JAMES MADISON UNIVERSITY®

20|24 SENIOR SYMPOSIUM

SCHOOL OF INTEGRATED SCIENCES

MAKING THE CONNECTIONS

Integrated Science and Technology

Intelligence Analysis

Geography

Throughout this book, you will discover an extensive array of scholarly achievements by our undergraduate students. Teams have dedicated countless hours to developing innovative approaches for defining, addressing, analyzing, and evaluating a wide range of complex and significant problems.

These projects exemplify a skill set needed in an increasingly specialized world—encompassing the challenging integration of science, technology, systems thinking, and domain-specific methodologies to generate new insights and solutions.

Capstones are inspired by student interests, commissioned by external sponsors, and guided by faculty advisers. Ideas are transformed into achievable projects by establishing clear goals, activities, timelines, and benchmarks. Along the way, undergraduates develop their independence and confidence as they navigate challenges, explore possibilities, and ultimately succeed.

This is just the beginning for our School of Integrated Sciences Class of 2024!

Stephanie Stockwell, Ph.D.
Co-Director, School of Integrated Sciences
Academic Unit Head, Integrated Science and Technology

Henry Way, Ph.D.
Co-Director, School of Integrated Sciences
Academic Unit Head, Geography and Intelligence Analysis

TABLE OF CONTENTS

INTEGRATED SCIENCE AND TECHNOLOGY

INTELLIGENCE ANALYSIS

GEOGRAPHY

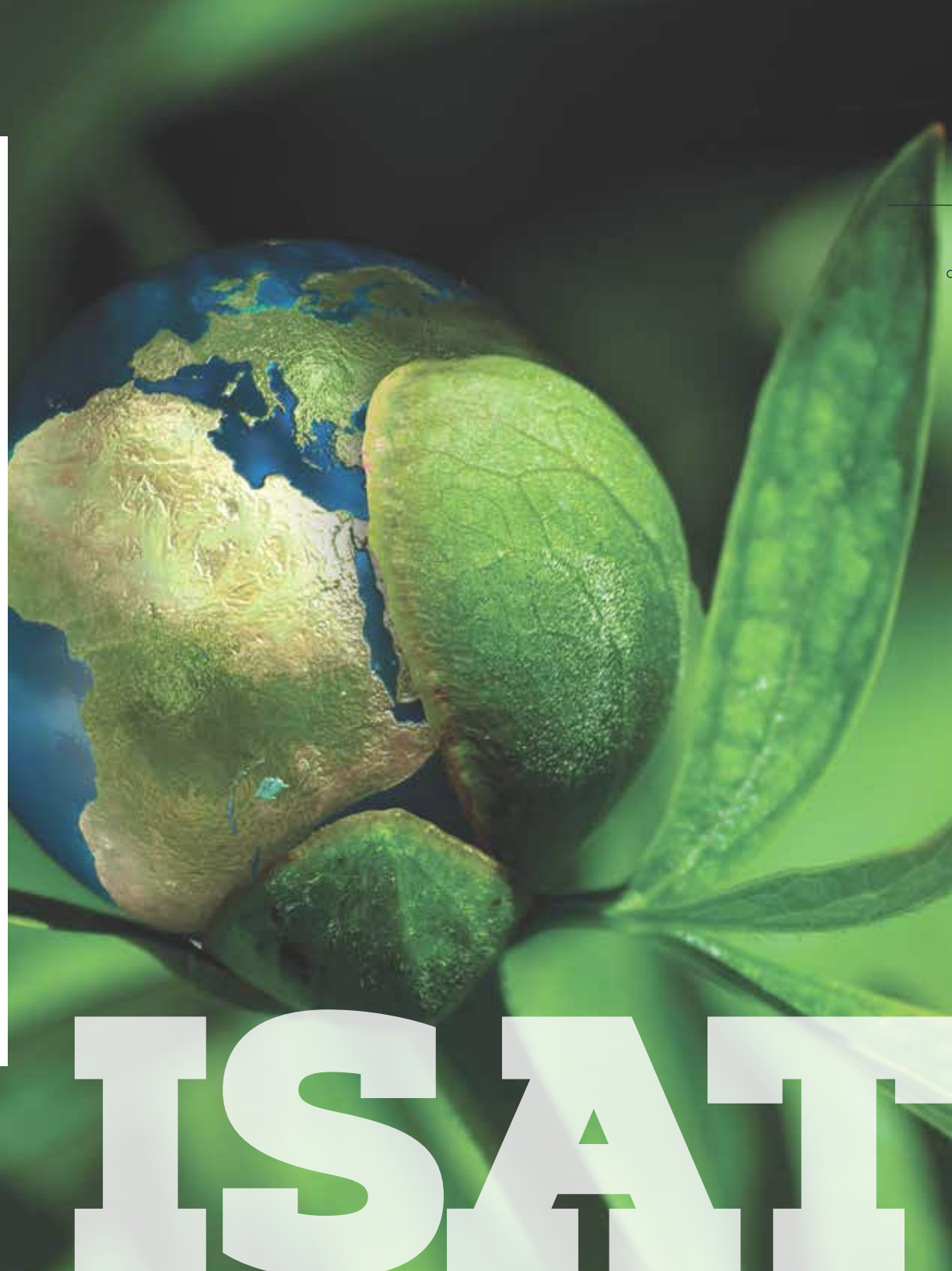
We integrate the United Nation's Sustainable Development Goals (SDG's) into our coursework and research. This connection adds real-world relevance and social impact, demonstrating how our efforts can contribute, even on a small scale, to important global goals.

"Our work has meaning beyond the classroom," says Bob Kolvoord, CISE Dean. "We are leading the way in demonstrating how diverse skills can be applied for the public good."

Incorporating SDGs builds students' understanding of global citizenship and empathy as they learn about challenges faced worldwide and gain perspective on how their fields can create positive change. This prepares our graduates to incorporate social responsibility and sustainability into their future careers and furthers JMU's mission to develop engaged and enlightened citizens.

Integrated Science and Technology

The Integrated Science and Technology B.S. degree program teaches students to be holistic problem solvers. Systems thinking methodologies are used to define and find leverage points within complex problems. A broad and integrated STEM skillset—with focus areas in biotechnology, computation, energy, environment and sustainability, and manufacturing—is then applied. Training in responsible innovation and anticipatory governance helps to ensure that today's solutions don't become tomorrow's problems. This strategic integrated approach delivers graduates that are uniquely versatile, confident, innovative, and collaborative.



ISAT

MODELING THE PERFORMANCE OF AN ATMOSPHERIC WATER GENERATION DEVICE

Student
Jessica Reilly

Advisers
Karim Altaii
Tony Chen

Sponsor
Punta Leona Hotel and Club, Costa Rica

The critical shortage of water resources demands urgent global attention. Research conducted by the United Nations Environment Programme (UNEP) has revealed that, at any given time, approximately 12,900 cubic kilometers of water exist in the atmosphere.

This revelation inspired the development of a device capable of converting atmospheric humidity into drinkable water. Our objective is to model the functionality of the device, analyze its capabilities, and explore possibilities on a global level.

We collected data from the device, conducted thorough analyses, and modeled the entire system using two distinct software programs—Engineering Equation Solver (EES).

By simulating results from the EES model, we aim to showcase the device's capabilities in various locations. Emphasizing the geothermal component of our device, our research contributions aim to address the pressing issue of water scarcity.

FUNGAL NETWORKS AND CARBON SEQUESTRATION AT JUBILEE FARM

Students

Bennett Raba
Sam McIntire
Peter Toporkov
Stepan Toporkov

Adviser

Jennifer Coffman

Sponsor

Jubilee Climate Farm

What are now called "conventional" farming practices are highly energy and resource-intensive, contributing greatly to the warming of our Earth.

Our project, located at Jubilee Climate Farm in Mt. Clinton, Virginia, analyzes a particular approach to sustainable farming intended to combat anthropogenic climate change through carbon sequestration methods while increasing the production of nutrient-dense foods.

We studied the impacts and possible benefits of integrating Johnson-Su Bioreactor compost to increase fungal activity in the soil and thus sequester carbon. Out of 16 contiguous garden beds, we randomly selected 8 to receive applications of Johnson-Su Bioreactor derived compost, while the other eight were treated according to standard USDA organic practices. We also included a grass control plot. Soil samples were collected three times – prior to compost application, after compost application and the harvest of the focal crop of sweet potatoes, and then after the beds "wintered over." We measured soil organic matter using three complementary methods: on-site microBIOMETER testing for fungal and bacterial content, crucible burns in a JMU lab to analyze organic matter, and soil samples sent to a professional lab (Waypoint Analytical) for comparison. We also tracked crop yield per garden plot and bed and gained a more holistic picture of the complex nature of carbon farming through carbon accounting via an assessment of the farm's overall carbon footprint.

CLEAN POWERED MICROGRID FOR TANGIER, VIRGINIA

Students

Ryan Carroll
Marco Chua
Peter Fyffe
Drew Lavoie
Nick Prentice
Malachi Walker

Adviser

Jonathan Miles

Sponsors

VA Department of Emergency Management
VA Department of Energy
Town of Tangier

Our project involved on-site data collection and analysis, modeling, and planning for a clean-powered microgrid on Tangier Island, Virginia, and provides a benchmark for future microgrid development projects and calls attention to the impacts of climate change facing Tangier Island, Virginia.

Tangier covers an area of less than one square mile and is less than four feet above sea level at its highest point, thus prone to adverse effects from climate change, such as rising sea levels. Electric power is delivered to Tangier via a sub-sea cable that runs across the Chesapeake Bay from Onancock, Virginia. This cable has been in place since 1977 and is nearing its end of life. Diesel generators provide backup power but are costly to operate and are polluting.

We have developed a model and plan for installing a renewable energy-powered microgrid that provides stable, sustainable energy to Tangier residents.

Our project lays the groundwork for the design and deployment of the microgrid, and incorporates research on components to be deployed, permitting pathways, wildlife and environmental issues, and an energy assessment.

Our goal is to facilitate the creation of a self-sustaining island community and a model for future microgrid development projects while bringing attention to the energy and environmental challenges that face Tangier Island and other rural, remote island communities.

EXPLORING THE FRONTIERS OF ANTI-AGING TECHNOLOGIES

Student
Evan Niehoff

Adviser
Shannon Conley

In the quest to conquer aging, recent scientific advancements have opened new frontiers, sparking excitement and ethical debates. The ever-evolving field of anti-aging technologies stands at a crucial juncture, teetering between groundbreaking discoveries and societal implications.

