USING THE B.A.S.S. (BASIN AREA STREAM SURVEY) SYSTEM WITH GIS TO QUANTIFY STREAM REHABILITATION AREAS

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THE BEAVER TAILWATER RESTORATION PROJECT

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The Beaver Dam Tailwater is located on the Upper White River in Carroll County, Arkansas. Water flows in this tailwater are influenced by U. S. Army Corps of Engineers flood control and hydropower operations. Tailwater flow rates normally range from a minimum of 65 c.f.s. to a maximum of 10,000 c.f.s. with historical averages of 7,900 c.f.s. During flood control operations the Corps of Engineers discharged 51,200 c.f.s. down the Beaver Tailwater in May, 1990.

Extensive erosion of the stream banks carried gravel into the river filling previously existing holding pools, creating new shoals and choking existing riffles. The annual erosion rate was estimated to be 37769.14 cu.ft./milyr. Significant fish cover, submerged trees, root wads, and bank cuts were either destroyed or washed away. An extensive restoration plan was developed for the upper four miles of this tailwater. Trout Unlimited in conjunction with two local chapters in two different states, the Arkansas Soil and Water Conservation Commission and the Arkansas Game and Fish Commission provided over $177,000.00 to fund this restoration project.

This tailwater restoration project includes stabilizing the eroding stream banks with cedar tree revetments, and log cribs. Bioengineering techniques utilized for bank stabilization includes contour willow brush layering, use of willow stakes and several bio-matting blankets. Boulder clusters were placed in the tailwater to create scouring, direct water flows and provide fish cover. Trees and root wads were placed in the tailwater for scouring, overhead fish cover and velocity breaks. This project will serve as an opportunity to evaluate various techniques that

can perhaps be used in future stream restoration projects.

RIPARIAN AND INSTREAM HABITAT CHARACTERISTICS OF SELECTED SITES IN THE OZARK PLATEAUS UNIT

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ILLINOIS RIVER STREAMBANK SURVEY

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The physical habitat survey of the Illinois River began in August 1994, stariing at the confluence of the river with Clear Creek, and ending at the City of Siloam Springs water intake on what is left of Lake Francis. Parameters surveyed included canopy, average stream width, average stream depth, bank angle, riparian zone width, cattle access points, rural access points, in-stream gravel removal sites, riffle-pool length, and streambank erosion. In addition, pH, turbidity, conductivity, dissolved oxygen, water temperature, and Secchi disk depth were measured in each pool.

The Illinois River begins at an elevation of 1,000 feet and drops to 920 feet over the 17 miles within the survey area (3.6 feet per mile). A total of 22 sites were identified as streambank erosion sites totalling 21.5 miles with an average length of 437.6 feet and height of 13.6 feet. The erosion sites accounted for 12.6 percent of the 17 miles of streambank sweyed.

A sudden rise in Secchi depth occurs near the Lake Francis dam and is probably due to the old lake sediments that are exposed or being resuspended. The streambanks are not covered with well established vegetation. Most of the vegetation consisted of ragweeds, not trees or grasses. The river behind the dam is not simply a wide shallow wetland but a winding river with riffles and pools. The substrate in the riffles is not rock but mudballs ranging in size from 1" to 8". This helps negate 17 miles of filtration through gravel bars and settlement. In effect, the river has reverted back to what it was at the Clear Creek confluence. This is further exemplified by the fact that the pool depths averaged 3.3 feet over the 17 miles. Riffle depths sometimes exceed pool depths because the stream channels are narrower and deeper from downcutting of the gravel bars. Though shallower, the pools were at bank full width. Normal riffie distribution in an Ozark stream is every 5 to 7 channel widths. The Illinois River exhibited a ratio of one riffle every 13 channel widths. This is possibly due to sedimentation of pools, resulting in shallower depths and the disappearance of the adjoining riffle. The influx of sediment from eroding streambanks increases embeddedness, resulting in a loss of habitat for benthic macroinvertebrates, and ultimately affects fish communities. Secchi disk, turbidity, the amount

of streambank erosion, and lack of riparian zone all contribute to a stressed stream system.

Some Effects of Instream Gravel Removal on Channel Stability and Habitat Quality in an Ozark Mountain Stream.

