Ecologically sustainable water management in Washington State, USA: Developing flow management tools for watershed planning

Presenter: Julian D. Olden, University of Washington

Abstract:
Washington's streams and rivers are naturally dynamic and complex ecological systems that provide significant economic, social, spiritual, and recreational value. Despite Washington's reputation as a perpetually rainy place, the water needs of people and natural ecosystems are increasingly in conflict. Century-long decline of Pacific salmon, degraded water quality of rivers flowing into the Puget Sound, and continued loss of wildlife habitat are all strong signals of current water demand stress in this region. Water managers are becoming increasingly cognizant of these pressures, yet there remains a critical knowledge gap of the ecological tradeoffs associated with various flow management practices, including instream flows as presently mandated in Washington. Here, we introduce a new research initiative to advance the science and develop the tools required for ecologically sustainable water management in Washington. Our approach follows the Ecological Limits of Hydrologic Alteration (ELOHA) framework by synthesizing the knowledge and data collected from individual rivers into a scientific framework that supports and guides the development of environmental flow standards at the regional scale. We present a state-wide hydrologic classification of unregulated rivers and quantify the range of natural flow variation that regulates characteristic ecological processes and habitat characteristics for distinct hydrologic types. This provides a baseline or reference condition against which ecological responses to alteration can be measured across multiple river segments falling along a gradient of hydrologic alteration. As an example, we develop flow-ecology relationships for hydrologic types according to population patterns of life history diversity for Chinook salmon (*Oncorhynchus tshawytscha*) throughout the Puget Sound. These results highlight the ecological effects of hydrologic alteration and help form the basis of flow management for both river ecosystem protection (proactive flow management) and sustainable restoration (reactive flow management) for salmon life history diversity.

Person Completing this Form
Julian Olden and Cathy Reidy Liermann

Today's Date
04/18/2008

Project Date and Duration
Begin 12/01/2007 - ongoing

Project Collaborators
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Project Location
Washington State, USA.

Study Area (km^2)
Washington State encompasses 176,477 km^2.

Aim/Purpose
Develop new analytical tools that support scientifically-credible, regional flow guidelines for the protection and restoration of streams and rivers in Washington.

Objectives
Objectives include the development of: 1) a statewide hydrologic classification, 2) flow-ecology response model, 3) statewide map of flow alteration, and 4) science-based environmental flow recommendations for a set of ecological goals.

Specific Activities and Methods
Hydrological classification for Washington watersheds will be developed by identifying unregulated streams and rivers exhibiting similar flow regimes and quantifying natural range of spatial and temporal variability in hydrologic characteristics. Data-driven curves relating each flow metric to each ecological health metric will be drawn for each hydrologic class. The curves within each hydrologic class will be integrated into a flow-ecology response model - an environmental flow management tool which will allow managers to model the simultaneous responses of the ecological health metrics to a particular flow alteration. Subsequent focused development of environmental flow standards for one example river per hydrologic class will provide validation and identification of gaps or weaknesses in the analytical framework, as well as demonstrating the entire water planning process for rivers exhibiting different hydrologic characteristics.

Data Used
USGS hydrologic gage data; EPA/USGS invertebrate data; EPA/USGS fish data, NOAA salmonid data; riparian vegetation data.

Data Generated
Hydrologic indices for WA State rivers
Degree flow alteration for WA State rivers
Ecological response data for unregulated WA State rivers
Predictive models for flow:ecology associations.

Results/Outcomes
By developing a regional hydrological classification, and calibrating ecological condition across the distribution of natural hydrologic characteristics for each class of stream, flow management plans will both incorporate empirical ecological data, and be formulated more efficiently by avoiding the need for site-specific data that neither exist nor will be available in the short term. The final integrated flow-ecology response model will be used to set flow targets such that the degree of flow modification does not exceed critical thresholds indicative of significant loss of biological health or ecosystem functioning.

Products
Hydrologic classification
Map of flow alteration
Flow-ecology response model
Case study results

Management and Policy Application
See "Results/Outcomes".

Monitoring
Unknown.

Funding
$84K annual for both 2008 and 2009

Funding Source
National Oceanographic and Atmospheric Administration Federal Columbia River Power System (**FCRPS**) Biological Opinion Funds

Documents
Pending.

Functional Connections between Fish Communities and Hydrology in the Tennessee River Valley, USA: A Conceptual Model

Presenter: Rodney Knight, U.S. Geological Survey

Abstract Functional connections between insectivorous fish, such as the slender madtom, *Noturus exilis*, and bigeye shiner, *Notropis boops*, and streamflow in the Tennessee River Valley were identified for three hydrologic metrics: constancy, moderate floods, and streamflow recession rates. These functional connections are important to fish for reasons that include habitat suitability as well as food availability. Constancy of streamflow (streamflow stability) is critical to maintaining wetted perimeter. Available wetted perimeter is important to providing fish with available habitat for spawning as well as providing increased surface area for invertebrate colonization and reproduction. Increased values of constancy and insectivore scores were positively correlated. The frequency of moderate flooding provides sufficient streamflow velocity to remove silt and sediment and adequate habitat disturbance to stimulate invertebrate growth. Site scores for insectivorous fishes increased as the frequency of moderate flooding decreased. Increased streamflow recession rates potentially strand fish in pools and other areas that are disconnected from flowing water. Increased recession rates potentially remove invertebrates as potential food sources that were suspended during high streamflow events. Increased streamflow recession rates were associated with decreased insectivore scores. Results from this study showed that hydrologic metrics are not the single environmental factor limiting the response of the fish community. Interactions among unmeasured environmental factors, such as nutrients, sediment, water chemistry and anthropogenic factors influence the structure of the fish community in the Tennessee River Valley. This is indicated by low insectivore scores occurring at otherwise optimal hydrologic metric values.

Person Completing this Form Rodney Knight

Today's Date 03/17/2008

Project Date and Duration October 2006 – March 2010

Project Collaborators

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Project Location – Tennessee River Valley, includes portions of Tennessee, Virginia, North Carolina, Georgia, Alabama, and Kentucky.

Study Area (km^2) 106,200

Aim/Purpose Identify hydrologic characteristics that are correlated to fish community health and structure

Objectives Develop a tool that can be used to estimate fish community health at unmonitored locations throughout the Tennessee River Valley.

Specific Activities and Methods Identify sites where streamflow data and fish community data are collocated. Use correlation analysis to identify common patterns between the two datasets.

Data Used – Digital continuous streamflow data from the U.S. Geological Survey's National Water Information System, digital fish community data from the Tennessee Valley

Authority, GIS derived physical basin descriptors such as land use, climate, channel shape, and drainage area.

Data Generated – Approximately 100 hydrologic metrics were calculated for each streamgage location used in the study. These include standard hydrologic descriptors such as low-flow values, duration values, and mean annual streamflow as well as ecologically relevant metrics describing the magnitude, duration, frequency, timing, and rate of change of the streamflow hydrograph.

Results/Outcomes Identification of three hydrologic metrics that limit the response of the fish community. Additionally, it was recognized that hydrology is only one of the factors that limit fish community structure. Other limiting factors include water chemistry and ecoregion.

Products Journal article (in review).

Management and Policy Application – The second and third phases of this study include the development and testing of a tool to predict hydrologic metrics at ungaged locations. Using this tool, managers would then have a method to estimate fish community health at stream locations without ecological data using hydrologic metrics proven to be relevant to the fish community. Additionally, managers would have hydrologic metrics that could be monitored to estimate potential change to fish community health with changes to the river.

Monitoring –

Funding approximately $700,000 (USD)

Funding Source Tennessee Wildlife Resources Agency, Tennessee Department of Environment and Conservation, and The Nature Conservancy

Documents –

Forest hydrology, channel network expansion, and fish distribution in headwater catchments, western Oregon, USA

Presenter: Christian Torgersen, U.S. Geological Survey

Abstract: Headwater streams are dynamic environments in which landscape characteristics exert strong influences on the distribution of stream fishes. Although geology, topographic factors, and land use have been shown to affect trout population density at a site-specific level, few studies have investigated landscape features associated with the spatial extent, or total linear distance occupied, of trout distribution in an entire watershed. To evaluate landscape influences on the distribution and abundance of coastal cutthroat trout (*Oncorhynchus clarki clarki*), we conducted spatially continuous surveys of stream habitat and trout abundance in forty randomly selected watersheds (500–1000 ha) in the Cascades, Coast Range, and Klamath Mountains ecoregions of western Oregon. Our investigation of coastal cutthroat trout populations across a broad range of headwater environments revealed that landscape features, including topography, annual precipitation, and stand replacement disturbance, were the primary factors associated with the spatial extent of trout distribution within watersheds. Variation in population density, however, was more difficult to predict due to site-level variability most likely resulting from localized disturbances. Understanding effects of basin-scale factors on trout distribution and abundance is critical in forested regions such as the Pacific Northwest where resource managers must consider potential impacts of logging on aquatic ecosystems.

