# Proceedings of the Colorado-Wyoming Chapter of the American Fisheries Society


"Incorporating Climate Change into Local Management Decisions"

February 23-26, 2009
Loveland, Colorado

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Trade Show/Vendors_____Steve Gale
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# General Information

## Registration

Annual meeting registration is located in the Entrance area (First National Bank Exhibition Hall, East Exhibition Hall entrance). Registration will be open:

Monday 6 pm – 8 pm  Tuesday 7 am – 12 pm, 1 pm – 5 pm  Wednesday 7 am – 12 pm

## Presentation Download

Presentations will be downloaded in the Sandhouse Room during the following times:

Monday 6 pm – 9 pm  Tuesday 7 am – 6 pm Wednesday 7 am – 12 pm

* All presentations must be downloaded by 7:30 am the morning of the scheduled presentation. Please be considerate to the audio-visual volunteers and avoid last minute submissions.

## Audio-Visual Preview

Presenters can practice their talks in the Sandhouse Room. This room is available:

Monday 6 pm – 9 pm  Tuesday 8 am – 6 pm  Wednesday 8 am – 4 pm

## Poster Session

Contributed posters will be displayed in the East Hall throughout the meeting. A list of poster titles and authors are at the end of the agenda and abstracts can be found on pages 30-33.

Dismantling of poster presentations is between 5:00 pm – 5:30 pm on Wednesday.

## Continuing Education

The 2009 Continuing Education Workshop is entitled, "Aquatic Macroinvertebrate Identification, Ecology and Metrics Useful in Fishery Management." This will be a full-day workshop taught on February 26th by Dr. Boris Kondratieff, Professor at Colorado State University.

This workshop will take place in conjunction with the annual meeting in Loveland. Cost is $35 for early registration, $50 for late registration.

## Raffle and Auction Display

Make sure to check out the great raffle and auction items in the Rodenberger Room.

Tickets will be on sale throughout the meeting. See page 1 for a list of raffle and auction donors.

## ***Trade Show***

The Trade Show will be located in the East Hall. See page 1 for a list of trade show vendors.

Dismantling of vendor exhibits is between 5:00 pm – 5:30 pm on Wednesday.

## ***Student Subunit Sales***

Please support the UW and CSU student subunits and stop by their display areas to purchase a hat, t-shirt, or pint glass. These items will be on sale throughout the meeting.

## ***Breaks and Lunch***

Morning and afternoon breaks will be held in the East Hall Tuesday and Wednesday. The continuing education workshop breaks will be held in the hallway, next to the Beard and Brown Rooms on Thursday. Refreshments and snacks will be provided.

All lunches are on your own, with the exception of the annual business lunch on Wednesday. Please see agenda for times. Pre-registration is required for the annual business meeting luncheon.

## ***CO-WY Business Luncheon***

The Colorado-Wyoming AFS Chapter business meeting luncheon will be held from 11:30 am – 1 pm on Wednesday. Lunch will be served in the East Hall. Please bring your plate back to the Morehouse Hall for the business meeting. All Chapter members are encouraged to attend. Pre-registration is required for the luncheon buffet. Name tags indicating you have paid for the business lunch will serve as meal tickets.

## ***Socials***

A Welcome Social will be held Monday evening from 6 pm – 10 pm in the East Hall.

The UW and CSU student subunits will host a Student Social on Tuesday evening from 6 pm – 10 pm at Dorothy's Catering, 2248 W. 1st Street, Loveland, Colorado (see map included in registration packet). Parking is limited and we encourage car-pooling. Everyone is welcome to attend. This is an excellent opportunity to socialize with our future biologists.

The Banquet Social on Wednesday will be held from 5:00 pm – 10 pm in the East Hall. Free beer and a cash bar will be available. Everyone is invited to the social and raffle. Pre-registration is required for the banquet buffet. Name tags will serve as meal tickets and are required for the buffet. Dinner will be served at 6 pm.

## ***Parking***

Parking for the First National Bank Exhibition Hall is located west of the building in Parking Lot B. Follow the signs.

# 2009 Annual CO/WY AFS Meeting
## Tuesday, February 24th

8:10-8:15 AM Opening Remarks and Presidential Message
Katharine Foster, CO/WY AFS President

## *Plenary Session: Incorporating Climate Change into Local Management Decisions*

8:15-8:20 AM Introduction to Plenary Session
Rick Henderson, Moderator

8:20-9:00 AM Keynote Address: Climate Change Impacts and Natural Resources in the Western United States
Dr. Stephen Gray, Wyoming State Climate Office

9:00-9:40 AM Implication of Climate Change for Fish Communities & Aquatic Habitats in Mountain Streams
Dr. Dan Isaak, USFS Rocky Mountain Research Station

9:40-10:10 AM Using Climate Change Models to Prioritize Restoration Activities
Warren Colyer, Trout Unlimited

10:10-10:30 AM Break

10:30-11:10 AM Agency Perspectives
Tom Nessler, Colorado Division of Wildlife
Mike Stone, Wyoming Game and Fish Department
Bruce Rosenlund, US Fish and Wildlife Service
Claudia Regan, US Forest Service

11:10-11:55 AM Panel Discussion
All Speakers

11:55-12:00 PM Concluding Remarks
Rick Henderson, Moderator

12:00-1:10 PM Lunch – On Your Own

## *Session 1: Climate Change*

Moderator: Jason Burckhardt, Wyoming Game and Fish Department

| | |
|---|---|
| 1:40-2:00 | Chris Kennedy (professional) "Water Temperature and Cutthroat Trout Recruitment in Rocky Mountain National Park" |
| 2:00-2:20 | Tom Annear (professional) "Challenges and opportunities for managing water for fisheries in a changing global climate: a status report of state and provincial instream flow programs in the U.S. and Canada and strategies for improving their effectiveness" |
| 2:20-2:40 | Ted Seddel (student) "Watershed-scale approach to assessing Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) abundance and habitat in the upper Colorado River headwaters" |
| 2:40-3:00 | Dwyane Meadows (professional) "Theodore Roosevelt Conservation Partnerships Fisheries Conservation Efforts and relationship to the American Fisheries Society" |
| 3:00-3:20 | Break |

| **SESSION 2: *Burbot, Suckers, Mussels & Sampling Gear***<br>**Moderator:** Jon Ewert, CDOW<br>**Moorehouse Hall** | | **SESSION 3: Invasive species, *Cattle & North Platte***<br>**Moderator:** Bobby Compton, WGFD<br>**Brown Room** |
|---|---|---|
| 3:20-3:40 | **Chris Moan** (professional) "Modeling the Effects of Water Temperature on Burbot (*Lota lota*) Consumption" | **Vicki Milano** (professional) "Colorado Invasive Species Implementation Plan" |
| 3:40-4:00 | **Wayne Hubert** (professional) "Trammel nets for the assessment of burbot stocks in lentic systems: Do they provide a reasonable tool?" | **Dennis Oberlie** (professional) "Determining rangeland suitability for cattle grazing based on distance-to-water, terrain and barriers-to-movement attributes" |
| 4:00-4:20 | **Wayne Hubert** (professional) "Management problems to be confronted in preservation of bluehead suckers and flannelmouth suckers in small, headwater streams in Wyoming?" | **Steve Gale** (professional) "A New Hope: Step One in restoring connectivity between the North Platte and Encampment rivers" |
| 4:20-4:40 | **Gordon Ewards, Jr** (professional) "Native mussels of Wyoming: Where'd this clam come from?" | **Christina Barrineau** (professional) "Seasonal evaluations of fishes in two constructed backwater habitats in the North Platte" |
| 4:40-5:00 | **Harry Crockett** (professional) "Evaluation of backpack electrofisher performance and its effect on sampling efficiency" | |

**Student Social - 6-10 pm**

# 2009 Annual CO/WY AFS Meeting
## Wednesday, February 25th

## *Session 4: Colorado River Fishes*

Moderator: Bill Janowsky, United States Forest Service

| | |
|---|---|
| 8:00-8:20 | Tom Chart (professional) "The Upper Colorado River Endangered Fish Recovery Program (Recovery Program): Nonnative Fish Management with Emphasis on Smallmouth Bass Control" |
| 8:20-8:40 | Boyd Wright (professional) "Northern pike control and evaluation in the middle Yampa River" |
| 8:40-9:00 | Kevin Bestgen (professional) "Response of the Native Fish Community of the Yampa River to Removal of Non-native Piscivores, 2003-2008" |
| 9:00-9:20 | Koreen Zelasko (student) "Survival rate estimation of hatchery-reared razorback suckers Xyrauchen texanus in the Upper Colorado River Basin, Utah and Colorado" |
| 9:20-9:40 | Brian Wolff (student) "Strontium isotopes can trace origins and movements of nonnative piscivores in the Yampa River basin" |
| 9:40-10:00 | Break |