Martin Maner and Mike Rodgers

Instream gravel removal is widely practiced in Ozark Highland streams in Arkansas. As a nonchemical stressor, this practice can contribute to increased turbidity and sedimentation within the stream. It may also play a significant role in stream bank erosion, channel instability, substrate particle size distribution, and habitat for aquatic organisms. The goal of the study is to evaluate changes in stream channel morphology, stream channel stability, substrate size distribution, and sedimentation between upstream (nonimpacted) and downstream sites. This information will be used to assess the impacts on the biological community, particular through the degradation of habitat quality. Evaluations are being conducted on Crooked Creek which is located in Boone and Marion Counties in north-central Arkansas. It is one of the most intensively mined streams in the region and has a reputation as one of the best smallmouth bass fisheries in the state.

Production Dynamics: A Useful Tool for Fisheries Research and Management

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Numerous static measures of fish populations (e.g., density or biomass) appear in the literature and may be of interest for specific applications, but the dynamic measure of production rate is by far the best indicator of a species' ecological success. Production is a synthesis of population density, biomass, recruitment, growth, and mortality and is especially responsive to the welfare of a population and environmental change. Production is defined as the rate of tissue elaboration over time, regardless of its fate, and represents a quantitative measure of energy flow through an ecosystem. The instantaneous growth rate method is most commonly used to estimate fish production with results expressed in units of mass per area over time (usually kg/ha/yr). Water quality and habitat have been shown to influence fish production dynamics, and species of higher trophic levels tend to exhibit lower production rates. Many fisheries managers and researchers routinely gather the population data required to estimate production, but rarely do so, presumably because the computations can be complex and cumbersome. Microcomputer software developed by the author to estimate fish population parameters, productions rates, and associated variances will be described and made available to facilitate the incorporation of production dynamics into fish population assessment for research and management.

FIVE YEARS OF SMALLMOUTH BASS PRODUCTION IN BEAVER RESERVOIR NURSERY POND, ARKANSAS

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Arkansas Game and Fish Commission stocked smallmouth bass into Beaver Reservoir between 1981 and 1994 in an attempt to establish that game fish. Between 1988 and 1994, smallmouth bass were stocked using the newly constructed 11 ha Beav-er Nursery Pond. Adult fish were captured from Bull Shoals Reservoir in April, allowed to spawn in the nursery pond, and young-of-year fish and their parents were then emptied into Beaver Reservoir. In 1990, Arkansas Coop Research Unit began estimating the number of young smallmouth bass produced in the Beaver Nursery Pond. During the first three years the nursery pond was released fish in late June. Estimated numbers of young-of-year fish were: 1990 = 118,000 fish, 1991 = 165,000 fish, 1992 = 57,000 fish; mean total lengths during those releases were 52 mm, 45 mm, and 53 mm respectively. In 1993, fish in the nursery pond were held until September 23. Numbers of young fish produced dropped by 50` from earlier years (62,000 fish) and nearly doubled in mean size (87 mm). Between 1990 and 1994 nearly 500,000 young smallmouth bass were stocked into Beaver Reservoir, along with approximately 2,000 adult fish. Success of the nursery pond stocking first found in 1992 when 56 young-of-year smallmouth bass were captured in Beaver Reservoir prior to release of the nursery pond fish.

COMPARISON OF GROWTH, RELATIVE WEIGHT AND HEALTH OF LARGEMOUTH BASS IN TWO ARKANSAS LAKES

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Abstract: Lake Ashbaugh and Swepco Lake are both located in northern Arkansas, yet at opposite ends of the state. Swepco Lake is unique among Arkansas reservoirs in that it receives thermal effluent from an electrical power station. Swepco Lake was intentionally stocked with Florida largemouth bass *(Micropterus salmoides salmoides)* (FLMB) a single time in 1980; Lake Ashbaugh was unintentionally stocked with FLMB alleles due to mixed broodstock within the state fisheries division. Both lakes have been identified as possessing high frequencies of Florida bass alleles. Largemouth bass were collected from Lake Ashbaugh (n = 152) and Swepco Lake (n = 53) with assistance from the Arkansas Game and Fish Commission. Length at age, relative weight, phenotype and health were determined for both populations. Length at age, total weight and length, absolute weight and relative weight were significantly greater for Swepco Lake largemouth bass than for Lake Ashbaugh bass (p>O.OO1). An autopsy-based fish health assessment revealed that Swepco bass also had greater health. Largemouth bass of Lake Ashbaugh were characterized by a heavy parasite load; Swepco Lake bass exhibited high deposition of mesenteric fat. Largemouth bass of both lakes exhibited high allele frequencies for the Florida subspecies, with the ratios largely reversed for each lake. There was a dominance of intergrade bass within both lakes. Despite these mixed alleles, there were no significant

differences identified for bass possessing or lacking Florida alleles for any of the parameters measured within each lake.

