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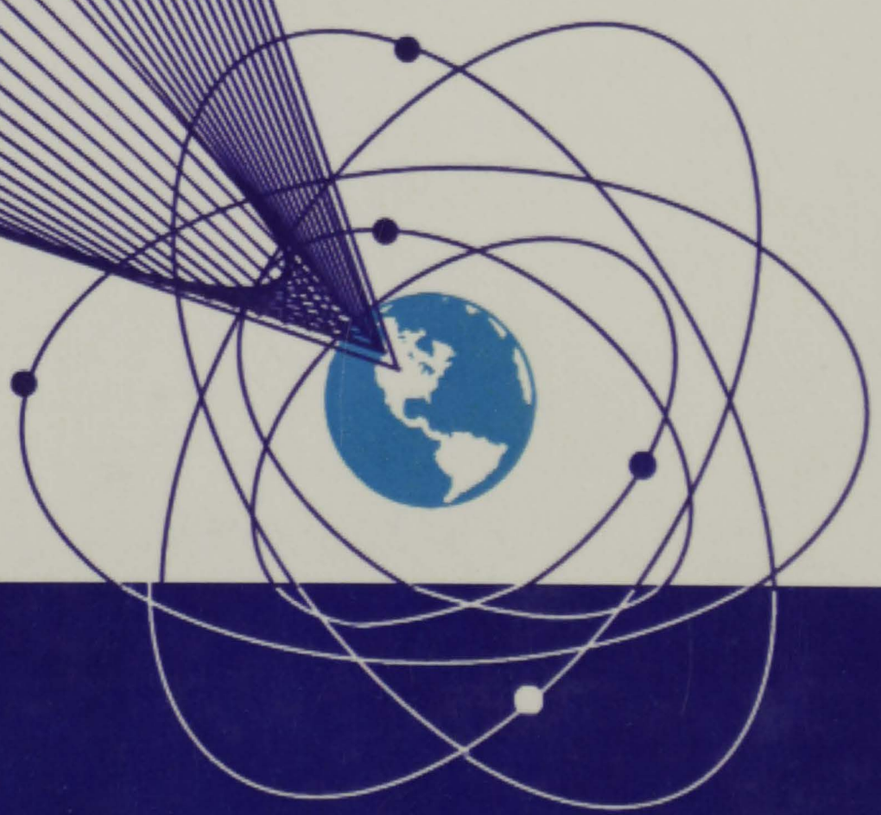

INTERMOUNTAIN JOURNAL OF SCIENCES

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.

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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.

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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.

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A Tracer Investigation Of Pheromone Dispersion In A Lodgepole Pine Forest Canopy

Holly G. Peterson, Environmental Engineering Department, Montana Tech of The University of Montana, Butte, MT 59701
Trisha N. Smith, Environmental Engineering Department, Montana Tech of The University of Montana, Butte, MT 59701
Harold W. Thistle, USDA Forest Service, 180 Canfield St., Morgantown, WV 26505
Brian K. Lamb, Laboratory for Atmospheric Research, Department of Civil and Environmental Engineering, Washington State University, Pullman, WA 99164-2910

Abstract

To improve our understanding of the transport of insect pheromone through a forest canopy, tracer experiments were conducted in 2000 amid a lodgepole pine (Pinus contorta) forest in Montana. Six tests were analyzed to visualize relationships between wind direction and plume behavior for downwind distances of 5, 10, and 30 m. Time series of sulfur hexafluoride showed intermittent plume events with peak-to-mean ratios as high as 81 at the 10-m arc. Average dispersion coefficients ranged approximately 4-8 m at the 5-m arc, 9-17 m at the 10-m arc, and 27-45 m at the 30-m arc. In addition, a simple empirical equation was developed to estimate average plume spread on these scales as a function of standard turbulence statistics and travel time. Predicted dispersion coefficients were within a factor of 2, or better, of observed values for 95% of the cases, and the average predicted-to-observed ratio was 1.07 for the dataset of 158 plume profiles. Results from this field campaign were site-specific, but they were part of a larger effort by the United States Department of Agriculture (USDA) Forest Service to characterize dispersion in a variety of forest types.

Key words: average plume spread, concentration fluctuations, dispersion coefficients, peak-to-mean ratios, pheromones, tracer experiments

Introduction

Bark beetles are native species, and they play important roles in forest ecosystems. Dramatic infestations, however, are currently causing decreased lumber sales and increased fire danger in western regions of the United States, Canada, and elsewhere. Between the years 1995-1999, bark beetles resulted in mortality of more than 7 million trees in the Rocky Mountains alone, and the species causing the most damage in this region are mountain pine beetles (*Dendroctonus ponderosae*) and Douglas-fir beetles (*dendroctonus pseudotsugae*) (USDA Forest Service 2000).

Because bark beetles and other insects communicate via fine-tuned systems of semiochemicals known as "pheromones," the USDA Forest Service and others have been developing methods of pest management involving application of natural and synthetic pheromones as alternatives to traditional insecticides (Suckling 2000). Effectiveness, however, depends on in-depth knowledge of transport and diffusion of pheromones in the atmosphere (Aylor 1976, Aylor et al. 1976, Elkinton et al. 1984, Farrell et al. 2002). An insect reacts instantly to pheromone concentrations above a threshold level, so short-term diffusion of pheromone plume dictates immediate behavior of the insect. Over time, however, the zone of influence affecting multiple insects is characterized in terms of average dispersion patterns.

In regulation and modeling of air pollution from industrial sources, dispersion patterns are of interest also, but on much larger scales. Concentrations at distances up to 50 km downwind of a smoke stack, for example, are normally estimated using com-

puter algorithms based on a formula known as the Gaussian plume equation (Turner 1969):

(1)

$$C_{xyz} = \frac{Q}{2\pi\sigma_y\sigma_z U} e^{\frac{-y^2}{2\sigma_y^2}} \left[e^{\frac{-(z+H_e)^2}{2\sigma_z^2}} + e^{\frac{-(z-H_e)^2}{2\sigma_z^2}} \right]$$

where C_{xyz} is concentration at a receptor with coordinates x,y,z; Q is mass release rate of the contaminant; H is effective stack height; U is mean wind speed, and σ_y and σ_z are dispersion coefficients in the y and z directions, respectively. Dispersion coefficients in Equation (1) represent standard deviations of the average horizontal and vertical concentration distributions in the plume (assumed to be Gaussian), and they are calculated using empirical equations that are functions of downwind distance (x) and atmospheric stability class (Gifford 1959).

Because regulatory models using the Gaussian plume approach only predict mean concentrations with averaging times between 1 hr and 1 yr, we have been studying near-instantaneous plume diffusion to characterize variability and peak concentrations on time scales similar to human breathing rates. Short-term peak concentrations are important because acute exposures may pose health risks for some toxic air pollutants and for chemical agents such as nerve gases. To study this, we have been 1) conducting field experiments using tracer technologies amid a variety of terrain types and meteorological conditions, 2) analyzing tracer concentration data in terms of instantaneous and average plume spread, and 3) using the field results to develop and to test air diffusion models (Peterson and Lamb 1992, 1995, Peterson et al. 1990, 1999, 2003).

Because of tracer technologies, we now know much more about instantaneous and average plume spread of air pollutants than we did 20 years ago, but many of the same uncertainties exist about how insect pheromones move through crops or forest canopies with complex micrometeorological conditions. This is not a new issue; almost three decades ago, Aylor (1976) stressed the importance of transport and diffusion processes on instantaneous and average time scales for pheromone research. Aylor et al. (1976) conducted an eloquent set of field experiments in a forest using gypsy moths (*Lymantria dispar L.*) to try to characterize disparity between instantaneous and average dispersion. While recording wind speed from a set of 1- and 2-dimensional anemometers, they released disparlure pheromone from a 1-mm orifice at a rate of 9.6 pg s^{-1}. Male gypsy moths in small mesh cages were located at downwind distances of 1.2, 2.5, and 5 m from the pheromone source, and pheromone response was quantified by counting the number of moths/cage showing rapid wing fanning during 1-min intervals. To account for plume meander, they moved cages as necessary to coincide with a plume of tufted cattail seeds that were released sequentially near the pheromone source. Results inferred peak concentrations up to 25 times higher than time-averaged concentrations.

Although research of Aylor (1976) and Aylor et al. (1976) was state-of-the-art for their time, they did not have the ability to resolve actual concentrations of pheromone. More recently, a technique called electroantennography (EAG) was developed to measure insect pheromones in the field (Van der Pers and Minks 1993, Thorpe and Tcheslavskaia 2001). In these studies, EAG devices measured changes in electrical signal for insect antennae in the presence of pheromone. The EAG signals, however, are difficult to quantify because of variability in dynamic response characteristics of antennae, and it is not yet possible to convert to absolute concentrations units.

To address these uncertainties, we have been studying dispersion of insect pheromones using tracer methods and equipment previously developed to study behavior of air pollution on larger scales. Our work has been part of a multi-institutional effort with the USDA Forest Service to characterize dispersion in a variety of forest types (Thistle et al. 2002a, 2002b, 2004). Overall goals are to 1) improve insight into the nature of turbulent dispersion through plant canopies,

and 2) develop tools for forest managers to predict pheromone plume spread. This paper describes one field campaign to characterize instantaneous and mean plume diffusion in a lodgepole pine (*Pinus contorta*) forest.

Potomac Field Experiments

During 19-28 July 2000, we conducted a set of field experiments amid a forested area in western Montana, approximately 16 km (10 mi) east of Missoula. Elevation of the Potomac field site (46°54'19"N, 113°126'45"W) was 1207 m above sea level, and lodgepole pine was the dominant vegetation with an average height of 30 m and a density of 1521 stems/ha. Equipment for the campaign included 1) a tracer release system, 2) an array of air samplers, 3) a fast-response tracer analyzer, and 4) meteorological sensors. Each unit is described as follows, and Figure 1 shows the field layout.

Throughout the experiments, we released sulfur hexafluoride (SF_6) as a tracer gas to simulate a generic insect pheromone. For more than two decades, we have used SF_6 to study average and near-instantaneous behavior of air pollutants for downwind distances ranging from 0.05 to 3.6 km (Peterson and Lamb 1992, 1995, Peterson et al. 1990, 1999, 2003), but this was one of the first intensive tracer experiments conducted in a forest canopy for pheromone research. Sulfur hexafluoride is an inert gas that is non-toxic, non-radioactive, colorless, and odorless, and SF_6 can be measured at very low concentrations, i.e., parts/trillion (ppt). In the Potomac field campaign, we released a 1-percent mixture of SF_6 and air from a gas cylinder through a mass flow controller. Release height was 1.2 m above the ground, and release location was the center of a sampling array.

Our sampling array consisted of syringe samplers arranged in three concentric circles with radii of 5, 10, and 30 m. Samplers were based on the design of Krasnec et al. (1984). Over a period of 4.5 hrs/day, each sampler sequentially collected nine air samples in 30-cc syringes with an averaging time of 30 min/syringe. In a typical test, we positioned samplers at a height of 1.2 m above the ground to characterize horizontal dispersion patterns. Time-averaged concentrations of SF_6 in the syringes were determined each day via subsequent analysis using a calibrated, fast-response analyzer based on the design of Benner and Lamb (1985) with an operational range on the order of 30 to 15,000 ppt.

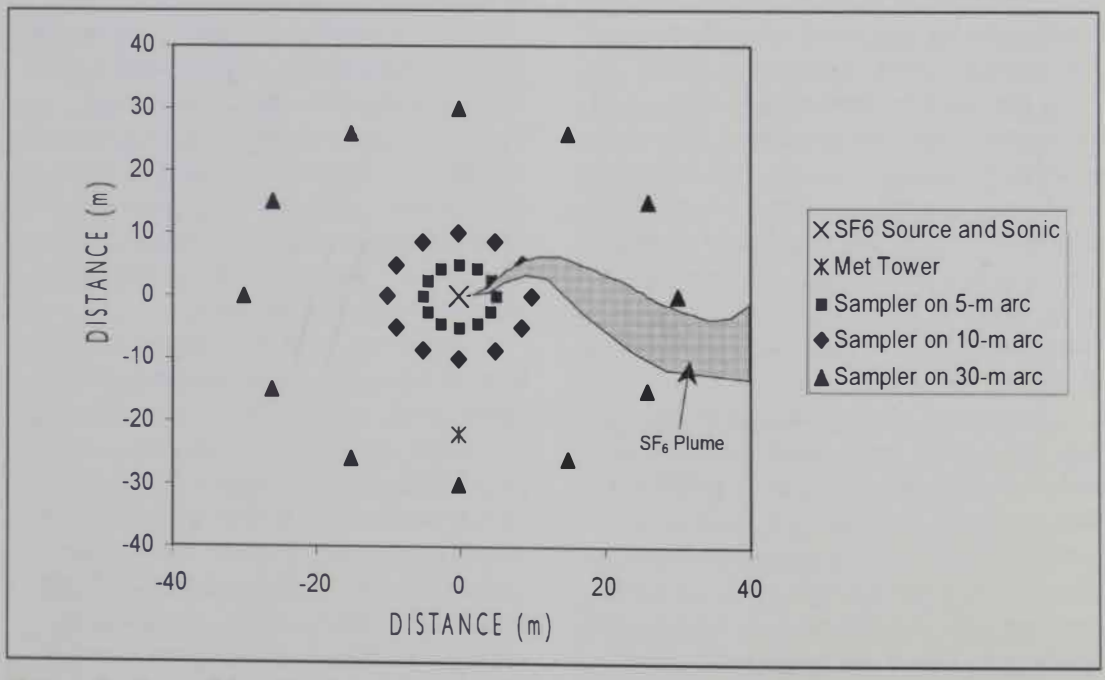

Figure 1. General layout of equipment during the Potomac field campaign.

In addition to time-averaged concentrations in the syringes, we measured near-instantaneous concentrations with a fast-response SF_6 analyzer positioned within the sampling array along the 10-m arc. Response time of this instrument was 0.6 s; the sampling rate was 1 Hz; and the sampling inlet was positioned at a height of 1.2 m.

For meteorological sensing, we equipped a tower with 3-dimensional sonic anemometers at heights of 1.5, 14.5, and 24.9 m above the ground. In addition, a sonic anemometer was located at the center of the sampling array with the tracer release system. The sampling rate of all anemometers was 10 Hz.

Results And Discussion

We describe conditions for six tests performed during morning hours when the average wind speed at the Potomac site was between 0.19 and 0.58 m s^{-1} (Table 1). Standard deviation of wind speed is a measure of turbulence, and during these tests, standard deviation in the horizontal u direction (σ_u) and standard deviation in the horizontal v direction (σ_v) varied between 0.04 and 0.44 m s^{-1}. Standard deviation of the vertical wind component, however, only ranged between 0.04 and 0.16 m s^{-1}. Average ambient temperatures were 282.3-293.3 K, and barometric pressures were 882-889 mb. Mass release rates of SF_6 were 102-110 µg s^{-1}.

Figure 2 illustrates of the nature of the wind fields during the six example tests. We graphed time series of wind azimuth on 2-dimensional, radial grids to show horizontal wind angle during each 30-min period with time (t) increasing from t = 0 s at the origin to t = 1800 s at the outer rings. In some of the tests, a dominant wind direction is obvious. Figures 2d and 2e, for example, indicate dominant wind flows to the west-northwest (W W) and south-southwest (SSW), respectively. In other tests, such as Figures 2a and 2f, winds appear to blow with two or three main bearings during distinct directional shifts. Lastly, Figures 2b and 2c contain a wide range of short-term shifts in wind direction covering all angles of the compass.

In Figure 3, concentration time series depict measurements from the fast-response SF_6 analyzer on the 10-m arc where analyzer positions correspond to specific receptor angles (Fig. 2). As expected, a variety of exposure patterns are identified. Distinct, dramatic concentration events in Figures 3a, 3d, and 3f corresponded to the tracer plume passing over the analyzer during major wind shifts, while the plume meandering back-

Table 1. Subset of Potomac Field Experiments - Test Conditions

Test	Date	Start Time	U	σ_u	σ_v	σ	T	P	Q_{SF6}
	(D-M-YR)	(MDT)	(m s-1)	(m s-1)	(m s-1)	(m s-1)	(K)	(mb)	(µg s-1)
P724P2	07-24-00	0700	0.24	0.06	0.06	0.05	282.3	889	110
P724P7	07-24-00	0930	0.57	0.26	0.23	0.11	291.7	889	106
P724P8	07-24-00	1000	0.58	0.37	0.44	0.16	293.2	889	106
P725P4	07-25-00	0800	0.19	0.04	0.06	0.04	290.6	884	102
P725P5	07-25-00	0830	0.51	0.17	0.15	0.10	293.3	884	102
P727P6	07-26-00	0900	0.29	0.10	0.09	0.06	287 9	882	107

Test duration - 30 min
U - average wind speed
σ_u - standard deviation of horizontal wind speed in the u direction
σ_v - standard deviation of horizontal wind speed in the v direction
σ - standard deviation of vertical wind speed in the w direction
T - ambient temperature
P - ambient pressure
Q_{SF6} - release rate of tracer gas

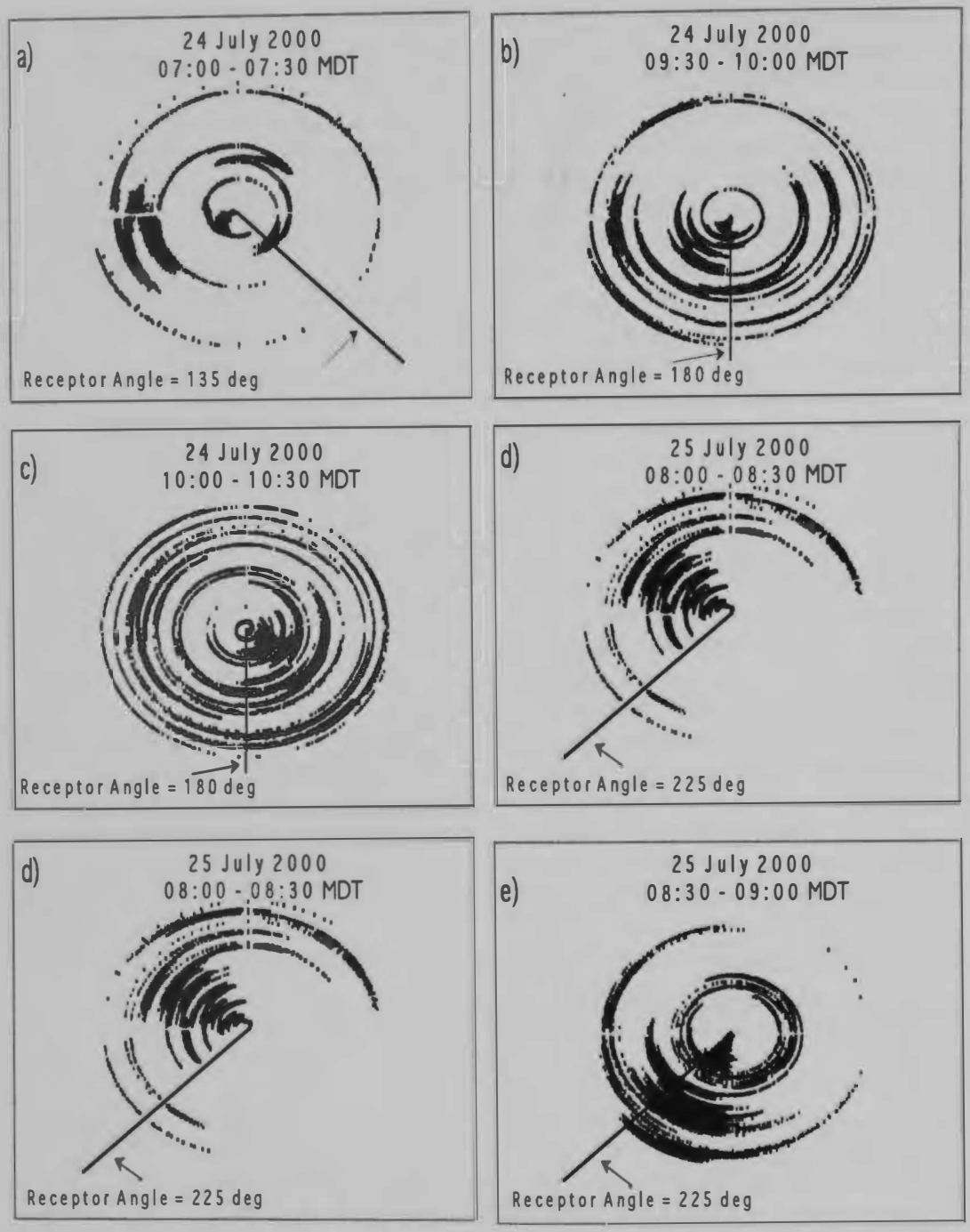

Figure 2. Radial time series of wind direction for: a) Test P724P2, b) Test P724P7, c) Test P724P8, d) Test P725P4, e) Test P725P5, and f) Test P727P6.

and-forth caused intermittent concentrations as illustrated in Figures 3b, 3c, and 3e.

During the past two decades, we have used a set of standard statistics to characterize time series of near-instantaneous exposure of air pollutants (Peterson et al. 2003). Statistics included: average concentration (C); standard deviation (σ_c); concentration fluctuation intensity (IN), where intensity is the ratio of standard deviation to the mean concentration; intermittency factor (I), where intermittency is the fraction of time non-zero concentrations are recorded at a receptor; and peak-to-mean ratio (P/M).

Concentration fluctuation statistics for the six Potomac tests were highly variable even though the SF_6 release rates were

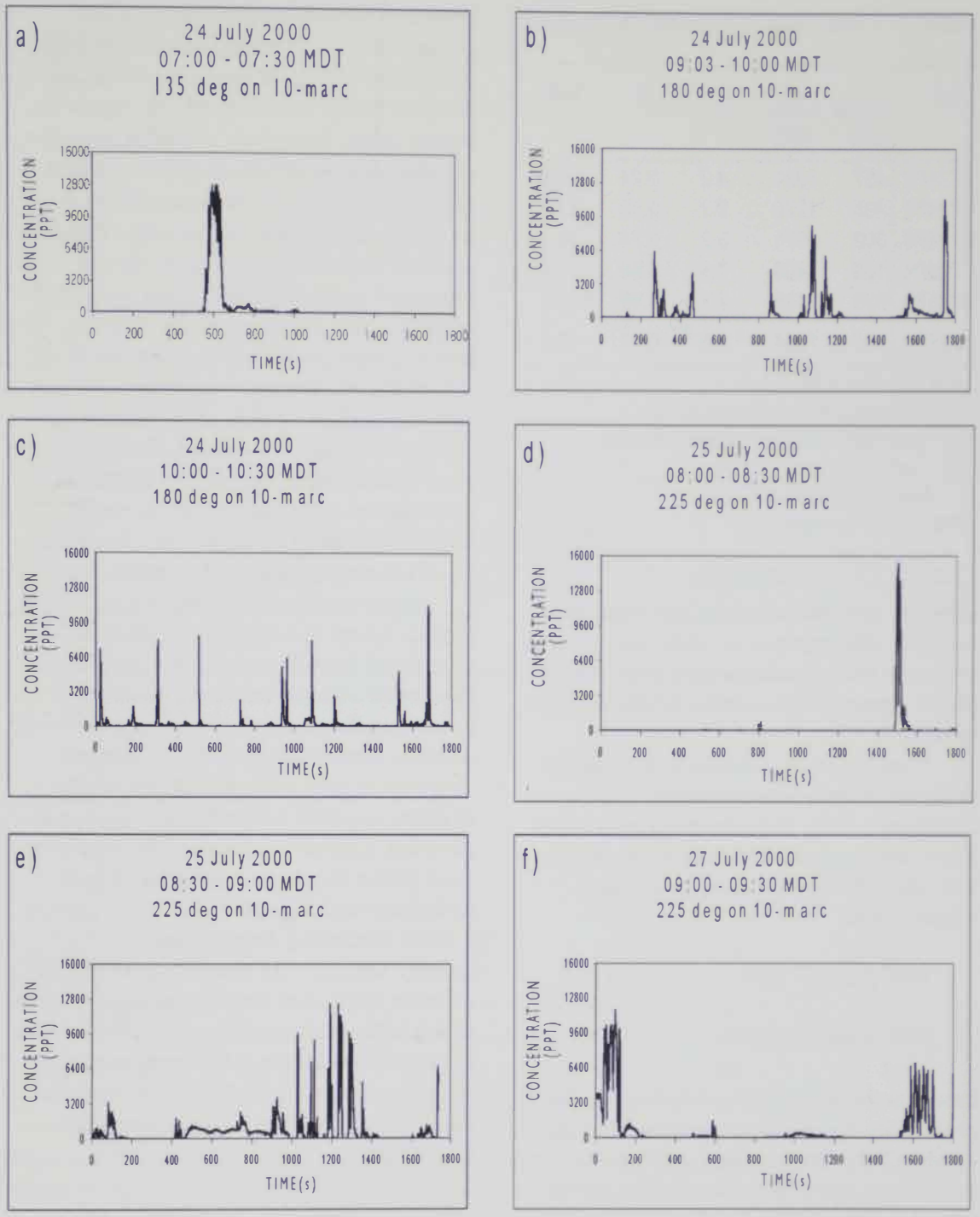

Figure 3. Time series of instantaneous concentration for: a) Test P724P2, b) Test P724P7, c) Test P724P8, d) Test P725P4, e) Test P725P5, and f) Test P727P6.

almost the same, and downwind distance was 10 m in all cases (Table 2). The 30-min mean concentration ranged 189-755 ppt, and standard deviation of concentration was between 971 and 1954 ppt. Standard deviation (σ_c) was always greater than the mean concentration (C) because exposure consisted of intermittent plume events separated by periods of zero concentration. Intensity ($IN = \sigma_c/C$) varied from 2.2 to 7.4; intermittency factor ranged 0.08-0.74; and peak-to-mean ratio was between 15.4 and 80.7. Low intensity, high intermittency, and low peak-to-mean ratio corresponded to exposures where the plume blew toward the analyzer more than away from it. High

Table 2. Concentration Fluctuation Statistics

Test	C (ppt)	σ_c (ppt)	IN	I	P/M
P724P2	457	1931	4.2	0.24	27.8
P724P7	465	1270	2.7	0.48	24.0
P724P8	302	971	3.2	0.74	36.9
P725P4	189	1409	7.4	0.08	80.7
P725P5	699	1538	2.2	0.59	17.6
P727P6	755	1954	2.6	0.47	15.4

Test Duration = 30 min
C - arithmetic mean concentration
σ_c – standard deviation of concentration
IN – concentration intensity
I – intermittency factor
P/M – peak-to-mean ratio

intensity, low intermittency, and high peak-to-mean ratio represented cases where winds primarily blew in another direction, but the plume impacted the receptor briefly during a wind shift.