Our project delves into these uncharted waters, aiming to demystify the science while fostering responsible innovation. Featuring a review article designed as a concise guide to the current landscape of anti-aging research, it summarizes key scientific developments, like senescent cells, and provides resources for deeper exploration. The aim is to enlighten readers about new anti-aging methods, spurring further inquiry. Complementing this is an innovative public engagement exercise, embedded as a demo in ISAT 171: Governance of Sociotechnical Systems module focused on Anticipatory Governance and the Responsible Innovation of Emerging Technologies. This activity utilizes a gamified scenario analysis using a card deck, guiding participants through the principles of responsible innovation: anticipation, reflexivity, inclusion, and responsiveness. Through interactive scenarios, participants explore various future outcomes, stakeholder perspectives, and ethical considerations of anti-aging technologies. The combination of the review article, the social context activity and analysis aims to provide a foundational understanding of anti-aging technologies and their societal implications, educate and stimulate thoughtful discussion, and foster responsible management of these emerging innovations.

VIRTUAL REALITY GAME-BASED VESTIBULAR REHABILITATION THERAPY

Students

Tymaree Markel Morton
Charlie Ruble
Izzy Webber

Adviser

Jonathan Spindel

Sponsor

Madison Trust

Vestibular rehabilitation therapy (VRT) is a set of simple exercises involving head, eye, and body movements used to treat patients with a wide range of vestibular and balance system disorders. While effective, successful application of VRT requires repetition multiple times daily and over many months to achieve results. Many patients lose interest as the exercises are often perceived as monotonous, uninteresting, and provoke symptoms before results are achieved.

In this study, the team is working to expand, develop, and test the application of virtual reality (VR) and Augmented Reality (AR) to VRT. Video game-based VRT (VG-VRT) can help address many issues associated with traditional VRT by making the therapy process more fun and engaging, enhancing patient compliance and follow-through.

The design of the VG-VRT system is to encourage movements like those in traditional VRT. Using the Oculus Quest 2 VR gaming system, we are developing, refining, and testing gamified environments using Unity, a VR development platform. The team is exploring the Oculus Quest 3 system that permits the design of VR and AR games to create more effective treatment platforms.

This continuing effort sets the stage for developing a full range of game environments that support collecting data essential to understanding the use and effectiveness of VG-VRT in improving results when compared to traditional VRT.

USING FUZZY COGNITIVE MAPS TO ASSESS AI IN END-OF-LIFE CARE FOR LGBTQ+ PATIENTS

Students

Tricia Wang
Taylor Manley
Abass Koroma
Josh Brewington

Advisers

Shannon Conley
Kyle Metta
Lee Ann Johnson (UVA)
Cathy Campbell (UVA)

Sponsor

4-VA

As students in JMU's Science, Technology, and Society (STS) Laboratory, we use tools and approaches from the interdisciplinary field of STS to reflect on what it means to be a responsible innovator and leverage technology for social good in the context of our technical interests in applied computing and Artificial Intelligence.

Our project utilizes Fuzzy Cognitive Maps to capture the complex interactions of systemic factors in healthcare. We aim to model and understand how AI integration can improve end-of-life care for LGBTQ+ patients. We balance technological advancement with ethical considerations, striving to propose AI applications that are both effective and sensitive to meet the unique needs of LGBTQ+ individuals. Through stakeholder engagement and comprehensive research, we envision a healthcare system that upholds equity and compassion, paving the way for inclusive practices in medical technology.

JMU DUKESAT: A SPACE-BASED MESH NETWORK DEVELOPMENT EFFORT

Students

Oscar Alejandro Pequeno Hernandez
Ali Nader Elhajj
Benjamin Garner

Advisers

Jonathan Spindel
Bryan Cage

Sponsors

Madison Trust
Northrop Grumman

CubeSats are small-scale satellites that are generally single-purpose. They provide great flexibility for many Low Earth Orbit (LEO) applications. LEO small satellites have become a popular tool as they are significantly more cost-effective to produce and launch than large systems. Therefore, they can be designed for specific applications, usually directed toward some form of earth observation or single-purpose scientific mission.

The purpose of the JMU DukeSAT development effort is to design, develop, and test a wireless mesh network in space. This work focuses on serving as a proof-of-concept for implementing a wireless mesh network (MeshSAT) for other small satellites to access in LEO. Satellites connected to the MeshSAT network would have access to more reliable connections to ground networks, increasing their utility for near real-time data transfer. As a stepping stone to space missions, a series of high-altitude balloon (HAB) launches have focused on testing program hardware at altitudes over 100,000 feet in conditions of low atmospheric pressure and sub-zero temperatures. These continuing experiments allow real-world testing of the program, networking, hardware, and software at altitude and set the stage for exploring alternative forms of ground-to-space communications, expanding efforts to develop and test prototype systems, and providing data required to support anticipated space missions.

PRE-SCREENING SKIN CANCER DETECTION DEVICE FOR UNDERSERVED COMMUNITIES

Students

Selina Matolak
Amber Oliver (Computer Science)

Advisers

Chris Bachmann
Afzal Upal

Skin cancer is the most common type of cancer in the United States. There is a need for a convenient app to perform pre-screening services for all to access. Skin Guardian Tech represents a groundbreaking mobile application fueled by state-of-the-art machine learning technology. Its core mission is to conduct meticulous prescreening for skin cancer, particularly melanoma, utilizing a straightforward camera image.

The primary goal is to empower individuals lacking healthcare access or facing financial constraints with the means to assess the potential risk of their skin condition in relation to melanoma skin cancer.

The project contains dedicated efforts in developing a 3D-printed prototype on a Raspberry Pi, a device that can be donated to local health centers, refugee locations, and support centers. This will increase the ability for all individuals, even those without smartphone accessibility to pre-screening services. It's crucial to emphasize that Skin Guardian Tech isn't a diagnostic tool but rather a guiding force, aiding individuals in making informed decisions about the necessity of seeking professional medical assistance.

CREATING A RIPARIAN BUFFER AT THE JMU FARM

Student
Reggie Wilcox

Adviser
Carole Nash

Sponsor
Degesch America

The JMU Farm is a 31-acre property along the North River and has been an integral part of JMU's story for nearly a century. Originally established as the Hooke Farm in 1848, its purpose shifted from farming to educational uses when the University acquired it in 1929. However, decades of streambank erosion are impacting the property and contributing to decreased water quality along the 1000-foot stretch of the river.

Our capstone project seeks to address the research question: how can we stabilize the riverbank while projecting the historic viewshed and improving public awareness. To combat erosion, we have addressed the problem from an environmental and educational standpoint.

We've planted a 75x350-foot meadow of native plants to increase soil stabilization and improve biodiversity. As the meadow matures, the root systems of these plants will stabilize the soil, improve native habitats, increase groundwater filtration, and sequester carbon and pollution, thereby enhancing the overall ecosystem services and well-being.

The project also includes a new interpretive sign from the Institute for the Stewardship of the Natural World's Campus Environmental Stewardship Tour, enriching the educational experience for visitors. By extending JMU's commitment to sustainability through the establishment of the meadow and bank stabilization, we aim to set a model for the community.

TRANSFORMING THE COMMUNITY TOOL BOX WITH DATA SCIENCE AND NLP

Students

Carlos Crespo
Hani Malik
Johnny Duenas

Adviser

Kyle Metta

Sponsor

The Community Tool Box

The Community Tool Box (CTB) is a vital online resource for individuals and organizations working towards community development and social change.

Our project aimed to enhance the CTB by analyzing its "Ask an Advisor" feature, which has accumulated over 2,000 queries over two decades. Despite being a rich resource, this archive has not been systematically examined until now.

Using data analytics and natural language processing, we analyzed these inquiries to uncover patterns, trends, and emerging areas of interest in community-driven change. Our approach employed topic modeling and burst analysis, allowing us to identify prevalent themes and knowledge gaps in the CTB's content. This analysis is crucial for updating and enriching the CTB, making it more relevant and user-friendly.

The goal was to provide a more structured, evidence-based resource for community changemakers. By understanding the nature of questions and responses in the "Ask an Advisor" section, we aimed to improve the CTB's utility in guiding effective community action. The insights gained from this project will inform future content development and strategies for the CTB, ensuring it remains a cutting-edge resource for community development. Our project enhances the CTB and contributes to the broader field of community health and development. By identifying unaddressed challenges and potential areas for growth, our work paves the way for more informed, effective community engagement and health equity initiatives.

DESIGN AND CONSTRUCTION OF A WAVE ENERGY CONVERTER FOR NEARSHORE APPLICATION

Students

Tristan Ripley
Eric Durham
Griffin Hullinger

Advisers

Karim Altaii
Mark Showalter

Fossil fuels have generated electricity and contributed to climate change since the 1800s. The irreversible consequences of the continued use of fossil fuels are forcing the world to replace them with renewable energy generation.

Wave energy converters (WECs) are a promising renewable energy generation technology that harnesses the world's most consistent, untapped form of kinetic energy: ocean waves. These waves have a theoretical capacity of up to 2 terra-watts (TW) and a capacity factor of 90%. WECs have serious potential to contribute to the world's clean energy transition and have advantages over other renewables like wind and solar. Still, they face unique design challenges that must be overcome to make the technology a more viable option for the future.

We aim to design and construct a "proof of concept" device that captures wave energy and turns it into usable electricity. Through our efforts, we contribute to advancing the potential of wave energy in fostering a cleaner and sustainable energy future.

AUTOMATED CHEMICAL MIXING SYSTEM FOR BIOFUEL SYNTHESIS

Students

Ryan Visco
Perry Evans
Benjamin Hite
Rex Nguyen

Adviser

Chris Bachmann

Sponsors

John Deere
Wholesome Energy

As the Shenandoah Valley Region transitions its power production from combustion-driven to low-carbon emitting sources, increased attention is being directed toward the agricultural sector. While our country's agriculture division provides us with essential food, it also generates significant amounts of harmful particulate matter. Our project aims to support the agricultural switch to biofuels by researching and designing a small-scale, fully automated chemical mixer.

Following our attendance at the Society of Automotive Engineers conference in January 2023, our team met with representatives at John Deere to discuss the future of diesel in the agricultural sector. Consultation with executive-level employees provided valuable insight into two potential directions for diesel fuel in the coming years: biodiesel and renewable diesel. Considering the complexity and heavy infrastructure reliance of our options, we narrowed our focus to biodiesels and their applications. With a clear understanding of the type of fuel we intended to synthesize, our team explored the development of a chemical mixer to synthesize the fuel. This process started with a background in fluid dynamics and mixing physics, which enabled us to accurately model our designs utilizing computer-aided design (CAD). After creating several designs, the team met with the owners of Wholesome Energy in Edinburg, Virginia, to seek their professional input on our prototypes.