Growth and Yield of Bighead Carp (Hypophthalmichthys nobilis) and Bighead-Silver Hybrids (Hypophthalmichthys nobilis x Hypophthalmichthys molitrix) and its Reciprocal in Fertilized Ponds

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Bighead carp (Hypophthalmichthys nobilis) were stocked at three densities (500, 320 and 130/ha) into O.lOha earthen ponds with an average weight of 0.36kg. Each treatment was replicated three times. Ponds were fertilized eight times based on weekly Secchi Disk readings with a water soluble fertilizer (12-46-9) and cottonseed meal. Hybrid bighead-silver carp (HBSC), their reciprocals (HSBC) and BHC were stocked in a separate study into 0.05ha earthen ponds at 500 fish/ha with three replicates of each treatment. Ponds were managed as described above. BHC Growth (g/d) was significantly affected by stocking density (P<.05) with the lowest growth (10.97 g/d) in the high BHC density and highest growth (15.63 g/d) in the lowest density. All fish reached minimum market size of 2.00 kg. Yields after 153d were 832, 692 and 355 kg/ha in the high, medium and low densities, respectively, and were significantly different (P<.05). After 168d of production, there was no significant difference in net yield between HBSC (897 ka/ha) and HSBC (829 kg/ha) (P.<05). BHC (1157 kg/ha) net yield was significantly greater than that of either hybrid (P<.05). Likewise average growth rates were significantly different (P.<05) between BHC (13.77 g/d) and either hybrid, but not between the HBSC (lO.92 g/d) and HSBC (9.88 g/d) hybrids. The highest BHC density produced the greatest yield and adequate size to supply a cannery. There was no discernible advantage in growth or yield of hybrid HBSC and HSBC over BHC.

EUTROPHICATION TRENDS INFERRED FROM HYPOLIMNETIC DISSOLVED OXYGEN DYNAMICS WITHIN SELECTED WHITE RIVER RESERVOIRS, NORTHERN ARKANSAS SOUTHERN MISSOURI, 1974-94

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Four major reservoirs exist in the White River Basin in northern Arkansas and southern Missouri. Beaver, Table Rock, and Bull Shoals Lakes form a chain of reservoirs on the mainstem of the White River. Norfork Lake is on the North Fork River, a tributary of the White River. Vertical water-column profiles of temperature and dissolved-oxygen concentrations have been collected monthly at sites near the dam of each reservoir since 1974. Hypolimnetic oxygen dynamics of these reservoirs were examined based on the near-dam data and used to infer temporal changes in eutrophication following the concept that the hypolimnetic oxygen deficit changes as eutrophication changes.

Based on the results of this study, it appears that eutrophication may have decreased in Beaver and Table Rock Lakes and remained stable in Bull Shoals and Norfork Lakes from 1974

to 1994. Beaver Lake is the youngest of the four reservoirs, constructed in 1963, and for the period of record, may have been in the initial stage of high productivity followed by a declining stage of productivity which generally occurs within a reservoir soon after impoundment. Table Rock Lake was constructed in 1959 and, for the period of record, may have been in the stage of declining productivity following the peak of productivity resulting from impoundment. The impoundment of Beaver Lake upstream may have also influenced the decline of productivity within Table Rock Lake. Bull Shoals and Norfork Lakes are older than Beaver and Table Rock Lakes, constructed in 1951 and 1944, respectively. The reason that no changes in eutrophication could be detected in Bull Shoals and Norfork Lakes could be that these reservoirs, for the period of record, were characterized by the stage of low and stable productivity which generally occurs within a reservoir many years after impoundment.

