



2021-2024

The National Institute for Modeling Biological Systems

Three Year Overview

Dr. Nina Fefferman, Director



Our Mission

The National Institute for Modeling Biological Systems (NIMBioS) is based at the University of Tennessee, Knoxville. Our mission is to support research efforts and researchers across the globe within the fields of mathematics, biology, ecology, public health, the life sciences and more. Building on our history starting out as an NSF Synthesis Center we are now operating as an independent institute, focusing on our unique strength in modeling.

We work to foster the collaborative and intellectual space that allows researchers, educators, students, and policy makers to come together and succeed at creative, ambitious, transdisciplinary efforts that each of us would struggle to accomplish on our own. We help researchers in mathematical biology to bring their spark of insight to fruition as a grant proposal, educational program, or new collaboration.

The mission of NIMBioS is two-fold: (1) to foster the maturation of cross-disciplinary approaches at the interface of mathematics and biology, and (2) the development of a cadre of researchers who are capable of conceiving and engaging in creative and collaborative connections across disciplines to effectively use appropriate and necessary mathematics to address fundamental and applied biological questions.

The Impact of NIMBioS

NIMBioS has been an integral part of advancing the field of mathematical biology since 2008. Our programs and results have enhanced collaborations between diverse academic communities, fostering convergent research and education in the United States and the world. NIMBioS has successfully survived a critical transition point in the life of the Institute. Under its initial Synthesis Center grant from NSF (2008-2021), NIMBioS received approximately \$34 million dollars to establish itself as a preeminent international research institute in mathematical biology.

The impacts from this endeavor helped shape more than a decade of progress across the entire field. At the close of the initial Center grant (non-renewable after 2021), we transitioned into a new phase in which the life of NIMBioS now relies predominantly on:

1. Providing research support and expertise in mathematical, computational, and quantitative methods, training, and outreach (either as fee-for-service through our recharge center, or as consultancies or direct subcontracts on external awards to our affiliates and staff) and, much more importantly
2. Catalyzing additional funding proposals from affiliated researchers.



Leadership Team



Dr. Nina Fefferman
Director

Dr. Nina Fefferman is responsible for setting our strategic vision and goals and helping build the core initiatives and communities that bring our members together. While her own research focuses on self-organizing, adaptive complex systems, she is excited by any creative or novel way to learn about natural and/or social systems using the language and perspectives of mathematics. In addition to directing NIMBioS, she is a Professor in both the departments of Mathematics and Ecology & Evolutionary Biology, the associate director of the UT One Health Initiative, and she will be the director of our new Center for the Analysis and Prediction of Pandemic Expansion. Fefferman is passionate about bringing researchers together to create novel insights that could not be achieved in isolation.



Dr. Elizabeth Derryberry
Outreach Director

Dr. Elizabeth Derryberry works to help broaden access to the joy of science, math, and all types of quantitative reasoning. She designs and leads efforts that help researchers communicate their work to broader audiences, support teachers in incorporating cutting edge science into lesson planning, and invites the public (at any age) to remain life-long STEM learners in all areas relating to quantitative life sciences and beyond. Derryberry is a Professor in the Department of Ecology and Evolutionary Biology.



Dr. Mona Papeş
Spatial Analysis Director

Dr. Mona Papeş is the director of the Spatial Analysis Lab. Her work supports spatial analysis research through proposal submissions and access to geospatial technology. By fostering a collaborative, cross-disciplinary environment, the lab's activities contribute to the NIMBioS mission and initiatives. Papeş is an Associate Professor in the Department of Ecology and Evolutionary Biology.



Dr. Belinda Akpa
Director of Data Sciences and AI

Dr. Belinda Akpa serves as the Director of Data Sciences and AI. In this role, she serves as a point of contact for individuals wanting to discuss models that primarily focus on, leverage, or integrate data sciences and AI methodologies. By acting as an interface between affiliated and unaffiliated researchers, Dr. Akpa facilitates opportune matchmaking amongst members of UT and NIMBioS's broader quantitative life sciences community. Akpa is an Associate Professor in the Department of Chemical and Biomolecular Engineering.