Previous tracer campaigns to study air pollution at downwind distances up to 1 km (Hanna 1984, Peterson and Lamb 1995) found that intensity and peak-to-mean ratio were described by the following simple relationships:

$$IN = [(2\ I^{-1}) - 1]^{1/2} \qquad (2)$$

$$P/M = [\ln(100\ I)]\ I^{-1} \qquad (3)$$

based on the assumption of an exponential probability distribution. As shown in Figure 4, when Potomac data were compared to Equations (2) and (3), observed intensities were 1.4-2.5 times higher than predicted by Equation (2), and peak-to-mean ratios were 1.9-6.3 times higher than predicted by Equation (3). Thus, narrow plume events measured 10 m downwind from the source in a forest were sharper than observed in air pollution studies, and while the assumption of an exponential probability distribution worked well in other conditions, it underestimated maximum concentrations within instantaneous plumes in this canopy.

Although Figures 3 and 4 addressed instantaneous plume diffusion, we depicted patterns of mean plume dispersion in addition to best-fit Gaussian curves for the 5-m, 10-m, and 30-m arcs in Figure 5. Again, in the field of air pollution, modelers use dispersion coefficients (σ) to describe plume spread for downwind distances out to 50 km and beyond. In the case of insect pheromones in a forest canopy, we are interested in mean plume spread on much smaller scales, but because the average concentration profiles (Fig. 5) tended to be approximately Gaussian in shape, we were able to calculate average dispersion coefficients at each arc. Dispersion coefficients at the 5-m arc ranged from 3.9 to 7.7 m (Table 3); along the 10-m arc, σ values varied between 8.5 and 17.0 m; and results for the 30-m arc were between 27.2 and 44.8 m.

Figure 6a shows how our average tracer plumes spread as a function of distance downwind from the source. We could have developed a simple empirical equation describing the slope of σ_y versus downwind distance from these data, but the relationship may or may not apply for dispersion in forest canopies with other tree types and densities. Logically, spread of the time-averaged plume should be a function of local turbulence and travel time ($T = x\ U^{-1}$, where x is the downwind distance and U is the average wind speed); hence, Figure 6b contains the dispersion coefficients as a function of the horizontal turbulence statistics (σ_u and σ_v) times travel time. A linear regression of the data resulted in the following empirical equation to predict an average dispersion coefficient:

$$\sigma_y = 2.06\ (\sigma_u^2 + \sigma_v^2)^{1/2}\ X\ U^{-1} \qquad (4)$$

where $R^2 = 0.69$, and predicted dispersion coefficients from Equation (4) were within a few meters of observed values (Table 3).

Because Equation (4) was developed using a subset of data, it was necessary to test the method with independent dispersion measurements. In Figure 7, predicted σ_y from Equation (4) was compared to observed σ_y for 158 profiles within the Potomac dataset. Approximately 99 percent

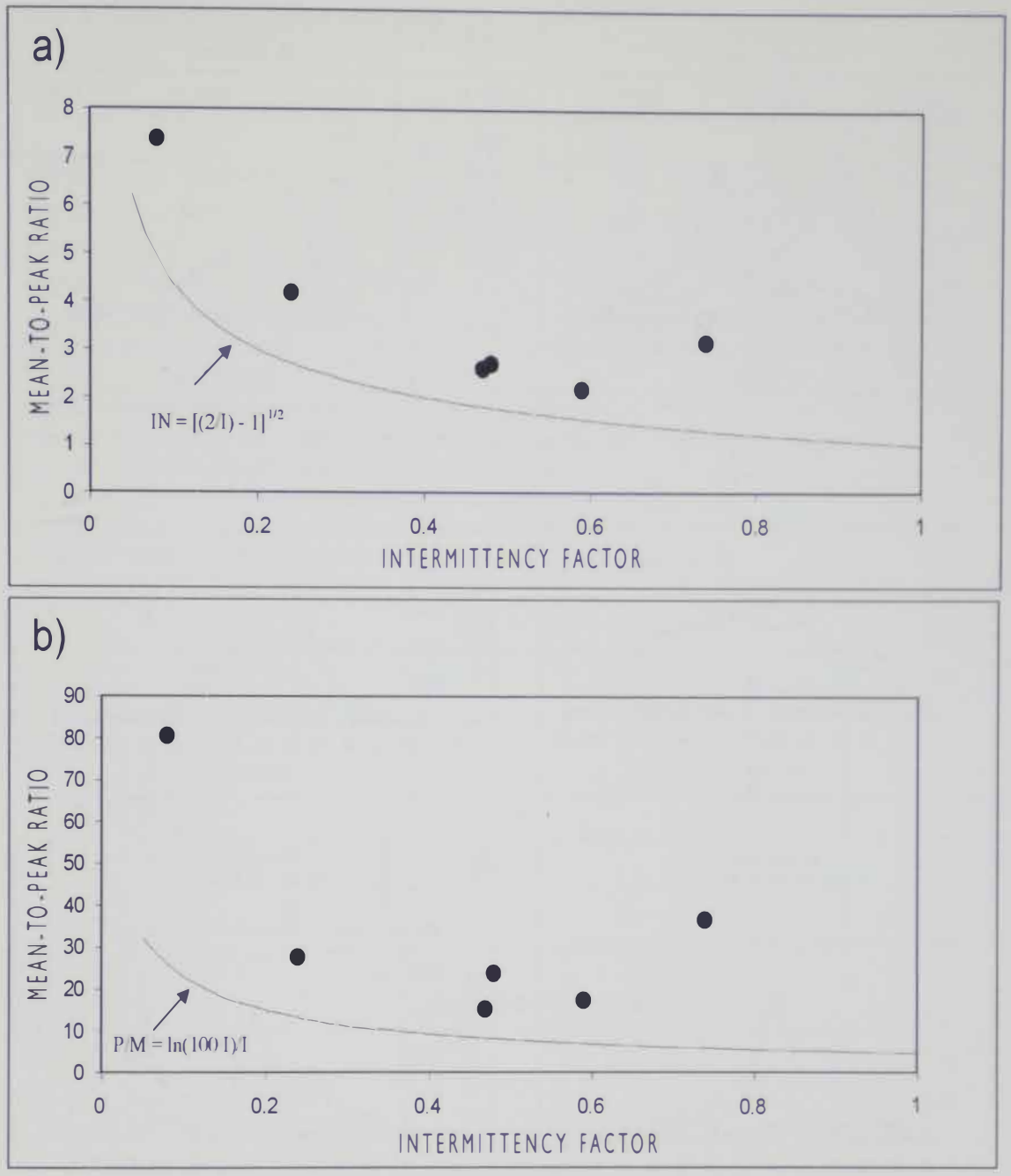

Figure 4. Relationships of a) concentration intensity and b) peak-to-mean ratio versus intermittency factor for the Potomac time series and curves from Equations (2) and (3) that assume an exponential probability distribution.

of the predicted dispersion coefficients were within a factor of 3 of the observed values, and 95 percent were within a factor of 2. The average predicted-to-observed ratio was 1.07 with a standard deviation of 0.44.

For the range of conditions tested at the Potomac site, this simple approach provided realistic estimates of average dispersion rates within 30 m of a pheromone source. In order to judge robustness of Equation (4), however, field results from additional forest settings will be considered in a follow-up paper.

Summary

Measurements of wind speed, wind direction, and tracer concentration revealed a wide range of turbulent motions resulting

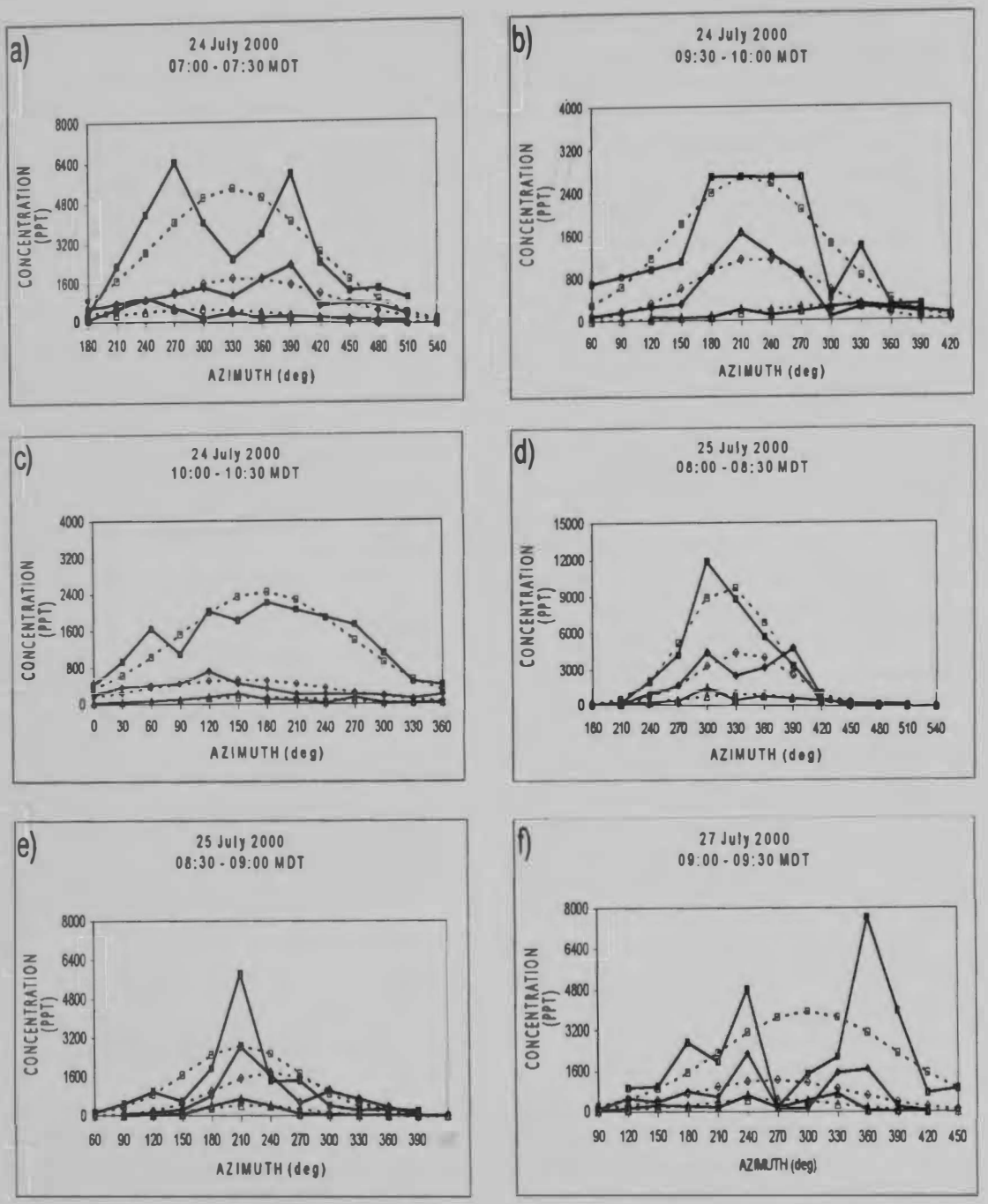

Figure 5. Average concentration profiles for: a) Test P724P2, b) Test P724P7, c) Test P724P8, d) Test P725P4, e) Test P725P5, and f) Test P727P6.

in intermittent plume exposure downwind of the SF_6 source. Peak-to-mean ratios were observed as high as 81 at the 10-m arc, and the concentration time series exhibited sharper peaks than predicted by exponential probability distributions.

Horizontal dispersion coefficients were used to develop a simple empirical equation for predicting mean dispersion as a function of the horizontal turbulence parameters and travel time. When tested against the Potomac set of 158 dispersion profiles, the method predicted within a factor of 3 for 99 percent of the cases, and within a factor of 2 for 95 percent of the data. Overall, the mean predicted-to-observed ratio was 1.07, but a variety of forest conditions must be tested before proposing it as a tool for forest managers.

Table 3. Time-Average Dispersion Data

Test	σ_y-5m	σ_y-5m^p	σ_y-10m	σ_y-10m^p	σ_y-30m	σ_y-30m^p
	(m)	(m)	(m)	(m)	(m)	(m)
P724P2	7.0	3.6	14.6	7.3	44.8	21.8
P724P7	6.5	6.3	11.3	12.5	43.3	37.6
P724P8	7.7	10.2	17.0	20.4	43.1	61.3
P725P4	3.9	3.9	8.5	7.8	29.9	23.5
P725P5	5.1	4.6	10.0	9.2	27.2	27.5
P727P6	7.6	4.8	14	9.6	36.6	28.7

σ_y-5m - Observed average dispersion coefficient along the 5-m arc
σ_y-5mp - Predicted average dispersion along the 5-m arc using Eq. (4)
σ_y-10m - Observed average dispersion coefficient along the 10-m arc
σ_y-10mP - Predicted average dispersion coefficient along the 10-m arc using Eq. (4)
σ_y-30m - Observed average dispersion coefficient along the 30-m arc
σ_y-30mP – Predicted average dispersion coefficient along the 30-m arc using Eq. (4)

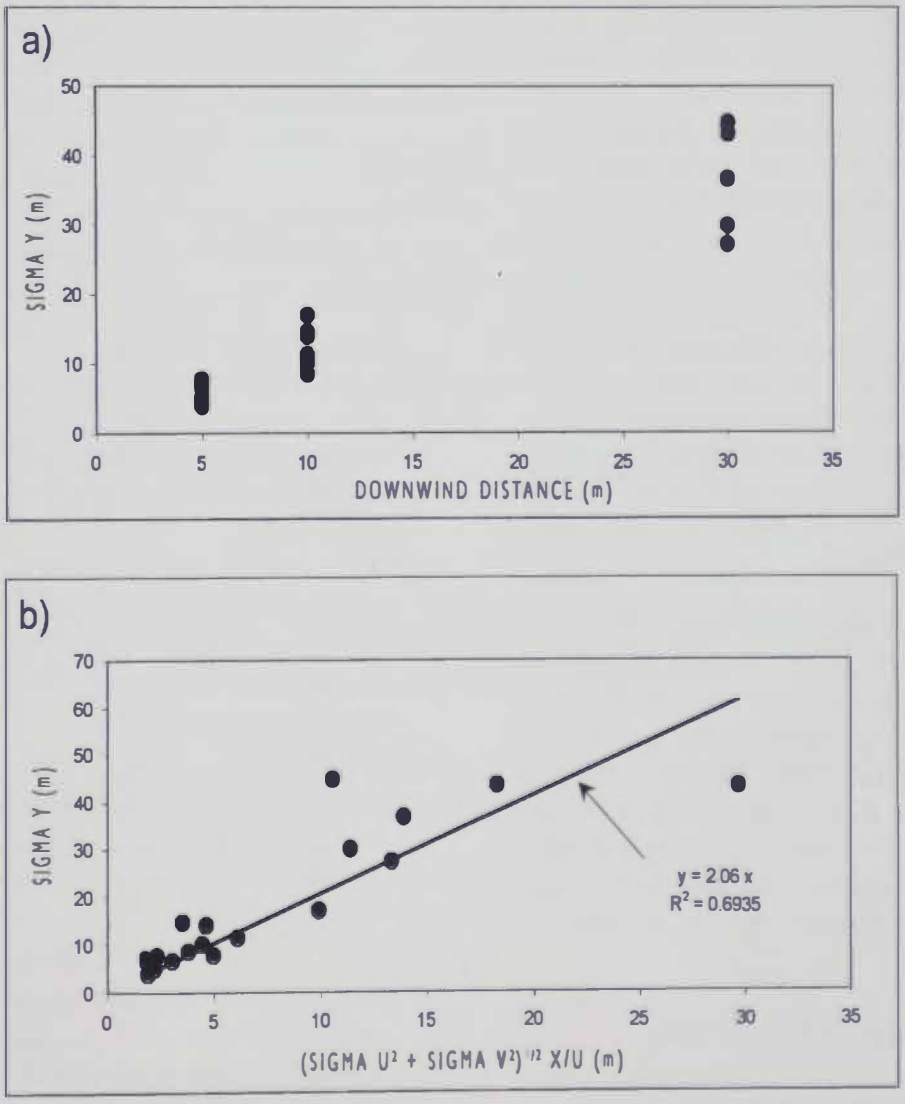

Figure 6. Average horizontal dispersion coefficient as a function of: a) downwind distance, and b) turbulence times travel time as $(\sigma_u^2+\sigma_v^2)^{1/2}$ X U.

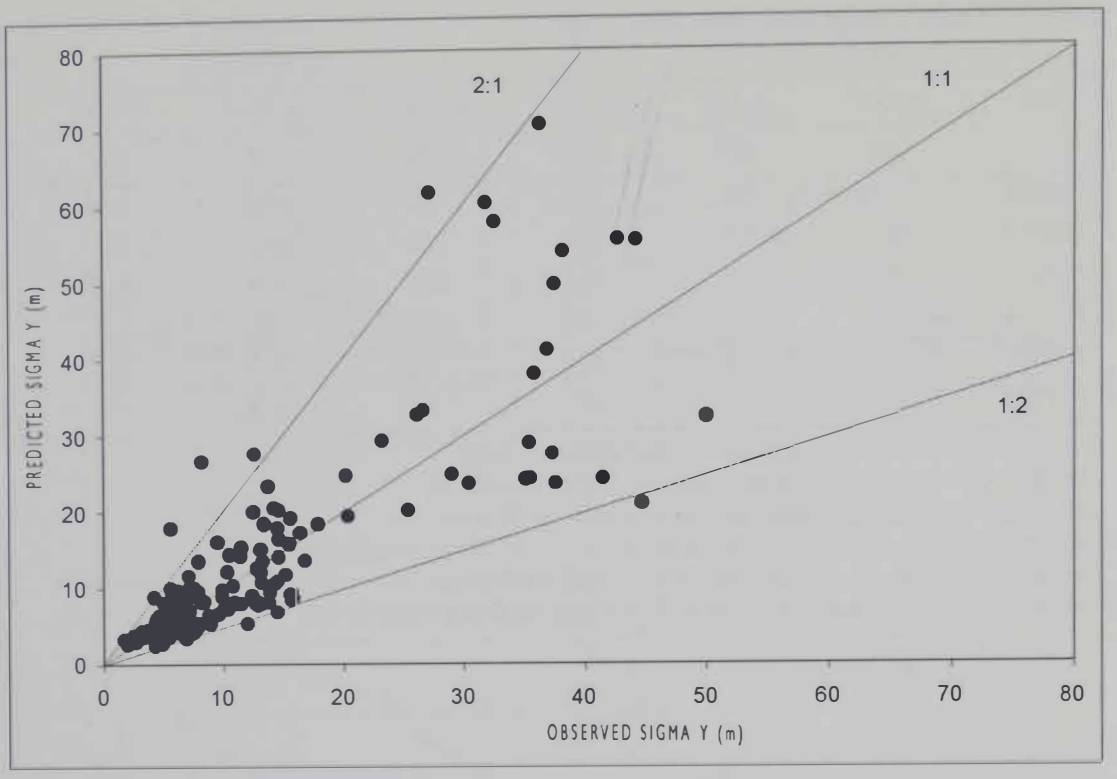

Figure 7. Predicted dispersion coefficients from Equation (4) versus observed values for the entire dataset of the Potomac field campaign. Also shown are the 2:1, 1:1, and 1:2 lines-of-correspondence.

Dispersion of pheromone through forest canopies is still not well understood. We are, however, making substantial advances via application of tracer technologies (previously used on larger scales for air pollution research) to small scales involved in pheromone transport.

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Literature Cited

Aylor, D. E. 1976. Estimating peak concentrations of pheromones in the forest. Perspectives in Forest Entomology. J. F. Anderson and H. K. Kaya eds. Academic Press, Inc. pp. 177-188.

Aylor, D. E., J. Parlange, and J. Granett. 1976. Turbulent dispersion of disparlure in the forest and male gypsy moth response. Environmental Entomology 1026-1032.

Benner, R. L., and B. Lamb. 1985. A fast response continuous analyzer for halogenated atmospheric tracers. Journal of Atmospheric and Oceanic Technolology 2:582-589.

Elkinton, J. S., R. T. Carde, and C. J. Mason. 1984. Evaluation of time-average dispersion models for estimating pheromone concentration in a deciduous forest. Journal of Chemical Ecology 10:1081-1108.

Farrell, J. A., J. Murlis, X. Long, W. Li, and R. T. Carde. 2002. Filament-based atmospheric dispersion model to achieve short time-scale structure of odor plumes. Environmental Fluid Mechanics 2:143-169.

Gifford, F. A. 1959. Statistical properties of a fluctuating plume dispersion model. Advances in Geophysics, Volume 6. Academic Press. Pp. 117-137.

Hanna, S. R. 1984. Concentration fluctuations in a smoke plume. Atmospheric Environment 12:1091-1106.

Kransec, J., D. Demaray, B. Lamb, and R. Benner. 1984. Automated sequential syringe sampler for atmospheric tracer studies. Journal of Atmospheric and Oceanic Technology 1:372-376.

Peterson, H. G., T. Donovan, S. O'Neill, and B. Lamb. 2003. Peak concentrations and plume diffusion in the atmospheric surface layer. Intermountain Journal of Sciences 9:87-100.

_____, and B. Lamb. 1992. Comparison of results from a meandering plume model with measured atmospheric tracer concentration fluctuations. Journal of Applied Meteorology 31:553-564.

_____ and _____. 1995. An investigation of instantaneous diffusion and concentration fluctuations Journal of Applied Meteorology 34:2724-2746.

_____, _____, and D. Stock. 1990. Interpretation of measured tracer concentration fluctuations using a sinusoidal meandering plume model. Journal of Applied Meteorology 29:1284-1299.

_____, D. Mazzolini, S. M. O'Neill and B. K. Lamb. 1999. Instantaneous spread of plumes in the surface layer Journal of Applied Meteorology. 38:343-352.

Suckling, D.M. 2000. Issues affecting the use of pheromones and other semiochemicals in orchards. Crop Protection 19: 677-683.

Thistle, H., G. Allwine, B. Lamb, T. Strand, H. Peterson, E. Holsten and P. Shea. 2002a. Near-field trunk space dispersion. ASAE Technical Paper #024017, ASAE, St. Josephs, MI.

_____, H. Peterson, B. Lamb, T. Strand, G. Allwine, E. Holsten and P. Shea. 2002b. Mass balance of pheromone-surrogate plumes in the canopy trunk space. ASAE Technical Paper No. 021006, ASAE, St. Josephs, MI.

_____, . G. Allwine, B. Lamb, T. Strand, E. Holsten and P. Shea. 2004. Surrogate pheromone plumes in three forest trunk spaces: composite statistics and case studies. Forest Science. In press.

Thorpe, K. and K. Tcheslavskaia. 2001. Portable electroantennogram (EAG) as a quality control tool to measure gypsy moth pheromone in the field. Proceedings of the 2001 Annual Gypsy Moth Review. Des Moines, IA. Pp. 113-121.

Turner, D.B. 1969. Workbook of Atmospheric Dispersion Estimates. U.S. Department of Health, Education, and Welfare. Cincinnati, OH. Public Health Service Publication No. 999-AP-26.

USDA Forest Service. 2000. Assessment and response to bark beetle outbreaks in the rocky mountain area. Rocky Mountain Research Station. General Technical Report RMRS-GTR-62.

Van der Pers, J. N. C. and A. K. Minks. 1993. Pheromone monitoring in the field using a single sensillum recording. Entomologia Experimentalis et Applicata 68: 237-245.

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Effects Of A Beginning Judo Class On Heart Rate

John Amtmann, Safety, Health and Industrial Hygiene Department Montana Tech, 1300 W. Park, Butte, MT 59701
Steve Berry, Safety, Health and Industrial Hygiene Department Montana Tech, 1300 W. Park, Butte, MT 59701
William K. Spath, Safety, Health and Industrial Hygiene Department Montana Tech, 1300 W. Park, Butte, MT 59701

Abstract

We evaluated the heart rate responses of 15 adult and six child subjects to beginning judo class sessions. Heart rate responses were compared to cardiovascular intensity ranges recommended by the American College of Sports Medicine (ACSM). Heart rate responses of adults ($n = 15$) averaged 70 percent of age-predicted maximum heart rate with a range of 96 beats/minute to 154 beats/minute. The heart rate responses of the children ($n = 6$) averaged 68 percent of age-predicted maximum heart rate with a range of 133-161 beats/min. Our results show that judo is effective in elevating heart rate to levels recommended by the ACSM for appropriate periods of time to improve cardiovascular fitness.

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

Introduction

Judo is a system of self-defense, and can take many forms. Like wrestling, judo is a grappling sport, but the participants wear a jacket called a Gi. A typical judo competition match may last from 3 to 10 min depending on the tournament and age of the participant. A match may be won by throwing an opponent to his/her back with force, by pinning them for 25 seconds on their back, or by gaining submission through a strangulation or joint locking technique. The opponent submits by "tapping out", tapping the opponent or the mat, signaling defeat (Ogasawara 1988).

Because most judo techniques are relatively safe for students who have been properly taught the fundamentals, techniques can be safely practiced at or near maximal intensity levels with a resisting opponent during training sessions. This is especially true for the judo ground grappling techniques employing positions of control, strangles, and joint locks (Ogasawara 1988).