Surface Chlorophyll Estimations on Bull Shoals Reservoir and Their Link to Land Use Practices

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Landsat 5 imagery data were used to produce a regression model for predicting surface chlorophyll concentrations on Bull Shoals Reservoir, Arkansas. Field data were collected concurrently with satellite flybys for four seasons during 1994-1995. Using a step-wise regression approach, best fit regression models were developed for each season. Once the models were determined,

they were applied to past satellite data which had no corresponding field data. The estimates were then compared to United States Geological Survey chlorophyll records to assess the accuracy of these predicted values. Chlorophyll estimates were used to produce thematic maps for each year analyzed. The maps were then imported into a geographical information system, where analyses to determine the influences of the surrounding land use practices were performed. This approach allowed us to review the trend of water quality within Bull Shoals Reservoir in relation to changing land use practices over the past several years. The thematic maps of chlorophyll values were used to identify areas of the reservoir that appeared to be experiencing water quality problems. These areas were then correlated to the land use practices most heavily represented in that area of the watershed. Once specific types of land use had been linked to changes in water quality, management practices could be addressed.

MOVEMENT OF WALLEYE AND STRIPED BASS IN NORFORK RESERVOIR, ARKANSAS

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Walleye and striped bass implanted with temperature-sensitive transmitters in 1994 and 1995 were tracked in Norfork Reservoir to determine movement, behavior and habitat preference. Results showed walleye preferred uplake riverine portions of the reservoir but ranged as far as midlake. Striped bass remained in the vicinity where netted and demonstrated home range tendencies until water quality deterioration forced them to the refuge areas at the dam during late summer stratification. Striped bass tracked for 24 hours in August and September 1995 demonstrated three distinct behaviors: quiescence, meandering, and cruising. During August tracking striped bass fed during diurnal periods, utilizing an area of about 21 km2. In September, striped bass fed nocturnally and wererelegated to an area of 2 km2. Angler harvest of both species was much higher than expected; 85% of both species in 1994 and 90% of tagged striped bass in 1995. Behavior, undenvater structures, basin morphometry, and reservoir water qualit,v conditions all contnbuted to movement and preferred habitat selection.

USE OF AN INDEX OF BIOTIC INTEGRITY TO ASSESS FOREST MANAGEMENT IMPACTS

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ABSTRACT: The Index of Biotic Integrity (IBI) uses a range of fish assemblage attributes to evaluate stream biotic integrity. The objectives of this study were to: 1) modify the IBI to reflect regional differences in fish assemblages in the Lower Ouachita Mountains Ecoregion: 2) use the IBI to compare water quality in streams of forested watersheds receiving varying intensities of timber management; 3) relate differences in IBI scores with correspanding differences in chemical, physical, or aquatic macroinvertebrate community characteristics. Using analysis of variance, the null hypothesis of equal mean IBI scores among streams was rejected (alpha = .05). Fisher's LSD Procedure revealed significant differences in IBI scores between one of the streams in an uneven-aged managed watershed and each of the other streams (reference, even-aged managed watershed, and uneven-aged managed watershed). Turbidity and total suspended solids had statistically significant relationships with IBI scores. Trophic composition appeared to have been impacted more by the effects of silvicultural activities, roads, and/or grazing than did fish species richness and composition. Further refinement of the IBI should enable its use in the Ouachita Mountains Ecoregion to help assess site impacts, monitor stream biotic integrity, and assess effectiveness of forestry best management practices.

FISH COMMUNITIES OF SITES REPRESENTATIVE OF SELECTED ENVIRONMENTAL SETTINGS IN OZARK STREAMS

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Thirteen stream sites in the Ozark Plateaus have been selected as part of the National Water-Quality Assessment Program (a long-term research and monitoring program of the U.S. Geological Survey) to represent selected environmental settings in the Ozark Plateaus. These sites were selected to represent various combinations of physiography/geology, land use, and stream size. Water quality, aquatic habitat, and biological communities (fish, benthic invertebrates, and periphyton) have been monitored at each site since 1993.

Fish communities can be a good integrator of overall habitat and water quality of a stream. One of the greatest differences found in the fish communities to date during the study is a relatively consistent increase in the abundance of stonerollers at sites in drainage basins with higher percentages df agricultural activities. Elevated concentrations of nutrients at these sites probably have resulded in greater production of attached algae. Stonerollers feed on attached algae. Stonerollers are a common fish in most Ozark streams, regardless of nutrient concentrations.

As expected, fewer species of fish were collected from sites on small streams than from large streams. Approximately 20 species were collected from small streams compared to approximately 40 species from large streams.