Person Completing this Form: Christian Torgersen
Today's Date 03/15/2008
Project Date and Duration: 03/01/1999 – present
Project Collaborators:

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Project Location: Oregon, USA
Study Area (km^2): 200,000 km^2

Aim/Purpose: The goal of this study is to investigate the relationships among aquatic and terrestrial organisms, in-stream habitat, and riparian-area and upslope conditions across broad geographic areas in western Oregon. Specifically, our goal is to explore how in-stream habitat and watershed characteristics (including riparian-area and upslope conditions) affect distribution and abundance of coastal cutthroat trout across broad geographic areas in western Oregon.

Objectives: The objectives of this study are to (1) examine variation in the spatial extent of coastal cutthroat trout distribution within watersheds in western Oregon; (2) develop explanatory models for predicting trout distribution based on landscape and in-stream variables; (3) evaluate potential effects of landscape disturbance on trout populations in headwater streams.

Specific Activities and Methods:

Spatially continuous data on in-stream physical habitat and cutthroat trout abundance were collected and mapped during baseflow conditions along 213 km of headwater catchments (500-1000 ha) over a 3-year period. Data analysis and preparation of manuscripts are ongoing.

Data Used: Spatial extent of coastal cutthroat trout distribution obtained from surveys of 40 catchments.

Data Generated: Dynamically segmented GIS data layers depicting spatial variation in aquatic habitat and fish distribution and abundance.

Results/Outcomes: Multiple linear regression model that uses landscape characteristics to predict coastal cutthroat trout distribution in unsampled headwater catchments.

Products: See Cooperative Forest Ecosystem Research Program web site <http://www.fsl.orst.edu/cfer/research/resproj/lndscp/lnd-stdy/l01_lndf.html>

Management and Policy Application: See Cooperative Forest Ecosystem Research Program web site <http://www.fsl.orst.edu/cfer/research/resproj/lndscp/lnd-stdy/l01_lndf.html>

Monitoring: Not applicable

Funding: $1,000,000 USD

Funding Source: USGS, Bureau of Land Management, Oregon Department of Forestry

Documents: See Cooperative Forest Ecosystem Research Program web site <http://www.fsl.orst.edu/cfer/research/resproj/lndscp/lnd-stdy/l01_lndf.ht

Influence of flow regime on life-history structure of stream fish assemblages, upper Missouri River basin, USA

Presenter: Valerie Kelly, U.S. Geological Survey

Abstract: It is widely recognized that streamflow regime provides a critical adaptive template to which species life-histories must be well adapted for the species to be successful. This analysis evaluates how life-history traits of species in stream fish assemblages co-vary across a gradient of flow regime in the upper Missouri River Basin. The following questions are addressed: Do species tend to cluster together with similar life-history strategies, or do a wide range of life-history strategies coexist? Do these patterns differ along a regional gradient of streamflow regime? What is the effect of stream size? Preliminary results indicate that dominant traits within assemblages can be organized along a significant life-history gradient defined by age and length of maturity as well as longevity. This gradient is roughly associated with elevation and stream size, although some non-intuitive results are observed for large streams. Streamflow variability appears to provide an important constraint on the distribution of colonizer species, although not for classic K-selected species. The analysis is ongoing.

Person completing this form:	Valerie Kelly
Today's Date:	March 18, 2008
Project date and duration:	Ongoing
Project collaborators:	Valerie Kelly U.S. Geological Survey (USGS) U.S. Environmental Protection Agency (EPA)
Study area:	Approximately 750,000 square kilometers, including (potentially) all tributary streams to the upper Missouri River--including South Dakota, most of North Dakota, more than half of Montana, and about a third of Wyoming, USA. The streams were selected randomly as part of the EMAP probabilistic survey protocol.
Aim/Purpose:	Support EPA interpretation of data from their Environmental Monitoring and Assessment Program (EMAP)
Specific Activities:	Develop method to quantify streamflow regime for ungaged sites; develop database of life-history attributes; multivariate analysis of relationships
Data used:	EMAP data, USGS streamflow data, life-history data from literature
Data generated:	Metrics of flow regime for EMAP sites
Results:	Streamflow regime classification. Predictive model of selected life-history characteristics based on climate, topography, and streamflow variability.
Products:	Methodology for estimating flow metrics for ungaged sites. Dissertation, Oregon State University.

Management and Policy application: Uncertain.

Monitoring:	Not applicable.
Funding:	$65,000
Funding source:	EPA
Documents:	None

Hydrologic regime and the conservation of salmon life history diversity, Puget Sound, USA

Presenter: Tim Beechie, National Oceanographic and Atmospheric Administration

Abstract

Life history diversity of imperiled Pacific salmon *Oncorhynchus* spp. substantially contributes to their persistence, and conservation of their diversity is a critical element of recovery efforts. Preserving and restoring diversity of life history traits depends in part on environmental factors affecting their expression. We analyzed relationships between annual hydrograph patterns and life history traits (spawn timing, age at spawning, age at outmigration, and body size) of Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) to identify environmental indicators of current and historic diversity. Based on mean monthly flow patterns, we identified three hydrologic regimes: snowmelt-dominated, rainfall-dominated, and transitional. Chinook populations in snowmelt-dominated areas contained higher proportions of the stream-type life history (juvenile residence >1 year in freshwater), had older spawners, and tended to spawn earlier in the year than populations in rainfall-dominated areas. There are few extant Puget Sound populations dominated by the stream-type life history, as several populations with high proportions of stream-type fish have been extirpated by construction of dams that prevent migration into snowmelt-dominated reaches. The few extant populations are thus a high priority for conservation. The low level of genetic distinction between stream-type and ocean-type (juvenile residence <1 year in freshwater) life histories suggests that allowing some portion of extant populations to recolonize habitats above dams might allow re-expression of suppressed life history characteristics, creating a broader spatial distribution of the stream-type life history. Climate change ultimately may limit the effectiveness of some conservation efforts, as stream-type Chinook may be dependent on a diminishing snowmelt-dominated habitat

Person Completing this Form: Tim Beechie
Today's Date -- March 19, 2008
Project Date and Duration -- Completed 2006
Project Collaborators: All National Oceanographic and Atmospheric Administration (NOAA) employees and contractors.
Project Location – Puget Sound, Washington State, USA
Study Area (km^2) – 35,500 km^2
Aim/Purpose – Assist with ID of populations in Puget Sound Chinook salmon
Objectives – relate Chinook salmon life history traits to hydrograph patterns
Specific Activities and Methods – Hydrograph patterns were identified using cluster analysis of gage data, then hydrograph patterns were mapped throughout Puget Sound based on relationship of hydrograph pattern to precipitation and elevation. We then examined statistical correlations among individual life history traits (e.g., spawn timing, outmigrant timing, etc.) and hydrograph types.

Data Used – USGS gage data, life history trait data from Puget Sound TRT --Technical Recovery Team for the Puget Sound area's endangered salmon (most of the work was on the Chinook populations).

Data Generated – Maps of hydrologic regimes

Results/Outcomes – Life history traits are related to hydrograph pattern: stream type life history most commonly found in snowmelt dominated regions, and ocean type life history in rainfall dominated areas**.**

Products – Publication : Beechie, T.J., M. Ruckelshaus, E. Buhle, A. Fullerton, L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation 130(4):560-572.

Management and Policy Application – Used in ID of Puget Sound populations for Puget Sound TRT.

Monitoring None

Funding Based funded

Funding Source NOAA Fisheries

Documents -- Publication : Beechie, T.J., M. Ruckelshaus, E. Buhle, A. Fullerton, L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation 130(4):560-572.

