Determining Differences in Streamflow Changes for Unregulated Streams in Kansas and Some Causes

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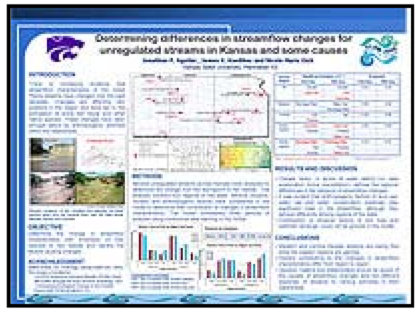

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Abstract

There is increasing evidence that streamflow characteristics of the Great Plains rivers have changed over the past decades that are affecting lotic systems in the region. Several unregulated streams across Kansas were analyzed to determine the change from the standpoint of fish habitat. The analysis covered four regions dividing the state roughly into western, central, northeastern and southeastern regions. Several physical, climatic and anthropogenic factors were considered in the model to determine their contribution to the streamflow at the 50- and 90-percent probability of exceedance. The model considered three periods of analysis with data starting in 1930. Results show that climate factor, in terms of water deficit, defines the regional differences in the behavior of streamflow changes. It was evident that anthropogenic factors, such as land use, water use and water conservation practices, play significant roles in the streamflow, but they behaved differently among regions of the state. The contribution of physical factors, such as soil type and potential recharge, could not be ignored in the model. This study could help decision makers in the management, conservation and rehabilitation of watersheds, streams and biotic systems especially in areas where water resources are limited.

Spatial Models for Predicting the Responses of RiverCommunities to Environmental Change

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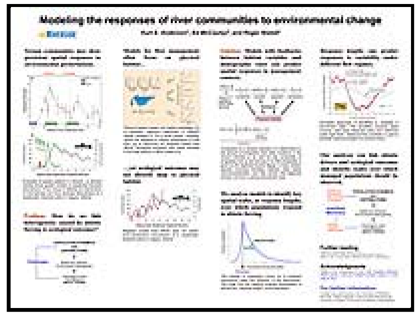

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Abstract

Managers have traditionally used simple hydrological and habitat–association methods to predict how changes in river flow regimes will affect the viability of instream populations and communities. Yet streams and rivers are characterized by dynamic feedbacks among abiotic and biotic components, a high degree of spatial and temporal variability, and connectivity between habitats, none of which can be adequately captured in commonly employed management methods. In recognition of these complexities, an emerging consensus advocates shifting the focus of management away from habitat provisions for target species and towards preserving viability of the larger river environment. Progress in this area has been hampered by the lack of modeling tools for understanding how river communities respond to spatially- and temporally-variable changes to the flow regime. We argue that process-oriented, dynamic ecological models, which consider linkages among abiotic and biotic compartments across scales and levels of biological organization, are better suited to guide flow regime management.

We use ecological dynamic models to identify a characteristic length scale, the response length, which identifies the spatial scale over which communities respond to environmental disturbances. Communities will respond most strongly to disturbances effecting dispersal at spatial scales smaller than the response length. In contrast, communities will often show more limited responses to disturbances effecting births and deaths occurring over spatial scales smaller than the response length, and will typically return to their pre–disturbance state faster. Therefore, the response length provides a means for approximating the spatial scale over which disturbances affect ecological dynamics, as well as the scale over which different populations should be sampled to effectively link flow alterations to ecological outcomes. The response length can be estimated using commonly collected ecological data, which we illustrate using examples of organisms in high-altitude California streams and Broadstone Stream in southern England. In the latter example, dispersal and life-history characteristics are explicitly linked to changes in flow conditions, allowing us to explore how population densities may respond to spatial variability in recruitment rates under different flow conditions. We outline our future plans for implementing the response length and related concepts in the South Saskatchewan River Basin in Alberta, Canada. Future research needs, such as the integration of spatially-explicit population dynamic models with hydrological and nutrient processing models, will also be explored.

The Effects of Future Development on Pocono Creek Streamflow and Ecological Integrity

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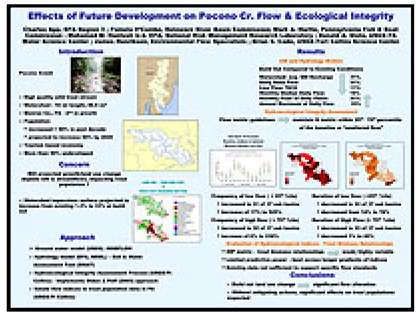

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Abstract

Pocono Creek, located in Monroe County, PA is a high quality wild trout stream whose watershed is threatened by a high rate of development with its accompanying land use change. This collaborative study, supported by the U.S. EPA Office of Research and Development Science and Technology Network for Sustainability, evaluated the effects of projected future land use change on both ground water and stream flow, and the effect of those flow changes on the aquatic ecology (specifically trout), of Pocono Creek. Study results will inform watershed management strategies to be developed by the local jurisdictions.

A ground water flow model and a hydrologic model of the Pocono Creek watershed were developed by the USGS PA office and the EPA Office of Research and Development respectively. The ground water flow model (MODFLOW) used the areal recharge values from the EPA hydrologic model and was calibrated to base flow measurements at 27 sites in the watershed. The ground water model was used to examine impacts of groundwater withdrawals and land use changes on base-flow.

The hydrologic model of the watershed utilized the Soil and Water Assessment Tool modeling framework to estimate the effect of land use changes on Pocono Creek stream flow. The model links precipitation data to the physical characteristics of the watershed to simulate daily stream flow. The model was calibrated to daily stream flow data for the period July, 2002 through May, 2004 and validated for the period June, 2004 through April, 2005.

The models were used to estimate the effect of land use changes (increased imperviousness) in Pocono Creek watershed on ground water recharge rates and the stream flow of Pocono Creek. A future “build out” scenario and a forested watershed (predevelopment) scenario were modeled and compared to the existing condition scenario. A 20-year Monte Carlo simulation based on historical precipitation records was performed with the watershed model to evaluate the impact of various land use scenarios on stream flow.

For the build out scenario, model results indicate that the watershed-averaged groundwater recharge is predicted to decline by 31%, causing the average daily base flow to be reduced by 31%. The seven day, ten year low flow (7Q10), is expected to decline by 11%, and the monthly median daily flow is expected to be reduced by 10% on the average. The monthly peak of simulated daily flows and annual maximum daily flow on the average are predicted to increase by 21% and 19%, respectively.

In addition to estimating the effects of land use changes on stream flow, an important project goal was to relate those stream flow changes to their effect on the aquatic ecosystem. This was accomplished through the Hydreoecological Integrity Assessment Process (HIP) approach. Results for the build out scenario indicate an ecologically significant degree of flow alteration using the Range of Variability Approach. A statistical analysis was performed relating the HIP flow metrics to trout abundance data for streams in Pennsylvania. This analysis indicated an association between certain HIP flow metrics and trout abundance.

Pee Dee River Instream Flow Study

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Abstract

This flow study was performed to support the relicensing of the Yadkin-Pee Dee River Hydroelectric Project, located in North Carolina, owned and operated by Progress Energy Carolinas, Inc. This highly complex study involved 350 km of river in North and South Carolina including the Blewett Falls Development, the first dam on the Pee Dee River, 303 km upstream of the Atlantic Ocean, and the Tillery Development, with 27 km of regulated river between the two developments. The study was scoped, executed, and completed under the supervision of a 20 member study team representing two federal agencies, two states, three NGO’s, and two hydropower owners. The study area encompassed the piedmont and coastal plain physiographic regions with a diverse aquatic assemblage represented by 83 species of fish and 18 mussel species including diadromous fish and rare, threatened and endangered species. IFIM models were developed for 177 km of river, represented by three reaches, eight sub reaches, and 74 transects. Habitat discharge relationships and habitat duration analyses were developed for 29 target species/life stages and guilds over a range of flows from 2 to 558 cms.

Several innovative techniques were successfully employed in this study. Study design and analysis was aided by high resolution aerial video of the study area recorded at low elevation from a helicopter and linked to GPS positioning. Field data collection along wide and deep river transects was performed with acoustic Doppler current profiling (ADCP). Habitat duration analysis (HDA) of 29 HSI models in nine sub reaches over 12 months at numerous flow scenarios generated thousands of pages of model data output. To facilitate data review, a proprietary interactive spreadsheet program was developed to quickly organize and summarize multiple alternative flow scenarios in an easily understandable format. A second technique involved the use of stage discharge relationships in an interactive spreadsheet to graphically depict and calculate transect wetted area statistics at user-defined discharges for mussel habitat analysis. Ultimately, the instream flow study team developed a set of flow scenarios that optimized aquatic habitat value as their final study result.

