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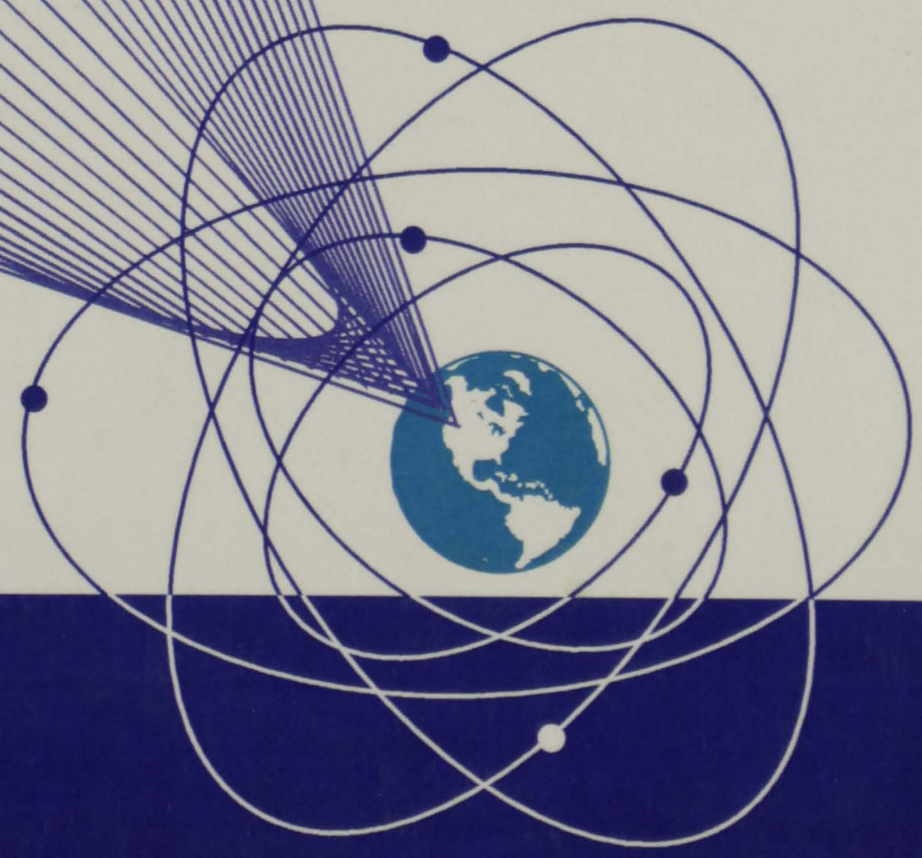
IJS



INTERMOUNTAIN JOURNAL OF SCIENCES

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

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

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

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

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

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

Literature Cited

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Modifications of a Turbulent Fountain for Use as a Fish Screen in Small High-Gradient Streams

Ronald W. Pierce, Montana Fish, Wildlife and Parks, Missoula, MT 59804
Ronald J. Krogstad, USDA Natural Resources Conservation Service, Bozeman, MT 59718
Gregory A. Neudecker, USDI Fish and Wildlife Service, Great Falls, MT 59404

Abstract

We tested the efficacy of a modified turbulent fountain for its ability to screen fish from an irrigation diversion in McCabe Creek, Montana. We released westslope cutthroat trout (Onchorynchus clarki lewisi) into the intake of a prototype fountain in order to field-test screening capability and impingement rates. We then corrected observed flaws in the screen and repeated the test to compare efficacy of the prototype to the modified, more "fish-friendly" design. Fish lengths were similar between the two tests. Following modification of the prototype screen, the number of impinged fish declined from 37 to 6 percent. The duration of impingement declined by 93 percent, from a median of 30 to 2 sec. This evaluation indicated that turbulent fountain screens, when designed and constructed with proper fisheries considerations, can be effective at screening fish and providing a low-maintenance, more practical alternative to traditional fish irrigation screening devices on small streams.

Key Words: fish screen, impingement, irrigation diversion, native fish recovery, turbulent fountain

Introduction

Populations of many native fishes in the western United States have declined in part because of entrainment in irrigation ditches (Schill 1984, Fleming et al. 1987, Der Hovanisian and Megargle 1998). In the Blackfoot drainage of Montana, unscreened irrigation ditches are common within the range of bull trout (*Salvelinus confluentus*), which is *threatened* (63 FR 31647) under the ESA (USDI Fish and Wildlife Service 2002), and westslope cutthroat trout (*Onchorynchus clarki lewisi)* a *species of special concern* in Montana (Pierce et al. 2002a). Blackfoot tributary assessments have identified irrigation ditches on 47 of 89 inventoried streams (Montana Fish, Wildlife and Parks files). As a tool to assist recovery of native fish populations, resource agencies, conservation groups, and irrigators are screening irrigation diversions to minimize population losses due to ditch entrainment. Screening irrigation ditches in the Blackfoot River drainage has contributed to increased fish densities in tributary populations as well as the overall densities of imperiled native fish in the Blackfoot River (Pierce et al. 2002b).

Although some states require irrigators to screen ditches, Montana relies on voluntary compliance. For voluntary screening programs to be effective, fish screening devices must meet fish screening objectives and provide adequate water supply for agricultural needs, operate effectively with little or no maintenance, and must be cost effective (Black 1998, personal observation). Although there are many options for screening irrigation ditches (Odeh 1999, Nordlum 1996), barrier screens are often expensive and require higher maintenance than many irrigators are willing to accept (Mefford and Kubitschek 1997, Fleming et al. 1987, Black 1998; personal observation).

Here, we discuss potential for a turbulent fountain, originally designed as a self-cleaning trash remover (Bondurant 1983) and then modified as an effective fish screen. A turbulent fountain screen consists of a circular, horizontal screen with a vertical riser pipe in the center. Water flows

up through the center pipe and spreads laterally over the screen pushing fish and any entrained debris outward towards the edge of the screen surface (Kemper and Bondurant 1985). Turbulent fountain screens operate entirely with hydraulic pressure as a single integrated diversion structure and contain no moving parts, require no external power and only minimal maintenance (*See* Bondurant and Kemper [1985] and Kincaid [2002] for original descriptions and diagrams of turbulent fountain screens).

As with other types of barrier screens used for fish protection, suitability of a turbulent fountain screen varies with site conditions. A turbulent fountain is most appropriate for small irrigation diversions with flows ranging from 0.03 to 0.15 m^3/sec, and a moderate level of hydraulic differential between the intake and the fountain riser, e.g. higher gradient streams, Kincaid (2002). Although turbulent fountain screens offer an effective, low-maintenance option for screening debris from small stream irrigation diversions (Bondurant and Kemper 1985), the efficacy of turbulent fountains is untested for screening fish.

To assess efficacy for screening fish, we designed and installed a prototype turbulent fountain fish screen on McCabe Creek, Montana. Our objectives for evaluating the turbulent fountain fish screen were to 1) determine the potential of a turbulent fountain system for screening fish, 2) assess impingement, i.e., fish contact with the face of the screen, and 3) provide guidance to irrigators regarding efficacy and design criteria of this alternative fish screen.

Methods

In addition to hydraulic design criteria defined by Bondurant and Kemper (1985), our prototype "fish screen" design incorporated a circular outer wall with an attached fish bypass pipe (Fig. 1), along with inflow and outflow capacity designed to maintain constant flow through the bypass pipe. The screen was designed for a maximum inflow of 0.14 m^3/sec, of which a maximum 0.085 m^3/sec was available for outflow, with the remainder available for the bypass. The screen incorporated a 1.25-mm mesh over a 1.68-m^2 circular stainless screen set at a 1-percent slope, with a maximum mean approach velocity of 0.122 m/sec over the surface of the screen. We also reduced the screen diameter from the recommended original criteria of 213 cm to 152 cm to more effectively wash fish and debris off the screen. Following construction, we evaluated the fish screening capability in 2000 and again in 2002 following correction of observed construction flaws.

In 2000 we captured 48 westslope cutthroat trout using a backpack-mounted, battery-powered DC electrofishing unit (Smith-Root). Fish were anesthetized with tricaine methanesulfonate, counted, and measured for total length. After fish recovered from the anesthetic, we released individual fish through the fountain intake. As fish exited the intake riser, we counted by size category (Table 1) and timed the duration of all fish impinged on the screen for ≥ 2 sec. After all fish passed, we walked up- and downstream of the bypass exit to visibly detect signs of related mortality or signs of injury.

During this impingement evaluation of our initial fish screen design, we identified two construction flaws that appeared to contribute to unnecessary impingement: 1) the close proximity of inner chamber to a portion of outer wall of the structure, and 2) a lower screen angle than specified in our prototype design (Fig. 2). Due to the first construction flaw, the fountain was unable to completely wash debris from the edge of the screen. At this location, fish were unable to wash free of the screen and were impinged on the screen against the debris. Based on this observation, we modified our original screen by adding a flow deflector shield to the fountain riser in order to direct water, debris and fish away from this area of screen. We also modified the shape of the screen from a low-angle flat screen to a rounded cone-shaped screen with a mean 1-percent slope (Fig. 1).

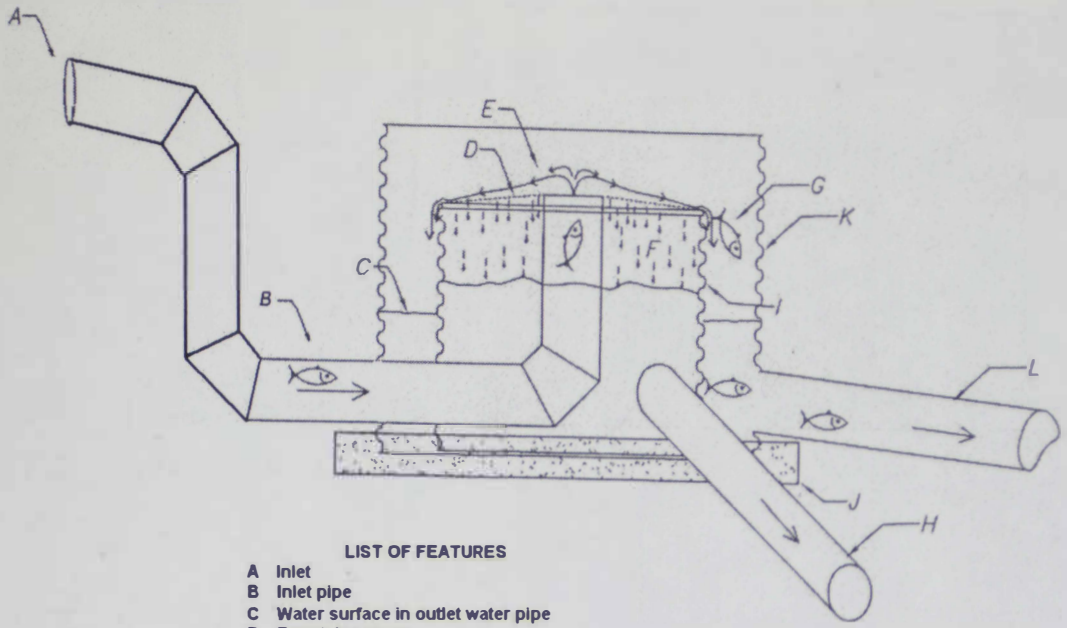

Figure 1. Conceptual design of a turbulent fountain fish screen with bypass to stream.

Following these screen modifications, in 2002 we repeated the impingement trial with 66 westslope cutthroat trout entrained through the fountain intake. Capture, handling, and observation of these fish were similar to the previous trial. During both experiments, the fountain intake was operating at full (0.14 m^3/sec) capacity.

We used Mann-Whitney nonparametric tests to compare lengths of fish in the initial trial to fish lengths in the second trial as well as duration of impingement between the prototype and modified design. A chi-square analysis was used to test whether the number of impinged fish varied by size class (50-110, 111-150, and >151 mm) between trials, where the number of impinged fish from the original design trial was used as the expected values of impingement in the modified design trial. In all cases, differences were considered significant at P-values ≤ 0.05.

Results

Prior to screen modification, 31 westslope cutthroat trout (65%) passed through the fountain with no impingement (< 2 seconds) on the screen. Seventeen fish (35%) were impinged for ≥ 2 seconds, of which 14 managed to work free of the

Table 1. Numbers and sizes of impinged fish before (2000) and after (2002) modification of the original screen

		Total lengths (mm)	Number fish	Size class of impinged fish (mm)		
Year	N	mean (SD), range	impinged	(50-110)	(111-150)	(>151)
2000	48	134(45), 61-241	17	9	3	5
2002	66	121(38), 61-216	4	2	1	1

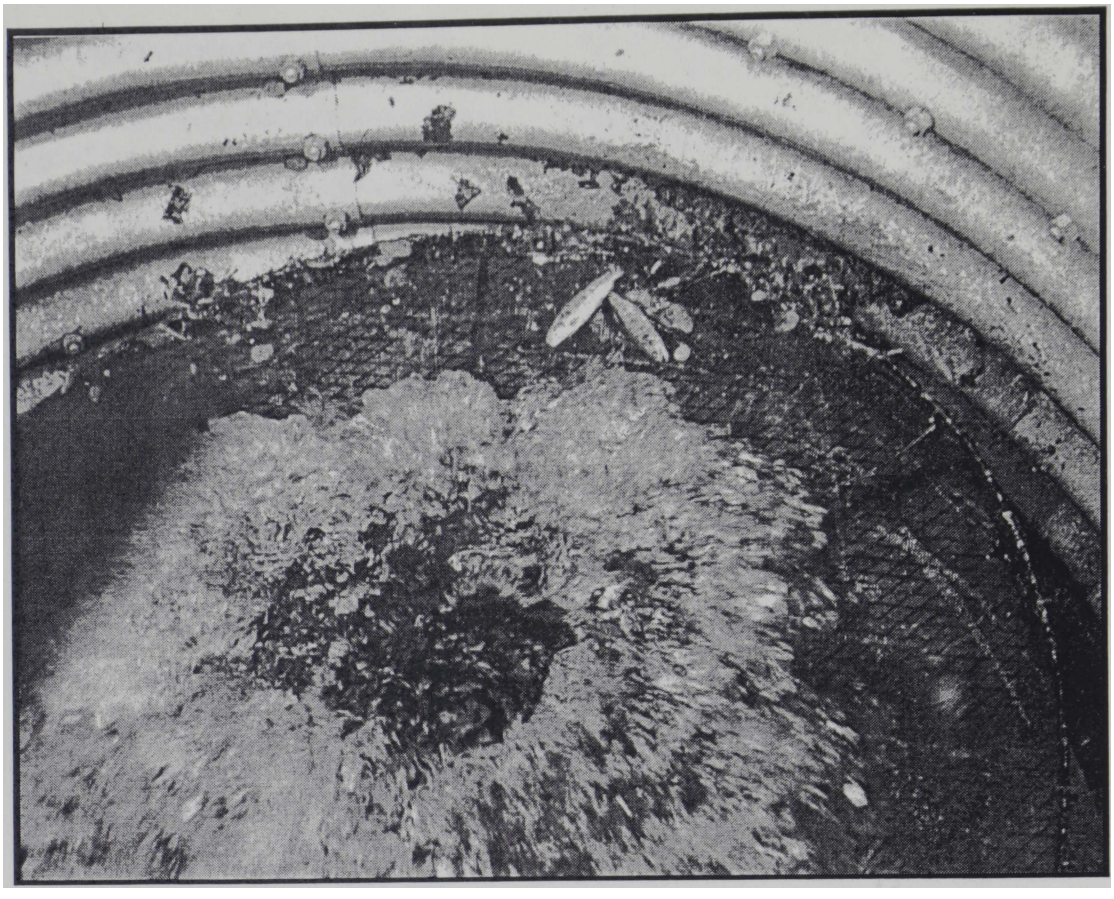

Figure 2. Fish impinged on the outer portion of the screen against the screen in area of debris collects.

screen (median impingement time = 30, range = 2-1560 sec). Three (6%) of the sampled fish remained in the fish screen after 26 min when we ended the experiment (Table 1).

