperation with the Montana Sustainable Rangeland Livestock Task Force, the MSU Extension Wildlife Program began a long-term monitoring effort in 2003 to determine impacts on wildlife habitat and wildlife abundance in response to control of leafy spurge with

sheep. Data were collected during spring and fall of 2003 and 2004 at 3 locations. Each site consisted of a grazed and non-grazed area at which we sampled small mammal abundance with Sherman live traps in a mark-recapture protocol. Avian survey were conducted from a fixed point at each site. Preliminary results indicated no differences in abundance of small mammals and birds after the first year of sheep presence. In 2003, leafy spurge was reduced by an average of 61 percent in areas where sheep grazed. Vegetative data will also be used to evaluate forage availability for large ungulates. Although sheep grazing has been demonstrated to be an effective and economical means of controlling leafy spurge, what effect this may have on wildlife habitat remains unclear. Trends in wildlife populations will not become apparent immediately following grazing by sheep as native plant communities may take years to recover after removal of an invasive weed.

Carnivore Conservation Trust: A Model For Joint Private-Government Funding To Conserve And Manage Carnivores In North America[TWS]

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Support for restoring and conserving carnivores within wildland areas of Canada, the U.S., and Mexico is significant, and many citizens value carnivores as an integral part of ecosystems. Despite this support, cost of recovery and management of carnivores is increasingly difficult for federal, provincial, and state wildlife agencies, and discretionary funds for wildlife including imperiled species have declined. Firearm sales proceeds allocated for traditional big game management and research on harvestable populations used for non-game wildlife including protected carnivores has met resistance from wildlife officials, and hunting constituencies in states and provinces where large wildland enclaves for managing wide-ranging and rare carnivores remain intact. For carnivore conservation to succeed, we believe funding must be consistent and comprehensive in scope, address practical problems and solutions that sustain and conserve both humans and carnivores, be capable of shaping and improving management policies over time, and be equitable to diverse community interests. To enjoin public support with federal, provincial, and state efforts for carnivore research, management, and public education, we propose a joint private-government stamp for meeting carnivore conservation costs. We suggest this effort be modeled similar to the conservation program for waterfowl in Canada and the U.S., e.g. North American Waterfowl Management Program, and be international in scope. We use geographically separate wolf conservation efforts across the United States, Canada, and Mexico to elucidate how funds from a Carnivore Trust and Conservation Stamp could be generated from joint private-public investments and applied to carnivore conservation and management in North America.

Conservation Of Native Canada Lynx In Northwest Wyoming: Promise And Pitfalls Of Agency Management[tws]

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Canada lynx (*Lynx canadensis*) were listed in 2000 as a threatened species, owing in part to a lack of provisions in agency land management plans for lynx protection and conservation. Effective implementation of the Endangered Species Act (ESA) depends heavily upon commitment of federal agencies to enforce its provisions. We evaluated implications of ongoing and proposed timber sales and recreation management on a Canada lynx subpopulation on the Bridger-Teton National Forest in the Wyoming Range of northwestern Wyoming. Although distant from established lynx populations, historical records and distributional patterns suggest that lynx in the Wyoming Range represent an indigenous but geographically isolated population that persists, in part, as a consequence of past selective harvest of stands that were 'tie-hacked' in the early 1900s. Using a LANDSAT vegetation image and relocations of radio-collared lynx (1996-2002), we examined patterns of lynx habitat use and assessed changes to vegetation due to timber harvest. We suggest that past selective timber harvest (tie hacking) was important in developing late successional forests that mimic vegetation structure and characteristics found in boreal environments that appear important to lynx. We also detail consequences of continuation of traditional timber practices that reduce habitat for lynx and their prey. We identify shortcomings of USDA Forest Service management that impede wildlife laws and policy, erode ESA effectiveness, and weaken science-based resource management. We recommend steps for improving lynx conservation on public lands.