Judo coaches believe that this activity is an excellent systematic method for improving physical fitness. In fact, Richards (1982) even recommends it as an activity to develop fitness for other sports. However, a literature review yielded no studies showing how judo affects the beginning and/or child participant. It is no secret that our nation's children are becoming less fit. Rates of childhood obesity are higher now than ever before, and the reason for this is usually because of an imbalance between caloric expenditure and intake (Strauss and Pollack 2001, Troiano and Flegal 1998).

The research question guiding this study was, will a beginning judo class increase heart rates to levels recommended by the American College of Sports Medicine (ACSM) for improvement of cardiovascular fitness? Therefore, the primary purpose of this descriptive study was to evaluate heart rate responses of beginning level adults and children and compare average heart rates during judo class sessions to cardiovascular intensity ranges recommended by ACSM.

The ACSM (2000) recommends an intensity of exercise between 55 and 65 percent up to 90 percent of maximum heart rate for improving cardiovascular fitness. This intensity range is intentionally broad so deconditioned or low-fit individuals may be prescribed intensities of 55 to 65 percent. For example, an individual with a maximum heart rate of 200 would be prescribed a heart rate range of 110/130-180 beats/min to improve cardiovascular fitness. If this individual had poor physical fitness, then exercising at a heart rate between 110 and 130 beats/min might be sufficient to improve fitness. A more physically fit individual may not improve cardiovascular fitness from this lower intensity and would probably have to exercise at an intensity corresponding to a heart rate between 130 and 180 to improve cardiovascular fitness.

Exercise activities can usually be sorted into three groups (American College of Sports Medicine 2000):

1. Group one activities require little skill, and energy expenditure is relatively constant. Examples are treadmill walking and cycle ergometry.

2. Group two activities require a moderate amount of skill, and energy expenditure is related to the individual's skill in the particular activity. Examples include swimming and cross country skiing.

3. Group three activities require a high level of skill and exercise intensity may be highly variable. Examples are racquet sports and basketball.

The activity of judo is considered a group three activity. Will relative beginners be able to maintain average heart rates at ACSM recommended levels for cardiorespiratory improvements? That is the question this research addresses.

Literature Review

A comprehensive literature review yielded no studies on heart rate effects from judo on beginners and/or children. One study focused on the effects of judo on substrate utilization during one 5-min match. The study included 16 male judo competitors with an average age of 18.4 years. The subjects were all 2nd or 3rd degree black belts. In other words, they were highly skilled. The researchers reported an average percent heart rate of 92 percent of maximal for the matches (Degoutte et al. 2003).

Several other sources published the metabolic costs of combat sports including judo, boxing, karate, tae kwon do, and wrestling. Kravitz et al. (2003) found a linear increase in heart rate with increasing punching frequencies in 18 trained subjects participating in fitness boxing trials. Punching tempos ranged from 60 to 120 beats/min and heart rates ranged from 67 to 93 percent of maximum depending on tempo.

According to McArdle et al. (1996), a 68-kg (150-lb) individual participating in judo would expend 13.3 kcal/min. Caloric expenditure for a 68-kg individual participating in wrestling, karate, boxing practice and competition is 13.2, 13.2, 9.4, and 15.1 kcal/min, respectively. ieman's (1995) Compendium of Physical Activities estimates caloric expenditure for judo, jujitsu, karate, kick boxing, and "tae kwan do" as 10 Mets, which equates to 11.9 kcal/min for a 68-kg individual. However, no designation of skill level and energy expenditure exists from these sources.

Maximum volume of oxygen consumed, or Max VO2, is a commonly used measure to evaluate cardiorespiratory fitness, and other researchers reported on the cardiorespiratory fitness of elite grappling athletes. Cipriano (1993) reported Max VO2 values between 60 and 70 $mlkg^{-1}min^{-1}$ for elite wrestlers. Horswill (2000) reported a range of 50-62 $mlkg^{-1}min^{-1}$ for scholastic age to Olympic level wrestlers.

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 the sport-specific requirements, physiological effects of training methods, and physiological profiles of high-level athletes rather than beginners.

Methods

Subjects

Five female and 10 male adults (age range 19-37 ys) who were registered for a beginning judo class, and six female children (age range 4-10 yrs) who participated in a winter judo camp at Montana Tech of the University of Montana served as subjects. The university approved all procedures and each adult subject and, for the children, a parent/guardian, signed an informed consent document. All subjects completed a physical activity readiness questionnaire, and none of the subjects were using any cardiac or pulmonary medication.

Procedures

We monitored the subjects' heart rates using a Polar T31 Heart Rate Monitor, which provided an average heart rate for the duration of the judo session. The subjects sat quietly for three minutes to establish resting heart rate. After recording resting heart rate, the class began as usual. The coaches were instructed to maintain normal class procedures. A typical judo class consists of the following phases (Dewey 2003):

1. Warm-up – which consisted of judo specific dynamic rhythmic movements that increased body temperature. The specific movements included jogging, free squats, judo falling called ukemi, grappling hip movements called ebbe/shrimping, and more.

2. Instruction – this phase usually includes a short review of past techniques and introduction of new techniques in a step-by-step manner.

3. Drills – making use of repetitive movements to reinforce what has been previously learned.

4. Randori (freestyle practice) – this is the sporting aspect of the session, where the students attempt to execute judo techniques on a resisting opponent for designated periods of time.

5. Fitness/Judo Exercises – this phase allowed for a variety of fun physical activities including judo freeze tag, judo dodge ball, push-ups, sit-ups, judo team soccer, and judo related relay races.

6. Cool-down – In general, the cool down phase allows time for heart rate and body temperature to return towards normal resting levels. Flexibility exercises are done during this phase.

Actual duration of each phase varies depending on various factors including age, experience, and objectives of the participants. For a beginner class, these phases may last anywhere from 5 to 20 min, however with more advanced athletes modifications to this general approach are often made. The major modification would be an increase in time spent during randori/freestyle practice essential for the competitive judo athlete (Pulkkinen 2001, Dewey 2003).

Heart rate monitors were checked at 5-min intervals by palpating a radial pulse for 15 sec and calculating a 1-min heart rate. We compared the palpated heart rate to the monitor's heart rate to ensure accuracy and recorded heart rate averages at the termination of the class. The adult class participated in the study 8-12 wks into the 16-wk semester, and the child class participated during the third and fourth weeks of a 4-wk camp to allow for development of some fundamental skills relative to judo. Because the heart rate monitors were telemetry units, subjects were not paired with each other because monitors would then be disrupted by the other subject's heart rate.

Results

We calculated age-predicted maximum heart rate (APMHR) by subtracting the subject's age from the constant 220 (American College of Sports Medicine 1995). Heart rate responses of the adults averaged 70 percent of age-predicted maximum heart rate with a range of 96 to 154 beats/min (Table 1). Heart rate responses of the children averaged 68 percent of age-predicted maximum heart rate with a range of 133 to 161 beats/min (Table 2). The classes were about 50 min in duration. Fourteen of 15 adult subjects and all six of the child subjects elevated their

Table 1. Adult heart rates.

Subject	Age	Mean HR*	% APMHR**
1	22	147	74
2	19	122	61
3	23	126	64
4	23	154	78
5	24	96	49
6	34	145	78
7	20	135	68
8	21	146	73
9	24	146	74
10	26	145	75
11	24	120	61
12	19	141	70
13	37	133	73
14	37	148	81
15	21	135	68
Mean	**24.93**	**135.93**	**69.80**
Std Dev	**6.09**	**14.97**	**8.33**

** Heart Rate*
*** Age Predicted Maximum Heart Rate*

heart rates to within the range of 55-90 percent of maximal heart rate recommended by ACSM to improve cardiovascular fitness.

Discussion

The adult subjects elevated their heart rates to 70 percent of APMHR, and the children elevated their heart rates to 68 percent of APMHR. The ACSM recommends elevating heart rate to 55/65—90 percent of maximum heart rate for at least 20 minutes for 3-5 days each week to improve cardiovascular efficiency, manage weight, and protect against chronic lifestyle-related disorders like heart disease.

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 beginners and children. Our results show that judo can be effective in elevating heart rate to levels recommended by the ACSM for appropriate periods of time to improve cardiovascular fitness. One adult subject only raised heart rate to 96 beats/minute (49% of APMHR), and some children were less enthusiastic than others during the classes. In a class with a variety of personalities, one can expect some

Table 2. Child heart rates.

Subject	Age	Mean HR*	% APMHR**
1	6	154.5	72.0
2	4	137.0	63.0
3	8	133.0	63.0
4	10	140.0	67.0
5	7	139.0	65.0
6	7	161.0	76.0
Mean	**7**	**144.08**	**67.67**
Std Dev	**2**	**11.05**	**5.28**

**Heart Rate*
***Age Predicted Maximum Heart Rate*

students to try harder than others, which we observed among our subjects. So, repeat studies may show more variability in their results depending on the personalities of the subjects.

Still, the average effect on heart rate is important because of the state of health of Americans, especially American children. Studies show that American children are becoming increasingly overweight (Strauss and Pollack 2001, Troiano and Flegal 1998). There are many compounding factors, but the overall cause is a positive energy balance; a mismatch between caloric intake and caloric expenditure.

Another heath concern is type 2 diabetes. Type 2 diabetes used to be referred to as "Adult Onset Diabetes." However, it has been described as a new epidemic effecting American children (Ratner-Kaufman 2002). Obesity and sedentary lifestyle are risk factors for the development of type 2 diabetes. The importance of identifying healthy but somewhat non-traditional activities such as judo may be a part of the solution for many American adults and children.

Further research should focus on the changes of the various components of health related fitness over greater periods of time, including body mass index (a height-weight measure), body composition, muscular strength, endurance and flexibility, oxygen consumption, and tracking heart rate changes during the specific phases of the judo session. These recommendations would provide more information about the overall effects of judo training on physical fitness.

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 cardiovascular 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 overall mission of the club and coaching quality.

Literature Cited

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

_____. 1995. ACSM's Guidelines for Exercise Testing and Prescription. 5th Edition, W.Kenney, ed. Williams and Wilkins, Media, PA .

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

Degoutte, F., Jouanel, and P. Filaire, E. 2003. Energy demands during a judo match and recovery. British Journal of Sports Medicine 37: 245-250.

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

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

Kravitz, L., L. Greene, Z.Burkett, and J. Wongsathikun. 2003. Cardiovascular response to punching tempo. Journal of Strength and Conditioning Research 17:104-109.

McArdle, W., F. Katch, and V. Katch. 1996. Exercise Physiology: Energy, Nutrition, and Human Performance. 4th Edition. Lippincott, Williams and Wilkins, Baltimore, MD.

Nieman, D. 1995. Fitness and Sports Medicine: A Health-Related Approach. 3rd Edition. Bull Publishing Co., Palo Alto, CA.

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

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. NSCA Journal. February-March, pp. 32-34.

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.

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ABSTRACTS

BIOLOGICAL SCIENCES – AQUATIC

THE MONTANA CHAPTER OF THE AMERICAN FISHERS SOCIETY[AFS] 2004 ANNUAL MEETING INTRODUCTION

Clint Muhfeld
President, Montana Chapter AFS
Montana Fish, Wildlife & Parks
490 N. Meridian Rd., Kalispell, MT 59901
cmuhfeld@state.mt.us

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.

Aquatic habitat degradation is occurring at alarming rates throughout the world due to human impacts on the environment. The stability of many rivers has been adversely affected by direct channel modifications or through changes in flow and sediment transport regimes. Consequently, many fish and aquatic species have declined in abundance and distribution as a result of habitat degradation and loss. Unless effective watershed planning and natural channel restoration programs are implemented on public and private lands, many river systems will continue to provide unsuitable habitat conditions for growth and survival of fish and other aquatic organisms.

In an effort to promote sound management and restoration of aquatic ecosystems, the Montana Chapter of the American Fisheries Society convened the annual meeting in Whitefish, Montana under the theme "*Theoretical and Practical Approaches for Watershed Restoration and Stream Habitat Improvement.*" The plenary session featured Dr. David Rosgen (Wildland Hydrology), a world-renown expert in river assessment and restoration, as the keynote speaker and leader of the Continuing Education Workshop. The keynote panel of experts explored theoretical and practical approaches to restoration, agency program direction and policy constraints, restoration and enhancement techniques and lessons learned, and fisheries responses to habitat restoration and passage improvements. The Yellowstone Task Force panel described geological and hydrological changes to the Yellowstone River, and provided research results on habitat native Yellowstone cutthroat trout populations. Additionally, contributed paper sessions included a variety of ongoing research projects focused on species of special concern, non-native species introductions, impacts of fire on fish and aquatic ecosystems, and hydroelectric development.

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

[AFS] *Montana Chapter of the American Fisheries Society Annual Meeting, Whitefish, MT. February 4-6, 2004*
[MAS] *Montana Academy of Sciences Invasive Species Symposium, Billings, MT. April 16, 2004*
[TWS] *Montana Chapter of the Wildlife Society Annual Meeting, Bozeman, MT. February 23-26, 2004*

The Montana Chapter of the American Fisheries Society offers the abstracts of its 2004 Annual Meeting to the readers of the *Intermountain Journal of Sciences* in the spirit of 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 8-11 February 2005 at Doubletree Hotel/Edgewater in Missoula, Montana.

River Morphology/Stability Analysis and Fish Habitat/Population Significance[AFS]

Dave Rosgen
Wildland Hydrology
11210 N. County Rd. 19, Fort Collins, CO 80524
wildlandhydrology@wildlandhydrology.com

Ron Pierce
Montana Fish, Wildlife & Parks
3201 Spurgin Road, Missoula, MT 59804
rpierce@state.mt.us

John M. Muhlfeld
River Design Group, Inc.
911 Wisconsin Avenue, Whitefish, MT 59937
jmuhlfeld@riverdesigngroup.net

Stability of rivers is key to understanding their physical and biological function and their "potential" state. Corresponding relations of habitat quality and fish population dynamics are directly related not only to stream type, but to stability as well. River stability (equilibrium) is defined as the ability of a stream, over time, in the present climate, to transport the flows and sediment produced by its watershed in such a manner to maintain its dimension, pattern and profile without either aggrading nor degrading. To predict and verify river stability involves a quantitative effort of assessment involving numerous measurements and prediction methods. The prediction level (III) and validation level (IV) are presented that allows the assessor to determine the nature, magnitude, cause and consequence of instability. The methodology involves prediction and validation to document the nature and rates of; bank erosion, aggradation, degradation, enlargement, lateral accretion, successional scenarios and associated stages, down-valley meander migration, changes in sediment competence and capacity, changes in river hydraulics, and riparian vegetation/channel interactions. Fish habitat assessments and population data will be presented demonstrating the importance of understanding river types and their state or condition. As biologists are often expected to improve the fisheries resource, it is imperative to integrate river morphology and stability with the biological assessments in order to make management recommendations and/or conduct restoration/enhancement. Detailed procedures for measurement and analysis are presented involving existing characteristics of channel properties including their dimension, pattern, profile, materials, sediment and hydraulic relations. This is done on both impacted and reference reaches. Reference reach data is assessed to document stability indices of the

stable form in order to complete a departure analysis of disturbed river systems. Reference reach data is also used to establish a range of morphological variables amongst stable rivers of a particular type and to establish dimensionless ratios for application in natural channel design. Example departure and potential condition analyses completed on disturbed stream reaches in the Prospect and Grave Creek drainages in western Montana are presented. Both study reaches have deviated significantly from their potential state, resulting in accelerated lateral erosion, channel widening, down valley meander migration, and subsequent meander abandonment. The predicted channel succession sequence has resulted in impaired channel form and function in both systems, reducing the availability of complex fish habitat for resident and migratory fish species. Example design plans and stream restoration applications are presented for the Grave Creek study reach. Pre- and post-construction effectiveness monitoring data are presented demonstrating the benefit of stream restoration applications to migratory adult bull trout habitat.

Montana's Future Fisheries Improvement Program[AFS]

Mark Lere
Montana Fish, Wildlife & Parks
P.O. Box 200701, Helena, MT 59620
mlere@state.mt.us

The Future Fisheries Improvement Act, passed by the 1995 legislature, established a funding program for voluntary habitat projects that protect and enhance Montana's wild and native fishes. The legislature expanded this program by passing the Bull Trout and Cutthroat Trout Enhancement Act in 1999, directing a portion of the program funding towards projects that enhance native bull trout and cutthroat trout. Funding for the Future Fisheries Improvement Program (Program) comes from the re-direction of River Restoration program funds, sale of Montana fishing licenses and expenditures from Montana's resource indemnity trust fund. Anyone or any entity proposing a good habitat project designed to enhance wild and native fishes will be considered for funding. To date, the Program has committed approximately $6.8 million to 353 habitat projects. Cost sharing with other funding partners has extended these committed funds by an additional $15 million. In general, projects funded to date fall into one of the following categories: channel re-naturalization (21%); riparian enhancement (21%); fish passage (19%); bank stabilization (15%); in-stream flow enhancement (9%); lake and reservoir enhancement (9%); and miscellaneous (6%). About 55 percent of the habitat projects completed under the Program have been monitored for their effectiveness in enhancing wild fish populations. Fish populations have responded positively in 42 percent of the monitored projects, while populations displayed no response in 8 percent of the projects. It remains premature to draw conclusions for the remaining 50 percent of the projects primarily due to the short time frames for populations to respond following project completion.

Stream Restoration From the Perspective of the Natural Resource Conservation Service[AFS]

D. James Suit
Natural Resource Conservation Service
Room 443, 10 East Babcock Street
Bozeman, MT 59715
jim.suit@mt.nrcs.usda.gov

Planners, designers and contractors developing and constructing stream restoration projects need to balance the hands on, the art, the necessary experience and the sciences to provide a quality stream restoration project that considers the human, social, environmental and economic needs associated with a particular stream project. The planner needs to ask what, if anything, should be done to a stream. Should it be left alone, should a change in management be given priority, or should the designer install many of the currently popular green engineering options? An experienced planner and/or designer should be able to answer these questions as they provide advice to their clients. No one discipline has all the answers. To conduct a quality stream restoration project requires training, experience, and several interdisciplinary professionals. The restoration requires quality planning, adequate design, drawings, specifications and necessary permits that are compliant with all federal and state law. A determination should be made whether a particular stream restoration is considered engineering and covered by the Montana Professional Engineers & Land Surveyors LAFS and Rules. This presentation will attempt to define the science required, the permits, the lAFS, and the interdisciplinary knowledge and abilities needed to conduct a quality and beneficial stream restoration project.

Stream Restoration From the Perpsective of a Water Resource Specialist Within the U.S. Forest Service[AFS]

Traci Sylte
Lolo National Forest
Bldg. 24, Fort Missoula, Missoula, MT 59804
tsylte@fs.fed.us

The Forest Service is engaged in many types of stream restoration and rehabilitation projects. With healthy watersheds as the ultimate objective, stream activities primarily focus on individual stream reaches, aquatic species passage at road crossings, road decommissioning, mining and grazing, and habitat enhancement. People educated in stream restoration are in short supply. Academia must begin providing specialized degrees in application-based fluvial geomorphology and environmental river mechanics. Agencies need to develop programs to assure employees are trained and remain current. Despite a huge work backlog and an increase in stream health awareness and past policy initiatives, restoration budgets have dwindled. Most restoration occurs as a byproduct of timber management or partnerships. Although congressional funding to the agency has increased, most money is allocated to currently popular initiatives or to fire or timber related programs. Moreover, a traditional timber and fire-focused philosophy combined with only verbal restoration support have many publics suspicious of National Forest work. Many restoration projects are tied up by timber related law suits. Sound restoration relies on our ability to work with the public, and

together as agencies, to be as credible, knowledgeable, and efficient as possible. The future of restoration, and arguably the Forest Service, depends on a turn in philosophy with restoration as the primary emphasis, with timber as the by-product, and with an urban strategic, ecologically based fire suppression program. Leadership must look beyond short-sighted, politically driven objectives and manage the agency for which it was created – "…assuring favorable conditions of flow."

Stream Restoration From the Perp ective of a Regulatory Agency[AFS]

Doug McDonald
U.S. Army Corps of Engineers
10 West 15th Street, Suite 2200, Helena, MT 59626
Douglas D. McDonald@usace.army.mil

Stream restoration projects require authorization under Section 404 of the Federal Clean Water Act. It is recognized that the purpose and intent of such projects is to restore and enhance aquatic resources. Most stream restoration projects are authorized under ationwide Permit #27. Providing specific information in the Joint Application Form can result in expedited reviews and authorization. Applications should include information on monitoring, Endangered Species Act coordination/consultation, mitigation, maintenance, and reference site data. Initial observations regarding the use and success of a specific feature such as root wads and rock/log structures shows mixed results. Compliance with required monitoring and other project specific conditions are not always met. Requiring mitigation of adverse impacts to wetlands has become routine. Now, mitigation for adverse impacts to the physical, biological and chemical components of a stream will also be required. Enhancing the stream and/or the riparian areas can mitigate impacts. The Corps has developed a Stream Mitigation Process and Document that outlines the program, and will likely be implemented in 2004. It will require applicants to mitigate for adverse impacts to a stream in addition to mitigating for unavoidable impacts to wetlands.

Context, Context, Context: Diag ostic Approach to Channel Assessment[AFS]

David R. Montgomery
Dept. of Earth & Space Sciences
University of Washington
Box 351310, Seattle, WA 98195-1310

Channel assessment procedures are often based on quantitative or qualitative ranking criteria that are scored to evaluate the "stability" or "condition" of a channel. Because of the often overwhelming importance of context in interpreting and evaluating - and therefore assessing – channel conditions, I argue that a diagnostic procedure, not unlike that followed in medical practice, provides a more logical basis for stream channel assessment and monitoring. In general, a particular indicator or measurement of stream channel condition can mean different things depending upon the local geomorphic context and history of the channel in question. A diagnostic framework assesses reach-level channel conditions as a function of location in the channel network, regional and local biogeomorphic context,

controlling influences such as sediment supply and transport capacity, riparian vegetation, the supply of in-channel flow obstructions, and disturbance history. A similar approach and level of understanding is needed to design effective monitoring programs, as stream type and channel state greatly affect the type and magnitude of channel response to changes in discharge and sediment loads. However, the formulation of specific diagnostic criteria and monitoring protocols must be tailored to specific geographic areas because of the variability in the controls on channel condition within river basins and between regions. The diagnostic approach to channel assessment and monitoring requires a relatively high level of training and experience, but proper application should result in useful interpretation of channel conditions and response potential.

A Geomorphic Approach to Natural Channel Design[AFS]

Dave Rosgen
Wildland Hydrology
11210 N. County Rd. 19, Fort Collins, Co 80524
wildlandhydrology@wildlandhydrology.com

The application of geomorphic principles and fundamental assessments are presented for the purposes of stream restoration using natural channel design procedures. Contrary to uniformed interpretations of the method…it is not a "cookbook" approach in river restoration. The analysis conducted involves analog, empirical and analytical methods. The methods involve 1) a watershed and river stability assessment to determine the source, nature, extent and consequence of channel change, 2) alternatives for recovery based on natural recovery potential, changes in management related to the cause of the disequilibrium, and direct restoration approaches, 3) selection of the potential stable valley and stream type, 4) development of reference reach and regional curve data, 5) design of stable dimension, pattern and profile, 6) hydraulic relations of proposed design channel, 7) sediment competence and capacity calculations, 8) stabilization methods, and 9) a monitoring plan. An example is presented demonstrating the application of the methodology. This methodology has been successfully implemented since 1968 on large and small rivers throughout a range of hydro-physiographic provinces.

Prioritizing Stream and Watershed Restoration: A Review of Approaches and a Recommended Interim Method[AFS]

Phil Roni
Watershed Program, Environmental Conservation Division
NOAA Fisheries
Northwest Fisheries Science Center
2725 Montlake Boulevard East, Seattle, WA 98112
phil.roni@noaa.gov

Hundreds of millions are spent annually on watershed restoration and habitat improvements in the western United States. It is generally accepted that watershed restoration should focus on restoring natural processes that create and maintain habitat rather than manipulating habitats. However, most process-based restoration is site-specific, i.e., conducted on a short stream reach. In an effort to synthesize site-specific techniques into

a process-based watershed restoration strategy, we reviewed the effectiveness of common stream restoration techniques at improving fish habitat, synthesize various methods for sequencing restoration actions, and developed a hierarchical strategy for prioritizing them. The hierarchical strategy we present is based on three key elements: 1) principles of watershed processes, 2) protecting high-quality habitats, and 3) knowledge of effectiveness of techniques. Initially, efforts should focus on protecting areas with intact processes and high-quality habitat. Following a watershed assessment, we recommend that restoration focus on reconnecting isolated high-quality habitats. Once the connectivity of habitats has been addressed, efforts should focus on restoring hydrology, geologic, and riparian processes through improvement and restoration of roads and riparian areas. Instream habitat enhancement should be employed only after restoring natural processes or in cases where short-term improvements in habitat are needed. Other approaches to prioritizing restoration are not completely incompatible with the above strategy. Information on species of interest, project cost, cost-effectiveness, access, ownership and other factors can be used to modify the prioritization method we describe above. Finally, our review of both restoration effectiveness and methods for prioritizing restoration emphasize the need for watershed assessments to understand watershed function and restoration opportunities as well as the need for rigorous monitoring to determine effectiveness of restoration techniques.

Conceptualizing Watershed to Channel Scale Groundwater-Stream Exchange Under Natural and Re-naturalized Conditions[AFS]

Willaim W. Woessner
Center for Riverine Science and Stream Re-naturalization
Department of Geology, University of Montana
Missoula, MT 59812
gl_www@selway.umt.edu

Physical and sociological constraints hamper attempts to improve or re-establish stream health. The role of groundwater in stream systems is usually poorly understood or ignored even through it underpins the ecology of stream and floodplain systems. Groundwater exchanges with the stream channel creating gaining, losing, flow-through and parallel-flow reaches. Such transfers of water, nutrients and temperature are critical components of stream-riparian-floodplain function. Groundwater and surface water interaction also creates hyporheic zones, areas in which groundwater and stream water mix at the channel bed scale. These zones also provide critical spawning and rearing areas for several salmonid species. Restoration, re-naturalization and remediation of stream systems should incorporate groundwater-stream exchange as one of its goals.