Following screen modifications, all but four (6%) of the 66 fish immediately passed through the fountain and screen with no impingement (< 2 seconds). Of the four impinged fish, all washed over the screen within four seconds (median = 2, range = 2-3 sec). For these four fish, all impingement occurred in a localized boundary area between the main flow and the shielded portion of the screen.

We detected no difference in total length of fish between the first and second tests (Mann-Whitney, $P = 0.081$, Table 1), nor did the proportion of impinged fish vary among the three size classes between the first and second trial ($x^2 = 3.0$, 2 df, $P = 0.223$). The number of impinged fish declined from 37 percent in the first test to 6 percent in the second test (Table 1). The duration of impingement between the first and second test also declined significantly (Mann-Whitney, $P = 0.006$).

Upon completion of both experiments, we walked up-and downstream of the bypass and found no evidence of injury or mortality resulting from impingement from either test.

Discussion

Our modifications and evaluations of turbulent fountain screens suggest that this device can provide an effective, low-cost, low-maintenance fish screening system. Our field trials further outline the importance of constructing screens to exact design specifications.

Based on our design, evaluate, and modify approach, the following observations will help ensure effective application of this screen in the future. Fabricators and installers should ensure

sufficient distance between the inner and outer chamber to facilitate movement of fish and entrained debris off the screen, plus include a sloped (or crowned) screen with a minimum 1-percent slope. Not only do lower angle screens increase impingement, but also several fish, once on the original more horizontal screen, attempted to swim towards the main flow (center) of the fountain. These fish remained on the screen for an extended time before escaping. A smaller-diameter inner chamber with minimal screen surface would also clean the screen more efficiently and reduce fish contact with the screen on its outer portion. A larger intake with excessive volume would serve a similar purpose by washing fish more quickly from the screen. Similarly, a smaller diameter out-flow pipe relative to intake pipe diameter forces upwelling on the outer portion of a sloped screen and assists in washing fish from the screen with less screen contact. Another possibility that was not tested might be to elevate the bypass pipe or otherwise submerge the screen in order to minimize fish contact with the screen and enhance fish passage over the screen.

Proper operation and maintenance of a fish screen is equally important to quality screen design (Nordlum 1996) to assure long-term effectiveness and function. In the Blackfoot River drainage, inadequate maintenance has reduced the effectiveness of many mechanical fish screens (paddlewheel and rotating drum). Because it has no mechanical parts, the turbulent fountain screen requires less maintenance than conventional fish screens and is cheaper to install and use. The total cost of the entire modified turbulent fountain system including the head gate was $9900, approximately 75 percent of the cost of self-powered paddlewheel driven fish screen and head gate of comparable flow capacity (Montana Fish, Wildlife and Parks data). While comparable in cost to electrically powered rotating drums of similar capacity, a turbulent fountain required lower maintenance at less expense. Throughout the three summers of use, the turbulent fountain required less manual cleaning than either traditional paddlewheel driven flat-plate screens or electrically powered rotating drums.

With proper design and construction, a turbulent fountain fish screen, as an integrated diversion structure, can meet multiple objectives. These include 1) volume control to an irrigation system and automatic removal of debris from a pipeline, 2) the elimination of entrainment into diversion ditches and the return of fish directly back to the stream immediately below the diversion point, 3) reduced impingement, 4) minimal screen maintenance, and 5) a cost-effective screening device. Unfortunately turbulent fountains have not been designed for volumes > 0.15 m^3/sec although Bondurant and Kemper (1985) suggest designs for higher flows are possible. Required hydraulic differential for larger diversions should also be evaluated in order to identify specific site requirements. Although turbulent fountain screens appear to minimize entrainment and impingement on small diversions, we did not fully measure all aspects of screen velocities (approach or sweeping), or all aspects of physical contact of fish with the screen. Future studies should also evaluate screen-injury potential such as scale loss, as well as other design improvements to expand this technology to areas where formal fish screening criteria currently preclude use of turbulent fountain fish screens.

Acknowledgements

We extend special thanks to the Two Creeks Ranch for agreeing to install the turbulent fountain fish screen. We also appreciate the data collection, analysis and helpful comments of FWP fisheries staff Winston Morton, David Schmetterling and Ryen Anderson. Funding for the fish screen was provided by the USDI Fish and Wildlife Service, atural Resource Conservation Service and Big Blackfoot Chapter of Trout Unlimited.

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ABSTRACTS

BIOLOGICAL SCIENCES - AQUATIC

THE HISTORY OF MONTANA'S INSTREAM FLOW PROTECTION PROGRAM[AFS]

Stan Bradshaw
Trout Unlimited, Montana Water Project
P.O. Box 412, Helena, MT 59624
sbradshaw@tu.org

Montana's water law is grounded in the doctrine of prior appropriation—the right to put water to a beneficial use is based on priority in time. When there is not enough water to meet all needs, the user with the earliest priority date gets water first. The conventional wisdom was that water left instream was not a beneficial use. In the 1960s, the idea of an instream beneficial use for fish first gained credibility. In 1969, the legislature passed legislation allowing the Montana Fish and Game Department to appropriate water for instream use on twelve streams. The Department filed claims on those streams in early 1970s. In 1973, the legislature codified Montana's water law into the Water Use Act. In addition, the legislature authorized state, local, and federal agencies to apply for instream flow reservations. There have been three instream reservations in Montana—the Yellowstone, the upper Missouri, and the Lower Missouri. The Water Use Act was amended in 1976 to require a statewide adjudication of water right claims filed prior to 1 July 1973. State and federal agencies claim instream rights in the adjudication. In 2002, the Montana Supreme Court affirmed that right of the agencies to file those claims. In 1989, the legislature authorized a pilot instream leasing program allowing the Montana Fish, Wildlife, and Parks to lease existing water rights with priority dates intact. In 1995, the legislature passed two statutes authorizing pilot programs for instream leases to be held by private entities.

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

[AFS] *Montana Chapter of the American Fisheries Society Annual Meeting, Great Falls, MT, February 11-14, 2003*

[MAS] *Montana Academy of Sciences Annual Meeting, Missoula, MT, April 19-20, 2003*

[TWS] *Montana Chapter of the Wildlife Society Annual Meeting, Lewistown, MT, February 25-27, 2003*

Montana's Water Allocation System and River Fisheries[AFS]

Rich Moy
Water Management Bureau Chief
Department of Natural Resources and Conservation
P.O. Box 201601, Helena, MT 59620
rmoy@state.mt.us

To understand how Montana's water allocation system may change in the 21st Century, we need to understand past changes. California miners brought the water law doctrine of first in time, first it right or the Prior Appropriation Doctrine to Montana in the 1860s. It is still alive and well. Before 1973, Montana did not have a water law to guide the orderly use and appropriation of state's waters. There was more than one way to obtain a water right. The passage of the 1973 Water Use Act changed this. The Act set up a centralized system of all water right records, one process for obtaining water rights, a system to adjudicate pre-1973 water rights and a statute to reserve water for future consumptive uses and to maintain instream flows. Even though our State Constitution requires that we "shall maintain and improve a clean and healthful environment for present and future generations", our water law allows streams and rivers to become fully appropriated and go dry. A number of changes in Montana's water law, however, have occurred over the past 30 years that recognize the importance of leaving water instream for fish and wildlife, recreation, and water quality dilution. These laws include water reservations, water leasing, basin closure, pre-1973 claims for fish and wildlife, and Murphy water rights. But the demand for more water by agriculture, industry, municipalities and instream users will only increase. The tools in our toolbox may not be enough. Everyone will need to work together to create new tools and solutions in the 21st Century.

Potential Impacts of Global Climate Change on Montana's Rivers[AFS]

Matt Reeves
University of Montana, School of Forestry
Numerical Terradynamic Simulation Group
Missoula, MT 59812
reeves@ntsg.umt.edu

The earth's climate is predicted to change due to a buildup of greenhouse gasses. The heat trapping property of these gasses is well documented and undisputed. At the global scale, sea ice extents are declining, carbon dioxide levels and average temperatures are increasing. Additionally, sea levels and the number of frost-free days are increasing. The earth is undeniably warming, yet predicting the extent of change, particularly in the environmentally diverse northern Rockies ecosystem, is challenging and remains debated. The general trends however, indicate that temperatures are rising across this region, while precipitation is decreasing. For example, in Helena Montana annual mean temperature has increased 1.3 °F, while precipitation has decreased up to 20 percent in some parts of the state. Temperature trends remain less ambiguous than either temporal or spatial variations in

expected precipitation. Projections made by the Intergovernmental Panel on Climate Change (IPCC) and results from the United Kingdom Hadley Centre's climate model (HadCM2) predict temperatures could rise by a range of 1-8 °F in spring and summer and by a range of 2-10 °F in fall and winter by 2001 within the region. Under this scenario, within Montana, growing seasons and forest and rangeland productivity will likely increase and snow pack will decrease thereby decreasing stream flows. This situation could alter floral and faunal composition of an area depending on length and severity of climate change.

Basin Closures, Murphy Rights and Water Reservations: Will Instream Flows be Adequately Protected in the 21st Century?[AFS]

Chris Hunter
Montana Fish, Wildlife and Parks
Helena, MT 59620
chunter@state.mt.us

Climate change, the legal trend toward the public trust doctrine and increasing urbanization will determine the protection that instream flows will receive in this century. Western water law is really quite young. It has changed substantially with regard to instream flows in the last quarter century. We now have the ability to reserve water for instream uses and also to lease water. The trend in water law is toward more protection for instream flow as the public trust doctrine is increasingly extended to water law. Bean Lake III is the most recent and local example. Over the course of the next century this trend will continue with more protections afforded to instream flows. Climate change will be a huge factor in how instream flows are viewed by society. Many climate change scientists believe that while flows will be higher during the winter in Montana, they will be lower and stream temperatures will be higher in the summer. The result will be a contraction in salmonid distribution in Montana. How will this affect society's view of instream flows? Will people demand that more water be left instream to try to reduce the impact on trout fisheries? At the same time it is likely that western Montana will continue to become more urbanized while eastern Montana continues to lose population. People in cities are more likely to support water for instream flows than are agricultural users. As the cities gain greater political influence in the state legislature there may be a greater political will to do more to establish and protect instream flows. My view is that during the course of the next century we will see stronger legal protection for instream flows. The publics increasing concern about instream flows due to the contraction of salmonid populations caused by climate change and the demographic/political shift to an urbanized western Montana will lead to greater protections for instream flows. By the end of the century the tools we rely on today will be a memory just like us.

River Flow Restoration: Do We Have the Necessary Tools and Resources?[AFS]

Stan Bradshaw
Trout Unlimited, Montana Water Project
P.O. Box 412, Helena, MT 59624
sbradshaw@tu.org

Any discussion of tools and resources has to be within the context of existing law that recognizes water rights as property. Current instream flow tools in Montana do two things: provide for some protection against future consumptive uses; and provide some drought relief on specific streams in which leases or conversions of existing, senior rights to instream rights have been negotiated with willing water users. Leasing and conversions of existing rights are slow to implement, but have shown promising tributary benefits. Current tools don't provide for base flows that trump all other water rights. It is unlikely that we'll soon see such a provision. If such a measure were to be enacted, it might not survive judicial scrutiny. The Public Trust Doctrine may offer an additional tool in the future. California, having applied to Public Trust Doctrine to water rights, has realized some benefits to instream values. It has not been, however, a panacea. Voluntary watershed efforts on the Blackfoot, Big Hole, and the Jefferson have shown some promising results, but have some limitations. Additional tools that have yet to be tapped to their fullest potential are management of existing storage to improve instream flows, expansive public interest criteria that incorporates instream values to assess new consumptive use permit applications, and the use of the Clean Water Act TMDL process. In addition, the Washington Supreme Court has held that stream flows are a component of water quality that can be protected under the Clean Water Act.

Hydrologic Impacts of Flood to Sprinkler Conversion[AFS]

Mike Roberts
Montana Department of Natural Resources and Conservation
Water Resource Division
1424 9th Ave., Helena, MT 59620
miroberts@state.mt.us

Flood irrigation techniques have been practiced in Montana for over a hundred years. Nearly half of the irrigated land in Montana still utilizes some form of flood irrigation. The recent trend of converting flood-irrigated land to sprinkler-irrigated lands will have impacts on streamflows. In most cases, by converting to sprinkler, irrigators divert less water to irrigate the same parcel of land that was historically flood irrigated. These conversions can provide benefits to water quality and if the excess water is left in the stream, short-term increases to streamflows. They also may increase hay production through more consistent application of water and by extending their irrigation season in water-short years. In some cases, water leftover by sprinkler conversions, water that typically would return to streams under flood operations, is used to put additional land into production. Consequently, sprinkler conversion projects can increase the overall volume of water consumed, deplete

returns flows, and cause a net depletion of streamflows. If water conservation is the goal of resource managers when conversions are made, they must carefully compare the water balance for the existing flood system to that for the proposed sprinkler system to determine the hydrologic consequences of this action.

The 2002 Farm Bill Conservation Program : Opportunities for Private Lands Conservation in Montana[AFS]

Carrie Mosley
Programs Specialist, Natural Resources Conservation Service
10 E. Babcock St., Rm. 410, Bozeman, MT 59715
cmosley@mt.usda.gov

Conservation programs of the 1996 Farm Bill administered by the Natural Resources Conservation Service (NRCS) brought millions of dollars to Montana's private landowners from 1997-2002. These volunteer conservation programs benefited Montana's soil, water, plant and animal resources. Recent passage of the Farm Security and Rural Investment Act (FSRIA) of 2002 will continue to strengthen the United States Department of Agriculture's (USDA) conservation efforts on American's private lands. FSRIA reauthorized many popular and effective programs such as the Environmental Quality Incentives Program (EQIP), the Wildlife Habitat Incentives Program (WHIP), the Wetland Reserve Program (WRP), the Farm and Ranchlands Protection Program (FRPP), the Conservation Reserve Program (CRP) and it's spin-off programs the Conservation Reserve Enhancement Program (CREP) and the Farmable Wetland Program (FWP). These programs were reauthorized with significant funding increases included. Also included in the 2002 Farm Bill are the new programs Grassland Reserve Program (GRP) and the Conservation Security Act (CSP) along with special provisions for limited resource producers, beginning farmers, and technical service providers.

Trout Unlimited's Western Water Project[AFS]

Laura Ziemer
321 E. Main St., Suite 411, Bozeman, MT 59715
lziemer@tu.org

In 1998, Trout Unlimited initiated its Western Water Project in two states, Colorado and Montana, in order to squarely address the problem of dewatered streams. Since then this experiment has paid off with steady progress in both creating additional tools for instream flow protection, and with on-the-ground projects to protect and enhance streamflows. ow five years later, the Western Water Project operates in six states with an additional federal issues staffer in Washington, D.C. Trout Unlimited is beginning to see region-wide results that are grounded in the specifics of each state. Just as the relative success of various "Tools for Instream Flow Protection" presented today are necessarily specific to particular river basins and tributaries, each Western state has its own politics, culture, and laws governing

water. One of the strengths of the Western Water Project is its ability to share knowledge across state boundaries, and gain a perspective on the uniqueness of state-based water law and politics. This presentation will compare and contrast the relative progress among the Intermountain West states, focusing on how other states compare to Montana's streamflow protection efforts. This presentation will attempt to integrate this AFS Meetings' prior presentations in the context of a broader, west-wide view, and set the stage for specific, Montana examples of streamflow protection that will follow. Inviting discussion, this presentation will conclude with suggestions on how Montana may be able to incorporate some of the progressive elements of streamflow protection that exist in other Western states.