Assessing Grizzly Bear Population Status At An Ecosystem Scale[tws]

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We describe preliminary results from a 2004 study to estimate the size and describe distribution of the grizzly bear (*Ursus arctos*) population from hair samples found on 31,400 km2 (7.75 million ac) in northwestern Montana. Microsatellite analysis of the hair will be used to identify individual bears for use in a mark-recapture population model. We employed two methods concurrently to sample bear hair. We used a 7x7-km grid to systematically distribute 2564 baited hair snag stations. The second approach included repeated hair collection visits to a network of 4750 bear rub trees, sign and fence posts, and power poles along trails and roads. No lure was used to attract bears to rub objects. During 4- to 14-day capture sessions, we collected 20,782 hair samples from baited sites. Collections from rub objects yielded 12,906 hair samples. Extensive fieldwork and logistical planning were required the previous year to prepare for the large sampling effort. Dedicated quality assurance staff worked with field crews to ensure consistent application of field protocols. We describe strategies for working at large scale, such as that 1) methods of coordinating

activities among the federal, state, tribal, and private entities involved with an ecosystem-scale project, and 2) procedures used during data collection and genetic analysis prevent, detect, and/or correct errors. We also discussed challenges and recommendations for directing 200 widely dispersed field employees and conducting fieldwork on extensive tracts of private property in remote areas where communication is often limited.

The Effect Of Snow Compaction On Coyote And Lynx Winter Ecology[TWS]

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Coyotes (*Canis latrans*) and Canada lynx (*Lynx canadensis*) are sympatric throughout much of the lynx's southern range. Researchers and managers have suggested that presence of compacted snowmobile trails may allow coyotes to access lynx habitat in winter from which they would have otherwise been excluded by deep, unconsolidated snow. This could then allow coyotes to more effectively compete with lynx for snowshoe hares, the lynx's primary prey, throughout the year. We investigated how coyotes interacted with compacted snow trails by conducting carnivore track surveys and snow tracking radio-collared coyotes in areas having both documented lynx presence and moderate levels of recreational snowmobile use. Coyotes generally remained in lynx habitat under deep snow conditions (>1 m) from January through March. Coyotes traveled an average of 368 m from compacted snow trails while randomly generated and located tracks in the same areas averaged 339 m from compacted snow trails. Coyotes were primarily scavengers in winter and feed sites were no closer to compacted snow than random expectation. Coyotes neither demonstrated a strong spatial affinity for compacted snowmobile trails nor did they prey heavily on snowshoe hares. Compacted snowmobile trails unlikely facilitated increased exploitation competition between coyotes and lynx for snowshoe hares on our study area.

Urban Wildlife: A Montana Oxymoron?[TWS]

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Expanding residential development into previously uninhabited wild and agricultural habitats has created situations in many Montana cities and towns where wildlife populations have adapted and thrived in numbers leading to numerous human-wildlife conflicts. Issues run the gambit of denuded landscape vegetation and vehicle-animal collisions to outright physical confrontations between wildlife, pets, and people. These situations present a number of problems and challenges to conventional methods of wildlife management and also raise public safety issues. In 2004 the Urban Wildlife Working Group (UWWG), comprised of FWP staff from across the state, city officials, and interested citizens, was formed with the aim of developing a framework upon which urban wildlife conflicts could be addressed. The primary focus of the Group was deer and associated property damage, vehicle collisions, human safety, and disease issues. Although other species were considered, deer were of the most immediate concern. The group suggested that proposed management options and policies for urban deer management also had potential to effectively manage other species of wildlife. This presentation will focus on the roots of urban wildlife issues, how they have been approached in Montana as well as other locales across the nation in the past and the findings and recommendations of the Urban Wildlife Working Group.