The HDA spreadsheet developed for the IFIM team became the primary tool for rapidly evaluating alternative flow scenarios and balancing power generation and various instream flow interests during relicensing negotiations. The use of these innovative techniques, coupled with a technically sound and defensible study, resulted in a settlement agreement on instream flow issues among the involved negotiating parties. The study showed the recommended flows provided flow enhancements for the aquatic community up to several orders of magnitude over existing conditions, while preserving economical and renewable, hydropower production from the Project.

Use of Instream Habitat Modeling for Regional Drought Response Planning

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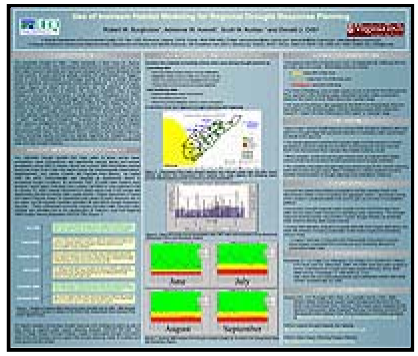

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Abstract

The Southeast is rich in water resources, both in terms of magnitude and diversity; however frequent and protracted droughts are a solemn reminder that our water resources are finite. The 1999 – 2002 drought resulted in widespread community impacts in Virginia, prompting the Commonwealth to explore policy, planning, and technological responses that integrate this triad into a statewide drought contingency framework. The Virginia Department of Environmental Quality's (VDEQ) Office of Water Supply Planning created a web-based drought information data portal and analysis tool to support the drought planning needs of localities and state governmental entities. The Virginia Drought Analysis Tool (VDAT) is a set of metrics that uses historic and real-time hydrologic and meteorological data to evaluate drought extent, demonstrate trends between interacting metrics (for example, rainfall deficit announces meteorological drought, which often is a pre-cursor to "hydrologic drought" in surface or sub-surface water stores), and forecast future conditions. The VDAT metrics are characterized into three drought stages: "watch", "warning", and "emergency". In addition to the standard metrics of precipitation departure, flow duration, and crop moisture, the drought indicators in the North Fork Shenandoah River basin include instream flow model indicators based on the needs of aquatic resources crucial to maintenance of water quality, bio-diversity and recreational uses, resulting in three flow thresholds corresponding to the three drought stages. The goal of VDAT is to provide the localities with an automatically updated, integrated set of drought status indications for these individual metrics, which decision makers can then use to determine appropriate local triggers which will allow them to plan for and respond to drought events. During summer 2008, we monitored the drought analysis tool at the North Fork Shenandoah River basin level and tracked flow duration, drought indicator, and locality drought response signals. Preliminary results indicate that improved coordination of drought response and water resources management activities at the local, regional and state levels are essential to guaranteeing the adequacy of Virginia's water supplies to meet social, economic and environmental needs during critical periods.

Environmental Flows for a Regulated River Under a New Hydro Scheme

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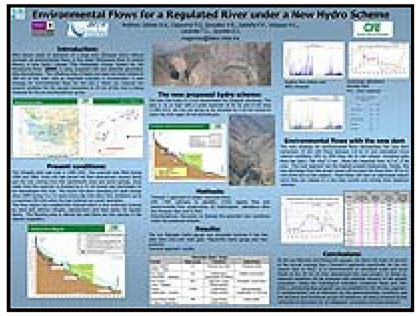

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Abstract

After eleven years of operation of a big dam (Zimapan Dam) with scarce provision on environmental flows, in the upper Moctezuma River in central Mexico, a new hydro scheme is being assessed with several potential generation sites. The latest scheme (Renewable Energy System for the Moctezuma River SERM) with two sites in the 190 km downstream the river has stated the need for a review of a new strategy for environmental flows which can improve the present condition for the aquatic ecosystem at least in some segments of the river.

The Federal Commission of Electricity (CFE) is responsible from planning to operate the main hydros in the country. The Zimapan dam was built in 1990-1993, during 1994 and 1995 the reservoir was filled and the flow downstream was just the one coming from the catchment area and some springs. Water from the reservoir is diverted by a 21 km tunnel and discharged 42 km downstream the river. Since 1995 it has been operating as peak energy from 4 to 12 hours every day with diary flow variations up to a maximum 59 m3/s when the two turbines are under operation. The environmental studies for the Moctezuma River using the Indicators of Hydrological Alterations IHA (TNC, 2007) with data from three hydrometric gauges Adjuntas (1986 -1999), Mazacintla (1959 -2001) and Tierra Blanca (1959-2002) downstream, pointed out important changes after 1994, related to reduction in large floods and extreme low flows, as well as increases in the high pulses resulting in a flatter hydrograph over the year. Other alterations are related to changes in frequency and rate of change. It was also emphasized that the rain season is earlier after the dam, beginning in April rather than in June, since more water is needed to be released from the reservoir before the rain season starts.
On the other hand, the first hydro of SERM was defined before the Agreement of Water Availability for the Moctezuma was issued (21 January 2008). That agreement states that 30% of the total annual runoff should be allocated for preserving aquatic ecosystems in this part of the river.

Under these assumptions and considering that the first hydro is 13 km downstream the Zimapan discharge, 32 m high with a small reservoir of 92 ha and 8 km long (7,550 hm3), from which 26 cms are going to be diverted by a 20 km tunnel to reach the river again 34 km downstream, the new strategy for environmental flows comprises alterations in three main river segments downstream the dam. In the first 23 km flows are going to be from 2.6 to 13 cms (simulated more natural conditions 10% to 50% from dry to rain season). After receiving a tributary, the next 11 km flows are expected from 3.25 to 18 cms. These flows are going to meet the stated volume by the Agreement, besides these river segments have the highest present biodiversity. Finally downstream the power house (34 km from the new dam) flows will be from 29 to 43 cms (from dry to rain season).

An agent-based model for environmental flow assessment in the Songhua River Basin, China

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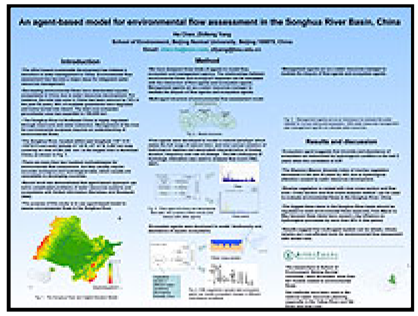

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Abstract

The effort toward sustainable development has initiated a transition in water management in China. Environmental flow assessment has become a major issue for integrated water resources management. The Songhua River in Northeast China is highly regulated through reservoirs and water extraction. Management of the river for environmental purposes requires an understanding of environmental flows. There are more than two hundred methodologies for environmental flow assessment, but they usually require accurate ecological and hydrological data, which usually are unavailable in developing countries. We analyzed the potential of multi-agent systems for the assessment of environmental flows in the Songhua River. Flow agents were developed to model a natural paradigm which states the full range of natural intra- and inter-annual variation of hydrological regimes and associated characteristics of timing, duration, frequency and rate of change. Ecosystem agents were developed to model the full native biodiversity and integrity of aquatic ecosystems. Management agents were developed to model the relationships between environmental flows and ecological response. Results suggest that multi-agent system can be simple, robust, reliable and cost-efficient tools for environmental flow assessment with limited data.

Grade Creek Wyoming: The Channel Reconstruction, Flow Restoration, and Mainstem Reconnection of a Migratory Cutthroat Trout Spawning Tributary

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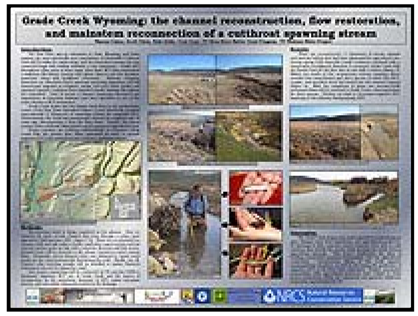

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Abstract

Reconnecting spawning tributaries with mainstem reaches of the Bear River (Utah, Idaho, and Wyoming) has been identified as a critical component for conserving fluvial Bonneville Cutthroat Trout [BCT] (Oncorhynchus clarki utah) populations in the drainage. This rare migratory life history constitutes a population component that uses mainstem portions of the Bear River for overwintering habitat. These fish then move large distances (up to 60 kilometers) during spring runoff to spawn in high elevation tributaries. Grade Creek, a spring fed tributary to the Smith's Fork, contains roughly 8 kilometers of suitable spawning habitat for this species. Historically, the creek provided access to some of the first spawning habitat encountered by BCT as they migrate upstream through the Smith's Fork from the Bear River. However, for greater than half a century an irrigation diversion has shunted water from Grade Creek into a neighboring drainage leaving the lower 4 kilometers of the creek permanently dewatered. As well as the loss of stream miles, this disconnection also isolated resident populations of several fish species including nonmigratory BCT and mottled sculpin (Cottus bairdi). Trout Unlimited (TU) partnered with private landowners, the Wyoming Game and Fish Department, the US Forest Service, the Natural Resource Conservation Service, and the Wyoming Wildlife and Natural Resource Trust to reestablish flows in lower Grade Creek reconnecting the tributary with the grater Bear River drainage.