INSTREAM FLOW RESTORATION IN THE JEFFERSON RIVER DRAINAGE[AFS]

Bruce Rehwinkel
Trout Unlimited
P.O. Box 412, Helena, MT 59624
brehwinkel@tu.org

Dave Amman
Montana Department of Natural Resources and Conservation
1825 11th Ave., Helena, MT 59620

Ron Spoon
Montana Fish, Wildlife and Parks
P.O. Box 1137. Townsend, MT 59644

The Jefferson River is perhaps one of Montana's most chronically dewatered rivers due to past over-appropriation of water rights in the drainage. Long-term monitoring of the fishery of the Jefferson show the impacts of flow shortage on the health of the fishery, which can be acute during drought years. Water users and the Jefferson Watershed Council (JWC) developed a drought plan in 1999 to attempt to reduce the impacts of drought on the fishery of the Jefferson. This plan was implemented in each of the last three years and the voluntary effort improved stream flow in a 25-mile reach of the upper Jefferson River. Although the "tool" of a voluntary drought plan is very beneficial and important to provide modest flow improvements during severe drought, a larger and more ambitious "tool" is needed to significantly improve stream flow. The JWC is exploring the concept of improving the water delivery system to benefit both water users and aquatic life. A pilot project designed to reduce ditch seepage loss in the Jefferson Canal was implemented on monitored in 2002. Results of this project document water savings and indicate that improving canal efficiency may be an effective tool to help restore instream flow in the Jefferson River. Results also showed that improved canal efficiency reduced the burden felt by water users that voluntarily contributed water to the river.

Restoring the Musselshell by Restoring Rural Democracy[AFS]

Bill Milton
Lower Musselshell Watershed Coordinator
823 Hwy 87 N., Roundup, MT 59072
bill_milton@hotmail.com

The Musselshell River, a tributary of the Upper Missouri, drains over 8000 mi^2 of central Montana's mountains and plains. Less than 10,000 people reside within the borders of the watershed. Over 350 farms and ranches located along the Musselshell's mainstem and the tributaries rely on seasonal stream flow to support some portion of their agricultural enterprises. A number of small communities rely on the waters for municipal needs. In the past, the river has supported a fair cold water fishery in the upper reaches and a warm water fishery in the lower reaches. In 1991, The Montana Legislature, declared the Musselshell a chronically dewatered stream. In 1996, the Musselshell was placed on Montana's 303(d) impaired stream list thus requiring a restoration plan be developed to voluntarily address streambank stability and flow management. The watershed has experienced various levels of drought for over six years. The presentation will briefly explore the possible meanings of the following statement: there is no shortcut to lasting solutions and lasting solutions never last. How does a community and a landscape come to terms with each other? In human perception scarcity always exists. The act of restoring instream flows implies scarcity. How does the idea of democracy and respecting the individual voice respond to scarcity? If there is a better outcome for the whole, what role do the parts play in realizing that outcome? The speaker will offer for discussion, one, a process for public dialogue, along with the corresponding attributes useful for that dialogue; and two, how the process when skillfully applied can lead and has led to better outcomes for people and the landscapes they live in.

Instream Flow Restoration in the Blackfoot River Drainage[AFS]

Ron Pierce
Montana Fish, Wildlife and Parks
3201 Spurgin Road, Missoula, MT 59804
bigfish@blackfoot.net

Since 1988, the Blackfoot River drainage has been the site of a private lands cooperative wild trout restoration initiative, focusing on the recovery of imperiled native fish. In 2002, Montana Fish, Wildlife and Parks identified habitat restoration opportunities on 94 percent (83 of 88) of inventoried streams, including 33 streams (38%) with potential for fisheries-related irrigation improvement such as instream flow enhancement. Tools to maintain and enhance instream flows in the Blackfoot are 1) a basin closure to new water right appropriations, 2) drought planning tools - the FWP Murphy water right and the Blackfoot Emergency Drought Response (BEDR) Plan, and 3) the aforementioned restoration program. The restoration program provides a long-term mechanism for increasing instream flows. On private lands, instream flow problems often overlap with other agricultural-related habitat problems ranging from degradation of riparian areas to non-point pollution of entire stream

reaches. Within this context, the Blackfoot restoration program attempts to address multiple limiting factors. Like all elements of the restoration program, enhancing instream flows relies largely on voluntary cooperation of private landowners. Meeting landowner and instream flow objectives remain critical to our long-term success. Technical aspects of enhancing instream flow as well the social considerations of three instream flow case studies outline the successes and challenges of instream flow enhancement. These case studies further illustrate methods of conflict resolution regarding strongly held utilitarian views of water-use held by many water-users and the role watershed groups can play regarding local social issues.

Factors Influencing the Distribution of Topeka Shiners in Kansas Streams[AFS]

Christopher S. Guy, Sally J. Schrank, Matthew R. Whiles, and Brent L. Brock
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59717
cguy@montana.edu

The Topeka shiner (*Notropis Topeka*) has declined in abundance throughout its historical range in the central U. S. As a result, this minnow was listed as a federally endangered species in 1999. The objective of our study was to quantitatively assess the instream physical, chemical, and biological parameters and landscape-level factors influencing the distribution (i.e., extant or extirpation) of Topeka shiners. We sampled 26 streams in the Flint Hills region of Kansas: 12 sites where Topeka shiners are extant, and 14 sites where they are extirpated. Multivariate analysis of variance was used to test whether variables were different between extant and extirpated sites. Mean catch per effort of largemouth bass in stream pools was higher at extirpated sites, and species diversity by trophic guild and richness in stream pools were higher at extirpated sites. Stepwise logistic regression was used to develop a model to predict whether Topeka shiners were extant or extirpated. Number of small impoundments per watershed area, catch per effort of largemouth bass (*Micropterus salmoides*) in pools, and length of pool were the only significant variables in the logistic model. Our model correctly classified 83 percent of extant sites and 85 percent of extirpated sites. In a landscape-level analysis of 111 streams, only number of small impoundments per watershed area was significant in the logistic model. These results provide predictive tools to assess instream and landscape-level characteristics for habitat management and possible reintroduction of Topeka shiners in Kansas Flint Hills streams.

Sauger Aggregation and Harvest in the Lower Yellowstone River[AFS]

Matthew E. Jaeger and Alexander V. Zale
Montana Cooperative Fisheries Research Unit
P.O. Box 173460, Montana State University
Bozeman, MT 59715.
zale@montana.edu

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

Brad Schmitz
Montana Department of Fish, Wildlife and Parks, Region 7
P.O. Box 1630, Miles City, MT 59301

Sauger (*Stizostedion canadense*) movement and exploitation rates were assessed and compared to determine susceptibility to overharvest in the lower Yellowstone River, Montana. Overharvest, especially at times when sauger were thought to be aggregated, had been identified as a possible factor contributing to low abundances. We investigated seasonal movement and aggregation by telemeterizing and tracking 30 fish in 2001 and 31 fish in 2002. Exploitation rates were assessed by tagging 1033 sauger with reward tags. Tag-shedding rate was estimated by double-tagging and nonreporting rate was estimated using postcards as tag surrogates. Sauger aggregated near spawning areas in spring and subsequently dispersed 5 to 300 km upstream where they remained for the rest of the year. Exploitation occurred primarily in early spring and late autumn. Exploitation rates were low overall (10-15%) and were lower in spring when sauger were aggregated than in autumn when they were dispersed. Tag-shedding rate of both tags was low (2%) and nonreporting rate was high (69%). Annual survival was high (70%). Entrainment in irrigation diversions may have accounted for as much as one third of natural mortality.

Spotted Bass Habitat Structure Use in an Experimental Stream[AFS]

Stan L. Proboszcz
Kansas Cooperative Fish and Wildlife Research Unit
205 Leasure Hall, Kansas State University, Manhattan, KS 66506
stanprob@ksu.edu

Christopher S. Guy
Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT, 59717

A common method used to enhance salmonid populations is to improve lotic habitat by installing habitat structures. However, the effects of habitat-enhancement structures have not been evaluated for spotted bass (*Micropterus punctulatus*) populations. This study was conducted to evaluate use of habitat-enhancement structures (half-log, rootwad, and undercut bank), by age-0 spotted bass in an experimental stream. Three habitat structures and a no structure area were randomly arranged in an experimental stream. Fish were observed for two days after structure placement. Light intensities and current velocities were measured for each habitat arrangement. Laboratory results were similar to natural stream habitat use by adult spotted bass. For example, each habitat structure type was used significantly more ($P < 0.05$) than the no structure area. Half-log was used significantly more ($P < 0.05$) (30 %) than both undercut bank (17 %) and rootwad (11 %). Light intensity and current velocity were important variables influencing habitat use. For example, use of half-log structure was a function of low velocity and light intensity. These results suggest half-log structure may provide the most suitable cover for age-0 spotted bass.

Coalbed Methane Investigations in the Tongue River Basin[AFS]

Carol Endicott
Confluence Consulting
211 North Grand Ave., Suite E, Bozeman, MT 59771-1133
cendicott@confluenceinc.com

Coalbed methane (CBM) is an emerging energy resource in many western states. Ground water, often rich in salts and other toxic constituents, is a by-product of CBM development. Management of this water presents a considerable challenge to methane producers and regulatory agencies. We conducted this investigation to assist decision making with regard to fate of the produced water. One component of this study was a review of the literature addressing effects of dissolved solids on fish, macroinvertebrate, and aquatic plants. In addition, we conducted assessments of the biological, chemical, and physical integrity of streams in the Tongue River basin using protocols developed by the EPA. These assessments provided both baseline data on streams likely to be influenced by CBM development and upstream/downstream comparisons of streams where CBM development was already occurring. A primary conclusion drawn from the literature review was that different taxa demonstrate wide variation in response to dissolved solids. Therefore, predicting effects based on laboratory tests is overly simplistic and unlikely to protect overall biological integrity. Baseline assessments of tributary streams in the Tongue River basin indicated varying levels of biological, chemical, and physical conditions among streams due to variation in land use, geology, and water quantity. Comparisons of streams above and below CBM development suggested that elevated dissolved solids may have deleterious effects on fish and aquatic life, however, drought and local geology may also be contributing factors. We recommend additional investigation to pinpoint sources of salts in the impacted stream. Finally, we recommend that methane producers and agencies collect baseline data to identify sensitive areas and adaptively manage CBM development.

Don't be Afraid: an Attempt to Use Alarm Pheromones of Fathead Minnows and Rainbow Trout as an Attractant to Enhance Gill Net Capture of Northern Pike in Milltown Reservoir[AFS]

David A. Schmetterling
Montana Fish, Wildlife and Parks
3201 Spurgin Rd., Missoula, MT 59801
dschmett@bigsky.net

Michael K. Young
Rocky Mountain Research Station
800 E. Beckwith Ave., Missoula, MT 59801

Illegally introduced northern pike in Milltown Reservoir, a shallow reservoir at the confluence of the Clark Fork and Blackfoot rivers, represent a threat to resident and migratory native fishes, among them federally threatened bull trout and state "species of special concern" westslope cutthroat trout. While annual drawdowns and seasonal trap netting have reduced northern pike abundance, we wished to increase the effectiveness of gillnetting to enhance removal of adult northern pike. Recent studies have demonstrated that many fishes are highly responsive to pheromones—molecules used for chemical communication in many fish species—and that this responsiveness can be exploited for management purposes. Because some studies revealed that northern pike are attracted to Schreckstoff, an alarm pheromone released from the skin cells of fathead minnows, and that this pheromone requires breakage of the skin cells and survives freezing, we obtained frozen, macerated fathead minnows to use as an attractant within gill nets modified into cylinders. Because rainbow trout also release Schreckstoff from their skin cells and because northern pike in Milltown Reservoir were previously exposed to this prey species, we created a paste of juvenile rainbow trout from fish obtained from the Arlee Fish Hatchery for the last several days of the experiment. The test was conducted for 10 days, with equal numbers of treatment (with attractant) and control (no attractant) nets, and all nets were checked at least twice daily. The results were very surprising, and suggested several improvements for future studies of this kind.

A History of Instream Flow Protection in Reece Creek, Yellowstone National Park[AFS]

Dan Mahony
USDI National Park Service
P.O. Box 168, Yellowstone National Park, Wyoming 82190
Dan_Mahony@nps.gov

National parks are regarded as pristine environments where optimal opportunities for native fish species preservation exist, yet aquatic habitat degradation does occur, often in boundary areas where only a portion of a watershed falls under National Park Service(NPS)

jurisdiction. Reese Creek, a small stream located at the northern boundary of Yellowstone National Park, was historically dewatered for irrigation by adjacent landowners. This stream is one of only a dozen Yellowstone River tributaries between Yellowstone Park and Livingston, MT. where Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) can spawn. In the early 1980s, NPS began negotiating with private irrigators to obtain an instream flow, but an acceptable agreement was not reached until 1991. Periodic sampling by U.S. Fish and Wildlife Service in 1984, 1986, and 1992 documented spawning by cutthroat trout, rainbow trout (*O. mykiss*), and hybrids of the two species. To provide better protection for fish using Reese Creek, in 1991 NPS added rotating self-cleaning fish screens to the diversion head gates in order to prevent fry entrainment into irrigation ditches. Unfortunately, improper design limited the usefulness of the screens. In 1999, improvements to the diversion structures, including installation of a solar power source, were completed. Subsequent sampling has yielded few fish in the irrigation ditches. Despite these improvements, additional genetic and population sampling and stream flow modeling at points of diversion need to be completed before Reese Creek can be recommended as a Yellowstone cutthroat trout restoration site.

Fish-Friendly Irrigation Methods on Small Western Montana Streams: Successes, Failures and Funding Opportunities[AFS]

Ron Pierce and Ladd Knotek
Montana Fish, Wildlife and Parks
3201 Spurgin Rd., Missoula, MT 59804
bigfish@blackfoot.net

Mark Lere
Montana Fish, Wildlife and Parks
1420 East 6th Ave., Helena, MT 59620-0701

Fisheries-related irrigation impacts in western Montana take three primary forms: 1) loss of habitat to dewatering, 2) reduced fish passage, and 3) entrainment of out-migrant fish to irrigation ditches. In west-central Montana, native salmonids (westslope cutthroat trout and bull trout) are heavily impacted by normal irrigation practices because they rely on diverted tributaries for spawning/rearing and exhibit movements that coincide with the irrigation season. Correcting fish passage and entrainment impacts during irrigation diversion operation usually requires some form of fish ladder and ditch screening device. Designs should: 1) consider the geomorphic and hydrologic setting, 2) identify specific fisheries and irrigation objectives, and 3) consider maintenance needs in order to be effective. The pros, cons and monitoring results of several fish ladders (Denil, step-pool and natural channel bypass) and five fish screening devices (flat plate screens (self-cleaning and manual), Brencail, rotating electric drums, infiltration galleries and turbulent fountain fish screens) are outlined. The Fisheries Restoration and Irrigation Mitigation Act (FRIMA), passed by Congress in 2000, established a funding program to plan, design and construct fish screens, fish passage devices and related features to mitigate impacts on fisheries associated with irrigation system water diversions by local government entities in the Pacific drainage of Oregon, Washington, Idaho and Montana. The FY2002 appropriation for Montana ($1 million) was used to fund 15 fish screen and passage projects located on waters west of the continental divide.