## *Session 5: Whirling Disease*

Moderator: Kevin Rogers, Colorado Division of Wildlife

| | |
|---|---|
| 10:00-10:20 | Dan Kowalski (professional) "Introduction of whirling disease resistant rainbow trout, Oncorhynchus mykiss, in the Gunnison River, Colorado" |
| 10:20-10:40 | Bill Atkinson (professional) "Rehabilitation of a rainbow trout fishery through the use of WD resistant strains in the Yampa River" |
| 10:40-11:00 | Eric Fetherman (student) "Heritability of myxospore count and genetic correlations in whirling disease resistant and susceptible strains of rainbow trout" |
| 11:00-11:15 | Barry Nehring (professional) "Distribution, Occurrence and Relative Abundance of Tubifex tubifex, the Aquatic Oligochaete Host for Myxobolus cerebralis in Colorado: Results of a 6-Year Assessment" |
| 11:15-11:30 | Barry Nehring (professional) "Wilderness and Whirling Disease: An Emerging Threat to Cutthroat Trout Recovery?" |
| 11:30-1:00 | **Chapter Business Lunch** |

## *Session 6: Plains Ecosystems*

Moderator: Dave Winter, United States Forest Service

| | |
|---|---|
| 1:10-1:30 | Jeff Falke (student) "Patterns in habitat use and phenology of an assemblage of larval fishes in a Great Plains stream: effects of drought and habitat drying across years" |
| 1:30-1:50 | Kristoph Kinzil (student) "Bendway weirs: would they aid the recovery of the endangered Rio Grande silvery minnow, Hybognathus amarus" |
| 1:50-2:10 | Anna Senecal (student) "How pristine is the fish community of the Powder River, the "last remnant" of the Great Plains river system?" |
| 2:10-2:30 | Sarah Laske (student) "Habitat Use of Roundtail Chub and Interaction with Lake Trout in Two Glacial Lakes, near Pinedale, Wyoming" |
| 2:30-2:50 | Jesse Lepak (student) "Factors affecting bioaccumulation of mercury in sport fish in Colorado reservoirs" |
| 2:50-3:20 | Break |

## *Session 7: Cutthroat Trout*

Moderator: Mark Smith, Wyoming Game and Fish Department

| | |
|---|---|
| 3:20-3:40 | Nathan Cook (student) "Status of anthropogenically - Isolated populations of Colorado River cutthroat trout in the upper North Fork Little Snake River Drainage" |
| 3:40-4:00 | Mandi Brandt (student) "Optimizing survival and growth of first-Feeding Colorado River cutthroat trout – Diet temperature, and density implications" |
| 4:00-4:20 | Carl Saunders (student) "Effects of cattle grazing on terrestrial invertebrate subsidies to trout in central Rocky Mountain rangeland streams" |
| 4:20-4:40 | Kelly Larkin (student) "Colorado River Cutthroat Trout Restoration Opportunities: A GIS Model for Identifying the Good, the Bad, and the Ugly" |
| 4:40-5:00 | Dave Winters (professional) "Multiple-Scale assessment results for the White River National Forests, implications for identifying future Colorado River cutthroat trout restoration based on watershed characterization and abundance of anthropogenic activities" |

**Abstracts on pages 30-33**

Darrell Snyder (professional). "Family level key for NA larvae"

Darrell Snyder (professional). "Common UCRB NN cyprinid larvae"

Richard Hays (student). "Spatial and temporal patterns of brown trout (*Salmo trutta*) spawning in an urban stream"

Ann Widmer (professional). "Durability of Gellan Gum Beads in Rio Grande Water"

Brett Johnson (professional). "Illegal stocking of aquatic organisms: a new website and outreach tool"

# 2009 Annual CO/WY AFS Meeting

## Plenary Panel

**Climate Change Impacts and Natural Resources in the Western United States**

Dr. Stephen Gray, Director, Water Resources Data System
Wyoming State Climatologist
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Tel: 307-766-6659
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**Implication of Climate Change for Fish Communities & Aquatic Habitats in Mountain Streams**

Dr. Dan Isaak, Fisheries Biologist
Rocky Mountain Research Station, Boise Aquatic Sciences Lab
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**Using Climate Change Models to Prioritize Restoration Activities**

Warren Colyer, Bear River Native Trout Program
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## Agency Perspectives

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Claudia Regan, Vegetation Ecologist
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**Water Temperature and Cutthroat Trout Recruitment in Rocky Mountain National Park**

**Chris Kennedy**
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The greenback cutthroat trout (GBC), *Oncorhynchus clarki stomias*, and the Colorado River cutthroat trout (CRC), *Oncorhynchus clarki pleuriticus*, are the only two trout native to the waters which are currently within what is now Rocky Mountain National Park (RMNP). Both subspecies are rare, with the GBC Federally listed as threatened and the CRC petitioned for listing under the Endangered Species Act. The main reason for the decline of both subspecies was the introduction of non-native trout which hybridize or displace them over time. Because of this, restoration projects have been confined to high elevation waters which are above fish migration barriers, such as waterfalls and cascades, which exclude non-native trout. Due to their high elevation location water temperatures may be limiting to some of these populations. The first year of life is critical period for long term persistence of these high elevation cutthroat trout populations. The timing of spawning, egg development, and availability of food once fry have emerged from the gravel are all temperature dependent. Water temperatures must be warm enough for fry to acquire enough fat reserves to survive their first winter. If this does not occur for several years the population may not persist. To assess the thermal requirements needed for cutthroat trout to survive their first year of life, spawning surveys, temperature monitoring and population surveys have been conducted since the early 1990's. Spawning surveys indicate that cutthroat trout consistently come out of lakes into inlets and outlets to begin spawning when the mean daily water temperature reaches and stays above 5° C. Trout growth typically only occurs at temperatures above 4° C. To quantify the amount of "warmth" each cutthroat population receives during the spawning season the number of centrigrade degree days (CDD) is calculated between the onset of spawning and the onset of winter. Data from population surveys conducted in the fall indicate that approximately 700 CDD are needed for fry to attain a large enough size to survive the winter. A climatic warming trend would benefit the cutthroat trout populations within RMNP by increasing recruitment success.

**Challenges and opportunities for managing water for fisheries in a changing global climate: a status report of state and provincial instream flow programs in the U.S. and Canada and strategies for improving their effectiveness**

**Tom Annear**
Wyoming Game and Fish Dept
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Given well-documented evidence of climate changes and the prospect of significantly altered hydrologic patterns in the future, managing water for fisheries will become an increasing challenge in the future. The Instream Flow Council (IFC) received funding from the USFWS Office of Sport Fish Restoration through their Multi-State Conservation Grant program in 2006 to conduct an assessment of the status and effectiveness of all state and provincial fish and wildlife agencies in the U. S. and Canada. A team of seven IFC members conducted 2 extensive on-line surveys of all state and provincial fish and wildlife agencies to identify characteristics and effectiveness of their agencies. They then conducted a week-long workshop in the fall of 2007 where most of the survey participants were brought together with project funds to develop strategies to address the primary drivers associated with instream flow effectiveness. A logic model was used to evaluate institutional, legal, public involvement and technical capabilities. Results were based on each agency's inputs, activities, outputs and outcomes associated with their instream flow efforts. The greatest challenge facing state agencies is not developing or applying better scientific methods though using the best available science is a critical part of any water management strategy. Participants overwhelming said that the greatest challenges they face deal with inadequate laws and policies, inadequate institutional structure and function, and an uninformed and uninvolved public. The characteristics and effectiveness of individual agencies were summarized in a program stage assessment matrix to reflect their primary strengths and challenges based on answers they provided. Colorado and Wyoming both exhibited relatively effective instream flow management characteristics for their agencies. These are discussed in the presentation with recommendations for areas that need special efforts to maintain or improve effectiveness for each agency.

**Watershed-scale approach to assessing Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) abundance and habitat in the upper Colorado River headwaters**

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**Robert E. Gresswell**
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Information concerning the effects of physical habitat on the distribution, abundance, and population structure of salmonid fishes has been routinely gathered at the site and reach scales, but data collected at these scales has provided little insight into spatial and temporal structure of fish assemblages within the stream network. This is especially relevant where periodic disturbances across the landscape are extensive, and effects are not uniform (spatially or temporally). To gain new insight into the relationships between trout abundance and population structure and the physical habitat at multiple spatial scales, we surveyed six watersheds in the upper Colorado River basin and assessed Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) abundance and habitat variables continuously throughout the stream network. The watersheds were selected randomly from a sampling frame based on presence of Colorado River cutthroat trout populations, percent beetle infestation of the watershed area, and erosion potential of the upslope geology. Although similar physical habitat conditions existed within and among several watersheds, fish distribution was patchy at the channel-unit scale, and physical habitat was not strongly related to distribution. However, at the reach scale, patterns of fish distribution explained a substantial amount of the variation in abundance. Further refining of these relationships will provide critical information necessary to assess future changes related to restoration activities, wildfire, and climate change.