Highway Crossing And Mortality Patterns Of Black Bear For Wildlife Passage Planning In Northwest Montana[TWS]

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Our understanding of the effects of highways on wildlife connectivity is limited due to a lack of detailed data on animal movements within transportation corridors. Prior to highway construction in my study area, we used hourly locations from GPS collars to (1) analyze spatial and temporal characteristics of crossing locations, (2) compare crossing frequencies to traffic volumes and crossing speeds to average speeds, (3) compare crossing behavior among classes of bears, and (4) assess the spatial distribution of crossing, road-kill, and planned passage locations. Results indicate that adult females and subadult males crossed highways more frequently than adult males. Both food-conditioned and non food-conditioned bears crossed highways, but food-conditioned bears crossed more frequently. Logistic regression analyses revealed that the odds of a bear crossing was more likely (1) at night, 2) near stream intersections and areas with higher stream density, (3) in open habitat areas closer to cover or areas with a higher percentage of cover within 200 m, and 4) closer to human development. Crossing activity was highest when movement rates were lowest and negatively correlated with traffic. Speed during crossings was higher than during non-crossing times. Crossing and road-kill locations were clustered. Crossings were significantly closer to road-kill and planned passage locations than random locations. Highways served as a partial barrier to wary bears, which crossed seldom-to-none, but were fully permeable to food-conditioned bears, which crossed frequently. Food-conditioned bears, however, carry a higher mortality risk due to an increased likelihood of management removal or vehicle collision.

Factors Affecting Survival Of Female Greater Sage Grouse In South Phillips County, Montana, 2001-2004[TWS]

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Populations of greater sage grouse (*Centrocercus urophasianus*) have declined by 69-99 percent from historic levels. We radio-collared 237 female sage grouse and measured 426 vegetation plots at 4 sites during 2001-2003 on a 3200-km^2 landscape in north-central Montana. We examined the relationship between hen survival and a suite of landscape-scale habitat and environmental conditions. Program MARK was used to model monthly survival rates for 11 seasonal intervals as influenced by a variety of habitat and environmental explanatory variables. Hen survival varied by season within years and by year within seasons. Nesting hens have higher breeding-season survival than non-nesting hens, and individuals at one site had lower hunting-season survival than at other sites. Although we presume hen

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survival to be high and vary little relative to other galliforms, we observed considerable variation. Process variation was 0.255 with an expected range of annual survival of 0.12-1.0. The ratio of process to total variation was 0.999, indicating that observed variation was real and not attributable to sampling variation. We observed a 4-fold difference in maximum and minimum annual survival, ranging from 0.96 for nesting birds in 2001-2002 to 0.24 for non-nesters in 2003-2004. Low annual survival in 2003 reflects compounded effects of a West Nile virus outbreak in August and a severe winter of 2003-2004. Increased hen mortality associated with severe winter weather contrasted with a prior belief that sage grouse populations are typically unaffected by winter weather conditions and underscores the importance of protecting winter sagebrush habitats.

Factors Influencing Nest Survival And Productivity Of Lewis's Woodpeckers Breeding In Aspen Riparia Woodlands[TWS]

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We initiated a study in 2002 to determine factors influencing nest survival and productivity of Lewis's Woodpeckers (*Melanerpes lewis*) breeding in aspen riparian woodlands in south-central Idaho. Lewis's Woodpecker, a sporadically distributed but often locally abundant species, breeds primarily in burned pine and riparian forests throughout the western United States. Although information is available on reproductive success and productivity in burned pine and cottonwood habitats, importance of aspen riparian woodlands as breeding habitat has not been explored for this species. Whereas aspen woodlands are used to a lesser degree than other habitats, they provide valuable breeding habitat for this species throughout the Intermountain West. We determined nest fate, i.e., fledge or failure, for 76 nests monitored during the breeding seasons of 2002-2004. We constructed an a *priori* model list to assess covariate(s) that best explained nest survival. We modeled daily survival rate of nests as a function of several covariates including nest initiation date, nest age, year, weather, nest site characteristics, and a linear time trend using a generalized linear models approach. The model receiving the strongest support indicates nest survival decreased for nests initiating late in the season and increased with increasing minimum daily temperature. High overall nest survival (74%) and high nest productivity (2.3 fledglings/successful nest, $n = 59$ nests) suggested that aspen riparian woodlands may provide potential source habitat for Lewis's Woodpecker.

