OMB Control No. 0648-0362
Expiration Date 7/31/2011

SEA GRANT PROJECT SUMMARY FORM (90-2)

INSTITUTION: University of Illinois Champaign-Urbana **ICODE:**
TITLE:
The Effects of Land Use Patterns on the Physiology of Freshwater Fish
PROJECT NUMBER: N/A
PROJECT STATUS: Ongoing Research

REVISION DATE:
INITIATION DATE: 7/15/08 **COMPLETION DATE: 7/15/10**
SUB PROGRAM: NRES
PRINCIPAL INVESTIGATOR: Zachary Blevins **EFFORT: 24 Months**
AFFILIATION: University of Illinois
AFFILIATION CODE:
ASSOCIATE INVESTIGATOR: Cory Suski **EFFORT: 24 Months**
AFFILIATION: University of Illinois
AFFILIATION CODE:
SEA GRANT FUNDS: $ 0 **STATE MATCHING FUNDS:** $0
LAST YEAR'S SEA GRANT FUNDS: $0 **LAST YEAR'S MATCHING FUNDS:** $0
PASS-THROUGH FUNDS: $0 **LAST YEAR'S PASS-THROUGH FUNDS:** $0
RELATED PROJECTS: PARENT PROJECTS: N/A
SEA GRANT STRATEGIC PLAN CLASSIFICATION: Land Use Planning, Restoration

RATIONALE & OBJECTIVES: Changes to terrestrial land use associated with increasing human populations, such as urbanization and agriculture, were recently identified by Czech et al. (2000) as the two greatest threats to biodiversity in the United States. Urbanization and agriculture can negatively impact terrestrial biodiversity by consuming habitat, altering habitat properties and increasing the degree of landscape fragmentation (Czech et al. 2000). Furthermore, recent research has demonstrated that alterations to terrestrial landscapes can exert pronounced negative impacts on adjacent aquatic ecosystems. Urbanization, agriculture, and deforestation, for example, can negatively impact watershed hydrology (water depth and/or water flow), sediment type and/or suspended sediment load, dissolved oxygen concentrations, input of nutrients and woody structure, and water temperature regime in adjacent aquatic ecosystems (Meador and Goldstein 2003).

Land use planning attempts to limit the negative impacts of developing land and preserve natural ecosystems through evaluation and implementation of cost-effective management practices to mitigate the impacts of human activities on surrounding areas. To accomplish this, community planners must first understand how changes in land use effect the organisms that live in the ecosystem that they are developing. Many of these areas contain stream ecosystems and planners must consider the health of communities within these streams. Traditional methods of assessing stream health include species richness and abundance estimates, water quality measurements, and habitat assessments. Although these methods are effective at looking at the end result of changes in land use patterns, they are also inherently slow and do not provide a quick assessment of fish health in response to changes in land use. Therefore, there is a *critical need* for a quicker, alternative method to assess the health of fish in streams affected by land use planning. Without this alternative method to assess the health of fish in streams land use planners will have to evaluate their conservation practices with slow, coarse tools, thereby preventing rapid evaluation and adjustment of land use activities.

Physiological tools represent a novel, quick method of evaluating fish health and the impacts of anthropogenic disturbance. Many studies have been conducted on the effects of stressors on physiological responses of fishes, but few have looked at connections between fish physiology and land use patterns. The *objective* of this study is to determine if land use patterns and physiological traits are correlated in stream fish species. Identifying this pattern is critical in the development of using physiological tools as a way to evaluate the effects of different land use planning strategies. To address this objective, we will conduct a series of laboratory and field-based sampling experiments that involve both heat

and hypoxia challenges, which will quantify the physiological characteristics of fish from two distinct land use types within multiple stream systems. Streams with agricultural and forested riparian zones will be evaluated because riparian zones are an important habitat characteristic that influence fish communities. For example, forested and agricultural riparian zones have been shown to influence stream nutrients, water temperatures, productivity, and other habitat characteristics, which have an impact on the species that live in these ecosystems. Typically, the increased fluxes of nutrients and lack of shading in streams with agricultural riparian zones lead to frequent heat and hypoxia challenges for fish and alter their physiological properties and responses. Results from this project will provide information on patterns that exist between fish of different riparian land use, and will provide the foundational information to develop physiological techniques that can assess aquatic ecosystem health.