Project partners are using a multistep approach to reconnect Grade Creek with the Smith's Fork and return flows to the channel. First, we restored the lower 1.2 kilometers of the creek that was destroyed when the reach was placed into a center pivot agricultural field (completed). Second, we are replacing an outmoded irrigation diversion and delivery ditch with a piped system and have negotiated for permanent surplus water to remain in the Grade Creek channel (October 2008). As an incentive for local ranchers, we will also install two solar driven stock watering troughs to replace cattle watering needs lost by piping the ditch (October 2008).

In early May of this year, one year ahead of schedule, favorable runoff conditions combined with a temporarily reconfigured diversion to return flow to lower Grade Creek for the first time in over 50 years. Within two weeks of this reconnection, sampling revealed that invertebrates and three species of native fish had already moved throughout the rewetted channel. TU and the USFS will compare two years of preproject fish and invertebrate data with post project monitoring to evaluate the effectiveness of the tributary reconnection. Migratory fish trapping will also be used to document the use of the creek by spawning fluvial BCT. Are hope is that this work will secure the resident BCT populations within Grade Creek as well as increasing fluvial migrant production in the watershed.

Restoring Flow to the Santa Fe River: Lessons from an Unfinished Agenda

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Abstract

The Santa Fe River in New Mexico, a tributary to the Rio Grande, is managed primarily for municipal water supply. With no legal protection for instream flow, the entire river is impounded in upstream reservoirs managed by the City of Santa Fe (which owns nearly all the water rights, and therefore can set its own policies, subject to State oversight). Water is released into the river only when the reservoirs are full, a situation normally limited to one or two months in the Spring. The ignominious condition of this historically important river has spawned many attempts to restore year-round flow. Various city commissions, and since 1999, an independent non-profit group, the Santa Fe Watershed Association, have inspired public support for reviving the river, but so far, the river remains dry. The 2007 designation of the Santa Fe River as the nation's #1 Most Endangered River (by American Rivers) has drawn national attention to the City's "scorched earth" river policies, but those policies remains in force.

This poster explores past and current efforts to reform the City's water policies and restore flow to the Santa Fe River. The presentation will be in four parts: (1) Methods Used, (2) SWOT Analysis, (3) Lessons Learned and (4) Suggested Actions.

1. Methods Used will be discussed in terms of the following categories: planning, outreach, education, publicity, political activism, policy dialogue, and strategic arguments (e.g., groundwater recharge, cultural and community amenity; tourism and business appeal; spiritual and ethical mandate; wildlife habitat and ecosystem health).

2. SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats): Strengths include broad support from public at large; an organized environmental community; scientific consensus around instream flow, local business support; official buy-in from city on the desirability of instream flow, etc. Weaknesses include lack of legal mandates for flow, lack of involvement from local water experts; hard-to-quantify nature of instream flow benefits. Opportunities range from Santa Fe's upcoming 400th anniversary in 2010; the important role of tourism in the local economy; the possibility of another designation as Most Endangered River, and spin-off influences of global warming education about co-existing with nature. Threats include competing scenarios and timeframes for restoring flow which could undermine any sense of urgency; legal obstacles, opposition by developers and potential opposition from the State Engineer's office.

3. Lessons being learned: (a) How to bring complex science into (necessarily simple) policy discussions; (b) Striking a balance between consensus-building vs. campaigning; (c) how to build coalitions of diverse stakeholders; (d) how and when to build a governance structure around watershed interests (e.g., a watershed council).

4. Suggested strategies and actions. [This section is an invitation for ideas from conference participants]. Questions include: What levels of government (federal/state/local can help speed the process, and how? How can we take advantage of Texas' experience on environmental flows? What else should we be doing?

A Comparative Analysis of Instream Flow Trout Habitat Models

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Abstract

As part of my master's research (at UNC and CSU) I was an Aquatic Ecology Modeler looking at the effect of stream discharge on trout habitat. The results of PHABSIM and SALMOD were compared using a dataset from the Poudre River, Colorado. PHABSIM is the dominant IFIM stream model used by the USFWS. The results of bottle neck analysis revealed that by high spring discharge (Q) can limit YOY recruitment as well as low Q in winter which limits trout habitat for adult life stages.

How much water do trout streams need?

Instream flow water allocations became common after the passage of the National Environmental Policy Act of 1969. Two contemporary models used by the Biological Resources Division are Physical habitat simulation System and SALMOD. The Physical habitat simulation System models the physical properties of a stream habitat (hydrology and substrate) and then conceptually represents the fish habitat requirements by weighted useable area (WUA) or habitats theoretically suitable for fish. The SALMOD model is an extension of the Physical HABitat SIMulation System model. SALMOD adds and incorporates fish cohorts throughout their life cycle. As part of monitoring the effects of a hydropower dam on the Tule river in California, the CompMech model was developed. This research will use a common dataset as input to compare the three stream models of Physical HABitat SIMulation System, SALMOD and CompMech. Model comparison will include advantages and disadvantages, the amount of data required to run the models (input files), the model output (output files), and how difficult it is to learn and use the models. The processes used by each model will be compared. CompMech and SALMOD will be used to study two variables, discharge and trout population. Population limiting events will be determined by simulating hydrographs that cause a 50 percent decline in trout population (number or biomass) over ten years or less.

Key words: Model, Instreamflow, SALMOD, PHABSIM

An Environmental Flows Information System for Texas

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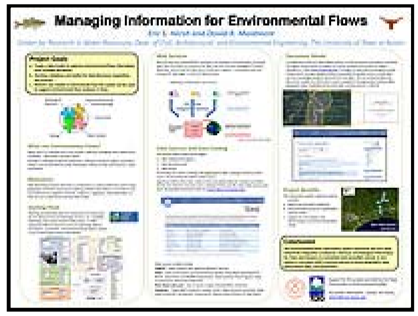

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Abstract

Data describing the stream flow, water chemistry, geomorphology, and biology of streams and rivers is often contained in a variety of formats and in many geographic locations. Thus, an information system is developed to organize and make available data relevant to the study of environmental flows in a consistent and accessible format. Relevant data from hydrology and hydraulics, water quality, climatology, geomorphology and physical processes, and biology is assembled to facilitate data discovery, acquisition, and sharing. Working symbiotically with the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) Hydrologic Information System (HIS) project, an NSF-supported effort to improve access to hydrologic data at the nation's universities, environmental flows data is stored in the CUAHSI Observations Data Model and web services are established for the computer-to-computer communication of data in order to extract data from disparate sources in disparate formats, to transform the data into the common language of CUAHSI WaterML, and to load the data into an end user's system. The environmental flows information system includes a linkage to a georeferenced digital archive of documents, providing for parallel access to both data and the knowledge products derived from that data. Via the Data Model and accompanying Document Model, an information system capable of managing observational data, geographic data, modeled/constructed data, and documents is offered. A prototype environmental flows information system is developed for the State of Texas which incorporates relevant known available datasets from federal, state, academic, river basin, and local sources. Tools are developed to assist in the publishing, visualization, and access of data and documents via map-based, spreadsheet-based, and other methods. The information system might be used to provide: (1) rapid low-cost data integration, (2) improved data access for the public, and (3) support for the analysis and determination of environmental flow needs. The environmental flows information system represents the integration of the physical, chemical, and biological information for rivers and streams in a consistent and accessible manner in one system in one place.

Year 12 of an Adaptive Management Experiment for Instream Flows in the Bridge River, British Columbia

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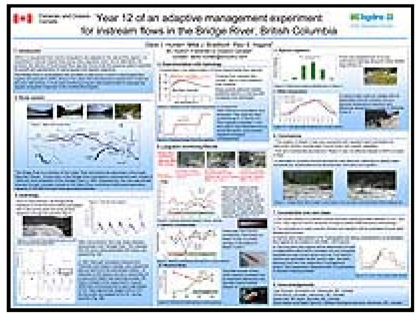

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Abstract

There have been relatively few cases where instream flow methodologies have been evaluated for their effectiveness. Consequently adaptive experimental management has been promoted as a means to empirically test the relationship between alternative flow regimes and valued ecosystem components such as fish abundance. In 1996 a long-term flow experiment was started to evaluate at least three different flow regimes in the Bridge River, a regulated tributary of the Fraser River, BC. An extensive monitoring program was initiated, primarily focused on juvenile salmon biomass, along with the secondary indicators of water quality, and primary and secondary productivity. The monitoring of two flow regimes is complete with consideration of options for the third currently underway. The experimental flow consisted of a hypolimnetic release from the impoundment dam using a refitted flow control structure. This initial flow rewetted 4 km of previously dry channel; the new reach was rapidly colonized by salmonids and it continues to be productive. The impacts of the augmented flow on downstream reaches previously wetted through ground water and tributary inputs are less clear. The dam releases have altered the thermal regime in the river and this has changed in life history of Chinook salmon (Oncorhynchus tshawytscha), and may be reducing their abundance. Other indicators may be relatively insensitive to the flow regime. Perhaps more importantly, since inception 12 years ago First Nation values and an associated much broader suite of indicators than just juvenile salmon biomass will be included in the final decision about flow. The length of the experiment, the investment in time and resources required, and First Nation involvement are all significant challenges to using adaptive management to resolve instream flow issues.