ARKANSAS WETLANDS CONSERVATION PLAN

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The *Arkansas Wetlands Conservation Plan* (PLAN) is a comprehensive planning document being developed by the Multi-Agency Wetlands Planning Team (MAWPT) which combines wetland inventory information and state strategy recommendations to:

* Address wetland issues and concerns (i.e. mitigation, BMP's, public outreach and education, etc.);
* Identify priority areas for restoration, protection, and enhancement through individual Watershed Wetland Strategies;
* Evaluate existing state agency resources, responsibilities, and wetland programs;
* Provide recommendations for plan implementation in an Arkansas Wetland Strategy.

The goal of the PLAN is to focus state resources into one coordinated effort to achieve a "bottom-up approach" to wetlands management which emphasizes voluntary conservation participation.

MAWPT's two-pronged approach to developing the PLAN includes:

* **Arkansas Wetlands Strategv-Non-watershed** specific evaluation of state wide issues, objectives, institutional capacities, state resources; and recommended steps for implementation, monitoring, and evaluation of *Arkansas Wetland Conservation Plan* to meet both state-wide and watershed objectives; and
* **Watershed Wetland Strategies--Identification** of emphasis areas within the watershed for prioritized wetland preservation, restoration, and/or enhancement to promote more efficient utilization of funding resources allocated voluntary, incentive-based conservation programs.

MAWPT members include: Arkansas Department of Pollution Control and Ecology, Arkansas Forestry Commission, Arkansas Game and Fish Commission, Arkansas Natural Heritage Commission, Arkansas Soil and Water Conservation Commission, and University of Arkansas Cooperative Extension Service.

Population Dynamics of Ozark Cavefish in Logan Cave National Wildlife Refuge

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The Logan Cave population of Ozark cavefish was surveyed 25 times from 23 SEP 93 to 09 SEP 95. A total of 113 individual Ozark cavefish of were captured and injected with visual implant tags, eleven fish with tags from a 1992 study were also captured, bringing the total number of fish greater than 30 mm captured to 124. Sixty-seven (54%) of these fish were recaptured at least once. Jolly-Seber (open population) estimates of abundance, survival, and recruitment were calculated from the capture-recapture data for each sampling period. These estimates fluctuated greatly over the two year period. In situ growth rate was determined by measuring the total length of each fish at capture and recapture intervals. Larger fish were found to grow at a slower rate than smaller fish. Movement between captures was also determined and compared to those calculated in the 1992 study. The mean total length of cavefish decreased as the study progressed due to a higher number of smaller fish in the population

FACTORS AFFECTING ELECTROFISHING EFFICENCY FOR FISHES OF THE SOUTH-EASTERN UNITED STATES.

Billy Justus and A1 Gibson. Mississippi Department of Environmental Quality. 1542 Old Whitfield Rd. Pearl, MS 39208.

Flectrofishing has become the prm~ary fish sampling method for Mississippi Department of Environmental Quality. In 1995 we visited 60 sites for a total of 125 occasions, and collected more than 300

composite samples for various contaminants. Sampling has been conducted at or near this rate since 1989. The gradient between the typically low conductivity of inland streams versus the typically high conductivity of estuararies has provided valuable information pertaining to the capabilities of electrofishing equipment on both ends of the spectrum. Additionally, our effort to document contaminant loading in a majority of MS water bodies has allowed our personnel to identify several factors which affect electrofishing efficiency and species-specific susceptibility. Some of the factors to be discussed include: water temperature, water conductivity, anode/cathode size, effects of seasonality on metabolism and depth preference, and manipulation of electrical settings to achieve proper power.

FRIENDS OF THE LITT LE RED

Sam Lester
Friends of the Little Red River

Friends of the Little Red is a non-profit organization which was incorporated November 3, 1993. The organization's primary goal is the preservation and enhancement of the Little Red River as a premier trophy trout stream and also to assist fishermen of all ages in developing awareness, knowledge, skills and commitment to result in informed decisions, responsible behavior and constructive actions concerning wildlife and the environment upon which all life depends.

Our live trophy release program is a unique effort to reduce the number of lunker trout removed for mounting purposes. Current taxidermy technology does not require that a fish be killed in order to secure "bragging rights" on the catch. The fisherman can have a fiberglass replica to hang on the wall and still release the fish to spawn and continue to grow. Considerable additional cost is involved as the replica must be cast from molds, assembled, and then painted to match the fish being replicated. Our organization feels we can influence the fisherman to carefully release his or her trophy by offering to pay the additional cost of a replica over the cost they would encounter for a skin mount.

