SCALE-IT Innovative Research and Education Grant

Applicants:
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Austin Milt

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PROJECT SUMMARY

We have developed a computational model to explore the consequences of cross-scale species interactions. It is common for interacting species to perceive the environment at different spatial scales, but these scale disparities are rarely addressed in ecological models. Because our model is broad enough to answer many related questions on this topic, it is a natural platform for a **Research Experience for Undergraduates (REU) project.**

The activities we propose for this grant focus on realizing the potential of our ongoing work. The major objectives of our project are **1) use our software to address a family of research questions**, **2) manuscript preparation and submission, 3) research extension, and 4) outreach, leadership and mentorship training. Our vision is to offer an REU for one undergraduate student**, which will include access to the well established REU activities offered by the REU program at the National Institute for Mathematical and Biological Synthesis (NIMBioS). Our proposed REU project, which we call SCALE-OUT, furthers research on cross-scale species interactions while creating mentorship opportunities for us and research opportunities for an undergraduate student from another (including **minority-serving**) institution. More broadly, we aim to **foster closer ties between SCALE-IT and other institutions at UTK**, namely the Department of Ecology and Evolutionary Biology (EEB) and NIMBioS.

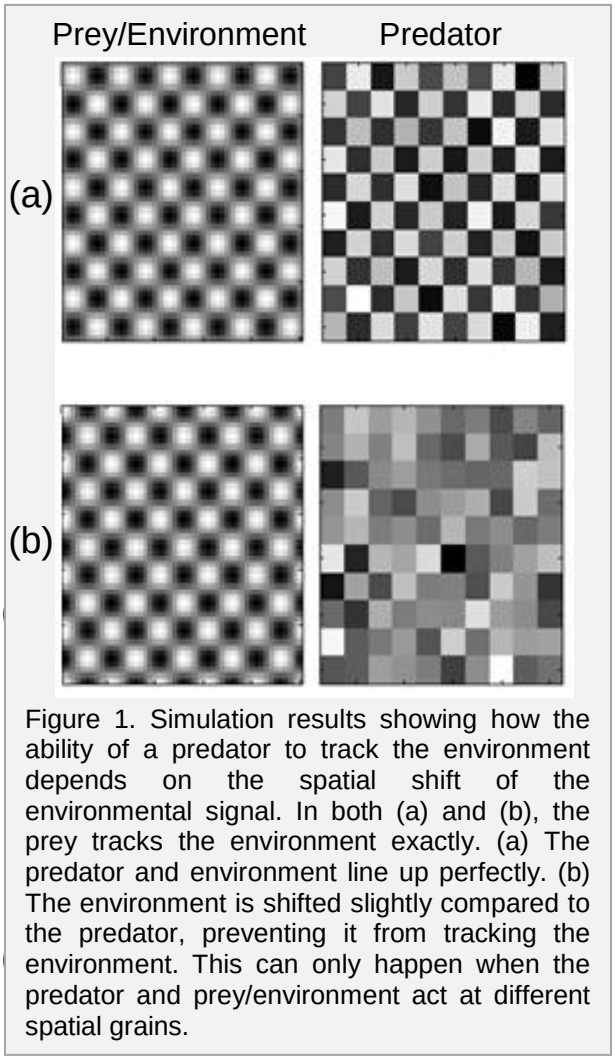

Figure 1. Simulation results showing how the ability of a predator to track the environment depends on the spatial shift of the environmental signal. In both (a) and (b), the prey tracks the environment exactly. (a) The predator and environment line up perfectly. (b) The environment is shifted slightly compared to the predator, preventing it from tracking the environment. This can only happen when the predator and prey/environment act at different spatial grains.

BACKGROUND

As active SCALE-IT researchers, our research team has developed a novel model that couples interacting species populations that perceive the environment at different spatial scales. Our research is guided by the question: **"How do interacting species track environmental signals when they operate at different spatial scales?"** We have already produced exciting results. For instance, the ability of a predator to track the environment through its prey changes as the signal of the environment shifts in space (Figure 1). Our model captures the novel finding that **this phenomenon can only occur in our model when predator and prey view the world at different spatial scales**.

JUSTIFICATION: *Achieving the SCALE-IT Vision…*

…Through Research: Our model is developed with cross-scale species interactions in mind, and is general enough to address many aspects of that topic. **Only with the support of this grant** can our team can continue to address challenging questions about scale-disparate species interactions. Such research is at the **interface of computation, mathematics, and biology** and has implications for understanding **food web formation and stability under extinction and climate change**, as well as basic population dynamics theory.

…Through Mentorship: As part of our work this coming year, we will propose an undergraduate-level project to conduct through the NIMBioS REU program. As future graduate students and researchers in computational biology, REU participants gain invaluable **experience in multiple fields** working as part of an **interdisciplinary team** on an interdisciplinary project. As future faculty and researchers, we can gain **mentoring, team management, and research skills we could not get elsewhere**. And by extending SCALE-IT's reach outside of the program, we can **broaden the SCALE-IT community** and ushering in a new class of SCALE-IT minded researchers.