Staff



Sherri Dugger
Business Manager

Sherri is an integral member of the team. She provides professional guidance and management of all financial and administrative processes. She assists researchers with proposal creation and submission for agency funding and provides oversight of budgets, financial planning, and other accounting operations.



Jondale Stratton
IT Manager

Jondale oversees NIMBioS technology planning, implementation, and operation. Jondale collaborates with researchers to understand their specific needs and provides innovative solutions to support their projects. From setting up a printer to running your project's computations on a high performance computing cluster, he's here to help.



Graham Derryberry
Research Programmer

Graham serves as the Research Programmer, helping researchers implement code to complete any computational aspects of their work. He advises how to structure new projects, handle large-scale datasets, assists with coding, and helps researchers restructure their own code for HPC environments, including sending processes to our cluster, Rocky.



Kristen Mecke
Project Manager

Kristen oversees various aspects of projects within NIMBioS. She is responsible for coordinating travel, purchasing supplies, keeping track of project deliverables and deadlines, assisting with reports, as well as planning and organizing events (from K12 outreach to multi-day workshops). She works closely with NIMBioS researchers to identify each project's needs.



Dr. Anne M. Ho
**Assistant Director of
Grant Development**

Anne supports researchers on proposals for external funding. She assists with all stages of this process, including locating appropriate funding sources, editing narratives, providing informal review feedback, aligning supplementary documents, and more. She has worked with researchers from several departments across UT.



Liliana Farabaugh
Communications Manager

Liliana oversees communication strategy and execution within NIMBioS. She crafts compelling messaging across various platforms to effectively convey NIMBioS' mission, values, and initiatives. She also works closely with researchers to craft narratives that showcase the significance and relevance of their work.



A Glance at Our Grants

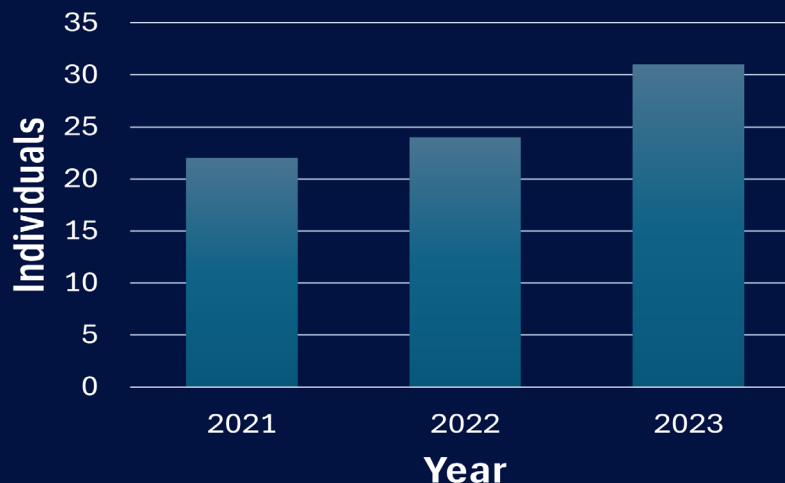
Since spring of 2021, NIMBioS has brought in over \$8.5 million of new funding, on top of several continuing multiyear projects funded before 2021.