To date we have teceived eighty completed live trophy release applications with only ten requesting a replica. The fish released included browns and rainbows from twenty-one to thirty-one inches in length. A twenty-nine inch brown reported on a live trophy release application is the current National Fresh Water Fishing Hall of Fame Catch and Release World Record holder on fly rod with six pound tippet.

Application of Ecotoxicology Research to Environmental Studies at Arkansas State University

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Arkansas State University's College of Arts and Sciences initiated and has furnished support for the Delta Project for Aquatic Ecosystem Studies since 1992. The university recognized that most research in the delta during the coming decade will include work directed toward the larger field of integrated environmental science and resource management. This field includes recognition of the shift from protecting against toxic damage to ensuring robust ecosystem condition. In order to

address those research topics at the interface, the Ecotoxicology Research Facility was established in 1994 and has been used in various projects to provide microcosm simulation for the testing and validation of effects level determinations. This presentation will provide a view of ongoing and completed research that has helped to establish critical partnerships to ensure that investments will have positive effects upon water quality, water use, and maintaining species and ecosystems as sentinels of early warning. Procedures used thus far in the facility research incorporate testing freshwater organisms both in the laboratory and through in-situ field exposures to evaluate the toxicity or bioaccumulation of contaminants associated with whole sediments and overlying water.

The Evaluation of Chloride as a Limiting Factor in Reconstituted Waters with the Amphipod, *Hyalella azteca* (Saussure).

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In order to standardize results from toxicity tests, a variety of reconstituted waters have been used. Historically, the amphipod, *H azteca* performs poorly in reconstituted waters, especially the softer waters. The purpose of this study was to determine if amphipod survival improved by increasing the chloride concentration of reconstituted water recommended by the America Society for Testing and Materials and the U. S. Environmental Protection Agency. Specifically, hardness and alkalinity were held constant and the chloride concentration was varied by substituting incremental amounts of calcium chloride (CaCl2) and magnesium chloride (MgCl2) for calcium sulfate (CaSO4) and magnesium sulfate (MgSO~). Three 96-h static tests with five concentrations of chloride were conducted. A significant difference was found for the five chloride concentrations tested (F value=99.05, P=.0001). Survival was lowest at l.9mg/L and 5.9mg/L was lower than 9.9, 17.9, and 33.9 mg/L chloride. The 96-h tests demonstrated that chloride concentrations of less than 17.9 mg/L are not adequate to avoid chloride deficiency in toxicity testing

Influence of pH and Hardness on Interactions Between Brook Charr and Rainbow Trout

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Anthropogenic acidification may affect ecological interactions between species. Field ev~idence shows that introduced rainbow trout often replace native brook charr in downstream (hardwater, circumneutral pH) but not headwater reaches (softwater, depressed pH). One explanation for this phenomenon may be competitive displacement moderated by abiotic factors. We tested the hypothesis that the putative competitive superiority of rainbow trout (RT) over brook charr (BC) in downstream but not upstream areas may be altered by changes in such factors. A factorial design was used to expose hatchery fingerlings of both species either alone, same species-paired, or opposite species-paired to high and low pH and water hardness levels. Fish were fed commercial trout chow at levels designed to effect competitive interaction between paired animals. Mortality and specific growth rate (SGR) were determined. Survival of both species was reduced in low

pH/hardness exposures. In soft water at high pH, RT exhibited significantly lower SGR in RT/RT pairs than in RT/BC pairs. At low pH, BC exhibited significantly higher SGR than RT in BC/RT pairs; this difference disappeared in high pH exposures. No differences in SGR among any fish pairs were seen in high hardness water at either pH level. These results suggest that interspecific interactions can be altered by environmental factors and may be a useful tool for evaluating sublethal anthropogenically-induced stress.

The Recovery of a Stream Fishery Subsequent to Mine Remediation.

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The degradation of aquatic ecosystems due to mine drainage is a significant environmental problem. Few investigations have evaluated the effectiveness of remediation programs and recovery of aquatic ecosystems. The Walker Mine produced an effluent containing elevated concentrations of Cu which entered Little Grizzly Creek from the mine's closure in 1941 until its sealing in 1987. This investigation determined fish community structure in Little Grizzly Creek and compared the results with previous studies. A 1980 study reported abundant trout populations at the upstream site while no fish were present at all downstream sites. A long-term, 1991 -1994, quantitative analysis of the fish population demonstrated some recovery, especially at the downstream sites. Recovery of the fishery was correlated with decreased Cu concentrations (water, sediment, attached algae, invertebrate and fish) and increased invertebrate diversity and densities.

