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:	**$ 300,000**

Legal Citation: M.L. 2010, Chp. 362, Sec. 2, Subd. 5i

Appropriation Language:
$300,000 is from the trust fund to the Board of Regents of the University of Minnesota to assess cold water aquatic insect abundance related to warming water temperatures as predictors of trout growth in southeastern Minnesota and assess options to minimize stream temperature changes. This appropriation is available until June 30, 2013, by which time the project must be completed and final products delivered.

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/Activity 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/Activity 1: **ENRTF Budget: $95,085**
Amount Spent: $ 0
Balance: $ 95,085

Deliverable/Outcome for Result/Activity 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**	Fall 2010	$30,760

cross sectional profiles. We expect streams where trout grow fastest during winter will have unique combinations of geology, substrate compositions that interact to produce the most highly buffered water temperatures)		
2.*Analysis of second set of 12 streams* (Same details as for deliverable #1, above)	Summer 2011	$31,680
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/Activity 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/Activity 2: **ENRTF Budget: $96,487**
Amount Spent: $ 0
Balance: $ 95,085

Deliverable/Outcome for Result/Activity 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/Activity 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/Activity 3:	**LCMR Budget**	**$108,428**
	Amount Spent	**$0**
	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. First year salary @ $ 10/hour for $ 10 hours/week/person for 26 weeks/person. Second and third years hourly salary increased by 3% to cover increases necessary to retain trained and experienced undergraduates that gain skills from year-to-year)
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)
(Lodging & meals reimbursed at actual amount up to @ $75/day for 5 people for 20 days per year = $7,500 for first year. Second and third years increased by 3% to cover predicted inflationary increases)
(Vehicle rental cost @ $63/day x 20 days/year = $1260 for first year. Second and third years increased by 3% to cover predicted inflationary increases)
(Vehicle mileage cost @ $0.23/mile for 5221 miles = $1201 for first year. Second and third years increased by 3% to cover predicted inflationary increases)
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 research findings 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

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 undergraduates@ 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 estimated maximum reimbursement of lodging and meals)	4,500	0	4,500	7,875	0	7,875	7,875	0	7,875	20,250	20,250
Travel expenses in Minnesota (Includes rental of four-wheel drive vehicle)	945	0	945	1,512	0	1,512	2,995	0	2,995	5,452	5,452
Travel expenses in Minnesota (Includes only mileage reimbursement)	1,233	0	1,233	1,926	0	1,926	1,926	0	1,926	5,085	5,085
COLUMN TOTAL	**$95,085**	**$0**	**$95,085**	**$96,487**	**$0**	**$96,487**	**$108,428**	**$0**	**$108,428**	**$300,000**	**$300,000**