The Use of a GIS-based Water Balance Model in Managing Stream Flows for Various Life History Stages of Resident and Fluvial Fish Species[AFS]

Carol Endicott
Confluence Consulting, Inc.
211 North Grand Ave., Suite E, Bozeman, MT 59771-1133
cendicott@confluenceinc.com

David Marshall
DTM Consulting
211 N. Grand Ave, Suite J, Bozeman, MT 59715

Because of increasing demands upon limited surface water and current drought conditions, native fish in Montana's streams face threats due to inadequate flow. Efforts to increase instream flow through water conservation efforts or water rights leasing have not kept up with this increasing threat. This paper outlines the integrated use of fish life history analysis and water balance modeling to determine an optimal strategy for managing flows using a three-stage process. First, flow requirements during critical life stages (i.e. spawning, incubation, emergence, drift, and rearing) are determined for the native fish assemblage in critical stream reaches. Second, a continuous simulation hydrologic model is constructed and calibrated using HSPF (Hydrologic Software Program Fortran) software developed by EPA. Data for the model are preprocessed and managed using ArcView GIS software. HSPF uses continuous meteorologic and hydrologic records to compute stream flow hydrographs taking into account rainfall interception, surface runoff, diversions, groundwater interactions, snowmelt, and evapotranspiration. Analysis of yearly, simulated hydrographs generated for the critical stream reaches is used to determine the instream flow deficits from the flow requirements. The third and final stage is to use the Montana DNRC water rights database, within the project GIS, to determine a cost effective permitted water right or combination of water rights that could be obtained or conserved to provide the additional flows to meet critical life stage requirements.

Some Effects of Streamflow and Reservoir Storage on Selected Trout Population Dynamic [AFS]

Richard Oswald
Montana Fish, Wildlife and Parks
730 N. Montana, Dillon, MT 59725
oswalddick@state.mt.us

Between 1982 and 2002, the Missouri River headwater drainages experienced two extremely wet climatic periods, each of which was followed by periods of extreme drought. Over the 20-year study period, trout populations in free-flowing rivers, irrigation storage reservoirs, and river tailwaters below reservoir dams were studied in order to discern salmonid population response to ample and reduced flow regimes. During the study, salmonid populations responded positively to ample flow regimes and declined markedly as

flow regimes were reduced during drought. Data strongly suggest that the population dynamics most predictably and significantly affected by flow include standing crop, densities of large, mature fish in the population, and condition factor, particularly that of the large, mature segment of the population. Population density and juvenile recruitment also responded positively to increased streamflow but were not always reduced under restricted flow conditions suggesting that other variables might influence those dynamics as significantly as flow.

Salmonids on the Fringe: Distribution, Habitat use, and Response of Salmonids to Upslope Riparian Forest Composition in High Gradient Headwater Streams, Southeast Alaska[AFS]

Mason D. Bryant and Brenda E. Wright
USDA Forest Service, Pacific Northwest Research Station
2770 Sherwood Ln., 2A, Juneau, AK 99801
mdbryant@fs.fed.us

Nikolas Zymonas
Ecology Department, Fish and Wildlife Program
Montana State University, Bozeman, MT 59717

We compared the species composition, habitat relationships, and longitudinal distribution of salmonids in small, 1st to 2nd order, high gradient headwater streams in two extensively logged watersheds in southeast Alaska. Fish populations were sampled by electrofishing and with minnow traps, and habitat measurements characterized channel morphology, large woody debris, and riparian vegetation. Dolly Varden (*Salvelinus malma*) were predominant in the high gradient reaches and were found in reaches with gradients exceeding 20 percent. Ripe sea-run Dolly Varden were observed in the uppermost accessible reaches. Juvenile coho salmon (*Oncorhynchus kisutch*) fry and parr were also found in high gradient ($\leq$ 10%) reaches and were the dominant species in the low gradient reaches. Juvenile steelhead trout (*O. mykiss*) were present during the spring and fall. Coastal cutthroat trout (*O. clarki clarki*) were found in one stream. Density of all species decreased as gradient increased. Significant and positive relationships were observed between density of Dolly Varden as well as juvenile coho salmon and the abundance of pools. A positive relationship was observed between juvenile coho salmon density and the number of pieces of large wood. The abundance of coho salmon parr was lower in streams with a history of landslides. Salmonids will use high gradient reaches where they are accessible and pools are present. Headwater tributaries comprise a large proportion of the stream length in most watersheds and the combined contribution from these tributaries to the fish community may be large. These results underscore the importance of maintaining continuity throughout the entire watershed.

Using Trace Element Compositions of Juvenile Westslope Cutthroat Trout Scales to Determine Stream Origin in the North Fork Flathead River, Montana[AFS]

Brian Marotz and Clint C. Muhlfeld
Montana Fish, Wildlife, and Parks
490 North Meridian Rd., Kalispell, MT 59901
bmarotz@state.mt.us

We used laser ablation inductively coupled mass spectrometry to quantify Mg:Ca, Mn:Ca, Sr:Ca, and Ba:Ca levels in scales from juvenile westslope cutthroat trout (*Oncorhynchus clarki* lewis)i collected from five streams of the North Fork Flathead River during summer 2001. We also determined Mg:Ca, Mn:Ca, Sr:Ca, and Ba:Ca levels in the water throughout the North Fork Flathead River drainage during the summer of 2001. The chemical compositions of trout scales were related to Sr:Ca and Ba:Ca levels in the water. Multivariate elemental signatures of the scales differed significantly among streams, and a canonical discriminant analysis revealed that streams were significantly separated in discriminant space. A forward stepwise discriminant function analysis was used to classify individual fish back to their natal stream. Overall classification accuracy was 91 percent, and ranged from 83 percent for Langford Creek to 100 percent for Camas Creek and Sage Creek. Finally, the trace element levels at the focus and edge of individual scales were significantly correlated, suggesting that the sampled fish were rearing in their respective natal tributary. These data indicate that trace element signatures may be used as natural tags to identify natal stream origin of cutthroat trout. In the future, this technique may be used to 1) monitor the effectiveness of habitat and passage programs, 2) identify and protect important populations, and 3) determine life history.

Status of Westslope Cutthroat Trout in the United States: 2002[AFS]

Bradley B. Shepard
Montana, Fish, Wildlife and Parks
Montana Cooperative Fishery Research Unit
Bozeman, MT 59717
bshepard@montana.edu

Bruce May and Wendi Urie
USDA Forest Service, Gallatin National Forest
Bozeman, MT 59715

The distribution and abundance of westslope cutthroat trout (*Oncorhynchus clarki lewisi*; WCT) have reportedly declined from historical levels over part or all of their historical range. For the U.S. range of WCT we used existing information provided by 112 fisheries professionals applied through a consistent methodology to assess the extent of their historical range, their current distribution, including genetic status, and evaluated the foreseeable risks to 539 populations designated as "conservation populations" by

management agencies. We estimated that WCT historically occupied about 56,500 miles of habitat within the U.S. WCT currently occupy an estimated 33,500 miles of historically occupied habitats (59%). Genetic testing has been completed across about 6100 miles of habitat (18% of occupied habitats), but sample sizes were variable and sample sizes of 25 fish or more (a sample size that likely would detect as little as 1-percent levels of introgression with a 95% level of confidence) made up only 30 percent of the samples. WCT with no evidence of genetic introgression currently occupied about 3400 miles (10%) of currently occupied habitats. Another 1000 miles of currently occupied habitats (3%) contained WCT that were probably part of a mixed stock where the WCT were not introgressed. We suggest that even though genetic sampling was nonrandom, sampling likely occurred more frequently in WCT populations that appeared non-introgressed, some, if not much, of the habitat currently occupied by WCT that has not been genetically tested likely support populations that are not introgressed. Much of the habitat currently occupied by WCT was located in designated parks (2%), wilderness areas (19%), and roadless areas (40%), and almost 70 percent of habitats currently occupied lie within federally managed lands. A total of 563 separate WCT populations currently occupying 24,450 miles of habitat were designated as "conservation populations". These conservation populations were spread throughout the historical range, occurring in 67 of 70 hydrologic units historically occupied by WCT. Most of these conservation populations were believed to be "isolets" (457 or 81%); however, metapopulations occupied much more of the habitat (21,600 miles or 88%). Of the 563 designated conservation populations, 339 (60%) had at least some component that was genetically unaltered and 172 (30%) consisted entirely of stream segments that were genetically unaltered. In general, more of the isolet populations were at higher risk due to temporal variability, population size, and isolation risk than metapopulations, but were at less risk from genetic and disease factors than metapopulations. These data and population designations suggest that two different conservation management strategies are needed and being implemented to conserve WCT. One strategy concentrates on preventing introgression, disease and competition risks by isolation and the other concentrates on preserving metapopulation function and multiple life histories by connecting occupied habitats.

The Sun Ranch Westslope Cutthroat Trout Recovery Program[AFS]

Buddy Drake
Drake and Associates
P.O. Box 4183, Bozeman, MT 59772

After mistakenly stocking hybridized fish into the Sun Ranch brood pond in September 2001, we eradicated all fry in the pond on 28 February 2002 by using antimycin through the ice. After completing this task, the steering committee, composed of representatives of Montana Fish, Wildlife and Parks, USDA Forest Service and the Sun Ranch, began identifying and selecting pure westslope cutthroat (*Oncorhynchus clarki lewisi*) donor streams in the Madison, Gallatin and Centennial drainages. Previous partial samples indicated pure, healthy westslope populations in Bean, Bear, and Jones Creeks, all in the Centennial Valley. Completed samples verified the purity of the West Fork of Cabin Creek in the Madison drainage, and the West Fork of Wilson Creek in the Gallatin. While attempting to collect fish for disease samples in the Centennial Valley, sampling crews

discovered that the adult populations in those three streams had mysteriously disappeared No fish over six inches was observed in any of those systems. As a result, this year's egg take occurred in the west forks of Cabin and Wilson creeks. On 14 October 2002, 589 pure westslope cutthroat trout fry were transferred from our hatchery to the brood pond.

The State of Montana's Aquatic Nuisance Species Management Plan[AFS]

Robert H. Wiltshire
Federation of Fly Fishers
215 E. Lewis St., Livingston, MT 59047
iffc@fedflyfishers.org

In 1990, the Non-indigenous Aquatic Nuisance Prevention and Control Act (NANPCA) was passed by Congress to address aquatic nuisance species (ANS) problems in the United States. This legislation provided an opportunity for federal cost-share support for implementation of state plans. The reauthorization of NANPCA in 1996 into the National Invasive Species Act (NISA) established a goal of preventing new ANS introductions and limiting the dispersal of existing ANS in all of the states. NISA specifies, among other things, that state plans identify feasible, cost-effective management practices and measures that can be implemented by the state to prevent and control ANS infestations in a manner that is environmentally sound. Throughout 2001 and 2002 development of a Montana ANS plan was conducted by a diverse group of public and private entities. The ANS Task Force has approved Montana's plan, making Montana eligible for federal cost-share funding in 2003. When fully implemented, this plan provides a comprehensive approach to dealing with ANS in Montana.

Abundance of Juvenile Salmonids along Stabilized and Natural Main-Channel Banks of the Upper Yellowstone River[AFS]

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

We compared juvenile salmonid use of stabilized banks (riprap, barbs, jetties) of the upper Yellowstone River to their use of natural, unaltered habitats by electrofishing in spring, summer, and fall, 2001 and 2002. Total fish captured during the study, by species, were rainbow trout (n = 2763, 62%), brown trout (n = 1189, 27%), mountain whitefish (n = 334, 8%), Yellowstone cutthroat trout (n = 166, 4%), and brook trout (n = 1, < 1%). Mean abundances of all species combined along 50-m sites were highest at riprap (12.2/ site), followed by jetties (10.6), outside bends (8.4), barbs (7.9), straight sections (5.4), and inside bends (1.5) were the lowest. Presence of boulders, either natural or artificially placed, was

the best indicator of juvenile fish presence regardless of bank type. Somewhat surprising, bank stabilization did not directly decrease quality or quantity of juvenile salmonid habitat along the main channel of the upper Yellowstone River. However, our study only looked at juvenile salmonids and did not address the effects of bank stabilization on habitat for sub-adult or adult fish, invertebrate availability and or spawning habitat.

Status of Wild Pallid Sturgeon in Montana[AFS]

Kevin Kapuscinski
Montana Fish, Wildlife and Parks
P.O. Box 165, Fort Peck, MT 59223
kkap@nemontel.net

Two pure pallid sturgeon populations exist in Montana waters of the Missouri River; one upstream of the Fort Peck Dam (RPMA #1), and one between the Fort Peck Dam and the headwaters of Lake Sakakawea, including the lower Yellowstone River (RPMA #2). These populations are comprised of large, old-aged individuals, as there has been no natural recruitment during the past 20 years. Attempts are made each year to collect broodfish from RPMAs #1 and #2, and a variety of assessments are conducted during the remainder of the field season in each area to monitor stocked hatchery-reared pallid sturgeon. Broodfish collection is becoming increasingly difficult in both areas as wild pallid sturgeon abundances dwindle. Krentz (1995) estimated that 50 wild pallid sturgeon remained in RPMA #1 during 1995. I employed a modified Schnabel procedure to estimate that 178 wild pallid sturgeon remained in RPMA #2 during 2001. Upper and lower 95-pecent confidence limits were 351 and 96, respectively. I used simple linear regression to quantify the relationship between wild pallid sturgeon abundance and time during 1991-2001. Assuming no natural recruitment, wild pallid sturgeon in RPMA #2 would be extirpated during 2017. Stocking hatchery-reared pallid sturgeon has been and continues to be the focus of recovery efforts in RPMA #2. The stocking plan goal for RPMA #2 is to have 1600 adult pallid sturgeon 15 years after ten years of stocking. This goal is unlikely to be achieved, as 5000-7000 hatchery-reared pallid sturgeon must be stocked each year during the next 13 years to reach the goal, and the most ever stocked was 3061 during 2002. An iridovirus and inability to capture broodfish has hindered the progress of the stocking plan, but current stocking strategies do not allow for stocking rates necessary to achieve the stocking plan goal. Furthermore, researchers cannot accurately estimate survival, growth, and condition of hatchery-reared pallid sturgeon due to extremely low recapture rates. Habitat rehabilitation must begin immediately if wild pallid sturgeon are to persist. The stocking plan can successfully augment the existing wild population only if the basic ecology of hatchery-reared pallid sturgeon is understood, survival of stocked individuals is quantified, and the stocking plan is modified accordingly.

