LCCMR ID: C17

Project Title: Adapting Aquatic Resource Management to Climate Change

Total Project Budget: $ $545,675

Proposed Project Time Period for the Funding Requested: July 2009 - June 2012 (3 yrs)

Other Non-State Funds: $ 0

First Name: Lucinda   **Last Name:** Johnson

Sponsoring Organization: UMD, NRRI

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Region:	County Name:	City / Township:
Statewide	Statewide	

Summary: The aim of this project is to provide region-specific tools and recommendations for adapting management of Minnesotas aquatic resources to projected climate change.

Main Proposal: 0808-1-057-proposal-0808-1-057-Main Proposal - Lucinda Johnson.doc

Project Budget: 0808-1-057-budget-0808-1-057-Budget - Lucinda Johnson.xls

Qualifications: 0808-1-057-qualifications-0808-1-057-Qualifications - Lucinda Johnson.doc

MAIN PROPOSAL
PROJECT TITLE: Adapting Aquatic Resource Management to Climate Change

I.   PROJECT STATEMENT:

The overall aim of this project is to provide region-specific tools and recommendations for adapting management of Minnesota's aquatic resources to climate change. In addition to the need for reduced emissions of greenhouse gases, we must address the realities of anticipated potential ecosystem responses to climate change. Management plans and practices must, therefore, be adapted to climate change. The Minnesota Statewide Conservation and Preservation Plan (SCPP) identified vulnerable areas within the state based on stressors and the value of particular aquatic resources. Vulnerability will strongly depend on climate change, e.g., in air and water annual temperature, precipitation, and storm frequency and intensity. Impacts of future climate change will, in general, exacerbate the impacts of current anthropogenic threats. The types of threats and the climate (current and future) vary greatly across the state of Minnesota. Regional approaches for adapting management and policy will therefore be required to maintain healthy aquatic resources in the state.

Using down-scaled climate projections (with uncertainty measures) developed during our current projects (Impacts on aquatic resources from climate change (2006), and Minnesota's Water Resources: Impacts of Climate Change - Phase II (2007), and vulnerability assessments from the SCPP **we will: 1) develop and apply mechanistic models specific to different resource types in regional case studies to connect climate to specific aquatic resources, 2) assess the vulnerability of significant aquatic resources to climate change across Minnesota and identify specific mechanisms posing threats, and 3) develop specific recommendations for mitigation and adaptation.**

In addition, a user-friendly on-line internet tool will be developed to deliver resulting data and recommendations to managers and stakeholders. Results from empirical models constructed in the 2006 project, relating past physical and biological responses to climate change will be augmented with mechanistic models (predicting e.g., flow, nutrient loading, water temperature, evaporation) that incorporate appropriate physical variables to develop robust and reliable projections.

II.   DESCRIPTION OF PROJECT RESULTS

Result 1: _Risk assessment for climate change._ **Budget: $** _324,726_

We will develop a set of regional projections of hydrological and ecological conditions, and identify the primary threats (e.g., erosion, thermal stress, eutrophication, stormwater runoff increases, drought, susceptibility to invasive species, turbidity, and other impairments) to different aquatic resources resulting from climate change in addition to human disturbances. Projected regional climate changes across the state include likely changes in precipitation patterns, as well as means and extremes in temperature and intensity of storm events. Stressors to aquatic ecosystems resulting from human activities are expected to be exacerbated by increased water temperatures, increased peak flows, and changes in precipitation patterns. We will augment results from the 2006 and 2007projects (which included the development of statistical models) by developing and applying causal-mechanistic models that will incorporate current and projected climate variables (e.g., air temperature, relative humidity, wind speed, and precipitation). Based on case studies conducted along climatic and disturbance gradients, we will model: 1) lake levels, 2) lake water quality, 3) stream temperatures, 4), stream flow, and 5) stream nutrient loading. Model estimates will be made for current and future climate conditions and data recorded under current and past conditions will be used to validate the models as necessary. The information on hydrologic and water quality parameters will be used to project the extent changes in 6) cold, cool and warm water fish habitat in lakes and 7) brook trout habitat in streams. The results will provide currently unavailable information (including some measures of uncertainty) on the response of different aquatic resources to predicted climate change, for prioritization of both mitigation and adaptation measures on a regional basis.

Deliverable	Completion Date
1. **Quantified responses to climate change**	**June 2012**
2. **Identification of potential threats**	**June 2012**

Result 2: _Enhance vulnerability map based on resource and region-specific impact analysis._ **Budget:** $ _88,017_

We will expand and enhance the vulnerability index used in the SCPP by incorporating the output of Result 1 to develop data reflecting the combined impacts of climate change (e.g., warmer temperatures, changes in precipitation patterns, increased peak flow), stressors, and resource value (system rarity, biodiversity, economic use, cultural use, water quality and quantity). Refined vulnerability predictions will be delivered in database and map forms. In the SCPP, aquatic resource value was mapped and stress levels (urbanization, agriculture, transportation

network, invasive species) were overlaid on that aquatic resource value map to highlight vulnerable areas. Existing human induced stresses to aquatic ecosystems are expected to be exacerbated by increased temperature, increased peak flow, and changes in precipitation patterns.