This total does not include the recent \$18 million brought in by NSF APPEX

NIMBioS has a strong track record of helping researchers frame and communicate their proposed efforts in ways that highlight the importance of advancing inter-, multi-, and transdisciplinary science to a diverse audience of reviewers and funders. Researchers considering writing their next proposal can come to NIMBioS for help at any stage in the process, from refining the initial concept to organizing the proposal to be coherent and compelling, to polishing the presentation. Our Assistant Director for Grant Development, Dr. Anne M. Ho plays a pivotal role at NIMBioS, contributing to our strong track record of assisting researchers in framing and effectively communicating their proposed efforts. Our new research projects have been funded by a range of agencies including the National Science Foundation (NSF), the Department of Defense (DOD), the Department of Energy (DOE), the US Department of Agriculture (USDA), the National Park Service (NPS), the Intelligence Advanced Research Projects Activity (IARPA), the Burroughs Wellcome Fund, the Pew Charitable Trusts, Oak Ridge National Laboratory (ORNL), and Oak Ridge Institute for Science and Education (ORISE).



Our Growing Number of Individual Participating PI's

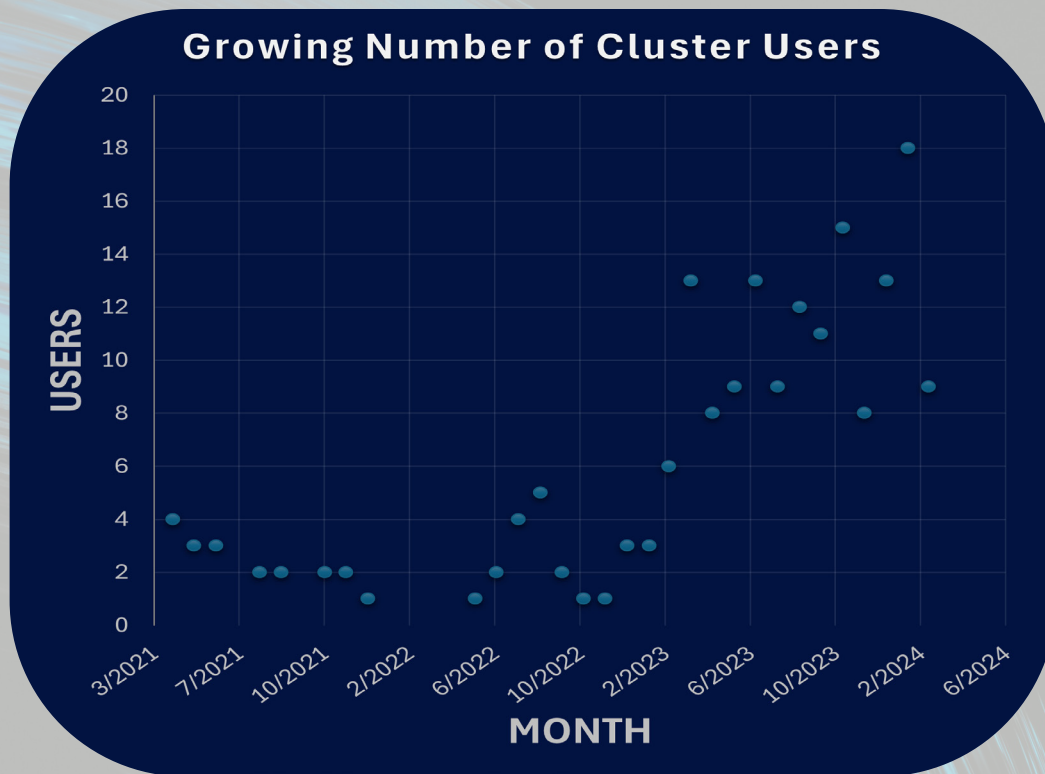




Rocky

What is Rocky?

To provide computing resources needed by quantitative life sciences researchers, we maintain Rocky, a high-performance computing cluster designed to handle compute-heavy, memory-intensive, big data, and time-consuming programs. It comprises a growing set of compute heavy nodes, memory intensive nodes, Ceph storage subsystem, and virtual hosting. Programs are submitted through a workload management system, Slurm, and are assigned to one or multiple nodes. We grow and refine these systems over time, according to the needs of our users. By maintaining these resources in-house, we ensure that we can seamlessly guide researchers through their use, lowering the barrier for entry into computational research for life scientists.