Restoration of Grave Creek: Applications, Results and Lessons Learned[AFS]

John M. Muhlfeld
River Design Group, Inc.
911 Wisconsin Avenue, Whitefish, MT 59937
jmuhlfeld@riverdesigngroup.net

The Grave Creek watershed in northwest Montana has been identified as a core bull trout (*Salvelinus confluentus*) recovery watershed. Subject to a century of land use activities including agriculture, grazing, logging, road construction, and rural development, Grave Creek is currently functioning below its probable geomorphic and biological potentials. In conjunction with the Montana Department of Fish, Wildlife & Parks, the USDI Fish and Wildlife Service, and the Kootenai River Network, we restored approximately one mile of channel corridor with primary emphasis on re-establishing migratory habitat for threatened bull trout in fall 2002. The pre-construction channel was over-widened and shallow with bankfull widths ranging from 45-240 feet, and a mean width to depth ratio of 93.5. Restoration techniques included reactivating abandoned meanders and installing bank stabilization and fish habitat structures that incorporate large diameter woody debris. The designed channel reduced the mean bankfull width and width to depth ratio to 52 and 22 ft, respectively. Post-construction project monitoring indicated an almost nine fold increase in the total number of pools present in the restored section of Grave Creek, increasing critical pool habitat for adult migratory bull trout by 230 percent relative to baseline conditions. Maximum pool depths were increased by 152 percent from pre-restoration conditions. Eighty-two percent of the structures performed as designed following spring runoff 2003. We measured less than optimal performance on 18 percent of the structures. Factors affecting structure performance included the location of the individual structures along the meander arc and detachment of the Mirafai fabric from the vane logs.

Practitioners at Risk: Managing Risk and Uncertainty at Stream Restoration[AFS]

Dale E. Miller
Mainstream Restoration, Inc.
321 East Main Street, Suite 205, Bozeman, MT 59715
dmiller@mainstreamrestoration.com

Stream restoration projects, especially those that involve natural channel design, have an inherent element of risk and uncertainty. Risk involves identifying the possible outcomes associated with different alternatives. Uncertainty involves a situation where probabilities cannot be assigned to outcomes. Since most stream restoration failures are related to the effects of flooding, the probability of risk can often be quantified using hydrologic analysis—if the threshold of failure is also quantified. With increased attention to geomorphic process, and the availability of readily applied hydraulic and sediment modeling tools, the mechanisms of failure can be quantified. Designers can use various techniques or measures to satisfy component-specific design criteria. Hydrologic probability, either unbounded by time or within a given time-window, can then be assigned to quantify the risks of project failure. Additionally, it is also appropriate to recognize the inherent uncertainty in restoration design.

Examples of uncertainty are the lack of sufficient, accurate or representative data, or where an equation or model is used at its boundary of applicability. Restoration practitioners should be encouraged to openly discuss and record the risk and uncertainty in their work, but should be careful of speaking in terms that denote certainty when such certainty does not exist. Using good science, practitioners should strive to describe and manage risk at a level acceptable to project stakeholders. Discussion of risk and uncertainty, use of design criteria, and adequate documentation of design will all contribute to further maturation of the profession.

Nevada Spring Creek Restoratio Helmville, Monta [AFS]

Don Peters
DJP Aquatic Consulting
4955 E. Carlton Creek Rd., Florence, MT 59833
fishpeters@aol.com

Through the efforts of numerous individuals and agencies, 4 miles of Nevada Spring Creek have been restored from the source to the mouth. Nevada Spring Creek suffered from a number of interrelated impairments due to an over-widening of the channel and severe nutrient enrichment. Prior to restoration maximum summer water temperatures exceeded 78° F within a 1/4 mile of the artesian water source. Water, livestock and land management in the drainage all contributed to the impaired status. Conservation easements along Nevada Spring Creek provided the long-term protections necessary to initiate and maintain the corrective restoration actions. Stream channel pattern, profile and dimension were mechanically altered to conform to an E4 and E6 channel type. Channel filling and new channel construction were two primary methods used for rehabilitating the channel. We utilized still evolving restoration techniques, including 1) Sod mat stacking on "high" bank reconstruction, 2) Alteration of bottom substrates to reduce weed growth and promote macro invertebrate production and, 3) A conveyor belt gravel delivery system. Maximum summer water temperatures have been reduced 17ºF and mean water temperature declined 13 ºF to 52 ºF at a point 2 mi downstream. Fall and winter thermal conditions have also been changed significantly with "warmer" groundwater affecting temperatures over the entire 4 miles of restored stream channel. All fish species were in low abundance in 2003 prior to completion of restoration work, except perhaps redside shiners (*Richardsonius balteatus*) in the lower Nevada Spring Creek system.

Rock Creek Feasibility Study[AFS]

Bruce Anderson
Land & Water Consulting
P.O. Box 8254, Missoula, MT 59807
bruce.anderson@landandwater.net

Rock Creek is a "Blue Ribbon" stream supporting a high value coldwater fishery. A feasibility study was conducted to evaluate restoration strategies for the reach extending 14.5 miles downstream from Skalkaho Road. This study endeavored to undertake a "systems approach" to evaluate channel process on Rock Creek. This approach sought to identify underlying causes of channel instability, and present recommendations to improve equilibrium condition. At first glance, the braided, unconfined reach of Rock Creek appears to be undergoing large-scale changes in channel stability, channel form, bedload transport and deposition, and riparian habitat. Channel morphology has probably adjusted to some degree

to land use, although data to support this assumption were lacking. Despite substantial agency and landowner experience, channel dynamics are not completely understood and no consensus exists in interpretation of cause/effect and natural versus altered channel conditions. Channel cross-section data were collected with survey grade GPS, and included geo-referenced field data (pebble counts, Rosgen classification, substrate scoring, riparian condition, etc). Hydraulic analysis was performed using HEC-RAS. Braided conditions were related in part to land use, with inherent geological factors being the predominant driving influence. Imposed sediment load from upstream reaches did not appear to account for braided conditions. Further, rather than being a net depositional or aggrading zone, the braided reach appeared to be a net producer of sediment. Restoration activities aimed at conversion of the braided reach to a single-thread morphology is not necessarily consistent with the geological setting, and requires tradeoffs in terms of fish habitat and recreational use.

Fish Community Response to Habitat Improvements in Western Washington Rivers[AFS]

George Pess, Phil Roni and Sarah Morley
Watershed Program, Environmental Conservation Division
NOAA Fisheries
Northwest Fisheries Science Center
2725 Montlake Blvd. E., Seattle, WA 98112
george.pess@noaa.gov, phil.roni@noaa.gov, sarah.morley@noaa.gov

Roger Peters
USDI Fish and Wildlife Service
510 Desmond Drive SE, Suite 102, Lacey, WA 98503
Roger_Peters@r1.fws.gov

Habitat enhancement and restoration techniques are used in streams throughout the world in an effort to increase and conserve fish stocks. However, few of these techniques have been thoroughly evaluated. Since 1996, we have been systematically evaluating various habitat restoration techniques in the Pacific Northwest United States. Here we summarize the results of almost a decade of our research evaluating anadromous fish response to habitat improvement techniques including: large woody debris (LWD) and boulder weir placement, reconnection of off-channel habitats, and constructed side-channels. In 30 small streams, higher levels of coho salmon (*Oncorhynchus kisutch*), steelhead (*O. mykiss*), cutthroat trout (*O. clarki*), and larval lamprey (*Lampetra* spp.) were found in reaches treated with LWD though the level of response varied by season and species. Higher levels of coho salmon were also found in streams treated with boulder weirs in 12 southwest Oregon streams. An increase in juvenile and adult salmon abundance and species richness was found in habitats associated with constructed logjams in two large western Washington rivers. We analyzed existing smolt-trapping data from over 30 off-channel habitat enhancement projects and found that constructed groundwater channels were particularly productive for juvenile coho salmon. We then examined groundwater channels intensively and found that constructed channels supported higher densities of coho salmon during the winter, but fish diversity was higher in naturally-occurring channels. Our results suggest that common habitat improvement techniques increase the abundance of salmonids as well as species richness, but results vary by species habitat preferences, season, and magnitude of habitat improvement.

Implementation and Assessment of Upstream Passage for Fluvial Bull Trout and Westlope Cutthroat Troat in a Large Clark Fork River Tributary[AFS]

Ladd Knotek and Raven Rashap
Montana Fish, Wildlife & Parks
3201 Spurgin Rd., Missoula, MT 59804
lknotek@state.mt.us

Bruce Farling
Montana Trout Unlimited
P.O. Box 7186, Missoula, MT 59807

Jeff McLaughlin
Bureau of Reclamation
Pacific NW Design Group
1150 North Curtis Rd., Boise, ID 83706

Rattlesnake Creek is a large (bankfull discharge ~ 1000 cfs), relatively pristine fourth order tributary of the Clark Fork River near Missoula, Montana that supports a mixed (native and non-native) salmonid community. The stream has been the focus of a series of fishery enhancement efforts in 1999-2003 that culminated in an upstream fish passage project at Mountain Water Company Dam located four miles from the mouth. The goal of the project was to enhance migratory bull trout (*Salvelinus confluentus*) and westslope cutthroat trout (*Oncorhynchus clarki lewisi*) populations by affording adults access to ~ 15 miles of upstream natal spawning areas that have been completely inaccessible to fluvial trout for nearly a century. Project implementation was preceded by a series of disease, genetics, and species composition surveys, as well as testing of aspects associated with final fish ladder design, operation and efficiency. In 2001-2003, we also evaluated the efficacy of the project using radio telemetry, floy and PIT tagging, redd counts and a fish trap operated just upstream of the fish ladder. Monitoring indicated that the permanent fish ladder is an effective means of passing adult migratory trout past the dam. The timing of adult trout migrations was closely tied to stream temperature and discharge. Fish ladder operational schedules were developed that encourage species-selective fish passage. Project monitoring also provided insight on adult fluvial trout growth rates, movements, mortality rates and habitat use.

Assessment of Culverts as Fish Passage Barrier in a Montana drainage Using a Multi-Tiered Approach[AFS]

D. Drake Burford and Thomas E. McMahon
Department of Ecology, Montana State University
Bozeman, MT 59717
drakeb@avicom.net

Culverts may be a major factor contributing to the fragmentation and isolation of fish populations by potentially restricting movement through important migratory corridors.

Culverts can impede movement of fish due to high water velocities, inadequate water depths, and excessive outfall heights, among other factors, depending on the swimming and jumping capabilities of the fishes. The objective of our study was to assess the extent to which culverts restrict movement of fishes across a large drainage basin. We used three different approaches to investigate fish passage through culverts throughout the upper Clearwater River drainage, Montana. First, we measured physical conditions at 48 culverts sites to determine fish passage status using the FishXing software package. Second, we electrofished above and below a subset of 23 culverts to assess what culvert characteristics may be influencing fish distribution, abundance, and size structure. At a further subset of 12 sites, we measured passage directly by monitoring movement of marked fish through culverts with varying physical characteristics. The large-scale assessment of culverts using FishXing indicated that over 90 percent impaired fish movement at some discharge. However, electrofishing results showed little difference in fish population characteristics above and below culverts. Results from the mark-recapture studies indicate that fish passage is occurring at 11 of 12 of the culverts studied, but over half showed a degree of restricted movement relative to control reaches. Our findings suggest that using a combination of methods is advantageous for thoroughly assessing fish passage through culverts.

Detection of (*Batrachochytrium Dendrobatidis*), the Chyrid Fungus Associated with Global Amphibian Declines, in Montana Amphibians[AFS]

Bryce A. Maxell
Fish and Wildlife Biology Program
University of Montana
Missoula, MT 59812
bryce.maxell@umontana.edu

Grant Hokit
Biology Professor
Carroll College
Helena, MT 59601

Kirwin Werner
Salish Kootenai College
Department of Environmental Science
P.O. Box 70, Pablo, MT 59855
jkw@ronan.net

In order to identify potential causes of declines in the northern leopard frog (*Rana pipiens*) and western toad (*Bufo boreas*) which have been noted since the 1980s and assess the risk posed to other amphibian species whose status is uncertain, we submitted 98 tissue samples gathered from 8 amphibian species across Montana for PCR based identification of the chytrid fungus (*Batrachochytrium dendrobatidis*). This chytrid fungus has been associated with declines, extirpations, and losses of numerous amphibian populations and entire species around the globe over the last 2 decades. Tissue samples from 30 museum voucher specimens of 3 species collected in the Flathead Valley in the 1970s, prior to amphibian declines in the area, were all negative for *B. dendrobatidis*. However, 4 species and 26 of 68 tissue

samples gathered during inventory work across the state since 1998 tested positive for *B dendrobatidis*. In light of its association with other amphibian declines, *B. dendrobatidis*, acting alone or synergistically with other stressors, is a potential cause of the declines observed and should be regarded as an ongoing threat to Montana amphibians. In order to prevent additional spread of this fungal pathogen personnel working in either lentic or lotic systems should thoroughly rinse and decontaminate all equipment with 10-percent bleach between (1) any sites where dead, dying, or ill amphibians are encountered, (2) sites located in different local watersheds or definitive clusters of sites, and (3) all breeding sites of sensitive species separated by > 1 km.

Streamlining Data Collection and Analysis for Support of TMDL and Water Quality Restoration Plan Development in Montana[AFS]

Amy Beussink (Rollins)
USDA Forest Service
Lolo National Forest
Bldg 24, Fort Missoula, Missoula, MT 59804

In recent years, the Lolo National Forest has participated in Total Maximum Daily Load (TMDL) and Water Quality Restoration Plan (WQRP) development for five watersheds in western Montana: Upper Lolo Creek (1999-2003), St. Regis River (2001-2004), Prospect Creek (2003 – 2004), Middle Blackfoot River (2003-2005) and Ninemile Creek (2003-2004). The TMDL development process for each of these 303 (d) listed water bodies has varied depending upon stakeholder participation, previous watershed assessment efforts, and the impaired beneficial uses and probable causes involved. "Aquatic life support" and "Cold-water fishery- trout" are impaired beneficial uses common to all of these water bodies with some of the probable causes including habitat alteration, siltation, flow alteration, and thermal modification (1996 and 2002 303(d) lists). After several years of providing collaborative support for TMDL development in these watersheds, specific data and certain analysis methods and models demonstrate greater potential for establishing targets and allocations in the resulting Water Quality Restoration Plans. An overview of field data, analysis methods and models used will be provided. These include Rosgen Surveys Level 1, 2 & 3, riffle stability index (RSI), R1/R4 fish habitat inventories, fish population surveys, water yield modeling (ECA), sediment modeling (WATSED/LoloSED, XDRAIN, Washington Method), culvert-fish passage assessments, queries of Forest Service databases including TSMRS and INFRA, and GIS analysis. Data, analysis methods and models with greatest potential will be highlighted, and their application to Water Quality Restoration Plans described in detail. The purpose of this presentation is to share insight into providing focused, efficient support of TMDL development so to expedite development and implementation of restoration plans.

The Catron and Nash Story: Urban Development as a Stream Restoration Tool[AFS]

Patrick Byorth
Montana Fish, Wildlife, & Parks
111 N 3rd Street, Livingston, MT 59047
pbyorth@montana.edu

In Western Montana, population growth and urban development are accelerating and affecting aquatic systems. For many aquatic biologists, active participation in community planning is critical to stream protection and restoration. Engaging in community planning and regulatory processes is an alternative means of restoring streams and aquatic habitats. Nash Spring Creek and East Catron Creek are suburban streams that were historically channelized for agriculture and more recently threatened by suburban development. Through the Natural Streambed and Land Preservation Act (310) permitting process, specifications and terms for realignment and restoration were directly negotiated with developers. In each case, the primary goal was to reconstruct each stream in a more naturally functioning state with improved habitat conditions. To document the affects of the reconstruction on fish, we conducted electrofishing surveys in several reaches of both streams. In Catron Creek, fish densities severely declined within a year of realignment. However, in some reaches fish densities and diversity increased over time. In Nash Spring Creek, total fish numbers recovered rapidly to levels similar to an unimpacted reach. However, channel realignment resulted in a shift of fish community structure. Pressures on aquatic resources created by suburban development are inevitable. However, biologists can instigate stream restoration and mitigate impacts by actively engaging in community planning and permitting processes.

Geomorphic Comparison of Holocene Terraces Bbetween the Sun River, Montana and the Sopachnaya River, Kamchatka: Implications to the Fisheries Resource Resulting from Floodplain Function and Land Use[AFS]

Steve Buckley and Mike Koopal
Watershed Consulting
410 Wisconsin Ave., Whitefish, MT 59937
steve@watershedconsulting.com
mikekoop@watershedconsulting.com

Impacts of land-use activities on a salmonid fishery are well documented. However, geomorphic evaluation of floodplain function and departure is often overlooked. Throughout many of the rivers in the northern Rocky Mountains, three major Holocene fluvial terraces have formed as rivers abandoned their floodplain in response to global climate change after the end of the Pleistocene. On the Sun River, the highest Holocene terrace stands 15 ft above bankfull, and is rarely preserved and never inundated. The middle terrace is found 6-8 ft above bankfull and is rarely inundated (>100-yr flood). This feature has well-developed loamy soil and has been deforested and farmed. The lowest terrace is 3 ft above bankfull and is inundated frequently (10-yr flood). The Sopachnaya River in Kamchatka, Russia has a similar geomorphic setting to the Sun River but flows through a pristine wilderness. There

are also two well-developed Holocene terraces, one at 15' and the other at 8' above bankfull stage. In marked contrast to the Sun River, there is no lower Holocene terrace. Instead, the low landforms associated with the Sopachnaya are active floodplains with organically rich deposition and young vegetation (< 20 yrs old). Although similar in many respects, the contrast in land-use and flow regulation between the two rivers points to the impacts of floodplain function. The Sun River has lost access to a wide floodplain, the floodplain vegetation has become decadent and the floodplain soils have desiccated. In contrast, the Sopachnaya displays frequent inundation, greater stability, and increased fish habitat diversity.

Wetland Sod for Bio-engineereed Streambank Stabilization and Wetland Revegation[45]

Paul B. Hook
Consultant
215 South 7th
Livingston, MT 59047
paulhook@earthlink.net

Katie M. Salsbury and Jeffrey M. Klausmann
Intermountain Aquatics, Inc., Driggs, ID 83422
katie@intermountainaquatics.com
jeff@intermountainaquatics.com

Wetland sod is a pre-vegetated coconut fiber mat containing well-established native plants that have been grown hydroponically to achieve high initial root density. It provides immediate soil stabilization and accelerated revegetation for stream and wetland restoration projects. In 2002-2003 we used wetland sod and other materials to stabilize 1340 m of eroding streambanks at 6 sites on the Teton River, SE Idaho, a predominantly groundwater-fed, free-flowing system. Before construction, banks averaged 1-1.5 m high and 1:1 or steeper slope, with silty clay loam texture and vegetation dominated by introduced pasture grasses. Using stable, natural reference sites as a guide, banks were excavated, reconstructed at an average slope of 4:1, and stabilized using long-term erosion control fabric, wetland sod planted with native sedges and rushes, and containerized willows and rooted and dormant cuttings. Within 1 month, wetland sod was fully rooted and could not be displaced by human or animal disturbance. Bank treatments successfully established native plant communities and withstood cattle trampling, grazing and peak flow events over 1 year. Total cost was $246/linear meter including design, permitting, construction, revegetation, irrigation and weed control. In a replicated field experiment in Teton County, Wyoming, we compared wetland sod and six other wetland revegetation methods in an off-stream, floodplain setting. Wetland sod and other methods using vegetative plant materials provided superior establishment of target species compared to broadcast seeding, passive revegetation, or salvaged marsh surface. Wetland sod was uniquely effective in reducing establishment of invasive, exotic, and other undesirable species.

Aquatic Conservation Efforts of a Private Organization—Can We Make A Difference Or Are We Just Turn(er)ing Circles?[AFS]

Carter G. Kruse
Turner Enterprises, Inc
1123 Research Dr., Bozeman, MT 59718
ckruse@montana.net

The Turner organization is uniquely positioned to conduct large-scale conservation projects because of our large land base and geographical extent. Our operational objectives are guided by the philosophy of managing landscapes in an ecologically sensitive manner to conserve native biological diversity while maintaining economic viability. As such, the objectives of our biological programs are to 1) conserve and restore native, imperiled, and endangered species and their habitats, 2) develop long-term working relationships with federal and state agencies and other non-governmental organizations to further conservation, 3) conduct scientifically credible research regarding conservation and management of imperiled species, and 4) work with and educate other private landowners. Since 1998 biologists within the Turner organization have worked diligently to build networks with state and federal agencies and implement on the ground projects. Aquatic native species conservation has focused primarily on native cutthroat trout (*Oncorhynchus clarki*) restoration projects with efforts ongoing to restore two subspecies on three properties in two states, including the infamous Cherry Creek project. Two of these projects, to our knowledge, are the largest (in contiguous stream km) ever attempted. We are involved in significant efforts to monitor and recover Chiricahua leopard frogs (*Rana chiricahuensis*) and Rio Grande suckers (*Catostomus plebius*) in the desert southwest, and restore the native bosque community along the Rio Grande River. The Turner "model," even considering some inconsistencies, has been very successful initiating on-the-ground projects as agencies and organizations recognize the scientific credibility, logistical organization, and financial resources that we can bring to the table. Ultimately, collaboration is the key to success on many of these projects and we remain committed to their successful conclusion.

Paradise Stabilized: Juvenile Salmonid Abandances in the Yellowstone River[AFS]

Alexander V. Zale
Montana Cooperative Fishery Research Unit, USGS
Department of Ecology, Montana State University
Bozeman, MT 59717
zale@montana.edu

Juvenile salmonid abundances along bank habitats of the Yellowstone River near Livingston, Montana, were assessed to evaluate the effects of bank stabilization on recruitment to the fishery. Use of stabilized main-channel banks (riprap, barbs, jetties) was similar or higher than that of natural, unaltered main-channel banks. Artificially-placed boulders and shoreline irregularities associated with stabilized banks likely attracted juvenile salmonids. Some natural bank reaches included little cover and were used by few fish. Juvenile abundances at all banktypes were low relative to other rivers and were likely

insufficient to maintain the fishery; immigration may therefore be an important component of recruitment here. Abundances of juvenile salmonids in ephemeral lateral side channels during spring runoff were higher than among main-channel banks. Bank stabilization that reduces the frequency and duration of inundation of side channels, or reduces side-channel formation rates, or directly precludes inundation or accessibility of side channels likely decreases juvenile fish habitat and possibly recruitment. A comprehensive understanding of recruitment dynamics in the Yellowstone River is necessary to competently evaluate the effects of anthropogenic alterations. Management of development along the Yellowstone River will continue to be contentious until consensus is reached on how much lateral migration the river will be allowed.

Channel Modifiction and Fish Habitat in the Upper Yellowstone River[AFS]

Zachary H. Bowen, Ken D. Bovee, and Terry J. Waddle
U.S. Geological Survey
Fort Collins Science Center
2150 Centre Avenue, Building C,
Fort Collins, CO 80526-8118
zack_bowen@usgs.gov

A two-dimensional hydrodynamic simulation model was coupled with a geographic information system (GIS) to produce a variety of habitat classification maps for three study reaches in the upper Yellowstone River basin in Montana. Data from these maps were used to examine potential effects of channel modification on shallow, slow current velocity (SSCV) habitats that are important refugia and nursery areas for young salmonids. At low flows, channel modifications were found to contribute additional SSCV habitat, but this contribution was negligible at higher discharges. During runoff, when young salmonids are most vulnerable to downstream displacement, the largest areas of SSCV habitat occurred in side channels, point bars, and overbank areas. Based on simulations in modified and unmodified sub-reaches, channel simplification results in decreased availability of SSCV habitat, particularly during runoff. The combined results of the fish population and fish habitat studies present strong evidence that during runoff, SSCV habitat is most abundant in side channel and overbank areas and that juvenile salmonids use these habitats as refugia. Channel modifications that result in reduced availability of side channel and overbank habitats, particularly during runoff, will probably cause local reductions in juvenile abundances during the runoff period. Effects of reduced juvenile abundances during runoff on adult numbers later in the year will depend on (1) the extent of channel modification, (2) patterns of fish displacement and movement, (3) longitudinal connectivity between reaches that contain refugia and those that do not, and (4) the relative importance of other limiting factors.

An Assessment of Reproductive Isolation Between Yellowstone Cutthroat Trout and Rainbow Trout in the Yellowstone River, Montana[AFS]

James N. De Rito and Alexander V. Zale
Montana Cooperative Fishery Research Unit, USGS
Department of Ecology, Montana State University
Bozeman, MT 59717
jderito@montana.edu, zale@montana.edu

Bradley B. Shepard
Montana Fish, Wildlife, & Parks
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59718
bshepard@montana.edu

The genomic extinction of Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) has occurred throughout many parts of its historic range because of introgression with introduced rainbow trout (*O. mykiss*). However, relatively low levels of introgression have been detected in cutthroat trout within the Yellowstone River, implying they may be reproductively isolated from rainbow trout. If reproductive isolation exists, then determining its spatial and temporal components could assist managers in better conserving genetically pure cutthroat trout. Reproductive isolation was assessed by radio-tagging and tracking 164 trout (98 cutthroat, 37 rainbow, and 29 cutthroat x rainbow trout hybrids) captured in four areas of a 133-km segment of the mainstem Yellowstone River during three spawning seasons (2001-2003). A total of 72 spawning fish (42 cutthroat trout, 17 rainbow trout, and 13 hybrids) were documented moving into potential spawning sites in tributaries (n = 55) or within the mainstem river (n = 17) during the April through early July spawning season. Spatial overlap of spawning sites was documented between cutthroat trout and rainbow trout or hybrids in both tributaries and the river. However, both rainbow trout and hybrids spawned earlier than cutthroat trout. Therefore, differential timing of spawning is more likely the predominant mechanism for maintaining reproductive isolation. Maintaining temporal reproductive isolation may be facilitated by leasing water in tributary streams to allow for later spawning by cutthroat trout. In addition, entrainment of post-spawn cutthroat trout into irrigation diversions on tributary streams indicates that screening of diversions would be beneficial.