Pallid Sturgeon Recovery - The Past and the Future[AFS]

Steven Krentz
USDI Fish and Wildlife Service
Missouri River Fish and Wildlife Management Assistance Office
3425 Miriam Ave., Bismarck, ND 58501
steven_krentz@fws.gov

Pallid sturgeon and the topic of extinction is not a new concept. After all, that is what led biologists to come to the conclusion that the species desperately needed the protection of the Endangered Species Act and listed this unique species as endangered. Endangered is classified under the Endangered Species Act as any species which is in danger of extinction throughout all or a significant portion of its range. The fact that we are again discussing the risk of extinction suggests that the existing data for pallid sturgeon supports that this species will "blink out" if actions are not continued to preserve, protect and restore habitats it needs to complete its life history. Recovery efforts are underway and will continue to insure that future generations can say they've seen a "dinosaur fish". With a cooperative efforts of State, Federal, Tribal, and public involvement, the pallid sturgeon can be recovered and those efforts will also prevent other similar species from following the same path. Current efforts on stocking and restoring habitats that benefit pallid sturgeon recovery will likely prevent the extinction of the pallid sturgeon in some of the best remaining habitat available in Montana and North Dakota.

The Plight of the Pallid Sturgeon...Why We've Got to be Right, Right Now[AFS]

Bob Snyder
Montana Fish, Wildlife and Parks
P.O. Box 200701, Helena, MT 59620-0701
bsnyder@state.mt.us

The pallid sturgeon (*Scaphirhynchus albus*) is functionally extinct in Montana. Spawning is spurious with no recruitment to the two Montana populations in at least 50 years. The population consists entirely of all old-aged fish predicted to decline to extinction in 2017. Little is known about this species and recovery planning is occurring without an understanding of most of the requirements of the species. This environment of uncertainty is affecting the decisions about the restoration of the pallid sturgeon. Because of the imminent demise of the wild pallid sturgeon population, there isn't time to be wrong. The wild pallid populations in the upper and lower Missouri and Yellowstone rivers, the only sources of gametes available for augmentation stocking until the captive broodstock program at Gavins Point NFH is proven, are a tenuous and undependable sources of eggs. The wild populations will probably become extinct before the hatchery-based populations are established. Unless adequate numbers of hatchery fish are stocked, there will be insufficient, or no, fish that survive to sexual maturity, making recovery of the species impossible. Five recommendations are made including: sufficient numbers of hatchery fish need to be released; improvements are needed in capture, handling and fish culture techniques; habitat

restoration needs to start immediately; decisions should use worst-case estimates; the decision-making process needs improvements; there needs to be a stronger commitment to the recovery of the pallid sturgeon by the USDA Fish and Wildlife Service and Montana Fish Wildlife and Parks.

Use of Remote-site Incubators to Reestablish Lacustrine Arctic Grayling Spawning Stocks[AFS]

Glenn D. Boltz and Lynn R. Kaeding
USDA Fish and Wildlife Service, Branch of Native Fishes Management
4052 Bridger Canyon Road, Bozeman, MT 59715
Lynn_Kaeding@fws.gov

The lacustrine Arctic grayling (*Thymallus arcticus*) that inhabit the Upper and Lower Red Rock Lakes, in the upper Centennial Valley of southwest Montana, spawn exclusively in the lakes' tributaries. Both the distribution and number of those spawning stocks declined substantially during the previous century. Our main objective was to evaluate the use of remote-site incubators (RSIs) to produce Arctic grayling fry of wild parentage. The five streams adjacent to which RSI sites were established were either present-day or historical Arctic grayling spawning habitats. Native, adult Arctic grayling caught from nearby Red Rock Creek were artificially spawned, and their fertilized eggs were placed in 12 RSIs in 2000, 8 in 2001, and 10 in 2002. Estimated percent fry emergence for individual RSIs ranged between 0.0 percent and 94.5 percent (mean, 44.8%). Multiple-group logistic regression revealed that most of the variation in percent emergence was explained by models that had year and RSI site as predictors. Mean percent emergence in 2000 (73.4% $\pm$ 15.1% [i.e., the 95% CI]) was larger than those in 2001 and 2002 (pooled mean, 26.5% $\pm$ 11.9%), which did not differ. Among RSI sites, mean percent emergence at East Elk Springs Creek (69.8% $\pm$ 22.2%) was larger than the mean of the pooled data for the other sites (35.3% $\pm$ 13.5%), whose means did not differ among themselves. In 2002, Arctic grayling were observed spawning in Elk Springs Creek, downstream from 2 RSI sites, where such spawning was last reported in the late 1960s. We believe the Arctic grayling observed spawning in 2002 were produced in the RSIs in 2000. Additional indications of Arctic grayling spawning in this and other study streams will be sought in 2003. We conclude that RSIs may be a useful tool in our attempts to reestablish Arctic grayling spawning stocks in the Red Rock Lakes area.

Efficacy and Safety of AQUI-S™ as an Anesthetic[AFS]

Jim Bowker, Molly Poehling, Dan Carty, Dr. Dave Erdahl, and Bonnie Johnson
USDA Fish and Wildlife Service,
Aquatic Animal Drug Approval Partnership Program
Fish Technology Center, 4050 Bridger Canyon Road, Bozeman, MT 59715
molly_poehling@fws.gov

Anesthetics are widely used in the culture of captive populations of fish and management of wild fish populations. Most aquatic biologists have used the fish anesthetics

FINQUEL™ or Tricaine-S™ (i.e., MS-222), which are approved by the U.S. Food and Drug Administration (FDA). Both products work well; however, the FDA-imposed 21-d post-exposure withdrawal period limits their use. Consequently, there is a niche for a fish anesthetic that can be used with no post-exposure withdrawal period. AQUI-S™ is an anesthetic that may fill this niche, and thus the USDI Fish and Wildlife Service's (FWS) Aquatic Animal Drug Approval Partnership (AADAP) program is involved in efforts to gain FDA approval of AQUI-S™ for use on all fish. At concentrations of 40 - 60 mg/L, AQUI-S™ rapidly anesthetizes salmonids to the handle-able stage; however, at these same concentrations, cool- and warm-water fishes are anesthetized relatively slowly. Thus, testing cool- and warm-water fishes at AQUI-S™ concentrations > 60 mg/L will be required. The FWS AADAP program has also initiated studies to determine (1) whether the highest proposed AQUI-S™ efficacious exposure concentrations provide an adequate margin of safety to the fish being treated, (2) product stability over the course of 1 d, and (3) reproducibility of time required to anesthetize fish to the handle-able stage. An overview of efficacy data, as well as preliminary results from other recently initiated studies, will be presented.

Radio Telemetry and Water Chemistry Describe the Behavior of Rainbow Trout Attempting Upstream Passage at Milltown Dam, Montana[AFS]

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

Milltown Dam, located at the confluence of the Clark Fork and Blackfoot rivers has no provision for upstream fish passage, but a fish trap located in the center of the dam in the radial gate raceway has been used to capture and transport some fish around the dam. In order to determine how fish approach the dam on their upstream migrations, how long it takes them to find the fish trap and how the water source in the trap affects fish captures, I implanted 16 rainbow trout with radio transmitters and individually tagged 621 I captured in the fish trap. I transported all radio tagged and 197 VI tagged rainbow trout 4.3 km downstream of Milltown Dam. I used a data-logging receiver to determine locations of radio tagged fish in the tailrace. In order to determine which water source fish were using, I analyzed the concentration of Barium from within the trap and adjacent rivers. After tagging and translocation, fish returned to Milltown Dam rapidly (most < 2 days) and were first detected along river margins. Once rainbow trout arrived at the dam, they stayed there up to 48 days attempting to pass upstream. Ninety-five percent of all the fish locations ($n = 4831$) were in their capture water source. Fish entered a foreign water source after a mean of 12 days, but stayed briefly. These data imply the necessity for two fish traps or fishways at the dam that accommodate both water sources for the duration of a fish's migration period.

Factors Influencing Brook Trout Invasion and Their Replacement of Westslope Cutthroat Trout[AFS]

Bradley B. Shepard
Montana Fish, Wildlife and Parks and Montana Cooperative Fishery Research Unit
Ecology Department, Montana State University, Bozeman, Montana 59717
bshepard@montana.edu

Distribution and abundance of westslope cutthroat trout (*Oncorhynchus clarki lewisi*; WCT) and brook trout *Salvelinus fontinalis* and their relation to habitat characteristics were studied in three adjacent streams of the upper Jerry Creek watershed, a tributary to the Big Hole River in southwestern Montana. WCT dominated populations in Delano and upper Jerry creeks, while brook trout dominated populations in Libby Creek. Densities of WCT were significantly different among the three streams (ANOVA; $P = 0.001$) with Libby Creek containing significantly lower WCT densities than the other two streams. While small sample size precluded statistical testing, observations of habitat characteristics indicated that Libby Creek had higher average daily water temperatures (1 to 2 °C higher with maximums >14° C versus < 12° C in adjacent Delano Creek), more woody debris, a higher level of fine sediments within the streambed, and a higher proportion of pool habitats than the other two streams. The only known differences in management between these three streams was the fact that timber was harvested using clear-cut techniques along the stream channel of Libby Creek. While similar areas of timber were harvested in the Delano and Jerry watersheds, these harvests did not include riparian clear-cutting. While this evidence must be considered circumstantial, it appears that brook trout invasion and either displacement or replacement of WCT in this drainage may be related to one or more of the following factors, either operating alone or in synergy: increases in water temperature; increases in levels of fine sediments within the streambed; increases in frequency of woody debris; and/or increases in pool frequency. Since past studies have implicated timber harvest activities for raising water temperatures, increasing delivery of fine sediments to stream channels, and increasing woody debris delivered to the stream channel immediately following harvest; it is possible that timber harvest activities in Libby Creek contributed to the observed differences in species composition between these three streams. More research is needed to statistically validate these observations.

Impacts of Terrestrial Weeds on Aquatic Habitats and the Anglers Against Weeds Program[AFS]

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

Invasive weeds infest millions of acres in the Western U.S. resulting in diminished ecosystem diversity, loss of productivity and expensive control projects. Although no studies have been conducted that directly measure the impacts of terrestrial weeds on riparian and aquatic habitats, existing data suggests that the impacts may be significant. Increased water

runoff, increased sediment transport and loss of native vegetation can all be expected from noxious weed infestation. Control of weeds in riparian areas is problematic. Few herbicides can safely be used in these areas and biological control is often not effective. Anglers Against Weeds is a program that enlists outdoor recreationists in riparian control efforts to create weed free access sites. This program results in healthier riparian areas, an informed sporting public and improved landowner/ angler relations.

Iodophor Use During Water-Hardening of Westslope Cutthroat Trout Eggs[AFS]

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

Michael E. Barnes
South Dakota Department of Game, Fish and Parks, McNenny State Fish Hatchery
19619 Trout Loop, Spearfish, SD 57783

Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) eggs were subjected to iodophor (active iodine) concentrations of 0, 25, 50, 75, 100, and 125 mg/L during water hardening for 30 m. Embryo survival to the eyed-egg stage was not significantly different between any of the treatments. Because of their relative safety and their potential to decrease coldwater disease outbreaks, the use of iodophor concentrations of up to 125 mg/L for 30 m during water hardening of westslope cutthroat trout eggs is recommended.

Successful Off-Season Use of Westslope Cutthroat Trout Males[AFS]

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

Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) adults normally spawn in streams in the spring when the water temperature is around 10 °C and flows in streams are high. In this experiment, westslope cutthroat males were successful when artificially spawned with a hatchery-reared, fall-spawning rainbow trout (*O. mykiss*) on a November spawn date. We are not aware of any other literature documenting successful off-season spawning of any cutthroat trout.

Note: Results from this study were published in the Int. J. Sci. 9(2/3):59-61.

BIOLOGICAL SCIENCES - TERRESTRIAL

WEST NILE VIRUS EMERGENCE IN MONTANA, 2002[TWS]

Keith Aune and Neil Anderson
Montana Fish, Wildlife and Parks
1400 South 19th Avenue, Bozeman, MT 59718

Dr. Tom Linfield.
Montana Department of Livestock
Helena, MT 59620

Dr. Todd Damrow
Montana Department of Public Health and Human Services
Helena, MT 59620

Since it first emerged in North America (New York, 1999), 44 states and 5 provinces have detected West Nile Virus (WNV) in humans, birds, mosquitoes, horses, or other animals. Anticipating its emergence in Montana, five state agencies stepped up surveillance, improved laboratory capabilities, and increased educational efforts related to WNV. The first clinical case of WNV in Montana was initially reported 22 August 2002 in a horse near Shepherd and subsequently confirmed by supplemental laboratory testing 28 August 2002. Since then, WNV infection was confirmed in Montana among an additional 134 horses, one human, (two other Montana resident acquired the disease while visiting out of state) and two birds. Onset of clinical illness in the first human case was in mid-September. Although not isolated from any mosquitoes trapped at various sites across Montana, WNV has been reported in 26 counties in central and eastern Montana and is expected to reach across western Montana next year. West Nile virus is normally transmitted between birds and mosquitoes. Birds act as the reservoir and amplifying host. Of 51 birds tested among 14 species to date, we have detected West Nile virus in only 2 birds—a red-tailed hawk and a black-billed magpie. Different bird species respond differently when exposed to the virus, some becoming viremic and carrying the virus while not becoming sick (e.g. chickens); others, such as Corvids (crows, blue jays, and ravens), are very susceptible to the virus, readily developing an often-fatal clinical disease. Mosquitoes become infected by feeding upon viremic birds and subsequently infect other birds, humans, or horses. Although WNV has been detected in several species of mosquitoes in Montana, *Culex* spp. (i.e., *C. pipiens*), *Aedes* spp., and *Ochlerotatus* spp. are the principle agents WNV transmission. Once infected, mammals are considered to be "dead-end" hosts, as they typically do not develop a level of viremia capable of being infective. Some evidence also suggests possible direct bird-to-bird transmission. We attribute early recognition of emergence of WNV in Montana to increased public awareness. With several hundred documented cases in neighboring states (North Dakota, South Dakota, and Wyoming), Montana anticipated introduction of the disease and was not "taken by surprise." Implications of the presence of WNV in Montana and future surveillance activity are discussed.

Winter Movement Patterns of a Recolonizing Wolf Populations

Eric J. Bergman and Robert A. Garrott
Montana State University
Bozeman, MT 59717

A largely unanswered question concerning the ecology of wolves (*Canis lupus*) centers around what habitat and landscape factors substantially influence their movement patterns. To address this question, we are studying fine-scale movements and broader-scale habitat use of wolves in a Yellowstone prey system. By focusing on the winter ranges of Yellowstone's non-migratory Madison-Firehole elk herd and Central bison herd, we hope to use intensively studied ungulate populations as well as other environmental features to tease apart the influential drivers of wolf movement. Wolf spatial data were collected on multiple scales over the past four winters. At the broadest scale, wolf core-use areas have been delineated based on 522 ground-based telemetry locations. At a finer scale, snow tracking resulted in 1287 km of data that are being used to model wolf movement patterns across a heterogeneous landscape of terrain, vegetation, and prey availability. At the finest scale, 272 wolf-kill sites were visited to gain insight into locations of concentrated wolf hunting efforts and sites of higher elk vulnerability. We present preliminary conclusions in the context of potential management implications as well as possible affects on predator-prey models in large mammal systems.

Beaver and Man – They Can Co-Exist[TWS]

Lynn Burton
Range Management Specialist
Gallatin National Forest
3710 West Fallon Street, Suite C, Bozeman, MT 59718

Beaver (*Castor Canadensis*) have been considered a nuisance as populations re-establish on much of the former range they were extirpated from in the mid 1800s. Society is slowly becoming informed of the role beaver play in establishing and maintaining fully functioning riparian ecosystems. Some values in having beaver dams, such as for flood control and improved fishery habitat, will be explored. Understanding beaver habits and working with them can minimize confrontations and build valuable partnerships. Examples of man working with beaver to protect roads, trees, and adjacent uplands will also be explored.

