Environment and Natural Resources Trust Fund (ENRTF)
2010 Work Program

Date of Report: 20 November 2009
Date of Next Progress Report: 31 December 2010
Date of Work Program Approval:
Project Completion Date: June 30, 2013

I. PROJECT TITLE: Trout Streams Assessment

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Location: Southeast Minnesota, counties are: Dakota, Goodhue, Rice, Wabasha, Winona, Olmsted, Dodge, Steele, Waseca, Freeborn, Mower, Fillmore, Houston

Total ENRTF Project Budget:	**ENRTF Appropriation**	**$ 300,000**
	Minus Amount Spent:	**$ 0**
	Equal Balance:	**$ 300,00**

Legal Citation: ML 2010, Chap.[____], Sec.[____], Subd._____.

Appropriation Language:

II. PROJECT SUMMARY AND RESULTS: Trout require streams with excellent water quality that are fed by groundwaters which keep streams cold in summer but ice-free in winter. The trout sport-fishing industry is vulnerable to global climate changes that can increase stream temperatures, alter the cold-adapted aquatic insects that form trout diets, and affect trout reproduction. Increasing air temperatures are predicted to increase the maximum water temperatures during summer, but also are very likely to dramatically change winter thermal conditions in trout streams. Our objectives are to: (1) investigate the role of stream bank vegetation and adjacent land use to minimize changes in stream temperatures in relation to climate change during summer; (2) determine winter diets and growth of trout populations; and (3) determine kinds, abundances, and timing of growth patterns of cold-adapted insects that are essential in winter diets of trout. We will work on 36 trout streams in the Driftless Area in SE Minnesota, using GIS coupled with habitat surveys for objective (1); seining and standard diet analysis techniques for objective (2); and rapid bioassessment protocols for objective (3). The project will identify and rank the streams most vulnerable to increases in summer high temperatures, and will identify cold-adapted insects that are most critical to trout diets and growth during winter. Trout fishing annually provides more than $150 million dollars in direct expenditures to local economies in Minnesota and $654 million through the Driftless Region (Trout Unlimited, 2008). With re-circulating dollars this represents more than one-billion dollars of economic stimulus to local economies. Our results will enable us to identify streams and food species that are most vulnerable to increasing temperatures, and translate scientific results into management strategies to protect and conserve this valuable industry.

III. PROGRESS SUMMARY AS OF *[insert date of Work Program progress report]***:**

IV. OUTLINE OF PROJECT RESULTS*:*

Result 1: The physical, geologic and riparian settings in which stream systems occur are known to modulate surface water temperatures. We hypothesize that specific combinations in these parameters can result in more effective buffering of summer water temperatures in trout streams of southeastern Minnesota. We will seek to identify the combinations that function on local- to landscape-levels to produce the most buffered thermal conditions.

Description: Result 1 is structured to determine present-day configurations of riparian vegetation, adjacent land use and geological setting that provide the greatest capacity to buffer changes in thermal regime of stream waters during both summer and winter over the largest longitudinal distances of stream, and thus maximize habitats appropriate for foraging and reproduction of trout. Streams not fitting this profile will be considered as “most at-risk” as global climates warm and can be targeted for management.

Summary Budget Information for Result 1: **ENRTF Budget: $95,085**
Amount Spent: $ 0
Balance: $ 95,085

Deliverable/Outcome for Result 1	**Completion Date**	**Budget**
1. *Analysis of first set of 12 streams* (Estimates of adjacent land use percentage, summary of local geology and type/depth to bedrock or broken rock strata, percent riparian cover, patterns of variation in water temperature, stream width, depth in riffles and pools, and cross sectional profiles. We expect streams where trout grow fastest during winter will have unigue combinations of geology, substrate compositions and most highly buffered water temperatures)	Fall 2010	$30,760
2.*Analysis of second set of 12 streams* (Same	Summer 2011	$31,680

details as for deliverable #1, above)		
3.*Analysis of third set of twelve streams* (Same details as for deliverable #1 & #2, above)	Fall 2011	$32,645

Result Completion Date: *December 2011*
Result Status as of: December 2010
Result Status as of: August 2011
Result Status as of: December 2011
Final Report Summary: June 2013

Result 2: Diets of trout during winter are poorly documented and often reported at taxonomic levels that mask the importance of individual species (e.g. Chironomidae are known to be common prey, but more than 50 genera could be included in the diet). Without more detailed knowledge of the insect taxa that trout consume in winter, and the thermal preferences and life-history biology of these prey insects, it is not possible to predict how increasing thermal regimes will influence trout diets. We hypothesize that differing thermal preferences and life histories of prey will be important controls on winter growth and yield of trout, and that these differences in prey have potential to account for a large amount of the variability in trout yield that is presently known for streams in southeast Minnesota.

Description: Trout will be obtained using routine electro-shocking methods during December through March in each of 12 streams/year for the three years of our study. The streams will be the same as investigated for Objectives 1 and 3. Diet will be determined using a gastric-lavage technique, modified for use in winter. We have successfully used our Standard Operating Procedure (SOP) for the technique over the past two winters and are confident that it is an appropriate technique for this objective. After identification and quantification of diet items, the resulting data will be analyzed with a fish bioenergetics model (Hanson *et al*. 1997) to determine the extent to which patterns of increasing UCS aquatic insect species can be quantitatively related to caloric density.

Field work for Result 2 will be coordinated with field work for Result 3 and, when possible, will be completed concurrently. Field work each year will be done on the same 12 streams as were analyzed in Result 1. Field work will be initiated in mid-November and completed by mid-March. Sample processing, data analyses and summary will be completed by the end of June for each of the three years of the grant. The summary prepared during year three will cover results from all three years and will included a full-project synthesis of results obtained.

Summary Budget Information for Result 2: **ENRTF Budget: $96,487**
Amount Spent: $ 0
Balance: $ 95,085

Deliverable/Outcome for Result 2	Completion Date	Budget
1.Analysis of fish diets in first set of 12 streams **(Quantification of types and quantities of food items consumed, scientific names and trophic habits of invertebrtates that are eaten, analysis of monthly variation and variation across streams in compositions of diets, summaries of life stage for each species of food eaten by fish. We expect winter diets will consist primarily of ultra-cold adapted, winter developing aquatic insects such as Chironomidae and Plecoptera in streams where trout grow fastest during winter)**	Summer 2011	$31,212
2.Analysis of fish diets in second set of 12 streams **(Same details as for deliverable #1, above)**	Spring 2012	$32,149
3.Analysis of fish diets in third set of 12 streams (**Same details as for deliverable #1 and #2, above)**	Spring 2013	$33,123

Result Completion Date: March 2013
Result Status as of: August 2011
Result Status as of: August 2012
Result Status as of: April 2013
Final Report Summary: June 2013

Result 3: Winter dynamics, including species composition and abundances, of aquatic insects strongly control patterns of productivity and yield of trout that have been documented in streams of southeastern Minnesota, and we propose to focus our efforts toward developing a better understand winter dynamics. We hypothesize that factors identified in Objective 1 will also be critical in controlling the types and abundances of aquatic insects in the streams. We will focus on UCS winter-developing species to better understand how in-stream habitat can be structured to increase abundances and growth of UCS species that are shown to be important in trout diets as demonstrated by results of Objective 2.

Description:
Comprehensive studies at lower latitudes in the Central Plains have shown that more than 50 species of aquatic insects grow and emerge as adults during winter (Ferrington 2000, 2007). At least 25 species are now known to occur in trout streams in SE MN,

and most that are UCS species are exclusively constrained to development and emergence during winter (Ferrington, unpublished data). It appears that UCS species are most diverse and possibly most abundant in trout streams that have fastest growth rates and yields of trout. Several of the UCS insects are undescribed species. The focus of this objective will be to quantify the patterns of diversity and population abundances of UCS species across the 36 streams used for Objective 1 & 2, and that represent a gradient of trout growth and yield. We will use routine methods to quantify abundances (PIBS samplers, lab sorting & quantification) combined with lab rearings in cold growth chambers to assist in identification and description of unidentified species. We will also use a method for collecting surface floating pupal exuviae of Chironomidae to profile the emergence periods and phenologies of USC species. This method has be developed by Ferrington *et al*. (1991) and utilized successfully in a variety of pollution assessment projects and basic ecological research by him over the past 29 years.