Deliverable	Completion Date
1. **Enhanced SCPP vulnerability map**	**June 2012**

Result 3: *Recommend appropriate conservation and management practices, and develop management tools for identifying trends in water quality and habitat.* **Budget:** $132,932

   We will identify the most appropriate conservation practices or programs (e.g., land purchase, CRP, RIM, BMP) **for a given resource based on anthropogenic stresses and climate change** using the enhanced vulnerability data (Result 2) and down-scaled climate projections (2006 project)**.** The SCPP identified tiers of practices for resources with varying levels of vulnerability. These included land purchase for highly valued, least vulnerable resources; enrollment in existing conservation programs and other incentive-based conservation strategies for less valued, more vulnerable resources, and application of appropriate Best Management Practices for those resources with moderate to high vulnerability.

   In addition, **we propose a map-based, lake-searchable and area-definable tool for disseminating results** that will allow users to: 1) select specific lakes or groups of lakes to retrieve trends and relationships between lake condition, stressors, and climate; 2) retrieve historic and current lake data in an easily downloadable format, and 3) graphically display lake x time trends with statistical information. Prototype data retrieval, display and visualization tools developed for the climate change projects and the SCPP will be enhanced to allow managers to query climate, water quality, and vulnerability data and easily generate trends and forecasts. This task is based on the EPA concept of providing public access to monitoring data in a timely manner to improve environmental decision making, and reduce the need for highly sophisticated GIS and programming expertise.

Deliverable	Completion Date
1. **Recommended practices based on regional vulnerability**	**June 2012**
2. **Develop user-friendly data and forecasting tools for managers**	**December 2011**

III. PROJECT STRATEGY AND TIMELINE

A. Project Partners
Dr. H. Stefan, Dr. W. Herb- Univ. of Minnesota, Dept of Civil Engineering, St. Anthony Falls Laboratory; Drs. R. Axler, T. Brown and G. Host - Natural Resources Research Institute, Univ. Minnesota Duluth.
Current partners (2006 and 2007 projects) include staff at the MN DNR (D. Pereira, K. Rusterholz; C. Turner, D. Wright, J. Zandlo); MPCA (P. Ciborowski, E. Swain). We anticipate continued cooperation with these agencies and individuals. Continued cooperation is anticipated.

B. Project Impact
Current efforts addressing climate change (e.g., Governor's Task Force) have focused on mitigation- i.e., reducing greenhouse gases to reduce the extent of future climate change. However, the climate is already changing and the current levels of greenhouse gases in the atmosphere commit us to additional warming. In the face of these changes, resource managers and planners must develop tools and strategies that reflect a new climate regime. The data and the resulting tools that we propose will address a need identified by Minnesota's resource management and regulatory agencies to provide predictions about water quality and biotic responses to climate change in a form easily used by non-specialists.

C. Time: This project will require three years for completion.

D. Long-Term Strategy
In the 2006 project, we document trends in lake water quality, lake levels, evaporation and fish communities due to past climate conditions. The 2007 project develops empirical (statistical) models to predict future conditions based on past and projected climate. These models are limited by the availability of existing data. Causal- mechanistic models will allow us to develop specific projections of the behavior of aquatic systems based on the fundamental processes that control the system. These predictions will provide more robust predictions that can be used to design monitoring and assessment tools and practices for the long term sustainability of aquatic resources in the state under future climatic conditions. Our proposal addresses only aquatic resources, but similar approaches could be implemented to assess impacts and vulnerability in terrestrial systems as well. A formal vulnerability assessment, including socio-economic factors would be a logical extension of this project.

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET

BUDGET ITEM	AMOUNT	% FTE
Personnel: Lucinda Johnson, Principal Investigator (Project Administration; Stream WQ modeling; Fish Distribution);	$ 31,876	8%
Richard Axler, Co-PI (Result 3; Tool Development; Water Quality Modeling); 5% Yrs 2,3	$ 14,609	Yr 2,3: 5%
Terry Brown, Co-PI (Results 1-3; GIS; Computer Programming);	$ 80,603	Yr 1, 2: 25%; Yr 3 50%.
George Host, Co-PI (Result 2, Vulnerability Index)	$ 6,679	Yr. 3: 5%
Heinz Stefan, Co-PI (Result 1, 2, 3: General Oversight of Modeling)	$ -	0%
William Herb, Research Assoc. (Result 1, 2, 3: Stream Temp Modeling)	$ 103,574	Yr 1,2: 50%; Yr 3, 25%
Research Associate, TBN (Result 1: Storm Intensity; climate modeling)	$ 40,293	50%
Norm Will, Info Tech Professional (Result 3: Computer Programmer)	$ 44,915	Yr. 3: 60%
Connie Host, (Results 1,3: GIS Technician)	$ 27,201	20%
Graduate Research Assistant (Result 1, 2, 3: Lake level, water quality modeling)	$ 91,484	Yr 1,2: 50%; Yr 3: 25%
Graduate Research Assistant (Results 1,2,3: Stream Water Quality Modeling)	$ 86,341	Yr 1,2: 50%; Yr 3: 25%
Travel: (Project meetings Project participant quarterly meetings; In-state Conferences)	$ 10,500	
GIS Lab user fee: Rates approved by UMN. $4.10/hour/1098 hrs, for lab assistance, use of computers and GIS software	$ 4,500	
Supplies:	$ 3,100	
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 545,675	