METHODOLOGY:

Study Species: The model organism that will be examined as part of this study is the Creek Chub (*Semolitus atromaculatus)*. The creek chub is an ideal organism for this work because it is highly abundant in the Eastern U.S., persists in highly disturbed habitats as well as pristine aquatic ecosystems, and has been shown to move less than 700 meters within streams in a given year making its physiological condition highly influenced by local stream habitat.

Site Selection: Because the focus of this study is on the effects of riparian land use on stream fish physiology, potential sampling sites will be chosen by defining candidate streams that are contrasting according to riparian land use characteristics: forested streams vs. agricultural streams. Forested streams are defined in this study as having greater than 60% riparian forest in the watershed up to each study site. Agricultural sites are defined as having greater than 60% riparian agriculture or cropland in the watershed up to each study site. Land use proportions of 2nd order streams will be calculated for the riparian zone (land use within 30 m of the stream) of several potential candidate streams using ArcView GIS. Following identification of candidate forested and agricultural streams using GIS parameters, the actual sites that will be sampled for fish will be selected through collaboration with knowledgeable professionals from both the Illinois Natural History Survey (INHS) and the Illinois Department of Natural Resources (IDNR) who have conducted spatial analyses of land use parameters across the state.

Sampling in the wild: Following the identification of sampling sites within both forested and agricultural streams, creek chubs will be collected for physiological analyses using standard backpack electroshocking equipment. One group of creek chubs (N = 6-9 individuals) from each of the sites with different land-use regimes will be sampled for blood and muscle to generate baseline physiological parameters from free-swimming wild fish. For this, fish will first be stunned by electroshocking gear in the stream, and stunned fish will immediately be transferred to a vessel containing an overdose of anesthetic. Following cessation of ventilation, blood and muscle samples will be collected from fish and frozen in liquid nitrogen until they can be stored in a -80°C freezer for analysis. The blood and muscle samples that are collected in this study will allow for the determination of differences in baseline physiological characteristics between agricultural and forested stream sites. A second group of creek chubs from the same two candidate sites will be collected using electroshocking gear and returned to the aquatic holding facility at the University of Illinois for controlled laboratory experiments involving heat and hypoxia challenges. Creek chubs will be held in outdoor poly tanks supplied with water from natural, earthen ponds at ambient temperature conditions. The importance of collecting this data is to compare differences between baseline physiological parameters of fish from agricultural and forested sites

Hypoxia experiment: To quantify physiological differences that may exist across the two sites due to land-use regime, creek chubs will be exposed to a hypoxia challenge that will consist of a 3.5 mg/L ± 0.1 mg/L treatment for 4 hours. For this, one group of creek chubs from both candidate streams (N = 6-8 individuals) will be moved from the poly tanks to individual, aerated, darkened holding chambers continuously supplied with recirculating pond water. Fish will be left in these chambers for approximately 24 hours to allow them to acclimate to the individual chambers. Following this 24 hour acclimation period, the flow of water to the each chamber will be terminated, and fish will be lethally sampled for blood and muscle as described above; this will generate control (resting) physiological values for laboratory-confined creek chubs. Following this treatment, a second group of creek chubs will be moved from the poly tanks to individual, aerated, darkened holding chambers continuously supplied with recirculating pond water as described above. After a 24 hour acclimation, hypoxic conditions within each chamber will be created by pumping nitrogen gas into chambers to displace oxygen (Suski et al., 2006). A portable oxygen meter will be used to verify that dissolved oxygen concentration during

the hypoxia exposure will remain at 3.5 mg/L ± 0.1, and temperature will likely remain constant at approximately 20.0 °C ± 0.1 °C thereby preventing confounding effects of temperature change. After a 4 hour exposure to this hypoxia treatment, the flow of water to the individual chambers will be terminated, and fish will be sampled for blood and muscle as described above. This experiment will look at patterns in the stress response of fish from agricultural and forested sites to hypoxia challenges. If these patterns exist, then land use planners may be able to use these techniques as a tool to test for hypoxic stress in streams adjacent to development areas.