EVALUATING THE ERODIBILITY OF STREAM BANKS ON JMU'S CAMPUS

Students

Kota Meltzer
Oliver Hite
Richard McFadden
Johnny Quinones

Adviser

Robert Brent

Sponsor

JMU Facilities Management

The history of urbanization in Harrisonburg, coupled with construction on James Madison University's campus, has greatly increased the amount of storm water runoff in the area. This excess runoff erodes stream channels, increases sedimentation, and degrades the health of local streams. To help prevent erosion, JMU has completed several stream restoration projects on campus, and more are planned.

Our project assessed the risk of erosion associated with restored and unrestored streams on campus using the Bank Erosion Hazard Index. This assessment will evaluate the effectiveness of previous restoration projects and prioritize streams for new projects based on erosion risk. We hope our research will be used to implement additional erosion prevention measures on JMU's campus and improve local water quality.

CONSTRUCTING A SELF-SUFFICIENT BOAT POWERED BY SOLAR PANELS

Student
Ryan Masi

Adviser
Steven Frysinger

Ground transportation has significantly improved with innovations such as electric cars and trucks. However, there has been less focus on innovating water transportation to enhance energy efficiency and reduce emissions.

As interest in water activities grows, there is a pressing need for innovation to meet demand while addressing environmental concerns.

Despite the long history of motorboats, since the 1880s, there has been minimal effort to develop electric vessels.

In the United States alone, motorboats and vessels accounted for 50.1 million metric tons of CO2 in 2021 posing threats to the climate and marine life. Similar to the initial skepticism surrounding electric cars, concerns about the practicability of an all-electric boat persist.

My capstone project aims to address this gap by developing a self-sufficient fishing boat using solar panels. This initiative supports the transition to renewable energy in water transportation.

This project demonstrates practical solutions by showcasing the feasibility of an all-electric boat for consumers.

Renewable energy benefits the environment by reducing harmful emissions and saves the consumer money by eliminating the need to purchase fuel.

IMPROVING STUDENT RECYCLING BEHAVIOR AT JMU

Students
Stephen Afriyie
Braedon Miller

Advisers
Christie-Joy Hartman
Jared Stoltzfus

Sponsor
JMU Institute for Stewardship of the Natural World

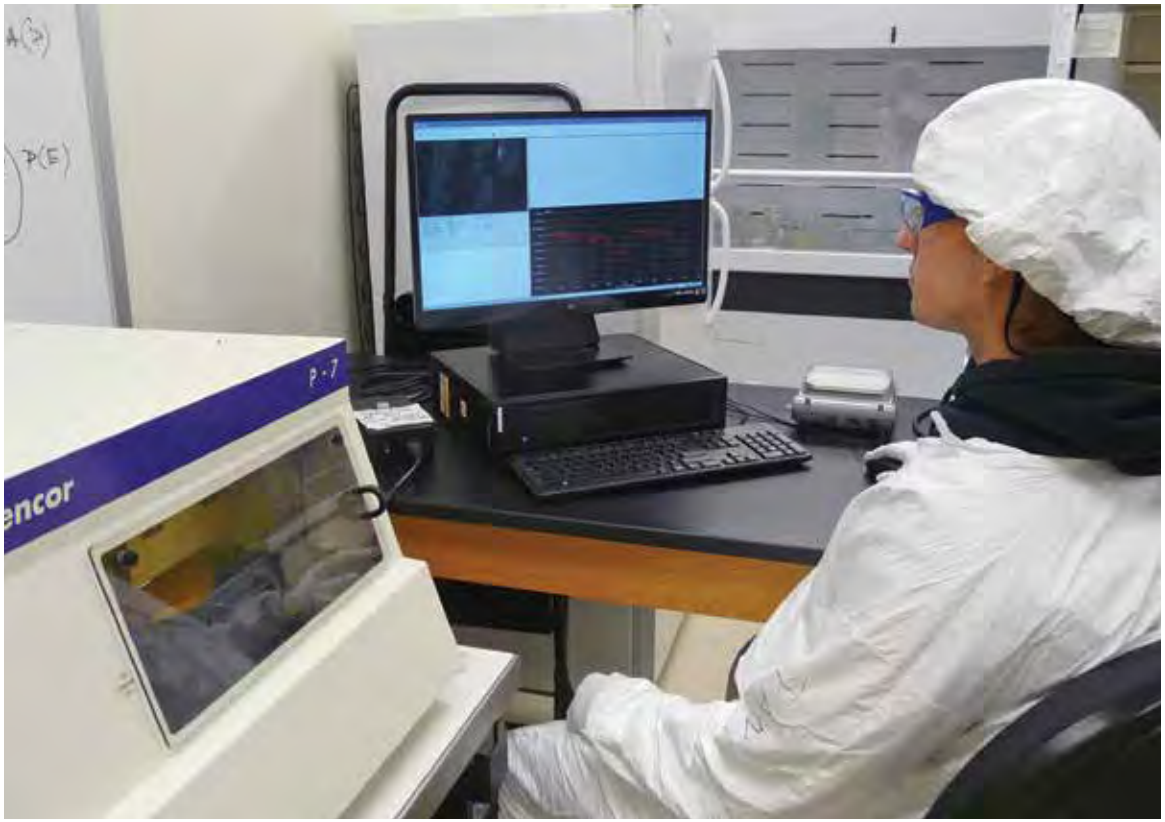
In a 2021 survey by The Princeton Review, 75% of the respondents indicated that a college's commitment to the environment would contribute to the decision about whether to apply to or attend that university/institution.

A 2019 survey revealed a value for environmental stewardship was similarly held by the 71% of JMU student respondents who indicated that it is important JMU students take action to help the environment. However, a JMU student researcher found that many students place recyclable items in the trash and/or place incorrect items in recycling bins, which hampers recycling efforts.

Our project aimed to improve students' on-campus recycling behavior by correcting bin signs on campus and providing feedback to raise awareness about the problems.

In two JMU buildings, we quantified and characterized the recyclable items in the trash bins and the wrong items in the recycling bins, corrected standard signage, posted informational posters, analyzed bin contents after these two interventions, and made recommendations. We will share the results with JMU's Executive Council for the Institute for Stewardship of the Natural World to inform JMU's efforts to increase the amount of JMU materials from the 40% that are currently diverted from landfill.

ANTI-REFLECTIVE COATINGS FOR SOLAR ENERGY APPLICATIONS



Student
Ian Lawson

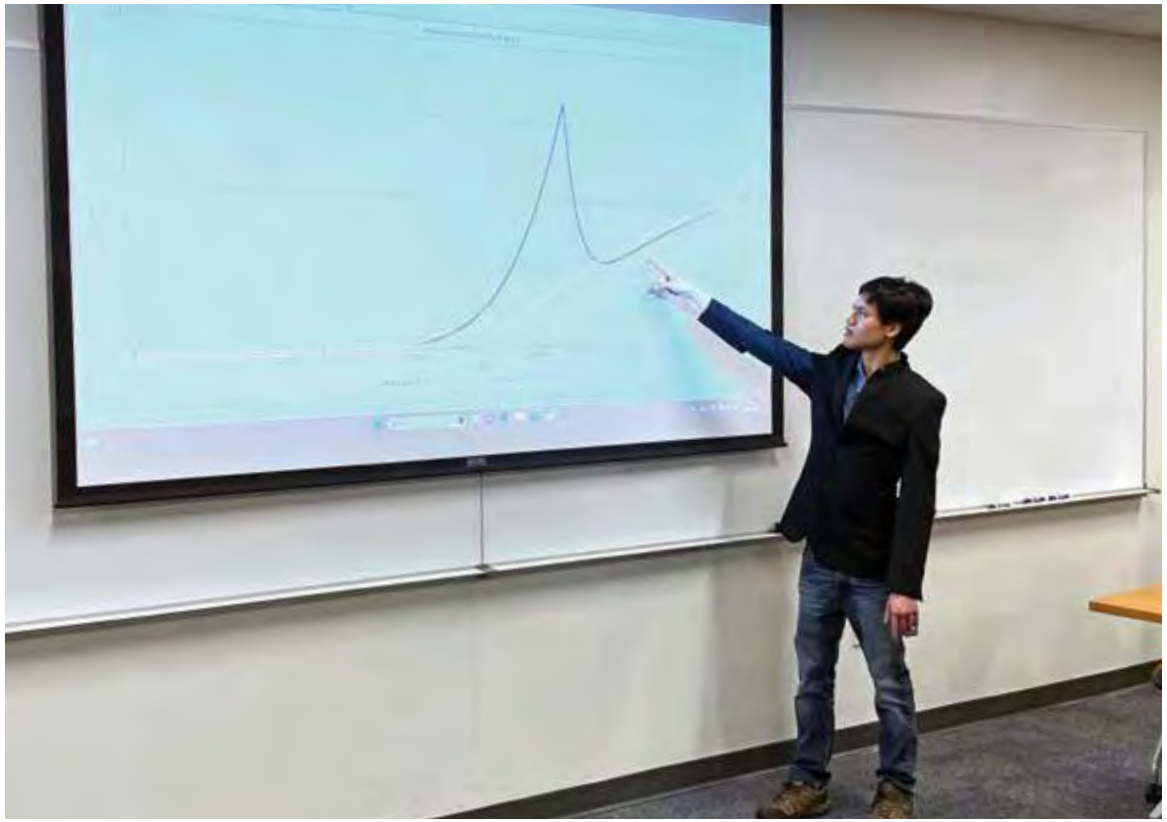
Adviser
David Lawrence

Anti-reflective coatings increase the efficiency of solar cells, generating more electricity. This is important in large-scale solar installations, where a small increase in efficiency can lead to significant gains in energy production. The efficiency of solar cells is critical in adopting solar energy as an economically viable energy source.

This project aims to design and synthesize anti-reflective coatings for potential solar energy applications. This will be accomplished by procuring silica (SiO_2) nano- and micro-particles and applying them onto a reflective surface to create a thin coating.

To produce this coating, the silica particles will be suspended in water or another solvent. This suspension will then be applied to the surface using spin-coating, dip-coating, or drop-casting to create a uniform coating. The particles will then be spin-coated with a polymer. Alternatively, the silica particles will be suspended in a polymer solution so the particles and polymer can be coated simultaneously. The effectiveness of the anti-reflective coatings will be measured through optical reflectance spectroscopy. The effectiveness of the application method will be assessed through surface profiling and scanning electron microscopy (SEM). Through multiple syntheses, the coating may be optimized to improve solar cell efficiency. Following these results, a cost-benefit analysis will be performed to evaluate the material's potential for improvements in the solar panel industry.