Summary Budget Information for Result 3: LCMR Budget $108,428
Balance $108,428

Deliverable/Outcome	**Completion Date**	**Budget**
1.*Analysis of composition and abundances of UCS species that are potential items for fish to feed on in first set of 12 streams* (Will collect, estimate species composition, abundance and tolerances of UCS on substrates in the streams. Will differentiate by type of stream substrate, feeding habits of UCS and types of life cycles, and maximum size when mature. We expect the aquatic insects that will be most abundant will consist primarily of ultra-cold adapted, winter developing aquatic insects such as Chironomidae and Plecoptera in streams where trout grow fastest during winter)	Fall 2011	$35,070
2. *Analysis of composition and abundances of UCS species that are potential items for fish to feed on in second set of 12 streams* (Same details as for deliverable #1, above)	Summer 2012	$36,132
3. *Analysis of composition and abundances of UCS species that are potential items for fish to feed on in third set of 12 streams* (Same details as for deliverable #1 & #2, above)	May 2013	$37,225

Result Completion Date: May 2013
Result Status as of: December 2011
Result Status as of: August 2012
Result Status as of: June 2013

V. TOTAL ENRTF PROJECT BUDGET:

Personnel: $ 117,454 (salary for 2 graduate students each for 3 years) plus $ 69,792 Tuition (three years for each of two grad students). Category total = $ 187,246
Personnel: $ 16,983 (fringe benefits for 2 graduate students each for 3 years)
Personnel: $ 23,182 (salary for 3 undergraduate students each for 3 years)
Contracts: $ NONE
Equipment/Tools/Supplies: $ 41,801 (Disposable field supplies, chemicals and lab supplies)
Travel: $ 30,788 (ALL IN-STATE TRAVEL, includes mileage & lodging & meals)
Additional Budget Items: NONE

TOTAL ENRTF PROJECT BUDGET: $ 300,000

Explanation of Capital Expenditures Greater Than $3,500: NONE

VI. PROJECT STRATEGY:

A. Project Partners: No partners or subcontractors identified at this time.

B. Project Impact and Long-term Strategy:

Management strategies to slow or reverse conditions associated with global climate change optimistically will require a decade or more to develop and implement strategies that can be applied on scales large enough to provide world-wide protection of trout streams. In the intervening time, conditions in most vulnerable trout streams in SE Minnesota will continue to deteriorate. Consequently, our proposal is focused on learning how to identify the characteristics of the most vulnerable streams in southeast Minnesota where high concentrations of productive trout streams provide an array of streams with potentially differing vulnerabilities in a small geographic area. We will investigate the role of riparian vegetation and adjacent land use as potential modulators or controlling factors that minimize changes in stream thermal regimes as air temperatures vary in contrasting landscapes. Consequently, we expect that our findings will provide a road map for how to prioritize conservation and management activities, rather than address mechanisms to reduce or reverse large-scale patterns of climate change. By developing methods to identify highly vulnerable streams with high trout productivity and diverse cold-adapted, winter developing invertebrates that form the trophic basis for trout, it will be possible to more effectively allocate efforts to conserve genetic and biological diversity. We will work with state agencies and Non-profit conservation organizations, Watershed District and Water Management Organizations to try to develop conservation resource management plans and to help implement management recommendations based on scientific findings.

ADDITIONAL BACKGROUND AND CONTEXT: Minnesota has 689 designated trout streams that represent a valuable natural resource with high economic, sport and esthetic importance. Concentrated in the Arrowhead Region of the northeast and the Driftless Region in the southeast, the sport fishing industry in trout streams annually provides more than $150 million dollars in direct expenditures to local economies in Minnesota (Gartner *et al*. 2002) and $654 million throughout the Driftless Region of MN, WI, IL and IA (Trout Unlimited, 2008). In terms of direct and recirculating dollars in today's market place this natural resource likely generates more than $1.1 billion dollars per year of additional economic value to the state. In SE Minnesota, the trout sport fishing industry provides economic diversification and alternative sources of vitality to numerous small towns that otherwise predominantly rely on agriculture for their economic fabric.

Global climate change models predict Minnesota freshwater systems will warm to levels that can radically change the composition and productivity of their aquatic fauna and flora (NRDC 2002, Eaton and Scheller 1996) over the next 20+ years if trends in climate change are not modified. Cold-water adapted trout and other Salmonids are dependent on low summer stream temperatures and corresponding high dissolved oxygen levels for successful reproduction, and are among the most vulnerable freshwater water fish species to anthropogenic stresses. Trout streams located in SE Minnesota, and other similar mid-latitudes across the globe, are in areas where summer thermal regimes are nearly marginal in terms of conditions for cold water fish species. Although these streams currently support harvestable yields of trout, many are highly vulnerable to warming climates. Only subtle increases in ambient air and water temperatures undoubtedly will cause trout to experience reduced reproductive success. Under such conditions, trout streams will undergo decreased productivity and yield, and may even experience extirpation of populations (Clark *et al.* 2001, Meisner 1990) that can irreplaceably decrease genetic variability of populations in isolated watersheds within the next 20 years.

Because of their vulnerability to altered thermal regimes and other human-induced pollution stresses, the trout streams in southeast Minnesota are ideal field-based systems in which to study insipient effects of global warming on a resource that has high economic, sport and esthetic importance, both in Minnesota and elsewhere across the globe. Recent reports by the Minnesota Department of Natural Resources show a wide range in growth rates and total fish yield in southeastern streams (Dieterman *et al.* 2006, Dieterman *et al.* 2004) based on studies during warmer months of the year. Although the summer conditions are relatively well-understood, processes and patterns during warmer months do not adequately account for substantial amounts of the variability in growth and yield of trout (Dovciak and Perry 2002). It is therefore likely that differences in thermal regimes and availability of food resources in winter strongly constrain trout productivity, resulting in differential growth rates and yields.

In recent years, an insect fauna capable of growing at low water temperatures has been discovered (Ferrington 2000, 2003, Bouchard and Ferrington, 2009). Several species are fast-growing and appear to be capable of producing multiple generations in winter, and this fauna is especially well-represented in trout streams but are not common in warmer-water streams. For example, our recent research has shown that the most productive trout streams are strongly thermally buffered by groundwater sources and springs that feed into the stream at 9° C, and result in open water though winter (Ferrington, unpublished data). During winter, temperatures in these streams range from 2° through 8° C and the streams harbor unusual aquatic insects that are ultra-cold stenotherm (UCS) species that are able to survive freezing in water (as larvae), but also survive exposure to air temperatures lower than -20°C (Carillo et al. 2004, Bouchard et al. 2006a, 2006b) as adults. We predict that increases as small as 2°C in average water temperatures can reduce productivity of larvae of several of these UCS species, and posit that the winter dynamics of the UCS insects strongly control patterns of trout productivity and yield that have to date primarily been documented only during summer.

We propose two additional research objectives designed to provide better understanding of the winter dynamics of the valuable stream systems. We expect that modifications of winter ecosystem dynamics will serve as initial evidence of insipient responses to altered thermal regimes related to climate warming. We will work as a coordinated, inter-disciplinary team consisting of three faculty, two graduate students and several undergraduate student technicians, to better understand winter dynamics.

C. Other Funds Proposed to be Spent during the Project Period: None

D. Spending HIstory: *This project builds on findinsg of a Ph.D. dissertation by Dr. R. W. Bouchard (graduated 2008) that discovered some of the unusual ultra-cold stenothermic aquatic insects in trout streams near the Minneapolis/Saint Paul Metro Area. Total funding for this research came from a variety of sources including grants, in-kind contributions and scholarships from the University of Minnesota Graduate School and private donors. Total amount estimated to average $ 34,000/year for five years. More recently, Ferrington has received a Minnesota SeaGrant to work on similar, but not identical, patterns of seasonal dynamics of aquatic insects in trout streams near Duluth in relation to land use/land cover characteristics of impervious substrates instream catchments. This project is still ongoing, but has been funded for $ 35,000 in direct expenses and an additional award of $ 35,732 for salary, tuition and fringe benefits for one graduate student research assistant.*

VII. DISSEMINATION:

Web Site Development--- A World Wide Web site for the project will be established and maintained through the on-line resources of the Chironomidae Research Group, Department of Entomology, College of Foods, Agricultural and Natural Resources Sciences at the University of Minnesota. The web site will have a link to data bases that are built through this project for use by ecologists, conservationists, policy makers, and the public. The web site will provide additional and regularly updated information not contained in full in peer-reviewed publications and will synthesize past, current, and future research in this area. The information will be presented through text, multimedia (e.g. photos, figures, video), and links to relevant websites.