Temporal Patterns of Channel Migration, Fluvial Events, and Associated Vegetatio Along the Upper Yellowstone River, Montana[AFS]

Michael F. Merigliano and Mary Louise Polzin
College of Forestry and Conservation, University of Montana
Missoula, MT 59812
mmerig a forestry.umt.edu

As part of the Governor's Upper Yellowstone River Task Force and the U.S. Army Corps of Engineers Cumulative Effects study along the upper Yellowstone River, we examined the vegetation along the river from Gardiner to Springdale, Montana. The study goal was to gain an understanding of fluvial geomorphic processes and it relation to flood plain vegetation. We used repeat photography and mapped cottonwood (*Populus angustifolia*) tree ages to quantify flood plain and vegetation dynamics in several geomorphic settings. The reference model for flood plain dynamics was exponential decay, which provides a rate of erosion and deposition at steady state. Flood plain dynamics and vegetation composition along the upper Yellowstone River flood plain varied by geomorphic setting, which in turn varied from broad, un-confined braided channel systems to single-thread channels with narrow flood plains confined by glacial terraces and bedrock. Although the general appearance of the vegetation and river system is similar to that of 100 years ago, retrospective age distributions and real-time trend analysis reveal a reduction in fluvial activity, cottonwood recruitment on an area basis, and cottonwood forest area. The flood plain turnover period for the braided reaches is between 550 and 1700 years. Dated flood plain area was positively correlated with flood size, and cottonwood area decay curves indicate that most flood plain erosion and deposition occurs during large floods. Agriculture caused a net reduction in forest area in the last 50 years, but loss to natural succession was about twice the loss due to agricultural conversion.

Historical Channel Changes and Geomorphology of the Upper Yellowstone River[AFS]

Chuck Dalby and Jim Robinson
Water Management Bureau
Department of Natural Resources and Conservation
1424 9th Ave.
PO Box 201601, Helena, MT 59620-1601
cdalby@state.mt.us, jrobinson@state.mt.us

In response to lateral erosion and flooding caused by near 100-year floods in 1974, 1996 and 1997, extensive segments of the upper Yellowstone River and flood plain have been modified using dikes, levees, riprap, and jetties (barbs). Confinement of river channels often leads to reduced migration rates, channel incision, bed coarsening, and loss of hydraulic connectivity with side-channels. As part of cooperative investigations sponsored by the Upper Yellowstone River Task Force, we (1) mapped the contemporary (1999) fluvial geomorphology of the upper Yellowstone River (137 km reach—Gardiner to pringdale, Montana) and historic channel changes (1948-1999), (2) developed a process-based geomorphic channel classification, e.g. modified Montgomery-Buffington, of the 1999 channel, (3) mapped contemporary and historic (1954, 1973, 1999) channel modifications

and revetments, and (4) measured and analyzed retrospective geomorphic effects of channel modifications (in progress). Dikes, levees, and road prisms have increased 265 percent (34,700 to 92,250 feet) between 1954 and 1999; riprap increased 400 percent (27,400 to 111, 260 ft), and jetties and barbs increased 600 percent (47 to 292). Of the total channel length, 14 percent (19 km) was strongly affected by channel modification (riprap, levees, etc); another 6 percent (8 km) was affected by combined natural and human constraints. Local channel response to confinement includes channel incision (Livingston area), aggradation and modification of channel alignment. In spite of these modifications, the channel is remarkably resilient and the overall stability and physical characteristics of about 80 percent of the study area remain similar to those of the Yellowstone River in 1948.

Continued Invasion of Nonnative Trout and Associated Changes in Fish Communities in Shields River Tributaries From 1974 to 2003[AFS]

Bradley B. Shepard
Montana Fish, Wildlife & Parks
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59717-3460
bshepard@montana.edu

Nonnative brook trout (*Salvelinus fontinalis*) have been implicated as part of the reason for the documented decline of cutthroat trout (*Oncorhynchus clarki spp.*); however, a question remains as to whether brook trout continue to invade cutthroat trout habitats or whether they rapidly expanded following their initial releases in the early to middle twentieth century and have remained relatively static since that time. I assessed whether brook trout continued to invade Yellowstone cutthroat trout (*O. c. bouveri*; YCT) habitats, and whether they displaced cutthroat trout, in the Shields River drainage from 1974 to 2003. Sampling was repeated during 2001-2003 in 17 sites that had been surveyed in 1974. There was no apparent change in the fish community in four sites (YCT remained allopatric in three sites and YCT and brook trout were at similar proportions in another site); brook trout had recently invaded two sites; brook trout currently made up a higher proportion of the fish community in seven sites; Yellowstone cutthroat trout made up a higher proportion of the fish community in two sites; and brown trout appeared to be replacing brook trout in two sites. These results appeared to be spatially dependent and fish community dynamics and water temperature may be playing a role. These data suggest brook trout are continuing to invade habitats within the upper Shields drainage and often displace Yellowstone cutthroat trout, similar to what has been found for westslope cutthroat trout (*O. c. lewisi*) although in contrast to what was found in the Snake River drainage in Idaho.

They're (Almost) Gone: Removal of Northern Pike from Milltown Reservoir, Montana—It's Just Like Pulling Knapweed, Only Less Controversial[AFS]

David A. Schmetterling
Montana Fish, Wildlife & Parks
3201 Spurgin Rd., Missoula, MT 59804
dschmetterling *a* state.mt.us

Illegally introduced northern pike (*Esox lucius*) in Milltown Reservoir represent a threat to resident and migratory native fishes. By 1999, northern pike were the most abundant species in the reservoir. I evaluated two methods to reduce the population size of northern pike and predation on native fish: summer reservoir drawdowns (targeting age-0 fish) and trap netting (to remove adults during spawning). In 2002, the population of northern pike was 2,883 ± 663 (95% CI) and trap netting removed 985 adults (34%). By 2003 the population was reduced to 786 ± 169 and I trapped 432 (55%), reducing the density of northern pike by 88 percent in 14 months. Between 2000 and 2002, bull and westslope cutthroat trout were seasonally common in northern pike stomachs. In 2003, none were detected in stomachs despite greater sampling, suggesting that the reduced northern pike population size reduced predation. Summer drawdowns killed an estimated 10,000 northern pike in 1999, 9500 in 2001, 7100 in 2002, and 3670 in 2003. Whereas drawdowns from 1999-2002 only killed northern pike, largemouth bass, yellow perch and pumpkinseed (illegally introduced non-native fish), in 2003 largescale suckers, and northern pikeminnow were detected, signifying recovery of native fishes. Any management activity that involves killing animals has the potential for controversy, whether from concerns over pesticides or lack of understanding the program's goals. Initially, managing and removing northern pike was controversial in Missoula, but as a result of public education, the public is supportive of northern pike control and ultimately the removal of Milltown Dam.

Population Characteristics of Lake Trout in Lake McDonald, Glacier National Park: Implciations for Removal[AFS]

Andrew M. Dux and Christopher S. Guy
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59717
adux@montana.edu, cguy@montana.edu

Leo Marnell
USDI National Park Service
Glacier National Park, Science Center
West Glacier, MT 59936
leo_marnell@nps.gov

Wade A. Fredenberg
USDI Fish and Wildlife Service
Creston Fish and Wildlife Center
780 Creston Hatchery Rd., Kalispell, MT 59901
wade_fredenberg@fws.gov

Native species, particularly bull trout (*Salvelinus confluentus*), have suffered dramatic population declines since the establishment of nonnative lake trout (*Salvelinus namaycush*) in Lake McDonald, Glacier National Park (GNP). In an attempt to prevent the further decline of these populations GNP is considering a lake trout removal program. This study was conducted to examine the population characteristics of lake trout and model the effects of varying exploitation on lake trout abundance and yield. Saggital otoliths were removed from 157 lake trout captured from May through September 2003. Otoliths were sectioned and aged by two readers using a compound microscope. Mean length at age varied from 235 mm at age 5 to 465 mm at age 10 and time to reach 450 mm was 9.3 years. The von Bertalanffy growth model was used to estimate theoretical maximum length (730 mm), growth coefficient (0.104), and the time when length would theoretically equal 0 mm (0.102). The overall (i.e., sexes pooled) weight-length model was $\log_{10}$weight = -5.44 +3.11($\log_{10}$length). Growth in length and weight was typically lower than lake trout in Flathead Lake, Montana. Our model simulations for a population of 100,000 individuals indicated that an exploitation of 73 percent was needed to reduce the number of 450 mm lake trout to zero. Growth overfishing only occurred at 20 percent exploitation when conditional natural mortality was 10 percent. These data illustrate that complete removal of lake trout in Lake McDonald is unlikely; however, moderate levels of exploitation did reduce yield estimates when natural mortality was low.

Interactions Among Three Top-level Predator in Harlan County Reservoir, Nebraska[AFS]

Nathan W. Olson and Christopher S. Guy
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59717
cguy@montana.edu

Keith D. Koupal
Nebraska Game and Parks Commission
District VI Office
1617 1st Avenue, Kearney, NE 68847

Walleye (*Stizostedion vitreum*), white bass (*Morone chrysops*), and hybrid striped bass (*M. chrysops* x *M. saxatilis*) are common top-level predators in Midwestern reservoirs. However, the ecology and interactions among these three species are not well understood. Therefore, we compared food habits and vertical distribution of walleye, white bass, and hybrid striped bass to quantify resource overlap. Food habits and vertical distribution data were collected during the evening, i.e., 2000 h to 0200 h, monthly from June through September 2002 and 2003. Food habits and vertical distribution data were collected from 554 white bass (155-392 mm TL), 241 hybrid striped bass (315-720 mm TL), and 181 walleye (231-962 mm TL). Diet overlap was high for hybrid striped bass and walleye in June (Pianka index [O_{jk}] = 0.935), and was high among all three predators from July through September (Pianka index [O_{jk}] = 0.920-0.996). Primary diet items consisted of chironomids and freshwater drum (*Aplodinotus grunniens*) in June and gizzard shad (*Dorosoma cepedianum*) from July through September. Walleye and hybrid striped bass exhibited the greatest diet breadth (Levin's standardized index [B_A] = 0.031-0.130) during all months. Vertical distribution overlapped for all species during June in both years. Our results indicate substantial overlap among walleye, white bass, and hybrid striped bass with respect to diet and spatial distribution in Harlan County Reservoir. Thus, it is likely that competition could occur among these species when resources are limited.

Life-history Characterstics of an Adfluvial Population of Bull Trout in a Northern Idaho Stream[AFS]

Christopher C. Downs
Idaho Department of Fish and Game
1402 E. Spring Creek Rd., Clark Fork, ID 83811
cdowns@sandpoint.net

Robert Jakubowski
Avista Corporation
P.O. Box 1463, Noxon, MT 59853
jak@sandpoint.net

We utilized a rotary screw trap and weirs to capture migrating bull trout (*Salvelinus confluentus*) in Trestle Creek, Idaho, from 2000 through 2002, in order to estimate their abundance, understand basic life-history characteristics, and to evaluate survival rates in the tributary and lake environment. Age-0 outmigrants accounted for greater than 85 percent of the total annual catch of juvenile bull trout in Trestle Creek in all years. We believe this is largely due to density-dependent competition for rearing habitat, rather than a successful life-history strategy. Age-2 and age-3 outmigrants accounted for the majority of the outmigration of age-1 and older juveniles. We estimated 1276, 1094, and 1147 age-1 and older juvenile bull trout outmigrated from Trestle Creek in 2000, 2001, and 2002, respectively. Annual outmigration of juvenile bull trout occurred primarily at night in two pulses, one occurring in the spring and the other in the fall. The median distance moved downstream per night by juveniles captured in the fall was 315 m (n = 40) and 295 m (n = 17), in 2001 and 2002, respectively. Adult bull trout also migrated primarily at night, with 92 percent of the detections (n = 631) at the PIT tag weir in 2001 and 2002 occurring between sunset and sunrise. Of those PIT tagged adults marked in 2000 that returned to spawn in either 2001 or 2002, 92.6 percent (n = 224) returned annually versus 7.4 percent (n = 18) returning in alternate years. We detected a total of 224 of the 393 (56.9%) adult bull trout originally marked in Trestle Creek in 2000, in Trestle Creek in 2001. Based on juvenile outmigration and adult escapement data, we speculate juvenile rearing habitat currently represents a population bottleneck in Trestle Creek. We marked 889 outmigrating juvenile bull trout with PIT tags and will be using their return to estimate lake survival over the next several years.

Assessment of Tributary Potential for Wild Rainbow Trout Recruitment in Hebgan Reservoir, Montana[AFS]

Darin A. Watschke
USDA Forest Service &
Department of Ecology, Montana State University
29 AJM Johnson Hall
Bozeman, MT 59717
dwatschke@hotmail.com

Thomas E. McMahon
Department of Ecology, Montana State University
310 Lewis Hall
Bozeman, MT 59717
tmcmahon@montana.edu

Conversion of trout stocking to self-sustaining wild trout populations has been a cornerstone of fisheries management in Montana rivers for the past 30 years. However, trout fisheries in Montana reservoirs are almost entirely maintained by stocking hatchery fish. An exception is Hebgen Reservoir, where wild rainbow trout (*Oncorhynchus mykiss*) were established in 1979, with annual supplementation of hatchery-reared rainbow trout. Continued, unexpectedly low catch rates of rainbow trout led to the objective of this study to assess tributary recruitment of wild rainbow trout and identify potential limiting factors. A combination of redd surveys, adult and fry trapping, and measurement of spawning and rearing habitat and water temperature, was used to assess spawning use and habitat characteristics of 11 tributaries in 2002 and 2003. A total of 5642 redds were counted, suggesting numbers of spawners was not limiting. However, most spawning production (80%) was confined to two of the 11 tributaries (Duck Creek and S.Fork of the Madison River). Redd density was associated with available spawning habitat (percent spawning gravels) and rearing habitat (percent pools and ponds). Mean daily water temperature, from May through July, varied widely among tributaries (5.6 to 16.5 °C) while most spawning production (90%) was associated with temperatures from 8.5 to 13 °C. Downstream trapping indicated that production of age-1+ juvenile trout may contribute significantly more to juvenile recruitment to the reservoir than previously thought. The apparent high juvenile recruitment to the reservoir suggests that conditions within the reservoir may be more likely limiting the numbers of adult wild trout recruiting to the fishery.

Application of a Two-dimensional Habitat Model for Instream Flow Investigations on the Flathead River, Upstream of Flathead Lake, Montana[AFS]

William J. Miller
Miller Ecological Consultants, Inc.
1113 Stoney Hill Dr., Suite A, Fort Collins, CO 80525
mec@millereco.com

Doran J. Geise
Spatial Sciences and Imaging
1113 Stoney Hill Dr., Suite B, Fort Collins, CO 80525
dgeise@spatial-sciences.com

A modified Instream Flow Incremental Methodology (IFIM) approach was used on the mainstem Flathead River from the South Fork Flathead River downstream to Flathead Lake. This study quantified changes in habitat for the target fish species, bull trout (*Salvelinus confluentus*) and westslope cutthroat trout (*Oncorhynchus clarki lewisi*), as a function of discharge. Two- dimensional hydraulic simulations were combined with habitat suitability criteria in a GIS analysis format to determine habitat area as a function of discharge. Results of the analysis showed that habitat area is more available at lower discharges than higher discharges. Comparison of the pre-dam hydrology with post-dam hydrology showed that pre-dam baseflows provided more stable habitat than the highly variable post-dam flow regime. The GIS analysis showed that sub-adult fish, in particular bull trout, were required to use less productive stream margin areas that are constantly wet and then dried as flows fluctuate. These areas have highly varying productivity for lower trophic levels and consequently are less productive for higher trophic levels, especially bull trout sub-adults. The analysis demonstrates that highly variable flows likely put stress on a bull trout subadult and westslope cutthroat trout, due to the additional movement required to find suitable habitat. The GIS approach presented here provides both a visual characterization of habitat as well as Arcview project data that can be used for additional analysis of flow regimes and spatial variability of habitat within the three reaches of the river.

Bacterial Coldwater Disease: Hatchery Epidemiology and Control[APS]

Eileen K. N. Ryce
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59717
eryce@montana.edu

Alexander V. Zale
Montana Cooperative Fishery Research Unit, U GS
Department of Ecology, Montana tate University
Bozeman, MT 59717
zale@montana.edu

Mark Sweeney and Jay Pravecek
Washoe Park State Fish Hatchery
Montana Fish, Wildlife and Parks
600 West Pennsylvania St., Anaconda, MT 59711
washoehatchery@hotmail.com

Bacterial coldwater disease, caused by the gram-negative bacterium (*Flavobacterium psychrophilum*), has caused significant losses of hatchery-reared salmonids worldwide. It is especially problematic at hatcheries rearing fish for native species restoration. Washoe Park State Fish Hatchery typically loses 30 to 45 percent of their annual westslope cutthroat trout (*Oncorhynchus clarki lewisi*) production to the disease. Using Washoe Park as a test case, our goal was to develop practical hatchery-management strategies to better control the pathogen and the disease. Our main objectives were to determine where the pathogen is, how it is transmitted, and what factors cause disease outbreaks. We found the bacterium in the hatchery water source, in water within the hatchery, and in production and broodstock fish. It was transmitted both horizontally and vertically, with both male and female adults passing the pathogen on to juveniles. Chronic stress and low levels of acute stress, such as a simulated planting event, did not result in disease outbreaks. However, a combination of acute stress events involved with moving fish to an outside environment, caused a disease outbreak. Measures have been implemented at Washoe Park to reduce horizontal transmission, and tactics to reduce vertical transmission will be tested in 2004. It is unlikely that the pathogen can be eradicated completely, but management to reduce the number of fish carrying the pathogen may minimize losses during outbreaks.

Does Wildfire Favor Invasion of Nonnative Fishes?[AFS]

Clint M. Sestrich and Thomas E. McMahon
Department of Ecology, Montana State University
Bozeman, MT 59717
csestrich@montana.edu
tmcmahon@montana.edu

Micheal K. Young
USDA Forest Service
Rocky Mountain Research Station
P.O. Box 8089, Missoula, Montana 59807
mkyoung@fs.fed.us

Many studies have documented rapid recovery of fish populations following wildfire disturbance. However, it is not known if wildfire effects can tip the balance in favor of nonnative fishes. Therefore, we are testing the hypothesis that increases in stream temperature, sedimentation, and reduced habitat complexity following wildfires favor nonnative trout in mixed native and nonnative salmonid communities. We are conducting the study in the upper Bitterroot River drainage in western Montana, the site of a 1440 km^2 wildfire complex in 2000. Westslope cutthroat trout (*Oncorhynchus clarki lewisi*), bull trout (*Salvelinus confluentus*), and brook trout (*Salvelinus fontinalis*) are patchily distributed across the drainage. Pre-fire fish population data for many basins in the watershed allow unique comparisons of changes in fish species composition and abundance among sites varying in fire severity, presence of fire-induced debris flows, and distance to source populations for colonization of defaunated reaches. We found that mean daily temperatures in reaches affected by high-severity fire increased by 3.7 °C compared to 0.9 °C in unburned reaches. Following initial fire-induced population declines, reaches in high-severity burns averaged a 110 percent increase in fish abundance from 2001 to 2002. In contrast, populations in reaches affected by debris flows increased little from 2001and averaged only 8 percent of pre-fire abundance in 2002. Although analyses of 2003 data are preliminary, brook trout abundance appears to be increasing relative to native bull trout and westslope cutthroat trout in reaches with fire-induced sediment and temperature increases.

Predicitng Post-fire Sediment Risks to Streams[AFS]

Kevin Hyde
The University of Montana &USDA Forest Service
Rocky Mountain Research Station
Missoula, MT 59812
kdhyde@fs.fed.us

Severe erosion that commonly follows intense wildfires throughout the Mountain West radically alters aquatic habitats. Before human encroachment local fish populations survived these disturbances by escaping to and/or repopulating from unaffected refuge areas. Habitat loss and degradation limits these areas and increases the threat of post-fire erosion. Therefore we need to identify locations where the potential for severe post-fire erosion overlaps degraded or spatially limited aquatic habitat. Gully rejuvenation usually results in

high volume debris flows. These flows represent the most severe form of post-fire erosion, delivering large pulses of fine sediments, rocky debris, and wood from ephemeral channels into perennial stream systems. Gully rejuvenation is more likely to occur where high severity burns impacts relatively large portions of, and is concentrated near, watershed divides. This paper presents a GIS-based technique using satellite derived burn severity mapping to identify potential sources of severe post-fire erosion. 1st and 2nd order ephemeral basins are delineated and assigned a Burn Severity Distribution Index (BSDI) value. Basins with high values are identified as highly probable debris flow sources if the burned area receives a intense rainfall soon after a fire. A model is proposed to assess the risk of severe erosion response as a function of the BSDI. A method to co-ordinate this risk analysis with aquatic habitat assessment is demonstrated. This approach may prove to be useful for Burned Area Emergency Rehabilitation (BAER) teams as they identify aquatic resources most at risk following wildland fire.

Effects of Wildfire in an Aquatic Habitat of the Wigwam River 70 Yers Later—Insights into Temporal Dynamics in Watershed Processes, Channel Condition and Riparian Function AFS

Kim C. Green
Apex Geoscience Consultants Ltd.
1220 Government Street,
Nelson, B.C., Canada,V1L 3K8

The Wigwam River situated in Southeastern B.C.—Northwestern Montana is identified as a key bull trout (*Salvelinus confluentus*) spawning habitat in the Lake Koocanusa basin and has been the focus of international attention for the past decade following declining bull trout populations during the late 1900s. A reconnaissance level hydro-geomorphological assessment of the Wigwam River has provided a unique insight into the long-term changes in watershed processes following an extensive wildfire that removed over 70 percent of the forest in the 40000-ha drainage during the early 1930s. The most significant changes in watershed processes following the fire included large sustained increases in sediment delivery throughout the drainage and extensive deforestation of riparian areas along much of the main stem channel and many of the tributary channels. These impacts have resulted in long-term changes in the sediment budget, riparian function and channel condition that have been both beneficial and detrimental to aquatic habitat. The Wigwam River study provides insights into the long-term effects of a large wildfire event on aquatic habitat and the evolution of watershed processes and channel condition in the decades following a severe disturbance event. Recognizing these long-term changes has provided an understanding of natural disturbance regimes and temporal variability of watershed and channel processes. This information has assisted forest managers in identifying key management concerns to protect aquatic values in the Wigwam River.

They're (Almost) Everywhere: Movement Patterns and Habitat Use in Boreal Toads in Western Montana Basins[AFS]

Michael K. Young
USDA Forest Service
Rocky Mountain Research Station
P.O. Box 8089, Missoula, MT a 59807
mkyoung@fs.fed.us

David A. Schmetterling
Montana Fish, Wildlife and Parks
3201 Spurgin Rd., Missoula, Montana 59804
dschmett@bigsky.net

The boreal toad (*Bufo boreas*) is widely distributed in western North America, but it has declined precipitously in the southern Rocky Mountains and may be declining in western Montana. Previous studies indicated that adult boreal toads were sedentary, and typically occupied summer habitats far from water. We devised a new method for detecting the presence of toads using upstream-facing hoop nets in two drainages in June 2003. In July-August 2003 in two streams, we conducted a more intensive study of in-channel movements using hoop nets and PIT tags and of overall movements and habitat use using radio telemetry. In 17 streams in the Blackfoot and Bitterroot river basins, we captured 83 boreal toads at 13 sites in 8 streams. Intensive trapping in Slate and Little Blue Joint creeks in the Bitterroot River basin produced 514 captures of 117 adult and 203 juvenile toads. Juveniles dominated catches initially but declined throughout summer, whereas adult catches were unrelated to season. Of the 125 PIT-tagged toads, two-thirds were recaptured 1-7 times in hoop nets and the median total distance moved was over 1 km. The median total distance moved by radio-tagged toads was over 2 km, but up to 12 km. Only 17 percent of relocations of radio-tagged toads were at upland sites; 62 percent were in riparian zones and 21 percent were in or adjacent to water. We believe that hoop nets are effective for monitoring the presence of boreal toads and that boreal toad life histories may be far more aquatically oriented than previously recognized.

Age Structure, Growth Rate, and Condition of *Margaritifera Falcata* (Gould, 1850), A Native Freshwater Mussel in West-Central Idaho[AFS]

Kristi Overberg
GEI Consultants, Inc.
127 East Front Str. Suite 216. Missoula, MT 59802
koverberg@geiconsultants.com

The western pearl mussel, (*Margaritifera falcate*, Gould 1850) is an ecologically important bioindicator of aquatic health because of its (1) responsiveness to environmental change, (2) widespread distribution, (3) dependence on salmonids as a host fish for distribution and survival, (4) sedentary life style after the glochidia stage, (5) visible annual

growth rings, and (6) long lifespan (> 100 years). Population structure and condition of *M. falcata* were assessed in Bear Valley Creek (BVC), Idaho 50 years after dredging activities and subsequent disturbances from restoration efforts had ceased. Mussels were collected, measured for length and weight, and aged from five randomly chosen reaches in BVC. Fewer juvenile mussels (~10 years) were observed and mussel distribution was sparser in the upper versus lower reaches in BVC. Mussel age ranged from 8-48 years, lengths ranged from 28-97 mm of which half were less than 60 mm, and overall growth rates averaged 1.28 $g \cdot yr^{-1}$. Growth patterns were not linear, but decreased with age from 3.90 $mm \cdot yr^{-1}$ (0-15 yrs) to 1.85 $mm \cdot yr^{-1}$ (15-50 yrs). Overall, BVC sustains a diverse population of *M. falcata*. However, mussel distribution ceased in the vicinity of the old dredge site and upstream. Potential reasons explaining the limitation in mussel distribution include (1) chemical constituents in the water needed to create shell material are limiting, (2) range of host fish may be limited, or (3) the physical disturbance from dredging and restoration activities may have buried or removed some mussels in the past delaying recolonization.