LIFE-CYCLE ANALYSIS OF ELECTRIC VEHICLES



Student
Ben Letteri

Adviser
Rod MacDonald

Electric vehicles play an important role in reducing carbon emissions within the transportation sector. Achieving a significant reduction in carbon emissions necessitates that 75 percent of passenger cars and light trucks transition to electric by 2050. This shift in the transportation sector will require wrecking yards to change how they manage damaged and scrapped vehicles.

This project involved a thorough review of literature and data to develop a computer simulation model capable of examining the likely outcomes of this transition.

Findings indicate that it will take several decades for the used electric parts market to develop. In the short term, wrecking yards should prioritize strategies focused on the disassembly and recycling of battery packs and electric motors containing materials such as lithium and neodymium. Additionally, implementing practices to prevent environmental hazards will be imperative.

GOING FOR THE GREEN: MANUFACTURING GOLF BALL CORES WITH RECYCLED RUBBER

Student
Carson Peters

Adviser
Rebecca Simmons

For the past 100 years, golf ball cores have been made from natural and synthetic rubber. The supply of natural rubber is depleting due to disease and overharvesting.

Synthetic rubbers are polymers made from petroleum byproducts, which require fossil fuels for production. Continuing to rely on these sources of rubber is unsustainable for manufacturing and progressively harms the environment. Landfills in the United States receive five million tons of rubber annually, which can take anywhere from ten to one hundred years to degrade.

This project explores the possibility of utilizing alternative forms of rubber for golf ball cores. Several forms of recycled waste rubber and alternative forms of synthetic rubber were tested to determine how these more sustainable golf ball cores would perform compared to existing ones.

In 2023, the governing bodies of golf, the United States Golf Association (USGA) and Royal and Ancient Golf Club of St. Andrews (R&A), declared a rollback on golf balls to limit distance, resulting in changes to both the design and production process. This change suggests that regulating organizations are more receptive to changing golf ball requirements and production rules in the future.

ANALYZING THE LITHIUM SUPPLY CHAIN IN THE TRANSITION TO RENEWABLE ENERGY

Students

Connor Devens
Elliott Rodgers

Advisers

Rebecca Simmons
Rod MacDonald

In the global push towards a sustainable future, the increasing reliance on renewable energy highlights the critical role of lithium, a key component in energy storage solutions. This project investigates how increasing demand, environmental concerns, public policy, social implications, and limited reserves impact the transition to a renewable energy future in the United States.

Currently, 90% of the United States' consumed lithium is derived from international supply chains, which are heavily influenced by geopolitical relations. To ensure energy security and independence, domestic mining and refining must increase to meet projected demand. Using the known U.S. lithium extraction locations, facilities in both Nevada and North Carolina, we used system dynamic modeling to evaluate how the U.S. can meet its projected demand from within its borders to align with the goals set forth by the 2015 Paris Agreement, California's Advanced Clean Cars II rule, and other government policies that drive the renewable energy transition.

SMALL-SCALE BLACK SOLDIER FLY PRODUCTION FOR SUSTAINABLE FOOD WASTE MANAGEMENT

Students

Griffin Albrecht
Jon Stiles

Adviser

Jared Stoltzfus

JMU generates approximately six tons of food waste each month during the school year. While much of it is composted off-site, this is not the best use, according to the EPA. This project aims to unlock the overlooked potential of Black Soldier Flies (BSF) as a novel approach to composting. This could benefit our local poultry industry, small farmers, or even families with backyard flocks of chickens.

Our investigation explores the feasibility of employing BSF to manage food waste by converting it into protein-rich larvae suitable for poultry feed. This innovative method could reduce transportation costs to distant composting facilities and create higher-value products and is scalable to the volume of waste generated. Our research will delve into the impact of various food scraps, including coffee grounds, on the yield of BSF larvae throughout their approximately one-month life cycle.

We will weigh the food waste in the beginning and the larvae and resulting frass at the end to determine each feed type's food conversion ratio. By including market analysis for dried larvae, our project seeks to assign a potential dollar value to BSF production from food waste. Ultimately, we hope our research can lead to a unique business model for food waste management and provide resources for small-scale BSF production for backyard flocks.

ADDRESSING FOOD INSECURITY WITH IMPROVED FOOD RECOVERY

Student
Declan Arnott

Adviser
Jared Stoltzfus

In Virginia, millions of pounds of perfectly edible food are discarded annually, while simultaneously, 1 in 12 Virginians grapple with food insecurity.

The Harrisonburg community is not immune from these statistics, with JMU contributing both to food waste and student hunger.

While various solutions exist to address both issues, this project explores the largely untapped potential of addressing them simultaneously.

This project identifies local organizations addressing food insecurity and major sources of recoverable food. Interviews with food bank operators in Harrisonburg provide a localized perspective, shedding light on current practices and challenges.

Through a combination of local case studies and a broader examination of diverse food recovery methods, we identify barriers, opportunities, and best management practices for food recovery programs.

The goal is to promote effective strategies that maximize the recovery and redistribution of edible food, contributing significantly to the mitigation of food insecurity in Virginia.

INVASIVE SPECIES AND RIPARIAN BUFFER REMEDIATION ON THE SHENANDOAH RIVER

Students
Annalise Henzler
Erin Early

Adviser
Jared Stoltzfus

Sponsor
Town of Shenandoah

The South Fork of the Shenandoah River, known for its diverse aquatic life and recreational activities, faces ecological challenges due to human activities. Riparian buffer and streambank erosion, coupled with invasive algal species, threaten the ecosystem and interfere with recreation.

We aim to restore a section of riparian buffer and create a management plan for controlling invasive species. This involves constructing rock weirs to recreate eroded stream banks, backfilling them with soil, and planting flowers, shrubs, and trees to add beauty while preventing future erosion. We're simultaneously collaborating with the Town of Shenandoah to identify effective methods for reducing invasive algae without harming the ecosystem or the river's dam. This dual approach aims to improve the health of the South Fork, preserving its biodiversity without compromising its recreational value. The project underscores our commitment to sustainable environmental practices and community collaboration in safeguarding the river's ecological integrity.

EVALUATING THE STRENGTH AND THERMAL PROPERTIES OF HEMPCRETE

Students
Bey Dewey
Henry Long
Shayan Shamloo

Advisers
Jared Stoltzfus
Hao Zhang

Sponsor
Pure Shenandoah

Hempcrete, an eco-friendly building material comprised of hemp plant fibers and a binding agent, has gained traction amid increasing interest in sustainable construction. Until January 1, 2022, growing hemp was illegal in Virginia, resulting in limited local knowledge and experience with hempcrete. However, with legalization and the emergence of companies like Pure Shenandoah, who cultivate hemp for fibers and oil, there's newfound potential for hempcrete production in the region.

To support this emerging industry, we are conducting tests on various binders, mixture ratios, and compression to assess their impacts on insulation values and compressive strength. While hempcrete may not replace concrete entirely, our goal is to showcase its beneficial properties and applicability in various settings. Addressing factors such as insulation and strength is crucial for increasing hempcrete's adoption as a viable building material.

Collaborating with local hemp-related industries and sharing research results with the building materials community can contribute to wider acceptance. The legalization of hemp cultivation and the development of hempcrete support local industries like Pure Shenandoah and align with the broader trend toward sustainable construction practices. By demonstrating hempcrete's positive attributes, we hope to contribute to its integration into mainstream construction practices, promoting a more environmentally conscious approach in the building industry.

CONTROLLING AMMONIA USING BIOCHAR IN POULTRY HOUSES

Students
Timothy Brown
Ian Buswell

Adviser
Wayne Teel

Sponsor
VA Department of Forestry

For this research project, we conducted ammonia readings at two farms located about 35 minutes away from JMU. These farms are part of Shenandoah Valley Organics (SVO), Farmer Focus. Our goal was to investigate whether biochar has ammonia-capturing properties in poultry houses.

We visited both farms every Monday to collect ammonia readings from five houses. Initially, data was collected from one biochar house and one control house on each farm. As the semester progressed, we expanded our study to include three biochar houses and two control houses, collecting litter samples for lab experiments. The chicken breed varied throughout the semester. We recorded the external and internal temperatures of the houses to explore any correlation between the temperature and the ammonia levels. We also recorded the operation of the ventilation system fans during data collection.

In the lab, we weighed poultry litter and produced biochar at temperatures ranging from 350 to 650 degrees Celsius. We examined the biochar using an SEM microscope, capturing images under different settings.

UNDERWATER ACOUSTIC DETECTION FOR ILLICIT SHIP ACTIVITY

Students

Willa Denton
Harrison Keller
Hannah Snell

Advisers

Philip Baxter
Tim Walton

Sponsor

National Geospatial-Intelligence Agency

This project uses machine learning algorithms to detect and distinguish different features from maritime vessels enabling the location of those that have disabled their Automatic Identification System (AIS) transponders. The National Geospatial-Intelligence Agency (NGA) asked our group, "How do you find ships that do not want to be found?"

Our approach involves deploying hydrophones and using machine learning algorithms to determine the source of sound and its coordinates. Our hypothesis suggests that by strategically placing hydrophones in locations where ships tend to turn off their transponders, becoming 'dark ships' – we can use machine learning algorithms and triangulation to determine the vessel and its location.

To train our algorithm in sound detection, we utilized parameters such as decibels, frequency, and activations, among other key features distinguishing acoustic sound waves.

Initially, we used recordings of our voices from varying distances, analyzing the data for patterns that aid in determining the speaker's identity and location.

Moving forward, our objective is to validate this proof of concept by incorporating boat sounds and geospatial intelligence to map the paths of dark ships.

PERCEPTIONS OF PRIVACY IN THE AGE OF THE SMART HOME

Students

Aarushi Sharma
Amanda Davis

Advisers

Emily York
Tolu Odumosu, Morgan State University

Smart devices, employing advanced programming techniques like artificial intelligence and machine learning, are integral for user interactions and autonomy within networks. However, the lack of transparency in data collection processes poses significant security and privacy concerns for consumers.

This project aims to address the lack of transparency surrounding smart device data collection by focusing on characterizing JMU students' perceptions of these devices. It seeks to determine the impact of data visualization on user attitudes towards smart devices, considering the potential influence on their perception and consent regarding data release.

Unveiling the hidden processes of smart device data collection, this project employs a comprehensive approach, including a survey of JMU students that assesses their knowledge of data collection from smart home devices. Simultaneously, data is collected from smart devices to uncover passive data collection without user awareness. By visualizing user data, the project aims to determine when and where smart devices communicate. The overarching goal is to empower users with knowledge, improve transparency about their data utilization, and enhance our understanding of user perceptions surrounding data collection through smart devices.