As part of the project web site, a separate page will be produced for the public and educators. It will be less technical and provide information on the emergence of insects from trout streams, field trip possibilities, educational experiments, information for use in lesson plans, and links to additional information and organizations.

Funding for this project comes at a propitious time for Leonard Ferrington in terms of outreach potential. Ferrington previously was awarded a Faculty Fellowship from the Digital Media Center, Office of Information Technology at the University of Minnesota (Twin Cities). The proposal is titled "*From Verification to Modeling: Adding Complexity and Realism to Web-Based Environmental Assessment Tools*" and the full text of the proposal is available on-line. Activities completed or planned during the fellowship include developing assessment tools to judge use and effectiveness of interactive digital media. The techniques learned during the fellowship tenure will be integrated into digital media resulting from this project.

During the first half of the project efforts will be completed to teach citizen volunteer groups in southeastern Minnesota the mechanics of making collections of surface-floating pupal exuviae of Chironomidae, and the benefits and short-comings of using the method as part of their monitoring activities. We also will contact fly-fishing groups, Trout Unlimited and private businesses of colleagues and friends such as Streamside Adventures (www.streamsideadventures.com) to assist in advertising our outreach activities.

VIII. REPORTING REQUIREMENTS: Periodic work program progress reports will be submitted not later than 31 December 2010, 31 August 2011, 31 December 2011, 31 August 2012, 31 December 2012, 15 April 2013 and 15 May 2013. A final work program report and associated products will be submitted between June 30 and August 1, 2012 as requested by the LCCMR.

IX RESEARCH ADDENDUM: Attached as Separate EXCEL File: Attachment A and Attachment B appended to this document

Environment and Natural Resources Trust Fund

Research Addendum for Peer Review

Project Manager Name: **Leonard C. Ferrington Jr.**

Project Manager Email address: **ferri016@umn.edu**

Project Title: **Trout Streams Assessment**

Project number: **Proposal # 026-A3**

1. Abstract

Trout require streams with excellent water quality that are fed by groundwaters which keep streams cold in summer but ice-free in winter. The trout sport-fishing industry is vulnerable to global climate changes that can increase stream temperatures, alter the cold-adapted aquatic insects that form trout diets, and affect trout reproduction. Increasing air temperatures are predicted to increase the maximum water temperatures during summer, but also are very likely to dramatically change winter thermal conditions in trout streams. Our objectives are to: (1) investigate the role of stream bank vegetation and adjacent land use to minimize changes in stream temperatures in relation to climate change during summer; (2) determine winter diets and growth of trout populations; and (3) determine kinds, abundances, and timing of growth patterns of cold-adapted insects that are essential in winter diets of trout. We will work on 36 trout streams in the Driftless Area, using GIS coupled with habitat surveys for objective (1); seining and standard diet analysis techniques for objective (2); and rapid bioassessment protocols for objective (3). The project will identify and rank the streams most vulnerable to increases in summer high temperatures, and will identify cold-adapted insects that are most critical to trout diets and growth during winter. Trout fishing annually provides more than $150 million dollars in direct expenditures to local economies in Minnesota and $654 million through the Driftless Region (Trout Unlimited, 2008). With re-circulating dollars this represents more than one-billion dollars of economic stimulus to local economies. Our results will enable us to identify streams and food species that are most vulnerable to increasing temperatures, and translate scientific results into management strategies to protect and conserve this valuable industry.

2. Background

Minnesota has 689 designated trout streams that represent a valuable natural resource with high economic, sport and esthetic importance. Concentrated in the Arrowhead Region of the northeast and the Driftless Region in the southeast, the sport fishing industry in trout streams annually provides more than $150 million dollars in direct expenditures to local economies in Minnesota (Gartner *et al*. 2002) and $654 million throughout the Driftless Region of MN, WI, IL and IA (Trout Unlimited, 2008). In terms of direct and recirculating dollars in today's market place this natural resource likely generates more than $1.1 billion dollars per year of additional economic value to the state. In SE Minnesota, the trout sport fishing industry provides economic diversification and alternative sources of vitality to numerous small towns that otherwise predominantly rely on agriculture for their economic fabric.

Global climate change models predict Minnesota freshwater systems will warm to levels that can radically change the composition and productivity of their aquatic fauna and flora (NRDC 2002, Eaton and Scheller 1996) over the next 20+ years if trends in climate change are not modified. Cold-water adapted trout and other Salmonids are dependent on low summer stream temperatures and corresponding high dissolved oxygen levels for successful reproduction, and are among the most vulnerable freshwater water fish species to anthropogenic stresses. Trout streams located in SE Minnesota, and other similar mid-latitudes across the globe, are in areas where summer thermal regimes are nearly marginal in terms of conditions for cold water fish species. Although these streams currently support harvestable yields of trout, many are highly vulnerable to warming climates. Only subtle increases in ambient air and water temperatures undoubtedly will cause trout to experience reduced reproductive success. Under such conditions, trout streams will undergo decreased productivity and yield, and may even experience extirpation of populations (Clark *et al.* 2001, Meisner 1990) that can irreplaceably decrease genetic variability of populations in isolated watersheds within the next 20 years.

Management strategies to slow or reverse conditions associated with global climate change optimistically will require a decade or more to develop and implement strategies that can be applied on scales large enough to provide world-wide protection of trout streams. In the intervening time, conditions in most vulnerable streams will continue to deteriorate. Consequently, our proposal is focused on learning how to identify the characteristics of the most vulnerable streams in southeast Minnesota where high concentrations of productive trout streams provide an array of streams with potentially differing vulnerabilities in a small geographic area. We will investigate the role of riparian vegetation and adjacent land use as potential modulators or controlling factors that minimize changes in stream thermal regimes as air temperatures vary in contrasting landscapes. Consequently, we expect that our findings will provide a road map for how to prioritize conservation and management activities, rather than address mechanisms to reduce or reverse large-scale patterns of climate change. By developing methods to identify highly vulnerable streams with high trout productivity and diverse cold-adapted, winter developing invertebrates that form the trophic basis for trout, it will be possible to more effectively allocate efforts to conserve genetic and biological diversity.

Because of their vulnerability to altered thermal regimes and other human-induced pollution stresses, the trout streams in southeast Minnesota are ideal field-based systems in which to study insipient effects of global warming on a resource that has high economic, sport and esthetic importance, both in Minnesota and elsewhere across the globe. Recent reports by the Minnesota Department of Natural Resources show a wide range in growth rates and total fish yield in southeastern streams (Dieterman *et al.* 2006, Dieterman *et al.* 2004) based on studies during warmer months of the year. Although the summer conditions are relatively well-understood, processes and patterns during warmer months do not adequately account for substantial amounts of the variability in growth and yield of trout (Dovciak and Perry 2002). It is therefore likely that differences in thermal regimes and availability of food resources in winter strongly constrain trout productivity, resulting in differential growth rates and yields.

In recent years, an insect fauna capable of growing at low water temperatures has been discovered (Ferrington 2000, 2003, Bouchard and Ferrington, 2009). Several species are fast-growing and appear to be capable of producing multiple generations in winter, and this fauna is especially well-represented in trout streams but are not common in warmer-water streams. For example, our recent research has shown that the most productive trout streams are strongly thermally buffered by groundwater sources and springs that feed into the stream at 9° C, and result in open water though winter (Ferrington, unpublished data). During winter, temperatures in these streams range from 2° through 8° C and the streams harbor unusual aquatic insects that are ultra-cold stenotherm (UCS) species that are able to survive freezing in water (as larvae), but also survive exposure to air temperatures lower than -20°C (Carillo et al. 2004, Bouchard et al. 2006a, 2006b) as adults. We predict that increases as small as 2°C in average water temperatures can reduce productivity of larvae of several of these UCS species, and posit that the winter dynamics of the UCS insects strongly control patterns of trout productivity and yield that have to date primarily been documented only during summer.

We propose two additional research objectives designed to provide better understanding of the winter dynamics of the valuable stream systems. We expect that modifications of winter ecosystem dynamics will serve as initial evidence of insipient responses to altered thermal regimes related to climate warming. We will work as a coordinated, inter-disciplinary team consisting of three faculty, two graduate students and several undergraduate student technicians, to better understand winter dynamics.