**Theodore Roosevelt Conservation Partnerships Fisheries Conservation Efforts and relationship to the American Fisheries Society**

**Dwayne M. Meadows**
Theodore Roosevelt Conservation Partnership
707 South 15th, Laramie, WY 82070
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The TRCP will be presenting on conservation partnerships and how we work to improve national policy to best protect fish and wildlife habitat. This presentation will cover all 7 of TRCP's initiatives; our partner organizations and how we are working together to best protect fisheries. The overall focus will be collaborative efforts to create balance national policy on conservation issue, and particularly the role that the American Fisheries Society can and does support these efforts.

**Modeling the Effects of Water Temperature on Burbot (*Lota lota*) Consumption**

**Chris Moan**
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The energetic needs of fish are directly related to environmental temperatures. I used bioenergetics modeling to predict how an increase in monthly water temperatures affects the physiological processes of burbot and then applied the results of the model to a wild population to estimate how this change relates to the natural environment. Recent illegal introduction of burbot outside their native range in Wyoming has lead to concerns about their ecological impact, including the effect burbot consumption has on established sport fisheries. Using the model, burbot predation increased with an increase in water temperature. The direct effects of burbot predation on the fish community showed little change when applied to a wild population, while the indirect effects, mainly competition for prey, may pose the greatest threat to sport fisheries.

**Trammel nets for the assessment of burbot stocks in lentic systems: Do they provide a reasonable tool?**

**Matthew Abrahamse & Wayne Hubert**
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Trammel nets have been found to be a sampling gear that is selective for burbot in lakes and reservoirs. Burbot were sampled in water bodies of the Wind River drainage, Wyoming, during fall 2007 and spring 2008 using a standard sampling protocol. A crew of 2 people in a single boat could retrieve, process fish, and re-set three trammel nets during a work day enabling 12 net-nights of effort during a single week. Twelve net-nights of effort were expended on each of nine water bodies during both fall and spring. Estimates of catch per unit effort (C/f) and proportional size distribution (PSD) were computed from these data. In this presentation we describe the precision of the C/f and PSD estimates and assess the sufficiency of the sampling effort. We found that when a $\log_{10}$-transformation was applied to the C/f data, 12 net-nights of effort were sufficient to estimate the mean within 10% at $\alpha = 0.10$ among all of the water bodies during both seasons. However, the numbers of fish sampled with 12 net-nights of effort were not sufficient to obtain very precise estimates of PSD for most of the water bodies. We conclude that 12 net-nights of effort were sufficient to assess relative abundance of burbot in lakes and reservoirs, but more effort would be needed to obtain sufficient samples of fish to assess length structure using PSD as an index.

**Management problems to be confronted in preservation of bluehead suckers and flannelmouth suckers in small, headwater streams in Wyoming**

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**Diana Sweet**
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Three small headwater streams in Wyoming with sympatric populations of bluehead suckers *Catostomus discobolus* and flannelmouth suckers *C. latipinnis* have been identified as waters where these species may be preserved within their native ranges. The streams are Muddy Creek in the Little Snake River watershed and Little Sandy Creek and the Big Sandy River in the Green River watershed. Recent research projects conducted at the University of Wyoming have identified management problems that need to be confronted for the continued persistence of native catostomids in the studied streams. The problems include genetic integration of the native catostomids with introduced white suckers *C. commersoni* and longnose suckers *C. catostomus*; competition between the native and the introduced catostomids; occurrence of small, isolated populations of the native catostomids; and predation by introduced burbot *Lota lota* affecting recruitment of native catostomids. The severity of the management problems will be discussed along with management alternatives for both the near term and the long term.

**Native mussels of Wyoming: Where'd this clam come from?**

**Gordon P. Edwards Jr.**
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Freshwater mussels are inconspicuous but ecologically valuable. They are important bioindicators with complex life cycles tied to many native fishes and illustrate striking evolutionary adaptations. North America hosts the world's highest diversity of freshwater mussels (over 300 species) but more than half of the native mussels in the Midwest U.S. are listed as threatened or endangered. Many mussels continue to decline. Wyoming remains in a discovery phase because no efforts have focused statewide on mussels. The Wyoming Game and Fish Department is statutorily charged with managing "all wildlife" (excluding insects) and current federal mandates such as the Comprehensive Wildlife Conservation Strategy require improved knowledge of non-game species such as mussels. A retired geology professor and a consulting archaeologist inspired awareness of Wyoming's native mussels, and continue providing valuable management guidance. Small-scale, unorganized surveys and the incidental observations of Department personnel have provided a window into species distributions, but our data lacks spatial continuity and prohibits confident population assessments. At least seven species of freshwater mussels are known to inhabit Wyoming waters, including fatmucket, giant floater, cylindrical papershell, western pearlshell, white heelsplitter, California floater, and plain pocketbook. Living specimens of the latter three species were only discovered since the fall of 2007. A potential eighth species, the black sandshell, was discovered in the recent fossil record with other extant species in 2006. Wyoming arranged an agreement with the University of Colorado Museum to curate a voucher collection of its mussels. A State Wildlife Grant project was proposed to initiate standardized baseline surveys for native mussels in 2010 throughout Wyoming.

**Evaluation of backpack electrofisher performance and its effect on sampling efficiency**

**Harry Crockett**
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We measured power, voltage and amperage output of 12 backpack electrofishers representing 5 models, both gas- and battery-powered, at several simulated water conductivities. Based on observation of fish behavior during backpack electrofishing, we developed curves predicting optimal voltage for any given ambient conductivity for several warmwater stream fish species, in accordance with methods described by Kolz & Reynolds (1989). Criteria for optimal power transfer included fish behavioral response, absence of apparent injuries, and rapid and apparently complete recovery. By applying the power transfer curves, we determined whether each electrofisher model would be able to deliver optimal power during sampling at the conductivities that were simulated in the test. Sampling data from 23 sites were evaluated to determine whether divergence from optimal power levels affected either the probability of detecting species or catch per unit effort. For both metrics, the amount by which selected electrofisher voltage diverged from optimal had a modest but discernible effect, suggesting that variance across sampling sites and occasions could be moderately reduced by standardizing for optimal power transfer.

**Determining rangeland suitability for cattle grazing based on distance-to-water, terrain and barriers-to-movement attributes**

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Methods for evaluating the suitability of rangelands for cattle grazing based on slope and distance-to-water have been developed. Current methods do not account for the distance cattle must travel around steep terrain (barriers-to-movement) to reach water. Failure to adjust grazing suitability for terrain issues and travel distances to water can result in rangeland degradation.

The project goal is to develop a grazing suitability model and test it for the Lander Field Office of the Bureau of Land Management. The primary objective is to develop a GIS Model that creates a systematic process to calculate areas suitable for grazing using slope and distance-to-water that accounts for terrain barriers. The GIS-based calculations would then be compared with previous hand-generated suitability calculations to check their validity. Finally, the project would document the methodology and data used for calculations. This would allow for modification of the model to local conditions and the addition of supplementary attributes. The model was tested on six pastures having three different terrain types within the Lander Field Office. The model uses elevation data to calculate slope and determine terrain-based movement barriers. The water source layer is a combination of streams, wetlands, and water well locations. The pasture boundary layer was provided by the BLM. The importance of the barriers-to-movement modification increases as steepness of the terrain increases. The accuracy of the model improves with complete water well or stock pond data, which requires local knowledge. The terrain classification categories can be changed based on knowledge of cattle use in a pasture. The model can be modified to reflect seasonal and long-term changes in water availability by adjusting the water source layer. The model can also be used in combination with NRCS's Grazing Land Spatial Analysis Tool and the USDA's Soil Data Viewer to adjust predicted forage production. In addition, the model can also be used to evaluate the need and location of additional water sources and fencing. An important use of this model is to identify areas of moderate grazing use, which would aid in establishing grazing monitoring.