Heat Shock Experiment: In addition to the hypoxia challenge, a complementary heat challenge will be given to creek chubs using techniques similar to those described above. Following 24 hours acclimation to the chambers, creek chub will be subjected to a heat challenge of 30° C ± 0.1^0C for a four hour exposure period. Water temperatures inside the chambers will take less than 5 min to change and, due to aeration in each individual chamber, water will likely remained fully oxygenated throughout the experiment minimizing the impact of reduced oxygen concentration during the thermal challenge. Following this 4 hour exposure period, creek chubs will be sampled for blood and muscle as described above. This experiment will help determine differences in the stress response of fish from agricultural and forested sites to thermal challenges which can occur due to disturbances in the riparian zone due to development. These results will help develop tools for land use planners to assess thermal stress in aquatic ecosystems due to changes in riparian land use.

Metabolic Rates: In addition to responses of blood and muscle parameters, the resting metabolic rate (RMR) while facing heat and hypoxia challenges will also be quantified using computerized, intermittent-flow respirometry (LoligoSystems, Hobro, Denmark) (Steffensen 1989) for creek chubs from candidate streams. Metabolic rate is a commonly studied stress responses in which organisms that are stressed have increased oxygen demands. To quantify the impact of hypoxia and thermal challenges on the resting metabolic rate of creek chub, fish will be randomly selected (equal numbers from each site) to be inserted into one of four respirometry chambers. Fish mass (mg) will be held constant between each site to prevent the confounding results of weight-based oxygen consumption rates. Four replicates of two creek chubs from each site will be held in chambers and undergo three treatments. Eight creek chubs will be evaluated for each site and treatment combination using the same temperature and oxygen settings from above. Fish will be exposed to treatments for a 12 hour period (8:00 p.m. – 8 a.m.) and allowed 24 hours to recover following each treatment. Between replicates all equipment will be cleaned with iodine to prevent excess bacterial build-up that can influence dissolved oxygen readings. Oxygen consumption values will be compared between treatments to determine the effects of heat and hypoxia on metabolic rates of creek chub. Background oxygen consumption rates, will also be measured in each of the chambers. By looking at metabolic rate this study will be able to determine differences in agricultural and forested site fish metabolic rates in response to thermal and hypoxic challenges providing another tool for land use planners to test for environmental stress in aquatic ecosystems.

RELEVANCE TO SEA GRANT PROGRAMS:

Illinois-Indiana sea grant collaborates with land use planners to accommodate population growth while protecting natural ecosystems. The proposed project is relevant to this program because it will provide a foundation for the use of physiology as a tool to look at aquatic ecosystem health in a way land use planners can assess the effectiveness of their management programs in protecting natural ecosystems. With this knowledge land use planners will be able to determine which practices are effective at preventing damage to aquatic ecosystems leading to better and more cost-effective methods. This study will provide a foundation of developing physiological tools to evaluate ecosystem health which will be of benefit to Sea Grant because it aligns with the organizations ideas of collaborating with regional planners to promote cost effective management strategies and aquatic ecosystem sustainability.