Nebraska's Niobrara River Instream Flow Initiative: A Multidisciplinary Approach

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Abstract

In May 2006 the Nebraska Game and Parks Commission (Commission) passed a resolution for an agency initiative to develop recommendations for instream appropriations in the Niobrara River for fish, wildlife and recreation needs.
The Niobrara River is approximately 690 km long, rising in the High Plains in eastern Wyoming, then flows east across northern Nebraska to the Missouri River on Nebraska's northeast border. Two reaches of the Niobrara were designated in 1991 under the National Wild and Scenic Rivers Act. One 121 km reach near Valentine, Nebraska is designated as a National Scenic River. The upper 48 km of this Scenic River reach is recognized as one of the nation's premier canoeing rivers. The second reach encompasses the lower 40 km of the Niobrara River above its confluence with the Missouri River is designated as a National Recreation River.

The Commission established a series of planning teams to initiate a collaborative multi-disciplinary approach for the Niobrara River Initiative. These include a Core Team that coordinates project development and progress, a Science Team, a Partnership Team, a Public Outreach and Education Team, and a Legal Team. The Core Team provides status reports to an Internal Oversight Team of agency administrators.

Funding is provided from three major sources; Federal Aid to Sport Fish Restoration and Wildlife funds for staff time, Nebraska Environmental Trust two-year grant for contracted studies and public outreach efforts, and a National Park Service grant to cost-share selected studies. The National Park Service has a strong presence on the river due to their management of the National Scenic and Recreation River reaches. TNC and the USFWS are providing in-kind services for the Initiative. Commission partners include three federal agencies, four local natural resource districts, one irrigation district, a local Niobrara Council, and four non-governmental conservation organizations.

Contracted studies currently include: Hydrologic and water budget analyses of the Niobrara River using the USGS HIP software and climate data by the University of Nebraska-Lincoln (UNL); a bibliography of reports and literature on the basin by UNL; Hydraulic geometry and macro-scale habitat evaluations of the river by the U.S. Geological Service (USGS); Flows and recreational floating on the Scenic River reach by Confluence Research and Consulting (CRC); and Socio-economics of recreational floating and irrigation uses in the Niobrara River basin by University of Nebraska-Omaha (UNO). The Commission plans to help fund a U.S. Fish and Wildlife Service fishery study on the lower 48 km of the Niobrara River. Early results show the river hydrology has been affected by irrigation development; geospatial data and macro-scale habitats classifications are identified; scenic reach optimal flows for canoeing , tubing, and some whitewater kayaking have been evaluated. Additional depletions of 50-100 cfs would reduce days of acceptable recreational floating.

Nebraska's first instream application for a recreation appropriation for canoeing should be filed during 2009, pending completion of ongoing studies. In addition the Commission is planning for fish and wildlife studies for later Niobrara River Initiative instream appropriations.

Instream Flow Setting in the Wenatchee Watershed: A Case Study of Collaborative Decision-Making in Chelan County, WA

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Abstract

The Instream Flow Instrumental Methodology (IFIM) was used to establish instream flows for the Wenatchee Watershed in Washington State by a diverse group of stakeholders that make up the Wenatchee Watershed Planning Unit (WWPU). The WWPU was established under Washington State's Watershed Planning Act (RCW 90.82) to develop and implement watershed plans that, in the Wenatchee, address instream flow, water quantity, salmon habitat and water quality issues. This process used PHABSIM for the mainstem river and four tributaries and Toe-Width for one tributary resulting in a comprehensive water management strategy that established minimum instream flow levels for seven control points, established a water reservation of 4 cfs for future domestic use, set maximum allocations above the instream flows, and outlined mitigation efforts to offset negative environmental impacts. This water management strategy was adopted into rule by the Washington State Department of Ecology in December 2007.

While the IFIM construct was used to guide the overall instream flow-setting process, the success of the effort rested squarely on issues not commonly identified by practitioners as part of IFIM. The authors will present the Wenatchee instream flow rule and overall water management strategy as a case study of the five "hidden" steps to IFIM success and outline for IFIM practitioners how to successfully navigate these issues. These five issues significantly shaped the instream flow-setting process and ultimately led to its success. The five "hidden" steps to IFIM success will be juxtaposed with the standard IFIM approach to identify strengths and weaknesses of IFIM and provide guidance and potential solutions for other instream flow setting efforts.

The five "hidden" steps to IFIM success identified in the Wenatchee case study are as follows. First, complex group dynamics and interpersonal relationships fostered trust-building and commitments to be made for the seven year project. Second, the diversity of the 28-member planning unit, including members completely unfamiliar with instream flow concepts, contributed to a broader understanding of different interest groups and, in the end, a more durable end product. Third, funding from a variety of sources and the associated and complicated financial management supported the effort and also diverted significant time and resources away from the effort. Fourth, developing the scope of technical work across various agency interests in conjunction with other members of the planning unit allowed for buy-in across the board. Fifth, successful implementation of the water management strategy relies on the relationships built during the process, consistent funding, and long-term commitments to continue to participate in and monitor the effort.

Can urbanization reverse ground-water depletion? Insight from a case study in Hebei Province, North China Plain

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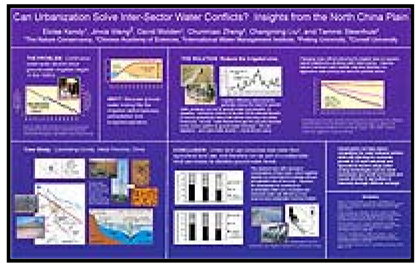

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Abstract

China, like many countries, is experiencing an unprecedented rate of urbanization. Urbanization is usually thought to intensify inter-sectoral water conflicts. In contrast, this paper considers urbanization as part of a viable solution to a water shortage problem.
By evaluating water consumption, or depletion, in terms of actual evaporation and transpiration, as opposed to the amount withdrawn from water sources, this paper argues that urbanization has a positive role to play in lessening inter-sectoral water competition and in reversing groundwater depletion. We focus particularly on the potential for urbanization to alleviate severe groundwater shortages in the North China Plain, where aquifers supply water for both urban and agricultural uses.

In the North China Plain, water is withdrawn from and returned to a single primary source: the unconfined alluvial aquifer beneath the plain. Reduction in pumping for irrigation triggers a corresponding reduction in groundwater recharge (infiltrated precipitation and excess irrigation water, which percolates through the soil profile, down to the water table) from irrigated cropland. Consequently, despite decades of reducing pumping, the water table has continued to decline at a steady rate, averaging 0.5 meter/year. The declining water table is clear evidence that the water budget is not in balance, as consumption perpetually exceeds replenishment of the hydrologic system.

We examine several management options in terms of their net water consumption, and how that would affect the overall water balance. Interbasin water transfer (Nanshui Beidiao) will provide a critical water supplement to some local areas, but will not by itself abate regional groundwater declines. Crop changes such as substituting vegetable crops for the current wheat/maize rotation is unlikely to generate sufficient water savings, due to the extended growing season of vegetables compared to maize. Reintroduction of annual winter fallowing would alleviate groundwater declines, independent of other land-use changes; however, for social and economic reasons, land fallowing is not likely to be widely accepted. Irrigation-efficiency technologies such as sprinklers and underground pipes, which reduce seepage from the soil profile, do not save water in the North China Plain because seepage provides valuable recharge to the underground water source. In contrast, technologies that reduce the evaporation component of evapotranspiration do reduce outflow from the overall hydrologic system, and therefore can save water. Increasing water prices for the industrial sector also is a viable water-saving strategy. In contrast, increasing agricultural water prices is unlikely to reduce irrigation water consumption unless prices become high enough to take land out of production.

Finally, we considered urbanization. Although withdrawals for urban water use may be large, urban water consumption generally is much less than agricultural water consumption, on a per-area basis. Thus, a key to relieving inter-sector water conflicts in the face of rural-to-urban land-use change is to capitalize on this paradox by maximizing the reuse and minimizing the consumption of water withdrawn for urban supplies.

Thus, at the regional scale, urbanization can help achieve reverse ground-water declines by replacing some agricultural land use, particularly under two conditions: (1) both the industrial and agricultural sectors adopt water-saving technologies, and (2) urban wastewater and runoff are treated and reused directly in agriculture or indirectly through artificial recharge. Combined, the two conditions must result in a net decrease in water consumption at the regional scale. These points are illustrated with a case study of rural Luancheng County and adjacent industrialized Shijiazhuang City in Hebei Province.