Using Fish Assesmblages as Indicators of Aquatic Ecosystem Integrity in Montana Prairie Streams[ABS]

Robert G. Bramblett and Alexander V. Zale
Montana Cooperative Fishery Research Unit
U. S. Geological Survey
Department of Ecology, Montana State University
Bozeman, MT 59717
zale@montana.edu

Thomas R. Johnson
U. S. Environmental Protection Agency
Region 8
999 18th Street. Denver, CO 80202

Daniel Heggem
U. S. Environmental Protection Agency
Landscape Ecology Branch, Office of Research and Development
P.O. Box 93478, Las Vegas, NV 89193-3478

Prairie streams in Montana are affected primarily by non-point source pollution and stream habitat degradation, which make assessment with traditional methods such as water chemistry analysis difficult. Quantitative indicators of biological integrity are generally lacking for prairie streams, and little is know about what constitutes a healthy Montana prairie stream fish assemblage. We developed a multimetric index of biological integrity (IBI) for Montana prairie streams using fish assemblages. Choosing effective fish metrics in prairie streams is challenging because native fish assemblages are often depauperate and prairie fishes are adapted to harsh environment fluctuations. We screened fish-assemblage metrics by testing for responsiveness to anthropogenic stress, lack of responsiveness to natural factors, temporal stability, and lack of redundancy. The resulting IBI was comprised of 10 fish-assemblage metrics based on species richness and composition, tolerance to human-induced stress, trophic and reproductive guilds, and age structure. The number of native species, number of native families, number of catostomid and ictalurid species, proportion of invertivorous cyprinids, number of benthic invertivorous species, proportion of litho-obligate

reproductive guild individuals, proportion of native individuals, and number of species with long-lived individuals declined with increasing anthropogenic stress, whereas proportion of tolerant individuals and proportion of tolerant reproductive guild individuals increased with increasing anthropogenic stress. We propose that this IBI can be used as a quantitative measure of ecosystem integrity for use in management of Montana prairie streams faced with threats such as introduced species, agriculture, and coal bed methane extraction.

Fish Entrainment Investigations from the Yellowstone, Sun and St. Mary Rivers in 2003, with Prelimnary Evaluations of an Experimental Electric Barrier at the St. Mary Diversion[AFS]

Steve Hiebert, Juddson Sechrist and Eric Best
USDI Bureau of Reclamation
Fisheries Applications Research Group
Denver, CO 80225
Shiebert@do.usbr.gov

Sue Camp
USDI Bureau of Reclamation
Montana Area Office
Billings, MT 59107

Jim Mogen
USDI Fish and Wildlife Service
Branch of Native Fishes Management
Bozeman, MT 59717

Efficient, economical methods are needed to reduce the loss of fishes to agriculture diversions. Such methods depend on developing techniques for quantifying canal entrainment and fish barrier effectiveness. Three entrainment projects conducted this year were designed to both quantify entrained fish as well as evaluate any present or future fish protection measures employed at the diversions. Fort Shaw (Sun River) and Huntley (Yellowstone River) diversions are unscreened with fyke net systems (nets) developed and installed to sieve 100 percent of diverted flows. At Huntley, 7628 fish were collected comprising 28 species, while over 2500 fish, comprising 10 species were collected at Fort Shaw, during 2003. Standardized sampling efforts indicated diel differences in catch for most species. The St. Mary diversion entrainment sampling was initiated in 2002 with nets sub-sampling a large portion of the irrigation flows (60-81%) in standardized effort periods. Netting during the 2002 season showed highest entrainment at night and later in the irrigation season. Bull (*Salvelinus confluentus*) and cutthroat (*Oncorhynchus clarki*) trout represented relatively small proportions (1.1% and 9.4%) of catch totals. An experimental electrical barrier was installed in the canal head works during 2003 and the nets were used to conduct initial evaluations of its effectiveness. First year data indicates that, at the manufacturers recommended settings and voltage fields, the barrier has low effectiveness on small fish (< 200mmTL). Further work is necessary to determine appropriate settings and configurations; however, effectiveness and operational data obtained from the barrier evaluation will be valuable in determination of its utility at other sites.

Configuring Libby Dam Operation for Recovering the Endangered Kootenai White Sturgeon—What Will Society Bear to Save This Ancient Species?[AFS]

Brian Marotz
Montana Fish, Wildlife & Parks
490 N. Meridian Rd., Kalispell, MT 59901
bmarotz a state.mt.us

Natural recruitment of white sturgeon (*Acipenser transmontanus*) in the Kootenai River became rare after Libby Dam became operational in 1972. Flow and temperature regulation resulting from dam operation have likely contributed to recruitment failure. Less than 600 wild individuals remain and the complete loss of the wild population is predicted by 2060. Before the wild adults vanish, 3000-6000 of their progeny from the Kootenai Tribe of Idaho's sturgeon aquaculture facility will have survived to maturity. However, recovery of the white sturgeon requires natural reproduction. Evidence suggests that a naturalized spring freshet is needed to initiate migration to the spawning reach. Spawning now occurs over sand substrate unsuitable for survival. The historic spawning reach, which is thought to be further upstream, is heavily embedded with sand. Previously, the spring freshet flushed fine sediments from spawning cobble and model results indicate that a higher river stage provided a survival advantage for early life stages. The US Fish and Wildlife Service's 2000 Biological Opinion (BiOp) implemented a tiered flow strategy to assess possible thresholds between recruitment success and failure. The BiOp also recommends increasing the discharge capacity of Libby Dam by 5,000 cfs in 2004 and an additional 5000 cfs by 2007. Unfortunately, Libby Dam cannot currently pass the additional 10 kcfs without the use of the spillway, and a spill of < 2 kcfs exceeds Montana's water quality standard of 110 percent gas supersaturation. Excess gas causes gas bubble trauma in river fish including federally listed (threatened) bull trout. Therefore, the Army Corps of Engineers is analyzing 10 alternatives to conform to the BiOp; all present challenges. Flows required to flush sediments may be prevented by human development in the flood plain. Survival of the species and public acceptance of recovery actions require shifting emphasis from a high spring peak to a gradually descending hydrograph, and from the spawning period to survival during the first few months of life.

Sheppard Creek: A Case Study of a Brook Trout Electrofishing Removal Effort and Lesson Learned[AFS]

Beth Gardner
Flathead National Forest
Swan Lake Ranger District
200 Ranger Station Rd., Bigfork, MT 59911
bgardner@fs.fed.us

Sheppard Creek contains one of the last, remnant westslope cutthroat trout (*Oncorhymcus clarki lewisi*) populations in the Stillwater River basin. Unfortunately, recent monitoring indicated that this population was declining rapidly. The imminent threat to cutthroat trout persistence was judged to be competition from non-native brook trout, rather than habitat degradation. The Flathead National Forest, along with numerous partners, installed a barrier to block any further invasion and then began a systematic removal of brook

trout by means of electrofishing. Electrofishing crews made multiple passes over 3.8 mi of habitat every year for three years. All brook trout were counted and removed, while cutthroat trout were released unharmed. No habitat restoration took place. Following three consecutive years of work, the brook trout population decreased by 95 percent from an estimated total population of 5622 to 283. Cutthroat trout numbers are estimated to have climbed from 252 to 864. These results demonstrate that electrofishing removal of brook trout can be an effective method to stabilize and possibly recover a cutthroat trout population. A lesson learned is that this method is less controversial than chemical treatment and can be quickly implemented. This is a labor-intensive method but costs can be reduced by selectively focusing efforts on key spawning areas and employing volunteers. The long-term prognosis of this project is uncertain. Crews may be able to ultimately remove all brook trout, but if not, periodic efforts should be able to keep Sheppard Creek cutthroat trout numbers more secure.

The Un-streaming of Mitchell Slough; How Landowners Along a Spring Creek Will Not Be Required to Obtain 310 Permits[AFS]

Chris Clancy
Montana Fish, Wildlife & Parks
3201 Spurgin Rd., Missoula, MT 59804
cclancy@state.mt.us

"It looks like a stream. The fish think it's a stream. So it must be a ditch," is how one individual described a recent decision by the Bitterroot Conservation District (BCD). In the 4-1 vote the BCD ruled that Mitchell Slough is not a natural perennial flowing stream and therefore stream alteration work will not require 310 permits. Mitchell Slough is a 10-mile long body of water that evidence indicates was once historic sloughs and channels of the Bitterroot River. Agricultural modifications over the years have changed the flow and geomorphic patterns of Mitchell Slough. It is fed by Bitterroot River water diverted at a headgate, yet it gains considerable amounts of groundwater, and conductivity is significantly higher where it re-enters the Bitterroot River. Historically, it supported a diverse fishery, including a moderate population of trout. Recent work by some landowners has likely increased the trout population and it appears to be a significant spawning area for Bitterroot River rainbow and brown trout. Yet, at this time, stream alteration work will not require 310 permits. The BCD reached it's decision largely based on data provided by consultants. Public agencies were not allowed access to key properties.

Overview of Rainbow Trout Broodstock Management and Egg Production Technique at Ennis National Fish Hatchery[AFS]

Sean H. Henderson
Ennis National Fish Hatchery
180 Fish Hatchery Rd., Ennis, MT 59729
sean_henderson@fws.gov

It isn't often that two broodstock fish culturists from different facilities cross paths. Most techniques utilized at any given facility are a result of shared ideas but also, often, the result of practical inspiration formed out of ingenuity and trial and error. Over the last twenty years there have been several important advances in broodstock management, spawning, and egg handling methods. Many of these ideas have either been adopted or developed at Ennis National Fish Hatchery. What follows is a survey of methods and techniques currentl applied at Ennis National Fish Hatchery and include four significant aspects of broodstock management: Genetics, Nutrition, Egg Handling/ Incubation and a review of Spawning Technique. It is hoped that through sharing information some of the above mentioned ideas will provide material for other broodstock/ production facilities and vice versa.

Poster Presentations

Trammel Net Efficiency for Juvenile Pallid and Shovelnose Sturgeon [AFS]

Eric W. Oldenburg, Paul C. Gerrity, and Christopher S. Guy
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
301 Lewis Hall, Bozeman, MT 59717
cguy@montana.edu

William M. Gardner
Montana Fish, Wildlife, & Parks
P.O. Box 938
2358 Airport Rd., Lewistown, MT 59457
bgardner@state.mt.us

Pallid sturgeon (*Scaphirhynchus albus*) and shovelnose sturgeon (*Scaphirhynchus platorynchus*) have declined throughout the Mississippi River basin because of anthropogenic habitat alterations. To accurately document continued decline or recovery of sturgeon (*Scaphirhynchus* spp.), the efficiency of sampling these species needs to be evaluated. Drifting trammel nets are considered to be an important tool for sampling sturgeon in lotic systems. However, little information exists on the efficiency of drifting trammel nets for sampling sturgeon. Thus, our objective was to evaluate the efficiency of drifting trammel nets for sampling juvenile pallid sturgeon and shovelnose sturgeon. In July and Augu t of 2003,

we attempted to recapture 10 radio-tagged juvenile pallid sturgeon and shovelnose sturgeon in the Missouri River above Fort Peck Reservoir. After a radio-tagged fish was located, a trammel net was deployed 75 m upstream and retrieved 45 m downstream of the fish location. A maximum of four drifts were attempted at each location. Overall efficiency was 35 percent; whereas, first drift efficiency was 40 percent, second drift efficiency was 50 percent, and all remaining drifts were unsuccessful. Capture efficiency was 60 percent when combining the first and second drifts. Stepwise logistic regression was used to model the probability that a drift would not capture a sturgeon. However, none of the abiotic variables were significant ($P > 0.05$) in the logistic regression model. Nevertheless, these results suggest that drifting trammel nets are a relatively effective sampling gear for pallid sturgeon and shovelnose sturgeon.

Food Habits of Hatchery-reared Juvenile Pallid Sturgeon and Juvenile Shovelnose Sturgeon in the Missouri River Above Fort Peck Reservoir, Montana[AFS]

Paul C. Gerrity And Christopher S. Guy
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59717
pcgerrity@montana.edu

William M. Gardner
Montana Fish, Wildlife, & Parks
P.O. Box 938
2358 Airport Rd., Lewistown, MT 59457
bgardner@state.mt.us

Natural recruitment of pallid sturgeon (*Scaphirhynchus albus)* has not been observed in the Missouri River above Fort Peck Reservoir, Montana, for at least the past 20 years. In an effort to recover the species, 736 age-1 hatchery-reared juvenile pallid sturgeon (HRJPS) were released in 1998 and 2,300 were released in 2002. However, the ecology of juvenile pallid sturgeon is relatively unknown, and more scientific information is needed to assist in the recovery of the species. Therefore, we examined the stomach contents of HRJPS and juvenile shovelnose sturgeon (JSNS) (*Scaphirhynchus platorynchus*) from the Missouri River above Fort Peck Reservoir from June through September 2003. Stomach contents from HRJPS and JSNS were obtained using a gastric lavage to allow captured fish to be released unharmed. Gastric lavage was performed on 61 JSNS and 16 HRJPS. Stomach contents were obtained from 50 percent of the HRJPS and 71 percent of the JSNS. Fish remains, *Ephemeroptera nymphs*, *Chironomidae* larvae, *Trichoptera* larvae, plant material, and detritus were found in HRJPS stomach contents. Fish composed the majority of the wet weight of HRJPS diets (82%), while Chironomidae composed 93 percent of the diet by number. Aquatic invertebrates composed the majority of the diet for shovelnose sturgeon. In addition, no fish were found in any shovelnose sturgeon stomach contents. This is the first documented food habits data for juvenile pallid sturgeon and these data illustrate that pallid sturgeon are piscivorous as juveniles.

The Kootenai River Network (KRN)[AFS]

Rox Rogers
NW Montana Partners for Fish and Wildlife Program, Kootenai River Network
Creston Fish and Wildlife Center
780 Creston Hatchery Rd., Kalispell, MT 59901
rox_rogers@fws.gov

The Kootenai River Network (KRN) is an international alliance for water quality and aquatic resources. The group formed late in 1991 in response to citizen's concerns of threatened or deteriorating water quality and aquatic resources in the Kootenai River Basin. KRN's mission is to operate as "a cooperative international partnership of individuals, diverse citizen groups, and agencies dedicated to the utilization, restoration, promotion and protection of water resources in the Kootenai-Kootenay River watershed." To accomplish this mission, the following goals have been developed: 1) Involve individuals and their communities in sharing the value of the Kootenai/ay watershed; 2) Improve communication among agencies and diverse citizen groups throughout the Kootenai/ay watershed; 3) Facilitate habitat enhancement and rehabilitation; 4) Fully use best available science practices to facilitate proactive water resources management; and 5) Pursue coordination of efforts regarding Water Resources models and measurement techniques. The KRN has been successful in bringing together interstate, international, and tribal interests of different political jurisdictions to form a watershed-based organization dedicated to solving priority environmental problems and bridging jurisdictional obstacles to achieve watershed management. The KRN would like an opportunity to set up an educational display at the MT AFS meeting. The function of the display is to convey, at a glance, the essence of the Kootenai/ay River network. In order to capture viewer's attention and convey our messages, we are using a combination of pictures with cut-lines of text on an upright display. The display demonstrates KRN activities such as partnerships, educational workshops, site tours, committees, mission statement, and profiles habitat restoration activities in the Kootenai/ay to benefit native fisheries and wetland dependant wildlife. The display will either be a stand-up or table-top display.

Wild Fish Habitat Initiative: Technical Resources on Habitat Restoration for Resource Professionals and Project Managers[AFS]

M. Boucher, W.C. Fraser, and M.D. White
Montana Water Center, Montana State University
101 Huffman, Bozeman, MT 59717
mboucher@montana.edu, wfraser@montana.edu, mdwhite@montana.edu

Habitat degradation is one of the principal reasons for the listing of wild fish as "threatened" or "endangered" under the Federal Endangered Species Act and can exacerbate the detrimental effects of fish predators, exotic competitors, and diseases such as whirling disease. In addition, land values are diminished by habitat degradation and the subsequent loss of wild fish populations. In recent years, many fish habitat enhancement and restoration techniques have been implemented; project results, however, have not been shared widely and their efficacy is not well understood. The *Wild Fish Habitat Initiative* seeks to augment the success of habitat restoration programs by conducting targeted research related to habitat restoration techniques, and by implementing a technology transfer program to share

information on project results and to provide technical information to land owners and project managers. Research projects administered through the Initiative include investigations on thermal tolerances of westslope cutthroat trout (*Oncorhymcus clarki lewisi*), the epidemiology and control of Bacterial Coldwater Disease, and the effectiveness of irrigation diversions in western Montana. The technology transfer program includes online bibliographic and restoration manual resources, as well as a case history database of restoration projects implemented in the intermountain west.

Fridley Creek Reconnection Project[AFS]

Daniel E. March
Land & Water Consulting, Inc.
801 N. Last Chance Gulch, Helena, MT 59601
dan.march@landandwater.net

Fridley Creek is located south of Emigrant, Montana flowing east out of the Gallatin Range into the Paradise Valley. The stream was historically a tributary to the Yellowstone River but has been disconnected due to interception by an irrigation canal. Reconnection of Fridley Creek to the Yellowstone River allows a positive exchange of fish between the two systems that did not occur before the project. Re-establishing fish exchange is especially beneficial at this location because so many tributaries in this portion of the drainage are disconnected or are severely dewatered each year. Fridley Creek already supported a self-sustaining population of native Yellowstone Cutthroat trout (*Oncorhymcus clarki*). The reconnection will aid increased spawning and recruitment of Yellowstone Cutthroat to the Yellowstone River. The poster presentation will discuss: Benefits to native trout, water rights, fish passage, sediment transport and other design considerations of reconnection of Fridley Creek to the Yellowstone River.

Distribution, Species Richness, and Predictive Modeling of Montana Prairie Fishes[AFS]

Melissa R. Jones-wuellner, Robert G. Bramblett,
Christopher S. Guy, And Alexander V. Zale
Montana Cooperative Fishery Research Unit
Department of Ecology
Montana State University
Bozeman, MT 59717
mjones@montana.edu

The distribution and abundances of fish in prairie streams of eastern Montana are poorly known. Knowledge of fish assemblages and their habitat is critical to effectively conserve species and their environment. In 1999, the Montana Cooperative Fishery Research Unit initiated a large-scale research program to gain a better understanding of prairie-stream ecosystems; four Montana Fish, Wildlife, and Parks regions joined the effort in 2003. Most sampling locations were at streams that had no previous fish collections. Thirty-eight fish species were sampled; 28 species were native and 10 were introduced. Species richness varied from 0 to 17 per sample. The most common native species was fathead minnow (*Pimephales promelas*) and common carp (*Cyprinus carpio*) was the most prevalent introduced species. Although many streams sampled were intermittent with isolated pools,

most (82%) sites had fish present. In-stream habitat features, including widths, depths, and substrates were measured. Landscape habitat features including elevation, watershed area, soil type, and connectivity were obtained from GIS databases. As a pilot effort, we prepared models for the Musselshell River basin using landscape and site-level habitat data to predict the presence or absence of fish species. Additionally, we will construct models for all fish species in the prairie ecoregions of Montana, and assess the relative importance of site-level and landscape habitat features. By identifying the relationships between fish distribution and habitat characteristics, we hope to identify critical habitat for conservation of native fish species and assemblages.

Influence Of Water Temperature And Competition On Growth And Survival Of Westslope Cutthroat Trout, *Oncorhynchus Clarki Lewisi* AFS

Beth A. Bear And Thomas E. McMahon
Department of Ecology, Montana State University
Bozeman, MT 59717
bbear@montana.edu, tmcmahon@montana.edu

Alexander V. Zale
Montana Cooperative Fishery Research Unit
Montana State University
Bozeman, MT 59717
zale@montana.edu

Historically, westslope cutthroat trout (*Oncorhynchus clarki lewisi*) ranged widely over western Montana, Idaho, and portions of eastern Washington and Oregon. Like many cutthroat and other native trout, westslope cutthroat trout now persist in only a small portion of their native range, and are listed as a "species of special concern" in Montana. Leading causes for their decline are habitat degradation and displacement by nonnative rainbow trout (*Oncorhynchus mykiss*), and brook trout (*Salvelinus fontinalis*). Many remaining populations are isolated in cold, headwater portions of streams that westslope cutthroat trout previously occupied entirely. Water temperature may play a critical role in segregating westslope cutthroat trout because it significantly influences the distribution, growth, and survival of salmonids. In addition, increased water temperature is thought to favor non-natives in many cases, yet the effect of temperature on competition between westslope cutthroat trout and non-natives is unknown. Furthermore, hybridization between westslope cutthroat trout and nonnative rainbow trout has resulted in a decline in populations of genetically pure westslopes. However, little is known about the thermal requirements of westslope cutthroat trout and of westslope cutthroat x rainbow trout hybrids, which now occur widely across the historical range of pure westslope cutthroat trout. This laboratory study aims at testing how temperature affects the vital processes of growth and survival of westslope cutthroat trout. This study will use a laboratory design that allows simultaneous assessment of fish growth and survival under different thermal regimes over long time periods. This study will compare the thermal requirements of westslope cutthroat trout, rainbow trout, brook trout, and westslope cutthroat x rainbow trout hybrids. With increased global warming, warmer water temperature in streams may constitute a major problem for native, cold-water species such as westslope cutthroat trout. Understanding the effect of water temperature on this unique trout will help guide protection and restoration efforts in the future.

New Tools To Mosaic And Georeference Imagery: Dime "The New Tool"Showcasing The Flathead National Forest Post Fire Management[AFS]

Dale R. Johnson
Positive Systems, Inc.
Whitefish, MT 59937
djohnson@possys.com

With the introduction of new imagery from satellites, digital cameras and the increased use of scanned film aerial photography, there is a great need for tools that quickly and cost effectively mosaic and georeference imagery to use in a GIS or Image Processing Systems. New technology and production processes, such as those found in the DIME Software, have recently been developed to allow users to preprocess their imagery more efficiently so that it can easily become a useful addition to their GIS. This new, lower cost, capability is particularly useful in applications such as Timber Management, Environmental Monitoring, or other Land Management activities and applications. The Poster will show a recent image mosaic of the Flathead National Forest, 2003 fire and discuss potential uses of that imagery. Positive Systems is a products and service company based in Whitefish Montana. Past and current customers include NASA, the USDA Forest Service and Farm Service Agency.

Preliminary Evaluation Of Entrainment Losses And The Efficiency Of Fish Screens At Skalkaho Creek[AFS]

Steve Gale And Alexander V. Zale
Montana Cooperative Fishery Research Unit
Montana State University
301D Lewis Hall
Bozeman, MT 59717
sgale@montana.edu

We are quantifying entrainment of downstream-migrant westslope cutthroat trout (*Oncorhynchus clarki lewisi*) into seven irrigation canals on Skalkaho Creek, a 40.1-km long tributary of the Bitterroot River. Post-spawn adults migrating back to the Bitterroot River, age-1 juveniles migrating downstream from nursery reaches, and age-0 juveniles migrating downstream after emergence are believed to be entrained, become trapped, and die in the irrigation canal system, but the magnitude of this loss is unknown. Private landowners and irrigators in the drainage have expressed concern over this problem and the Montana Department of Fish, Wildlife and Parks will install fish screens in 2004 at three diversions to preclude such losses. We are quantifying the entrainment of westslope cutthroat trout before (2003) and after (2004) installation, as well as the efficiency of the three fish screens after installation. Radio telemetry is used to track movements of 30 adult and 50 age-1 westslope cutthroat trout annually in Skalkaho Creek to determine their fate. Trap netting in irrigation ditches is used to estimate abundances of entrained age-0 juveniles. Passage efficiency of fish screens is assessed by PIT-tagging entrained fish to determine bypass success rates and durations. No radio tagged adults were entrained in 2003. Fluvial adults were able to migrate upstream and downstream past the diversion dams. Both age-0 and age-1 juveniles were entrained by the Highline Ditch, the furthest upstream canal. It diverts most of Skalkaho

Creek during the peak of the irrigation season, which corresponds to the peak of emergence and downstream movement of age-0 westslope cutthroat trout.

Clark Fork River Response To Reduction In Nutrient Loading From Watershed[AFS]

Vicki Watson
Environmental Studies
University of Montana
Missoula, MT 59812
vicki.watson@umontana.edu

Gary Ingman, John Babcock and Bruce Anderson
Land & Water Consulting
P.O. Box 8254, Missoula, MT 59807

In 1998, a public-private partnership signed an agreement to reduce nutrient loading to the Clark Fork River to address nuisance algae growths in the river. In the intervening years, nutrient loads and concentrations have been reduced at most sites for some nutrients, but not for the critical nutrient soluble nitrogen. Changes in algae levels are more difficult to detect because of the great variability in algae levels that are influenced by many factors in addition to nutrients. Statistical trends in instream nutrient and algae levels from 1998 to 2002 are presented. Recommendations are made for future monitoring and restoration actions.

