AFS Fisheries Administration Section – 2014 SFR "Outstanding Project of the Year" Nomination

Title: Development and evaluation of watershed models for predicting stream fishery potential

Category: Research and Surveys **Agency:** Wisconsin Department of Natural Resources

Time Period: 2003-2014 **Submitted by:** John Lyons, Matthew Diebel, Matthew Mitro, WDNR

Need: Wisconsin, like all Great Lakes states, has a tremendous diversity and quantity of stream and river habitats, fishes, and fisheries. Management of these important resources requires an understanding of the current status and potential of these waters and their fisheries and a framework to identify future threats and management opportunities. However, the sheer volume of habitat and the number and variety of fisheries have made such estimates elusive and hindered development of a broadly applicable classification system for management. Without such a system it is difficult to make predictions of how habitat conditions, fish populations, and fisheries will change in response to riparian and watershed land-use shifts, flow modifications, climate change, and other human impacts. Fortunately, new large-scale databases, GIS tools, and sophisticated statistical modeling techniques allow us to finally begin to assess and classify streams and their fisheries at a statewide scale and to develop predictive models for stream fisheries. However, a coordinated and concerted effort needs to be made to link these new databases, tools, and techniques and then use them to create useful classifications and predictive models for the streams and rivers of the Great Lakes states generally and for Wisconsin specifically.

Objectives: 1) Develop and test GIS-based watershed-scale statistical models for estimating stream water temperature, flow, and habitat suitability for stream and river fishes. 2) Using these models, predict water temperature, flow, and fish occurrence for all streams and river reaches in the state and classify these reaches into "Natural Communities" for management. 3) Develop and apply models that project fish species responses to watershed and riparian land-use shifts, flow modifications, and climate change. 4) Develop possible fisheries management actions to address projected responses.

Results: 1) In collaboration and cooperation with the Michigan DNR, Michigan State University, the U.S. Geological Survey, the International Joint Commission, and the Nature Conservancy and with additional funding from U.S. EPA, U.S. Fish and Wildlife Service, and Dane County (Wisconsin), we have developed an extensive database of stream temperature, flow, and fish species occurrences for thousands of streams and rivers from the Great Lakes region. We have employed artificial neural net analysis to construct empirical statistical models to predict summer water temperatures and linear regression and mixed-effects analysis to build empirical statistical models to predict annual and seasonal stream flows. Both sets of models have performed well, explaining about 75-79% of the variance for the water temperature dataset and 93-98% for the flow dataset and producing estimates within 10-40% of true values in over 85% of independent test cases. Using water temperatures and stream flows estimated from these models coupled with geo-referenced data on stream channel characteristics, valley slope and groundwater potential, surficial and bedrock geology, and current climate and land-use, we have used random-forest statistical analyses to develop species distribution models for 79 common stream and river fishes. These models have also performed well, accurately predicting presence and absence for 67-98% (mean 85%) of cases in validation tests.

2) Using the results from the models, we have estimated the water temperature, flow, and probability of fish species occurrences at all stream and river reaches in the Great Lakes region at the 1:100,000 map scale (~150,000 miles; 160,000 reaches) and at the 1:24,000 map scale for Wisconsin (~55,000 miles; 125,000 reaches). Based on estimated water temperatures and flows we have established four stream thermal classes (cold, cool-cold, cool-warm, warm) and four stream-size classes (ephemeral, headwater, mainstem, river) and combined these to create a stream classification with 10 "Natural Communities", each with a characteristic fish fauna and fishery potential.

3) Using a variety of projections of future land-use patterns, ground and surface water withdrawals, and climate change, we have applied the water temperature, flow, and fish models to project future habitat conditions, Natural Communities, and fishery potential for all Wisconsin streams and rivers.

4) Based on projected changes, we have developed impact-specific fisheries management strategies and tactics for responding to potential shifts in stream and river habitats and their fisheries.

Benefits and Evaluation: The water temperature, flow, and fish models, their associated Natural Community classification framework, and the current predictions and future projections of possible human impacts, which we collectively term the "Stream Model", represent a unique and innovative new approach and have provided tremendous benefits to fisheries and water resources management programs in Wisconsin. Within the Wisconsin DNR, the Stream Model now serves as the template for organizing, carrying out, and interpreting stream and river monitoring for both fisheries management and for bioassessment of environmental quality. Stream Model outputs are utilized in communication with public stakeholders, regulated businesses, and other government agencies (http://dnr.wi.gov/topic/Rivers/naturalcommunities.html), including required reporting to the U.S. Congress on stream and river restoration progress under the Clean Water Act. Stream Model estimates of current habitat conditions coupled with future projections of potential human impacts have informed and guided specific high-priority and high-visibility management actions, such as the public planning process for state fisheries properties and easements in the Driftless Area of southwestern Wisconsin (http://dnr.wi.gov/topic/lands/masterplanning/driftlessstreams/). At a broader scale, the Stream Model has provided a common terminology and classification system for better collaboration and cooperation among states. For example, Stream Model thermal and stream-size classifications and predictions have facilitated the sharing of data, experiences, and management tools between Wisconsin and Michigan, especially related to efforts to protect water temperatures and base flows in trout streams subject to groundwater withdrawals. The Stream Model has been particularly useful in quantifying likely climate change impacts on fisheries and suggesting possible management adaptations. To make climate change projections and potential management responses more accessible to the public, we've worked with collaborators in other agencies to develop an open online application that allows users to examine future fish distributions at a variety of spatial scales under different climate change projections and to overlay information about land use, protected areas, and overall human disturbance to explore adaptation strategies (http://wimcloud.usgs.gov/apps/FishVisDev/FishVis.html#). These few examples represent just a small sampling of the potential applications of the Stream Model to promote better fisheries and environmental management in streams and rivers of the Great Lakes region.