We offer a simple, quantitative water-balance approach for planning a mosaic of future landscapes, which together

consume no more water than is naturally replenished to the North China Plain, and therefore can effectively arrest groundwater declines. We demonstrate this approach using various combinations of urban and agricultural land-use practices. Though urbanization alone cannot stabilize declining water supplies, we show how it can be part of an integrated solution.

Watershed Influences and In-Lake Processes – a Regional Scale Approach to Monitoring Instream Flows to a Drinking Water Reservoir, Lake Houston, Texas

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Abstract

Since 1983, the U.S. Geological Survey (USGS), in cooperation with the City of Houston, Texas, has collected water-quality data at Lake Houston and its major tributaries. Lake Houston currently supplies about twenty percent of the total source water for the city; however, as a result of groundwater subsidence regulations (effective in 2010) the lake will become the primary source water supply in the future. With increased demand for Lake Houston water, a comprehensive understanding of the factors that affect water quality in the lake is needed. Of particular concern are: 1) the timing of large inflows from the surrounding watershed and 2) the in-lake processes that might affect drinking water-quality by causing tastes and odors. In 2006, the USGS and the City of Houston initiated a study to evaluate the effects of each of these processes on water quality in Lake Houston. Two real-time water-quality monitoring stations were installed on Spring Creek and the East Fork San Jacinto River in 2005 to monitor watershed inflows. An additional monitoring station was added on Cypress Creek in 2008. The data from these monitors can be used to estimate concentrations of select constituents of concern for the lake by developing relations to real-time surrogate components of temperature, specific conductance, pH, dissolved oxygen, and turbidity. Three real-time water-quality monitoring stations with vertical profiling capabilities were installed in the southwestern quadrant of Lake Houston to monitor in-lake processes. Water quality samples are being collected and analyzed on a monthly basis, with bi-weekly samples in the summer months at all sites. The City of Houston is participating in this unique study as part of its efforts to ensure the long-term sustainability of Lake Houston as a high quality source water. Preliminary results of this study show the viability of the network to evaluate the influence of the watershed on in-lake processes and the use of both watershed and in-lake real-time data as a decision support tool for drinking water treatment operations. Results of this study may be applied to other drinking water reservoirs in Texas and Nation-wide.

The Organization of Instream Flow Provision

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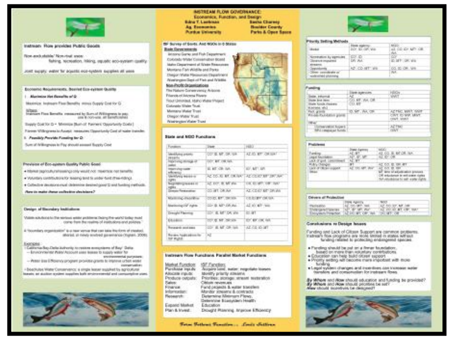

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Abstract

In the 1970's many western states recognized the need for instream flow protection and introduced legislation to allow for this. Then, in the 1990s, water trusts and NGOs became more active in acquiring water rights or leases for instream flow provision.

This poster examines how activities contributing to instream flow provision are managed among state agencies, water trusts, and other NGOs. State agencies and trusts studied through a detailed survey include Colorado, Arizona, Idaho, Montana, Oregon, and Washington. Activities include identifying priority streams, identifying leases or rights, stream bank restoration activities, monitoring, drought planning, education, and research. Combining responses by state, the poster identifies common needs. Future innovations may see improved realignment and/or expansion of these activities among public agencies and NGOs.

A Collaborative Approach toFlow Restoration in a Large River Basin: Connecticut River, USA

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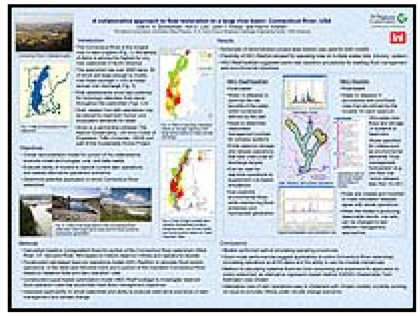

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Abstract

The Nature Conservancy and partners have identified altered hydrology as a primary threat to the Connecticut River watershed, and are working to restore the river to improve aquatic biodiversity. This goal requires an understanding of how water flows in the Connecticut River and its tributaries, and how the operations of dams in the basin work together to influence the current hydrologic regime. To gain this understanding, we are developing a basin-wide hydrologic model that can be used to evaluate dam operations throughout the basin. We will pair this hydrologic model with ecological information to develop flow restoration scenarios that will continue providing flood control and hydropower generation while supporting aquatic and riparian species.

The first step toward construction of this model is the completion of a demonstration project for a small portion of the basin with the goal of testing technologies for analyzing the entire watershed. This work was done by a team that includes U.S. Army Corps of Engineers, The Nature Conservancy, U.S. Geological Survey, and Tufts University. Objectives of the demonstration project include: (1) examine potential models, cost, and data needs and assess utility of selected models for application at a whole-basin scale; (2) evaluate the ability of the models to capture current dam operations and assess alternative operations scenarios; (3) engage stakeholders to support development of alternative future scenarios of dam operations, land use, and climate change.

We calculated unregulated flows for the West and Ashuelot Rivers, two tributaries to the Connecticut, as input to our demonstration model. We developed a rule-based dam operations model (HEC-ResSim) to simulate operations at four flood-control dams on the two tributaries, and developed alternative operations scenarios for the dams that explore options for minimizing potential ecological impacts of dam operations for flood control and recreation. A goal-based optimization model has also been developed for the two tributaries and a portion of the mainstem Connecticut River that allows us to model operations at hydropower dams and explore operations scenarios that meet flow restoration objectives while maximizing power generation. We are combining this work with development of qualitative and quantitative relationships between degree of flow alteration and response of species and natural communities.

This demonstration project has guided the selection of technologies that are best for application to the entire Connecticut River basin. We are now in the process of expanding the model to provide estimates of baseline flows, current flows, and flows for alternative scenarios of dam operations and water management for points of interest throughout the basin, including each of 65 large dams and sites of conservation interest (e.g., floodplains, locations of rare species, aquatic communities representative of different river types, etc.). This model is intended to be used to recommend flow restoration targets and changes to dam operations. We are working closely with water managers and natural resource agency staff in four states to craft alternative scenarios of water management that address ecological needs, as well as the needs and interests of a wide range of stakeholders.

The Magpie River Ramping Study: Physical Responses to Flow Alteration

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Abstract

Regulation of rivers by waterpower facilities result in flow regimes with marked changes to the magnitude, duration, frequency, timing, and rate of change of flow compared to natural conditions. Changes in the flow regime are met with associated changes in sediment, biogeochemical, and thermal regimes, possibly evoking a biological response and a change to the ecology of the riverine system. The Magpie River Ramping Study is a long-term collaborative research effort between the Department of Fisheries and Oceans, Ontario Ministry of Natural Resources, and Brookfield Power Corporation to investigate the effects of increasing the rate of change of flow, to optimize energy production, on downstream ecology. The Before-After-Control-Impact (BACI) experimental design being conducted on the Magpie river (impact river) near Wawa, Ontario and Batchawana river (control/reference river) near Sault. Ste. Marie, Ontario began in 2002 with ramping rate restrictions on the Steephill Falls waterpower facility (WPF) that were later lifted in October 2004 and will remain unlimited until results of the study are evaluated in 2008. The purpose of the present research is to elucidate and quantify ecologically meaningful differences in the physical regimes of the two rivers and pre- and post-impact on the Magpie River to assist the interpretation of results of concurrent biological monitoring. Instream measurements of water level, turbidity, and temperature were recorded at sites distributed longitudinally on both rivers. This included 3 sites located 2.5 km, 7.5 km, and 13.5 km dowstream of the Steephill Falls WPF and 1 site above Steephill Falls dam, outside the zone of influence of the headwater pond. Two sites, covering a similar longitudinal extent were established on the Batchawana River. Discrete water samples were taken to measure suspended sediment concentrations and velocity profiles measured at each monitoring site at different water levels to produce rating curves to convert the continuous water level measurements to discharge. The Batchawana river's streamflow pattern resembled strongly the natural flow pattern of the Magpie river prior to regulation, providing some assurance of its use as a control site for monitoring natural variability. The altered streamflow pattern at Steephill Falls WPF prior to October 2004 was essentially a cumulative response to variable energy demand and water supply and technological and regulatory constraints (e.g. maximum turbinable flow [45 m3 sec-1] and ecological flow requirements [low flow and rate of change of flow], respectively. Lifting the ramping rate constraint in 2004 resulted in distinct, and surprising, changes in the streamflow regime, particularly in the peaking frequency, duration and timing, highlighting the complexity of altered flow regimes and interdependence of flow components. Examination of these changes to the entire streamflow pattern and associated impacts on thermal and sediment regimes is discussed.