Tools for determining environmental flows for riparian vegetation: an introduction to riparian vegetation-flow response guilds

Presenter: David M. Merritt, US Forest Service

SUMMARY

1. Riparian vegetation composition, structure and cover are governed to a large degree by river flow regime and flow-mediated fluvial processes. River flow regime exerts selective pressures on riparian vegetation, resulting in adaptations (trait syndromes) to specific flow attributes. Widespread alteration of river flow regimes by humans has resulted in shifts in riparian vegetation. Some of the negative effects of altered flow regimes on vegetation may be reversed through the restoration of key components of river flow regime.
2. A number of models have been developed that quantitatively relate components of river flow regime to attributes of riparian vegetation at the individual, population, community levels. Predictive models range from simple statistical relationships, to more complex stochastic matrix population models and dynamic simulation models. In a review of dozens of predictive models, I found that most treat one or a few species, have many simplifying assumptions such as stable channel form, and most do not specify the time-scale of response. In many cases, these models are very effective in developing alternative river flow management plans for specific river reaches or segments, however most of them are not directly transferable to other rivers or other regions.
3. A primary goal in community ecology is to develop general frameworks for prediction of vegetation response to changing environmental conditions. The development of *riparian vegetation flow response guilds* offers such a framework for incorporation of information from rivers for which flow standards have been developed to maintain attributes of the vegetation to rivers for which little or no information is available.
4. We organize riparian plants into non-phylogenetic groupings of species with shared traits that are related to components of hydrologic regime: life history, reproductive strategy, morphology, adaptations to fluvial disturbance, and adaptations to water availability. Plants from any river may be grouped into these functional guilds and related to hydrologic attributes of a specific class of river using probabilistic response curves.
5. The probabilistic models produced enable prediction of the likelihood of each of the response guilds given projected changes in flow, facilitating an examination of trade-offs and risks associated with various management strategies. Riparian response guilds may be decomposed to the species level for individual projects or used to develop flow management guidelines for regional water management plans.

Collaborators:

David M. Merritt, US Forest Service Stream Systems Technology Center, Fort Collins, Colo.
LeRoy Poff, Colorado State University, Fort Collins, Colorado
Michael Scott, US Geological Survey, Fort Collins, Colorado
David Lytle, Oregon State University, Corvallis, Oregon
Greg Auble, US Geological Survey, Fort Collins, Colorado

Developing instream flow criteria to support ecologically sustainable water resource management in Pennsylvania, USA

Presenters[1]*:*
Michele DePhilip, The Nature Conservancy
Julie Zimmerman, The Nature Conservancy

Person Completing this Form – Michele DePhilip
Today's Date – 04/18/2008
Project Date and Duration – Approximately 18 months (Fall 2006 - Spring 2008)
Project Collaborators
Colin Apse, The Nature Conservancy Eastern US Freshwater Program, Brunswick, Maine
Michele DePhilip, The Nature Conservancy in Pennsylvania, Harrisburg, Pennsylvania
Julie Zimmerman, The Nature Conservancy, Bethesda, Maryland
Mark Smith, The Nature Conservancy Eastern US Freshwater Program, Boston, Massachusetts

Project Location – Pennsylvania (statewide), USA, with pilot study in Pennsylvania portion of Susquehanna River (approximately 60% of Pennsylvania is within Susquehanna River Basin)
Aim/Purpose – The Nature Conservancy, in close collaboration with representatives of state and federal agencies and river basin commissions, is leading a process to make recommendations on how instream flow protection could be improved within Pennsylvania. Recommendations will address approaches for establishing baseline, current, and future flow conditions and assessing flow alteration in Pennsylvania streams, developing quantitative relationships between flow alteration and ecological responses, defining instream flow criteria, and applying these criteria to decisions about water use. These recommendations are being developed at the request of Pennsylvania natural resource and water management agencies, primarily Pennsylvania Department of Environmental Protection.

Objectives:
1. Complete a review of tools and models from other states and countries that are useful for
   - Establishing Baseline Hydrologic Conditions
   - Establishing Current or Future Hydrologic Conditions
   - Selecting Hydrologic Statistics & Assessing Hydrologic Alteration
   - Defining Instream Flow Criteria & Developing Flow Ecology Relationships
   - Using of Instream Flow Criteria in Decision-Making
2. Complete a pilot hydrologic classification that is applicable statewide.

[1] This work will be covered in two presentations at the USGS-TNC workshop held April 29-30, 2008. M. DePhilip's presentation is an overview of the entire project; J. Zimmerman's presentation focuses on the pilot study to develop relationships between aquatic insect communities and hydrologic alteration.

3. Complete a pilot study or studies to quantify relationships between flow alteration and ecological responses using existing data.
4. Illustrate strengths and weaknesses of various approaches and make recommendations on the most promising approaches given data availability and water management issues in Pennsylvania. Provide general cost estimates for most promising applications.
5. Establish an Instream Flow Advisory Committee to engage in this process, with the expectation that this committee would continue to engage on instream flow issues and act on some or all of the recommendations.

Specific Activities, Methods, and Data Used – A combination of literature review and personal communication with other practitioners was used to identify and review promising approaches for developing technical tools and incorporating best available science into water management decisions. Data used in the pilot studies are briefly described below.

Pilot analysis to develop flow alteration – ecological response curves – Statewide registered and estimated water withdrawal and discharge data and available surface water were provided by Pennsylvania Department of Environmental Protection and USGS. Macroinvertebrate monitoring data, and associated metrics were provided by Susquehanna River Basin Commission.

Pilot hydrological classification – Pilot stream classification completed using USGS Hydroecological Integrity Assessment Process (HIP) software. Reference gages selected with input from USGS. Regression models based on catchment characteristics were developed to assign hydrologic 'types' to ungaged sites. Data on catchment characteristics were provided by USGS.

Funding – $109K US dollar
Funding Source – Pennsylvania Growing Greener Environmental Stewardship and Watershed Protection Grant

Documents – Draft report, not yet available for distribution: Apse, Colin, DePhilip, Michele, and Smith, Mark P., Developing Instream Flow Criteria to Support Ecologically Sustainable Water Resource Planning and Management: Phase 1, draft report to the Pennsylvania Instream Flow Advisory Committee (final report to be complete June 2008).

Evaluating the effects of hydrologic changes on stream fish and macroinvertebrate assemblages in New Jersey Pinelands streams, USA

Presenter: Jonathan Kennen, U.S. Geological Survey

Abstract: Water-supply development has been linked to changes in streamflow patterns, which can affect stream biodiversity. Relations of hydrologic, water-quality, and landscape parameters to stream fish and macroinvertebrate-assemblages were evaluated at 43 Pinelands stream reaches as part of a multiagency cooperative effort. Nearly 3 years of daily flow data prior to and encapsulating the sampling period were developed using records from nearby indexed continuous streamflow gages. Macroinvertebrate samples were collected during low- and high-flow periods in 2004 and 2005. Corresponding data on water chemistry, physical conditions, and landscape configuration were collected. More than 170 flow parameters accounting for duration, frequency, magnitude, timing, and rate of change of flow events were calculated. Patterns in fish and macroinvertebrate-assemblage structure among sites were examined using nonmetric multidimensional scaling (NMS) and general linear modeling (GLM) techniques. The primary NMS axis and indices of assemblage condition were significantly related to changes in flow regime (e.g., high- and low-flow duration, flashiness), instream habitat, and landscape alteration. GLM results are being used to identify hydrologic parameters associated with ecosystem disturbance, develop predictive flow-ecology response relations, assess withdrawal effects on assemblage structure, and provide water managers with a strong scientific basis for establishing targeted limits on hydrologic changes for maintaining aquatic health.

Person Completing this Form: Jonathan G. Kennen, Aquatic Ecologist, U.S. Geological Survey, 810 Bear Tavern Rd. Suite 206, West Trenton, New Jersey 08628.

Today's Date – 03/15/2008

Project Date and Duration – The work plan was approved by the Pinelands Commission in October 2003. The anticipated completion date for the Kirkwood-Cohansey Project is June 2009.

Project Collaborators:

Coauthors: Melissa Riskin
Hydrologic Technician
U.S. Geological Survey
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John Bunnell
Principal Research Scientist
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New Lisbon, NJ 08064

The Kirkwood-Cohansey Project is a multiagency study that includes the Pinelands Commission, U. S. Geological Survey, U.S. Fish and Wildlife Service, Rutgers University, and the New Jersey Department of Environmental Protection.

Project Location – USA, Atlantic Coastal, New Jersey. The environmental setting for the Kirkwood-Cohansey Project includes several Pinelands watersheds that represent a range of hydrologic, geological, land-cover, and ecological conditions. The Pump Branch/Albertson Brook, Morses Mill Stream, Bass River, Rancocas Creek, Mullica River, Cedar Creek, and Batsto River systems are the primary study areas for stream-assemblage investigations. These drainages include a range of stream orders, water-quality conditions, and land-use characteristics. Intermittent-pond vegetation, anuran larval-development, forested wetlands, and swamp pink (*Helonias bullata)* studies are also being conducted within the study areas. Relations at the local and landscape scale are being developed.