Common Loon Breeding Ecology And Population Status In Northwest Montana[tws]

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Approximately 200 adult common loons *(Gavia immer)* migrate to northwest Montana each spring from wintering grounds on the Pacific Ocean. They produce an average of 30-50 chicks each spring. Rapid increases in lakeshore development and recreation activity on many northwest Montana lakes prompted Montana Fish, Wildlife and Parks to list common loons as a sensitive species. Loons are habitat specialists, thus lakeshore development and recreation may be leading to decreased nesting opportunities and lower loon chick production on area lakes. Biologists and managers from state, federal, and private entities joined to form the Common Loon Working Group. Their goal was to coordinate population monitoring and guide research and management activities. State Wildlife Grant funding was awarded to fund research in an effort to better understand relationships between physical lake characteristics, human use factors, and loon nesting ecology. An ongoing loon-banding program has also been initiated in Montana. Preliminary results regarding nest success, chick survival, and lakes monitored were presented. Hypotheses concerning effects of development and recreation activity on nest success and chick survival were discussed. Significant observations from the loon banding project including breeding and wintering re-sightings as well as plans for future research in Montana were presented.

Prairie Dog Conservation In Montana: Past, Present And Future[tws]

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Coordinated prairie dog conservation began in Montana during the mid 1980s with a survey of prairie dog colonies in eastern Montana and publication of an annotated prairie dog bibliography in 1986 by the Montana Black-footed Ferret Working Group (MPDWG). These actions were undertaken with a desire to manage prairie dogs for re-introduction of the endangered black-footed ferret. In response to the social and biological complexities of prairie dog management, the Montana Prairie Dog Working Group was formed in 1996. Participants in the MPDWG include the full spectrum of viewpoints on prairie dogs (state and federal agencies, tribal representatives, business people, private landowners, non-governmental organizations). The MPDWG worked collaboratively to develop the prairie dog conservation plan for Montana (2002) and continues to support implementation of this plan. Current efforts and accomplishments include a local prairie dog planning effort in NC and NE Montana, developing a statewide prairie dog monitoring strategy and a feasible landowner incentive program, and establishing a Translocation Protocol guiding all future translocations of prairie dogs. The USDI Fish and Wildlife Service issued a finding of "warranted but precluded" for the black-tailed prairie dog in February 2000 and removed the species from further consideration for listing in 2004 under the Endangered Species Act (ESA). A petition

to list white-tailed prairie dog was deemed "not warranted" in 2004. In the face of concern about implications of listing under the ESA, widely divergent perceptions of prairie dogs as either destructive pests or ecosystem engineers, and declines of species that are associated with prairie dog colonies, the MPDWG continues an interesting, collaborative effort to promote prairie dog conservation. A discussion of the history of prairie dog conservation and associated social, biological, and political challenges were presented.

Snowshoe Hare Fecal Pellet Deposition And Disappearance Rates Near Seeley Lake, Montana[TWS]

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We investigated fecal deposition and disappearance rates of snowshoe hare (*Lepus americanus*) in the Seeley-Swan area of western Montana to evaluate whether the deposition rate was comparable across forest types (diets), years, and seasons, and whether the disappearance rate was comparable over the landscape. These rates may be contributing to the variation causing low precision when the Krebs method is applied in Montana, and affecting the power of regression analysis to predict estimates of population densities. Weak locally-derived equations compromise the validity and generality of an assumed strong relationship between hares and pellets at the southern extension of their geographical range. We collected depositional data from 49 captive hares and found mean daily production was similar between diets (western larch [*Larix occidentalis*], Douglas-fir [*Pseudotsuga menziesii*]) and years (2002-03, 2003-04) but was differed ($P \leq 0.025$) between seasons (summer, winter). An adult hare feeding on either diet, regardless of year, deposited 575 ± 108 (mean ± 1 SD) pellets/day during summer and 467 ± 82 pellets/day during winter. We monitored pellets in the field and found the disappearance rate between pellet types (summer, winter) differed ($P = 0.020$), but disappearance was similar across the landscape within a pellet type. From October 2002 to August 2003, 90 percent of both pellet types remained, while 57 percent of summer pellets and 72 percent of winter pellets remained at the last count in June 2004. This information has influential implications for implementing the Krebs protocol and performing regression analysis, and advances in hare research benefit its specialist predator, the threatened Canada lynx (*Lynx canadensis*).