Appropriate Management Levels For Wild Horses: Setting Science-Based Limited in the Pryor Mountains, MT[TWS]

Linda Coates-Markle
USDI Bureau of Land Management
Billings Field Office
5001 Southgate Drive, Billings, MT 59107
lcmarkle@mt.blm.gov

The Bureau of Land Management (BLM) responds to regulations whereby it manages wild horses on public lands as self-sustaining, healthy populations in balance with other uses and the productive capacity of their environment. By definition, this requires BLM to manage herds for long-term successful production of viable offspring, but not to the detriment of supporting rangeland. The BLM must also consider terminology such as "Appropriate Management Level" (AML) for herd size, and "Thriving Natural Ecological Balance" (TNEB) for the supporting system in order to evaluate management options. Vagueness in interpretation and changing definitions over the years have contributed to confusion on the part of both BLM managers and public alike. This paper reports efforts from the Pryor Mountain Wild Horse Range, Montana, to consider AML as a range with both a scientific-established minimum and maximum threshold size. Eight years of cooperative agency and university-supported research generated these results. Genetic studies of the herd are used to set a minimum population size beneath which limited animal numbers might be detrimental to long-term herd genetic viability. Spatial Ecosystem Modeling is used to set an upper threshold size beyond which population numbers might have a detrimental impact on the health of multiple ecosystem components.

Changing Status of Montana's Wolverine Population With the Past Century in Review[TWS]

Brian Giddings
State Furbearer Coordinator
Montana Fish, Wildlife and Parks
P.O. Box 200701, Helena, MT 59620
bgiddings@state.mt.us

In the early 1900s wolverine (*Gulo luscus*) were considered to be a vanishing species in the western U.S. and near extinction in Montana. Changes in wildlife management philosophies and a reduction in predator control programs are believed to have allowed wolverine to re-colonize parts of Montana during the next 50 years. Population expansion continued through the 1970s when the state gave wolverine protection as a furbearer with a regulated harvest and a requirement to collect harvest data. Species distribution data accumulated since 1977 indicated that wolverine now occupy >35,000 mi^2 of montane forest habitat in the western portion of the state. Harvest distribution has remained relatively stable over the past 25 years with evidence that population expansions have occurred into central and southwest mountain ranges. Harvest data also indicate a stable annual average harvest of 10 wolverine, stable to increasing species distribution, a 50/50 sex ratio, and an

appropriate age distribution of over 50 percent juveniles and yearlings represented in the harvest sample. Since 1990-1991, FWP has supplemented harvest information with snow track survey based data and collection of species occurrence records to monitor long-term trends in distribution and population size. The harvest sample continues to provide accurate sex and age data, distribution, reproductive data, food habits information, and genetic samples. Based on harvest-generated data, new wolverine management strategies may be considered in the future.

Spatial and Temporal Response of Grizzly Bears to Recreational Use on Trails[TWS]

Tabitha A. Graves
University Hall 309, University of Montana, Missoula, MT 59812

Christopher Servheen
USDI Fish and Wildlife Service
University Hall 309, University of Montana. Missoula, MT 59812
grizz@selway.umt.edu

Don Godtel
Lewis and Clark National Forest
1101 15th St. North, Great Falls, MT 59403

Many human activities affect how bears use habitat, but effects of motorized recreational vehicle use on trails have not been formally assessed. We used hourly locations from four GPS-collared female bears in the Lewis and Clark National Forest to assess spatial and temporal distributions of bears relative to trail locations and to recreational use on trails. When availability was defined as circles equal to 95 percent of move distances around the previous bear location, all bears used areas near trails less than expected. We iteratively reclassified trail habitat versus non-trail habitat as increasing buffers in 50-m increments around trails until we reached a buffer-width at which bears used areas near trails in proportion to availability. Compositional analysis results showed that bears selected against areas within 250-900 m from ATV trails and within 450-600 m from single-track trails, which had some motorbike use. The distance from trails at which bear use approximated availability varied by individual bear, time of day, season, and type of trail. We assessed selection characteristics based on the nearest motorized route with logistic regression. Although explanatory power was low, two patterns of selection emerged. Three bears selected against areas near trails with high levels of motorized use and were more likely to use areas further from trails. One bear used areas closer to trails extensively in the spring and somewhat in the summer. Selection against areas near highways was stronger than selection against areas near ATV and single-track trails.

Assessing Elk Group Size and Distributional Responses to Wolves in Winter[TWS]

Justin A. Gude, Robert A. Garrott, and Scott Creel
Ecology Department
310 Lewis Hall, Montana State University, Bozeman, MT 59717
rgarrott@montana.edu

As the gray wolf (*Canis lupus*) population expands outward from Yellowstone National Park, wolves may potentially induce changes in behavior of wintering elk populations. Certain anti-predator responses to wolves, such as changes in mean group size and animal distribution, are of interest due to their relationship to resource management policies, procedures, and objectives on private and public lands that compose wintering areas. Specifically this research attempts to quantify the effects of a wolf pack on mean elk group size and distribution on a winter range. Ground-based telemetry and tracking techniques were used to estimate wolf movements in the area and resulted in 267 wolf locations and 23 wolf kill locations in the first of what will be two field seasons of data collection. Data on elk group size and distribution was gathered via 257 surveys of km^2 units around wolf locations, wolf kill locations, and in areas without recent wolf presence. To analyze these data, hypotheses of elk group size and distributional responses to predation pressure are being constructed in the form of statistical models grouped into 3 categories for comparison using Akaike's Information Criterion: (1) no response, (2) behavioral response independent of frequency of exposure to wolves (typical prey response), and (3) behavioral response dependent on frequency of exposure to wolves (risk- allocation). We discuss results of preliminary analyses in the context of wolf and elk management and potential implications on population dynamics of these two species.

Memoranda of Understanding and Its Use to Reduce Loss of Migratory Birds By Collision and Electrocution From Utility Transmission Lines[TWS]

Lou Hanebury
USDI Fish and Wildlife Service
Ecological Services
2900 4th Ave. North, Rm. 301, Billings, MT 59101
lou_hanebury@fws.gov

Sam Milodragovich
Northwestern Energy
Butte, MT 59701

Roger Parker
Senior Resident Agent
USDI Fish and Wildlife Service, Division of Law Enforcement
2900 4th Ave. North, Rm. 300, Billings, MT 59101

Significant numbers of migratory birds and eagles in Montana are lost each year due to collision and electrocution from transmission lines. Increased energy-related development may result in increased avian mortality across the state. The Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act and Endangered Species Act prohibit the taking of migratory birds, eagles or listed species, respectively. Utility companies may be discouraged from monitoring bird losses on their transmission lines due to the threat of prosecution. Memoranda of Understanding (MOU) between utility companies, state game agencies and the USDI Fish and Wildlife Service are a cooperative, non-adversarial endeavor. The Service can exercise its discretionary authority not to submit for prosecution the unlawful take of migratory birds that occur on company properties of those companies that make a good faith effort to eliminate the take of migratory birds. Under the MOU, companies will develop a comprehensive Avian Protection Plan to monitor avian losses and take reasonable steps to resolve any situations occurring on company property, which may pose a threat to migratory birds. The first MOU between a utility company in Montana, Montana Fish, Wildlife and Parks and the USDI Fish and Wildlife Service should be signed in 2003

Patterns in Black Bear Cub Orphaning in West-Central Montana[TWS]

Robert E. Henderson
Montana Fish, Wildlife and Parks
3201 Spurgin Road. Missoula, MT 59804

Montana Fish, Wildlife and Parks wardens and biologists in west-central Montana (Region 2) reported 29 instances of orphaned black bear (*Ursus americanus*) cubs for the 5-year period of 1997-2001. In the 10,650-mi^2 study area, 1147 black bears (768 males, 379 females) were reported harvested by hunters during the same period. No instance of orphaned grizzly bear (*U. arctos horribilis*) cubs was reported. In the 29 instances, wardens and biologists found and retrieved 43 black bear cubs. Frequency of orphaning varied from 1 to 12 cases/year, averaging 5.8 cases annually. Seventy-nine percent (23) of orphaning occurred in just 2 of the 5 years. Most orphaning (12) occurred in 2000 when western Montana experienced severe drought and numerous large wildfires. In 1998 FWP personnel reported almost as many orphan bear cases (11) when severe shortages of wild berry crops occurred across western Montana and northern Idaho. The direct cause of orphaning was not determined in 45 percent of the cases. In 16 cases for which cause was determined, hunting accounted for 6 (38%) of orphaning, 3 during the spring hunting seasons and 3 during fall hunting seasons. Other causes were motor vehicle collisions (25%), wildfires (19%), early emergence (6%), dogs (6%), and trapping of nuisance bears (6%). Orphaning occurred from March through December. July (1 case), August (7 cases), September (10 cases) and October (6 cases) accounted for 79 percent of orphaning during the 5 years. Timing (late summer/fall) of most orphaning and known causes (motor vehicles, wildfires, hunters, dogs, nuisance bear trapping) suggested that environmental factors contributed prominently to orphaning. In two years with the most orphaning, physiological stress induced by poor berry crops, drought, and wildfires, probably disrupted mother/cub social bonds and forced bears to forage in low-elevation (and human-occupied) habitats where females and cubs experienced higher mortality rates.

Insect Abundance in Relation to Peromycus Maniculatus Abundance and Population Growth Rate in Western and Central Montana[TWS]

Kevin D. Hughes, Richard Douglass, and Brent Lonner
Department of Biology, Montana Tech of the University of Montana
1300 W. Park St.. Butte, MT 59701

We have monitored deer mouse (*Peromyscus maniculatus*) populations on 18 trapping grids at 6 study sites in western and central Montana for the last 8 years. For the last 3 years we used pitfall traps to monitor insect abundance on 6 grids (one at each study site) to investigate the relationship between deer mouse abundance/population growth rate and insect abundance. We present some preliminary results from our study and discuss implications related to management and monitoring of Hantavirus and other zoonotic diseases.

Note: Results from this study were published in the Int. J. Sci. 9(2/3):78-86.

Science Design for Proposed Northern Divide Grizzly Bear Population Estimate[TWS]

Kate Kendall, Marci Johnson, and Jeff Stetz
USGS Northern Rocky Mountain Science Center, Glacier Field Station
Glacier National Park, West Glacier MT 59936

Baseline information on the status of the grizzly bear (*Ursus arctos horribilis*) population in northwestern Montana is needed to assess management measures designed to recover this threatened population. Planning has begun for a proposed study to estimate population size in the Northern Continental Divide Ecosystem using hair snag stations and DNA identification of individuals. Here we will report on the results of a September 2002 workshop in which a group of experts met to discuss science design issues related to this proposed project. The study area boundary will include most, but not all of the 32,000 km^2 of occupied habitat. Hair snags will be distributed on a 5X5-km grid for a total of almost 1300 snag sites. Sampling will be conducted during each of five 14-day snag sessions. Concurrent with sampling at baited hair snag sites, we will collect hair from unbaited bear rub trees along trails. We will use results from the two types of sampling in a mark-recapture estimate of population size.

The Open Lands Dilemma: The Challenge of Big Game Management and Transportation Planning in Open Landscapes— a Case Study of the Missouri Breaks National Movement[TWS]

Jack Lyon
P.O. Box 9045
Missoula, MT 59807
ljack@micro-mania.net

Jim Posewitz
The Orion Institute.
Helena, MT 59601

Matt Becker
Missouri Breaks Research Coordinator, The Wilderness Society
Bozeman, MT 59715

Dawn Hartley
Center for Landscape Analysis, The Wilderness Society
1424 4th Ave., Ste. 816, Seattle, WA 98101

Significant attention has been paid recently to the effect of road densities and spatial arrangement on big game habitat security, hunter opportunity, and ethical hunting environments. However, the vast majority of research has been performed in forested environments, and the applicability of big game habitat security standards and guidelines to open landscapes, such as the Northern High Plains, is questionable due to significant differences in vegetation cover and topography. At the same time these landscapes are often heavily roaded and are becoming increasingly popular with hunters and recreationists. In addition, open landscapes are more conducive to off-road vehicle (ORV) travel, and impacts of this growing use on big game vulnerability and on ethical hunting are not fully understood. The open-landscape challenges facing public lands managers trying to balance management mandates with big game habitat security, hunter and recreational opportunity, and ethical hunting environments are illustrated using the newly created Missouri Breaks National Monument. The need for creating science-based recommendations to help address these issues in development of current public land management plans, as well as the need for more research into habitat security standards for these environments, are proposed.

Movements and Mortality of American White Pelicans Breeding at Medicine Lake National Wlidlife Refuge[TWS]

Elizabeth Madden
USDI Fish and Wildlife Service, Medicine Lake National Wildlife Refuge
223 North Shore Road. Medicine Lake, MT 59247

Mike Assenmacher and Marco Restani
Department of Biological Sciences
St. Cloud State University, St. Cloud, MN 56301

Status of American white pelicans (*Pelecanus erythrorhyncos*) has been of conservation concern because the species nests in large colonies vulnerable to disturbance and habitat loss. Improved protection and greater public awareness are credited with arresting population decline after the 1960s. During recent decades, populations have increased to levels where they are now considered a nuisance on some wintering grounds, e.g., depredation on fish farms. Knowledge of colony dynamics and migratory movements from the northern Great Plains may help alleviate human-pelican conflicts in the Mississippi Delta region. We analyzed encounter data from pelicans banded at Medicine Lake National Wildlife Refuge (MLNWR) from 1957 to 1984 to determine long-range movements. MLNWR contains one of the largest nesting colonies in North America, with an average of 4000 nests counted annually the past decade. Band encounters (n = 253) revealed that pelicans from MLNWR use the Mississippi and Central flyways to reach wintering areas primarily along the Gulf of Mexico. Movements of five satellite-tagged pelicans in 2002 corroborate patterns inferred from banding data. Most band encounters were of dead birds with cause of death including shooting, electrocution/collision, and entanglement. To help guide proper management by USDI Fish and Wildlife Service, on-going research at MLNWR will focus on determining habitat use and foraging areas of breeding pelicans, assessing local population dynamics, and investigating factors influencing productivity and survival.

Black-Footed Ferret Recovery in Montana—Where Do We Go From Here?[TWS]

Randy Matchett
USDI Fish and Wildlife Service, Charles M. Russell NWR
Airport Road, Lewistown, MT 59457

Black-footed ferret (*Mustela nigripes*) reintroductions to Montana began in 1994 on the UL Bend National Wildlife Refuge in southern Phillips County. Reintroductions continued each fall through 1999 and a total of 187 ferrets were released. At least 188 wild-born kits were observed from 1995 to 2002. The number of wild-born kits observed each fall increased steadily from 1995-2000. Habitat, i.e. extent and density of black-tailed prairie dog colonies, was presumed to be limiting population growth beyond the 20-30 breeding adults observed each spring from 1996 to 2001. The UL Bend ferret population began a

dramatic decline during summer 2001, and by November 2002, only four remained (3 male 1 female). A total of 180 ferrets were released on the Fort Belknap Reservation from 1997 to 2000. At least eight kits were produced in the wild from 1998 to 2002. Spring surveys at Fort Belknap located £6 breeding adults each year and only a single male was observed during 2002. No ferrets are currently known alive at Fort Belknap. Forty-five ferrets have been released on USDI Bureau of Land Management lands, midway between UL Bend and Fort Belknap from 2001-2002. Two wild-born kits were observed and fall 2002 surveys found seven ferrets (5 male, 2 female). More than 600 ferrets have been input into Montana over the last 9 years. Today's total population numbers < 10. Causes for these declines, some manageable and others not, are discussed. Management plans for black-tailed prairie dogs are currently being developed and will likely determine if black-footed ferrets can exist in Montana.