The Dynamic Duo Behind Rocky's Success

Jondale Stratton, our IT Manager, and Graham Derryberry, our Research Programmer allow us to tackle complex research questions and drive innovation across disciplines. We are grateful for their exceptional support in making Rocky a success, enabling our mathbio researchers to push the boundaries of computational biology and mathematics.



Some Projects that Utilize Rocky

Data Storage for University of Tennessee Herbarium: The University of Tennessee Herbarium is a plant research collection with 685,000 specimens used to study climate change, invasive species, and plant biodiversity. Many specimens have been photographed and made available online through public databases for researchers worldwide. Rocky at NIMBioS is used to archive the original RAW images of these plant specimens as backups for the online images. Below is a photograph of *Delphinium tricorne* (dwarf larkspur), collected by one of the student herbarium technicians. This image is among thousands archived for safekeeping using Rocky storage at NIMBioS. (Fig. 1)

Epi Simulation: Our Flexible Epidemic Simulator comes from a project team from our US NSF PREEMPT PIPP Phase I grant. A multidisciplinary group of researchers came together to re-envision what features a simulation toolbox should have to enable creative questions to be explored at the interface of their disciplines. The resulting simulator incorporates the ability to configure elements from sociology, economics, epidemiology, and demography, and can simulate an epidemic on a resulting realistic social network, projecting a population of over a million individuals for a month of interaction time in under 5 minutes on Rocky. We are building towards a release that will enable researchers from all over the world to use this simulator for free for small, isolated simulations, and to request working with us for larger requests to run longer, larger, or more comprehensive studies on Rocky that will use more resources. (Fig. 2)

Elizabeth Derryberry's Birdsong Project: Our urban white-crowned sparrow song project examines how birds' songs change in response to fluctuations in ambient noise levels. Shutdowns associated with the COVID-19 pandemic led to reductions in motor vehicle traffic, which reduced noise levels in many urban areas. We focused on the San Francisco metro area and nearby rural areas to track how bird songs changed in response to shifts in the soundscape during these shutdowns. We found that noise levels in urban areas were substantially lower during the initial shutdown, and that birds responded by producing higher performance songs at lower amplitudes. These behavioral changes effectively increased communication distance and song salience. Since 2020, we have annually recorded song in the same areas at the same time of year as the initial shutdown. With this longitudinal dataset, we will be able to examine the robustness and resilience of an avian communication system. Rocky is essential to this research effort, providing both a reliable storage platform as well as a place to automate analysis of the spectral and amplitude characteristics of thousands of song recordings. (Fig. 3)



Fig. 1

...and more!

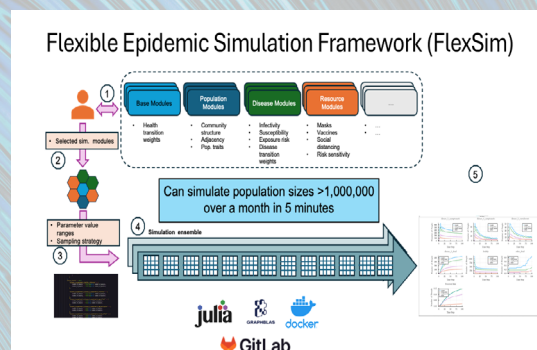


Fig. 2



Fig. 3



Outreach

At NIMBioS, we maintain a number of programs to allow researchers to choose à la carte from a menu of fully supported options for translating their research into educational games, podcasts, and even summer camp activities, with help from expert science communicators, K-12 educators, and entertainers.



Empowering STEM Education through Easy as Play

In our ongoing commitment to advancing STEM education, NIMBioS proudly presents Easy as Play (formerly Biology in a Box), a flagship initiative within our outreach endeavors. With a dedication to accessibility and engagement, we pursue the development and support of the STEM pipeline, delivering outreach and education services, particularly to underserved communities.