**A New Hope: Step One in restoring connectivity between the North Platte and Encampment rivers**

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The Encampment River is a major tributary to the North Platte River and is believed to be important to the long-term persistence of trout populations in the Upper North Platte watershed. Our goal is to manage for tributary conditions that will improve trout movements, spawning, and recruitment to the North Platte River. Since the early 1900s, an irrigation diversion dam on the Encampment River located about a ½ mile upstream from the confluence with the North Platte River has most likely precluded spawning trout from moving upstream. A fish ladder was installed in 1985, but high spring flows in 1986 washed out the fish ladder and threatened the integrity of the diversion dam. Trout populations could benefit in both the Encampment and North Platte rivers if passage was again provided. It was necessary to collect information on potential benefits before pursuing such a major fish passage project. A combination of Floy tags (N = 249 in 2007) and radio transmitters (N = 32 in 2008) was used to document movements of brown trout collected below the diversion dam and released upstream of the dam. Movements were monitored by ground relocations and fixed-wing telemetry flights. The final fates of radio tagged fish were determined along with upstream and downstream migration barriers and spawning timing and locations. Spawning occurred from late September to late October and most occurred from the diversion dam upstream 8 river miles. No other upstream migration barriers were documented, but 44% of fish encountering the diversion dam while migrating downstream were entrained in the irrigation canal. The distance between the furthest upstream relocation and downstream relocation is over 60 river miles. Providing fish passage around the diversion dam would help restore the fluvial life history of salmonids in the Encampment River watershed and enhance trout populations in the Upper North Platte River watershed.

**Seasonal Evaluations of Fishes in Two Constructed Backwater Habitats in the North Platte River, Wyoming**

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Historically, the North Platte River was typical of other Great Plains region rivers with shifting fine substrates, variable flows, and multiple channels. Today, the North Platte River is the most impounded river in Wyoming, and consequently is now characterized by coarse substrates, regulated flows, and a predominant single channel. In 2005, two habitat projects on the North Platte River in Goshen County, Wyoming, were initiated to develop backwater habitat in abandoned side channels. Native and non-native fish presence within the backwater habitats was evaluated seasonally in 2007 and 2008 for a total of five surveys for each backwater. Fifteen species have been identified within each backwater habitat. Only one species captured in the backwater upstream of Torrington, Wyoming is an introduced species, whereas ten species collected from the backwater near the Nebraska border are native to Wyoming. Overall, the October sampling in 2007 and 2008 resulted in the highest numbers of total fish and fish species at both backwaters. Seasonal evaluations of the backwaters will continue to help determine use of this habitat type by both native and introduced species for future habitat projects.

**The Upper Colorado River Endangered Fish Recovery Program (Recovery Program): Nonnative Fish Management with Emphasis on Smallmouth Bass Control**

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The Recovery Program was established in 1988 under a cooperative agreement to recover four endangered fish species while providing water for human needs. Nonnative fish management has been one of five core elements of the Recovery Program since its inception; the others being habitat management, habitat development, endangered fish propagation and stocking, and research/ monitoring / data management. Through the late 1990's, nonnative fish research investigated the feasibility of controlling populations of: a) small bodied nonnative cyprinids and centrarchids known to negatively interact with endangered species in nursery habitats; b) channel catfish, which were/are ubiquitous throughout the Upper Basin; and c) northern pike in the Yampa River drainage. Smallmouth bass occurrence in Upper Basin fish collections was very low until the late 1990's when their abundance increased dramatically throughout the lower 130 miles of the Yampa River and soon thereafter through approximately 100 miles of the Green River. This rapid increase in smallmouth bass numbers has been attributed to a combination of events: a) a large release of smallmouth bass from Elkhead Reservoir located in the upper Yampa River drainage during an emergency draw down, which was then coincident with; b) highly favorable environmental conditions for nonnative fish in the Yampa and Green rivers during a prolonged period of drought. The Recovery Program responded with large scale mechanical removal efforts (boat based electrofishing) beginning in 2004. Those efforts have increased considerably through 2007 to achieve a target annual exploitation rate of 65% (minimal threshold necessary as determined through modeling). This exploitation target has been met in relatively small river reaches and only in recent years. Catch metrics (density estimates, exploitation rates, and catch per unit effort), recapture data, and population size structure collected since 2004 are presented to describe smallmouth bass population dynamics and to provide a preliminary evaluation of the Recovery Program's effectiveness. We discuss alternative control methodologies under consideration as well as a recent solicitation for a programmatic evaluation of removal efforts through 2008.

**Northern pike control and evaluation in the middle Yampa River**

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Non-native northern pike in the Yampa River pose a threat to the recovery of the endangered fishes of the Upper Colorado River basin by directly preying on these fishes. In 2003, the Upper Colorado River Basin Endangered Fish Recovery Program initiated several projects with the objectives of reducing northern pike numbers via mechanical removal in the Middle Yampa and Green Rivers, and evaluating these efforts with annual mark-recapture abundance estimation. In 2008, following five years of removal and evaluation, numbers of northern pike inhabiting Critical Habitat of the Yampa River has changed little, though size structure has changed some, tending toward a population comprised of smaller fish. Exploitation rates have been relatively high, ranging from 50% to 70% throughout the five years these studies have existed. Movement patterns of recaptured northern pike suggest that recruitment of northern pike from upstream sources is inhibiting researchers' ability to effectively control northern pike in Critical Habitat of the Yampa River. Future success of these projects may be dependent on eliminating upstream recruitment sources.

**Response of the Native Fish Community of the Yampa River to Removal of Non-native Piscivores, 2003-2008**

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Mechanical removal of several non-native fish predators has been implemented in several rivers of the Upper Colorado River Basin in an effort to restore once-abundant native fishes. From 2003-2008, we sampled small-bodied fishes in low-velocity habitat in treatment (piscivorous fish removal) and control (no removal) reaches with a variety of gears to assess whether predator removal benefited the native fish community in the Yampa River, Colorado. Through 2007, main channel fish communities were dominated by non-natives, particularly young-of-year (YOY) smallmouth bass. Native fishes were rare in main channel habitat, and were usually present only in isolated pools where smallmouth bass were uncommon. Although still uncommon, higher frequency of native fishes in main stem samples since 2005, were coincident with increased removal of YOY smallmouth bass, particularly in the treatment reach. Native fish abundance in main channel samples in the control and treatment reach was particularly high in 2008, when flows were relatively high and cool late in the year. Positive native fish response was likely due to synergistic effects of bass removal and return to a higher, more normal hydrologic regime, which delayed spawning, and reduced growth and perhaps abundance, of smallmouth bass in the Yampa River, Colorado.

**Survival rate estimation of hatchery-reared razorback suckers *Xyrauchen texanus* in the Upper Colorado River Basin, Utah and Colorado**

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We used tag recapture data to estimate apparent survival, φ, and capture probability, *p*, for hatchery-reared, federally endangered razorback suckers *Xyrauchen texanus* stocked into Upper Colorado River Basin streams. Effects investigated included: river, river reach, year, season, fish total length (TL), 1st year in the river (ry1) versus subsequent years (post-ry1), and sampling effort. Recapture data were also used to describe post-stocking movement of razorback suckers. Total length at stocking had a positive effect on 1st-interval (ry1) survival rates. Averaging over stocking season, ry1 survival rates of razorback suckers stocked at <200 mm TL approached 0 but increased to ≥0.75 for the few fish >500 mm TL. Survival rate for razorback suckers stocked at the average length of 252.5 mm TL was low: 0.05 (95% confidence interval (CI): 0.042 – 0.071). Season of stocking also had a large effect on 1st-interval survival of razorback suckers: predicted survival for average length razorback suckers stocked in summer was <0.02 (95% CI: 0.012 – 0.022), but was 0.08 (0.057 – 0.100), 0.08 (0.057 – 0.118) and 0.07 (0.044 – 0.094) for fish stocked in autumn, winter, and spring, respectively. Overall survival rate for razorback suckers through any interval subsequent to their first interval in the river (post-ry1) was estimated at 0.75 (95% CI: 0.688 – 0.801), similar to the 0.70 rate assumed for adult fish in the integrated stocking plan. Capture probability estimates were relatively low, ranging from 0.002 – 0.128 for fish of average TL at stocking. Mean distance traveled, time elapsed, and rate of travel by razorback suckers on any leg of movement were 54.7 RK (range: 0 – 514.9), 254 days (range: 0 – 3,164), and 0.87 RK/d (range: 0 – 55.37), respectively, and highest for first legs (stocking to first capture) compared to subsequent legs. Nearly all (92.7%) movements were in a downstream direction. Movement out of stocking reaches was more frequent in the Colorado and Gunnison River subbasins (36.9%, range: 30.1 – 100%) than the Green River subbasin (7.7%, range: 2.9 – 10.3%). Our results will help guide production and stocking strategies for hatcheries and managers attempting to restore razorback sucker in the Colorado River Basin.