HERPETOLOGY IN MONTANA: PAST, PRESENT, AND FUTURE[TWS]

Bryce A. Maxell
Wildlife Biology Program, University of Montana
Missoula, MT 59812
nathist@selway.umt.edu

J. Kirwin Werner
Department of Environmental Sciences, Salish Kootenai College
Pablo, MT 59855

Paul Hendricks
Montana Natural Heritage Program
909 Locust Street, Missoula, MT 59802

Dennis Flath
Montana Department of Fish, Wildlife, and Parks
365 West River Road. Belgrade, MT 59714

We are pleased to announce the publication of our book on Herpetology in Montana, which summarizes the history of herpetology in Montana from Lewis and Clark's arrival in 1805 to the present. We summarize the current status of the state's herpetofauna. We give checklists of the 12 amphibian and 17 reptile species known to be native to the state. We provide dichotomous keys for amphibian eggs, larvae, and adults, and reptile adults. We present individual species accounts for native species that (1) map 4636 museum vouchers and 7003 observation records in distribution maps, (2) list the earliest literature and voucher records, (3) list the maximum elevation reported and maximum elevation documented with a voucher specimen, (4) list voucher specimens by county of collection, and (5) provide a bibliographic index for 508 abstracts, unpublished reports, theses, dissertations, and published articles that contain information on species in Montana and Yellowstone ational Park. We also provide accounts that review information on the seven species or subspecies which are possibly native to the state, but for which we currently lack adequate

documentation, and the 13 species or subspecies that have been reported as exotic in the state. We briefly review highlights of the manuscript and discuss current issues of critical management concern and direction of inventory and monitoring programs designed to assess status of amphibians and reptiles in Montana.

Shorebird Survey Results and Management Activities at Bowdoin National Wildlife Refuge, Montana[TWS]

Dwain M. "Fritz" Prellwitz
USDI Fish and Wildlife Service, Bowdoin National Wildlife Refuge
HC 65 Box 5700, Malta, MT 59538
fritz_prellwitz@fws.gov

Shorebirds have always been an important component of the wildlife resource at Bowdoin National Wildlife Refuge (NWR) in northern Montana, but recent events have heightened interest. Listing of the piping plover (*Charadrius melodus*) as a threatened species in 1985 prompted intensive surveys for breeding pairs, nests and broods starting in 1986. Discovery of breeding pairs on the nearby USDI Bureau of Reclamation's (BR) Nelson Reservoir broadened the survey area. A second major event was the decision in 1996 to establish an International Shorebird Survey (ISS) route on the refuge and begin gathering population data for use in applying for designation as a Western Hemisphere Shorebird Reserve Network (WHSRN) regional site. Weekly surveys of the ISS route from early spring until freeze-up in fall were expanded to include nesting studies, and banding of incubating adults, and nestlings of willets (*Catoptrophorus semipalmatus*), marbled godwits (*Limosa fedoa*), long-billed curlews (*Numenius americanus*) and upland sandpipers (*Bartramia longicauda*). Apparent nest success was consistently high at 74 percent (range 63.2-78.9%, $n = 77$) during 1999-2002. One hundred and one shorebirds were banded with recapture of five adult birds in subsequent years. Four of eight adult willets banded in 1999 were recaptured, including two birds on the same nest bowls from which originally captured. Bowdoin NWR received its WHSRN designation in 2002 after documenting peak numbers of 38 shorebird species in the range of 45 to 58 thousand birds. Piping plover nests on Nelson Reservoir have been threatened by inundation from rising irrigation water since 1989. Techniques were developed to elevate or move nests to avoid inundation. Completed projects for improving nesting habitat on Nelson Reservoir in cooperation with BR included elevating two islands and grading or disking vegetation on two gravel beaches. A 200-ac diked subimpoundment on the Dry Lake Unit at Bowdoin was completed in 2002 with the intent of consistently providing an ideal water level for nesting plovers.

Wetland Mitigation Issues Related to the Reconstruction of U.S. Highway 93 on the Flathead Indian Reservation[TWS]

Mary B. Price
Wetlands/Riparian Ecologist
Confederated Salish and Kootenai Tribes
P.O. Box 278. Pablo, MT 59855
maryp@cskt.org

U.S. Highway 93 traverses some of the most ecologically sensitive wetland, riparian, and aquatic habitat on the Flathead Indian Reservation. In December 2000, the Confederated Salish and Kootenai Tribes, the Montana Department of Transportation, and the Federal Highway Administration entered into a Memorandum of Agreement (MOA) for the U.S. Highway 93 Evaro-Polson Project. The MOA identifies the three entities' preferred conceptual roadway improvements including alignment, lane configuration, major design elements and mitigation concepts for 30.8 mi (49.6 km) of the project. The MOA also specifies a process for environmental and design phases of the Highway 93 project. This process, as it relates to wetlands, riparian, and aquatic issues, highway design details, mitigation designs, and the integration of the MOA with federal, state, and tribal environmental regulations, is presented. The MOA also commits the three entities to cooperate in preparing a Supplemental Environmental Impact Statement (SEIS) for 11.2 mi (18.1 km) of the highway that traverse the Ninepipe glacial pothole wetlands complex. I also present a summary of the current status of the U.S. Highway 93 Ninepipe SEIS and design alternatives being evaluated.

Black Death on the Prairie: Plague, Prairie Dogs, and Burrowing Owls[TWS]

Marco Restani
Department of Biological Sciences
St. Cloud State University. St Cloud, MN 56301

Sylvatic plague represents the biggest challenge to the conservation of black-tailed prairie dogs (*Cynomys ludovicianus*) and their habitat associates, such as the burrowing owl. Plague epizootics can decimate prairie dog populations by 95-100 percent. Decreases in prairie dogs may eventually lead to the loss of burrowing owls (*Athene cunicularia*) as nesting holes unattended by prairie dogs collapse. I studied the direct and indirect effects of plague on prairie dogs and burrowing owls from 1999 to 2002 on the Ft. Belknap Indian Reservation, Montana. A plague epizootic was detected on the reservation in autumn 1999. The epizootic reduced occupied prairie dog habitat by over 50 percent in two years. Plague also reduced mean colony size and increased colony edge. Owls nested among fewer prairie dogs at the local and landscape scales. Despite these apparent changes to owl habitat, the population size and productivity of nesting owls remained relatively constant. Density of prairie dogs rebounded to pre-plague levels after only 3 years, but overall range of prairie dogs has increased slowly. Long-term management of prairie dogs in Montana will be difficult because of the cyclic nature of plague.

Factors Affecting survival and Recruitment in Female Merriam's Turkeys[TWS]

Mark A. Rumble
Center for Great Plains Ecosystem Research
USDA Forest Service Rocky Mountain Research Station
501 East St. Joseph St., Rapid City, SD 57701

Brian F. Wakeling
Game Branch, Arizona Game and Fish Department
2221 West Greenway Road, Phoenix, AZ 85203

Lester D. Flake
Department of Wildlife and Fisheries Sciences, South Dakota State University
P.O. Box 2140B, Brookings, SD 57007

Merriam's turkeys (*Meleagris gallopavo merriami*) historically occurred in ponderosa pine (Pinus ponderosa) and Gambel's oak (*Quercus gambelli*) forests in the southwestern U.S. They have been successfully transplanted into a wide array of habitats outside their original range. Some introduced populations are more robust than those within the original range. Annual survival fluctuates widely, ranging from 30 to 76 percent for adults. Survival of subadult hens is typically lower. Predation is the primary mortality factor and coyotes are the most common predator. Percent of females attempting to nest (nesting rates) ranges from ~30 percent to >90 percent for adults. Yearling females nest at lower rates, but within the historic range of Merriam's turkeys, nesting by yearling hens may be almost nonexistent. Management that would increase nesting by yearlings probably has the greatest potential to influence populations given the existing biological limitations to Merriam's turkeys. Nesting rates of adult and yearling hens is likely related to habitat quality or productivity, possibly through nutrition. Survival of poults is low. High quality meadows with abundant herbaceous vegetation and invertebrates may contribute to increased survival of poults.

Note: Results of this study were published in the Int. J. Sci. 9(1):26-39.

The Indirect Effects of Fire on Bird Species Composition and Detections in Mixed-Grass Prairie[TWS]

Renae A. Schmitt
Wildlife Biology Program, University of Montana
205 Natural Science Bldg., Missoula, MT 59812

Fire is a common event in grassland habitats and is important in structuring habitat for many breeding bird species. Fire directly alters vegetation characteristics and indirectly affects breeding bird communities by making potential nest sites and territories suitable for some bird species and unsuitable for others. A fire on the Little Missouri National Grassland in western North Dakota provided an opportunity to study indirect effects of fire on the bird community. In 2001 and 2002 I conducted point count and transect surveys in burned and

unburned areas of the grassland and measured vegetation features. In 2002 I also earched for and monitored nests of Western Meadowlarks (*Sturnella neglecta*), Vesper Sparrows (*Pooecetes gramineus*), and Grasshopper Sparrow (*Ammodramus savannarum*). Litter depth and plant species composition differed between treatments both years, but vegetation density only differed in 2001. The proportions of survey points and transects with detection of common bird species did not differ significantly between treatments. Preliminary analyses suggest that most vegetation variables do not accurately predict the presence of bird common species. Nest success was low for the three bird species, i.e., western meadowlark, 14 percent; vesper sparrow, 37 percent; and Grasshopper Sparrow, 34 percent. Analysis of nest site vegetation characteristics may not indicate what features deter nest predation but may help us understand what habitat features these species select. The low severity of the fire may explain minimal differences in vegetation features and bird species composition. Grazing by cattle most likely had a confounding effect.

Montana Wolf Planning: Process, Progress...More Process and More Progress... There Is a Light at the End of the Tunnel![TWS]

Carolyn A. Sime
Montana Fish, Wildlife & Parks
490 N. Meridian Rd. Kalispell, MT 59901

Former Governor Racicot appointed the Montana Wolf Management Advisory Council in April 2000 by to advise Montana Fish Wildlife & Parks (FWP) as it prepares a management plan for the gray wolf (*Canis lupus*) upon federal delisting. The Council was a diverse group, representing the interests of conservationists, hunters, landowners, livestock producers, outfitters, educators, and others. Governor Martz directed FWP to use the work of the Council to frame the "Montana Wolf Conservation and Management Planning Document." While the planning document reflected what a state wolf management plan could be, FWP still needed to explore various alternatives before adopting a management plan in full compliance with the legal requirements of the Montana Environmental Policy Act. Using this document as a basis for discussion, FWP opened the "scoping" comment period for its wolf management environmental impact statement (EIS) in February 2002. FWP collected about 6700 individual comments. Because wolf recovery and eventual state management are issues of such great significance to Montana, Governor Martz reappointed the original Wolf Management Advisory Council. FWP consulted with the Council prior to finalizing the EIS alternatives. Ultimately, FWP crafted five alternatives that ranged from little to no management to aggressive management. The Council's work will be presented as one of the alternatives. FWP's Wolf Conservation and Management Draft EIS will be released in late winter, 2003. FWP will accept public comments on its draft EIS at a series of community work sessions, via written letters, or email. FWP expects to complete the EIS in summer, 2003. More information can be found at www.fwp.state.mt.us.

The Effects of the 2000 Wildfires on Bird Abundance and Species composition in the Bitterroot National Forest[TWS]

Kristina M. Smucker
Wildlife Biology Program
University of Montana, Missoula, MT 59812

Disturbance events, such as windstorms, hurricanes, floods, and wildfires, maintain a range of successional stages with each offering habitat for a different suite of species. In the interior northwest, wildfire is the primary recurring disturbance that has maintained diversity in habitat types. During summer 2000 wildfires burned 13 transects that were part of the Landbird Monitoring Program's (LBMP) long-term monitoring effort in the Bitterroot National Forest. The Northern Region of the USDA Forest Service initiated the LBMP to assess bird habitat relationships and long-term population trends. As a result, one to five years of pre-fire data on bird abundance have been collected using 10-minute point counts. I conducted point counts on 13 burned and 13 unburned transects in the Bitterroot NF during summers 2001 and 2002. This represented the first opportunity to examine changes in bird abundance and species composition following stand-replacing wildfire. I compared relative bird abundance before and after wildfire for all species detected on at least 40 points. Post-fire changes in bird abundance were greatest at points that burned at high severity, where tree mortality was > 80 percent. Foliage-gleaning insectivores decreased following wildfire whereas aerial insectivores increased slightly.

Backcountry Recreation Impacts to Wildlife: An Application of The Wildlife Society's Online Bibliography[TWS]

Douglas Tempel and Vita Wright
Research Application Program, Aldo Leopold Wilderness Research Institute
P.O. Box 8089, Missoula, MT 59807
dtempel@fs.fed.us

As part of the Leopold Institute's Linking Wilderness Research and Management series, we're developing an annotated reading list on the effects of backcountry recreation on wildlife. Within a national context, we're organizing the literature into a framework for assessing and managing these impacts. This includes describing the value of wilderness to wildlife, the value of wildlife to wilderness, impacts to individuals, populations or communities, and potential management approaches. The searchable database developed by the Montana Chapter of The Wildlife Society served as a valuable starting point for gathering literature on this topic. We will describe our experience accessing information in the database and review the types of information it did and did not contain. After clarifying differences between the TWS database and our reading list, we summarize the information we compiled. Impacts of recreation on wildlife include increased energetic demands during critical times, loss of habitat and exposure to predators as a result of human presence, and loss of habitat through vegetation alteration by recreational activities. Management

approaches include direct actions such as restricting visitor numbers, activities, or access to some areas, as well as the indirect management of visitors using techniques such as visitor education or the careful location and design of trails, trailheads, and adjacent roads and campgrounds. Our intent with this volume is to (1) promote improved understanding of backcountry recreation impacts on wildlife, (2) familiarize readers with current literature on various management approaches, and (3) facilitate access to references focused on this topic.

Browse Condition and Trend on Montana Ungulate Range[TWS]

Scott K. Thompson and Carl L. Wambolt
Montana State University
119 Linfield Hall, Bozeman, MT
sktmt@hotmail.com

Ungulate impacts on woody vegetation have been a concern in Montana for a half-century. Exclosures were built on many areas of concern to determine if ungulates were affecting browse species. Most exclosures were built many decades ago, thus allowing impacts of long-term browsing to be realized. Our objective was to determine condition and trend of a variety of browse species. We achieved this by comparing browse species growing inside exclosures with browse species on environmentally similar areas outside. Thirty-two exclosures restricting the access of all ungulates were evaluated across many different environmental types. We used methods that evaluated short shrub species (< 2 m), tall shrub species (> 2 m), and trees and found browsing to have impacted browse species at 22 sites. In addition, five sites were considered areas of caution and were likely coming out of a period of intense browsing or entering a period of intense browsing. No browsing impacts were found at two sites. At the remaining three sites, we attributed differences in browse species inside and outside exclosures to factors other than browsing such as natural successional changes. Sites with no browsing effects were not related geographically within Montana. Impacts were found at both the oldest exclosure (57 yrs) and most recent exclosure (10 yrs). These findings imply browsing levels have been and remain a deterrent to development of browse communities throughout Montana.