Study Area (km^2): Study Area is the Pinelands National Reserve (PNR) created by Congress under the National Parks and Recreation Act of 1978. The PNR is the first National Reserve in the nation. The PNR encompasses approximately 4,452 km^2 covering portions of seven counties and all or parts of 56 municipalities.

Aim/Purpose: Assess the probable ecological effects of induced stream-flow and groundwater-level changes on aquatic and wetland communities and evaluate the hydrologic effects of groundwater diversions from the Kirkwood-Cohansey aquifer on stream flows and wetland water levels as per New Jersey Public Law 2001, Chapter 16.

Objectives: Evaluate flow-ecology linkages by developing ecological response models relating fish and invertebrate-assemblage response to changes in streamflow processes. Assess the effects of water-level changes on wetland communities and develop broad landscape models that use projected changes in water levels to predict the effect on wetland communities including endangered species (e.g., Swamp Pink*)*.

Specific Activities and Methods: Stream assemblage sampling, flow monitoring, water-quality & field parameters, habitat and stream vegetation, GIS Data –Land use/cover. Water level mapping, establish and maintain a continuous streamflow-gaging station at a downstream end of each study area, quantify and balance the major water-budget components (precipitation, ET, surface runoff, withdrawals, groundwater discharge to streams, changes in storage, and recharge), pump tests to characterize wetland/aquifer interactions under unstressed conditions by evaluating head gradients, use build-out and water-demand assessments and hypothetical demands to prepare hydrologic model input-data sets to simulate the effect of various pumping scenarios on each study area, develop ecological response models (e.g., GLM), wetland forest indicator species models, and spatially distributed models at a landscape scale relating wetland-forest community types and indicator species to changes in water level (e.g., machine learning models such as CART and RandomForest). Open access database development.

Data Used – Fish and invertebrate assemblage data at 43 sites sampled at during high and low-flow periods. Indices of fish and invertebrate assemblage condition, hydrologic, water use, GIS land use/cover, habitat, vegetation cover, and water-quality data.

Data Generated – Hydrographs for all sampling sites, 171 hydrologic metrics, stream and wetland community data matrices and indices, ancillary environmental data, water budget data, aquifer stress test data, water demand and build-out data.

Results/Outcomes: Fish, invertebrate, and wetland assemblage response models relating changes in assemblage structure to changes in stream hydrology and water-levels, respectively. Water-level maps and build out projections. Spatially distributed CART and Random Forest models of mapped environmental characteristics that analyze the effect of various scenarios of natural and induced changes in the duration and frequency of saturation and flooding on the spatial distribution of wetland-forest community types and indicator species (i.e., shifts in community types associated with changes in water-table patterns). Regression models linking changes in water availability to alterations in intermittent-pond vegetation, anuran larval-development, forested wetlands, and swamp pink (*Helonias bullata*) populations.

Products – A series of reports and papers covering all aspects of the project (fish, invertebrate, anuran, and wetland assemblages, hydrology, endangereed species, water balance, build out, physiological stress, hydrologic framwork, etc.), an open access database, GIS models relating landscape-scale changes in species, biological communities, and ecosystem processes to changes in hydrologic regimes. The ultimate goal is to also produce a single final product that is a compendium of all reports.

Management and Policy Application – Results of this project will be used to determine how the current and future water-supply needs within the Pinelands area may be met while protecting the Kirkwood-Cohansey aquifer system and avoiding any adverse ecological impact on the Pinelands Natural Reserve.

Monitoring: Hydrologic baseline and groundwater level monitoring.

Funding: 5,500,000 USD

Funding Source: New Jersey Legislature

Documents – Kirkwood Cohansey Project
http://www.state.nj.us/pinelands/science/kirkwood/\
Workplan for the Kirkwood Cohansey Project:
http://www.state.nj.us/pinelands/infor/broch/Kirkwood-Cohansey%20Project%20Work%20Plan.pdf

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Development of an adaptive, decision support model for evaluating the effects of water use in the lower Flint River Basin, Georgia, USA

Presenter: James T. Peterson, U.S. Geological Survey

River regulation and water use are among the foremost problems faced by natural resource managers. Identifying and quantifying the effects of river regulation and water development on aquatic communities is crucial for evaluating potential conservation strategies. To evaluate the influence of water use on stream fishes, I developed empirical models relating changes in flow regime to changes in fish distribution in the Lower Flint River Basin, GA. I then used these models to examine changes in species-specific distribution patterns under 4 simulated water use scenarios. The simulations predicted a decrease in the distribution of 15 fish species relative to the no water use scenario, regardless of the biological dynamics simulated. The estimates of the effects of water use, however, were influenced by the assumptions about how other factors affect fish population dynamics. While it is clear that seasonal streamflows affect fish populations, remaining uncertainty about biological system dynamics make it difficult to predict with certainty the biological effects of water management decisions. I believe that an adaptive approach could be incorporated into decision making to resolve the uncertainties about the dynamics of fish populations and improve water resource decision-making.

Today's Date: 1 February 2008
Project Title: The development and evaluation of tools for evaluating flow requirements in streams in the Lower Flint River Basin, Georgia
Project Date: August 2001 – December 2005
Project Collaborators: James T. Peterson (USGS Georgia Cooperative Fish and Wildlife Research Unit, University of Georgia, Athens); C. Rhett Jackson (Warnell School of Forestry and Natural Resources, University of Georgia, Athens); Mike Harris (GA Department of Natural Resources)
Project Location: Lower Flint River Basin, Georgia
Study Area: 15,100 km^2
Purpose: Evaluate the influence of water use and develop streamflow standards in the Lower Flint River Basin.
Objectives: Develop dynamic, spatially-explicit methods for evaluating the effects of water use on stream fish populations in the Lower Flint River Basin.
Methods: We developed empirical models relating streamflow to: (1) water temperature and stream dissolved oxygen concentrations; (2) the amount and types of stream

habitats available for fishes; (3) changes in fish community structure; and (4) meta-demographic parameters of 15 fish species. We then used these models to simulate changes in water quality, habitat availability, fish community structure, and species-specific distribution patterns under four simulated water use levels using simulated flow data provided by the Georgia Department of Natural Resources, Environmental Protection Division (EPD) hydrologists.

Data: HSPF surface water simulations under four water use scenarios created by Georgia EPD, daily discharge data from USGS gages, USGS 1:100k hydrography, 30-m DEM from the National Elevation Dataset, 2001 UGA NARSL landcover data, seasonal fish and habitat samples collected 2001-2004.

Results: Model evaluation indicated that most of our models were relatively accurate with estimated error rates averaging less than +/- 20%. Spatially-explicit simulations of fish distribution patterns under water use scenarios predicted losses in species distribution for all 15 species, regardless of the biological mechanisms simulated. We predicted that species distributions were reduced, on average, by 28% and were negatively related to increased water. The simulation results also indicated that the estimates of the effects of water use on species-specific distribution were influenced by the assumptions about the biological system dynamics. This demonstrates that decisions on how best to conserve water for ecological needs would be further complicated by the uncertainty about biological system dynamics. For example, assumptions about biological mechanisms would likely determine where (e.g., which streams) water would best be conserved.

Policy Application: No listed fish species are present in the Lower Flint River Basin. However, results of this study were the motivation for the current development of a habitat conservation plan for three Federally-listed species of mussels in the basin.

Long-Term Monitoring: None to date

Funding ($) 356,000

Funding Source: Georgia Department of Natural Resources

Documents: Peterson, J. T., C. R. Jackson, G. Li, J. McCargo, and R. McPherson. 2006. The development and evaluation of tools for evaluating flow requirements in streams in the Lower Flint River Basin, Georgia. Report to the Georgia Department of Natural Resources, Social Circle, Georgia.

Peterson, J. C. Moore, S. Wenger, K. Kennedy, E. Irwin, and M. Freeman. 2007. Adaptive management applied to aquatic natural resources. Chapter 6.4 in Proceedings of the 2007 Georgia Water Resources Conference, March 27-29, Athens.

McCargo, J. 2004. Influence of Drought on Seasonal Fish Assemblages and Habitat in the Lower Flint River Basin, Georgia. MS Thesis. University of Georgia, Athens.

McPherson, R. 2005 An Assessment of Fish Community Structure and Seasonal Habitat Use Of Headwater Confined Channels and Headwater Wetlands in the Lower Flint River Basin, Southwest Georgia. MS Thesis. University of Georgia, Athens.