**Strontium isotopes can trace origins and movements of nonnative piscivores in the Yampa River basin**

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Determining the origins and movements of nonnative piscivores is a growing concern for managers in the Yampa River basin because of the negative impacts of these fishes on endangered fish. Traditional fisheries methods, such as tagging, have proven to be problematic due to the large spatial scale and limited sampling season of the Yampa River system. The emerging field of otolith microchemistry has provided some promising results in determining origins and movements of invasive fishes. Previous research in the Yampa River basin showed that otolith trace element analysis could identify source populations, but trace element signatures of waters were not stable over time. Thus, all source locations would need to be sampled regularly to track possible changes in trace element chemistry. We are embarking on research in the Yampa system and elsewhere in the Upper Colorado River basin examining the utility of the isotope ratio $^{87}Sr$:$^{86}Sr$ in otoliths as a tracer, using a multi-collector laser ablation inductively coupled plasma mass spectrometer (LA-ICPMS). This work is providing compelling new evidence suggesting that strontium isotope ratios are stable over time, similar among species, and may be used to identify many specific source locations. Thus, the use of $^{87}Sr$:$^{86}Sr$ eliminates the need for annual baseline signature updates and collection of each problematic species from each source, both of which would lead to lower collection effort and analysis costs compared to studies using trace elements.

**Introduction of Whirling Disease Resistant Rainbow Trout in the Gunnison River, Colorado**

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The Gunnison River in southwest Colorado supported a healthy wild rainbow trout population before the introduction of *Myxobolus cerebralis* in the mid 1990's. The parasite has increased mortality of age 0 rainbows and poor recruitment has resulted in a near complete collapse of the rainbow population. The Colorado Division of Wildlife has experimented with whirling disease resistant strains of rainbow trout in a variety of management and research applications. To evaluate these fish in the wild, resistant strains were bred with wild strain fish and experimentally stocked with controls in the Gunnison River in the Gunnison Gorge National Conservation Area. The objective of this study was to evaluate the growth, survival, reproduction, and whirling disease infection of the experimental fish and attempt to re-establish wild rainbow trout reproduction in the Gunnison River. Resistant rainbows of the German or Hofer strain were bred with Colorado River rainbows and stocked in two reaches of the Gunnison River from 2004 to 2007. Fish were monitored with annual mark recapture population estimates in October and reproduction was monitored with multiple pass removal fry estimates in August. Tissue samples were taken from fry and analyzed with amplified fragment length polymorphisms (AFLP) to determine the presence of genetic markers associated with the resistant strain. Tag loss, emigration, and low survival of stocked fish complicated survival comparisons in some years, but the resistant strain rainbows had higher survival and growth than wild strain fish. Pepsin-trypsin digest analysis revealed that resistant strain fish developed a less severe WD infection in prevalence and severity than did the wild strain. AFLP analysis confirmed that the resistant strain fish successfully reproduced in 2007 and 2008. Age 0 fish from 2007 successfully recruited to age 1. The stocking of resistant strain fish has not increased the biomass of rainbows in areas with high brown trout densities but has increased rainbow numbers where browns are less prevalent. The experimental fish have survived and reproduced successfully and have introduced some resistance to *Myxobolus cerebralis* into the rainbow trout population of the Gunnison River.

**Rehabilitation of a rainbow trout fishery through the use of WD Resistant Strains in the Yampa River**

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Loss of year-classes due to recruitment failure has occurred in several major wild rainbow trout populations in Colorado. These losses have been associated with the severe onset of Whirling Disease (WD), caused by *Myxobolis cerebralis (Schisler,- 2006)*. In comparison to many of the longer-term Whirling disease (WD) research projects throughout the state of Colorado, studies on the Yampa River have an abbreviated history. Nonetheless, population level impacts, as a result of WD infectivity, have been realized in a seven mile stretch of river between Stagecoach Reservoir and Lake Catamount. Beginning in 2003, recruitment reductions were apparent, and complete loss of multiple age cohorts had occurred by 2006. Annual stocking of wild-strain fingerling rainbow trout has been one management approach directed towards offsetting the loss of natural reproduction in streams impacted by *M.cerebralis* (*Nehring,- 2006)*. This rainbow trout population was supported primarily by natural reproduction from 1996 – 2006. A plant of 5,000 – Colorado River rainbow trout fingerlings stocked in 2001 failed to recruit to the population. In 2002, a combined field and laboratory experiment was designed to compare infection levels in rainbow trout among various stream systems throughout Colorado. Studies on this section of the Yampa River were incorporated in this experiment. As a result of this study, Service Creek, a major tributary to Yampa River within this reach, was identified as a point source of infectivity. Subsequent *T. tubifex* worm sampling, as well as water filtration studies, conducted by *Nehring,- et.al (personal communication)* confirmed this initial finding.

The use of WD resistant strains of rainbow trout has shown promise in efforts to restore rainbow trout populations throughout Colorado. Beginning in 2006, CDOW began rainbow crosses, derived from the Hofer strain rainbow, which has exhibited higher levels of resistance in prior studies, into this population. Follow-up electrofishing studies, including fry studies, have revealed encouraging results. Recruitment of these plants into the population has been observed. Additional genetic work and *M. cerebralis* myxospore burden studies are planned for this study reach. In an additional effort to combat the effects of *M. cerebralis* in this section of the Yampa River, efforts are underway to develop a Hofer–Harrison Lake strain brood stock in Lake Catamount. This involves extensive removal efforts to control a robust northern pike population which has been established since the mid-1990s. The overarching objective is to establish a spawn operation on Harrison Creek, a main tributary of the lake, and establish a naturally reproducing rainbow trout population throughout the system.

**Heritability of Myxospore Count and Genetic Correlations in Whirling Disease Resistant and Susceptible Strains of Rainbow Trout**

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The mechanisms for resistance to *Myxobolus cerebralis* seen in the German Rainbow (GR) strain of rainbow trout are suspected to be polygenic and at least partly additive. However, the genes involved in *M. cerebralis* resistance are relatively unknown. We used a quantitative genetics approach and estimated heritability to evaluate how resistance to *M. cerebralis* is acquired in different strains of rainbow trout. Heritability was evaluated using a random single pair mating design. For the *M. cerebralis* exposure experiment, pairs of individuals were spawned from the brood stock populations of GR, F1 (GR x CRR) and Colorado River Rainbow (CRR) individuals to create unique families containing full sibling offspring for each of five strains, the GR, CRR, F1, F2 (F1 x F1) and B2 (F1 x CRR) strains. All five strains were exposed to the whirling disease parasite and reared for five months to ensure the full development of myxospores. Myxospore count was used to quantify severity of infection and variability in the count was used to estimate heritability. Our estimates of heritability of myxospore count include both additive and dominance variance components and measures the extent to which phenotypic variation is determined by genotypic variation. Myxospore counts were log transformed prior to analysis. Heritability of myxospore count was lowest in the GR, F1, and F2 strains (0.34, 0.41 and 0.32, respectively). The B2 strain showed the highest heritability of myxospore count (0.93). The CRR strain also showed a high heritability (0.65) but was lower than the B2 strain. Genetic correlations between heritability of myxospore count and mean survival characteristics, including deformities, growth, and critical swimming velocity were also estimated. Our data suggest that hatchery breeding programs can select for rainbow trout strains with decreased myxospore levels and management efforts to reintroduce rainbow trout into infected Colorado rivers may be successful.

**Distribution, Occurrence and Relative Abundance of *Tubifex tubifex*, the Aquatic Oligochaete Host for *Myxobolus cerebralis* in Colorado: Results of a 6-Year Assessment**

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Whirling Disease (WD), a malady that can severely impact some salmonid species, is caused by exposure to the myxozoan parasite *Myxobolus cerebralis (Mc)*. Two hosts, a salmonid fish and the aquatic oligochaete *Tubifex tubifex* must exist in sympatry within an aquatic ecosystem for the life cycle of the parasite to be completed. The *Mc* parasite was first detected in Colorado in late 1987 in trout at two aquaculture facilities in the Arkansas River basin. Over the next 10 years the parasite became widely distributed throughout lake and stream ecosystems that supported trout. Research efforts throughout the 1990s demonstrated that rainbow trout, brook trout and Colorado's native cutthroat trout are all highly susceptible to infection. By the end of the 20th century much had been learned about the occurrence and impacts of the parasite on Colorado's brook, brown and rainbow trout populations. However, no systematic study of the occurrence of *M. cerebralis* in high elevation habitats capable of supporting Colorado's native cutthroat trout had been undertaken. Presence of the susceptible lineage (III) of *T.tubifex* would be a critical factor in determining the potential for spread of the *Mc* parasite into high elevation habitats. If the susceptible oligochaete host could not exist above some thermal or elevation barrier, cutthroat trout would not be at risk in those habitats. First and second order streams and lakes at higher elevations (≥ 2744 m or 9,000 feet) are the habitats where cutthroat trout tend to occur. To remedy this information deficit, a 6-year study (2003 – 2008) was undertaken to 1) determine if the *Mc* parasite was spreading into these habitats 2) determine the spatial and elevational distribution, frequency of occurrence, and relative abundance of the oligochaete host *T.tubifex*, and 3) assess the risk for establishment. Genetic testing revealed DNA of lineage III *T. tubifex* was detected in aquatic oligochaetes collected from 199 of 353 sites ranging up to more than 12,000 feet in elevation, indicating there is significant risk for establishment of the life cycle if *Myxobolus cerebralis* is introduced.