THE ISAT PODCAST: EXPLORING TOPICS IN SCIENCE, TECHNOLOGY AND SOCIETY

Student
Jadon Moon

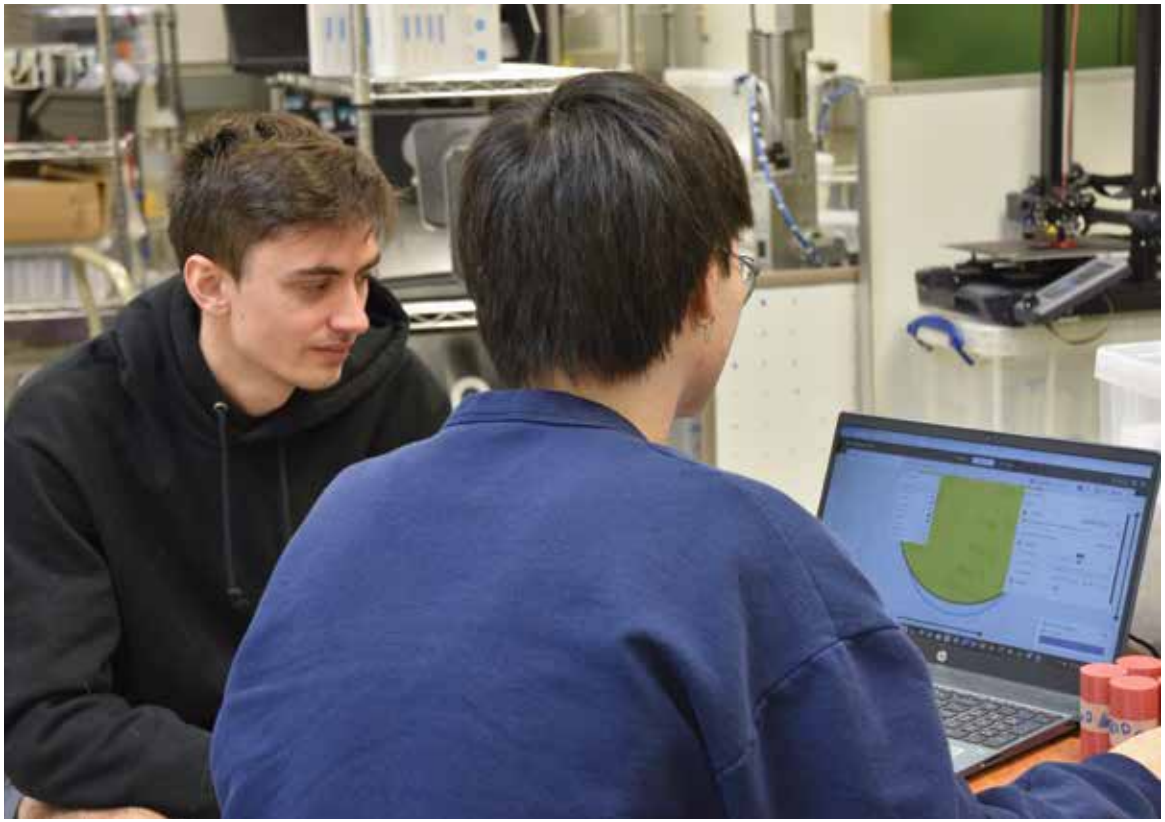
Advisers
Raafat Zaini
Emily York

Many scientific topics today are seen in a very narrow light, largely due to how they are presented in the media. Providing more holistic and well-rounded perspectives on such topics will allow audiences to develop a more informed opinion and encourage them to conduct their own research. Such concepts should also be presented in an accessible and engaging way, as many topics are only presented on biased platforms in a one-sided delivery method.

Our project aims to provide listeners with an engaging podcast series that explores topics in science, technology and society through the holistic perspective of the JMU Integrated Science and Technology (ISAT) program and the role of integrated programs like ISAT in higher education.

We seek to communicate complex topics to a broad audience and explore aspects of a complex production process. Documentation of the process will also be conducted to make the framing of the approach clear to everyone.

3D PRINTING INFILL PATTERNS FOR SUSTAINABLE MATERIAL ARCHITECTURE DESIGN



Students

Stephen Hwang
Jack Wills

Adviser

Hao Zhang

This project explored the mechanical implications of various infill patterns used in 3D printing. With the burgeoning use of 3D printing in industries ranging from aerospace to healthcare, optimizing the strength-to-weight ratio and material efficiency of printed parts has become critical.

This study systematically analyzed how different infill geometries – such as honeycomb, grid, and triangular patterns – influence the mechanical properties of 3D-printed objects. It also analyzed the compression, resilience, and max load behaviors of commonly used infill patterns in 3D printing through experiments on printed test specimens. Additionally, it considered the impact of infill density and printing material on these properties. The findings offered insights into the relationship between infill pattern design and the resulting structural integrity, provided valuable guidelines for material conservation and efficiency improvements in 3D printing applications.

The outcome of this research contributes to the field of additive manufacturing and serves as a resource for engineers and designers seeking to optimize 3D-printed components for specific applications. The project concludes with recommendations for selecting infill patterns based on desired mechanical characteristics, paving the way for more efficient and sustainable 3D printing practices.

Intelligence Analysis

In a world of uncertainty and unpredictability, unbiased and thoughtful analysis is invaluable. The Intelligence Analysis B.S. degree program educates students in a range of structured thinking techniques and an array of technology tools, combined with an understanding of broader contextual issues. IA graduates are flexible and critical thinkers capable of bringing increased clarity to uncertain situations in areas ranging from national security to business to law enforcement and beyond.

FORECASTING PRC INFLUENCE OVER THE FIRST ISLAND CHAIN BY 2027

Students
Madison Barrett
Sam Casper
Parker Perkins
Jenna Sliman

Advisers
Stephen Marrin
Jennifer Davis

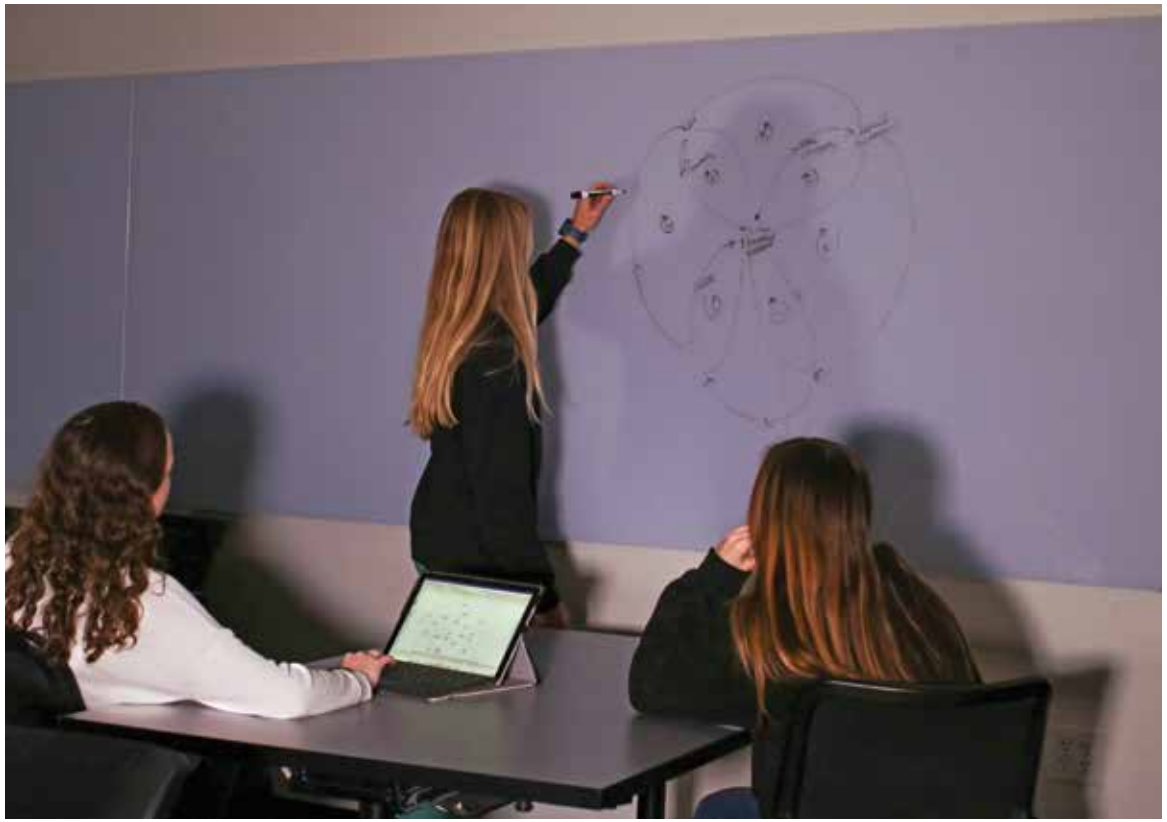
Sponsor
U.S. Department of Defense

The People's Republic of China (PRC) has introduced that 2027, the 100th year anniversary of the People's Liberation Army (PLA), as a milestone year for short-term goals in the broader 2049 goals (the centennial of the PRC) to better the country.

These goals have the potential to impact American interests, especially in the South China Sea, where the PRC claims ownership inside their 9-dash line. Along this line is the First Island Chain (FIC), a 'J-shaped' stretch of islands, including islands such as Taiwan and Borneo. The FIC is significant because it is home to critical trade routes, natural resources, and nations with strategic U.S. relationships.

This project forecasts the likelihood of the People's Republic of China increasing its influence within the FIC by the year 2027 and investigates impacts on American interests in the region. It uses various methods, including structured analytic techniques and geospatial analysis. By answering this question, decision-makers such as the U.S. Indo-Pacific Command (USINDOPACOM) will be better informed on the future of the First Island Chain and how the US is likely to be impacted.