PRELIMINARY RESULTS*:*

During the summer of 2008, creek chubs from a single forested site and a single agricultural site were collected. Hypoxia and heat experiments from this single site were conducted and preliminary analysis of blood parameters has been completed. Measurements of whole animal metabolic rates using intermittent flow respirometry revealed differences in sites and treatments ($p<0.05$). The metabolic rate of creek chubs from the forested site (Brushy Creek) was significantly higher than that of chubs from agricultural site (Cottonwood Creek) when challenged with a temperature of 30° C (Fig 1). Creek chubs from the disturbed site had lower metabolic rates than fish from the forested site when exposed to hypoxic conditions; however, the differences were not statistically significant (Fig 1). Similarly, creek chubs from the forested site

exhibited significantly higher cortisol concentrations in plasma in response to high temperature challenges than fish from the agricultural site ($p<0.05$) (Fig 2). The below results suggest that there are connections between land use and the stress physiology of fish. These connections are an important in developing physiological tools as a way to evaluate land use planning practices on stream ecosystems. By looking at a number of physiological methods this study provides a holistic view of the stress physiology of stream fish as it relates to different land use practices and will build a foundation for future studies using physiological techniques for ecological assessment.

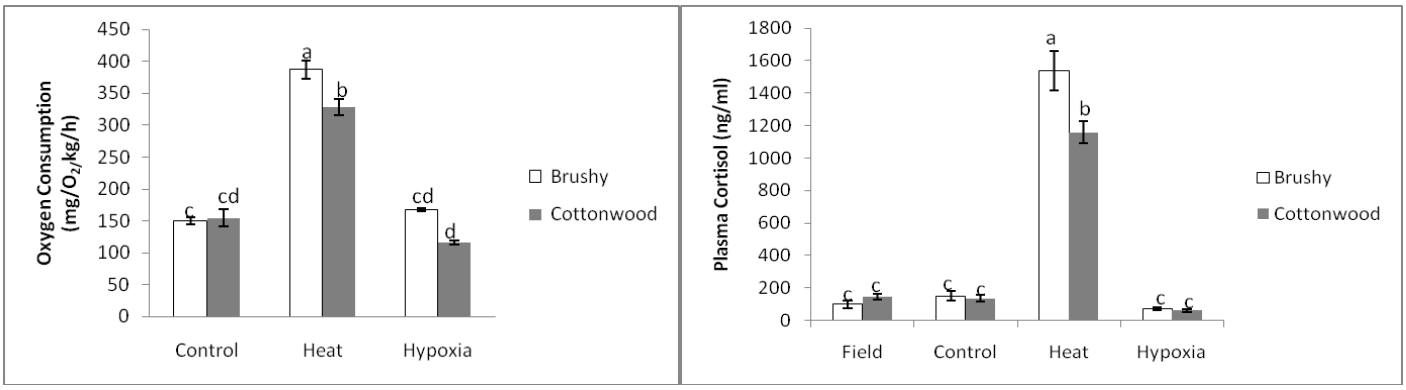

Figure 1 (Left). Oxygen consumption of creek chubs (n=8) for a forested site (Brushy) and an agricultural site (Cottonwood). Control, heat treatment (30^0 C), and hypoxia treatments (3.5 mg O_2/L) contain letters that represent significant differences between sites. Results demonstrate that fish from the forested site have significantly higher metabolic rates following a prolonged heat challenge, demonstrating a link between land use type and physiological response(s) to stressors.

Figure 2 (Right). Concentrations of cortisol in plasma for creek chubs (n=6) for each treatment and site except field sites where (n=10). Control (20° C, 7.5 mg/L dissolved oxygen), heat (30° C), and hypoxia (3.5 mg/L dissolved oxygen) contain letters that represent significant differences between sites. Brushy Creek (open bars) is a highly forested, relatively undisturbed stream site and Cottonwood Creek (grey bars) is the highly agricultural, disturbed site. Sample sizes are 8 fish for each bar. Error bars represent standard error.

REFERENCES:

Czech, B., P. R. Krausman and P. K. Devers. 2000. Economic associations among causes of species endangerment in the United States. BioScience 50:593-601.

Meador, M. R. and R. M. Goldstein. 2003. Assessing water quality at large geographic scales: relations among land use, water physicochemistry, riparian condition, and fish community structure. Environmental Management 31:504-517.