**Wilderness and Whirling Disease: An Emerging Threat to Cutthroat Trout Recovery?**

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Whirling disease (WD) is caused by *Myxobolus cerebralis (Mc),* a metazoan parasite that requires 2 hosts (a susceptible salmonid fish and an aquatic oligochaete-*Tubifex tubifex*) to complete its life cycle. First detected in November 1987, the parasite became widely established in streams and lakes throughout Colorado over the next decade. The primary mechanisms of establishment and dispersal were the stocking of infected trout and migration of infected fish within and between connected lakes and streams. Studies in the 1990s demonstrated that WD was the primary factor leading to the demise of wild rainbow trout populations in Colorado and Montana. Tests of fry and fingerling trout held in sentinel cages for 12-18 months and exposed to ambient levels of infection in the Colorado River revealed Colorado's 3 sub-species of cutthroat trout were highly susceptible to infection and experienced 85-87% mortality after 90 to 130 days of exposure. At the end of the 20th century, little was known about the spread of *M. cerebralis* into largely pristine, higher elevation aquatic habitats capable of supporting native cutthroat trout in the western U.S. However, cutthroat trout fry production has fallen precipitously in two high profile lake-stream ecosystems over the past decade. *Myxobolus cerebralis* was first detected in cutthroat trout in Yellowstone Lake in 1998. It is now recognized that the cutthroat trout populations in Yellowstone Lake and the Yellowstone River are in peril due to the combined impacts of lake trout predation and *M. cerebralis* infection. The *Mc* parasite was first detected in native cutthroat trout in Trappers Lake in the Flat Tops Wilderness in 2003, but initial infections may have occurred in 1999. Results of a 6-year study (2003-2008) reveal trout infected with *Myxobolus cerebralis* have been collected from 11 streams and 6 lakes in 6 separate wilderness areas of Colorado. Infections have been detected at 4 locations over 11,000 feet and 2 over 12,000 feet. Infections among the trout in 10 of the 17 aquatic ecosystems in the wilderness areas are severe enough to be causing population level impacts.

**Patterns in habitat use and phenology of an assemblage of larval fishes in a Great Plains stream: effects of drought and habitat drying across years**

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Great Plains streams are harsh, dynamic environments for fishes and are increasingly degraded by human-caused impacts, including groundwater extraction. Although well adapted to harsh conditions, plains stream fishes are in decline, due in part to interactions between natural and anthropogenic stream drying. Effects of these factors on early life stages may serve as a bottleneck regulating their populations. To address these issues, we sampled larval fish and characterized spawning habitat from 2005-2007 in three 6.4-km segments of the Arikaree River, CO along a gradient of intermittency, wet to dry, from upstream to downstream. We developed a spawning phenology by estimating the initiation of hatching for the six most abundant fishes using an inverse prediction procedure based on larval length over time and known size at hatching, and compared our estimates to environmental factors that may serve as spawning cues. Cumulative growing season degree days had the strongest effect on initial hatching dates. Additionally, we modeled larval occupancy, abundance, and detectability for the six species as a function of spawning habitat characteristics using multiple-state occupancy models. High abundance of larvae of most species were related to measures of habitat size (e.g., area and depth) and habitat type, although spatial location (i.e., segment in which larvae occurred) also influenced abundance of some species. Detectability of larvae differed among species, and was influenced by habitat depth and larval size. Results of our modeling suggest that multiple samples from individual habitats within a season are needed to adequately detect and predict occupancy by larval plains fishes. Finally, we used an integrated model of habitat suitability and occupancy to investigate patterns of colonization and extinction among years for each species. Colonization and extinction rates for individual species differed by segment, and were influenced by among-year climate variability. Temporal availability of spawning habitats of adequate size and distribution are critical for successful recruitment in plains fish populations. Therefore, conservation efforts should focus on sustaining flows in these systems that are sufficient to maintain spawning habitats above critical size thresholds needed for successful spawning.

**Bendway weirs: would they aid the recovery of the endangered Rio Grande silvery minnow**

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Rehabilitation of the Middle Rio Grande River in central New Mexico river rehabilitation has become necessary to mitigate the effects of over a century of water and land development. The major concern for restoration involves the federally-endangered Rio Grande silvery minnow (*Hybognathus amarus;* RGSM). Bendway weirs, erosion control and channel-stabilization structures placed transverse to the channel flow, have been used to prevent river migration while enhancing aquatic habitat. Habitat improvement plans on the Middle Rio Grande include the installation of bendway weirs, but the potential benefits of these structures for Rio Grande silvery minnow are unknown. We conducted a theoretical study on the flow conditions created by Bendway weirs to determine if it is possible to create physical habitat for RGSM while simultaneously protecting the riverbank. Our study suggested that Bendway weir installation could lead to the reduction of downstream displacement of RGSM eggs, the creation of RGSM feeding and refugia habitat, and the creation of drought/low flow habitat through scour hole formation. We also noted that the weirs could also serve as potential habitat for predators, and suggest further studies to determine the full impact of Bendway weir installation.

**How pristine is the fish community of the Powder River, the "last remnant" of the Great Plains river system?**

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Wyoming's Powder River has long been touted as the last example of a pristine prairie river system. In light of the heightened development plans slated for the Powder River Basin, justification for this long-standing claim was sought. Sampling of the Powder River fish assemblage was conducted during the summer of 2008 using a 7.6- x 1.2-m treated, bag seine with 4.8 mm ACE netting. Data on species, numbers caught, and frequencies of occurrence in total length categories were collected for all fishes sampled. In addition to sampling fish, habitat information (habitat type, depth, current velocity, substrate type, and cover availability) was collected. Change in assemblage structure over time was assessed through the comparison of a "reference fish assemblage," to the summer fish assemblage as inferred from 1995 sampling conducted by Timothy Patton and 2008 sampling. The reference fish assemblage was compiled using data collected from 1964 to 1980 by summing proportions of fishes in each data set and assigning ranks to the ten most abundant taxa. A cluster analysis using data on relative abundance of fishes and habitat revealed distinct groupings of fishes, or guilds, based on summer habitat use. Examination of apparent functional organization of native and introduced fishes at the sub-assemblage level yielded insights regarding potential mechanisms for directional changes in the assemblage. We conclude that while the array of native species comprising the Powder River fish assemblage is largely preserved, the relative abundances of fishes have experienced substantial changes associated with increases in invasive fish species. The proposed guild structure points to niche overlap between native and invasive fishes as a potential mechanism.

**Habitat Use of Roundtail Chub and Interaction with Lake Trout in Two Glacial Lakes, near Pinedale, Wyoming**

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The roundtail chub *Gila robusta*, an endemic species in the Colorado River basin, is currently suffering from habitat degradation and fragmentation, and competition and predation from nonnative fishes. Within Wyoming, lakes of the upper Green River drainage are one of few places where substantial populations of roundtail chub remain. We initiated field work in 2008 to investigate habitat use by native roundtail chub and introduced lake trout *Salvelinus namaycush* in Little Half Moon and Half Moon lakes, Wyoming. Our objectives were to: (1) develop methods to assess habitat use by roundtail chub and lake trout in these lakes, (2) describe habitat use by roundtail chub and lake trout during periods of thermal stratification and non-stratification, and (3) assess the diet of lake trout to determine if predation on roundtail chub is prevalent. Five strata were developed to sample and describe habitat use: (1) littoral zone with cover, (2) littoral zone with no cover, (3) benthic zone, (4) pelagic zone at the surface, and (5) pelagic zone beneath six meters. In both lakes, catch per unit effort of roundtail chub was highest in littoral areas with cover present. Roundtail chub were also caught in littoral areas without cover but were rarely caught in other strata. Thermal stratification had little effect on the distribution of roundtail chub. In both lakes, lake trout were broadly distributed across the littoral and benthic zones when the lakes were not thermally stratified. However, after thermal stratification, lake trout were seldom captured in the littoral zone and overcall catch rates declined. The results indicate that roundtail chubs and lake trout have overlapping habitat use only when water temperatures are cool and the lakes are not thermally stratified. We are currently analyzing lake trout stomachs to determine the prevalence of roundtail chub in the diet.