Enhanced Homeschool Program

Beginning in Spring 2023, the Enhanced Homeschool Program offers immersive learning experiences beyond traditional classroom settings, providing hands-on activities designed to deepen student understanding of various subjects. This program, exemplified by events like “Birds of a Feather, Learn Together,” is organized by NIMBioS in partnership with the McClung Museum and the Ecology and Evolutionary Biology Department. With a focus on sparking enthusiasm, broadening perspectives, and democratizing access to science, the program engages approximately 20 students each spring.



Girl Scouts Math in Nature Badge Series

The Math in Nature Badge Series, a collaboration between NIMBioS and the Girl Scout Council of the Southern Appalachians since 2022, offers engaging nature-inspired math activities for Junior and Brownie Girl Scouts. Participants explore shapes and patterns in nature, interact with female mathematicians, and take part in hands-on activities like crafting bird feeders. Through the program, scouts earn badges symbolizing their math skills and understanding. With a maximum of 50 participants each year, it is a unique opportunity for scouts to learn and grow in a fun and educational environment.





Outreach

EDGE Summer Program

In June 2024 and June 2025, the EDGE Summer Program, hosted by NIMBioS with support from The Office of Research, Innovation, and Economic Development (ORIED) at the University of Tennessee, will empower women for success in mathematical sciences doctoral programs. With 14 participants each year, attendees engage in daily lectures covering Algebra, Analysis, Measure Theory, and Machine Learning, preparing them for graduate research and exams.

Led by EDGE mentors, including graduate students and alumni, collaborative problem-solving sessions enhance practical skills in a rigorous academic setting.



**MORSELS
FROM
NUMBERS
AND NATURE**

Morsels from Numbers and Nature:

Morsels from Numbers and Nature provides an engaging platform for mathematics and biology researchers at all career levels to convene and exchange insights on their ongoing research and perspectives. This community-oriented forum features 5-10 minute informal virtual presentations, fostering an atmosphere for open discussion and constructive feedback.



To date, there have been 10 successful talks, and the series will mark its one-year anniversary in October 2024, showcasing its dedication to advancing interdisciplinary dialogue and collaboration. All of the talks are posted on the NIMBioS YouTube channel which has 3.92k subscribers.

Adventures in STEM

The National Institute for Modeling Biological Systems (NIMBioS), the Institute for a Secure and Sustainable Environment (ISSE), the Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks (CURENT), and the University of Tennessee (UT) collaborated to host “Adventures in STEM,” where middle school students engage in Science, Technology, Engineering, and Math (STEM) concepts. The program linked math, engineering, and sustainability through fun, hands-on activities, teamwork, field trips, and interactions with scientists and engineers. The camp offered activities focused on ecology, biodiversity, electric circuitry, renewable energy, solar and wind power, and more.





Professional Development and Training

Training is integral to our mission. The majority of our research grants include training opportunities for graduate students, postdoctoral researchers, and undergraduates. We are committed to preparing the next generation of interdisciplinary scholars through research experiences and mentorship, equipping them with the skills and knowledge needed to succeed in their respective fields.

Burroughs Wellcome Fund supported virtual Tasting Menu

The “Tasting Menu of Quantitative Modeling” event, hosted by NIMBioS on July 8th and 9th, 2022, offered 177 participants a virtual exploration of the potential of mathematical and statistical models in research. Through presentations, Q&A sessions, and collaborative discussions, attendees discovered how models could enhance research impact and streamline complex interactions across diverse fields. Co-sponsored by the EDGE Foundation and supported by the Burroughs Wellcome Fund, the event provided opportunities for collaboration and learning. Whether attendees joined for the entire event or dropped in as their schedules allowed, they had the opportunity to appreciate the significant impact of quantitative models in their work.