Newton, J. 2006. Two mechanisms of low oxygen stress to Hood Canal biota and their associated areas of risk. (Online). Available at http://www.hoodcanal.washington.edu/documents/HYPOXI/oxygen_stress.pdf.

Schurmann H, Steffensen J.F. 1997. Effects of temperature, hypoxia and activity on the metabolism of juvenile Atlantic cod. Journal of Fish Biology 50:1166–1180

Suski, C. D., S. S. Killen, M. B. Morrissey, S. G. Lund and B. L. Tufts. 2003. Physiological changes in largemouth bass caused by live-release angling tournaments in southeastern Ontario. North American Journal of Fisheries Management 23, 760–769.

Suski, C. D., S. S. Killen, J. D. Kieffer and B. L. Tufts. 2006. The influence of environmental temperature and oxygen concentration on the recovery of largemouth bass from exercise: implications for live-release angling tournaments. Journal of Fish Biology 68:120-136.

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SEA GRANT BUDGET FORM 90-4

GRANTEE: University of Illinois			**GRANT/PROJECT NO.:** N/A	
PRINCIPAL INVESTIGATOR: Zachary Blevins Co-PI: Cory Suski			**DURATION:** 24 months **Cumm 7/15/08-7/15/10**	
A. SALARIES AND WAGES:	**man-months**			
	No. of People	**Amount of Effort**	**Sea Grant Funds**	**Matching Funds**
1. Senior Personnel				
a. (Co) Principal Investigator	0	0	0	0
b. Associate (Faculty or Staff):	0	0	0	0
Subtotal:	**0**	**0**	**0**	**0**
2. Other Personnel				
a. Professionals:	0	0	0	0
b. Research Associates:	0	0	0	0
c. Res. Asst./Grad Students:	0	0	0	0
d. Prof. School Students:	0	0	0	0
e. Pre-Bachelor Student(s):	0	0	0	0
f. Secretarial-Clerical:	0	0	0	0
g. Technicians:	0	0	0	0
h. Other:	0	0	0	0
Total Salaries and Wages	**0**	**0**	**0**	**0**
B. FRINGE BENEFITS:			0	0
Total Personnel (A and B)			0	0
C. PERMANENT EQUIPMENT:			0	0
D. EXPENDABLE SUPPLIES AND EQUIPMENT:			2000	0
E. TRAVEL:				
1. Domestic			490	0
2. International			0	0
Total Travel			490	**0**
F. PUBLICATION AND DOCUMENTATION COSTS:			0	0
G. OTHER COSTS:				
Communications			0	0
Copying			0	0
Postage/Mailing			0	0
Contractual Services			0	0

Membership/Sponsorship Fees			0	0
Training/Continuing Education			0	0
Project/Person Recognition			0	0
Housing/Board/Research			0	0
Tuition Remission			0	0
Other:	10. Other		0	0
Other:	11. Other		0	0
Total Other Costs:			0	0
TOTAL DIRECT COST (A through G):			2490	0
INDIRECT COST	On Campus	58.50%	3510	0
	Off Campus	0.00%	0	0
Total Indirect Cost:			3510	
TOTAL COSTS			6000	0

BUDGET NARRATIVE

Wages:
No funds from this scholarship will be used for wages**.**

Fringe Benefits:
No funds from this scholarship will be used as fringe benefits.

Permanent Equipment:
All permanent equipment has been purchased for this study.

Expendable Supplies and Equipment:
From previous studies performed in the Suski lab, the cost of supplies and equipment to perform similar blood/muscle studies are $20 dollars per fish. In order to conduct analysis on 100 fish expenditures would total $2,000 dollars on lab supplies such as gloves, falcon tubes, enzymes, and other reagents used for physiological analysis.

Travel:
Travel expenditures are estimated to be around $490 dollars. An average trip to sampling sites is around 100 miles at $0.49 per mile. This means that each trip costs approximately $49. There will be 10 sampling trips throughout this project which will cost an additional $490.

Publication and Document Cost:
No funds from this scholarship would go to publication or document costs.