A Method to Combine Bivariate Habitat Suitability Criteria with 2D Hydraulic Simulations to Better Predict Habitat Versus Flow Relationships Using a GIS Spatial Analysis Tool.

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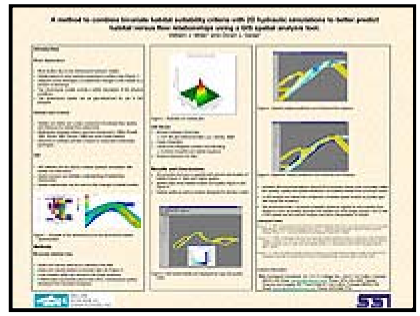

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Abstract

In recent years, two dimensional hydraulic simulations are more the rule rather than the exception in instream flow studies. Two dimensional data collection and simulations are well suited to GIS spatial analysis. We have developed a GIS tool for spatial analysis of habitat suitability criteria (HSC) to determine the weighted usable area for two dimensional hydraulic simulations. Field data from habitat studies on warm water (desert sucker Catastomus clarkii) and cold water (bull trout Salvelinus confluentus) species were used for the calculation of habitat suitability indices. Univariate independent habitat suitability functions have long been the standard for one dimensional PHABSIM modeling. Multivariate suitability criteria were first introduced to PHABSIM in the 1980s but were never widely applied. Bivariate HSC were calculated for two life stages of each species from the field data set using a commercial statistical software. The bivariate histogram frequency data was reduced to an exponential polynomial function describing depth and velocity in habitat selection by fish. This information is then used in assigning habitat suitability by spatial location for use in modeling instream habitat in a GIS analysis tool.

HSC were combined with two dimensional hydraulic simulations and analyzed using GIS to accurately represent habitat location, quantity and quality. The GIS tool uses the spatial grids from River 2D output to develop an analysis framework. The HSC for the species of interest are used to convert the physical data at each model node to an HSC value. The HSC values are then converted to a spatial grid for summation of total habitat. Habitat is displayed by quality (color coded) on the plan view maps developed for the study site. The predicted habitat quality was compared to observed fish locations and the bivariate criteria accurately reflect the observed data.

The GIS tool can output comma delimited files of habitat for each flow simulated. Habitat quality is binned in 0.1 increments from 0.0 to 1.0. The total habitat at each flow is the summation of each separate habitat quality bin.

We conclude that instream flow recommendations derived from bivariate criteria more accurately reflect the quantity, quality and spatial distribution of available habitat than univariate criteria. A GIS analysis tool allows the comparison of habitat spatial location by quality type with actual fish locations. We recommend that 1) bivariate suitability criteria be applied in new instream flow studies to more accurately represent the habitat use of the target species; and 2) that a GIS spatial tool be used for analysis and aid in interpretation of results.

Brown Trout Recruitment Variability in a Tailwater Influenced by Daily Flow Fluctuation

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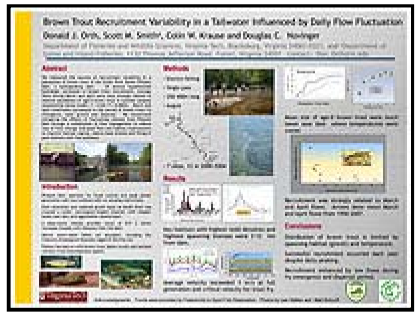

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Abstract

Over the 50 years of operations of Philpott Dam for flood control and peak power generation with no ramping restrictions, the flow alteration and reduced gravel input on Smith River has created a wider, rectangular-shaped channel, with steeper banks. Additionally, because of a deep-water release the water temperature at the dam is 8-9 ° C increases linearly with distance from the dam. A diverse assemblage of native warm-water fishes was replaced by depauparate populations of natives fishes, including the Federally Endangered Roanoke logperch Percina rex. Consequently the primary angling opportunities are for wild brown trout Salmo trutta and stocked rainbow trout Oncorhynchus mykiss. The channel pattern is caused by channel degradation, tributary head-cutting, bank erosion, and downstream aggradation and has limited the length of productive trout habitat to between 3 and 12 river kilometers from the dam. Here the channel appears to contain key habitats where we found the highest redd densities, abundance, and spawner biomass for brown trout (Salmo trutta). Although, brown trout actively removed fine sediment via redd construction and spawning, thereby increasing gravel permeability, the fine sediments from tributaries and bank erosion rapidly intruded into the spawning gravel in downstream reaches of the river. The relative abundance of brown trout was negatively related to distance from Philpott Dam ($r2 = 0.923$; $P = 0.0006$). Distribution of brown trout is likely due to a combination of spawning locations and temperature gradient. Average peak flow and duration of generating flows significantly depressed abundance and recruitment of brown trout. Low productivity of insects, crayfish, and fish has resulted in slow growth and poor condition of brown trout and average angling success. Recruitment of brown trout to the fishable size classes appears to be constrained by the daily hydropower peaking operations and we evaluated several hydrologic measures as correlates to brown trout recruitment. The number of age-0 brown trout produced each year was most strongly related to the average magnitude flow during March and April (exponential decay model; $r2 = 0.9504$; $P = 0.0001$), a time of brown trout fry emergence and dispersal. We recommend mitigating the effects of fluctuating releases from Philpott Dam through a combination of flow management to reduce rate of flow change and peak flow and habitat improvement to reduce bank erosion and filling of pool habitats with fine sediment.

Assessing Effects of Flow and Habitat Changes after Re-licensing at the Tapoco Hydroelectric Project on Cheoah River, North Carolina

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Abstract

Since 1927, stream flow within the 9.1-mile bypass reach of Cheoah River, western NC (Tapoco Hydroelectric Project) was limited to seepage and occasional spills from Santeetlah Dam along with supplemental flow from downstream tributaries. Historic flows and current inflows to the Santeetlah Reservoir are characterized by highest base flows in winter and early spring; similarly, high flows are most likely and predictably greater magnitude and longer duration during winter/spring. Remnant populations of cool-water and warm-water fishes have survived, characterized by smallmouth bass, rock bass, tangerine darters, various minnows, and other fishes. A small, remnant population of the endangered Appalachian elktoe (Alasmidonta raveneliana) occurs throughout the reach, which is designated critical habitat for the mussel. Santeetlah Dam diminished sediment and gravel export to the lower river system, which is important spawning habitat for fish and macro-invertebrates. Following a four-year collaborative re-licensing process, Alcoa Power Generating Inc filed its license application in 2003 for the Tapoco Hydroelectric Project. The Federal Energy Regulatory Commission issued a new license for a period of 40 years, effective March 1, 2005. The new license includes requirements for a base flow regime that provides seasonally variable flows from 40- 100 cfs to enhance aquatic habitat, along with periodic high flow events designed to facilitate ecological processes, gravel augmentation, and effectiveness monitoring of the Cheoah River. Consideration for Santeetlah Reservoir levels, hydro electric generation, enhanced fishing opportunities, and recreational boating were part of the balance for establishing a flow regime. The high flow events provide a range of recreational boating opportunities on a predictable basis, including on average, 15 days during the commercial rafting season. We developed a monitoring scheme based on the following hypotheses:
(1) Source populations will be one constraint for restoration of certain species; (2) Essential habitat will be constraint for restoration of other species, particularly species with habitat affinity with gravel (5-65 mm); (3) Grain size distributions in certain habitats can be restored with annual gravel augmentation at least in reaches nearer the dam; and (4) Redistribution of natural and artificial gravel additions after flood flows will increase habitable areas. Fish abundance and diversity was documented by snorkeling gravel augmented reaches and control reaches during July 2008. To assess the influence flow restoration, sites sampled by electro-shocking in 2004 were re-sampled during July 2008. Gravel augmentation was initiated at multiple sites and sites with higher gradient and steeper banks resulted in the highest entrainment and fastest stream bed enhancement. Monitoring the effectiveness of gravel augmentation has focused on nest building fishes that may be influenced by flow and available substrate. Microhabitat assessments of river chub mounds (Nocomis micropogon) were conducted during peak spawning season (May 2008) and chubs consistently built mounds in close proximity to velocity shelters and areas with lower flow. Chub mounds built from newly-added gravel were documented at the most downstream site. Not all native fish species are expected to re-colonize the bypass reach due to a variety of constraints and management interventions will be devised based on findings of routine monitoring.