3. Hypothesis

Statement of hypothesis and associated context that form the basis for research project:

Objective 1: The physical, geologic and riparian settings in which stream systems occur are known to modulate surface water temperatures. **We hypothesize that specific combinations in these parameters can result in more effective buffering of summer water temperatures in trout streams of southeastern Minnesota**. We will seek to identify the combinations that function on local- to landscape-levels to produce the most buffered thermal conditions.

CONTEXT FOR OBJECTIVE 1: Biodiversity of the Driftless Region is tightly coupled to the hydrogeology of the region. The ways water flows through shallow aquifers controls water temperatures of springs and streams, water chemistry, hydrology and ultimately biodiversity of the region. These ecosystems are structured on an east-west gradient (Troelstrup and Perry 1989). On the western edge of the region, surficial geology is sandstone; springs have low temporal variance in temperature, chemistry and discharge; and land use impacts are associated most clearly with surface hydrology. In these settings, streams often are summer-warm and winter-cold, and stream communities are eurythermal (i.e., more able to excel under conditions of variable thermal regime). Streams in the eastern portion of the gradient are dominated by springs and groundwater input. They are summer cold but winter-warm, having relatively lower thermal, chemical and hydrologic variance. Land use impacts on these systems often are mediated through groundwater interaction, as water passes through sink holes and out springs. These conditions favor very unusual cold-adapted aquatic insects that are abundant and grow at ambient stream temperatures of approximately 2 to 10 degrees Centigrade. Physical, geologic and riparian settings define the areas of stream systems where trout and organisms that form their winter diets can be most abundant and productive.

Objective 2: Diets of trout during winter are poorly documented and often reported at taxonomic levels that mask the importance of individual species (e.g. Chironomidae are known to be common prey, but more than 50 genera could be included in the diet). Without more detailed knowledge of the insect taxa that trout consume in winter, and the thermal preferences and life-history biology of these prey insects, it is not possible to predict how increasing thermal regimes will influence trout diets. **We hypothesize that differing thermal preferences and life histories of prey will be important controls on winter growth and yield of trout, and that**

these differences in prey have potential to account for a large amount of the variability in trout yield that is presently known for streams in southeast Minnesota.

CONTEXT FOR OBJECTIVE 2: The breadth of winter diet for trout populations over a gradient of streams with differing thermal regimes is not well known. Newman (1982), however, determined monthly patterns for a single population in Washington County, MN and demonstrated a transition in invertebrate consumption from summer (dominated by mayflies and terrestrial insects washed into streams) to winter (Newman and Waters 1984), including increased consumption of species that we now know include the ultra-cold stenotherm (UCS) species that develop and emerge during winter (Bouchard and Ferrington 2009). If populations of UCS species vary as a function of trout growth and yield, then we can expect to see diets reflect the pattern of increasing UCS insects across an increasing gradient of trout growth and yield. Diets will be analyzed with a fish bioenergetics model (Hanson *et al*. 1997) to determine the extent to which patterns of increasing growth and yield can be quantitatively related to caloric density of UCS prey items.

Objective 3: As explained for Objective 2, we posit that winter dynamics of aquatic insects strongly control patterns of productivity and yield of trout that have been documented in streams of southeastern Minnesota, and propose to focus our efforts toward better understand winter dynamics. **We hypothesize that factors identified in Objective 1 will also be critical in controlling the types and abundances of aquatic insects in the streams.** We will focus on UCS winter-developing species to better understand how in-stream habitat can be structured to increase abundances and growth of UCS species that are shown to be important in trout diets as demonstrated by results of Objective 2.

In addition, ***we hypothesize that modifications of winter dynamics of UCS aquatic insects will be the first evidence of insipient responses to altered thermal regimes resulting from climate change. Consequently, a broader conceptual goal of our efforts is to develop a predictive model to predict thermal stress on trout, and UCS-adapted aquatic insects that form critical elements of the food chain of trout, before stress-related responses result in declining reproduction, growth, or productivity of trout populations in these summer-cold but winter-warm stream habitats.***

CONTEXT FOR OBJECTIVE 3: It appears that UCS species are most diverse and possibly most abundant in trout streams that have highest growth rates and yields of trout (unpublished observations, Bouchard and Ferrington). Several UCS are undescribed species. The focus of this specific objective will be to learn how to quantify patterns of diversity and population abundances of UCS species across streams that represent a gradient of trout growth and yield. The null hypothesis for this topic is that there will be no significant relationship between UCS species abundances and growth and yield of trout. We expect to reject the null hypothesis and that data will support acceptance of the alternative one-tailed hypothesis that there is a positive relationship between abundances of UCS aquatic insect species and growth and yield of trout.

4. **Methodology** - Describe the methodology to be employed.

Objective 1: Biodiversity of the Driftless Region is tightly coupled to the hydrogeology of the region. The flows of groundwater through shallow aquifers controls water temperatures of springs and streams, water chemistry, hydrology and, ultimately, aquatic biodiversity of the region. Global change will alter these systems in major ways. Most predictions suggest that southern Minnesota will become warmer and wetter over the next 20-50 years. Those changes will influence vegetation, hydrology, water chemistry and thermal regime of the waters. Riparian structure and other adjacent land-use patterns can act as dampening mechanisms to slow or ameliorate longitudinal changes in thermal regimes of streams with increasing air temperatures. This aim is structured to determine present-day configurations of riparian vegetation, adjacent land use and geological setting that provide the greatest capacity to buffer changes in thermal regime of stream waters during both summer and winter over the largest longitudinal distances of stream, and thus maximize habitats appropriate for foraging and reproduction of trout. Streams not fitting this profile will be considered as "most at-risk" as global climates warm and can be targeted for management.

We will assess riparian vegetation structure, adjacent land use and geologic setting of 36 streams through a stratified random sampling design. We will test the hypothesis that there is a significant relationship of these landscape features and longitudinal dampening of thermal gradients in streams similar to the approach of Perry and Easter (2004). We will use GIS and stream morphometric analyses, combined with hydrologic and geologic modeling, to quantify riparian setting and associated stream-bed evolution to provide a context within which to assess these parameters relative to trout production and yield.

Results of this objective will complement and provide a habitat template for the other specific aims by placing thermal regimes, as well as invertebrate and fish community dynamics, in a context of regional patterns significant to global climate change and regional economic health. The same 36 streams will be studied in all other specific aims.

Objective 2: Trout will be obtained using routine electro-shocking methods during December through March in each of 12 streams/year for the three years of our study. The streams will be the same as investigated for Objectives 1 and 3. Diet will be determined using a gastric-lavage technique, modified for use in winter. We have successfully used our SOP for the technique over the past two winters and are confident that it is an appropriate technique for this objective. After identification and quantification of diet items, the resulting data will be analyzed with a fish bioenergetics model (Hanson *et al* . 1997) to determine the extent to which patterns of increasing UCS aquatic insect species can be quantitatively related to caloric density.

Objective 3: Comprehensive studies at lower latitudes in the Central Plains have shown that more than 50 species of aquatic insects grow and emerge as adults during winter (Ferrington 2000, 2007). At least 25 species are now known to occur in trout streams in SE MN, and most that are UCS species are exclusively constrained to development and emergence during winter (Ferrington, unpublished data). It appears that UCS species are most diverse and possibly most abundant in trout streams that have fastest growth rates and yields of trout. Several of the UCS insects are undescribed species. The focus of this objective will be to quantify the patterns of diversity and population abundances of UCS species across the 36 streams used for Objective 1 & 2, and that represent a gradient of trout growth and yield. We will use routine methods to quantify abundances (PIBS samplers, lab sorting & quantification) combined with lab rearings in cold growth chambers to assist in identification and description of unidentified species. We will also use a method for collecting surface floating pupal exuviae of Chironomidae to profile the emergence periods and phenologies of USC species. This method has be developed by Ferrington *et al*. (1991) and utilized successfully in a variety of pollution assessment projects and basic ecological research by him over the past 29 years.

5. Results and Deliverables

We anticipate that this project will result in at least one publication in a peer-reviewed scientific journal for each of our objective. It is also possible that the research associated with objective 3 will result in the discovery of undescribed species of winter-active aquatic insects. In addition, the project will generate autecological data for several species. The autecological information will consist the first studies of trophic status, functional feeding group data, growth rates, voltinism, and phonological patterns for some species. Consequently, additional publications will likely be generated.

In addition to publications, we will assemble and maintain comprehensive data bases of original measurements taken for each objective. We will consult with colleagues at various agencies, both at state (MPCA and DNR), regional (EPA Region 5) and national levels (EPA, USDA) to determine a format for data structures and search capabilities that will provide efficient use of our raw data. Our data files will be accessible through the web page interface for the project (see details in **Section 9, Dissemination and Use**).