Other Costs:
No funds from this scholarship would go to any of the items under other costs.

Indirect costs:
The University of Illinois' preferred indirect cost rate is 58.5% meaning that $3,510 dollars of this scholarship fund would go directly to the University.

Zachary William Blevins

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Permanent Address: 649 Highway B • Mansfield, Missouri 65704
Contact Information: (417) 459-0023• zblevins@illinois.edu

EDUCATION

Masters Canidate in Natural Resources and Environmental Science, May 2010 (Expected)
University of Illinois
Grade Point Average: 3.77/4.0

Bachelor of Science in Fisheries and Wildlife, May 2008
University of Missouri-Columbia
Grade Point Average: 3.73/4.0

Graduate of Mansfield High School, May 2004
Mansfield, MO
Grade Point Average: 3.85/4.0

RELATED EXPERIENCE

Resource Science Assistant, Resource Science Center, Columbia, Missouri
May 2004-May 2007

- Collected data on endangered species in tributaries of the Osage River drainage. i.e. Niangua Darter (*Etheostoma Niangua),* Ozark Cavefish (*Amblyopsis rosa),* and Topeka Shiner (*Notropis topeka).*
- Familiar with both backpack and boat electroshocking equipment.
- Familiar with running small horsepower boats.
- Worked with programs such as access, excel, and word.
- Familiar with the use of PDA equipment.
- Responsible for the care-taking of Resource Science Center aquarium.
- Familiar with water quality parameters and measurements

Creel Clerk and Academic Hourly, Lake Michigan Biological Station, Zion, Illinois
June 2007-September 2007

- Responsible for acquiring length, weight, species information on fish in the possession of anglers.
- Collected data on angler expenditures and effort.
- Lab work included stomach diet analysis, fish aging, and prey base analysis
- Field work included larval fish sampling, benthic core sampling, and artificial reef evaluation

Limnology Lab Technician, University of Missouri Columbia, Columbia, MO

- Responsible for lab procedures such as chlorophyll, total suspended solids, and phaeo pigment measurements.

- Responsible for data entry and data analysis.
- Learned procedures important to getting accurate water quality measurements.

AWARDS AND HONORS

- Dean's List 8 of 8 Semesters
- Wudrack Scholarship
- Granville M. Smith CAFNR Scholarship Recipient
- Pheasants Forever Scholarship
- 2006 Conservation Federation Fisheries Scholarship
- Bill and June Baker Agriculture Scholarship
- Elizabeth Schell Scholarship
- Residence Hall Community Academic Chair for Highest GPA
- American Fisheries Society Student Chapter President
- American Fisheries Society Student Chapter Treasurer
- School of Natural Resources Student Council Officer
- The Wildlife Society Mammals Program Committee Member
- Website Manager School of Natural Resources Student Council

ACTIVITIES AND AFFILIATIONS

- University of Missouri Chapter of the Wildlife Society
- University of Missouri Chapter of the American Fisheries Society
- Missouri Stream Team – Stream Team #442
- University of Missouri SNR Student Council
- Forestry Club Member
- National Honor Society Member
- Pheasant Forever Member

REFERENCES

- *Cory Suski,* Fisheries Professor University of Illinois, Champaign, Illinois
  (217) 369-8814
- *Dave Wahl,* Illinois Natural History Survey Biological Station Director, Sullivan, Illinois
  (217) 728-4400
- *Douglas Novinger,* Resource Science Center Scientist, Columbia, Missouri
  (573) 882 – 9909
- *Wayne Brofka,* , Illinois Natural History Survey Technical Scientist, Zion, Illinois
  (847) 872-8677

UNOFFICIAL TRANSCRIPT

TRANSCRIPT TOTALS (GRADUATE - URBANA-CHAMPAIGN) -Top-

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Total Institution:	26.000	13.000	13.000	12.000	45.32	3.77
Total Transfer:	0.000	0.000	0.000	0.000	0.00	0.00
Overall:	26.000	13.000	13.000	12.000	45.32	3.77


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