Design of a Naturalized Flow Regime – An Example from the Lower Missouri River, U.S.A.

Presenter: Robb Jacobson, U.S. Geological Survey

Abstract
A group of river managers, stakeholders, and scientists met during summer 2005 to design a more naturalized flow regime for the Lower Missouri River (LMOR). The objective was to comply with requirements under the U.S. Endangered Species Act to support reproduction and survival of threatened and endangered species, with emphasis on the endangered pallid sturgeon (*Scaphirhynchus albus)*, while minimizing negative effects to existing social and economic benefits of prevailing river management. Specific hydrograph requirements for pallid sturgeon reproduction are unknown, hence much of the design process was based on features of the natural flow regime. Environmental flow components (EFCs) extracted from the reference natural flow regime were used to design and assess performance of alternative flow regimes.

The design process incorporated a primary stage in which conceptual hydrographs were developed and assessed for their general ecological and social-economic performance. The second stage accounted for hydroclimatic variation by coding the conceptual hydrographs into reservoir release rules, adding constraints for downstream flooding and low-storage precludes, and running the rules through 100 years of hydroclimatic simulation. The output flow regimes were then evaluated for presumed ecological benefits based on how closely they resembled EFCs in the reference flow regime. Flow regimes also were assessed for social-economic cost indicators, including days of flooding of low-lying agricultural land, days over flood stage, and storage levels in system reservoirs.

Our experience with flow-regime design on the LMOR underscored the lack of confidence stakeholders place in the value of the natural flow regime as a measure of ecosystem benefit in the absence of fundamental scientific documentation. Stakeholders desired proof of ecological benefits commensurate with their certainty of economic losses. We also gained insight into processes of integrating science into a collaborative management exercise. Although the 2005 collaborative effort failed to reach a consensus among stakeholders on a naturalized flow regime, the process was successful in pilot-testing a design approach; it helped focus science efforts on key knowledge gaps; and it demonstrated the potential for collaborations among scientists, stakeholders, and managers in river management decision making.

Person Completing this Form
Robert Jacobson
Today's Date -- 03/14/2008
Project Date and Duration -- 05/01/2005 – 10/01/2005
Project Collaborators
There were over 40 stakeholders participating in this process Most are listed at:

http://missouririver.ecr.gov/spring.asp?link=116

Project Location – Missouri River Basin, U.S. and Canada, parts of Montana, Wyoming, North Dakota, South Dakota, Minnesota, Colorado, Nebraska, Iowa, Kansas, Missouri.

Study Area (km^2) -- 1,300,000 km^2

Aim/Purpose – Develop a socially and economically acceptable naturalized flow regime for the Lower Missouri River.

Objectives – Provide guidelines for design of spring pulses intended to support reproduction and survival of endangered species, including the pallid sturgeon, interior least tern, and piping plover.

Specific Activities and Methods – Comparisons among alternative flow regimes based on inferred ecosystem benefits and social-economic costs. See Jacobson and Galat (in press).

Data Used – Mostly outputs from the Corps of Engineers Missouri River Daily Routing Model (U.S. Army Corps of Engineers, 1998; 2005)

Data Generated – Statistical analysis of flow pulses and social-economic costs. See Jacobson (in press).

Results/Outcomes – Changes were made to Missouri River Annual Operating Plan to reflect more naturally shaped spring pulses. Size and ability to implement spring pulses are still problematic.

Products – Model outputs : (U.S. Army Corps of Engineers, 2005)
Analysis: (Jacobson, in press; Jacobson and Galat, in press)

Management and Policy Application – Changes were made to Missouri River Annual Operating Plan to reflect more naturally shaped spring pulses. Size and ability to implement spring pulses are still problematic.

Monitoring – Monitoring, assessment, and research to address success of flow regime and other management actions are presently $14.3 million per year.

Funding -- The analysis of the case study cost probably $50,000 - $75,000. Total cost of Missouri River recovery over the past 5 years has been $265 million. Flow regime naturalization is an integral part of this cost but it would be very difficult to separate it out.

Funding Source – Analysis of the case study was paid for by US Geological Survey. The remainder of the funds were provided by U.S. Army Corps of Engineers.

Documents –

U.S. Institute for Environmental Conflict Resolution Missouri River Spring Rise web site: http://missouririver.ecr.gov/spring.asp?link=100

Jacobson, R.B., in press, Analysis of pulsed flow modification alternatives, Lower Missouri River, 2005: U.S. Geological Survey Open-File Report 2008-1113, xx p. http://pubs.usgs.gov/of/2008/1113.

Jacobson, R.B., and Galat, D.L., in press, Design of a naturalized hydrograph on the Lower Missouri River: Ecohydrologyftp://ftpext.usgs.gov/pub/cr/mo/columbia/Jacobson/ecohydrology/lmor_flow_modification_pre_press_jacobson_galat_ecohydrology.pdf.

U.S. Army Corps of Engineers, 1998, Reservoir regulation studies--Daily routing model studies, master water control manual Missouri River review and update study: U.S. Army Corps of Engineers, Northwest Division, v. 2A, 137 p.

U.S. Army Corps of Engineers, 2005, Spring rise formulation alternatives, U.S. Army Corps of Engineers, Northwestern Division; accessed August 1, 2007: url:http://www.nwd-mr.usace.army.mil/mmanual/rdeis-files.html.

The Massachusetts Sustainable-Yield Estimator: A decision-support tool to estimate continuous daily streamflow at ungaged locations in Massachusetts, USA

Presenter: Stacey Archfield, U.S. Geological Survey

Abstract

Federal, State and local water supply, regulatory, and planning agencies require easy-to-use, technically-defensible, decision-support (DS) applications that can evaluate impacts of proposed water withdrawals, determine baseline streamflow conditions needed for sustainability of aquatic habitat, and estimate inflows to drinking-water-supply reservoirs for safe yield analyses at ungaged locations. An interactive, point-and-click DS application was developed in combination with a geographic-information system and probabilistic methods to address these needs. The DS application estimates unimpacted daily streamflow at any user-selected location – gaged or ungaged -- on a perennial stream in Massachusetts. A new method is proposed to estimate a daily flow-duration curve at an ungaged site by exploiting the structure of the ordered flows. This method offers substantial improvement -- particularly for low flows -- over traditional regression-based approaches that relate flows at selected quantiles to measurable basin characteristics. A time series of daily flows is then created by transferring the timing of the daily flows at an index gage to the ungaged site at equivalent exceedance probabilities. Estimated daily streamflows show remarkably good agreement with observed daily flows and are comparable to the agreement obtained from a calibrated rainfall-runoff model. Confidence intervals around daily streamflow estimates are also computed by the DS system and these intervals are based on the probabilistic structure of jack-knifed errors at 66 streamflow-gaging stations throughout southern New England.

Person Completing this Form: Stacey Archfield, U.S. Geological Survey Massachusetts-Rhode Island Water Science Center

Today's Date: 03/20/2008

Project Date and Duration: 10/01/05 to 09/30/2008

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Project Location: Massachusetts, USA

Study Area (km^2): 27,337

Aim/Purpose: Users of the SYE application will be able to compare estimated flows to a user-specified instream-flow target and compute a sustainable yield (the amount of water available for withdrawal from the basin while maintaining flow requirements for aquatic habitat). The calculation of sustainable yield will be based not only on user-specified instream-flow targets (time-varying or constant flow targets) but also for a user-specified time period (drought year, wet year, or average year).

Objectives: Develop an interactive, point-and-click tool, built upon a geographic-information system, to estimate the unimpacted streamflow at any location on a perennial stream in Massachusetts.

Specific Activities and Methods:

To estimate unimpacted flows, a flow-duration curve at the ungaged basin will be estimated by a set of equations that relate basin characteristics to properties of flow-duration curves. A new method is proposed to estimate a daily flow-duration curve at an ungaged site by exploiting the structure of the ordered flows. This method offers substantial improvement -- particularly for low flows -- over traditional regression-based approaches that relate flows at selected quantiles to measurable basin characteristics. A time series of daily streamflow is then created from the estimated flow-duration curve by use of the QPPQ-transform method (Fennessey, 1994), which transfers the timing of the daily flows at an index gage to the ungaged site by equating the exceedance probabilities at the index gage and ungaged site. Estimated daily streamflows show good agreement with observed daily flows and are comparable to the agreement obtained from a calibrated rainfall-runoff model.