The Effects of Thinning and Prescribed Fire on Foraging Patterns of Bark-Gleaning Birds[TWS]

Jennifer C. Woolf
Wildlife Biology Program, School of Forestry
University of Montana, Missoula, MT 59812

Fire suppression in western forests has changed the mosaic of successional stages of forest that once existed. In the western United States, recent large-scale, high-intensity fires have been attributed to the lack of fire in forest systems for the past century. The Montana

Department of Natural Resources (DNRC) is integrating ponderosa pine forest restoration into their timber harvest program with a commercial thin that is combined with a selective cut and followed by a prescribed burn. Many studies have considered the effects of forest management practices on nest availability for cavity nesters, but little published information exists on how thinning combined with prescribed fire affects their foraging patterns. Snags can provide important nesting habitat for cavity nesters, but it has been suggested that food availability may be the limiting factor for woodpeckers. In this project, I examined the foraging patterns of bark-gleaning birds on sites treated by the DNRC versus untreated sites. I determined which tree characteristics are important in the selection of forage trees for five different species: red-breasted nuthatches, white-breasted nuthatches, mountain chickadees, hairy woodpeckers, and black-backed woodpeckers. Treated and untreated sites were analyzed separately to determine if the same tree characteristics were important on both sites. Selection of forage trees with certain characteristics occurred on both sites for most species.

MOLECULAR CELLULAR BIOLOGY AND NEUROSCIENCES

ADAPTATION TO A CHOLESTEROL FREE ENVIRONMENT BY *TRICHOLPLUSIA NI* (TN) INSECT CELLS[MAS]

Dan Nicholls and Amber Osborne
MSU-Billings, Billings, MT 59101

For many years, researchers have known that cholesterol is an integral component of eukaryotic cell membranes. Cholesterol is found in the bilayer membrane and helps to maintain cellular membrane structure and fluidity. Recent research has found that a specific invertebrate cell line can be grown in cell culture without any cholesterol contained in the cells. Insect cells are not capable of synthesizing cholesterol and therefore require supplementation in their media. Surprisingly, withdrawal of exogenous cholesterol from a *Trichoplusia ni* cell line is not lethal for these cells. This suggests that sterols are not essential for the viability of certain animal cells. This brings up worthwhile questions. How do these cells maintain membrane structure and fluidity without cholesterol? Is there a structural change in the fatty acids of the membrane lipids or does some other lipid take cholesterol's place in the bilayer membrane? Utilizing analytical gas chromatography the composition of membrane lipids from cholesterol depleted *Trichoplusia ni* cells was analyzed and characterized.

ABSTRACTS FROM THE SINKS SYMPOSIUM

The following abstracts are from the "Sinks Symposium—Exploring the Origin and Management of Fishes in the Sinks Drainages of Southeast Idaho." The Idaho Chapter of the American Fisheries Society sponsored the symposium in Pocatello 27 February 2002. For more information related to the symposium contact Rob Van Kirk: *vankrobe@isu.edu*.

GEOGRAPHY AND FISHES OF THE SINKS DRAINAGES OF SOUTHEASTERN IDAHO

Robert W. Van Kirk
Department of Mathematics
Idaho State University, Pocatello, ID 83209

Bart L. Gamett
Salmon-Challis National Forest
P.O. Box 507, Mackay, ID 83251

The Sinks Drainages are a collection of closed surface drainage basins in southeast Idaho consisting of five U.S. Geological Survey hydrologic cataloging units: Beaver-Camas (17040214), Medicine Lodge (17040215), Birch (17040216), Little Lost (17040217), and Big Lost (17040218), in order from east to west. The streams of these basins originate in the Pioneer, Lost River, Lemhi, and Centennial mountain ranges and flow generally east and south, eventually sinking into the fractured basalts of the Snake River Plain. Adjacent drainages with surface connections to major river systems are the Big and Little Wood, Salmon, and Henrys Fork in the Snake River basin, and the Red Rock in the upper Missouri River basin. Twenty-seven fish species and three hybrids have been documented in the Sinks Drainages. However, because the Sinks Drainage streams are isolated from these major river basins, the origin of their aquatic fauna is not clear. Stocking of nonnative fish species into Sinks Drainage streams began in the 19th century, further confounding the problem of determining the native fish assemblages of these streams. It is possible that bull trout (*Salvelinus confluentus*), a federally listed species under the Endangered Species Act, and cutthroat trout (*Oncorhynchus clarki*), a state species of special concern, are native to at least some of the Sinks streams. Thus, refined knowledge of historical and current presence/absence of these species has important implications for management of fish and related resources in the Sinks Drainages.

Geologic and Hydrologic History of the Sinks Drainages

Paul K. Link
Department of Geosciences
Idaho State University, Pocatello, ID 83209

The Sinks Drainages have been controlled by topographic uplift and subsidence of the northeast-migrating Yellowstone hotspot over the last 17 million years. From Oligocene to middle Miocene (30 to 12 Ma), drainage was eastward from the eroded roots of the Idaho batholith and probably into the Missouri River. As the topographic bulge associated with the hotspot began to affect eastern Idaho (10 to 4 Ma), the Snake River Plain became an uplifted volcanic plateau, and drainage was radial, away from the volcanic locus. The Lost River, Lemhi, and Beaverhead ranges were uplifted, and the Big and Little Lost Rivers drained northward into the Salmon River. Ancestral Medicine Lodge and Camas creeks drained eastward into the Green River. Pliocene to Holocene subsidence of the Snake River Plain resulted in northward migration of the headwaters of the now south-draining Big and Little Lost rivers and Birch Creek and integration of the west-flowing Snake River, likely near its present location. Pleistocene construction of the northeast-trending Axial Volcanic High and northwest-trending basaltic rift zones resulted in isolation of the northern drainages from the Snake River. The result was formation of the Big Lost Trough and Lake Terreton basins and the modern Sinks Drainage pattern. Pleistocene to Holocene connections among Sinks Drainage streams occurred via common drainage into a lake system on the Snake River Plain. Periodic Pleistocene connections with the Snake River were also likely. Recent volcanism on the Yellowstone Plateau and desiccation of the Snake River Plain lakes produced the present drainage system.

Evolution and Historical Distribution of Fishes in Western North America in Relation to the Sinks Drainages

Robert J. Behnke
Department of Fishery and Wildlife Biology
Colorado State University, Fort Collins, CO 80523

The native fishes of the Sinks Drainages are derived from former connections to contiguous drainages: upper Snake, Wood (middle Snake), Salmon (Columbia), and Beaverhead (upper Missouri). The shorthead sculpin (*Cottus confusus*) is the only fish native to all five Sinks Drainages. The shorthead ancestor could have come only from the Salmon River. Its dispersal to the other drainages probably occurred via Lake Terreton, which connected them until about 10,000 years ago. This suggests that the ancestors of all other native species arrived after Lake Terreton's desiccation. The mountain whitefish (*Prosopium williamsoni*), native only to the Big Lost drainage, illustrates unresolved problems concerning native fishes of the Sinks Drainages. Cutthroat (*Oncorhynchus clarki*) and bull (*Salvelinus confluentus*) trout are typical inhabitants of first and second order streams in the region. Sculpins (*Cottus*), speckled dace (*Rhinichthys osculus*), and mountain sucker (*Catostomus playtyrhynchus*) would be likely to occur in second and third order streams. The mountain whitefish is typically found in third and fourth order streams. Thus, it would be expected that transfer of whitefish into the Big Lost drainage should have

included all associated species that also occur in lower order streams. Of these, only the Paiute sculpin (*C. beldingi*) appears to be native to the Big Lost. The distribution of other fishes assumed to be native to the Sinks Drainages is similarly problematic. Introductions of fish by humans over the past 120 years add to the difficulty of making a definitive determination of the native fish fauna of the Sinks Drainages.

Preliminary Biogeographic Assessment of the Sinks Drainages based on Aquatic Invertebrates

Daniel L. Gustafson
Department of Ecology
Montana State University, Bozeman, MT 59717-3460

The Sinks Drainages do not form a natural zoogeographic unit. The smallest area that includes the Sinks Drainages that has a unique invertebrate fauna also includes the Boise headwaters, the Wood rivers, the Salmon headwaters, the Henrys Fork and the Missouri headwaters. This larger area formed the northwest limits of the upper Snake paleoriver. This river was not connected to the Columbia River, but flowed east and then later across the southwest states to various outlets before its capture by the Columbia. Volcanic eruptions and uplift from the Yellowstone hotspot disrupted this drainage and eliminated much of the original fauna. Some extinction-resistant taxa survived in the Big Lost, Little Lost, and Birch drainages, but no endemic taxa are yet known in medicine Lodge or Beaver-Camas. Miocene relict taxa of the Northern rocky Mountain Refugium have not been found in the Sinks Drainages or henrys Form but these do occur immediately to the north. Late-arriving species from the Great Basin into the upper Snake do not occur north of the Snake River, except in the lower Henrys Fork. The absence of the mussel *Margaritifera* in the Sinks Drainages suggests that no ancestral salmonids lived or survived there; existing salmonids arrived later by more limited transfers, natural or anthropogenic. Other fish species may have survived the original drainage breakup in the Big and Little Lost Rivers. These were most likely derived from upper Snake River, except in the Little Lost, where transfer from the Salmon drainage to the north is indicated.

The Distribution and Potential Origin of Sculpin Species in the Sinks Drainages

Bart L. Gamett
Salmon-Challis National Forest
P.O. Box 507, Mackay, ID 83251

Donald W. Zaroban
Orma J. Smith Museum of Natural History
2112 Cleveland Blvd., Caldwell, ID 83605-4432

Three sculpin species are known from the Sinks Drainages: shorthead (*Cottus confuses*), Paiute (*C. beldingi*), and mottled (*C. bairdi*). The shorthead sculpin has been found in all

five Sinks Drainages. Distribution patterns and geomorphic evidence suggest that the shorthead entered one or more of the Sinks Drainages from the Salmon River at least 10,000 years ago. The species then likely gained access to other streams via Lake Terreton. Morphological assessments and preliminary genetic analysis indicate that the shorthead sculpin of the Sinks Drainages are distinct from shorthead sculpin in other drainages. The mottled sculpin is found in the Beaver-Camas, Medicine Lodge, and Birch drainages but is not known from the Big Lost River and Little Lost River drainages. Distribution patterns and geomorphic evidence suggest that the mottled sculpin entered the Medicine Lodge Creek and Beaver-Camas Creek drainages from the Henrys Fork within the last few thousand years and that the occurrence of mottled sculpin in Birch Creek is either a reporting error or due to anthropogenic introduction. The Big Lost River is the only drainage within the Sinks known to contain Paiute sculpin. It is unclear how or when this species entered this basin. Early sampling efforts and distribution patterns suggest that this species is native to the drainage. Additional genetic analyses are being pursued to help clarify the origin of the sculpin in the Sinks Drainages and assess how much genetic change has occurred in these species since they were isolated.

Genetic Analysis to Infer the Origin of Mountain Whitefish *Prosopium williamsoni* in the Big Lost River

Andrew Whiteley
Wild Trout and Salmon Genetics Lab, University of Montana, Missoula, MT 59812

Bart L. Gamett
Salmon-Challis National Forest, P.O. Box 507, Mackay, ID 83251

We analyzed mountain whitefish (*Prosopium williamsoni*) from the Big Lost River and surrounding watersheds at 32 allozyme loci and four microsatellite loci. Populations analyzed from surrounding watersheds were from the Snake River above and below Shoshone Falls and from the Salmon River. Mountain whitefish from the Big Lost River appear to have entered the system via the upper Snake because the Big Lost River population shares allozyme and microsatellite alleles with the upper Snake populations but not with the Salmon River populations. The Big Lost River mountain whitefish population is characterized by an extreme lack of genetic variation; of the 32 allozyme loci analyzed, only one was variable. Heterozygosity at the four microsatellites was zero, greatly reduced from upper Snake populations, where the average heterozygosity at the same four loci was 0.294. Finally, mountain whitefish from the Big Lost River are highly genetically differentiated from surrounding populations. This fact is best demonstrated by fixation of a unique allele in the Big Lost River population at one of the microsatellite loci. We can infer from these data that genetic exchange has not occurred between whitefish in the Big Lost River and surrounding watersheds for a long time period. Genetic and morphological differences may warrant consideration of Big Lost River mountain whitefish as a separate subspecies.

Settlement of Southeastern Idaho, With Reference to Fisheries Resources

Ron Hatzenbuehler
Department of History, Idaho State University, Pocatello, ID 83209
Ron HatzenbuehlerDepart

When European-Americans arrived in what became southeastern Idaho, they began living in an environment that Indians had been using for probably 10,000 years. Because no single location offered sufficient resources year round, native people migrated seasonally, making a living without diminishing the resources of any single area. Archaeological evidence indicates that the native people of eastern Idaho relied on aquatic resources, primarily whitefish (*Prosopium williamsoni*), cutthroat trout (*Oncorhynchus clarki*), and salmon (*Oncorhynchus* spp.). The first permanent European-American settlements in Idaho Territory date to the 1860s, when members of the Church of Jesus Christ of Latter-Day Saints moved northward from Cache Valley, Utah. Large-scale settlement of Idaho and the other western states came with the introduction of the railroad. In 1874, the first railroad, the narrow gauge Utah Northern, entered Idaho Territory at Preston. By 1880, the railroad had reached the Montana border. In 1885, the entire 245 miles of narrow gauge track from Pocatello to Silver Bow, Montana was widened. Other railroads later linked outlying cities, including Mackay (1901) in the Sinks Drainages. The railroad brought not only people and economic expansion; it also brought nonnative fish. Historical records indicate that trout were not native to the Big Lost River, but in 1896 or 1897 wagons went from Mackay to Blackfoot to get fish that had been transported there by train. These fish were stocked into the Big Lost. In June 1914, the railroad brought 100,000 trout to Mackay for introduction into Warm Springs Creek, a Big Lost tributary.

The Origin of Fishes in the Sinks Drainages of Southeastern Idaho: a Summary

Bart L. Garnett
Salmon-Challis National Forest, P.O. Box 507, Mackay, ID 83251

Historical records, distribution patterns, and geomorphic history suggest that only a few fish species are native to the Sinks Drainages. There is strong evidence that shorthead sculpin (*Cottus confusus*), Paiute sculpin (*C. beldingi*), mottled sculpin (*C. bairdi*), mountain whitefish (*Prosopium williamsoni*), and cutthroat trout (*Oncorhynchus clarki*) are native to at least some of the Sinks Drainages. Rainbow (*O. mykiss*) and bull trout (*Salvelinus confluentus*) are apparently not native to the Big Lost, Birch, Medicine Lodge, and Beaver-Camas watersheds, but it is unclear whether these species are native to the Little Lost. If so, they likely entered this watershed within the last 10,000 years via headwater transfer from the Salmon drainage. Shorthead sculpin, which appear to be native to all five of the Sinks Drainages, likely entered one or more of the Sinks streams at least 10,000 years ago from the Salmon River drainage and subsequently dispersed to the remaining streams through glacial Lake Terreton. It is unclear how or when Paiute sculpin, which are known only from the Big Lost River drainage, entered this system. Mottled sculpin and cutthroat trout appear to be native only to the Medicine Lodge and Camas-Beaver drainages and appear to have entered

these streams from the Henrys Fork drainage within the last 10,000 years. Thus, the cutthroat is the Yellowstone subspecies *O. c. bouvieri*. Mountain whitefish, which are known only from the Big Lost River drainage, appear to have migrated from the Snake River at least 10,000 years ago and may represent an endemic subspecies.

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