In-person Burroughs Wellcome Fund supported Interdisciplinary Lab Residency in Mathematical Biology

Nine participants from underrepresented communities, who initially attended the virtual Tasting Menu, traveled to NIMBioS for a 2-day workshop supported by the EDGE Foundation on September 29-30, 2022. This workshop provided an opportunity for participants to develop collaborative skills, strengthen their professional networks, and explore strategies for building and participating in supportive interdisciplinary research teams. Following the workshop, each participant was paired with a mentor for an additional 1-week visit, either in person or virtually. These experiences were uniquely tailored to each individual, enhancing their professional growth and research capabilities.



NSF TRIPODS+X Workshop (Lemonade Lab)

NIMBioS hosted the Lemonade Lab workshop at Park Vista in Gatlinburg, TN, on October 18-19, 2022. Seventeen participants from various states, domains, and industries attended this in-person event, which was the second NSF TRIPODS+X workshop since 2019. The first day focused on sharing skills, identifying support needs, designing project “toolboxes,” discussing ML/AI limitations, and engaging in team-building activities. The second day featured “learning booths” on topics such as the NASA Earth Engine data catalog, NASA DAAC migration, cloud-based research platforms, diverse data paradigms, physics-informed ML, and cloud automation. The workshop concluded with planning deliverables like a webpage and manuscript. As of Spring 2024, participants continue to meet to complete their manuscript.



Spatial Analysis Laboratory

For researchers who would like to add a spatial aspect to their research, we offer three main categories of services:

- Consulting for data analyses and geospatial modeling
 - Drone data collection
 - Terrestrial laser scanning (LiDAR)

We maintain licenses to dedicated software for spatial analyses and an array of geospatial equipment (e.g., LiDAR scanner; drones; thermal, multispectral, and hyperspectral cameras; etc.), a lab bench imaging system, and many equipment accessories.

Using terrestrial laser scanning improve mangrove biomass estimation: This project was led by researchers from the University of Tennessee and NIMBioS in collaboration with Todd Schroeder from the U.S. Forest Service, focuses on improving methods for assessing mangrove structure and biomass in the US Gulf. In August 2023, the team was working in Rookery Bay, an area struck by Hurricane Ian in 2022, studying red, black, and white mangroves. These mangrove ecosystems are crucial for carbon storage and provide support for marine life, making them essential for ecosystem health and sustainable management decisions.



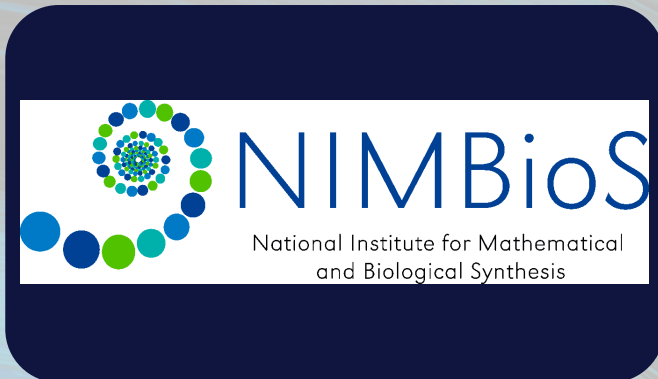
Kristen Mecke, our Project Manager, is instrumental in driving the success of numerous efforts at NIMBioS, especially within SAL. Notably, she has played a key role in the 2022 Lemonade Lab Workshop held in Gatlinburg, Tennessee. Her exceptional project management skills ensure the execution and impactful outcomes of these initiatives, reflecting her dedication to advancing interdisciplinary research and fostering collaborative spaces.



Institute Relaunch

In 2024, NIMBioS relaunched with a renewed focus on our unique strength in modeling, accompanied by a new website and logo. This rebranding initiative marks a significant step forward in our journey as an institute, demonstrating our dedication to advancing transdisciplinary research in the quantitative life sciences.

Liliana Farabaugh, our Communications Manager, played a pivotal role in implementing this transformation, ensuring that our communications strategy aligns with our mission. From crafting compelling narratives to implementing user-friendly design elements, we are committed to enhancing engagement and fostering connections within the scientific community and beyond.