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
ML 2006, Chap. 243, Sec. 20, Subd. 7.: *ML 2007, [Chap. 30], Sec.[1], Subd. 5(k)*	$250,000 / $300,000	*$ 12,000 / $219,671*
Other Non-State $ Being Leveraged During Project Period:	$ -	*0*
Other State $ Being Spent During Project Period:	$ -	*0*
In-kind Services During Project Period:	$ -	0
Past Spending: *List money spent or to be spent on this specific project, cash and/or in-kind, for 2-year timeframe prior to July 1, 2009*		0
		$ -

LCCMR 2007
Adapting Aquatic Resource Management to Climate Change
Lucinda B. Johnson, Natural Resources Research Institute, University of Minnesota Duluth

Key Qualifications
Dr. Johnson is an Associate Center Director and Sr. Research Associate at the Natural Resources Research Institute. She is an aquatic and landscape ecologist with broad expertise in quantifying interactions between aquatic and terrestrial ecosystems. Her research focuses on indicator development in aquatic ecosystems, and the effects of multiple stressors, including climate change, on rivers and wetlands.

Education
Michigan State University, Zoology, Ph.D. 1999
State Univ. of New York, College of Env. Sci. and Forestry, Entomology, M.S. 1984.
Duke University, Botany. B.A. 1976

Selected Grants (Total > $14M)
Minnesota's Water Resources: Impacts of Climate Change- Phase II. Legislative and Citizen's Commission on Minnesota's Resources. $300,000. PI, with R. Axler, R. Newman, H. Stefan, R. Skaggs, V. Card. 2007-2010.
Impacts on Minnesota's aquatic resources from climate change. LCCMR, 2006 – 2009. PI with R. Axler, V. Card, R. Newman, R. Skaggs, H. Stefan. $250,000. 2006-2009.
Effects of multiple stressors on aquatic communities. Environmental Protection Agency, STAR Program 2003-2006. Co-PI with P Schoff, and G Guntenspergen. $746,433. .
Testing Indicators of Coastal Ecosystem Integrity Using Fish and Macroinvertebrates, EPA-STAR, 2001-2005. PI $893,628. Subproject of: Development of Environmental Indicators of Condition, Integrity, and Sustainability in the Great Lakes Basin, G. Niemi, and 27 P.I.'s $6,000,000. 2001-2005.

Selected Publications:
Rohr, J.R., A.M. Schotthoefer, T.R. Raffel, H.J. Carrick, N. Halstead, J.T. Hoverman, C.M. Johnson, **L.B. Johnson,** C. Lieske, M.D. Piwoni, P.K. Schoff, V.R. Beasley. 2008. Agrochemicals increase trematode infections in a declining amphibian species. Nature *in press.*
Hollehorst, T., T. Brown, G. E. Host, **L.B. Johnson** and J.J.H. Ciborowski. 2007. A Multiscale Watershed Approach to Indicator Development for Coastal Ecosystems of the Great Lakes. J. Great Lakes Res. 33 (Special Issue 3):13-26.
Kling, G., Hayhoe, K. **L. Johnson,** J. Magnuson, S. Polasky, S. Robinson, B. Shuter, M. Wander D. Wubbles, D. Zak. 2003. *Confronting Climate Change in the Great Lakes Region. Sustaining the Ecology and Well Being of Our North American Heartland.* Union of Concerned Scientists and Ecological Society of America.
Schomberg, J., Host, G.E. **Johnson, L.B**., and Richards, C. 2005. Evaluating the influence of landform, surficial geology, and land use on streams using hydrologic simulation modeling. Aquatic Sciences 67(4):528-540.

Natural Resources Research Institute is a part of the University of Minnesota Duluth. Its mission is to promote private sector employment based on natural resources, in an environmentally sensitive manner. The NRRI scientists have extensive experience in managing large, interdisciplinary projects whose objectives include the development of tools for environmental assessment and resource management. These tools promote citizen education leading to improved understanding of how human activities influence water quality and ecosystem health. Our scientists have been heavily involved in climate change work, in addition to participating as core team members of the MN Statewide Conservation and Protection Plan, where they were instrumental in developing the vulnerability index. Collaborators at the St. Anthony Falls Hydrologic Laboratory have extensive experience developing and implementing mechanistic models, including lake level, stream temperature, and lake water quality.

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