Basic Information: Eligible for both the Mills & USGS Programs

1. **Title:** The effects of land use change on threatened and endangered mussel species in Texas utilizing ecological niche modeling.

2. **Student information:**
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Ph.D. Wildlife and Fisheries Sciences (Spring 2020 - Fall 2023, expected)

3. **Faculty Advisor:**
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Texas A&M University, Department of Wildlife and Fisheries Science

4. **Funds Pursued:** Either program will fit my needs and eligibility.

5. **Allocation of Funds:** The funds will be used for expanding previous research preformed by Khan and Randklev 2019 assessing changes over time in land use/cover and flow/discharge and the effects of those changes on threatened and endangered mussel species to the all Texas watersheds. The outcomes of the proposed project will be used to better inform water resource managers of minimum base conditions needed for the conservation and preservation of mussels in Texas. Please see Figure 1. Bellow for expected timeline

6. **Abstract**

Freshwater mussels are among the most impacted aquatic species globally due to human-induced impacts. Changes to the natural flow regime whether it be increases in extreme high flow or low flow events has been suggested as a primary factor in the overall decline of this group. Currently, it is not well understood how natural and altered flow regimes affect freshwater mussels because baseline relationships between freshwater mussels and hydrologic conditions have not been established. This is problematic because such relationships are a critical step in developing and adopting environmental flow standards that can accommodate both mussels and humans. The goal of this study is to begin addressing this issue by using long-term discharge records and land use and survey data (over 20,000 records across the state) to examine how occupancy for species being considered for listing under the U.S. Endangered Species Act has changed over time. The resulting information can then be used by natural resource managers to better anticipate how changes in flow will affect threatened mussel species, aide in the development of water management practices that lead to recovery for imperiled species, and provide a mechanistic understanding for mussel diversity patterns across the state.

7. **Proposed Research**

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

Freshwater mussels typically occur in dense multispecies aggregations, known as mussel beds, which are patchily distributed within streams and rivers. At high flows, mussel species richness and abundance are often maximized in areas where bed mobility is minimized (Morales et al., 2006; Gangloff & Feminella, 2007; Allen & Vaughn, 2011; Stoeckl & Geist, 2016) and at low flows in areas that remained wetted and are thermally buffered (Gagnon et al., 2004; Steuer et al., 2008; Maloney et al., 2012). A mismatch between these two constraints due to natural changes in the flow regime or those brought on by anthropogenic impacts can lead to scenarios in which a habitat patch is suitable for mussels only during low or high flows, but not both. Such a mismatch can occur gradually, in the case of climate change or low to moderate land use change, or suddenly with river impoundments or extensive changes in land use. In either case, the reduction in the availability, quality, and persistence of a given habitat patch can lead to

population declines and eventually extirpation and/or extinction. These declines are a problem because freshwater mussels provide essential ecosystem services such as nutrient cycling, water filtration, and habitat for other aquatic organisms (Vaughn & Hakenkamp, 2001; Vaughn et al., 2008; Geist, 2010; Lummer et al., 2016), as such their decline will have long-term negative consequences for the ecological function of riverine systems.

Given the importance of flow to mussels it is surprising that environmental flow (eflow) recommendations to ensure their persistence are generally lacking. This knowledge gap is largely due to the fact that baseline relationships between freshwater mussels and hydrologic conditions have not been established. In Texas, Senate Bill 3 was proposed to address flow standards to support ecological functions and wildlife and thus provides a framework for determining these relationships, but the abiotic and biotic needs of mussels have yet to be fully taken into account. This means current flow recommendations may not be adequate to protect rare or even common mussel species while meeting social and economic water needs. However, there are analytical frameworks available for remedying this knowledge gap which have been applied to freshwater fish. For example, Mims and Olden (2012) used discharge records and fish trait data to identify hydrologic metrics that explained the prevalence of fish species across the United States. Khan and Randklev (2019) successfully adapted their approach to rare mussel species in east Texas but did not look at the entire state, incorporate land use variables, or use the resulting data to guide eflow recommendations. Thus, significant knowledge gaps continue to exist on mussel-flow relationships that if addressed could empower natural resource managers to better anticipate how changes in flow will affect threatened mussel species, aide in the development of water management practices that lead to recovery for imperiled species, and provide a mechanistic understanding for mussel diversity patterns across the state.