IMPACT OF U.S.-P.R.C. ECONOMIC INTERDEPENDENCE ON U.S. AI



Students

Isabelle Calhoun
Madeline Psimas
Kelly Riley

Advisers

Stephen Marrin
Jennifer Davis

Sponsor

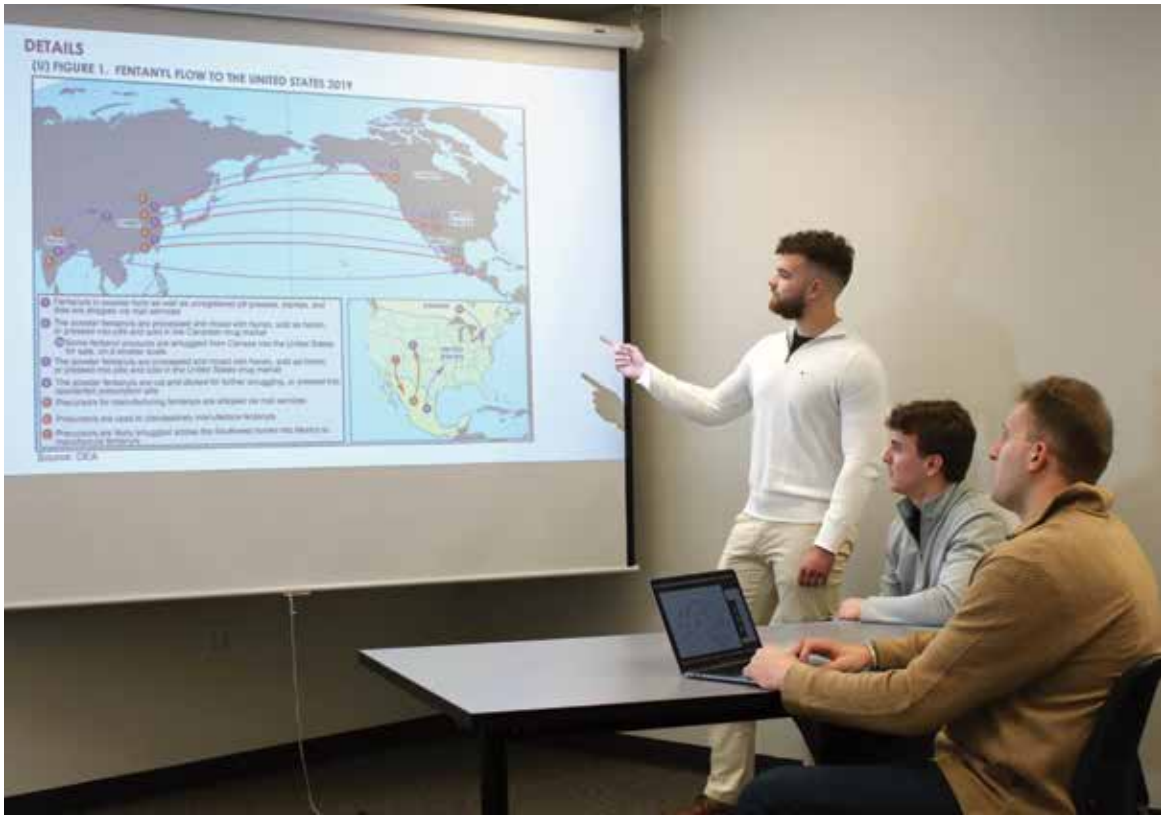
U.S. Department of Defense

The growing geopolitical rivalry between the United States (U.S.) and the People's Republic of China (PRC) raises concerns about the strategic vulnerability of US Artificial Intelligence (AI) defense technologies. The U.S. is heavily reliant on the PRC for critical minerals essential for the development of AI, an advanced technology that is revolutionizing the future of warfare. This has prompted the U.S. to reduce economic interdependence to mitigate vulnerabilities and create robust supply chains.

This project specifically analyzes the vulnerabilities in critical mineral supply chains, the policies aimed at mitigating them, and their implications for U.S. AI competitiveness. AI technologies are vital for advancing U.S. defense efforts by surpassing human capabilities to address evolving threats and proactively prepare for emerging threats from adversaries.

We present a forecast of how likely reduced U.S. dependence on PRC supply chains will significantly impact the competitiveness of U.S. AI technologies by 2027. To formulate our analysis, we use causal loop diagramming, divergent scenarios development, and various structured analytic techniques.

FORECASTING CHINESE AND U.S. COOPERATION ON ILLICIT FENTANYL ENFORCEMENT



Students

RJ Feerick
Sean Stanaway
Chaz Snead

Advisers

Jennifer Davis
Stephen Marrin

Sponsor

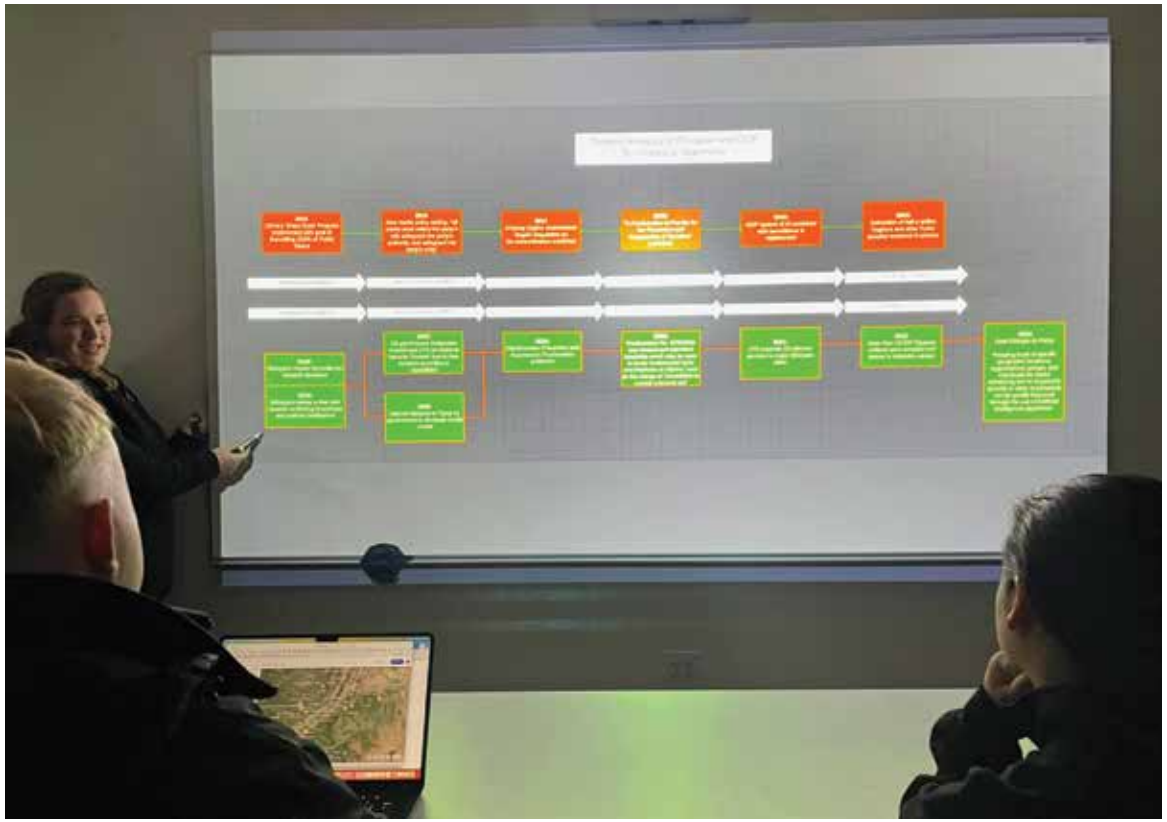
The MITRE Corporation

China is the primary country of origin for illicit fentanyl precursors due to its pharmaceutical and chemical entities. Mexican Transnational Criminal Organizations (TCOs) receive these precursor chemicals to manufacture finished fentanyl, a highly potent synthetic drug. However, there has been a decrease in exported fentanyl from China due to enacted regulations from the Chinese government.

For the past decade, the relationship between China and the United States (U.S.) has declined because of increased tensions and strategic competition, complicating efforts to effectively enforce fentanyl regulations. Nevertheless, improved cooperation between China and the U.S. is attainable because they both share a common struggle with this issue.

"How likely is China to increase cooperation with the U.S. regarding fentanyl precursor enforcement efforts within the next 5 years?" This project, with sponsorship from MITRE, supports efforts to understand the degree to which fentanyl is likely to pose a problem in the future by assessing future cooperation from China to enforce fentanyl precursor shipment regulations. The methodologies utilized in this product are causal loop diagramming, outside-in thinking, and divergent scenario development. These methods benefit the product by displaying possible strategies Chinese entities will adopt, other trends and factors that prompt the issue in the United States, and separate actors that play a role in the manufacturing and distribution of fentanyl.

FORECASTING ETHIOPIA'S ADOPTION OF CCP TARGETING TECHNOLOGY FOR ATROCITIES



Students

Devin Fitzgerald
Morgan Ryan
John Kelly

Advisers

Jennifer Davis
Stephen Marrin

Our project forecasts the likelihood that Ethiopia will adopt technological advances used by the Chinese Communist Party (CCP) to commit crimes against humanity. In doing so, it evaluates technological indicators, systems, and geospatial analysis of at-risk areas in Ethiopia's Tigray region.

The Ethiopian government and the CCP use technology to oppress the Tigrayans and Uyghurs, respectively. Currently, Ethiopian crimes against humanity on the Tigrayans include ethnic cleansing and restriction of aid, in conjunction with ethnic internet access restrictions, internet shutdowns, and media control.

Despite the 2022 Ethiopia-Tigray Peace Agreement's mission of reducing instability, the conflict threatens Ethiopia and the United States' alliance. The Ethiopian government has purchased U.S.-banned, CCP-owned surveillance technology and drafted a bill to legalize altering data and implementing additional surveillance, which mirrors the beginning of the CCP's technological oppression of the Uyghurs. The CCP's use of surveillance technology, including AI, exacerbates the reeducation of Uyghur forced sterilization, human trafficking, and ethnic cleansing. By using system dynamics and the coup vulnerability method, we evaluate the likelihood that Ethiopia will adopt the CCP's oppressive technological advancements in the next five years.

CRACKS IN THE KREMLIN? FORECASTING RUSSIAN REGIME CHANGE THROUGH 2029

Students
Kiara Michael
Brandon Price
Jack O'Grady

Advisers
Jennifer Davis
Stephen Marrin

Sponsor
The MITRE Corporation

The Russian Federation has aggressively pursued anti-Western policies such as its ongoing invasion of Ukraine, which regularly impacts United States interests, specifically the security of its allies and its influence abroad. At the head of the government, and responsible for these policies, is President Vladimir Putin, who has drastically centralized power in Russia during his 20 years and now commands authoritarian control over the nation. Given the immense power of his position and influence on policy, a regime change event, removing him from power, could significantly impact U.S. interests abroad and the security of its allies.

Our project aims to provide an evaluation of several regime change scenarios and analyze their impacts on U.S. interests, along with forecasting the most likely scenario. These scenarios include natural death, military coup, political ousting, and democratization. To complete this project, we are utilizing structured analytic techniques, hypothesis testing, data mining, and counterfactual reasoning.

FORECASTING CHINESE NAVAL EXPANSION IN THE GULF OF GUINEA

Students

Connor Allen
Jason Wiarda
Griffith Bullard

Advisers

Stephen Marrin
Jennifer Davis

Sponsor

National Geospatial-Intelligence Agency

The Department of Defense (DoD) has acknowledged the significant threats posed by an increased Chinese naval presence in the Gulf of Guinea, which will be militarily useful during wartime, allowing the repair and refueling of warships.