**Factors affecting bioaccumulation of mercury in sport fish in Colorado reservoirs**

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Mercury (Hg) testing by the Colorado Department of Public Health and Environment (CDPHE) has uncovered a growing number of Colorado waters that contain fish with Hg concentrations that exceed 0.3 ppm, the USEPA (2001) fish tissue residue criterion for the protection of human health. In 2008, Colorado Division of Wildlife (CDOW) funded a three-year investigation to address the issue of Hg contamination in Colorado reservoirs. The goal of this research is to characterize the relative importance of factors influencing Hg bioaccumulation in reservoirs and evaluate the efficacy of fishery management strategies to reduce Hg concentrations in sport fish. We selected to study four Colorado reservoirs based on their attributes (e.g., similar size, fish assemblages and available data). Carter and Horsetooth reservoirs were selected to represent contaminated food webs, both having Hg consumption advisories for walleye (*Sander vitreus*). Chatfield and Union reservoirs also contain walleye and were selected to represent food webs without fish consumption advisories. We collected zooplankton (pelagic), chironomids (profundal), crayfish (littoral), prey fish and walleye from each reservoir to characterize Hg bioaccumulation in food webs. We also characterized abiotic factors thought to influence Hg dynamics in reservoirs including water level fluctuation, water temperature, secchi depth, conductivity and water chemistry (e.g., DO, P, Al). Preliminary findings suggest that we can evaluate the importance of several factors (e.g., reservoir productivity, hypoxia, walleye growth and water level fluctuations) that have been found to influence Hg bioaccumulation in eastern North America. We have already encountered some unexpected results that have yielded valuable and new perspectives on Hg cycling. Furthermore, our findings provide a better understanding of Hg bioaccumulation that will be used to design fishery management strategies aimed at remediating Hg contamination in reservoirs.

**Status of Anthropogenically-Isolated populations of Colorado River cutthroat trout in the upper North Fork Little Snake River Drainage**

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Inland cutthroat trout *Oncorhynchus clarkii spp.* have declined in abundance and distribution due to habitat degradation, overharvest, and negative interactions with nonnative fishes. Colorado River cutthroat trout *O. c. pleuriticus* currently occupy 13% of their historical range and genetically pure populations are rare. The upper North Fork Little Snake River Drainage (NFLSRD) on the Medicine Bow-Routt National Forest contains eight populations of genetically pure Colorado River cutthroat trout that are isolated by water diversion structures built by the City of Cheyenne. The purpose of this research was to evaluate the status of these populations through abundance estimates, population growth rates, assessment of age structure, and available habitat. While most populations do not appear to have declined in abundance over time, most are small enough to be at risk of loosing genetic variation or inbreeding. Available lengths of stream habitat in all eight streams were below recommended minimums for long-term cutthroat trout viability. Recruitment of young fish was limited in two of the shortest streams. The results of this study indicate that several of the small isolated Colorado River cutthroat trout populations in the upper NFLSRD may not be able to persist without human intervention.

**Optimizing Survival and Growth of First-Feeding Colorado River Cutthroat Trout – Diet Temperature, and Density Implications**

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Cutthroat trout formerly occupied an expansive area of western North America. However, due to habitat loss, over-fishing, and introduction of non-native trout they have experienced population declines sometimes leading to threatened/endangered status or extinction. Propagation programs are now necessary for recovery or restoration of these subspecies. Optimal culture conditions for cutthroat trout are largely unknown, so these fish are often reared using rainbow trout diets and culture techniques leading to poor hatchery performance relative to these other salmonids. This study was designed to identify diets, rearing temperatures, and rearing densities that produce optimal growth, condition, and survival of Colorado River cutthroat trout (CRCT; *Oncorhynchus clarkii pleuriticus*), which may be applicable to other inland cutthroat trout subspecies. We separately determined the effects of diet, rearing temperature, and rearing density on CRCT performance. Colorado River cutthroat trout were reared at 10°C and fed one of five commercial diets, two experimental diets, or a commercial diet combined with *Artemia* in a 119-day blinded feeding trial. Fish fed the *Artemia*-supplemented diet were 24% heavier, and had 7% higher survival than fish fed a non-supplemented diet. There were significant differences amongst non-supplemented diets, with soft-moist diets yielding lower performance and high protein, low moisture diets producing larger fish. Skretting nutra-plus (SNP), a premium salmon fry diet, produced the highest growth. There were significant differences in survival (68-86%) amongst diets. A 120-day temperature study used the top-two performing diets (SNP and Rangen regular trout, both supplemented with *Artemia*) from the diet experiment in conjunction with temperatures of 12.6-19.9°C. The optimal diet-temperature combination (SNP – 16.4°C) for growth was determined using quadratic regression. Survival was inversely related to temperature and was higher for fish fed SNP. The optimal diet-temperature combination was used in a 120-day rearing density experiment (150, 300, 450, and 600 fish/tank). Generally, growth was inversely related to density; however, fish in the 150 fish/tank treatment were the same size as fish in the 300 fish/tank treatment. Lower growth in the 150 fish/tank treatment may be due to a lack of learned feeding behavior. There were no statistically significant differences in survival amongst densities.

**Effects of cattle grazing on terrestrial invertebrate subsidies to trout in central Rocky Mountain rangeland streams**

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Research worldwide indicates that input of terrestrial invertebrate prey to streams provides about 50% of annual energy for stream fish. We tested whether terrestrial invertebrate input to rangeland streams is as great in western Wyoming and northern Colorado, and how it is modified by cattle grazing. During summers 2004 through 2008 we sampled falling invertebrate input and trout diets in streams that had riparian zones under four different grazing systems including season-long, intensive-rotation, and wildlife-only grazing regimes. Input of terrestrial invertebrates in both regions was similar to estimates for other semi-arid regions and was consistently greater in streams with riparian zones under rotational systems versus season-long grazing. In turn, trout inhabiting streams managed under rotational grazing consistently consumed more invertebrate biomass (both aquatic and terrestrial) than fish in sites under season-long grazing. Moreover, >50% of biomass in trout diets in all streams consisted of terrestrial invertebrates, regardless of grazing management. Total trout biomass also was greater in streams under rotational grazing systems in the more arid region. Currently, we are analyzing the results of a broad-scale evaluation of grazing effects on terrestrial prey resource subsidies to trout in 16 Colorado streams. Additionally, we have recently completed a large scale field grazing experiment evaluating the effects of four grazing treatments: control, moderate (4-6 " stubble height) and intensive (2-3 " stubble height) grazing, and intensive grazing with 66% woody vegetation removal. Results from these studies will be used to determine the extent to which inputs of terrestrial prey provide important resources that sustain trout in western rangeland streams, whether prescribed grazing management may increase trout biomass, and if patterns are consistent across the central Rocky Mountain region. We will present a broad overview of these current projects.

**Colorado River Cutthroat Trout Restoration Opportunities: A GIS Model for Identifying the Good, the Bad, and the Ugly**

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Large-scale assessments for native trout management have become useful tools in identifying spatial distributions and the population status for North American trout species range-wide. However, due to the scale, these assessments may not be entirely useful for public land biologists in setting restoration priorities. The Colorado River cutthroat trout (*Oncorhynchus* spp) is one of 14 cutthroat trout subspecies experiencing range-wide declines. Using Colorado River cutthroat trout as a target species, we are proposing a GIS model that may assist biologists in setting restoration priorities at a finer scale. The model will include several variables that we feel are important for predicting where potentially suitable habitats are located. The variables included in the model are: roads, whirling disease, barriers (natural and man-made), water conveyance and development, non-native fish presence, land use/management, and mountain pine beetle/tree mortality. The model will be able to identify potential restoration sites based on the relative importance of each variable, giving us "the good, the bad, and the ugly.