The Impacts Of The Forest Highways Program O Wildlife And Wildlife Habitat: A Growing Threat[TWS]

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We believe the Federal Highway Administration's Forest Highway Program will have serious, ongoing detrimental impacts on wildlife, fisheries, and ecosystems across public lands in the west and operates contrary to ongoing efforts to assure healthy ecosystems. About 29,000 mi of State and local roads are designated as Forest Highways in the United States. The Forest Highway Program is promoted to provide "safe and adequate access to and through National Forest System (NFS) lands for visitors, recreationists, resource users, and

others that is not met by other transportation programs." The term "Forest Highway" means a forest road under the jurisdiction of, and maintained by, a public authority and open to public travel. Forest Highways are to "assist ...economic development and promote tourism and travel." The 2003 budget for Forest Highways was $162.4 million. USDA Forest Service Chief Dale Bosworth identified 4 threats to national forests and grasslands: (1) fire and fuels, (2) invasive species, (3) loss of open space, and (4) unmanaged recreation. The Forest Highways Program will directly contribute to increases in all these categories. Motorized access management is one of the most contentious issues in public land management. The impacts of Forest Highway Program paving and "improvement" on public lands will (1) increase traffic and traffic speeds, increase recreational impacts through developments like campgrounds, (2) increase direct wildlife and fish mortality due to increased human presence, and (3) fragment populations and habitats. Impacts will be more serious where public lands are intermingled with private lands. Paving forest roads in areas of intermingled ownership will likely increase subdivision, with all its well-known problems, as people find it easier to commute to and from homes on high-speed, paved roads. We suggest that application of the Forest Highways Program be reconsidered. We believe that this program and funding for this program should properly be viewed as a threat to healthy ecosystems and healthy wildlife communities rather than a benign program to assist rural and community economic development.

Factors Influencing Wildlife Use Of Underpasses And Culverts Along I-90 In Western Montana[TWS]

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Underpasses and culverts have potential to mitigate negative impacts of roads by maintaining connectivity between populations and decreasing wildlife collisions with vehicles. Knowledge regarding factors affecting wildlife use of highway crossing structures allows managers and planners to make informed decisions regarding highway mitigation efforts. Using heat and motion sensitive cameras, we monitored 7 underpasses and 3 culverts for 1 year along Interstate 90 (I-90) in western Montana. We assessed wildlife use of crossing structures in relation to surrounding variables such as human presence, topography, and distance to hiding cover. We obtained 1658 wildlife photos at underpasses and 52 photographs of animals in culverts. Primary users of underpasses were ungulates, 3 black bears, and 5 coyotes. Although terrain funneled ungulates toward underpasses, ungulate use of underpasses was not related to human structures or hiding cover. Infrequent carnivore use at underpasses may indicate that they use crossing structures opportunistically.

How Does Harvest Mortality Affect Sage Grouse Population Dynamics?[tws]

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Sage grouse (*Centrocercus urophasianus*) have been extirpated in five states and one province, and their populations have reportedly declined over the remainder of their historical range. Many studies have been conducted to determine rates of reproduction and survival, but the effects of hunting on population dynamics of sage grouse has been less studied. Both additive and compensatory mortality hypotheses have been suggested as factors affecting harvest mortality rates of sage grouse, but compelling evidence for either hypothesis is lacking. To assess the effect of harvest on population dynamics and the relationship between harvest and these competing hypotheses, we began radio-marking and monitoring sage grouse on two sites, one open and one closed to hunting, in south-central Montana during spring 2003. We have been monitoring the level, timing, and, whenever possible, the causes of female mortality from spring through the end of hunting season each year. We also monitored reproductive effort and success in these birds to allow us to compare productivity between the two sites, which will especially be of interest should we find evidence that density was reduced by harvest on the hunted site. Results to date were presented regarding levels of female mortality during hunting season, breeding effort and success, and overall mortality of females during the first 2 of 3 years of study. Useful future research regarding the effects of harvest on sage-grouse populations was discussed.