Ground- and surface-water withdrawals, ground-water discharges, and return flows will be used to estimate the time series of impacted streamflow. The impacts of ground-water withdrawals and discharges on streamflow will be estimated by an analytical solution that uses properties of the aquifer, time-varying withdrawal or discharge rates, and the distance between the stream and the withdrawal or discharge location to estimate streamflow depletion or augmentation, respectively (Barlow, 2000). Time-varying streamflow depletion will then be subtracted from the estimated unimpacted flows. Surface-water withdrawals and return flows will be directly subtracted from or added to the estimated unimpacted flows, respectively. Users of the application will be able to add new withdrawals, discharges and/or return flows as well as edit existing withdrawal, discharge and/or return flow data.

Data Used: Basin characteristics and daily streamflow at 66 minimally-altered streamflow-gaging stations in southern New England. Water-use data for all ground- and surface-water withdrawals, ground-water discharges, and surface-water return flows in Massachusetts from 2000 to 2004.

Data Generated: Time series of unimpacted, continuous daily streamflow from October 1, 1960 through September 30, 2004 at any ungaged location in Massachusetts and a time series of impacted, continuous streamflow resulting from water use in any ungaged basin from 2000 through 2004.

Results/Outcomes: Project will develop a method to estimate unimpacted and impacted continuous daily streamflow at ungaged locations in Massachusetts.

Products: The Sustainable-Yield-Estimator (SYE) decision-support tool and user's guide; U.S. Geological Survey Scientific Investigations Report, which will include documentation of the methodologies; various publications in refereed journals.

Management and Policy Application: The Sustainable-Yield-Estimator tool computes an unimpacted continuous, daily hydrograph for a specific historical time period (for example, a daily time series of flows from 1960 to 2004). Based on user-defined constraints such as existing water-use in the basin and instream-flow regimes necessary for sustainability of aquatic habitat, the tool then computes the sustainable yield of the basin, defined as the difference between the estimated hydrograph and the user-specified instream-flow regime. Users can quickly and easily compute the sustainable yield of the basin for a variety of water-management scenarios and instream-flow regimes. For fixed ungaged basins, these results can be applied to water-budget analyses at ungaged sites.

Monitoring: None.

Funding: $350,000

Funding Source: U.S. Geological Survey Cooperative Water Program and the Massachusetts Department of Environmental Protection

Documents: Publications and decision-support tool are currently in review.

References:

Barlow, P.M., 2000, Documentation of computer program STRMDEPL-A program to calculate streamflow depletion by wells using analytical solutions, In Zarriello, P.J. and Ries, K.G. III, 2000, A precipitation-runoff model for the analysis of the effects of withdrawals on streamflow, Ipswich River Basin, Mass., U.S. Geological Survey Water-Resources Investigation Report 00-4029, 99 p.

Fennessey, N.M., 1994, A hydro-climatological model of daily streamflow for the northeast United States: Medford, MA, Tufts University, Ph.D. dissertation, variously paged.

Predicting the natural flow regime: models for assessing hydrological alteration in streams

Presenter: Daren M. Carlisle, U.S. Geological Survey

Ecological assessments of streams are incomplete without understanding whether the natural flow regime is intact. Assessing hydrologic alteration (i.e., condition) requires that we quantify the attributes of the flow regime that would be expected in the absence of anthropogenic disturbance. Our objective was to evaluate whether indicators of the natural flow regime could be predicted at regional and national spatial scales using geospatial data. We first selected 1,272 gaged river basins throughout the contiguous U.S. where the hydrologic regimes were either least disturbed or near pristine. Using the period of record for these sites, we calculated 13 hydrologic indicators of magnitude, frequency, duration, timing, and rate of change. We used a robust modeling approach to evaluate the precision with which each indicator could be predicted with a single national and several regional models. We compared the precision of predictive models to that of "null" models, where expected values of each indicator were constant across hydrologic regions and ecoregions. A single national predictive model produced the most precise estimates for most indicators. Error rates ranged from 15-40%, but were <=25% for most indicators. We selected three gaged, non-reference sites to illustrate how predictive models could be used to assess site-specific hydrologic condition. These examples show how the model accurately estimates pre-disturbance hydrology and how reservoir construction and urbanization can affect hydrologic condition.

Collaborators:

Daren M. Carlisle, US Geological Survey, National Water Quality Assessment, Reston, Virginia

James Falcone, US Geological Survey, Reston, Virginia

David M. Wolock, US Geological Survey, Lawrence, Kansas

Michael R. Meador, US Geological Survey, Reston, Virginia

Richard H. Norris, Cooperative Research Centre for Freshwater Ecology, University of Canberra, Canberra, Australian Capital Territory, Australia

Water availability for ecological needs – hydrologic components of the Flint River Science Thrust Project, Georgia, USA

Presenter: Lauren Hay, U.S. Geological Survey

The Upper Flint River Basin in Georgia is being studied as part of the Science Thrust project of the USGS, a federally funded program to address key national science priorities. The interdisciplinary nature of this project has brought together USGS scientists from each of the disciplines to work as a team towards advancing the linkage of hydrology and stream ecology. Specific project goals include:

- Develop conceptual models that relate hydrology, geomorphology, and water quality to biological management objectives.
- Evaluate and determine the major factors driving the conceptual models and determine additional data needs.
- Use the upper Flint River Basin to demonstrate a spatially explicit predictive model for evaluating water-supply development options that links watershed conditions to biological management objectives.
- Identify research and monitoring needed to address critical uncertainties and data gaps determined during model development.

This presentation will present the current and projected science results from a hydrologic perspective..

Person Completing this Form: Lauren Hay, USGS
Today's Date -- 03/14/2008
Project Date and Duration -- 2007 - ?
Project Collaborators

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Project Location – Upper Flint River basin, Georgia, USA
Study Area (km^2): 4,700

Aim/Purpose: To advance the linkage of landscape, hydrology and stream ecology.
Objectives:

- Develop conceptual models that relate hydrology, geomorphology, and water quality to biological management objectives.
- Evaluate and determine the major factors driving the conceptual models and determine additional data needs.
- Use the upper Flint River Basin to demonstrate a spatially explicit predictive model for evaluating water-supply development options that links watershed conditions to biological management objectives.
- Identify research and monitoring needed to address critical uncertainties and data gaps determined during model development.

Specific Activities and Methods PRMS was set up to simulate distributed flow values at for the Upper Flint River basin.
Data Used land use/ land cover, stream gage data, climate data
Data Generated – distributed flow at various resolutions
Results/Outcomes: in progress
Products – in progress.
Management and Policy Application -- The distributed flow and associated statistics are used to predict fish assemblage response to various scenarios
Monitoring : ?
Funding for my specific portion -- none
Funding Source

Using Streamstats to Estimate Flow Statistics for Ungaged Sites in the United States

Presenter: Kernell G. Ries, U.S. Geological Survey

StreamStats is a Web-based Geographic Information System (GIS) application that was created by the U. S. Geological Survey (USGS), in cooperation with Environmental Systems Research Institute, Inc. (ESRI), to provide users with access to an assortment of analytical tools that are useful for water resources planning and management. StreamStats allows users to easily obtain streamflow statistics, basin characteristics, and descriptive information for USGS data-collection stations and for user-selected ungaged sites. It also allows users to identify stream reaches that are upstream and downstream from user-selected sites, and to identify and obtain information for locations along the streams where activities that may affect streamflow conditions are taking place. This functionality can be accessed through a map-based user interface that appears in the user's Web browser, or individual functions can be requested remotely as Web services by other Web or desktop computer applications.

StreamStats can estimate streamflow statistics for ungaged sites either on the basis of regional regression equations or on the basis of the known flows for nearby streamgaging stations. Estimates of streamflow statistics that are obtained from regression equations are based on the assumption of natural flow conditions at the ungaged site. If human activities such as dam regulation and water withdrawals substantially affect the timing, magnitude, or duration of flows at a selected site, then the regression-equation estimates provided by StreamStats should be adjusted by the user to account for those activities.

Users should understand that there are errors associated with estimates determined from available data for the stations as well as estimates determined from regression-equations, and some disagreement between the two sets of estimates is expected. If the flows at the stations are affected by human activities, then users should not assume that the differences between the data-based estimates and the regression-equation estimates are equivalent to the effects of human activities on streamflow at the stations.

When StreamStats is used to obtain regression-equation estimates for sites with basin characteristics outside the ranges of the basin characteristics for the stations used to develop the regression equations, the estimates are extrapolated. Errors associated with these estimates are unknown and may be very large. StreamStats provides a warning when extrapolation occurs.