Effects of Increased Minimum Environmental Flows on the Fishes of the Ouachita River, Arkansas

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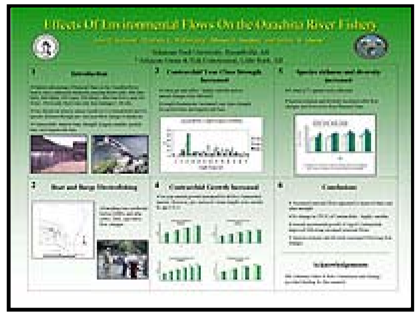

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Abstract

The upper Ouachita River in Arkansas flows through three impoundments, the last of which is Lake Catherine, impounded by Remmel Dam. Remmel Dam is an 11-megawatt hydroelectric powerpeaking facility. As a part of the Federal Energy Regulatory Commission relicensing of the Remmel Dam, continuous, seasonally-based instream flows were initiated in early 2001. We collected fish community baseline data (2000) and examined short-term (2001, 2002, and 2005) changes using barge and backpack electrofishing following alterations in flow downstream from Remmel Dam. In addition, we monitored changes in sportfish population characteristics using boat electrofishing in 2000, 2001 and 2005. A total of 71 species was collected in riffle and shallow run habitats. Species richness increased after flow changes were implemented. Average richness was 27, 31, 36, and 36 species in 2000, 2001, 2002, and 2005, respectively. Richness also increased downstream. The most abundant species collected were greenside darter (Etheostoma blennioides), longear sunfish (Lepomis megalotis), banded darter (Etheostoma zonale), central stoneroller (Campostoma anomalum), orangebelly darter (Etheostoma radiosum), gravel chub (Erimystax x-punctatus), spotted sunfish (Lepomis punctatus), and shadow bass (Ambloplites ariommus). Fishes in the Families Cyprinidae and Percidae increased in relative abundance and species richness from 2000 to 2005. Average Shannon-Weaver species diversity increased from 2000 (2.19) to 2001 (2.24) and again in 2002 (2.40). However, diversity declined in 2005 (1.90) due to increased relative abundances of greenside darter, banded darter, central stoneroller, and orangebelly darter. This increase in abundance reduced community evenness and as a result species diversity declined. Also of interest was the appearance of new Percidae species following flow changes that included crystal darter (Ammocrypta asperlla), longnose darter (Percina nasuta), and dusky darter (Percina sciera). Population characteristics were monitored for five species of sportfish that included shadow bass, bluegill (Lepomis macrochirus) , longear sunfish, spotted bass (Micropterus punctulatus), and largemouth bass (Micropterus salmoides). No annual differences in average relative abundances (catch per unit effort) were found for any of the species. Average length and weight of shadow bass and bluegill were similar each year. Longear sunfish, spotted bass, and largemouth bass average length and weight declined from 2000 to 2005. However, reduced average size reflected recent strong year class strengths as indicated from length-frequency distributions. Annual incremental growth was used to directly compare pre- and post-flow change. First year incremental growth improved for all five species following increased flows. The larger size of age-1 fish may have important implications for survival and prey base needs for these fish. However, improved growth was not maintained as both pre- and post-flow average lengths were similar after fish were 3 to 4 years old. This was supported by both incremental growth analyses and von Bertlanffy growth equations based on back-calculated length at age. Overall, our study revealed increased species richness, changes in species diversity, and strong year class strength and improved first year growth for selected sportfish following increased flows.

Sustainable Water Allocation and Instream Flow policy in the New England Region: Understanding the implications of climatic variability and change

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Abstract

In the northeastern United States, emerging policy and rulemaking framework to support instream flow allocation seeks to improve the health of stream and riparian ecosystems. State of Maine's major substantive rule is based on seasonally varying flows that bear semblance to the historical hydrologic regime. This imposes constraints on water withdrawals and water quality objectives can be similarly incorporated. The framework assumes: a. a relatively stable envelope of hydrologic variability, and b. attempts to mimic the natural flow regime are protective of the key species.

Specifically, Maine's instream flow policy (Chapter 587, authored by the Maine Department of Environmental Protection), is a key example of forward-looking legislation that emphasizes instream flow requirements as critical to ecosystems health and sustainability. In Chapter 587, historical median flow values for certain months (February, April, June, August, October, and December) are used to establish minimum instream flows for six different seasons described in the document (January 1 - March 15, March 16 - May 15, May 16 - June 30, July 1 - September 15, September 16 - November 15, November 16 - December 31). In relation to the annual hydrograph at each streamgauge, these seasons provide an approximation to the within-year variability, likely conducive to the life cycle of the endangered Atlantic salmon.

In this poster, the spatial and temporal variations in the annual cycle of streamflow in the northeast United States is investigated. Changing envelope of interannual variability and seasonal-advance of the Spring freshet are examined. Changes in the historical median flows (consistent with Maine's flow policy) across the key seasons are analyzed with a view to understand the adequacy of minimum seasonal flows based on past hydrologic record. In order to determine the nature of recent changes in regional hydrology, this study examines the past 55 years of New England flow and temperatures data. Changes in streamflow are identified using multiple techniques, including summary statistics, Mann-Kendall analysis, and a new resampling test that compares observed changes to random samples within the data set of interest. By correlating seasonal windows of changing hydrology to appropriate metrics of temperature variability, and interpreting those changes using risk analysis, this study notes increases in the risk of extreme events, like flooding, during the ecologically sensitive period of spring peak flows. The analysis presented here highlights the importance of examining the regional hydrologic variability and change within the broader context of hydroclimatic change, and the importance of characterizing and communicating uncertainty as a key element of deliberation and policy implementation.

Habitat Models for Definition of Protected Instream Flows for the Lamprey River in New Hampshire

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Abstract

The Rushing Rivers Institute (RRI) is assessing the Lamprey River of New Hampshire to develop a Water Management Plan (WMP) through the determination of Protected Instream Flow (PISF). PISF is defined as the amount of water necessary to accommodate instream needs such as water-based recreation, navigation, aesthetics, fish and wildlife habitat, water quality, and needs by downstream users. PISF values must be established which protect legislatively mandated Instream Public Uses, Outstanding Characteristics, and Resources entities. The collected data and models will support multi-criteria decision analysis, a foundation for the WMP.

Our approach is to develop flow regime criteria that protect aquatic and riparian life while balancing those needs with public and private water uses. Intensive analysis of techniques leads to the conclusion that physical habitat simulations provide the most desirable results and have the greatest potential for broad application. RRI has been developing a new physical habitat model with special emphasis on its application by state resource agencies that are typically responsible for establishing instream flow criteria. The result of this effort is an assessment framework called MesoHABSIM which improves the concept of habitat modeling by addressing the requirements for watershed management of running waters. MesoHABSIM modifies the data acquisition technique and analytical approach of earlier efforts by changing the scale of resolution from micro- to meso- scales, providing a mechanism that allows the assessment of habitat changes at the watershed scale. The suitability of each mesohabitat for a target fish community is assessed using field surveys, and field data are subsequently analyzed using multivariate statistics. The variation in cumulative area of suitable habitat is a measure of environmental quality associated with alterations in flow and channel structure.

Using habitat rating curves in conjunction with flow time series for each river segment we create a time series of baseline habitat conditions which are analyzed for flow levels critical to the protected use. We apply continuous under threshold habitat duration curves (CUT-curves) to identify four habitat levels that correspond with different protection thresholds. The results are recommendations for seasonal habitat regimes consisting of allowable habitat quantity together with duration and frequencies of flow events with habitat under specific thresholds.

Instream Flow Assessment of a Groundwater Dependent Ecosystem in Southern Oklahoma

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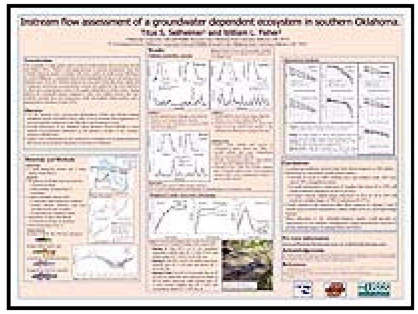

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Abstract

The availability of high quality water is critical to both humans and ecosystems. A recent proposal was made by rapidly expanding municipalities in central Oklahoma to begin transferring groundwater from the Arbuckle-Simpson aquifer, a sensitive sole-source aquifer in south-central Oklahoma. Concerned citizens and municipalities living on and getting their drinking water from the Arbuckle-Simpson lobbied the legislature to pass a temporary moratorium on groundwater transfer to allow for a comprehensive study of the aquifer and its ecosystems. We conducted an instream flow assessment using Physical Habitat Simulation (PHABSIM) on springs and streams with four spring-dependent species: two minnows, southern redbelly dace (Phoxinus erthyrogaster) and redspot chub (Nocomis asper); and two darters, least darter (Etheostoma microperca) and orangethroat darter (Etheostoma spectabile). Spring habitats are unique compared to other river habitats because they have constant flow and temperature, small and isolated habitat patches, and a general lack of predators.