From Lemons To Lemonade: The State Of Gray Wolf Conservation And Management In Montana[tws]

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This winter marks a milestone. Ten years have passed since gray wolves were reintroduced into Yellowstone National Park and the central Idaho wilderness. Whereas biological criteria for recovery in the northern Rockies have been met or exceeded since 2000, approved management plans are required from Montana, Idaho, and Wyoming in order for the USDI Fish and Wildlife Service (USFWS) to propose delisting. Lack of an approved plan from Wyoming postpones delisting. Meanwhile, wolf numbers and distribution in Montana and across the northern Rockies have expanded since the early 1980s, both due to natural recolonization in northwest Montana and immigration from Yellowstone ational Park and central Idaho. The State of Montana has begun taking advantage of provisions in federal

regulations that make it possible for Montana Fish, Wildlife and Parks (FWP) to become a designated agent of the USFWS. In finalizing cooperative agreements for the northwest Montana "threatened" area and the "experimental" area across southern Montana, FWP has begun implementing as much of the state's approved wolf conservation and management plan as allowed by federal regulations. Making lemonade symbolizes the beginning of the transition from a federal species recovery effort to long-term conservation and management led by FWP and eventual delisting.

Movements Of Lynx At Multiple Scales In Northwest Montana: Preliminary Results[TWS]

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The future of the Canada lynx (*Lynx canadensis*) likely rests on multi-scale management for healthy and connected populations. To best direct such management, we are studying lynx movement at local and landscape scales with the following objectives: 1) describe lynx dispersal in terms of extent, timing, and crossings of natural and anthropogenic barriers; and 2) determine how lynx movements correlate to changes in local and landscape scales of habitat pattern. In 2003 we supplemented our studies in Seeley Lake, Montana with a new study area in the Purcell Mountains of northwest Montana. After first delineating the local distribution of lynx based on snow-track surveys, we deployed two forms of satellite telemetry to monitor lynx movements across spatial scales. Dispersal is a landscape-scale phenomenon that we are studying with ARGOS-based satellite telemetry, allowing us to remotely track dispersal movements. Currently, only ARGOS collars are suitable (110 g) for tracking kittens (9 month-olds). During the winter of 2003-2004, we instrumented 10 lynx kittens across both study areas with ARGOS collars; we are currently deploying additional ARGOS collars in 2005. To track local movements, we deployed a lightweight (~200g) store-on-board, GPS collars. In 2004, we tested this technology by deploying and retrieving data from collars placed on 2 males this winter. Preliminary data suggest GPS collars will provide lynx location data of greater quality and quantity than previously possible. We are currently deploying additional GPS collars on lynx in 2005.

Elk Use Of Forage And Cover In Response To Wildfire And Severe Snow Conditions[TWS]

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Managers lack ecological context for applying recent experimental evidence that penned, fed elk (*Cervus elaphus nelsoni*) in northeastern Oregon did not benefit from forested thermal cover during winter. We offer additional context, based on measures of cover and forage use by a wild, free-roaming elk population from 1988 through 2004 on the Blackfoot-Clearwater Wildlife Management Area in western Montana. A 2250-ha wildfire in October 1991 and severe winter in 1996-1997 allowed us to assess the effects of stochastic variation in forage

availability and energy costs of foraging. Predictable availability of forage and space during early winter in the rangeland vegetation type was more important than non-forest shrub and forest types in shaping the normal winter home range of this elk population. However, herbaceous and shrub forages in non-forest types were most vulnerable to decreasing availability due to deep and/or crusted snow during the course of most winters, which was not alleviated with forage enhancement (e.g., the 1991 burn). Elk were confined to forest types throughout the severe winter. We posit that energy costs of foraging play an overarching role in determining the use of habitat components by wintering elk, and that forest stands are important to mitigate for a normal range of environmental restrictions in forage availability. We recommend forest management practices on elk winter ranges that maintain and recruit a mix of shade (to minimize snow crusting), snow intercept, understory forage, lichen production and litter-fall, and microsite components of thermal cover such as large-diameter boles and dense thickets.