6. **Timetable** - Layout the proposed times for completing the proposed research including proposed dates for individual results and deliverables.

Year	Task	Summer	Fall	Winter	Spring
First	Develop web site	XXX			
First	Field work Obj. 1	XXX			
First	Data analysis Obj. 1		XXXXX		
First	Field work Objs. 2 & 3			XXXXX	X
First	Data analysis Objs. 2 & 3			XX	XXXXX
Second	Update web site		XXXXX		XXXXX
Second	Field work Obj. 1	XXX			
Second	Data analysis Obj. 1		XXXXX		
Second	Field work Objs. 2 & 3			XXXXX	X
Second	Data analysis Objs. 2 & 3			XX	XXXXX
Third	Update web site		XXXXX		XXXXX
Third	Field work Obj. 1	XXX			
Third	Data analysis Obj. 1		XXXXX		
Third	Field work Objs. 2 & 3			XXXXX	X
Third	Data analysis Objs. 2 & 3			XX	XXXXX
Third	Write final reports & ms.		XXX	XXXXX	XXXXX

7. **Budget** - Update the budget sheet from the original proposal based on the amount of funding recommended. Additional details can be added to the budget sheet to more fully describe the budget (The budget sheet is expandable so that additional information can be provided). Additional narrative on the budget can also be provided to more fully explain how the funds will be spent. The "Other Funding" section of the budget sheet should also be updated and include sufficient detail so that the source and amount of contribution is clear.

Budget: 2009 LCCMR Proposal, Ferrington *et al.*	**Year 1**	**Year 2**	**Year 3**	**Project**
PROJECT DURATION: 1 July 2010 - 30 June 2013				**Summary**
Graduate Students				
2 @ 19,000/year salary	$38,000	$39,140	$40,314	$117,454
Tuition @ 11290/yr/student	$22,580	$23,257	$23,955	$69,792
Fringe Benefits (calculated as 14.46% of salary)	$5,495	$5,660	$5,829	$16,984
3 Undergraduates				
@ $10.00/hour, 10 hour/week for 25 weeks/year	$7,500	$7,725	$7,957	$23,182
Domestic Travel				
Per Diem for field work				
@ $ 75/day/person for 5 persons for 20 days	$7,500	$7,725	$7,957	$23,182
Vehicle Rental @ $0.55/mile for 4800 mile/vehicle	$2,460	$2,534	$2,610	$7,604
Disposable Supplies, Chemicals and lab materials				
By Specific Objectives				
Objective 1	$4,508	$4,643	$4,783	$13,934
Objective 2	$4,508	$4,643	$4,783	$13,934
Objective 3	$4,508	$4,643	$4,783	$13,934
Direct Costs	$97,059	$99,970	$102,971	$300,000
IDC	$0	$0	$0	$0
Total Direct Costs	$97,059	$99,970	$102,971	$300,000
NOTE: Initial unit costs are shown in this column.				
Costs for years 2-3 are increased				
by 3%/year to cover inflation				
Cumulative costs on yearly basis				
are shown in columns B-D				
Cumulative project costs for each category is given in column E				

8. **Credentials** - Provide brief background of the principal investigators and cooperators who will carry out the proposed research and selected publications (targeted/abbreviated resumes are acceptable).

Two-page biographical sketches for Perry, Vondracek and Ferrington are included after the literature cited.

9. **Dissemination and Use** – Describe how the findings of the research will be disseminated and describe the expected audience and potential use.

Web Site Development--- A World Wide Web site for the project will be established and maintained through the on-line resources of the Chironomidae Research Group, Department of Entomology, College of Foods, Agricultural and Natural Resources Sciences at the University of Minnesota. The web site will have a link to data bases that are built through this project for use by ecologists, conservationists, policy makers, and the public. The web site will provide additional and regularly updated information not contained in full in peer-reviewed publications and will synthesize past, current, and future research in this area. The information will be presented through text, multimedia (e.g. photos, figures, video), and links to relevant websites.

As part of the project web site, a separate page will be produced for the public and educators. It will be less technical and provide information on the emergence of insects from trout streams, field trip possibilities, educational experiments, information for use in lesson plans, and links to additional information and organizations.

Funding for this project comes at a propitious time for Leonard Ferrington in terms of outreach potential. Ferrington previously was awarded a Faculty Fellowship from the Digital Media Center, Office of Information Technology at the University of Minnesota (Twin Cities). The proposal is titled "*From Verification to Modeling: Adding Complexity and Realism to Web-Based Environmental Assessment Tools*" and the full text of the proposal is available on-line. Activities completed or planned during the fellowship include developing assessment tools to judge use and effectiveness of interactive digital media. The techniques learned during the fellowship tenure will be integrated into digital media resulting from this project.

During the first half of the project efforts will be completed to teach citizen volunteer groups in southeastern Minnesota the mechanics of making collections of surface-floating pupal exuviae of Chironomidae, and the benefits and short-comings of using the method as part of their monitoring activities. We also will contact fly-fishing groups, Trout Unlimited and private businesses of colleagues and friends such as Streamside Adventures (www.streamsideadventures.com) to assist in advertising our outreach activities.

Literature Cited and Other Pertinent Readings

Baust, J. G. & J. S. Edwards. 1979. Mechanisms of freezing tolerance in an Antarctic midge, *Belgica antarctica*. Physiological Entomology 4:1-5. **(Reading for specific topic 3)**

Bouchard, R. W., Jr. & L. C. Ferrington, Jr. 2009. Winter growth, development, and emergence of *Diamesa mendotae* Muttkowski (Diptera: Chironomidae) in Minnesota (USA) streams. Environmental Entomology 38(1): 250-259. **(Reading for specific topic 3)**

Bouchard, R. W. Jr., M. A. Carrillo, & L. C. Ferrington Jr. 2006. Lower Lethal Temperature for Adult Male *Diamesa mendotae* Muttkowski (Diptera: Chironomidae), a Winter-Emerging Diamesinae. Aquatic Insects. 28:57-66. **(Reading for specific topic 3)**

Bouchard, R. W. Jr., M. A. Carrillo, S. A. Kells & L. C. Ferrington Jr. 2006. Freeze tolerance in larvae of the winter-active *Diamesa mendotae* Muttkowski (Diptera: Chironomidae): a contrast to adult strategy for survival at low temperatures. Hydrobiologia 568:403-416. **(Reading for specific topic 3)**

Carrillo, M. A., C. A. Cannon, & L. C. Ferrington Jr. 2004. Effect of sex and age on the supercooling point of the winter-active *Diamesa mendotae* Muttkowski (Diptera:Chironomidae). Aquatic Insects 26:243-251. **(Reading for specific topic 3)**

Clark, M. E., K. A. Rose, D. A. Levine, & W. W. Hargrove. 2001. Predicting climate change effects on Appalachian trout: combining GIS and individual-based modeling. Ecological Implications 11: 161-178.

Dieterman, D. J., W. C. Thorn, & C. S. Anderson. 2004. Application of a bioenergetic model for brown trout to evaluate growth in southeast Minnesota streams. Minnesota Department of Natural Resources Investigational Report 513, 26 pp.

Dieterman, D. J., W. C. Thorn, C. S. Anderson, & J. L. Weiss. 2006. Summer habitat associations of large brown trout in southeast Minnesota streams. Minnesota Department of Natural Resources Investigational Report 539, 25 pp.

Eaton, J. G. & R. M. Scheller. 1996. Effects of climate warming on fish thermal habitat in the United States. Limnology and Oceanography 41: 1109-1115.

Ferrington, L. C. Jr. 2007. Hibernal emergence patterns of Chironomidae in lotic habitats of Kansas versus substrate composition. pp. 1-7, In: *Contributions to the Systematics and Ecology of Aquatic Diptera--- A Tribute to Ole A. Sæther*. T. Andersen (ed.). Misc Publications of the Ohio Biological Survey. **(Reading for specific topic 3)**

Ferrington, L. C. Jr. 2000. Hibernal emergence patterns of Chironomidae in lotic habitats of Kansas versus ambient air and water temperatures. pp. 375-382, In: *Late 20th Century Research on Chironomidae.* O. Hoffrichter (ed.). Shaker Verlag, Aachen, Germany. **(Reading for specific topic 3)**

Ferrington, L. C., Jr., *et al*. 1991. A Protocol for Using Surface-Floating Pupal Exuviae of Chironomidae for Rapid Bioassessment of Changing Water Quality. Pp.181-190. In: *Sediment and Stream Water Quality in a Changing Environment: Trends and Explanations*. IAHS Publication Number 203. 374 pp. **(Reading for specific topic 3)**

Dovciak, A. & J. A. Perry. 2002. In search of effective scales for stream management: Does agroecoregion, watershed, or their intersection best explain the variance in stream macroinvertebrate communities? Environmental Management 30(3):365-377 **(Reading for specific topic 1)**

Gartner, W. C., L. L. Love, D. Erkkila, & D. C. Fulton. 2002. Economic impact and social benefits study of coldwater angling in Minnesota. Final report to Minnesota Department of Natural Resources 130 pp.