Key words: Copper, Fishery, Recovery, Remediation
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Sexual Differences in Mortality and Sublethal Stress in Channel Catfish Following Exposure to Copper Sulfate

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Copper sulfate is regularly used in the aquaculture industry for the treatment of various ectoparasitic infestations. Male and female channel catfish (*Ictalurus punctatus) (* 100 fish per group) were treated for 10 weeks with three levels of copper sulfate (1.7, 2.7 and 3.6 mg/L). No mortality was seen at 1.7 mg/L copper sulfate. However, at the 2.7 mg/L dose, 19 females and 38 males died, and at 3.6 mg/L, 59 females and 75 males died. Livers were excised from survivors at two week intervals and immediately frozen. A cytosolic fraction was prepared from 3 samples from each dose and run on a Sephadex G-75 column to isolate fractions containing copper-binding proteins,

metallothioneins (MTs), which were subsequently measured using a Cd-saturation assay. Body and liver weights, body lengths, sex and liver somatic indices were also determined for each fish and compared with MT expression. MT expression showed an increasing trend in each dose group through the 6-week time point, followed by a general decrease toward control levels after this time. At 6 weeks, fish treated with 1.7 mg/L and 3.6 mg/L doses showed a level of MT expression significantly different from that of controls. At 8 weeks, only the 2.7 mg/L dose group was significantly different, and at 10 weeks, the 2.7 mg/L and 3.6 mg/L doses showed significant differences. Correlation coefficients were determined comparing the whole animal measurements with mean MT expression. Significant inverse correlations with MT were seen with male body weight ($r=0.48$, $p=0.033$ and with male length ($r=0.46$, $p=0.042$). The results of this study indicate potential differences in hepatic MT expression and whole animal responses to copper in male and female catfish.

Measurement of endocrine disrupting contaminants in the Mississippi Embavment.

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Research indicates that sublethal levels of some organic contaminants and trace elements in the environment may disrupt the endocrine systems of fish and wildlife, potentially causing problems such as reproductive failure, birth deformities, demasculinization, defeminization, and immune-system disorders. A number of the endocrine disrupting chemicals, including DDT, DDE, toxaphene, and atrazine, have been detected in the sediment and water column of streams in the Mississippi Embayment area. In order to begin to address issues related to contaminants and fish reproductive health, a cooperative effort between the U. S. Geological Survey's Mississippi Embayment National Water Quality Assessment project and the National Biological Survey's Biomonitoring of Environmental Status and Trends program was initiated during the fall of 1995. Twenty carp *(Cyprinus carpio)* were electroshocked at 10 locations in the lower Mississippi valley. Samples of tissues and fluids from the carp will be analyzed as follows: blood (for analyses of vitellogenin, estrogen, testosterone, and lysosome analysis; liver (for histopathological and macrophage aggregate analysis and determination of EROD activity); spleen (for histopathological and macrophage aggregate analysis and splenic-somaic index determination); and gonads (for histopathological analysis). The carcasses from each site were then individually wrapped, sorted by sex, and frozen for future chemical analyses which will include organochlorine and elemental contaminants by methods historically used by the National Contaminant Biomonitoring Program. Measurements of organics and trace elements in the tissue of whole fish and in stream sediments were taken simultaneously at these 10 sites, as well as 5 additional sites in the Mississippi Embayment area.

Potential Mechanisms for Differences in Aldicarb Toxicity Between Rainbow Trout and Channel Catfish

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Aldicarb is a carbamate insecticide used throughout the world in agricultural settings. Aldicarb toxicity results from the inhibition of various forms of acetylcholinesterase by aldicarb and its monooxygenated metabolite, aldicarb sulfoxide. Aldicarb is bioactivated to aldicarb sulfoxide by xenobiotic metabolizing enzymes, flavin-containing monooxygenases (FMOs). However a second oxidation, primArily catalyzed by isoforms of the cytochrome P450 monooxygenase system converts aldicarb sulfoxide to the sulfone which does not inhibit cholinesterase. Channel catfish are 100 times more resistant to aldicarb toxicity than rainbow trout after a 96 h waterborne exposure or 24 h following ip injection. However, rainbow trout were only 10 times more sensitive to aldicarb S-oxide, the bioactivated metabolite, than catfish 24 h following ip injection. Interestingly, catfish do not express FMOs and produce primarily non-toxic metabolites (sulfone) of aldicarb, whereas trout convert aldicarb to the toxic metabolite (sulfoxide) *in vivo.* Elimination profiles of injected aldicarb in both species fit a two compartment model, but half-lives were significantly different between each species. Aldicarb and metabolites were rapidly cleared from trout (respective ~ and ~ halflives being 3 ~nd 28 hrs), while halflives in catfish were significantly longer (and ~ halflives being 16 and 140 hrs). The major metAbolite from catfish after 24 h was aldicarb sulfone which was 9.3% of the total dose. In trout, aldicarb sulfoxide was the major metabolite (7.6% of total dose) without any measurable sulfone. Consequently, the lack of FMOs and the presence of aldicarb oxidizing cytochrome P450s appear to play a role in the differential toxicity observed between each species.