StreamStats was designed such that each state would be implemented separately, with a reliance on local partnerships to fund the individual applications, and a goal of eventual full national implementation. Idaho became the first state implemented in 2003. By mid-2007, 10 states had applications available to the public and 21 other states were in various stages of preparation for implementation.

The table below indicates statistics that can be estimated for ungaged sites in each state. In addition, StreamStats provides access to published streamflow statistics, basin characteristics, and descriptive information for USGS data-collection stations throughout the Nation. Information that is available varies substantially among stations.

State	Available Statistics for Ungaged Sites
Colorado	2- through 500-year floods; annual and monthly mean flows; 7-day 2-, 10-, and 50-year low flows
Connecticut	2- through 500-year floods
Delaware	2- through 500-year floods
Idaho	2- through 500-year floods; annual mean flow; 20-, 50-, and 80-percent exceedance flows for each month
Illinois	2- through 500-year floods
Indiana	2- through 500-year floods; 7-day 2-, and 10-year low flows
Maryland	2- through 500-year floods; 7-, 14, and 30-day low flows at 2-, 10-, and 20-year recurrence intervals for limited area of state, to be expanded within 18 months
Massachusetts	99- through 50-percent exceedance flows at selected percentiles; August median; 7-day, 10-year low flow
Ohio	2- through 500-year floods; annual and monthly mean flows; 25-, 50-, and 75-percent nonexceedance flows
Oregon	2- through 500-year floods, with many other flow statistics coming soon
Pennsylvania	7-day 2-, and 10-year low flows; 30-day 2-, and 10-year low flows; 90-day, 10-year low flows; mean annual flows; harmonic mean flows; 10-, 25-, and 50-year base flows; peak flows coming soon
Tennessee	2- through 500-year floods; 3-day 2-, 10-, and 20-year low flows; 7-day, 10-year low flows
Vermont	25-, 50-, and 75-percent exceedance flows
Washington	2- through 500-year floods

For further information, please visit http://streamstats.usgs.gov/ and http://water.usgs.gov/osw/programs/streamstats.html.

Watershed Flow Evaluation Tool, Colorado, USA

Presenter: John Sanderson, The Nature Conservancy

Abstract: Basins in Colorado have been tasked with identifying flow needs for their conservation and recreation priorities. Site-specific flow assessments can be used for some locations, but are too resource-intensive to be used for every geographic priority. The Watershed Flow Evaluation Tool (WFET) will provide a means for assessing flow status for specific attributes (e.g., native fish, cottonwood forests) within a stream type. The three major steps in the development of the WFET are: 1) use existing data and expert opinion to develop curves relating flow status to the status of specific environmental attributes, 2) develop a hydrologic foundation of daily natural and altered flows, and 3) combine flow-attribute curves and the hydrologic foundation to assign risk status for specific attributes across the entire watershed at a reach or sub-basin scale. The initial phase of this work will develop a WFET for a two watersheds up to ~4000 km^2, one on Colorado's East Slope and one on the West Slope.

Person Completing this Form:
John Sanderson
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Today's Date -- 3/17/2008
Project Date and Duration -- start: 1/15/2008; end 12/31/2008.
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Project Location – Colorado
Study Area (km^2) Pilots planned for 2 watersheds of ~3750 km^2 each.
Aim/Purpose: To provide a tool for water managers to assess flow status as it relates to priority stream attributes..
Objectives: To develop a map of flow status as it relates to specific stream attributes.
Specific Activities and Methods Existing data being compiled and interpreted for flow-attribute curves; Colorado Decision Support System StateMod surface water model being used to develop natural and altered flows.
Data Used – a variety of sources.
Data Generated – Flow-attribute curves; natural and altered flows at nodes that have not been used in the past by the CDSS.
Results/Outcomes: Flow-ecology curves; natural and altered flow data; map of flow status as it relates to stream attributes.
Products – contact John Sanderson
Management and Policy Application – current: to assess risk of losing stream attributes that have been identified as priorities; future: to assess risk associated with proposed water projects.
Monitoring: None
Funding ~$70k (not including in-kind)
Funding Source Colorado Water Conservation Board
Documents --

Water Withdrawal Assessment Process, Impact Assessment Model, and Automated Screening Tool, Michigan, USA

Presenter: Paul Seelbach, Michigan Department of Natural Resources

Abstract: Use of a collaborative model for environmental goal setting and program development is often encouraged, in lieu of the traditional polarized, negotiation model. The State of Michigan recently engaged a collaborative advisory council to design a new, science-based Water Withdrawal Assessment Process and make recommendations regarding its implementation as policy. We reflect on this relatively successful experience and discuss a series of key elements. Among these are: investment of time in co-learning and relationships; creation of a space safe from politics and constituents, so that team growth is possible; achieving joint scientific understanding of system principles and limitations; and coincidence with some larger-scale drivers (in this case the 2001 Annex to the Great Lakes Charter). As new Michigan water management law is now being finalized, the familiar negotiation model has re-appeared as dominant; but the broadly-supported framework established by the advisory council has served to guide and constrain this final debate.

Person Completing this Form: Paul Seelbach, Michigan Department of Natural Resources

Today's Date: 03/15/2008

Project Date and Duration: Feb 2006 to Mar 2008

Project Collaborators:

Initial development was under the legislatively-appointed Michigan Groundwater Conservation Advisory Council (MI GWCAC) and its Technical Subcommittee. (both now inactive). The program is currently under the Michigan Department of Environmental Quality. The agency lead is:

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Project Location: Michigan, USA

Study Area (km^2): ~117,400 (statewide)

Aim/Purpose: The Michigan legislature charged the MI GWCAC to design and make recommendations regarding a process to guide state assessment of proposed large-quantity (> 100,000 gpd) water withdrawals using scientific (hydrologic and ecologic) basis for decision making as per recent state legislative mandate and Annex 2001 of the Great Lakes Charter.

Objectives: To provide a suite of linked hydrologic and ecologic tools to be used in objective assessment of the potential for a proposed large-quantity withdrawal to adversely impact water-dependent natural resources. Tools are to be available in both screening (coarse filter) and detailed site review formats.

Specific Activities and Methods: Work was done within a collaborative framework that was overseen by the MI GWCAC, with members representing broad interests in societal water use; incorporated a national science review panel; and with technical work done by multiple agencies and universities.

All state river segments (N ~ 7,000) were delineated, classified, and mapped in GIS as 11 ecological types according to catchment area, estimated summer water temperatures, and estimated resident fish assemblages. Summer base flows (Index Flows) estimated for each segment using statewide regression models of gaged flows and GIS catchment attributes.

For each segment type, percent of Index Flow removable prior to causing an Adverse Resource Impact (ARI) determined from a marriage of: 1) fish assemblage – Index Flow habitat suitability curves developed from statewide survey datasets; and 2) placement of the ARI threshold line now being determined via legislative process. Several lower risk thresholds were added below the ARI threshold to help guide management options, again being determined via legislative process. For every segment the allowed removable discharges at the various thresholds were calculated as the Index Flow times the various percents removable.

For any specified large-quantity water withdrawal; with known attributes of location, depth, and withdrawal rate and interval; the impact of the proposed withdrawal on all nearby river segment discharges can be estimated using a generalized groundwater model that considered withdrawal distance and depth, and geologic texture.

For all affected segments, the discharge impact of the proposed withdrawal is compared to the allowed removable discharge thresholds, and a determination of risk of Adverse Resource Impact is made for each segment. The most impacted segment is used in the subsequent management determination.

The river segment and type maps, streamflow models, fish – flow curves and impact thresholds, and groundwater – stream impact models were linked within a GIS. This suite of models was made available in two formats: 1) a screening (coarse filter) format, where the models are presented through an internet-based interface that allows an interested party to explore the risks of various withdrawal proposals, and to possibly be approved to proceed with the withdrawal if the risks are minimal; and 2) a detailed site-review of the proposal by state Department of Environmental Quality staff; this option will likely reduce uncertainties related to hydrologic data and processes contained in the screening format.

In either format, the hydro-ecological assessment determines that the proposed withdrawal falls within one of several tiered zones of risk of Adverse Resource Impact. Final implantation of this zones idea is still being determined via legislative process, but the idea is that each successive zone (from low to medium to high risk) will carry specific messages of caution and associated responsibilities for water management engagement. Withdrawals in the highest risk zone will not be allowed.

Data Used: River segment mapping was based on the USGS National Hydrography Dataset Plus, as well as compiled statewide data from 140 long-term USGS streamflow gages, extensive river fishery surveys (1,700 fish assemblages and 800 temperatures), and GIS-based catchment summarizations of landscape and climate attributes.