Can Passive Solar Heating Be Used to Control the Spread of New Zealand Mud Snails?[AFS]

Robert H. Wiltshire
Federation of Fly Fishers
215 East Lewis, Livingston, MT 59047
ffdc@fedflyfishers.org

Since the first discovery of New Zealand mud snails (*Potamopyrgus antipodarum*) in Idaho's Snake River in 1997 they have spread to many waters in the West. Anglers and other recreationists are likely vectors in the transfer of this invader and all prevention programs must include public participation. Unfortunately, the public requires practical solutions before they will voluntarily change their behavior. It is known that *Potamopyrgus* is sensitive to high temperatures. Exposures of 40 °C (104 °F) for two hours can be lethal to *Potamopyrgus* and exposures to hotter temperatures prove lethal in shorter times. This experiment wa designed to determine if solar heated equipment storage containers could produce lethal temperatures. A variety of equipment storage containers were tested under differing conditions to determine if passive solar heating would develop and sustain temperatures that were high enough to provide sterilization. Our results show that although air temperatures inside the storage boxes exceeded 68 °C (155 °F) the insulating effects of the materials placed in the containers resulted in a failure to achieve lethal temperatures in all areas of the containers

Biological Sciences – Terrestrial

Snowshoe Hare Response to Pre-commercial Thinning in Northwest Montana[TWS]

David E. Ausband
Wildlife Biology Program
University of Montana
Health Sciences 203, Missoula, MT 59812

G. Ross Baty
Montana Department of Natural Resources and Conservation
2705 Spurgin Rd., Missoula, MT 59801

We assessed snowshoe hare (*Lepus americanus*) response to 2 distinct pre-commercial thinning treatments on a state forest in northwest Montana. One treatment retained five 0.2-ha patches of unthinned saplings totaling 8 percent of the sapling stand area, and the second retained five 0.8-ha patches totaling 35 percent of the sapling stand area. Hare use was also estimated within nearby mature conifer stands and a control sapling stand. We used snow tracking and fecal pellet density to estimate hare use before and after thinning treatments were applied. Hare use of sapling stands generally declined after thinning. However, results suggest that dense sapling patches retained at the 35 percent retention level may have provided habitat conditions similar enough to the unthinned control stand to not appreciably influence their use under the conditions we observed. Hares used retention patches regardless of size, even though large retention patches were four times larger than small retention patches. Because hares demonstrated a significant affinity for dense patches of residual forest any retention of untreated sapling patches may be beneficial for hares when applying pre-commercial thinning treatments. Use within a mature forest stand declined after thinning treatments were applied to 2 adjacent sapling stands suggesting that pre-commercial thinning may have broader effects than those directly associated with treated sapling stands. Results from the control stand and an adjacent mature stand suggest that during winter hares may benefit from maintaining a mosaic of suitable habitat patches within close proximity or connected to one another when applying pre-commercial thinning treatments.

Recovery And Delisting of the Gray Wolf in Montana, Idaho, And Wyoming[TWS]

Edward E. Bangs, Joseph A. Fontaine, Michael D. Jimenez, Thomas J. Meier
USDI Fish and Wildlife Service
100 N. Park, #320, Helena, MT 59601

Carter C. Niemeyer
USDI Fish and Wildlife Service
1387 Vinnel Way, Rm. 368, Boise, ID 83709

Douglas W. Smith
P.O. Box 168
Yellowstone National Park, WY 82190

Curt M. Mack
Nez Perce Tribe
1000 Mission, McCall, ID 83638

Val Asher
Turner Endangered Species Fund
1123 Research Drive, Bozeman, MT 59718

Larry Handegard
Montana State Director, USDA Wildlife Services
P.O. Box 1938, Billings, MT 59103.

Mark Collinge
Idaho State Director, USDA Wildlife Services
9134 W. Blackeagle Dr., Boise, ID 83709.

Rod Krischke
Wyoming State Director, USDA Wildlife Services
P.O. Box 59, Casper, WY 82602.

Carolyn Sime
Montana Department of Fish, Wildlife and Parks
490 N. Meridan Road, Kalispell, MT 59901

Dave Moody
Wyoming Game and Fish Department
260 Buena Vista, Lander, WY 82520

Steve Nadeau
Idaho Department of Fish and Game
600 S. Walnut, P.O. Box 25, Boise, ID 83707

Gray wolf (*Canis lupus*) populations were eliminated from the western United States by 1930. Naturally dispersing wolves from Canada recolonized northwestern Montana in the 1980s. In 1995 and 1996 wolves from western Canada were reintroduced to central Idaho and Yellowstone National Park, Wyoming. By late 2003, about 750 wolves were being managed in those three states under the federal Endangered Species Act. Wolf recovery proceeded

more quickly, with more benefits (public viewing and restoration of ecological processes) and fewer problems (livestock and pets depredations) than predicted. However, between 1987 and December 2002, a minimum of 237 cattle, 593 sheep, 57 dogs, a horse, and 9 llamas were killed by wolves and nearly $275,000 was paid from a private damage compensation fund. The USDI Fish and Wildlife Service relocated 117 wolves and killed over 150 to reduce future conflicts. Management also included non-lethal tools such harassment, barriers, guard animals, altering wolf activity patterns, livestock management, and practical research. Confirmed livestock loss from wolves is regionally uncommon, i.e., wolves caused 0.04 percent and 0.03 percent of all sheep and cattle deaths in Montana, Idaho, and Wyoming in 2000, but is inordinately controversial and significantly affected a few producers. Many hunters perceived that wolf predation dramatically reduced elk populations and hunter harvest and this issue became extremely controversial. Because over 85 percent of adult wolf mortality is human-caused, the interagency recovery program emphasizes resolving the concerns of local people to increase their tolerance of wolves. Wolves were reclassified from endangered to threatened status in April 2003 to recognize their recovery and to increase options for problem wolf management. Litigation by some environmental groups over reclassification is ongoing. The wolf population achieved its numerical, distribution and temporal recovery goal in December 2002. Montana, Idaho, and Wyoming finalized their state wolf management plans by September 2003. They will regulate human-caused mortality through defense of property regulations and public harvest programs so that wolves will not again be jeopardized with extinction. A proposal to delist wolves could occur by early 2004, and by late 2004 wolves could be managed solely by the states.

Small Aspen Stand Dynamics in the Elkhorn Mountains[TWS]

Jodie Canfield
Elkhorn Coordinator and Wildlife Biologist
Helena National Forest
415 South Front Street, Townsend, MT 59644

In an effort to better understand the dynamics of small aspen (*Populus tremuloides*) stands in dry habitats, the Slim Sam aspen project, located in the southeast portion of the Elkhorn Mountains, was initiated in 1999. Eighteen aspen stands were inventoried. Before treatment, on average, there were about four live sprouts/100 ft2 and aspen stands were generally in a state of decline. Factors contributing to the decline in the Slim Sam project area included shading from conifers, old age, and browsing and mechanical damage from livestock, moose, and elk. Eight stands were burned in the spring 2002. Six of the burned stands were fenced with 7-ft high wildlife fencing during summer 2002. In 8 of 18 stands, conifers were removed and placed around the outside of the stand to provide some protection from browsing animals. Two of the stands were not treated. Following the initial treatments, ground cover and sprout densities were assessed for two field seasons. This presentation summarizes the dynamics of different treatments in isolated aspen stands and compares cost and effectiveness of treatment types.

Recovery Of The Bald Eagle In Montana—an Update[TWS]

Kristi Dubois
Native Species Coordinator
Montana Fish, Wildlife And Parks
3201 Spurgin Rd, Missoula, MT 59804

Bald eagle (*Helicoetus leucocephalus*) populations have been increasing in Montana and throughout most of the U. . since 1980 and now exceed recovery goals in most areas. The current Montana population is over 300 nesting pairs. Delisting of the species will likely occur within the next few years. The Montana Bald Eagle Working Group is developing a post-delisting monitoring plan. I summarize a brief history of bald eagle management and population trends in Montana and provide an update on the delisting process.

Using Land Use Planning to Protect Montana's Wetlands and Riparian Areas[TWS]

Janet H. Ellis
Program Director
Montana Audubon
P.O. Box 595, Helena, MT 59624

As more and more people choose to build homes next to Montana's streams, rivers, lakes, and ponds, and as property values increase, pressures to develop our state's wetlands and riparian areas are increasing—often to the detriment of the very qualities that attracted buyers in the first place. As explained in A Planning Guide for Protecting Montana's Wetlands and Riparian Areas, many of the impacts to these areas can be avoided by land use planning decisions made at the local level. An overview of the handbook will be presented, along with information on how to determine an effective buffer size, and examples of how numerous communities—from Powell County to the city of Missoula, and from Chouteau County to the city of Bozeman—have used the principals outlined in the book to protect important resources. An update will be given on protection measures adopted by local governments since the guide was published. This publication was a cooperative venture between Montana Audubon, Montana Watercourse, and the Montana Department of Environmental Quality.

Climate Change In Montana[TWS]

Phil Farnes
Hydrologist, Snowcap Hydrology
P.O. Box 691, Bozeman, MT 59771-0691
farnes@montana.net

Records from climatological stations having approximately 100 years of record and snow courses with approximately 75 years of record were analyzed to determine how temperatures, precipitation, and snowpack have changed over the last century. Only stations that were not moved and those that had substantially complete data were analyzed. Comparisons have been made for annual and seasonal temperature and precipitation for stations in Montana and northwestern Wyoming. Many Montana snow courses have been measured since the mid-

1930s. Three snow courses that were established in Glacier National Park (GNP) in 1922 are still being measured on May 1. Only the 1 April (1 May for GNP) snow water equivalent (SWE) for snow courses that have been measured manually since the 1930's and have not been relocated were analyzed. Reduction in manual measurements due to implementation of the SNOTEL network has eliminated most of the early-season manual surveys and most of the snow courses that were co-located with SNOTEL sites. Annual or seasonal values were used to obtain 5-yr moving averages to help visualize trends. Annual and seasonal variability is probably more significant than small changes over long time periods. Wet and dry years and warm and cold years will still be part of our climate even though trends over longer periods may change. For example, it is not uncommon for annual precipitation to vary between 40 and 160 percent of average and annual temperatures to vary 3 °C above or below average.

Economic And Social Truths Underlying Modern Agriculture In Western Montana And Their Effect On Wildlife Habitats[TWS]

Les Gilman
Agricultural Specialist, Ranch Resources LLC
Chairman, Montana Governor's Rangeland Resource Executive Committee
Executive Director, Ruby Habitat Research Foundation
P.O. Box 638, Sheridan, MT 59749
lgilman@3rivers.net

Farming and ranching in harsh physical and economic environments have brought significant changes to the landscape of Western Montana over the last century. Those changes continue at an exponential rate. Farms and ranches that do not survive the challenges are destined for alternative uses. The opportunity for land managers, wildlife professionals, and conservationists is to find solutions to maintain open space and sustainable agricultural practices that are ultimately much more wildlife friendly than 20-ac tracts. A discussion of the history of land use from a 5th generation rancher and professional land manager will lend insight into the cause and effect of real life decisions and the results of those decisions on the social and natural resources of a community.

Common Loon Management: Implications From Sensitivity Analyses[TWS]

Christopher A. M. Hammond
Wildlife Biology Program
Department of Ecosystem and Conservation Sciences
College of Forestry and Conservation, University of Montana
32 Campus Drive. Missoula, MT 59812
chrisdaluna25@msn.com

The Montana Natural Heritage program gives the common loon (*Gavia immer*) a global rank of G5 (demonstrably secure), but a state rank of only S1 (critically imperiled). The USDA Forest Service status is sensitive. I investigated whether current management applications were adequate to address the state and federal rankings. Most management

agencies take the approach of protecting nesting birds and their chicks. Manager hope to maintain or increase population sizes in many portions of the common loon's range by using this approach. I used sensitivity analyses to determine which vital rate had the mo t influence on the population growth rate (l) of common loons. I altered the range of ariation in vital rates to mimic applied management applications to determine how management effort should be directed to accomplish the goals of common loon conservation. I found that chick urvival and fecundity had the most influence on l. I make suggestions on how to apply management strategies that increase these vital rates so that management objectives may be met.

Winter Feeding Ecology of Mule Deer, Elk, And Cattle Along Montana's East Front[rw]

Scott A. Hemmer, and C. Les Marcum

Department of Ecosystem and onservation ciences
University of Montana
Missoula, MT 59812

Richard Keigley
USDI Geological Survey
Bozeman, MT 59717

Gary Olson
Montana Department of Fish, Wildlife, and Parks
Conrad, MT 59425

Mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) populations have increased near the Theodore Roosevelt Memorial Ranch (TRMR) along Montana's East Front. The appearance of browse on the ranch suggested that some species have experienced intense browsing pressure. The purpose of this study was to examine the condition of chokecherry (*Prunus virginiana*), aspen (*Populus tremuloides*), and creeping juniper (*Juniperus horizontalis*) on the TRMR and assess the future impacts of current browsing pressure on these plant species. Other goals of the study were to reconstruct a browsing history for chokecherry and aspen relative to recent increases in ungulate numbers, and examine winter forage utilization through fecal analysis. The effect of browsing on species condition was determined by comparing growth rates and live dead indices of plants exposed to browsing to those of plants protected by exclosures. Results indicate that most aspen were not intensely browsed, but the condition of chokecherry and horizontal juniper had been affected by browsing. Aspen appeared to be growing out of the browse zone and attaining their potential height, but current browsing pressure prevented chokecherry stems from reaching their normal stature. Browsing history indicated that increased browsing pressure on chokecherry and aspen in the mid-to-late 1980s, corresponded to a large increase in mule deer and elk numbers. However, fecal analysis suggested that chokecherry and aspen were not a significant component of mule deer and elk winter diets. In winter, mule deer fed primarily on Juniperus spp., and elk fed mostly on graminoids.

Ecology And Management Of Sylvatic Plague in Phillips County, Montana[TWS]

Brian E. Holmes
Division of Biological Sciences
University of Montana
Missoula, MT 59812
bholmes@tfn.net

Randy Matchett
USDI Fish and Wildlife Service
Charles M. Russell National Wildlife Refuge
P.O. Box 110, Airport Rd., Lewistown, MT 59457
Randy_Matchett@fws.gov

Sylvatic plague is a disease that was introduced into North America ~1900 and has since become well-established in native rodent populations in the western United States. The etiologic agent of plague is the bacterium *Yersinia pestis*, and most transmission between hosts occurs indirectly through the bite of an infected flea. Susceptibility to the disease varies widely among taxa. Aside from human cases, concern over plague in the U.S. has centered around effects on prairie dogs, which are uniformly susceptible to the disease. Efforts to restore populations of black-tailed prairie dogs in Montana have centered in Phillips County where ongoing efforts to reintroduce black-footed ferrets are ongoing. Currently, wildlife managers have few tools with which to manage or mitigate the effects of plague. One commonly used tool is the application of insecticides to prairie dog burrows to reduce flea abundance. We present an overview of plague ecology and the results of a dusting trial. We used a before-after control-impact design to test the effects of DeltaDust (0.05% Deltamethrin) on flea abundance in prairie dog burrows, on prairie dogs, and on associated small mammals. This and previous studies demonstrate that dusting prairie dog burrows is an effective way to reduce flea abundance in burrows and on prairie dogs. In addition, this study shows that flea abundance is also reduced on sympatric small mammal species that may act as reservoir hosts for *Y. pestis*.

Challenges, Opportunities And Techniques For Wetland Wildlife Habitat Restoration And Management On Montana's Private Lands[TWS]

Peter Husby
State Wildlife Biologist
USDA Natural Resource Conservation Service
Bozeman, MT 59715

Seventy percent of Montana's wildlife habitat occurs on private land. As a result, private landowners have a key role in restoration and management of our wildlife habitat. This presentation overviews the challenges and opportunities associated with wetland wildlife habitat restoration and management on private land and summarizes the Natural Resources Conservation Service's work to assist private landowners with that effort including wetland

and riparian habitat restoration, a brief overview of Farm Bill Program funding support, and techniques for wetland habitat management on working lands.

Wolverine Ecology And Management In The Greater Yellowstone Ecosystem, A Program Overview And Update[TWS]

Kristine H. Inman, Robert M. Inman, Craig Groves, Anthony J. McCue, and Nate Berg
Wildlife Conservation Society
Greater Yellowstone Wolverine Study
2023 Stadium Drive, Suite 1A, Bozeman, MT 59715
kinman@wcs.org

The status of wolverine (*Gulo gulo*) populations in the lower 48 remains uncertain and the ecological requirements of the species are not well described. Federal and state resource managers need information in order to make well-informed policy decisions that affect land-use practices and populations of wolverines. This project is designed to provide baseline ecological data and answer specific questions relevant to wolverine management and related land-use policies. Our study objectives are to document wolverine demographic parameters, determine if and how wolverine populations may be affected by human recreational activities, identify wolverine dispersal corridors and/or linkage areas between mountain ranges in the GYA, and collaboratively design and implement management strategies and actions aimed towards the long-term persistence of wolverines in the GYA. Two areas, the Madison Range Complex of southwestern Montana and southeastern Idaho (MFA) and the Teton Range of northwestern Wyoming (TFA), have been selected for intensive study. These areas are representative of the land management jurisdictions and human-use impacts that are common to the Greater Yellowstone Area (GYA). Seventeen different wolverines (9♀, 8) have been captured since 2001 and 11 (7♀, 4 ♂) are currently radio-instrumented. Four wolverines were fit with store-on-board GPS collars, and one was fit with a atellite collar. uccess and failure of collars and preliminary results regarding mortality and reproductive rates, habitat use, home range size, and winter recreational use will be discussed. This research program is designed as a comprehensive, long-term effort to address specific wolverine management questions and collect information that can be integrated into a landscape species approach to conservation planning in the Greater Yellowstone Ecosystem.

Beyond Bait:
Opportunities for Passive Bear Hair Collection[TWS]

Katherine C. Kendall
U.S. Geological Survey, Glacier National Park
West Glacier, MT 59936
kkendall@usgs.gov

Jeff Stetz
University of Montana
Science Center, Glacier National Park,
WestGlacier, MT 59936
jstetz@usgs.gov

We surveyed trails, forest roads, power lines, and fences on 32,300 km^2 in northwestern Montana to identify trees and other objects that bears rub against. Genetic analysis of passively deposited hair (as opposed to that obtained by attracting bears with bait) is used to identify individual bears to document bear presence, obtain minimum counts, and as capture events for mark-recapture population estimates. Hair will be collected from barbed wire and other hair snags attached to the rub surface. Hair samples from barbed wire are larger, have more follicles, require less time to collect than hair on bark, and define discrete samples that help prevent getting samples from more than one individual. Of the over 5000 rub objects we identified, the majority were trees along 7500 km of hiking trails. We summarize characteristics of rub trees and other objects including species and diameter of tree, amount and type of bear use, distance from trails, and maximum and minimum height of rubbing. The density of rub trees along forested trails varied widely but it was rare to find any area devoid of rubbing activity. When large diameter trees were not available, such as in clear cut logging units, recently burned areas, and tree line communities, bears used sign posts or small diameter trees to rub against. In areas with high levels of pack animal use, ~ 60 percent of the bear rub trees were also bumped by stock packs. We report on the effectiveness of pack stock-friendly, alternate hair grabbing devices tested in the field.

Efforts to Re-establish Northern Leopard Frog on the Flathead Indian Reservatio

Janene Lichtenberg, and Art Soukkala
Confederated Salish and Kootenai Tribes
Wildlife Management Program
P.O. Box 278, Pablo, MT
janenel a cskt.org

J. Kirwin Werner
Salish Kootenai College
Department of Environmental Science
P.O. Box 70, Pablo, MT 59855
jkw@ronan.net

The northern leopard frog (*Rana pipiens*) was once common throughout Montana but is now extirpated from most of western Montana including the Flathead Indian Reservation The Confederated Salish and Kootenai Tribe's Wildlife Management Program is working to return leopard frogs to the Flathead Indian Reservation. Potential source populations were identified through DNA testing in 2001. Reintroduction methodology was tested using Columbia spotted frogs (*Rana luteiventris*) in 2002. In 2003, eight egg masses were collected from five leopard frog source populations. Each mass was placed within a float that in turn was placed inside an enclosure to protect the eggs from predators and keep track of individuals. An estimated 16,500 tadpoles hatched from these egg masses. Five hundred tadpoles were released into each enclosure and the remaining tadpoles were released into the surrounding water. Tadpoles outside the enclosures grew and developed more quickly than the tadpoles inside enclosures, however, survival within the enclosures was high, 68 percent. During July 2003, we released 1342 tadpoles and 21 metamorphs from within the enclosures into the surrounding water. Time constrained surveys were conducted after the release to monitor leopard frog metamorphs until the end of September 2003. Intensive surveys will be conducted in spring 2004 to estimate winter survival and to determine dispersal distances from the release sites. We plan to continue similar reintroduction and long-term monitoring efforts at current and additional release sites.

Detection Of (*Batrachochytrium Dendrobatidis*), The Chytrid Fungus Associated With Global Amphibian Declines, In Montana Amphibians[TWS]

Bryce Maxell
Fish and Wildlife Biology Program
University of Montana
Missoula, MT
bryce.maxell@umontana.edu

Grant Hokit
Biology Professor, Carroll College
Helena, MT 59601

J. Kirwin Werner
Salish Kootenai College
Department of Environmental Science
P.O. Box 70, Pablo, MT 59855
jkw@ronan.net

In order to identify potential causes of declines in the northern leopard frog (Rana pipiens) and western toad (*Bufo boreas*), which have been noted since the 1980s, and assess the risk posed to other amphibian species whose status is uncertain, we submitted 98 tissue samples gathered from eight amphibian species across Montana for PCR based identification of the chytrid fungus (*Batrachochytrium dendrobatidis*). This chytrid fungus has been associated with declines, extirpations, and losses of numerous amphibian populations and entire species around the globe over the last two decades. Tissue samples from 30 museum voucher specimens of three species collected in the Flathead Valley in the 1970s, prior to amphibian declines in the area, were all negative for *B. dendrobatidis*. However, four species and 26 of 68 tissue samples gathered during inventory work across the state since 1998 tested positive for *B. dendrobatidis*. In light of its association with other amphibian declines, *B. dendrobatidis*, acting alone or synergistically with other stressors, is a potential cause of the declines observed and should be regarded as an ongoing threat to Montana amphibians. In order to prevent additional spread of this fungal pathogen personnel working in either lentic or lotic systems should thoroughly rinse and decontaminate all equipment with 10-percent bleach between (1) any sites where dead, dying, or ill amphibians are encountered, (2) sites located in different local watersheds or definitive clusters of sites, and (3) all breeding sites of sensitive species separated by > 1 km.

Landscape-scale Nesting Behavior of Greater Sage-grouse in North-central Montana[TWS]

Brendan J. Moynahan
Wildlife Biology Program,College of Forestry and Conservation
University of Montana, Missoula, MT 59812
moynahan@selway.umt.edu

The long-term decline of greater sage grouse (*Centrocercus urophasianus*) over much of their historic range is a concern of managers of sagebrush (*Artemisia* spp.) habitats. Because sage grouse range widely across expanses of sagebrush habitats, and due to the extent of public land holdings in north-central Montana, conservation or recovery efforts for sage grouse are likely to be applied at the landscape scale (rather than the scale of the nest-site, for example). Much of current management focus center on the area around leks because leks appear to be the center of year-round activity. Therefore, it is important to understand where sage grouse nest and rear their broods in relation to leks. As part of a larger doctoral research project, 247 female sage grouse were radio-marked during springs 2001-2003 to estimate reproductive parameters. With the resultant wealth of GPS locations on sage grouse nests, the spatial relationship between nests and leks can be quantified. In general, sage grouse in this study nested further away from leks than expected, though distances varied among four study sites. Renesting attempts within a year were generally close to the first nest location (within several hundred meters). Finally, individuals tracked in successive years typically nested within several hundred meters of the previous year's nest location. Though habitat conservation and enhancement efforts must target more land than first expected, individual birds exhibit some degree of nest-area fidelity. Focusing on particular geographic areas centered on leks may be an effective strategy.

Cause-specific Mortality of Calf Elk in the Garnet Mountain Range, Montana[TWS]

Jarod D. Raithel, and Daniel H. Pletscher
Wildlife Biology Program, School of Forestry and Conservation
University of Montana
Missoula, MT 59812
jarod_raithel@hotmail.com
pletsch@forestry.umt.edu

Michael J. Thompson
Wildlife Biologist
Montana Department of Fish, Wildlife and Parks
Region 2, 3201 Spurgin Road, Missoula, MT 59804
mthompson@state.mt.us

Recruitment rates of Rocky Mountain elk (*Cervus elaphus*) have been chronically low in recent years and may have progressively declined over the past 2 decades across western Montana. Calf:cow ratios generated from spring classification flights on our study site, Montana Hunting District 292-00, have declined from 41 calves:100 cows in 1988 to 19 calves:100 cows in 2003. In spring of 2002 and 2003, a total of 69 neonatal calf elk ≤ 8 days old were captured and instrumented with mortality-sensing radio transmitter that

were attached with ear tags or expandable, break-away collars. In 2002, 17 of 27 radio-marked calves died. In 2003 we have documented just three mortalities among 42 calves radio-marked this year. Sources of mortality include: black bear (n = 8), cougar (n = 3), undetermined predator (n = 2), malnutrition (n = 2), abandonment (n = 2), coyote (n = 1), human hunter (n = 1), and disease/drowning (n = 1). Estimated mean calf birth date was 29-30 May in both years. The sex ratio of calves captured was 11 male:15 female in 2002 and 23 male:17 female in 2003. Birth weights for calves were estimated by plotting a linear regression of estimated calf elk age at capture versus calf elk capture weight for each sex. Estimated mean male calf birth weight in 2003 was 1.6 kg greater than that of 2002, and estimated mean female calf birth weight in 2003 was 0.7 kg greater than that of 2002; however 95-percent confidence intervals about these estimates overlapped. This study is planned to continue through 2006.