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

The overall goal of this proposal is to better understand how changes in the flow regime and land use have affected occupancy of imperiled mussel species in Texas. The resulting information from this study can then be used to guide development of water management practices that lead to recovery for imperiled species, while providing for social and economic needs, and provide a mechanistic understanding for mussel diversity patterns across the state. The specific objectives of this study are the following:

Objective 1. Examine hydrologic change throughout central Texas to determine which basins and aspects of flow have been affected.
Objective 2. Examine how changes in flow have impacted mussel occupancy for rare species.
Objective 3. Examine land use/cover in central Texas and how that has changed relative to flow and mussel occupancy.
Objective 4. Provide recommendations on land use/cover and flow that can be used by conservationists and natural resource managers.

c. *Methods, procedures and facilities:*

To address Objective 1, I will identify USGS stream gauge stations within 20km of mussel recording sites in Texas with sufficient data for analysis. Gauges will be considered sufficient if they exhibit at least 15 years of continuous data and have a similar temporal overlap to ensure a common period of climatic conditions. Second, based on Khan and Randklev (2019) I plan to evaluate the following hydrologic parameters : base flow index, 7-day minimum, 7-day maximum, low pulse duration, high pulse duration, number of zero days, low pulse count, high pulse count, date of minimum, date of maximum, and number

of reversals. These parameters will be evaluated over time using Indicators of Hydrologic Alteration (IHA), which is a software program developed by the Nature Conservancy (Richter et al. 1996). IHA statistically characterizes various aspects of flow (i.e., hydrologic parameters), which can then be used to quantify hydrologic alterations. Finally, I will use linear regression models in IHA to determine if and how my focal hydrologic parameters have changed over time throughout Texas.

To address Objective 2, I will assess changes in occupancy of threatened and endangered mussel species as they relate to the above IHA parameters. First, I will utilize occurrence data from compiled survey data (collected from the 1800s to present day) collected from numerous sources, including federal and state agencies, museums, universities, and private companies. Second, I will pair mussel occurrence records with the USGS stream gauges evaluated in Objective 1. Finally, I will relate mussel presence/absence (and other measures of diversity) to my focal hydrologic parameters to determine which one best explains occupancy. To do this I plan to use boosted regression trees and quantile regression to identify biologically relevant threshold relationships.

To address Objective 3, I will compare mussel species occurrences relative to land use/cover change and flow/discharge shifts using the identified hydrological parameters found in Objective 2 and land use/cover changes identified through Geodatacrawler. I plan to take an ensemble modeling approach, wherein, multiple analytical models (e.g., MAXENT, boosted regression trees, logistic regression) are used to predict occupancy and then the prediction of each model is combined to provide a final prediction with improved accuracy.

To address Objective 4, Based on the results of Objectives 1 – 3, I will then summarize relationships between flow, land use and species occurrence. Emphasis will be placed on describing threshold relationships and then either relating them back to existing water management frameworks or proposing ways in which they can be used to develop new ones.

d. *Statement of expected results or benefits:*

The results of this study will address knowledge gaps pertaining to mussel-flow relationships that are critical for determining how mussels are impacted by altered flow regimes and identifying solutions to mitigate those impacts. The information from this project will help natural resource managers to better anticipate how changes in flow will affect threatened mussel species, aide in the development of water management practices that lead to recovery for imperiled species, and provide a mechanistic understanding for mussel diversity patterns across the state.

8. Intended career path

I intend to pursue a career as an academic professional working in the field of stream ecology, habitat modeling and restoration of threatened and endangered aquatic species.

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Figures 1.

Project Timeline

Project Timeline

Calendar Year	**2020**			**2021**			**2022**			**2023**		
Semester	**Spr**	**Sum**	**Fall**	**Spr**	**Sum**	**Fall**	**Spr**	**Sum**	**Fall**	**Spr**	**Sum**	**Fall**
Texas Watersheds												
Collection of historical data and preparation for analysis	x	x										
Modeling changes and shifts and flow and discharge			x	x								
Modeling land use and cover changes in Texas					x	x						
Modeling effects of flow and land use change on mussel communities							x	x				
Dissemination to water resource managers									x	x		
Journal preparation									x	x	x	x