The Gulf of Guinea is an important body of water for commercial and military purposes along the western coast of Africa. There has been an uptick in People's Republic of China investment in ports along the Gulf during the 21st century, further enhancing their ability to increase their military presence in the region.

This forecast assesses the likelihood and strategic implications of an increased People's Liberation Army Navy (PLAN) presence in the Gulf of Guinea, preparing the U.S. for possible threats and assessing new Chinese capabilities.

Utilizing open-source intelligence and satellite imagery from Maxar's Global Enhanced GEOINT Delivery, we conducted geospatial analysis on dual-use deep seaports along the Gulf of Guinea. By tracking the development of dual-use ports through time-series analysis, we can monitor the port's developments to assess PLAN capabilities in the Gulf. Employing future-based methodologies, we evaluate a future environment in which the PLAN has increased its naval presence in the Gulf in order to forecast the implications on DoD interests.

STEALING THE SAHEL: FORECASTING RUSSIAN MERCENARY OPERATIONS IN AFRICA

Students
Austin Hayward
Matt Meisner
Laney Snodgrass
Nick Traber

Advisers
Jennifer Davis
Stephen Marrin

Sponsor
The MITRE Corporation

Russian Private Military Companies (PMCs) challenge U.S. interests in a region of growing strategic interest. The Sahel, a region of Africa along the Southern Sahara Desert, now accounts for more terrorism deaths than any other region, including the Middle East. The region is increasingly unstable even as Sahel nations replace the Western allies with Russia as their partner of choice. PMCs are now filling roles previously supported by Western security partnerships. Moscow supports PMCs as a high-return, low-cost option to oppose U.S. diplomatic relations, counterterrorism, and power competition strategies in the Sahel.

This project forecasts Russian PMCs operations to identify potential U.S. partnerships and strategies in a region of growing interest. Three primary driving forces impacting Russian PMC activity are examined. First, the level of support from Moscow is indicated by the changing number of Russian PMCs. Second, the variety of PMC operations grants them flexibility to operate in different nations. Third, the financial motivations that underlie PMC operations in the Sahel, both from host nations and Moscow. The project features Geographic Information Systems to map the activities and presence of PMCs in the Sahel as well as an analysis of causal interactions and case study comparisons.

Through this, the team developed impactful scenarios to forecast how Russian PMC operations in the Sahel are likely to evolve over the next five years.

ADAPTING INTERNATIONAL LAW TO WEAPONIZED UNMANNED AERIAL SYSTEMS

Students

Abbey Glavin
Athena Lambropoulos
Caleb Hubbard
Joseph Altieri
Lauren Poirer
Tyler Guerke

Adviser

John Robinson

Sponsor

The MITRE Corporation

The use of Unmanned Aerial Systems (UAS) in modern warfare is increasing. This project aims to analyze UAS future implications on U.S. military strategy and international legislation. By examining conflicts like the war between Russia and Ukraine and HAMAS attacks on Israel, we aim to understand how UAS are utilized, their ethical implications, their international impact, and their implications for modern warfare. The project employs analytical methodologies such as the quad chart, causal loop diagram, and case studies to provide insights into this evolving issue.

ASSESSING THE WEAPONIZATION THREAT OF SOUTHERN BORDER MIGRATION

Students

Julia Trojanowski
Brendan Bernbaum
Alexandra Posey
Tyler Gray

Adviser

John Robinson

Sponsor

ESRI

Our capstone evaluates the evolving threat of strategic engineered migration and its potential weaponization by Russia to cause political instability in the United States over the next two years. This assessment, sponsored by ESRI, seeks to address the complexities of this emerging national security threat.

We aim to offer our client valuable insights regarding Russia's actions/motives in manipulating mass human migration. Simultaneously, we are developing a comprehensive understanding of the weaponization of this new evolving threat.

To achieve our goals, we are applying a multifaceted approach incorporating causal loop diagramming (CLD), futures analysis, and case studies/data sampling. We provide a thorough understanding of Russia's role in mass migration, connecting past behaviors to potential future scenarios.

Our ultimate research goal is to produce a high-quality intelligence product that offers the Department of Homeland Security with a strategic framework to anticipate, understand, and effectively mitigate the threat of weaponized migration, protecting the United States against potential political instability induced by foreign manipulation of migration patterns.

LABOR TRAFFICKING IN THE GREATER HORN OF AFRICA ALONG THE BELT AND ROAD INITIATIVE

Students
Amanda Acord
Ben Conahan
Soren Scott
Isabelle Robinson

Adviser
John Robinson

Sponsor
ESRI

The question of whether China will extend its labor trafficking practices into the Greater Horn of Africa (GHoA) through the Belt and Road Initiative (BRI) in the next 6 to 24 months, and how the potential impact on U.S. sanctions enforcement is critical to US security.

Forecasting China labor trafficking within African BRI industries is essential to understanding the implications for effective US sanctions enforcement, Chinese economic hegemony, and how it would strengthen PRC soft-power projection over BRI member nations. China heavily invests in industrializing extractive and maritime industries through the BRI, supporting the growth of strategically valuable industries through the acquisition of debt in economically vulnerable nations.

In the GHoA countries, intranational issues such as low median age, low life expectancy, and underdeveloped healthcare exist, but they have critical resources or are in proximity to strategically valuable locations, making these nations vulnerable to becoming targets of potential future Chinese state-sanctioned labor trafficking. Available data and literature have not yet answered the research question and indicate that China has not extended forced labor practices outside its borders. However, the analysis explores how labor trafficking along the BRI project could manifest and identifies African nations at risk of becoming a target of Chinese forced labor practices in the longer term.

ASSESSING SAHEL COUP EFFECTS ON REGIONAL STABILITY

Students
Andrew Britland
Shay Dauphinais
Autumn Tewksbury
Anthony Zampino

Adviser
John Robinson

Sponsor
The MITRE Corporation

Our capstone project addresses the likelihood of recurring military coups in the Sahel region and their impact on U.S. interests and U.S. policy execution within the next 3-5 years.

The analysis encompasses three main focal points: the potential emergence of a terrorist safe haven, the implications of increased adversarial influence, and the ramifications for U.S. economic interests in the region. For example, ISIS/Daesh-affiliated groups maintain a presence in the region and could potentially establish it as their base to conduct attacks against the U.S. Additionally, China has certain exclusivity agreements concerning resources in the Sahel region, which limits U.S. economic opportunities with nations such as Niger and Chad.

The project offers a comprehensive analytical outlook, providing insights into potential scenarios following the recent military coups in the Sahel. We will use case studies, a timeline, scenarios, and data visualization tools to deliver a rigorous and comprehensive answer to our research question. Inherent limitations of our research include the unpredictability of political events, limited data availability, and time restrictions. It aims to equip decision-makers with valuable perspectives to navigate the complex challenges and opportunities in U.S.-Africa relations amidst evolving regional dynamics. For example, it could help in deciding U.S. decisions regarding which countries to trade with and where to establish future military bases.

ASSESSING THE THREAT OF FENTANYL WEAPONIZATION

Students

Dwight Matthias
Tyler Dank
Gavin Abney
Mitchell Sibenik

Adviser

John Robinson

Sponsor

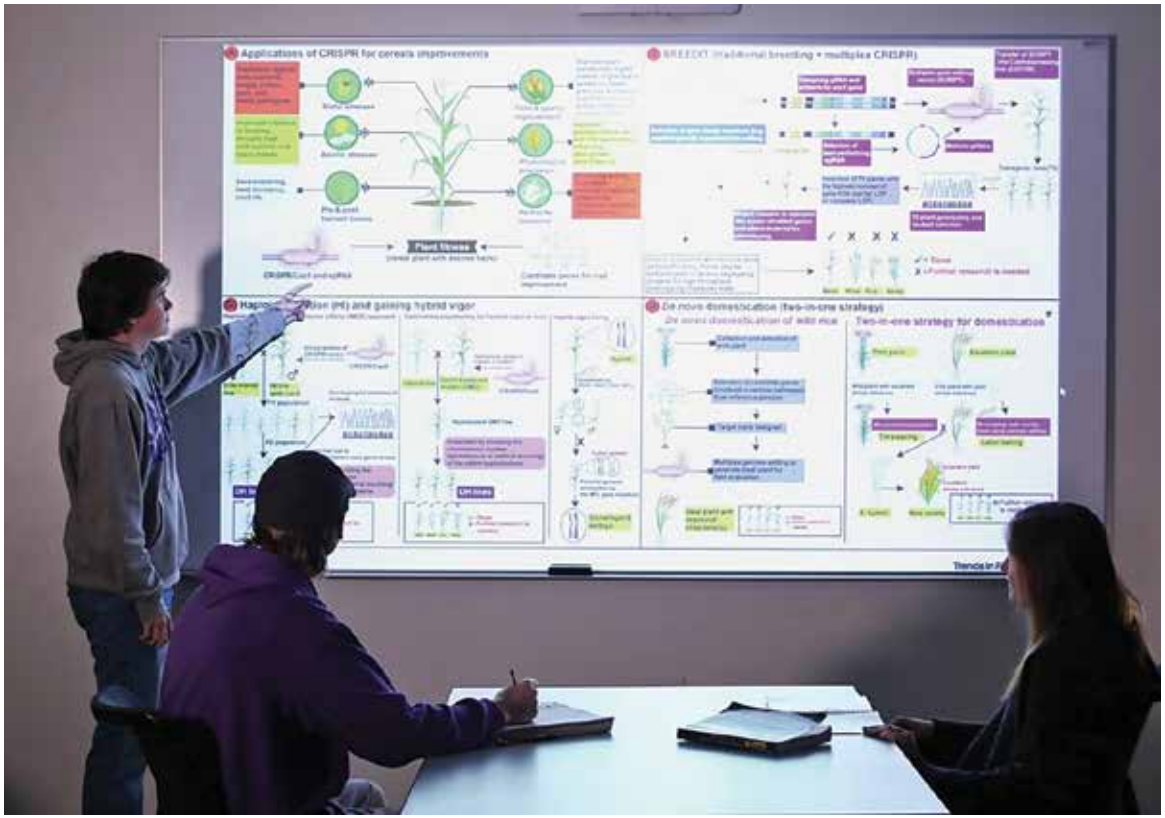
The MITRE Corporation

Our research examines the critical concern raised by the Department of Homeland Security (DHS) regarding the potential weaponization of fentanyl for domestic attacks by 2026. Fentanyl, a potent synthetic opioid, presents a significant challenge due to its extensive availability, the absence of cost-effective detection methods, and its capability for misuse in violent acts.