Hanson, P. C., T. B. Johnson, D. E. Schindler, & J. F. Kitchell. 1997. Fish Bioenergetics 3.0. University of Wisconsin Center for Limnology and University of Wisconsin Sea Grant Institute, Madison, WI. Used for bioenergetics modeling. **(Reading for specific topic 2)**

Henson, F. G. & R. M. Newman. 2000. Effect of temperature on growth at ration and gastric evacuation rate of ruffe (Gymnocephalus cernuus). Transactions of the American Fisheries Society 129(2): 552-560. **(Reading for specific topic 2)**

Johnson, H. L. & H. G. Stefan. 2006. Indicators of climate warming in Minnesota: lake ice covers and snow melt runoff. Climate Change 75: 421-453

Meisner, J. D. 1990. Effect of climate warming on the southern margins of the native range of brook trout, *Salvelinus fontinalis*. Canadian Journal of Fisheries and Aquatic Science 47: 1065-1070.

Mohseni, O., T. R. Erickson, & H. G. Stefan. 2002. Upper bounds of stream temperatures in the contiguous United States Journal of Environmental Engineering 128: 4-11.

Nerbonne, B. A. & B. Vondracek. 2001. Effects of land use on benthic macroinvertebrates and fish in the Whitewater River, Minnesota. Environmental Management 28:87-99. **(Reading for specific topics 2 & 3)**

Newman, R. M. 1982. Size-selective predation on *Gammarus pseudolimnaeus* by stream trout and sculpins in Valley Creek, Minnesota. M.S. Thesis, University of Minnesota, St. Paul, MN. 85 pp. **(Reading for specific topic 2)**

Newman, R. M. & T. F. Waters. 1984. Size-selective predation on *Gammarus pseudolimnaeus* by trout and sculpins. Ecology 65: 1535-1545**. (Reading for specific topic 2)**

NRDC Report. 2002. Effects of global warming on trout and salmon in U. S. streams. May, 2002. 44 pages. Available on-line at: http://www.defenders.org/publications/fishreport.pdf

Perry, J. A. & K. W. Easter. 2004. Resolving the scale incompatibility dilemma in river basin management. Water Resources Research 40 (8): http://www.agu.org/pubs/current/wr/index.php?month=July **(Reading for specific topic 1)**

Sovell, L. A., B. Vondracek, J. A. Frost, & K. G. Mumford. 2000. Impacts of rotational grazing and riparian buffers on physicochemical and biological characteristics of southeastern Minnesota streams. Environmental Management 26:629-641. **(Reading for specific topics 1 & 2)**

Troelstrup, N. H., Jr. & J. A. Perry. 1989. Water quality in southeastern Minnesota streams: observations along a gradient of land use and geology. Journal of the Minnesota Academy of Science 5:6-13. **(Reading for specific topic 1)**

Jim Perry
BIOGRAPHICAL SKETCH

PRESENT POSITION:
Department of Fisheries, Wildlife & Conservation Biology, University of Minnesota
HT Morse Distinguished University Professor, 1999-Present

PREVIOUS POSITIONS:
Professor, University of Minnesota,1982-Present
Head, Department of Fisheries, Wildlife, and Conservation Biology, 2000-2006
Director of Graduate Studies, Water Resources Science, 1999-2001 and 1988-1992
Director, Center for Natural Resource Policy and Management, 1985-2002

EDUCATION:

Idaho State University	Ph. D.	1981	Biology
Western State	Master's	1973	Biology
Colorado State	B. Sc.	1968	Fisheries

CURRENT/RECENT RESEARCH SUPPORT:
Stream classification for TMDL assessment using a dimensionless, reference reach approach. Co-PI US EPA $800,080 2003-2006
Quantifying the variability of stream health indicators for TMDL development. Co-PI Minnesota PCA $124,016, 2003-2005
Classification of aquatic habitats in the St. Croix National Scenic River. PI National Park Service $50,000 2003-2005
Development of a Water Resources Plan for Voyageur's National Park, US National Park Service. $65,000 PI, 1999-2003

SELECTED PEER-REVIEWED PUBLICATIONS:
Savanick, S, L Baker and J Perry. 2006. Case Study for Evaluating Campus Sustainability: Nitrogen Balance for the University of Minnesota Urban Ecosystems Published on-line first; available at http://www.springerlink.com/content/1573-1642

Savanick, S and J Perry. 2006. Using the campus nitrogen budget to teach about the nitrogen cycle Journal of Geoscience Education 54: 312-319

Dahl, K, J Perry and MD Williams (in press). The effects of Domoic Acid on the gonadotropin releasing hormone (GT1-7) neuronal cell line. Bios IN PRESS

Savanick S and J Perry. 2006. Using the campus nitrogen budget to teach about the nitrogen cycle. Journal of Geoscience Education Vol 54 http://www.nagt.org/nagt/jge/abstracts/may06.html#v54p312

Perry, JA and KW Easter. 2004. Resolving the scale incompatibility dilemma in river basin Management Water Resources Research 40 (8): http://www.agu.org/pubs/current/wr/index.php?month=July

Talmage, P, JA Perry and R Goldstein. 2002. Relation of Instream Habitat and Physical Conditions to Fish Communities of Agricultural Streams in the Northern Midwest journal of fish management 22: 825-833

Dovciak, A and JA Perry. 2002. In search of effective scales for stream management: Does agroecoregion, watershed, or their intersection best explain the variance in stream macroinvertebrate communities? Environmental Management 30(3): 365-377

AWARDS:
Gordon L Starr Award for Excellence in Student Service, 2004
CISW Award for the Interdisciplinary Teaching of Writing, 2003
University of Minnesota Award for Outstanding Service, 2002
Elected Fellow, American Institute of Fishery Research Biologists, 2002
Morse Alumni Award for Distinguished Service to Undergraduate Education, 1999
Appointment to Academy of Distinguished Teachers, University of Minnesota, 1997
Richard C Newman Art of Teaching Award, College of Natural Resources, University of Minnesota, 1997
Visiting Scholar, Green College, and Oxford Forestry Institute, University of Oxford, 1991
Senior Fellow, National Academy of Sciences, Warsaw and Lodz, Poland, 1991
Senior Research Fellow, American Institute of Indian Studies, New Delhi and Madras, 1985

BRUCE VONDRACEK
Curriculum Vitae

CURRENT PROFESSIONAL POSITION

Assistant Unit Leader-Fisheries, Minnesota Cooperative Fish and Wildlife Research Unit and
Adjunct Professor, Department of Fisheries and Wildlife, and Conservation Biology, University of Minnesota, Saint Paul, MN 55108

PAST PROFESSIONAL POSITIONS

University of Minnesota
Adjunct Associate Professor, Department of Fisheries and Wildlife, and Conservation Biology (1994-2001)
Adjunct Assistant Professor, Department of Fisheries and Wildlife and Conservation Biology Program (1991-1994)
The Ohio State University
Assistant Unit Leader-Fisheries, Ohio Cooperative Fish and Wildlife Research Unit (1988-1991)
Assistant Professor, Department of Zoology (1988-1991)
Adjunct Assistant Professor, School of Natural Resources (1989-1991)
University of California, Davis
Postgraduate Researcher, Wildlife and Fisheries Biology (1981-1987)

EDUCATION

Ph.D. Ecology, University of California, Davis (1981)

RECENT RESEARCH SUPPORT (since 2005)

Eighteen grants, research contracts or awards (PI or Co-PI) last five years, total **$3,478769.00**:

2008 Scaleable Indices of Watershed Health. Minnesota Department of Natural Resources. $110,000

2007 Development of an ecological assessment method for Minnesota lakes. Minnesota Department of Natural Resources. $78,000
Empowering water quality decisions: reducing uncertainty and bounding variability of stream ecosystem indicators. Minnesota Department of Natural Resources. $278,069
Predicting large wood transport and effects on stream geomorphology in northern Minnesota streams. Minnesota Department of Natural Resources. $64,000
Evaluating riparian timber harvesting guidelines: phase 3. Legislative Citizens Committee on Minnesota Resources. $400,000
Understanding the importance of weak-tie networks in complex human-environment systems: ecosocial feedback in multifunctional agriculture. National Science Foundation. $925,000

2006 Ecological exchangebility of sculpins in southeast Minnesota, Minnesota Department of Natural Resources, $16,000
Minnesota Riparian Management Study: comparison of effects on stream habitat and fish nine years after harvest treatments. Minnesota Department of Natural Resources $18,000, US Forest Service $10,450, and National Council for Air and Stream Improvement $20,000
Integrated Water Resource Management: Bridging knowledge gaps to achieve common TMDL goals. Water Resources Center, University of Minnesota. $10,000

2005 Evaluating Riparian Timber Harvesting Guidelines: Phase II. Legislative Committee on Minnesota Resources. $333,000
Mortality of Walleye Caught in Live-Release Tournaments: Assessment, Reduction, and Determination of Acceptable Levels. Minnesota Department of Natural Resources. $259,144
Evaluating Riparian Timber Harvesting Guidelines: 2005 Bridge Funding. Minnesota Forest Resource Council $11,000
Effects of riparian forest harvest on instream habitat and fish and invertebrate communities. Funding: Minnesota Department of Natural Resources. $37,500

PUBLICATIONS (**Sixty** publications since 1980. Publications since 2006 listed next.)

Asmus, B., J. Magner, B. Vondracek, and J. Perry. Physical integrity: the missing link in biological monitoring and TMDLs. (Accepted by Environmental Monitoring and Assessment).

Magner, J. A., B. Vondracek, and K. N. Brooks. 2008. Channel stability, habitat and water quality in South-eastern Minnesota (USA) streams: assessing managed grazing practices. Environmental Management 42:377–390.

Frost Nerbonne, J. A., B. Ward, A. Ollila, M. Williams, and B. Vondracek. 2008. Volunteer sampling bias using multihabitat sampling for macroinvertebrates. Journal North American Benthological Society 27(3):640–646.

Blann, K. L., J. Anderson, G. Sands, and B. Vondracek. Effects of agricultural subsurface drainage on aquatic ecosystems: a review. (Accepted by Critical Reviews in Environmental Science and Technology, scheduled for publication late 2009).

Zimmerman, J. K. H. and B. Vondracek. 2007. Interactions between sculpin and trout: slimy sculpin growth and diet in relation to native and nonnative trout. Transactions of the American Fisheries Society 136:1791-1800.

Zimmerman, J. K. H. and B. Vondracek. 2007. Brown trout and food web interactions in a Minnesota stream. Freshwater Biology 52:123-136.

Petersen, A. and B. Vondracek. 2006. Vegetative buffer strips around sinkholes to improve water quality. Journal of Soil and Water Conservation 61:380-390.

Zimmerman, J. K. H. and B. Vondracek. 2006. Interactions between slimy sculpin and a native versus a nonnative trout: consequences for growth. Canadian Journal of Fisheries and Aquatic Sciences 63:1526-1535.

Zimmerman, J. K. H. and B. Vondracek. 2006. Stream enclosure effects on drifting invertebrates and fish growth: do enclosure experiments produce biased results? Journal of the North American Benthological Society 25:453-464.

PAPERS PRESENTED: **One Hundred Sixty-Three** papers presented since 1977. **Twenty-Four** were invited presentations at various Universities or scientific societies.

GRADUATE STUDENT ADVISING (Current Students)

Bethany Blick (WRS)	Veronica Bullock (CB)	Joel Chirhart (WRS)	Christine Dolph (WRS)
David Huff (CB)	Matt Kocian (CB)	Kara Raymond (WRS)	Kathrine Ruddick (CB)

SERVICE AND OTHER ACTIVITIES

Affirmative Action Committee, member, Equal Opportunities Section, American Fisheries Society, 1989-1991
Associate editor, Transactions of the American Fisheries Society, 1991-1993
Awards Committee, chair, Minnesota Chapter of the American Fisheries Society, 1994-1996
Awards Committee, member, North Central Division of the American Fisheries Society, 1995
Executive Committee, member, Minnesota Chapter of the American Fisheries Society, 1995
Fish and Wildlife Legislative Alliance, board member, representing the Minnesota Chapter of the American Fisheries Society, 1998-2004
J. Francis Allen Scholarship Committee, Equal Opportunity Section, American Fisheries Society chair: 1994 co-chair 2001, member 1990-1993 and 1995-1996
John E. Skinner Memorial Student Travel Award, member, American Fisheries Society, 1992
Mentoring for Professional Diversity in Fisheries Committee, member, Equal Opportunities Section, American Fisheries Society, 1994-1997
Minnesota Chapter of the Society for Conservation Biology, Vice President, 2006-present
North American Benthological Society, Member, Science and Policy Committee, 2007-present
North Central Division Representative to the Education Section of the American Fisheries Society, 1997-1998
Paper/Poster Judging Committee, chair, North Central Division of the American Fisheries Society, for Midwest Fish and Wildlife Conference, 1996
President elect, Minnesota Chapter of the American Fisheries Society, 1997
Plenary committee, co-chair, 62nd Annual meeting of the Midwest Fish and Wildlife Conference, 2000
President, Minnesota Chapter of the American Fisheries Society, 1998
Past President, Minnesota Chapter of the American Fisheries Society, 1999
Program Committee, Co-Chair, 50th Midwest Fish and Wildlife Conference, 1988
Program Committee, chair, 2004 annual meeting of the American Fisheries Society, 2002-2004
Program Committee, chair, 2004 annual meeting of the Minnesota Chapter of the Society for Conservation Biology held jointly with the Minnesota Chapter of the American Fisheries Society, 2003-2004
Resolutions Committee, Chair, Ohio Chapter of the American Fisheries Society, 1988-1990
Scholarship Committee, chair, Minnesota Chapter of the American Fisheries Society, 2001-present
Special Committee to Improve Support for the Program Chair, member, appointed by the president of the American Fisheries Society 2002
Vice President, Minnesota Chapter for Conservation Biology 2006-2007

LEONARD CHARLES FERRINGTON, JR.
Biographical Sketch

CURRENT PROFESSIONAL POSITION

Professor, Department of Entomology, University of Minnesota, Saint Paul, MN 55108
Co-Coordinator, Environmental Science, Policy & Management Degree Programs

PAST PROFESSIONAL POSITIONS

Associate Professor, Department of Entomology, University of Minnesota, Saint Paul, MN 55108 (2000-2003)
Director, Biological Water Quality and Freshwater Ecology Program, Kansas Biological Survey, University of Kansas, Lawrence, KS 66047 (1986-2000)
Associate Professor, Department of Entomology, University of Kansas, Lawrence, KS 66045 (1991-2000)
Head, Entomology Section, Kansas Applied Mesocosm Program, University of Kansas, Lawrence, KS (1989-2000)
Associate Scientist, Kansas Biological Survey, University of Kansas, Lawrence, KS 66047 (1986-2000)
Assistant Scientist, Kansas Biological Survey, University of Kansas, Lawrence, KS 66047 (1980-1986)

EDUCATION

Ph.D., University of Pittsburgh, 1980

RECENT RESEARCH SUPPORT

Sixty-five grants, research contracts, fellowships or awards since 1978, totaling **$ 3,329,670.00**. Grants/fellowships received since 1997 below:

2005 Grant from University of Minnesota, Technology Enhanced Learning Program (TEL) to develop "Volunteer Stream Monitoring Interactive Verification Programs" $ 9000.

2005 Grant from the Minnesota Metropolitan Council to Study Aquatic Invertebrates in Metro Area Streams. December 2005-December 2006. $ 14,728.

2005 Grant from U. S. Geological Survey and Water Resources Center (UM) to Refine a Rapid Bioassessment Technique for Integrating Biological Data into TMDL Assessments in Urban Streams. March 2005-February 2006. $ 18,799.