Data Generated: 1) For each of 7,000 stream segments: Ecological river type, August 50% exceedence discharge and discharge yield (normalized by catchment area; a measure of relative groundwater contribution); predicted fish assemblage, predicted July mean temperature. 2) For each of 11 ecological river types, characteristic fish assemblage and fish – baseflow impact response curves. 3) Summaries of the possible water withdrawal impact scenarios, run for statewide or targeted examples; e.g., the 200 applications from last year can be run through the assessment to see where they might have fallen. 4) An online suite of hydro-ecological models for education and exploration of potential environmental risks of water withdrawals.

Results/Outcomes: 1) High level of hydro-ecology literacy among a broad spectrum of state environmental policy leaders. 2) Widely understood and accepted statewide river classification. 3) Predictive models of local habitat conditions and fish communities across Michigan. Specifically, the model predicts how fish assemblages in different types of Michigan streams would change in response to decreased base flows, using habitat suitability information. 4) Useful and objective process for assessment of environmental risks of water withdrawals, based on sound hydrologic and ecologic principles and models. 5) Powerful science framework for ongoing state discussions of thoughtful water policy and legislation.

Products: 1) Coordinated statewide maps, databases, and models related to hydro-ecology of state's river systems. 2) Online screening tool for initial determination of whether a proposed ground water or surface water withdrawal will adversely impact fish populations in Michigan streams. 3) An objective process for use in site-specific state agency reviews of water withdrawal applications. 4) Peer-reviewed reports describing technical methods and a MI GWCAC report describing recommended use of models in a decision-making framework.

Management and Policy Application Proposed application: If online screening tool indicates that proposed withdrawal has a very low risk of affecting fish assemblages, then MDEQ will allow the withdrawal. If tool indicates a moderate or high risk of adverse affect, then applicant may revise application or conduct onsite study to refine the screening tool. To be used statewide. Policy details are currently being defined via legislative process; new legislation to implement some form of this water withdrawal assessment process is expected spring 2008.

Monitoring and Updating: We continuously stress that this 2008 process and tool must be seen as an initial step in a long-term, iterative development process. We expect significant updating of all components on a five-year cycle. We are beginning to develop field monitoring plans aimed at improving and refining the suite of models.

Funding: $604,000 USD cooperative agreements with USGS and universities; at least this in matching time from state agency staff.

Funding Source: Michigan state legislature, state agency payrolls, USGS Cooperative Water Program.

Documents: Michigan Groundwater Conservation Advisory Council (2007) Report to the Michigan Legislature in response to Public Act 34, 37 p., http://www.michigan.gov/documents/deq/Groundwater_report_206809_7.pdf

Several technical reports are in review or in press. When available, these will be posted on the above webpage.

Innovations to Support Instream Flow Determinations in Texas, USA

I: Hydroecological Integrity Process

Presenter: Wendy Gordon, Texas Commission on Environmental Quality

Abstract The U. S. Geological Survey has developed a series of tools that can actively support the determination of instream flow needs by providing a better understanding of the hydrologic regimes of rivers in a given area. This Hydroecological Integrity Assessment Process or HIP software comprises several parts that have been successfully tailored to meet the needs of individual states. Under contract, USGS has customized HIP using Texas-specific flow data from USGS gauging stations. The process resulted in four stream types (perennial stable, perennial flashy, intermittent stable, and intermittent flashy) and identified 10 primary flow indices that best describe each of those stream types. Using the Stream Classification Tool (SCT), future end users will be able to analyze gauge data from any gauge in the state and determine the stream type. Further analysis of hydrologic behavior at any given gauge location can be conducted using the Hydrologic Assessment Tool (HAT).

Person Completing this Form Wendy Gordon, Ph.D., Texas Commission on Environmental Quality
Today's Date 04/17/2008
Project Date and Duration 11/1/2006 to 8/31/2007
Project Collaborators James Henriksen, Ph.D., formerly of the USGS Fort Collins Science Center in CO
Project Location Texas, USA
Study Area (km^2) 695,621
Aim/Purpose see abstract
Objectives see abstract
Specific Activities and Methods USGS performed multivariate analysis of relatively unaltered streamflow gauge records to identify a small set of stream types.
Data Used USGS daily streamflow data from Texas
Data Generated Classification scheme based on hydrologic data; a listing of relatively unaltered streamflow gauges with periods of record
Results/Outcomes Stream Classification Tool (SCT); software for examining hydrologic behavior – Hydrological Assessment Tool (HAT)
Products Software not currently on USGS ftp site; manuals
Management and Policy Application Texas is too large a state to conduct detailed instream flow studies for all rivers and streams. Thus, developing classification schemes is one way to generalize or leverage the information we do have about instream flow needs across stream types or classes. This project was one of two undertaken to aid in that generalization process. Ideally, relationships between aquatic biota and hydrology and other physical parameters would be developed in order to fully operationalize the classification schemes for instream-flow protection.
Monitoring None

Funding $65,000 USD plus some in kind from USGS
Funding Source US EPA Clean Water Act Section 106 pass-through dollars to agency
Documents: Henriksen, Jim, 2008, Hydrologic Assessment Tool Training [manual for] Texas Commission for Environmental Quality. Unpublished report. To obtain a copy, contact Wendy Gordon.

For information about HIP: http://www.fort.usgs.gov/Resources/Research_Briefs/HIP.asp

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Innovations to Support Instream Flow Determinations in Texas, USA

II: Stream Classification System

Presenter: Wendy Gordon, Texas Commission on Environmental Quality

Abstract An integrated stream classification system was developed and tested for Texas based on quantitative data for 18 distinguishing parameters encompassing watershed and stream channel processes and functions from four disciplines: (1) Hydrology & Hydraulics, (2) Water Quality, (3) Geomorphology & Physical Processes, and (4) Climatology. The State of Texas was partitioned into five regions: East Texas, South-Central Texas, Lower Rio Grande Basin, West Texas, and North-Central Texas by 8-digit Hydrologic Unit Code (HUC) basin.

Person Completing this Form Wendy Gordon, Ph.D., Texas Commission on Environmental Quality

Today's Date 04/17/2008

Project Date and Duration 9/1/2006 to 8/31/2007

Project Collaborators Eric Hersh and David Maidment, Ph.D., Center for Research in Water Resources, The University of Texas at Austin

Project Location Texas, USA

Study Area (km^2) 695621

Aim/Purpose This stream classification system might be used to: (1) discern likely similarities and differences between rivers and streams of the State, (2) remotely characterize stream segments for which resources are insufficient for detailed field studies, (3) recognize streams and watersheds of the State as having common identities, (4) allow conclusions drawn from an instream flow study from a particular river reach to have a wider applicability than the particular study site, and (5) assist in prioritization of rivers and reaches for future instream flow studies.

Objectives Use Geographic Information System (GIS) technology to organize existing information relevant to the understanding of Texas streams and rivers (i.e., water quality, geologic and geomorphic, hydrologic and hydraulic, and biological data) and to develop a classification scheme such that particular classes or regions of streams and rivers could be recognized as having a common identity.

Specific Activities and Methods Used an existing, qualitative scheme of Texas rivers and streams presented in the National Research Council's review of the Texas Instream Flow Program as the basis of the project. Incorporated existing GIS-based data such as the National Hydrography Dataset and other data layers. Used eight-digit HUCs as the base layer for classification. Quantitative information such as climatology, soil type, water quality monitoring data were added to refine the qualitative classification scheme and produce a more quantitative scheme.

Data Used See report at http://www.crwr.utexas.edu/reports/pdf/2007/rpt07-02.pdf

Data Generated Classification scheme, data interpreted to the HUC level, and geodatabases

Results/Outcomes A more quantitatively-based classification scheme than we started with that can be further refined with the addition of biological data in particular.

Products Geodatabases and maps

Management and Policy Application Texas is too large a state to conduct detailed instream flow studies for all rivers and streams. Thus, developing classification schemes is one way to generalize or leverage the information we do have about instream flow needs across stream types or classes. This project was one of two undertaken to aid in that generalization process. Ideally, relationships between aquatic biota and hydrology and other physical parameters would be developed in order to fully operationalize the classification schemes for instream-flow protection.

Monitoring NA

Funding $75,000 USD

Funding Source US EPA Clean Water Act Section 106 pass through dollars to agency

Documents Hersh, Eric S. and Maidment, David R., 2007, An integrated stream classification system for Texas, Center for Research in Water Resources Online Report 07-02, 130 p., http://www.crwr.utexas.edu/reports/pdf/2007/rpt07-02.pdf