Our research identifies key factors contributing to this threat and offers essential insights to DHS, aiming to enhance understanding and response strategies to this emerging security risk. In response to the urgent demand for efficient detection technologies, our study aligns with the DHS's goals to counteract this growing threat and lessen the consequences of illicit fentanyl use.

Through a detailed examination of the implicated parties, the associated risks, and proposed interventions, this paper seeks to equip DHS with a comprehensive framework for preempting the weaponization of fentanyl and safeguarding public safety.

EVALUATING THE IMPACT OF PRC CRISPR CROP APPLICATIONS ON U.S. SECURITY



Students

Tyler Peters
Logan Howard
Cora Smith

Adviser

Stephen Marrin
Jennifer Davis

Sponsor

U.S. Department of Defense

China is a global superpower in CRISPR applied sciences, with 890 patents in the last two decades. The People's Republic of China's (PRC) 14th Five-Year Plan prioritizes matching internal food demands amid rising urbanization to decreased arable lands, which has political, military, economic, and agricultural implications for U.S. security. These implications include the PRC's ability to engage in and sustain a military conflict with Taiwan, heightened foreign farmland utilization, and diminished reliance upon U.S. agricultural products. Our project forecasts the likelihood that PRC will use agricultural biotechnology to achieve domestic grain self-sufficiency and investigates the drivers of agricultural trade dynamics, land use expansion, and cropping patterns on U.S. policy making. By evaluating the PRC's economic indicators, including food imports, strategic agricultural resources, and gene-edited soybeans, wheat, corn, and rice production, our research considers the role of food supply in signaling military conflict (or not) and the implications for U.S. product supply and distribution. We employ futures analysis techniques such as scenarios evaluating the likelihood of alternative outcomes. Through causal loop diagrams, divergent scenario development, and ripple effect analysis tables, our analysis more effectively examines the current state of China's use of biotechnology and the role PRC military strategy will play in the future. Further, we engage in change detection analysis of farmlands through remote sensing techniques to identify crop yield advantages of CRISPR technology.

FORECASTING CHINESE ENFORCEMENT OF THE NINE DASH LINE

Students

Abigail Joyce
Ronald Bell
Harry Chu
Andrew Duren

Advisers

Stephen Marrin
Jennifer Davis

Sponsor

National Geospatial-Intelligence Agency

The South China Sea is a historically contested body of water that contains several major trade routes where multiple countries maintain competing territorial and economic claims. China has claimed a majority of the SCS via the Nine Dash Line, a series of dash marks first noted by the Republic of China in 1947.

Our project examines the likelihood and implications of the CCP's capabilities and intentions to deny access to international commercial and military vessels within the Nine Dash Line claim. We selected the next three to five years as our analytic timeframe because CCP priorities and procurement cycles are unlikely to shift at the strategic level within this range. We conducted geospatial and imagery analysis of Chinese capabilities from high-resolution imagery to assess the current state of PLA weapons systems and deployments. Utilizing casual loop diagramming and divergent scenario development, we examine evolving trends and drivers to present a forecast on China's ability to secure the Nine Dash Line.

WATER WARS: FORECASTING THE RISK OF CONFLICT IN THE NILE RIVER

Students

Kayla Koyne
Kristen Lipold
Kendall Kiersey
Sarah Benson

Advisers

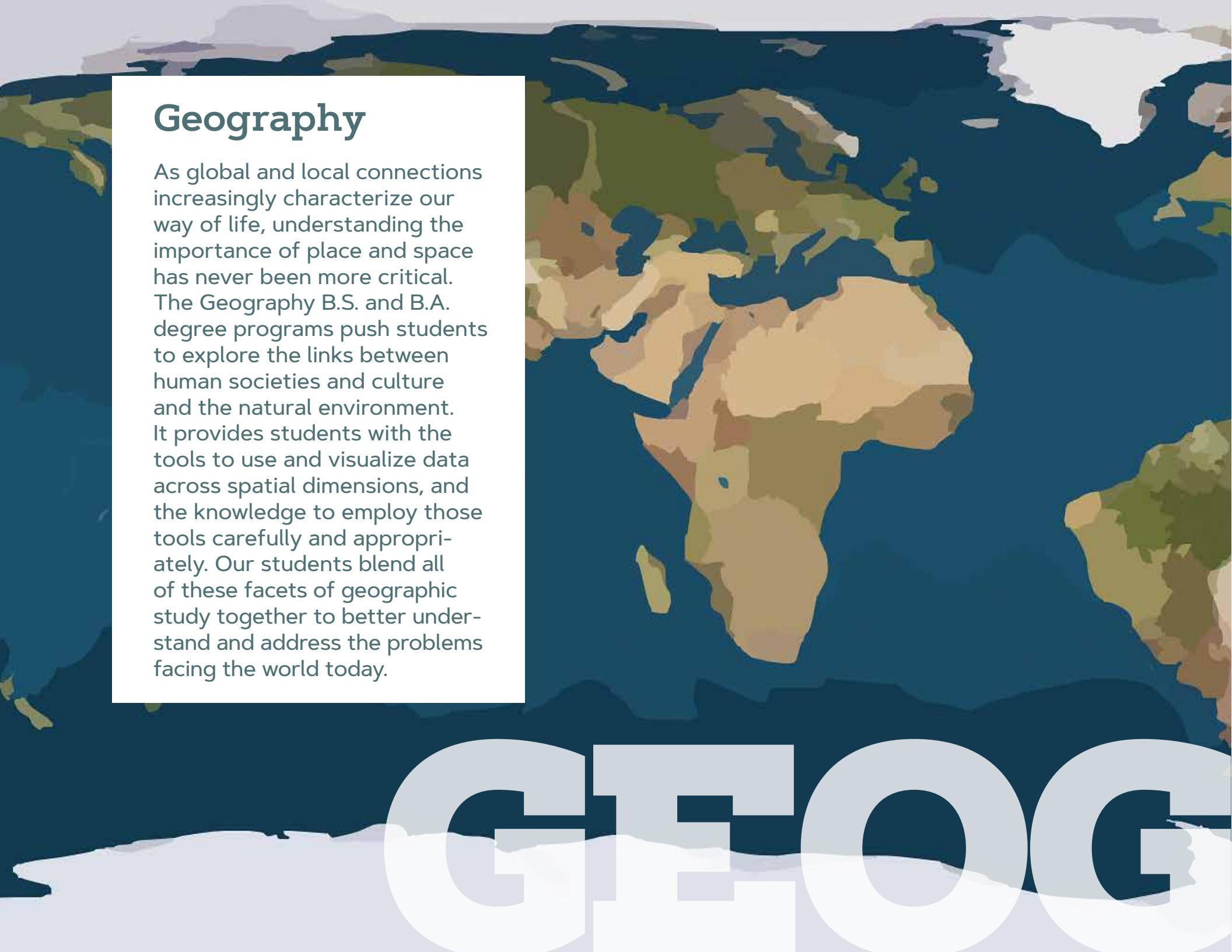
Jennifer Davis
Stephen Marrin

Sponsor

The MITRE Corporation

The Grand Ethiopian Renaissance Dam (GERD) is Ethiopia's newest hydroelectric dam on the Nile River. It currently accounts for 80 percent of water flow to downstream nations, including Egypt. Because the dam was constructed on the Nile in Ethiopia, the Ethiopian government has more power over the regulation of the Nile Waters. Egyptian officials perceive Ethiopia's newfound power along the Nile as a threat to their water security. Recurring diplomatic disputes and military threats between Egypt and Ethiopia regarding the filling and operation of the dam weaken regional stability and foster sentiments of violence. Additionally, the increasing effects of climate change put further stress on downstream nations, due to the fierce competition and uneven distribution of freshwater sourced from the Nile River. The long-standing partnership between the United States, Egypt, and Ethiopia aims to promote stability and international security; however, the emergence of water-based conflicts in the area threatens these goals.

Our project analyzes the likelihood of military conflict between Egypt and Ethiopia within the next three years. We provide an actionable timeline for our sponsor's hypothetical clients, USCENTCOM and USAFRICOM, ensuring the security of U.S. personnel. To accomplish this analytic task, our team employs various methodologies highlighting the causal forces and potential future scenarios arising from this conflict.



Geography

As global and local connections increasingly characterize our way of life, understanding the importance of place and space has never been more critical. The Geography B.S. and B.A. degree programs push students to explore the links between human societies and culture and the natural environment. It provides students with the tools to use and visualize data across spatial dimensions, and the knowledge to employ those tools carefully and appropriately. Our students blend all of these facets of geographic study together to better understand and address the problems facing the world today.

TEMPORAL AND SPATIAL ANALYSIS OF BUTTERFLY DIVERSITY IN HARRISONBURG, VA

Students

Jason Holman
Danny Miller
Dustin Rodriquez
Jacob Vejvoda

Advisers

Amy Goodall
Xiaojing Tang

We analyzed butterfly survey data collected by 34 teams of biogeography (GEOG 340) students during fall semesters from 2017 – 2024. The objectives were to investigate temporal and spatial patterns in butterfly diversity and abundance as reported across 12 study areas in Harrisonburg.

We found that students confirmed observations of 51 butterfly species from 5 families. Species most observed were cabbage white (*Pieris rapae*) and sachem (*Atalopedes campestris*). There were year-to-year differences in abundance of some species including the monarch (*Danaus plexippus*) and common buckeye (*Junonia coenia*).

Through remote sensing, our findings suggest that local and landscape scale habitats are important for butterfly diversity in an urban environment. Study areas with greater butterfly diversity and abundance had a greater density of flowering vegetation and greater connectivity among habitat patches. We report findings and include our methods to filter butterfly data biases and to conduct remote sensing for habitat assessment.

Acknowledgments

Our annual event would not be possible without the generous support of our donors and project sponsors:

4-VA
The Community Tool Box
Degesch America
ESRI
JMU Facilities Management
JMU Institute for Stewardship of the Natural World
John Deere
Jubilee Climate Farm
Madison Trust
The MITRE Corporation
National Geospatial-Intelligence Agency
Northrop Grumman
Punta Leona Hotel and Club
Pure Shenandoah
Society of Automotive Engineering Fellow Wholesome Energy
Town of Tangier
U.S. Department of Defense
Virginia Department of Emergency Management
Virginia Department of Energy
Virginia Department of Forestry

While the names of the family and friends within the School of Integrated Sciences community may not be explicitly mentioned within these pages, their support has been instrumental in the success of these projects. We sincerely thank them for their encouragement, patience, and support along the way.

JAMES MADISON
UNIVERSITY®

School of Integrated Sciences

MSC 4302, 801 Carrier Drive
Harrisonburg, VA 22807
540-568-2740 Phone
sis@jmu.edu
www.jmu.edu/sis

2024