WOLF DEN SITE SELECTION IN THE NORTHERN ROCKY MOUNTAINS [TWS]

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Because mortality of wolves (*Canis lupus*) is highest during the first 6 months of life, den site selection may affect reproductive success of wolf populations. We studied fine-scale denning habitat selection ($\leq$ 100 m of den sites) by comparing field-measured characteristics of 22 dens in Idaho, Montana, and Canada with paired random contrast sites within pack home ranges. In order of importance, wolves denned in areas that had greater canopy cover, hiding cover, herbaceous ground cover, and woody debris, and were closer to water than paired random sites. These factors suggest selection for physical protection and a readily available water source around den sites. We also compared 35 wolf dens to 35 paired contrast sites in Idaho, Montana, and Yellowstone National Park with respect to 6 remotely-sensed variables (elevation, slope, coniferous forest cover, solar radiation, distance to water, and distance to roads). We found no significant ($P < 0.10$ univariate) contrasts in the remotely-sensed variables, suggesting that some important variables can only be measured in the field. Nonetheless, a multivariate model based on the Mahalanobis distance with 4 of these remotely-sensed variables slope, elevation, coniferous forest cover, and solar radiation suggests that > 85% of dens will occur in potential denning habitat that occupies < 12 percent of the wolf recovery areas in the Northern Rocky Mountains. These results suggested optimal wolf denning habitat might be a limiting factor.

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The Efficacy Of Using Snow Tracks In Providing Genetic Data From Wolverine And Other Carnivores[TWS]

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Collecting noninvasive genetic samples from putative wolverine (*Gulo gulo*) snow tracks is an effective method for providing definitive species identification and more complex demographic data. We completed 54 backtracks and collected 169 hairs and 58 scats. Amplification rates of mitochondrial DNA (mtDNA) used for species identification were 74 and 24 percent for scats and hairs, respectively. Average distance to a collect a sample containing high quality mtDNA for species identification was 1331m. Genetic analysis confirmed 35 snow tracks (64%) as wolverine. The remaining 19 snow tracks consisted of 8 that did not provide samples and 11 that contained nonamplifiable samples. Collection of both hairs and scats provided 28 percent more track verifications than would have only one type of sample. We analyzed nuclear DNA (nDNA) from the same samples to produce individual genotypes. Amplification rates of nDNA from scats and hairs were 52 and 16 percent, respectively, and produced individual genotypes for 23 of the 54 snow tracks (43%). These results confirmed that snow tracking to collect noninvasive genetic samples can be used to verify species identification from snow tracks detected through any winter survey method, as well as to perform more complex monitoring such as minimum population estimates, tests of relatedness, or mark re-capture population estimates if sample sizes are large enough. While tested on wolverine, this method could be applied to other carnivores that live in snowy regions and are active during the winter months.

West Nile Virus And Sage grouse: An Update[TWS]

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Greater sage grouse have been extirpated from much of their original range, and population declines are typically associated with loss and degradation of sagebrush habitat. West Nile virus (WNv) was first detected in the Powder River Basin in 2002. In July and August 2003, we confirmed 17 WNv mortalities among radio-marked female sage grouse across four sites in Alberta, Montana, and Wyoming. During that period, adult female survival declined an average of 25 percent at WNv-infected sites compared to pre-WNv years (1998-2002), whereas no decline was observed at a site without WNv in western Wyoming. Comparisons of lek counts between impacted and unimpacted sites in the Powder River Basin indicate a pronounced local population decline in the affected area between 2003 and 2004. In 2004 WNv mortality was reported from Colorado, Wyoming, Montana, and California, although WNv mortality rates in the PRB appear to be lower than in 2003. To date, over 350 live or harvested sage grouse have tested negative for WNv, suggesting that sage-grouse have little innate resistance to WNv infection. Small, isolated populations of Gunnison sage grouse

(*C. minimus*) in Colorado and Utah and greater sage grouse in California, Utah, Wa hington, Alberta, and Saskatchewan may be at highest risk. If man-made surface water facilitates the spread of WNv, new debate will arise over how to best manage such activities in arid western landscapes. The emergence of WNv intensifies debate over how to best maintain large areas of high-quality habitat needed to support robust populations capable of withstanding catastrophic outbreaks of disease.