Our study sites included two spring-fed streams, one larger stream with high groundwater inputs, and a river with both groundwater and surface water inputs that is adjacent to the small spring-fed streams. These habitats meet the criteria for groundwater dependent ecosystems because they would not exist without the surface expression of groundwater. A total of 99 transects in all four sites were surveyed for channel elevation, and three sets of water surface elevation and water velocity were measured. Habitat suitability criteria were derived for the species at each site using nonparametric confidence limits based on underwater observations made by snorkelers. Simulations of flow were focused on declines in discharge, which is the expected effect of the proposed groundwater diversion.

Our results show that only a small proportion of the total available area in each habitat is considered to be preferred habitat (Weighted Usable Area [WUA]) by the four target species. In the spring habitats, a maximum of 10% of the total area is preferred habitat and that dropped to as little as 3% with decreased flows. The quantity of WUA decreased when lower discharges were simulated for all the target species. Declines in the small amount of habitat that is already available would likely degrade these populations of fishes. In the larger river habitat, the highest WUA occurred at the lowest discharge, which leads us to conclude that in the event of dewatering of the spring habitats, the river should provide some refuge habitat for spring dependent species.

Based on the findings of this study, groundwater removal from the aquifer near springs may have adverse impacts on fish habitat availability for spring dependent fish populations if seasonal trends in spring discharge are not maintained (higher in winter and lower in late summer). Quantifying the relationship of streamflow between gaged and ungaged springs in the Arbuckle-Simpson is a possible method to monitor and maintain flows in springs.

Developing Sustainable Watershed Management Strategies for Perennial Flashy/Runoff Streams

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Abstract

Increasingly, watershed planners are relying on science to protect watersheds' hydrologic characteristics, and the watershed's ecological community. When land use decision makers have information that provide a rational basis for "cause and effects" from land use changes on water resources, implementing customized watershed management strategies makes good sense.

Pocono Creek, located in Monroe County, PA, is a high quality wild trout stream whose watershed is being impacted by intense development. Linked by major highways to Philadelphia and New York City, Monroe County is an easy drive for over 26 million people. Tourism is the largest economic driver in the area, generating more than $1.5 billion annually. The Pocono's natural resources are the basis for this economy. The Pocono Creek collaborative study, supported by the U.S. EPA Office of Research and Development Science and Technology Network for Sustainability, used scientific studies to develop management strategies to sustain groundwater and surface water flows. Outcomes from groundwater, hydrologic and flow models were used to make watershed management decisions to assure the watershed's sustainability.

The groundwater model found that under a 20-year buildout scenario, recharge varied from an increase of 38% to a decrease of 61%. Simulated base flows were reduced from 38% to 63% . Withdrawals of 1 million gallons groundwater per day on sub-watersheds under buildout conditions showed decreased baseflows on Scot Run's (10%), Cranberry Creek (48%), Bulgers (46%) and Laural Lake Run (46%) as compared to the same withdrawals under year 2000 conditions.

The hydrologic model predicted that the watershed-averaged groundwater recharge will decline by 31% causing the average daily base flow to be reduced by 31%. The 7Q10 is expected to decline by 11%, and the monthly median daily flow is expected to be reduced by 10%. The monthly peak of simulated daily flows and annual maximum daily flow on the average are predicted to increase by 21% and 19%, respectively.

The USGS determined Pocono Creek's subbasin streams to be perennial runoff/flashy as defined by Poff (Poff 1996). The National Hydroecological Integrity Assessment software (Henriksen et al. 2006) was used to evaluate 27 hydrologic indices used to measure hydrological alteration and comparing baseline, future, and past flow scenarios. Environmental flow standards were applied to identify the degree of alteration projected for the future condition. A median value and a 75/25 percentile range determined if the standards were violated. Separate analyses examined relationships between projected development-related hydrologic changes and trout biomass.

Using these findings, the project team intends to develop sustainable watershed management strategies. The dynamic interchange between land and water and thus watershed hydrology and land use changes, suggests that a suite of management strategies will effectively protect baseflows in a watershed. Using “controllable flow indices” and applying sustainable flow standards to land use decisions will help sustain a high value public resource, i.e. trout.

Integrating all Aspects ofHabitat into Decision Making for Flow Regulation

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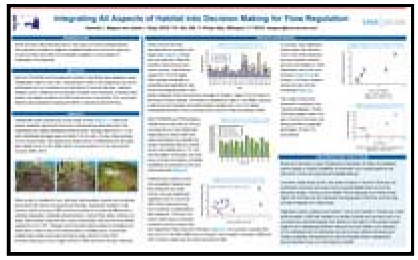

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Abstract

The headwaters of Ontelaunee Creek near Allentown, Pennsylvania, support a wild brook trout population and some brown trout, but are subject to a water withdrawal from adjacent springs and inputs from agricultural and developed lands. Modeling efforts indicate a roughly 10% loss of habitat for trout due to withdrawal, but 10 years of fish data indicate very weak or no correlation between low flows and trout biomass or other fish community measures. Percent pool habitat, however, is a highly significant predictor of trout biomass over the observed range and explains 82% of the observed variability in biomass. Pools provide refuge during low and high flows, and are themselves subject to creation and destruction during high flows. Much of the stream segment used for compliance was subject to channelization many years ago, and functions in a manner analogous to a rain gutter. Preferred water depths for trout habitat cannot be achieved without deleterious water velocities under the current physical setting. Regulation of low flows alone is not adequate to protect or enhance the fish community of upper Ontelaunee Creek. Creation of self-sustaining pools and watershed management are necessary to support the intended stream classification. There was an eventual recognition of the range of contributing factors in the permitting process for the withdrawal, and those factors were integrated into the decision. The value of extensive data on a stream to be regulated is underscored, including multi-year fish assessment and watershed evaluation in addition to instream physical measurements.

Effects of High Recreational Flows on Fishes, Amphibians and Macroinvertebrates: Research Results from the Pulsed Flow Program

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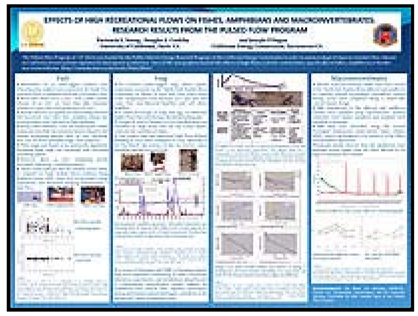

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Abstract

In order to assess short- and long-term ecological impacts of pulsed flow releases on California stream systems regulated for hydropower production, the Pulsed Flow Program was established with funding from the California Energy commission. Four of the nine projects researched on the effects of high recreational flows on biotic communities, specifically on fishes, amphibians or benthic macroinvertebrates.

1. Movements of twenty radio-tagged rainbow trout (Oncorhynchus mykiss) were tracked in the South Fork American River (California) from July to October, 2005. During this period the river had base flows of 5 m3s-1 with 4-hour midday releases of 40 m3s-1 on most days for whitewater rafting, plus increased releases on many days with peaks up to 110 m3s-1. Results showed no significant relationships between fish movement and water flow variables, release site, location within river, fish size, or fish condition. Using radio telemetry with electromyogram sensors the potential factors related to fish median swimming speeds, such as river discharge, time, sex, location, and pulse stage, were analyzed. Pulse stage was found to be statistically significant; increasing pulse stage was correlated with increasing swimming speeds. However, above 44 m3s-1, swimming activity decreased. These results indicate that the rainbow trout's ability to respond to high pulsed flows without being displaced incurs other costs such as increased energy expenditure and decreased foraging opportunities at high flows.

2. For foothill yellow-legged frogs (Rana boylii), oviposition occurred in the North Fork Feather River (California) in spring of 2004 and 2005 when mean water temperatures were between 10°C and 16°C and water flow was between baseflow and 55% above baseflow. A small percentage of frogs laid eggs at somewhat higher flows, but only during a declining hydrograph. Length of stay by females at river breeding sites was extended by high flows and, on the Cresta Reach, relatively low numbers of males. Late season rains and associated high flows delayed breeding in 2005 when compared to 2004, especially in the Poe Reach, the warmer of the two reaches where breeding typically occurred first.

3. Four analytical approaches (a review of literature and FERC re-licensing reports; long-term population monitoring in three watersheds; laboratory experiments; and simulations using River2D, a 2-dimensional hydrodynamic model) support the hypothesis that altered flow regimes, particularly spring and summer pulsed discharges, contribute to the decline of R. boylii in regulated rivers.

4. Benthic macroinvertebrate data from reaches of the North Fork Feather River, affected and unaffected by monthly pulsed recreational streamflow releases during 2004, were compared using a before-after control-impact design. Macroinvertebrate populations in the affected and unaffected reaches were sampled using representative artificial substrates (rock basket samplers) and standard kick-sampling techniques. Macroinvertebrate data were described using the recently developed hydropower multi-metric index (Hydro-MMI), which was designed to be sensitive to the effects of hydropower operations. The control-to-treated difference in Hydro-MMI was from pre-flow to post-flow. Seasonal trends showed that the unaffected reach generally scored higher than the reach affected by the high recreational flow releases.