Our communication services are showcased through real world examples, such as the websites for the University of Tennessee One Health working groups on Environmental Contaminants and Toxicology and Antimicrobial Resistance. Liliana collaborated with One Health staff to design and build these websites from scratch. These sites highlight the working groups' purposes and provide a resource page for field experts. This collaborative effort demonstrates our commitment to supporting scientific collaboration.

NIMBioS provides a comprehensive range of communication services designed to support researchers in mathematics, biology, ecology, public health, and the life sciences. This document outlines the services included as part of NIMBioS support. Reach out to us to see how we can assist you.





Some Current Projects at NIMBioS

PREEMPT (Predicting Emergence in Multidisciplinary Pandemic Tipping-points) (Led by N. Fefferman) is part of an NSF-sponsored initiative focused on fundamental research and capabilities needed to tackle grand challenges in infectious disease pandemics through prediction and prevention. The main goal of PREEMPT is to find innovative ways to address global pandemic issues through interdisciplinary collaboration. The PREEMPT team has developed an original process to set up efficient ways for interdisciplinary teams to work together by leading five separate projects of multidisciplinary teams, collaborations which have already resulted in the publication of four papers. Starting in 2024, we have been awarded an additional 18 million dollars from the NSF to continue this work in the form of the **NSF Center for Analysis and Prediction of Pandemic Expansion (APPEX)**. This center will support core research in pandemic science, new working groups, training opportunities for the next generation of researchers, and public outreach.



Heat grant (Led by E. Derryberry): The study combines mechanistic and functional approaches to provide new insights into individual-level variation in behavioral performance. Controlled experiments, using zebra finches as the study organism, will allow the group to identify the mechanisms and consequences of heat exposure on behavior. The core research aim will also be woven into inter-related educational and outreach activities for K12.

U.S Forest Service LiDAR project (Led by M. Papes): Mangrove forest plots are some of the least regularly sampled in the USFS Forest Inventory and Analysis Program (FIA), resulting in gross underestimation of forest area and large sampling errors. The aim of this project is to develop new remote sensing techniques to address these issues.



How People Benefit from and are Impacted by Nature (Led by P. Armsworth): With support from The Pew Charitable Trusts and the National Park Service, NIMBioS researchers have examined how people benefit from nature through activities such as recreation or hunting, as well as how they are impacted by environmental threats and hazards like wildfire risk, flooding, or drought. Their work highlights how environmental benefits and burdens are not distributed equally within society. Socially vulnerable communities often face the greatest threats from environmental burdens while also standing to benefit the most from nature's contributions to human well-being.



The INCUBATOR project (Led by V. Maroulas), funded by the United States Army STRONG program, was to develop tools and resources that use biological and mathematical structures arising from sound data, visual data, spatial data to create paired machine learning-human expert systems in order to develop a better anomaly detection system. This project exemplifies NIMBioS' goals to foster a collaborative space for transdisciplinary work by combining diverse disciplines, in this case, to develop enhanced algorithms for anomaly detection.

Opioid Epidemiological Modeling (Led by C. Strickland): In collaboration with ORNL and funded by the U.S. Department of Veterans Affairs, this study is aimed at epidemiological aspects of the opioid epidemic with the goal of quantifying the ways in which community-level opioid use impacts overdose risk for particularly vulnerable subgroups. By combining data with both individual- and population-level modeling approaches, we are working to produce a clinical tool that can inform health care providers about recent and short-term future trends in the community's opioid-use environment and how that affects specific patient overdose risk.



U.S. ARMY

...and more!



Girl Scouts Math In Nature
2023



McClung Enhanced Homeschool
2023



McClung Enhanced Homeschool
2024



Adventures in STEM 2023



NIMBioS Relaunch Lunch Event 2023



Adventures in STEM 2024



EDGE 2024



EDGE 2024



NIMBioS Relaunch Lunch Event 2023



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Come work with us!



Contact@nimbios.org