Cougar Ecology and Cougar-Wolf Interactions in Yellowstone National Park: A Guild Approach to Large Carnivore Conservation[TWS]

Toni K. Ruth, Polly C. Buotte, Howard B. Quigley, and Maurice G. Hornocker
Wildlife Conservation Society/Hornocker Wildlife Institute
P.O. Box 299. Gardiner, MT 59030

Cougars (*Puma concolor*) and wolves (*Canis lupus*) coexist on the Northern Range of Yellowstone National Park. Understanding of how these two species partition resources may influence the management of these predators and their prey populations. Our study is designed to examine cougar population characteristics including: density, sex and age structure, reproductive and survival rates, dispersal and recruitment events, prey selection, predation rate, and spatial movements. These parameters will be compared with estimates made prior to wolf restoration (Phase I data, Murphy 1998), and current parameters for the wolf population, to assess competition and resource partitioning between the two species. The cougar population was increasing during Phase I and stable in Phase II. Litter sizes have not changed, but a peak in births during summer months in Phase I has been replaced by a more even distribution of births occurring through the year. Mortality from harvest and other cougars has remained the same, but wolves have directly and indirectly killed cougars in two family groups. Prey selection and predation rates are similar between Phase I and II. Elk are the primary prey, the predation rate is nearly the same, and biomass killed per day is slightly greater in Phase II. Cougars kill proportionally more elk calves, and fewer cow and bull elk than wolves during winter. Wolves were known to have displaced cougars from kills in 23 percent of visits; bears in 19 percent of visits. We have begun using GPS collars to look at interactions and habitat use among cougars, wolves, and bears.

Fire Effects on Populations and Habitats of Sensitive Species of Wildlife in Ponderosa Pine Forests of the Interior West[TWS]

Vicki Saab
Research Wildlife Biologist
Rocky Mountain Research Station
Montana State University
1648 South 7th Avenue, Bozeman, Mt 59717-2780

The USDA Forest Service, Rocky Mountain Research Station, is leading the effort to examine fire effects on populations and habitats of wildlife in ponderosa pine forests on 12 sites in eight states across the western United States, including locations on National Forests, National Parks, and state and private lands. We have one site in Montana, in the Elkhorn Mountains on the Helena National Forest. Our goal is to understand the ecological consequences of fire management for wildlife in ponderosa pine forests. The target wildlife species are cavity-nesting birds and songbirds (also small mammals at selected locations). Cavity-nesting birds are a focus of this research because many of them depend on fire-maintained habitats for their dispersal and movements, they are designated as Management Indicator Species (MIS) and Sensitive Species by state and federal agencies, and they are responsive to timber and fire management activities. This presentation summarizes study objectives, methods, and some preliminary results for the Montana and western study sites.

Quantification of Noninvasive Population Sampling: A Comparison of Genetic and Independent Estimates for Cougars in Yellowstone National Park[TWS]

Michael A. Sawaya
Montana State University/ Yellowstone Cougar Project
Wildlife Conservation Society
P.O. Box 927. Gardiner, MT 59030
mikesawaya@hotmail.com

Toni K. Ruth
Yellowstone Cougar Project/Wildlife Conservation Society
P.O. Box 222. Gardiner, MT 59030
truth@montanadsl.net

Scott Creel, and Steve Kalinowski
Ecology Department
Montana State University
Bozeman, MT, 59717
screel@gemini.oscs.montana.edu

Many carnivores, including cougars (*Puma concolor*), are difficult to study due to their low densities and secretive nature. Estimating population size is important to the conservation and management of most carnivore species. Currently, no reliable method of

estimating cougar population size exists other than radio collaring, which is intrusive and expensive. Non-intrusive genetic sampling (NGS) has great potential as a tool for population enumeration and monitoring, but has not been adequately developed to date for cougars. The Yellowstone Cougar Project has radio-marked approximately 87 percent of the resident adult cougar population in the Northern Range of Yellowstone National Park (YNP) and has collected blood from all captured individuals (n = 68 as of winter 2002-2003). Therefore, the YNP Cougar Project provides a unique situation in which to test and develop NGS methods. In January 2003, we initiated a study to test and develop NGS methods. Backtracking was used to find hair at bed sites and scat at kill sites. Hair was also collected through the use of hair-snagging stations. Our study objectives include 1) evaluating the effect of varying sampling intensity for both backtracking and hair-snagging stations on population estimates, 2) quantifying genotyping error rates by comparing non-intrusively collected samples to blood and tissue samples taken during capture, 3) analyze hair and scat (DNA) samples to identify species and individual-specific information on cougars such as gender and relatedness. Currently, we are conducting the second field season in this 3-yr study. No genetic analysis has yet been performed, but we present some preliminary results.

Bat Conservation Strategy and Plan for the State of Montana[TWS]

Nathan A. Schwab
University of Montana
Health Sciences Building, Room 203
Missoula, MT 59812

Bats are among the least studied animals, yet make up the second most diverse order of mammals in the world. Fifteen species of bat occur in Montana and this diversity reflects the variety of resource requirements between species. The economic and ecological benefit of bats, mainly consumption of nocturnal insects including agricultural and forest pests, has only recently been acknowledged. This realized importance increases the need for the protection of the essential resources utilized by bats; primarily day and hibernation roosts, foraging habitat, and open water. Montana continues to observe the significance of its wildlife as one of only a few states that have initiated and drafted conservation plans for bats. This conservation plan outlines the necessary steps toward successful bat conservation through four mechanisms: Research, Management, Inventory and Monitoring, and Education.

Grizzly Bear Recovery: A Progress Report After 23 Years[TWS]

Christopher Servheen
USDI Fish and Wildlife Service
College of Forestry and Conservation, University Hall 309
University of Montana
Missoula, MT 59812

Wayne Kasworm
USDI Fish and Wildlife Service
475 Fish Hatchery Road, Libby, MT 59923

The grizzly bear (*Ursus arctos horribilis*) was listed as a threatened species under the Endangered Species Act in 1975. Six areas were identified in the 1975 listing as grizzly bear populations. Organized recovery efforts have been underway since 1981. The Interagency Grizzly Bear Committee representing state, federal, tribal, and county interests, implements the recovery program. The recovery program is a cooperative multi-agency effort with full state, federal, tribal and public participation. Significant progress has been made in the recovery of the Yellowstone and Northern Continental Divide populations. The Yellowstone population is increasing at approximately 4 percent/year, and recent work has demonstrated exponential expansion of range in the southern part of the ecosystem. All demographic targets in the Recovery Plan have now been met for the last 7 years in the Yellowstone ecosystem. The situation in the Northern Continental Divide Ecosystem (NCDE) also appears to be improving with bears expanding their range on all sides of the ecosystem. A detailed project to produce the first accurate population estimate for this ecosystem will start in 2004 to make a total population estimate in this ecosystem using DNA. The situation in the four other ecosystems is much less positive. Grizzly bear populations spanning the U.S.-Canadian border in the Cabinet/Yaak and Selkirk ecosystems are small and vulnerable, and occur in the southernmost extensions of Rocky Mountain habitat extending down from Canada. The North Cascades grizzly population is isolated on both the U.S. and Canadian sides and is considered the most endangered grizzly population in Canada. Certain political interests blocked an attempt to begin to reintroduce grizzlies into the Bitterroot ecosystem in 2000. Recent genetics work demonstrates that the south Selkirk grizzlies are an isolated population (no male or female connectivity) under 100 individuals with a 15-20 percent reduction in genetic diversity. The Purcell/Yaak population between Highway 3 in Canada and U.S. Highway 2 is demographically isolated (no female connectivity) with < 50 individuals. The Cabinet Mountains population is likely isolated from both the south Selkirk Mountain and the Purcell/Yaak populations. Aggressive conservation measures are necessary to recover these populations including augmentation with additional bears, mortality reduction programs, public outreach, and reestablishment of population linkage so these areas are no longer isolated. We are working on enhanced cooperative U.S. and Canadian efforts to address the issues facing these small grizzly populations and to build connectivity to existing larger populations and areas of vacant habitat. Limitations to grizzly recovery are funding and political resistance and interference. If funding, agency and political commitment, and public support are present, we believe recovery of grizzly bears is possible in all six areas where they were thought to exist in 1975. Success of the Yellowstone recovery effort is proof that a cooperative effort can recover a grizzly population. We know what to do to help the remaining populations, and we can do it if we are given the opportunity.

Wildlife, Fire And The Urban Interface[TWS]

Gayle Sitter
Fisheries and Threatened and Endagered Species
Montana-Dakota Office, USDI Bureau of Land Management
Billlings, MT 59101

When a wildfire starts, it is often too late to implement needed protection measures or too save unique or critical habitats. Using a proactive and interdisciplinary approach, we can often use fire and fuel reduction techniques to improve the habitats for threatened and endangered species This talk will show how these techniques can and have been used in bald eagle and sage grouse management.

Wolf-Prey Interactions in Yellowstone National Park[TWS]

Douglas W. Smith, , Kerry M. Murphy, and Debra S. Guernsey
Center for Resources
P.O Box 168, Yellowstone National Park, WY, 82190

Thomas D. Drummer
Mathematics Department, Michigan Technological University
Houghton, MI, 49931

Wolf-prey interactions were studied in Yellowstone National Park from 1995-2000. We intensively tracked wolves for 30 days in early (Nov-Dec) and late (Mar) winter from the ground and fixed-wing aircraft. Our objectives were to determine wolf killing rate (kills/wolf/30 days) and prey selection. The primary prey of wolves was elk (91%) but bison (3%), moose (2%), and deer (2%) were also killed (2% unknown). The proportion of elk calves, cows, and bulls killed was 43, 36, and 21 percent, respectively. Wolves selected for calves, against cows, and proportional to availability for bulls. Average age of cow elk killed by wolves was 14 years compared to 6 years for hunter-killed cows. Seasonally, calves were selected in early winter and bulls in late. Two distinct wolf-prey systems exist in Yellowstone: 1) the northern area with a large elk population, and 2) interior park with low elk but more bison and moose. Wolves killed a greater variety of prey (elk, bison, moose) in the interior area compared to the northern area (elk). Wolf killing rate increased from early (1.6 elk/wolf/30 days) to late (2.2 elk/wolf/30 days) winter. Averaging early and late winter data and correcting for scavenger removal, consumable biomass was 3.3 kg/wolf/day.

An Evaluation of Fisher Introductions in Montana[TWS]

Ray S. Vinkey, and Kerry R. Foresman
Wildlife Biology Program, College of Forestry and Conservation
University of Montana. Missoula, MT 59812

Brian J. Giddings
Montana Fish, Wildlife and Parks
1420 East Sixth Ave. Helena, MT 59620.

Michael K. Schwartz
Rocky Mountain Research Station
800 East Beckwith Ave. Missoula, MT 59807

Translocations play a crucial role in the conservation and restoration of wildlife populations. We investigated the impact of translocations on the distribution and genetic structure of fisher (*Martes pennanti*) populations in Montana. We documented the presence of fisher in the Cabinet Mountains, 10 years after the release of 110 fishers from the upper Midwest. Verifiable detections were made in four of 17 systematically surveyed sampling units. Surveys indicated that fishers are rare, but present and reproducing in an area where they were believed absent prior to the introduction. To approximate the occupied range of fisher throughout Montana, we mapped fisher distribution using contemporary occurrence data (harvest, sighting, and tracking records). The spatial and temporal extent of these records demonstrated that translocations have been successful in establishing, and/or augmenting, fisher populations in the state. To investigate the origin of extant populations in Montana tissue samples from Montana, British Columbia, Minnesota, and Wisconsin fishers were collected and two regions of the mitochondrial DNA genome were examined. Haplotype frequencies differed significantly by region with four haplotypes unique to British Columbia, two to the Midwest, and one to west-central Montana. The distribution of these haplotypes in Montana suggests that fisher populations in the state have multiple origins reflecting the history of translocations and the influence of native populations. Analysis of mitochondrial DNA sequence data indicated that fisher may not have been extirpated from Montana prior to the translocations. Fisher populations in west-central Montana appear be descended from both native and introduced animals.

Sage Grouse, Coal-bed Methane Development, And West Nile Virus In The Powder River Basin: Is There A Link?[TWS]

Brett L. Walker and David E. Naugle
Wildlife Biology Program, College of Forestry and Conservation
University of Montana, Missoula, MT 59812
Brett.Walker@umontana.edu

Sagebrush habitats in North America continue to be significantly altered by anthropogenic change. Simultaneously, populations of sagebrush-obligate species, including greater sage grouse (*Centrocercus urophasianus*), have experienced pronounced long-term declines. Conservation of Montana's sage grouse populations poses a significant challenge for biologists, land managers, landowners, hunters, and industry. Extensive coal-

bed methane (CBM) development is planned for the Powder River Basin in southeastern Montana, an area that supports robust populations of sage grouse. However, it's influence on grouse populations remains unknown. In 2003, we initiated a pilot study of demographic responses of sage grouse to CBM development on three sites in southeastern Montana and northeastern Wyoming. Preliminary analysis indicates that hens at the CBM site nested, on average, 7-8 days later and renested at significantly lower rates than hens on two non-CBM sites. Hen survival on the CBM site was dramatically lower than that on non-CBM sites due to an outbreak of West Nile Virus (WNV). Future research is geared toward identifying physiological, behavioral, and ecological mechanisms underlying demographic effects of CBM on populations and determining whether excess surface water produced by CBM increases risk of exposure to WNV for sage grouse.

$18 Billion For Conservation—how The 2002 Farm Bill Can Assist Provate Lands Wildlife Conservation Efforts[TWS]

Dave White
State Conservationist
USDA Natural Resources Conservation Service
Bozeman, MT 59715

Dave White was named state conservationist of the USDA Natural Resources Conservation Service (NRCS) in Montana effective May 19, 2002. White is responsible for NRCS operations within the state, including administration of conservation planning assistance to private landowners, conservation cost-share programs, Resource Conservation and Development, the Natural Resources Inventory, soil survey mapping, and water supply forecasting. Before coming to Montana, White worked as a professional staff member of the Senate Agriculture Committee. In this position, he helped develop the conservation and forestry titles of the 2002 Farm Bill. White said the farm bill will bring many new opportunities for landowners to protect Montana's natural resources. White has also worked for NRCS in Missouri, South Carolina, and Washington, D.C. He is an honors graduate from the University of Missouri with a BS degree in Agriculture. White is married and has two children.

Invasive Species Symposium

The following abstracts are from the "Invasive Species Symposium" at the campus of Montana State University—Billings 16 April 2004. The syposium was jointly sponsored by Montana State University—Billings, Montana Academy of Sciences, Montana Weed Control Association, and Center for Invasive Plant Management. For more information regarding the symposium, contact James Barron, Department of Biological and Physical Sciences, MSU - Billings: jbarron@msubillings.edu.

Role of Usda, Aphis, and PPQ in Prevention, Eradication, and Management of Invasive Plant Pests[MAS]

Gary Adams
State Plant Health Director
USDA Animal and Plant Health Inspection Service, PPQ
Helena, MT 59601

The United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine and the Department of Homeland Security, Customs and Border Protection are the first line of defense in preventing the introduction of new Plant and Animal pests. Since 1 March 2003 some of PPQ's responsibility has been transferred to the DHS, CBP. PPQ is responsible for inspecting propagative plant products, identification of potential pests, issuing or denying permits to import products that could pose a risk to plant health in the United States, and responding to potential and new introductions through eradication, containment, and/or management of plant pests. PPQ also regulates the importation of biological control organisms utilized for control of non-indigenous plant/ weeds.

Bozeman Fish Health Center's Invasive Species Diagnosis and Monitoring Program[MAS]

Linda Beck
USDI Fish and Wildlife Service
Fish Health Center, Bozeman, MT 59718

Invasive species have become an integral component to fish health. In the past, the Bozeman Fish Health Center primarily dealt with fish health diagnostics and hatchery certification. Currently, the facility is branching out to incorporate a more total ecosystem approach. Impacts to fish health from invasive species include infectious disease and environmental changes. Three infectious diseases the Center monitors in wild and hatchery systems are *Myxobolus cerebralis*, the causative agent of whirling disease, largemouth bass virus and spring viremia of carp virus. Examples of invertebrates that indirectly impact fish health are the New Zealand mudsnail (*Potamopyrgus antipodarum*), the Zebra Mussel (*Dreissena polymorpha*) and snail, *Melanoides tuberculata*. These organisms have an impact on the ecology of the aquatic environment and can also be utilized as an intermediate host for digenetic trematodes. The parasitic digenetic trematodes have the potential to become fish

pathogens. Research is being conducted to determine if any parasitism of fish is taking place via the New Zealand mudsnail.

Montana's Noxious Weeds—History and Needs[MAS]

Scott Bockness
Yellowstone County Weed Coordinator
Billings, MT 59101

The presentation provides an overview of the current status of the noxious weed problem in Montana. It contains some historical information regarding some of Montana's most invasive plant species and the most current data available on existing infestations of the various species. A current overview was presented of the multi-disciplined resources that are being applied to combat this ecological threat along with identification of the scope of future efforts needed to successfully reduce the invasive plant problem in Montana. Excerpts from the current Montana Noxious Weed Management Plan were included to reflect the coordinated efforts being implemented to give Montanans a clearer picture of the role that invasive plants play in our environment.

How Much Do We Know About the Effects of Wildfire on the Occurrence and Expansion of Non-native Plant Species' Distributions in Natural Areas?[MAS]

Mara Johnson, Lisa Rew, and Bruce Maxwell
Department of Land Resources and Environmental Sciences
Montana State University, Bozeman, MT 59717

Dr. Steve Sutherland
USDA Forest Service, Fire Sciences Lab
Missoula, MT 59801

Invasion of non-native plant species into natural and managed ecosystems is a widespread problem with potentially devastating ecological and economic consequences. Increased occurrence and severity of wildland fires has been identified as a potential threat to natural and managed ecosystems. Wildfire is often linked with the introduction of non-native species and subsequent expansion of their populations. However, much of the information concerning non-native species and wildfire is descriptive and anecdotal. In addition, much of the information available on wildfire and non-native plants comes from research in areas where the native vegetation composition, structure, and natural processes are no longer intact. We have performed an extensive literature search on non-native plant species and wildfire in natural areas of the Western United States. We have synthesized and critiqued this literature, identified research gaps, and clarified the information that is scientifically supported. For this symposium, we will focus on the information gathered on the relationship between wildfire and non-native plant species that is pertinent to the forest, shrubland, and grassland types of Montana.

Detecting Change in Invasive Plant Populations for Prioritization of Management[MAS]

Bruce Maxwell and Lisa Rew
Department of Land Resources and Environmental Sciences
Montana State University, Bozeman, MT 59717

Notoriously invasive plant species may not be increasing in population size in all environments. Therefore, it is crucial to develop methods that will allow quantification of invasiveness so that populations can be prioritized for management. Simulation models were used to identify efficient methods for detecting change in density and spatial extent of plant metapopulations. In addition, models allowed exploration of the relative importance of specific processes on population growth. Efficient methods for change detection may rely on species-specific knowledge of the dominant processes influencing population growth. Seed dispersal as well as response to intra- and interspecific density may be important properties to assess in order to select the best methods to detect change.

Whirling Disease In Yellowstone National Park[MAS]

Silvia Murcia and Billie L. Kerans
Montana State University, Bozeman, MT 59717
smurcia@montana.edu

Todd M. Koel
Yellowstone National Park
Mammoth, WY 82190

The European parasite *Myxobolus cerebralis* (the cause of salmonid whirling disease) exhibits a complex two-host life cycle involving an aquatic oligochaete (*Tubifex tubifex*) and a salmonid fish. This pathogen was first detected in Yellowstone cutthroat trout (YCT) from Yellowstone Lake in 1998. Between 1999 and 2001, a large-scale investigation to determine severity and spatial extent of M. cerebralis in the lake and its tributaries revealed that prevalence of the parasite ranged (in 1999) from greater than 20 percent in the northern section of Yellowstone Lake to 5 percent in the West Thumb. Sentinel fry exposures detected mild infection in Clear Creek in 2000 and in the Yellowstone River proper in 2001, and moderate to severe infection in fry exposed in Pelican Creek in 2000 and 2001. The present investigation began in 2002 focusing on these three YCT spawning tributaries described as *M. cerebralis*-positive using sentinel fry, collection of wild fry, collection of oligochaetes, prevalence of infection in oligochaetes, and measurement of physico-chemical features of the streams. Polymerase chain reaction (PCR) analyses have detected *M. cerebralis*-positive sentinel YCT from all study reaches in Pelican Creek but no infection in sentinel or wild fry from the study reaches in each of the Yellowstone River and Clear Creek. We collected 1020 live oligochaetes from the sentinel study reaches in 2002, four of which released actinospores that PCR tests failed to classify as *M. cerebralis*. About 150 oligochaetes that were not producing actinospores were also tested, two of which (from Pelican Creek) tested positive for *M. cerebralis*. Part of the environmental assessment data from each of the study reaches will be processed during spring 2003, but some physico-chemical characteristics (e.g., water temperature, conductivity) appear correlated to distribution and abundance of *M. cerebralis* in

tributaries to Yellowstone Lake. The goal is to identify potential factors influencing incidence of whirling disease in YCT to aid the park's fish biologists and other regional fisheries managers to develop possible management strategies for this invasive pathogen threatening native YCT and other salmonid populations.

Intensive Monitoring Of Linaria Vulgaris At The Patch Scale[MAS]

Charles Repath, Lisa Rew, and Bruce Maxwell
Resources and Environmental Sciences Department
Montana State University
Bozeman, MT 59717

Non-native species vary in their level of invasiveness in different natural plant communities. While land managers recognize this, the information behind this idea is anecdotal. Quantitative data for documenting, facilitating and directing management efforts does not exist. The invasion of Linaria vulgaris into native plant communities in the Rocky Mountains is a challenge for managers because this species is perceived to invade upland plant communities that lack obvious human disturbance. Our goal with this experiment was to gain an understanding of the demographic and ecological factors that facilitate *L. vulgaris* invasion of native plant communities. The study had three main objectives: to quantify the invasive potential of *L. vulgaris* in three different community types; to characterize which life history states are more responsible for invasiveness; and to quantify how population demographics and invasion rates vary between patch interiors and edges. Results from the first three years of the study indicate that rates of invasion varied significantly for each of the different plant communities. Seed production and seedling emergence have been extremely low over the study period and vegetative production has been the life history state most responsible for invasion. Finally, the data showed little difference for rates of invasion, in terms of both density and spatial extent, between patch edges (the invading front) and patch interiors for the three habitats studied.

Sampling To Understand Non-indigenous Plant Species Occurrence And Develop Probability Maps Of Occurrence[MAS]

Lisa Rew and Bruce Maxwell
Department of Land Resources and Environmental Sciences
Montana State University
Bozeman, MT 59717

Many natural areas have a mandate to preserve the natural systems under their control and to manage non-indigenous species. However, in order to manage such species one has to know which and where species occur. We believe that there is a three-phase process in non-indigenous management; inventory/survey, monitoring, and management. We surveyed the northern range of Yellowstone National Park using a stratified sampling method. Transect start locations were stratified on a known disturbance, roads and trails, but to ensure unbiased sampling they finished 2000 m from any road or trail. Continuous data were collected along each transect, information on biotic and abiotic variables were collected along with data on the occurrence of non-indigenous species. Logistic regression was used to analyze the data

for correlations between non-indigenous species occurrence and the independent variables. The best model was assessed using Akaike Information Criterion (AIC). Coefficients from the best model were then used to produce probability maps of target species for the area of interest.

Effect On Grassland Invasability Of Vegetation Type, Weakening Disturbance, And Destructive Disturbance[MAS]

Tad Weaver, L. Payson, J. Plaggemeyer, J. Hartz-Rubin.
Ecology Department, Montana State University
Bozeman, MT 59717

We expect invasability of steppe vegetation to differ among vegetation types and to be facilitated by disturbance, which weakens the community fabric (e.g. fire or grazing) or locally destroys it (cultivation, machine, or animal). Three experiments examine aspects of this hypothesis. We expect a colonizer to perform differently in environments with different physical or biotic stresses. Thus, invaders should perform differently on topographic gradients from moist tall-grass through mixed-grass to dry short-grass prairie. And, in a mixed-grass environment, invaders might perform differently in the native grass type or in clones of invading *Bromus inermis* (exotic grass) or *Symporicarpos occidentalis* (native shrub). On either gradient, a recently burned site might be more invasible than a healed site. Surrogate weeds both well adapted to the environment and having large seeds (*Hordeum vulgare*, grass, and *Helianthus annus*, forb) were planted into disturbances (7 cm dia) in five such great plains vegetation types, each with examples of recent burning. Survival to flowering was ~30-50 percent and equal in all the communities. Height (9-22 cm) and weight (0.2-0.7 gm/ plant) growth were poor and roughly equal throughout. One might conclude that, regardless of vegetation type, most of the limiting resource is used by the established community and unavailable to any invader. We expect colonizing success to increase linearly with the area of a denuding disturbance. This hypothesis was rejected when seeds planted in 1-, 10-, 10-, and 1000-cm^2 holes grew similarly and poorly while plants growing in >10,000-cm2 holes grew well. We speculate that, while disturbance released resources to invading plants in large disturbances, resources also released in smaller holes were pre-empted by roots invading from adjacent undisturbed vegetation. The experiment was conducted in two rangelands (dry *Bouteloua gracilis* and moister *Festuca idahoensis*) and replicated in five blocks and two years. The plants studied included, in order of seed size, grasses (*Zea mays*, *Triticum aestivum*, and *Bromus tectorum*) and forbs (*Helianthus annus*, *Melilotus officinalis*, and *Centaurea maculosa*). The forbs in 1000-cm^2 holes performed slightly better than the grasses, perhaps because forb taproots reached below densely rooted surface horizons. Some hypothesize that fire weakens native vegetation to facilitate weed invasion. A corollary is, that if invaders are perennial and fire resistant, successive fires will allow increase of the weed both by providing damaged sites for new infections and reducing resistance to lateral spread of established colonies. We tested this hypothesis by comparing ubiquity (percent of m^2 plots infected) and dominance (percent cover in infected plots) in management units protected from fire 1935-1972 and burned 0, 1, 2, 3, 4, 5, or 6 times since 1972. Vegetation of moist bottoms, mixed grass slope sites, and short-grass hilltop sub-sites was separately examined. Preliminary analyses show no fire-related difference in either establishment (ubiquity) or expansion (cover at occupied sites) for major weeds including *Bromus inermis* and *Poa pratens*is (exotic grasses) or *Symphoricarapos occidentalis* (native brush).

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