Swimming performance and behavior of golden shiner, Notemigonus crysoleucas, while schooling.

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Using a Blaz'ka swim tunnel the critical swimming speeds and behavior of golden shiner, *Notemigonus crysoleucas,* were examined. We used thirty minute critical swimming speeds to compare the performance of individual fish with that of fish swimming in a school. Individual fish demonstrated significantly decreased critical swimming speeds (mean=25.57+/ 5.49 s.d.) when compared with the critical swimming speed of the first individual of a school to fatigue (mean=31.7 +/- 3.67 s.d.). In addition,we found that the overall diameter of the school decreased signlficantly with increasing water flow. The crystal lattice arrangement of individuals in a school that has been suggested to allow for maximum hydrodynamic efficiency (Weihs 1975) was not observed. Instead, individuals frequently move from front to back and vice-versus. When fish were tested in such a way that they were swimming alone but in visual contact with another fish, they swam significantly faster than individuals swimming in the absence of visual contact. This suggests that intraspecific interactions may be important in the swimming performance of schooling fish.

GENETIC DIVERSITY AMONG SEVERAL SPECIES OF UNIONID MUSSELS IN

ARKANSAS

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ABSTRACT--Allozyme analysis was utilized to determine the genetic diversity of 319 individuals for four species of mussels *(Amblema plicata, Plectomerus dombeyanus, Quadrula pustulosa,* and *Q. quadrula)* in the Cache and White Rivers of Arkansas. Mussel populations of both rivers are subjected to frequent harvest, while White River populations are exposed to periodic habitat destruction due to dredging. Nine enzyme systems representing sixteen loci were selected for analyses based upon their expression in adductor muscle. Species of the Cache River exhibited the greatest polymorphism (P), yet heterozygosity (H) values between rivers were inconsistent. Ranges of P were from 0.572 for A. *plicata* to 0.360 for Q. *quadrula;* H values ranged from 0.049 for P. *dombeyanus* to 0.144 for Q. *pustulosa.* H and P values of the Amblemini of the Cache and White Rivers were consistent both in historical context and genetic diversity with those of previous studies. Populations were characterized by heterozygote deficiencies at all loci. Several determinants of heterozygote deficiency were investigated, with selection chosen as the probable mechanism. Although there are no visible signs of genetic decline associated with bottlenecking in the present study, mussel beds are on the decline in Arkansas, and loss of genetic diversity is detrimental to the stability of populations.

Bivalve Composition, Abundance, and Age Distribution in an Ozark Mountain Stream System

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We conducted a survey the past two years to determine the composition and distribution of bivalves within the Mulberry River system in the Ozark National Forest, Arkansas. We also determined relative abundance, and age and growth information from shells collected during the survey. We found twelvey mussel species, that were concentrated at three sites. The three sites were surveyed using a grid sampling method to estimate size of the mussel beds and the density of mussels in each bed. Live and dead specimens were identified and measured (maximum length) to develop length-frequency distributions for each species at each site. Live specimens were immediately returned to the site, and dead specimens were kept for age and growth analysis.

In the upper reaches of the system, the most abundant species were Lampsilis hydiana and Fusconaia flava. In the lower reaches, Corbicula fluminea was the dominant bivalve. The distance between the first downstream site that contained Corbicula fluminea and the uppermost site at which native mussels were found is approximately 22 miles. This is significant in that the range of area inhabitable by the native population may be threatened by encroaching unsuitable habitat upstream and an invading exotic species downstream. These data provide baseline information from which the status of the mussel populations of the Mulberry River system can be determined by future surveys.

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