2006 University of Minnesota TEL Grants, Faculty Fellowship Program for project titled "From Verification to Modeling: Adding Complexity and Realism to Web-Based Environmental Assessment Tools." $20,000 March 2006- June 2007

2007 Grant from National Park Service, US Department of the Interior for Evaluating the Habitat and Water Quality of the Saint Croix NSR using a Chironomidae Community Survey. $16,000 2007-2008

2007 Contract from Washington County Conservation District for development of Brown's Creek Impaired Biota TMDL – Phase II: Stressor Identification. $ 63, 627 December 2007- December 2008

PUBLICATIONS (**Sixty-four** publications since 1980. Publications since 2006 listed next.)

Bouchard, R.W. Jr., M.A. Carrillo, & L.C. Ferrington Jr. 2006 Lower Lethal Temperature for Adult Male *Diamesa mendotae* Muttkowski (Diptera: Chironomidae), a Winter-Emerging Diamesinae. Aquatic Insects 28(1): 57-66.

Bouchard, R.W. Jr., M.A. Carrillo, S.A. Kells & L.C. Ferrington Jr. 2006 Freeze tolerance in larvae of the winter-active *Diamesa mendotae* Muttkowski (Diptera: Chironomidae): a contrast to adult strategy for survival at low temperatures. Hydrobiologia.

Hayford, B. L. & L. C. Ferrington Jr. 2006. Distribution of Chironomidae in Hovsgol Nuur, Mongolia. Chapter 26, pp. 433-452. IN: C. E. Goulden, T. Sitnikova, J. Gelhaus & B. Boldgiv (eds.). *The Geology, Biodiversity, and Ecology of Lake Hövsgöl (Mongolia).* Backhuys Publishers.

Ferrington, L. C., Jr., & O. A. Sæther. 2006. *Rhagosmittia* and *Trondia*, two new genera of Orthocladiinae from Oceania and Australia (Diptera: Chironomidae) Aquatic Insects 28(4): 243-250.

Ferrington, L. C. Jr. 2007. Hibernal emergence patterns of Chironomidae in lotic habitats of Kansas versus substrate composition. Pp. 99-105, IN: T. Andersen (ed.), *Contributions to the Systematics and Ecology of Aquatic Diptera—A Tribute to Ole A. Sæther.* The Caddis Press, Columbus, Ohio.

Ferrington , L. C., Jr. 2008. Global biodiversity of Scorpionflies and Hangingflies (Mecoptera) in freshwater. Hydrobiologia (Special FADA Issue). 595(1): 447-455.

Ferrington , L. C., Jr. 2008. Global biodiversity of non-biting midges (Chironomidae: Diptera) in freshwater. Hydrobiologia (Special FADA Issue). 595(1): 447-455.

PAPERS PRESENTED: **Eighty-seven** papers presented since 1977. **Thirty-seven** were invited presentations at various Universities or scientific societies. **Fifty-one** abstracts published.

GRADUATE STUDENT ADVISING (Current Students)

Brian Scheutz (ENT)	Claire Serieyssol (WRS)
Alyssa Anderson (ENT)	Petra Kranzfelder (ENT)

SERVICE AND OTHER ACTIVITIES

President of the Kansas Entomological Society, 1984-1985.
Organized "Workshop on Toxic Substances in the Environment: Perspectives, Philosophies and Solutions?" Held at the University of Kansas, 20 May 1986.
Senior editor, Journal of the Kansas Entomological Society.
Member, Graduate Student Support Committee. Department of Entomology, University of Kansas. 1992-1995
Member, Committee to judge student oral papers at annual meetings of Kansas Entomological Society, 1991-1999.
Member, Committee to judge student papers for NABS Awards, 1991-1996, 1998, 1999.
Chairperson, Student Awards Committee, Department of Entomology, University of Kansas, July 1995-2000
Member, University Committee on Graduate Studies, elected to three year term. 1996-1999, University of Kansas.
Chairperson, University Committee on Graduate Studies, elected during 1998-1999, University of Kansas.
Member, Committee to revise bylaws of the Division of Biological Sciences, University of Kansas, 1998-1999.
Organized and moderated session on aquatic insects in wetland habitats, annual meeting, North-Central Branch of the Entomological Society of America, Minneapolis, MN, March 2000.
Member, Curriculum Committee, Department of Entomology, University of Minnesota, 2000-2001.
Chairperson, Curriculum Committee, Department of Entomology, University of Minnesota, 2001-2002.
Elected to Long Range Planning Committee, Department of Entomology, University of Minnesota, August 2002.
Member, Curriculum Committee, College of Agriculture, Foods & Environmental Sciences, August 2002.
Chairperson, Curriculum Committee, College of Agriculture, Foods & Environmental Sciences,
Participated in a Biodiversity Expedition to the Western Altai Mountains Region of Mongolia, 2004 and 2005.
Served as 2004-2005 Chair of the COAFES Curriculum Committee and as a Member-At-Large in 2005-2006.
Chair of the Curriculum Committee for the Water Resources Program, 2005-2006
Member of the Curriculum Committee for the Department of Entomology, 2005-2006.
Serve on a working group for Multi-State Collaborative Approaches to Water Quality Improvement.
Served as Chair for a special Working Group on International Programs for the NEWCO (=CFANS).
Elected as Track Coordinator, Environmental Science, Policy and Management Major in CFANS. 2008
Appointed as Co-Coordinator, Environmental Science, Policy and Management Major in CFANS. 2008-2011.

INTERNATIONAL ACTIVITIES (Selected examples)

Member, Executive Board of Directors for NABS Endowment. 1993-2002.
Session Chairperson, "Lotic Ecology of Chironomidae" at the XIII International Conference on Chironomidae, Freiburg, Germany, 6 September 1997. (Also presented one research paper)
Presented research paper at the XIV International Conference on Chironomidae, Rio de Janeiro, Brasil, 2000.
Presented research paper at Conference on Coldwater Lakes held at Lake Myvatn Research Lab, Iceland, 2001.
Organized and moderated session on Recent Advances in Chironomidae Research, 50th Annual Meeting of the North American Benthological Society, June 2002.
Chairperson, Executive Board of Directors for NABS Endowment. 2001-2002.
Organized and Hosted the XV International Conference on Chironomidae, Minneapolis, Minnesota, 2003.
Field work in Puerto Rico, Norway, Tasmania, Argentina, New Zealand, South Africa**,** Mongolia

Attachment A: Budget Detail for 2010 Projects - Summary and a Budget page for each partner (if applicable)

Project Title: ***Trout Streams Assessment***

Project Manager Name: ***Leonard C. Ferrington Jr.***

Trust Fund Appropriation: ***$ 300,000***

1) See list of non-eligible expenses, do not include any of these items in your budget sheet

2) Remove any budget item lines not applicable

2010 Trust Fund Budget	Result 1 Budget:	Amount Spent (date)	Balance (date)	Result 2 Budget:	Amount Spent (date)	Balance (date)	Result 3 Budget:	Amount Spent (date)	Balance (date)	TOTAL BUDGET	TOTAL BALANCE
	Quantifying Physical, Geological and Riparian Settings of Trout Streams in Relation to Thermal Regimes			*Quantifying and Modeling Winter Diets of Trout*			*Determination and Quantification of Dynamics of UCS Aquatic Insect Species that Grow and are Active in Winter*				
BUDGET ITEM											
PERSONNEL:	74,474	0	74,474	71,240	0	71,240	81,698	0	81,698	227,412	227,412
PERSONNEL: wages ($117,454 - for two Graduate Students @ 50% FTE for 3 years)											
PERSONNEL: benefits ($69,793 - academic tuition for 2 graduate students for 3 years)											
PERSONNEL: Fringe benefits ($16,983)											
PERSONNEL: wages for 3 Undergraduates ($23,182 - 3@ $10.00/hour for 10 hour/week for 25 weeks/year)											
Supplies: Disposable field and lab supplies (Including preservatives, sample jars, storage containers, nets sieves, slides, coverslips, mounting medium, forceps, probes, dissecting scalpel, petri dishes, labels, markers, pencils, pens, field & lab notebooks, chestwaders, field gloves, purchase remote sensing and LU/LC data)	13,933	0	13,933	13,934	0	13,934	13,934	0	13,934	41,801	41,801
Travel expenses in Minnesota (Includes meals, lodging, four-wheel drive vehicle rental, and mileage)	6,678	0	6,678	11,313	0	11,313	12,796	0	12,796	30,787	30,787
COLUMN TOTAL	**$95,085**	**$0**	**$95,085**	**$96,487**	**$0**	**$96,487**	**$108,428**	**$0**	**$108,428**	**$300,000**	**$300,000**