Sabbatical Report – Spring 2019
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Engaging Students in STEM in Early Research

Summary of Purpose

The goal of this project, Engaging Students in STEM in Early Research is to provide authentic mathematical and data science research opportunities to first and second year under-represented minorities (URM) interested in STEM majors. The research opportunities would focus on developing students awareness of and facility with mathematics as a scientific tool. The goal of this sabbatical project is to design at least four mathematical research experiences for first and second year STEM students that achieve the following outcomes:

- Build students mathematical abilities in calculus, statistics, and/or data analysis,
- Engage students in STEM early on with a STEM-focused High Impact Practice,
- Expose students to open and applied scientific and mathematical questions,
- Develop students' mathematical confidence, and
- Involve students with Santa Rosa Island Research Station (SRIRS) projects.

Mathematics and statistics are powerful scientific tools, but often students do not encounter the deep utility of these disciplines early in their academic careers. There are a number of scientific protocols developed specifically for the SRIRS to engage students in research. The Sandy Beach Ecology Monitoring program and associated data can be used in mathematical models for population dynamics. The Marine Debris Monitoring program and its data hold the potential for students to explore statistical questions and dynamical systems models. The research projects developed in this project start with the data from these and National Park Service (NPS) data sets to give students a hands-on, local mathematical modeling or data analysis questions. Students would learn specific mathematical tools and models and apply them to these questions.

These research projects are be designed to be delivered through a UNIV 198 or 298 courses. UNIV 198 Introduction to Interdisciplinary Research is a course designed to introduce students to quantitative and qualitative data set collection and interpretation. UNIV 298 Research Investigations is a course that integrate service learning into a research project to help student understand the needs of stakeholders in developing and answering research questions.

Summary of Work

During the course of the Spring 2018 semester, I developed curricula for two courses designed to engage lower-division students in authentic place-based research projects that teach mathematical tools and have students apply these tools to real world problems. These course-based undergraduate research projects are appropriate for first-year students and second-year students who have taken or are concurrently enrolled in a lower division calculus or statistics

course. The projects are designed for a semester long experience, but there are additional questions that could turn these into year-long projects.

UNIV 198 Introduction to Interdisciplinary Research - Costal Vulnerability Indices
In this course students would learn about different numerical models for Costal Vulnerability. For example, and early model students would be exposed to is an Exposure Index (EI):

$$EI = (\Pi_i^n R_i)^{1/n}$$

Where R_i is one of a number of variables such as geomorphology, net sea level change, wind exposure, and wave exposure. Students would learn how variables like these are quantified and normalized. Students explore how changes overtime in variables such as sea level and wave height change the vulnerability of the coast. Students use NPS park data and other costal data to apply various vulnerability indices to local areas. Students create report on the changes in costal vulnerability based on different scenarios affecting key variables.

Course material is drawn from the following sources:
The Development of a Coastal Risk Assessment Database: Vulnerability to Sea-Level Rise in the U.S. Southeast, 1994,Gornitz et al.
Modeling Coastal Vulnerability through Space and Time, 2016, Hopper and Meixler
Guidance for Developing Coastal Vulnerability Metrics, 2015, Wamsley et al.
Coastal Vulnerability Assessment of Channel Islands National Park (CHIS) to Sea-Level Rise, 2015, Pendleton et al.

UNIV 298 Research Investigations – Discrete Population Models
Are large area of study at the intersection of Mathematics and Biology is populations modeling. Discrete populations models are an accessible entry point into population modeling to first and second-year STEM students. While the mathematics behind these models is appropriate for students at this level, these models can exhibit very complicated, even chaotic, behavior.

In this course, student start out with single population models and population data sets from the NPS to determine the model parameters, for example birth and death, form the data. Students next assess the accuracy of their models and make report on future populations level based on potential changes to model parameters. Student then move on to multi-population models, modification of existing models and construction of new discrete population models.

Course material is drawn from the following sources:
Mathematical Biology I. An Introduction, 2002, Murray
Methods and Models in Mathematical Biology, 2015, Muller and Kuttler
Incorporating ecological drivers and uncertainty into a demographic population viability analysis for the island fox, 2009, Bakker et al.
Islands within an island: Repeated adaptive divergence in a single population, 2015, Langin et al.