Multi-scale Factors Related To Snowshoe Hare Densities In Fragmented Forests[TWS]

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Habitat needs of snowshoe hares (*Lepus americanus*) have been examined extensively at scales as large as forest stands, but few data exist to suggest how landscape composition and configuration affect hare populations. We explored how the surrounding forest matrix affected snowshoe hare densities in patches of suitable habitat using fecal pellets to index hare density. Using a multi-scale modeling approach, models that included a combination of landscape- and stand-level variables performed better than single-scale models, demonstrating a marked effect of matrix characteristics on snowshoe hare pellet density. Stand-level variables, especially sapling and medium-sized tree density, were the best univariate predictors of snowshoe hare pellet density, but pellet densities were also positively associated with the amount of boreal forest and the degree of landscape heterogeneity within 300 m of a patch of suitable hare habitat and negatively correlated with the amount of open-structured forest at that scale. Our results stressed the importance of stand-level vegetative factors, yet add an understanding of the extent to which the matrix affects snowshoe hare densities. Resource managers should consider the matrix, striving for greater heterogeneity, more boreal forest, and less open-structured habitat, when snowshoe hare densities are a concern.

A Cat Race Tail...of Houndsmen, Biologists, Administrators, Committees And Lawmakers In Northeast Montana— A History Of Montana Hb 142[TWS]

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Cougar hunting has been part of the fabric of northwest Montana's hunting heritage for over 100 years. From the late 1970s to the mid -1990s cougar populations increased dramatically throughout western Montana. Along with cougar population increases, the number of houndsmen and cougar hunters coming to northwest Montana from out of state increased as well. Popular press magazines were advertising northwest Montana as a destination cougar hunt for non-resident hunters. The high number of non-resident hunters that subsequently came to northwest Montana, in part, created challenges for Montana Fish, Wildife and Parks' (FWP) existing cougar management. Harvest quota management, allocation of the recreational opportunity, and quality of the hunting experience were issue

that both houndsmen and FWP staff raised. A potential solution presented itself in the form of a new Montana statute that became known as House Bill 142. The trials and tribulations of implementing a new law and subsequent hunting season regulations were explored in detail for this presentation. Following the implementation of Montana HB 142, hunting season quota over-runs decreased, percent nonresident harvest decreased, and opportunity for resident cougar hunting increased. This was accomplished over a two-year period by people dedicating countless hours at regional and statewide houndsmen, advisory, legislative, FWP Commission, and public meetings.

Behavioral Responses Of Elk To The Threat Of Wolf Predation: Sex-Specific Constrains[tws]

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We studied individual and herd-level behavioral responses of elk to spatial and temporal variation in the risk of predation by wolves over three winters in the Upper Gallatin drainage, Montana. We tested whether responses to risk were affected by body condition by measuring marrow fat levels of bulls and cows and relating differences in condition to differences in antipredator behavior and predation rate. Overall, elk responded to the presence of wolves by substantially decreasing group size and moving into or close to timber. In contrast to this general pattern, bull-only groups were smaller than average, and slightly increased in size in the presence of wolves. As a consequence, bull-only herds and mixed sex herds converged on a similar size when wolves were present. Individual vigilance levels were not correlated with herd size or distance to timber and were weakly correlated with individuals' position within the herd. Bulls were in worse body condition than cows throughout the winter, and condition deteriorated for both sexes as winter progressed. Vigilance in cows, but not bulls, increased in response to wolf presence, that indicated responses of bulls may have been constrained by condition. For cows, increases in vigilance produced a significant decrease in time spent grazing although bull grazing time was not affected by wolf presence. Some bulls moved into timber when wolves were present. Bulls were overselected by wolves, and cows were underselected. We conclude that bulls were less able to pay the foraging costs associated with the antipredator responses of cows.

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