…Through Communication: The significance of our research and mentorship can only be as effective as our ability to communicate it. We have already communicated the foundations of our research at a professional meeting (the 2012 UT-ORNL-KBRIN Bioinformatics Summit), and we will present posters at two more meetings this summer. By publishing this research, the exciting discoveries we continue to make will be **broadly communicated to the scientific community**. The poster presentation required by the REU program would put our REU undergraduate **ahead of his or her peers in science communication**.

BROADER IMPACTS: *Strengthening SCALE-IT's Ties…*

…to EEB: The department of Ecology and Evolutionary Biology has great capacity to generate research questions that invite a computational approach, but has not traditionally emphasized computation. By conducting and publishing research that is: (1) **led** by EEB graduate students, (2) **funded** by SCALE-IT, and (3) **mathematical/computational, SCALE-IT and the EEB Department will share** the success of our computational biology research team. Not only will our research demonstrate that SCALE-IT and computational research has a place in the field of ecology and evolutionary biology, it will serve as **an exemplar for future research that pursues EEB questions from a computational perspective.**

...*to NIMBioS:* As a national center whose interests overlap with SCALE-IT's, **NIMBioS has the potential to extend SCALE-IT's reach beyond UTK**. A SCALE-IT REU project (SCALE-OUT) with access to NIMBioS's REU program activities will create an opportunity for SCALE-IT to reach out to undergraduate students from different institutions.

SPECIFIC AIMS, OBJECTIVES, TASKS

Our lattice model is specifically designed to answer questions about differences in spatial perception and generation time between interacting species, but is general enough to address many such questions. Our specific aims for the coming year focus **on realizing the potential of our work** through publication, extension, and education.

Specific Aim 1: Address Research Sub-Questions. Three sub-questions are key to understanding the way that interacting species track the environment when they operate at different scales. Specifically, we will answer "How does the correlation between predator, prey, and the environment change as…" 1) the difference in operating scales changes? 2) the environment itself changes? and 3) the stability of species at small population sizes changes? Figure 1 shows a first step to answering sub-question 2. *Tasks:* In order to address these research sub-questions, we will **(1)** use image processing techniques such as 2D Fourier analysis, which can be employed to assess the similarity of predator and prey distributions to each other and the environment. Then, using findings from **(1)**, we will execute and analyze the following experiments: **(2)** vary the scale disparity between trophic levels, **(3)** vary the frequency and phase of the periodic environment, **(4)** vary the intrinsic growth rates of prey and predator. *Completion Date:* Spring 2013

Specific Aim 2: Publication and Presentation. Publication of our research will **increase the profile of SCALE-IT and our team**, and it will strengthen the connection between EEB and SCALE-IT. *Tasks:* **(1)** complete current research. **(2)** Prepare manuscript for submission to Oikos or The Journal of Theoretical Population Biology. *Deliverables:* **(1)** Submitted manuscript. **(2)** Oral presentation at The Ecological Society of America's Annual Meeting *Completion Date:* Late Summer 2013.

Specific Aim 3: REU Project. Our proposed REU project would allow us to extend this research, **build relationships between SCALE-IT and NIMBioS**, and create opportunities for an undergraduate **to develop valuable research and communication skills**. *Tasks:* **(1)** Develop 1-3 undergraduate-level research questions and identify possible approaches. **(2)** Identify and recruit 1-2 faculty and/or postdoctoral mentors to provide guidance on the project. **(3)** Design an REU project around these questions. **(4)** Recruit one REU student. **(6)** Mentor the REU student in research, teamwork and poster development. *Deliverables:* REU undergraduate **(1)** report and **(2)** poster presentation at the Undergraduate Research Conference at the Interface of Mathematics and Biology. *Completion Date:* Mid-August 2013.

Personnel. Our interdisciplinary research team will be made up of Christine Dumoulin, Austin Milt (Both 3rd year EEB students), and Kelly Rooker (1st year, Mathematics). Dr. Paul Armsworth will serve as the faculty advisor. An REU awardee from a discipline such as mathematics, computer science or biology will also be an integral part of the research team.

BUDGET

Graduate Student Research/Mentoring Time

Stipend Support, Christine Dumoulin (23% time = 4-5 hrs/wk)……..$10,000
Stipend Support, Austin Milt (23% time = 4-5 hrs/wk)……...$10,000
SUBTOTAL $20,000

REU student time and travel

$1500 for travel per student……...$1,500
$100 per student per day x 54 days ……...$5,400
SUBTOTAL $6,900

Journal Submission Fees

Oikos……$1,000
SUBTOTAL…….$1,000

Conference registration and travel

ESA's Annual Meeting in Minneapolis, MN, Aug 4 – 9, 2013

- Registration for Christine Dumoulin ……... $ 400
- Registration for Austin Milt …….…… $ 400
- Registration for Kelly Rooker ……...$ 400
- Round trip Airfare for Christine Dumoulin ……... ……$ 600
- Round trip Airfare for Austin Milt …… $ 600
- Round trip Airfare for Kelly Rooker ……$ 600
- Hotel Accomodations for Christine Dumoulin x6 nights …. $1,200
- Hotel Accomodations for Austin Milt x6 nights …….. $1,200
- Hotel Accomodations for Kelly Rooker x6 nights……$1,200

Travel For REU to go to NIMBioS Undergraduate Conference ….. $1,000
SUBTOTAL……. $7,600

TOTAL $35,500.00