**Multiple-Scale assessment results for the White River National Forests, implications for identifying future Colorado River Cutthroat (*Oncorhynchus clarkii pleuriticus*) restoration based on watershed characterization and abundance of anthropogenic activities**

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Results of a multiple-scale landscape assessment conducted on the White River National Forest (WRNF) and surrounding landscape identified several "clusters" of 6$^{th}$ level watersheds with similar ecological characteristics. Measures of landscape level ecological drivers that have major influences on finer scale habitat and biota were chosen and analyzed at 2 scales. The results produced a clustering of 6$^{th}$ level watersheds (HUCs) with similar ecological characteristics. Not surprisingly, most of the 154 HUCs intersecting or within the WRNF were characterized by high elevation and low productivity geology and stream gradients. Two clusters contained the highest combinations attributes important for aquatic productivity (clusters M4R and M5R). Of the 154, 6th HUCs identified in this analysis, only 24 are associated with these 2 groups of watersheds. One other cluster (M6R) exhibited high productivity characteristics, but only the higher elevation portions were on public lands. A total of 22 anthropogenic activities were evaluated across the assessment area, both individually and cumulatively. The highest concentration of activities was located in the south and eastern portion of the assessment area, with the Flat Top mountains (northern) area exhibiting markedly less activity. There was no relationship between the abundance of anthropogenic activities and aquatic/riparian resources at the 6$^{th}$ level watershed scale, most activities being related to access. However, there were a few HUCs that exhibited characteristics of high productivity and little management activity. While Colorado cutthroat trout occupied most of the watersheds in the assessment area historically, biologists are continually identifying new areas with relatively high chance of restoration success. While there are other social and logistical challenges associated with recovery efforts these results show that there may be a few watershed level opportunities available with relatively high productivity capabilities and few management activities.

## Larvae and Early Juveniles of Three Small, Non-native Cyprinids Common to the Upper Colorado River Basin: *Cyprinella lutrensis*, *Notropis stramineus*, and *Pimephales promelas*

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Red shiner *Cyprinella lutrensis*, sand shiner *Notropis stramineus*, and fathead *Pimephales promelas* are small-bodied, non-native cyprinids of common to the middle and lower reaches of Upper Colorado River Basin streams and rivers. To better facilitate visual identification of captured larvae and early juveniles, especially recently hatched protolarvae, prior descriptions and illustrations are being supplemented and assembled into more complete and comparable species accounts. This poster highlights some of the drawings and information being prepared and assembled for inclusion in a comprehensive guide to cyprinid larvae and early juveniles of the basin. In general, red shiner (RS) and sand shiner (SS) hatch, complete yolk absorption, and attain comparable developmental states at slightly smaller sizes (standard and total lengths) than fathead minnow FH, but RS usually attain a juvenile state at a notably smaller size than the others. Most protolarvae and mesolarvae can be distinguished by a combination of characters: RS and SS typically have distinctly oval eyes, FH round to slightly oval; SS and RS typically have 20-22 preanal myomeres, FH 23-24; RS are usually least pigmented, FH most; unlike the others, RS dorsal body pigment generally remains absent to very sparse, not developing a double line pattern anterior to the origin of the dorsal fin until after the mesolarval phase; the underside of the head remains essentially unpigmented in RS and SS, whereas oblique lines of pigment usually develop along or near the margin of the preopercles in FH; except anteriorly, the ventral surface of the abdomen is typically well speckled with evenly spaced melanophores in SS, moderately to sparsely pigmented with aggregations of melanophores, but sometimes unpigmented or becoming so in FH, and unpigmented in RS, except in some protolarvae which may have moderate to sparse aggregations of melanophores; and although the dorsal to dorso-lateral surfaces of the gut between the air bladder and vent are well pigmented in all three species, the pigment is usually closer to the surface and appears more intense in RS. Metalarvae and early juveniles are most readily distinguished using several adult characters.

**A Family-level Computer-interactive Key to the Larvae of Freshwater Fishes in the United States and Canada**

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Nearly 800 freshwater and anadromous fishes, representing about 40 families, are found in the United States and Canada. This key, an ongoing work-in-progress, currently covers 26 of those families and can be limited to any desired subset of those families, one of which has been predefined for the Upper Colorado River Basin. Summarizing mostly published descriptive information by family, I built a database in DELTA (DEscription Language for TAxonomy) format using DELTA Editor and created associated files for use by the host program, DELTA Intkey. The host program can be downloaded over the Internet without cost at website http://delta-intkey.com/ B select "Programs and Documentation," then "Intkey." The data and associated files for this key (including a "readme" instruction file) are available for download at http://welcome.warnercnr.colostate.edu/lfl-files-to-download.html B select "fam-na.zip." Computer-interactive keys are modern, flexible, and user friendly alternatives to dichotomous (and polychotomous) keys, but like dichotomous keys, they are tools to help facilitate identification and are not infallible. Among other limitations, errors in the data extracted from published descriptions may be perpetuated in this key, and it may suffer from inadequate or incomplete data for some taxa. Users are asked to notify me of any corrections or difficulties they may have, as well as forward suggestions for improvement.

**"Illegal Stocking of Aquatic Organisms": a new website and outreach tool**

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Illegal fish stocking is a global phenomenon, and the problem of anglers intentionally stocking fish to create recreational fisheries is particularly troublesome. With input from the Chapter's Illegal Stocking Task Force, I developed a website to: draw attention to the problem; educate stakeholders, agency personnel, and the legal system; and discourage would-be stockers from engaging in the practice. My goal is that the website evolves into a clearinghouse for illegal stocking information and outreach materials contributed from any entity concerned about the issue, worldwide. At present the website provides the following: fines and jail terms, plus law enforcement hotline numbers for 16 western states and provinces; a "how you can help" page; a short compilation of literature; and several brief synopses of illegal fish stocking cases. Screen shots from the website will be presented, and future plans for the site will be discussed. Audience comments for improvements to the website will be solicited.

**Spatial and temporal patterns of brown trout (*Salmo trutta*) spawning in an urban stream**

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Urban streams function as storm runoff drainage systems, public recreation sites, and habitat for aquatic biota (i.e., fishes). Spring Creek, a tributary to the Laramie River, is a spring-fed, urban stream in the City of Laramie, Wyoming. The riparian vegetation of Spring Creek (i.e. willows) is managed by the City to enable optimal conveyance of storm runoff. In addition to serving as a conduit for municipal runoff, Spring Creek also provides spawning habitat for brown trout (*Salmo trutta*) from the Laramie River. As part of a cooperative effort between the Wyoming Game and Fish Department and the University of Wyoming Student Subunit of the American Fisheries Society, a monitoring effort was implemented to document spawning activity in Spring Creek. The project goal was to gain an understanding of the function of Spring Creek as a spawning site for Laramie River brown trout, further enabling the effective, cooperative management of the creek by City officials and state fisheries managers. Surveys for brown trout redds were conducted over a 6 week period spanning October and November, 2008. Redd age, lengths, widths, GPS coordinates, and confidence categories denoting the certainty of positive redd identification were recorded for each redd surveyed. Spatial and temporal analyses were conducted to begin to examine the functional processes directing the seasonal use of Spring Creek as a spawning tributary. Fifty nine redds were identified within the 2-km study reach. Spatial analyses revealed distinct clusters of redds, suggesting selective use of available instream habitat. No temporal differences in frequency of new redd construction was observed among reaches. Preliminary work identified the potential for observer error based on confidence categories. Initial efforts have identified future research directions for the project including: (1) quantifying available spawning habitat; (2) measuring observer error and; (3) examining spatial and temporal similarities between the seasonal use of Spring Creek and Laramie River habitat by spawning brown trout.

**Durability of Gellan Gum Beads in Rio Grande Water**

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We conducted a simple laboratory experiment to determine whether gellan gum beads degraded in Rio Grande river water over a period of six days (144 hours). Gellan gum beads are a biodegradable food product that is frequently used as a surrogate for fish eggs and larvae when conducting experiments to quantify drift and dispersion of early life stages. During these experiments, beads are released into the river channel at an upstream location and subsequently sampled at downstream locations for up to several days. This methodology assumes that beads are available for capture for the duration of the experiment (i.e., beads have not substantially degraded), although the durability of gellan beads in river water has never been formally tested. We conducted six drift experiments in the Middle Rio Grande of New Mexico in 2005 and 2007, using gellan gum beads as surrogates for Rio Grande silvery minnow (*Hybognathus amarus*) eggs. At the collection location furthest downstream, beads were sampled up to 96 hours post release. To determine whether bead degradation may have biased the results, we conducted a laboratory experiment. Thirty gellan gum beads were placed into each of 12 two-liter canning jars that were filled with 1,500 ml river water collected from the Rio Grande at Central Bridge in Albuquerque, New Mexico in January 2009. Jars were randomly assigned to one of four treatments: 1) beads mixed for 48 hours, 2) beads mixed for 96 hours, 3) beads mixed for 144 hours, 4) beads in still water for 144 hours. Continuous mixing was produced by an aquarium pump and air stones. Beads were counted, measured for diameter, and weighed before and after each treatment. No significant differences were detected in bead count, bead diameter, or bead mass among treatments. Although field conditions were not perfectly reproduced in the laboratory, we conclude that bead degradation would not have substantially biased the results of the Rio Grande drift experiments.