Basic Information: Eligible for both the Mills & USGS Programs

1. **Title:** Determining drought tolerances of freshwater mussels in Texas and the implications for environmental flows

2. **Student information:**
Jennifer N. Morton
jnmorton@tamu.edu
Texas A&M University, Department of Wildlife and Fisheries Science
M.S. Wildlife and Fisheries Sciences (Fall 2016 - Spring 2018, expected)

3. **Faculty Advisor:**
Charles Randklev, Research Scientist
crandklev@ag.tamu.edu, (817) 966-3235
Texas A&M University, Department of Wildlife and Fisheries Science

4. The funds would be for initiating new research to study thermal and dessication tolerances of Texas freshwater mussels.

5. **Abstract**

Freshwater mussels are considered one of the most imperiled groups of aquatic organisms due to anthropogenic impacts, such as altered temperature regimes. Detailed knowledge on lethal temperatures for mussels has been limited to less than 5% of the species known to occur in North America, and nothing is known about thermal tolerances of Texas mussels. This lack of information is problematic because climate change coupled with increasing human water demand is expected to increase the frequency and intensity of droughts in Texas, which may negatively impact threatened mussel populations. I plan to test the upper physiological limits related to temperature and desiccation for a state-threatened species, *Fusconaia mitchelli* (false spike) and two common species, *Cyrtonaias tampicoensis* (Tampico pearlymussel) and *Amblema plicata* (three-ridge). Survival and behavior trends will be measured for adult and glochidial (larval) mussels in standard acute laboratory tests across a range of common and extreme water temperatures to determine median lethal temperatures (LT50). Desiccation tolerances will be measured across a range of temperatures and humidities to determine similar trends in survival and behavior for adult mussels. The collected temperature data can then be used in combination with real-world monitoring and modeling of flows to quantify environmental flow thresholds.

6. **Proposed Research**

a. *Statement of Critical Regional or State Water Problem*

In the coming decades, Texas is expected to face warmer temperatures and increasingly frequent and prolonged droughts due to global climate change (Shafer et al. 2014). Further exacerbating the effects of higher temperatures and drought, demand for water is also projected to increase, largely due to a growing Texas population, creating potential water supply deficits during extreme droughts (TWDB 2016). The compounding impacts of climate change and increased water demand due to population growth are likely to result in conflicts between human needs for water and those for environmental conservation.

As a group, freshwater mussels are already one of the most imperiled aquatic species, and in recent decades, mussel populations in Texas have been declining. Texas Parks and Wildlife has listed 15 species as state-threatened (TPWD 2010), including 12 that are currently being considered for federal protection under the Endangered Species Act (USFS 2011). There is increasing evidence that changes in water temperature, such as those caused by altered flow regimes, are leading to population declines, shifts in mussel assemblages, and changes in rates of mussel-contributed ecosystem services (Haag and Warren 2008, Allen et al. 2013). Unfortunately, quantitative information on lethal temperatures for freshwater mussels, as a whole, has been limited to only 14 species, and relatively little is known about the thermal tolerance of any Texas mussel species.

In 2007, the Texas Legislature passed two bills, Senate Bill 2 (2001) and Senate Bill 3 (2007), that prescribe programs to identify the flows necessary to conserve fish and wildlife resources while also providing sustained benefits for other human uses of water resources. Three agencies are tasked with conducting and directing studies to determine necessary flow regimes for each river: Texas Parks and Wildlife Department (TPWD), the Texas Commission on Environmental Quality (TCEQ), and the Texas Water Development Board (TWDB). By necessity, there will be trade-offs between ecological, social, and economic freshwater needs. However, without the physiological data to determine the range of optimal environmental flows, it is difficult to say what those trade-offs might be. Managing this scarce and valuable resource will involve an adaptive framework that takes into account both current and future thermal regimes as well as physiological tolerances of threatened species to meet both human and ecosystem needs.

b. *Nature, Scope and Objectives of the Research, including a timeline of activities*

The purpose of this proposal is to investigate how elevated temperatures, particularly from drought, affect freshwater mussels and the impacts this might have on mussel conservation. In particular, I will examine the upper physiological limits related to temperature and desiccation for multiple life stages of three mussel species, including both state-threatened and common species: *Fusconaia mitchelli*, false spike (Simpson in Dall 1895), *Cyrtonaias tampicoensis*, Tampico pearlymussel (Lea 1838), and *Amblema plicata*, three-ridge (Say 1817). I will then use the results of these trials to discuss how declines in mussel populations across Texas might be related to temperature and identify water management practices that can benefit remaining populations. My objectives are as follows:

Objective 1. Determine upper thermal limits and behavioral responses of adult and glochidial (larval) mussel species of concern using standard median lethal temperature (LT50) techniques.

Objective 2. Determine the behavioral responses of adult freshwater mussels to desiccation.

Objective 3. Verify the temperatures and humidities encountered by mussels in native habitats.

Project Timeline

Calendar Year	**2016**		**2017**			**2018**
Semester	**Sum**	**Fall**	**Spr**	**Sum**	**Fall**	**Spr**
Guadalupe River						
Lethal and sublethal effects of temperature (adults)	x	x	x			
Lethal and sublethal effects of temperature (glochidia)			x	x		
Field temperature/humidity monitoring	x	x	x	x	x	
Effects of desiccation (adults)		x	x	x		
Data analysis and thesis preparation				x	x	x

c. *Methods, procedures and facilities:*

To address Objective 1, I will use accepted methods modeled from the American Society of Testing Materials (ASTM) 2006 guidelines for toxicity testing of freshwater mussels. To examine the upper thermal limits, I will conduct both 96-h aerated static tests (for adult mussels) and 24-h static tests (for glochidia). Adult mussels and glochidia will be randomly assigned to one of 3 different acclimation treatments (22°C, 27°C, or 32°C), each consisting of 5 experimental temperatures ranging from 29°C-41°C. The experimental temperatures proposed for this study encompass the breadth of temperatures encountered by mussels in the Guadalupe River during the warmest months, as well as possible extremes. An unacclimated control of 20°C will be assessed side-by-side with experimental temperature treatments. The effects of temperature treatments on glochidia and adult mussels will be analyzed following ASTM (2006) guidelines to determine LT50s and LT05s and their 95% confidence intervals (CIs). Differences in survival between control and acclimation temperatures will be analyzed through pairwise comparisons.

To address Objective 2, I will conduct a series of dessication chamber trials following Holland (1991) to examine the emersion tolerances for *F. mitchelli*, *C. tampicoensis*, and *A. plicata*. Adult mussels will be randomly assigned to one of 3 different temperature treatments (15°C, 25°C, or 35°C), each consisting of 3 relative humidity (RH) treatments: <5%, 53%, or >95%. Mussel behavior and mortality will be assessed and recorded at regular intervals. Pair-wise comparisons of survival time as it relates to different combinations of temperature and RH will be determined using a two-way ANOVA.

To address Objective 3, I will deploy a suite of data loggers in the Guadalupe River to determine the normal range of air and water temperatures and relative humidities encountered by mussels. Water and air temperatures as well as relative humidity will be monitored at locations where mussels are known to occur and will be chosen to encompass possible temperature ranges (i.e. sun, shade, and depth).

d. *Statement of expected results or benefits:*
Thermal data on the upper physiological tolerances of three freshwater mussel species will be obtained. This data can then be used to inform environmental flow thresholds in the state of Texas as well as responses of mussel populations in Texas to future potential thermal regimes.

7. Budget

Either source of funds would be applicable to my project.

Category	Request	Justification	Matching Fund Amount	Matching Fund Source
Salary	$		$	
Fringe Benefits	$		$	
Travel	$		$	
Supplies	$		$	
Tuition	$5000	Spring and partial Fall tuition	$5000	TPWD, SWG grant
Other	$		$	
Total	**$5000**	*Not to exceed $5,000*		

8. Intended career path

I intend to pursue a career in government (either federal or state) with a focus on aquatic resource management and conservation (ideally working with freshwater mussels in Texas).

Works Cited

Allen, D. C., H. S. Galbraith, C. C. Vaughn, and D. E. Spooner. 2013. A tale of two rivers: Implications of water management practices for mussel biodiversity outcomes during droughts. Ambio 42:881–891.

ASTM (American Society of Testing Materials). 2006. Standard Guide for Conduction Laboratory Toxicity Tests with Freshwater Mussels. E2455-06. Page Annual Book of ASTM Standards, Volume. 11.06. American Society of Testing Materials International, West Conshohocken, Pennsylvania.

Haag, W. R., and M. L. Warren. 2008. Effects of Severe Drought on Freshwater Mussel Assemblages. Transactions of the American Fisheries Society 137:1165–1178.

Shafer, M., D. Ojima, J. M. Antle, D. Kluck, R. A. McPherson, S. Peterses, B. Scanlon, and K. Sherman. 2014. Great Plains. Climate change impacts in the United States: The third national climate assessment.:441–461.

Texas Water Development Board (TWDB). 2016. 2017 State Water Plan.