Annual Report 2024

INSTITUTE FOR RESILIENT ENVIRONMENTAL AND ENERGY SYSTEMS

The UNIVERSITY of OKLAHOMA

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CONTENTS

LAND ACKNOWLEDGEMENT

Long before the University of Oklahoma was established, the land on which the University now resides was the traditional home of the "Hasinais" Caddo Nation and "Kirikirʔiːs" Wichita & Affiliated Tribes.

We acknowledge this territory once also served as a hunting ground, trade exchange point, and migration route for the Apache, Comanche, Kiowa, and Osage nations.

Today, 39 tribal nations dwell in the state of Oklahoma as a result of settler and colonial policies that were designed to assimilate Native people.

The University of Oklahoma recognizes the historical connection our university has with its Indigenous community. We acknowledge, honor, and respect the diverse Indigenous peoples connected to this land. We fully recognize, support, and advocate for the sovereign rights of all of Oklahoma's 39 tribal nations. This acknowledgment is aligned with our university's core value of creating a diverse and inclusive community. It is an institutional responsibility to recognize and acknowledge the people, culture, and history that make up our entire OU community."

LETTER FROM THE DIRECTOR

At the close of fiscal year 2024, I find myself immensely proud of the achievements we have made together. With our leadership team, affiliated faculty, student and postdoctoral scholars, and our invaluable supporting staff, we have shaped IREES into a university-wide, transdisciplinary center of excellence focused on real-world challenges in support of the "Environment, Energy, and Sustainability" research vertical described in the University of Oklahoma's "Lead On, University" Strategic Plan and articulated in the Office of the Vice President for Research and Partnership's Strategic Research Framework.

In this annual report, you will read about some of the exceptional collaborative achievements of this past year, including many firsts for IREES and the University of Oklahoma in terms of new collaborative research teams created, new proposals developed and funded, the number and diversity of Oklahoma communities engaged, and the level of direct support provided to OU faculty and the University's research infrastructure. This past year was also marked by an intentional and successful effort to accelerate engagement with Tribal Nations in Oklahoma and OU's Native American student body. IREES directly supported the State of Oklahoma's efforts in its Priority Action Plan and promoted international programs in sustainability and climate change research that, in many ways, truly "Changed Lives."

At this time, I also find myself reflecting on the idea of possibilities. As Oklahoma's flagship university, it is incumbent upon us as an institution to continue to invest thoughtfully and with a sense of purpose. Collectively, we are cultivating an environment in which everyone is empowered to contribute their expertise to push forward the fundamental research and practical applications that will lead to transformational change. Additionally, the research infrastructure we've built together, in the form of new labs, fields sites, and technical support, is enabling new frontiers to be explored in transdisciplinary approaches to solving grand challenge questions. OU researchers have also demonstrated innovation in research and engagement and a nimbleness in adapting to a rapidly changing funding landscape. This year in IREES we met our goals, and I believe we are now in an even better position to fill the gap between our achievements and our aspirations.

In 2024, President Harroz announced that the Lead On Strategic Plan will undergo an evaluation and refresh to mark the halfway point of OU's eight-year strategic plan ensuring the continued relevance and impact of OU's investments. Some of this work is well underway. The IREES community is ready to assist with a revision of the OU Energy, Environment, and Sustainability Pillar, and I look forward to partnering with all of you as we set our sights on what's next.

Regards,

Tim Filley
Professor and Director
Institute for Resilient Environmental and Energy Systems

ABOUT IREES

IREES was established in August 2021 as a university-wide, multi-campus transdisciplinary center of excellence focused on real-world challenges in support of the environment, energy, and sustainability research vertical outlined in the University of Oklahoma's **Lead On, University** Strategic Plan. Our mission is to support the development of inclusive, equitable, and sustainable solutions to critical challenges at the intersection of society, the environment, and energy systems through convergent research, interdisciplinary education, and transformative partnerships.

THREE GOALS

1 Build a culture of convergence

Interacting complexities define today's challenges related to the environment, energy systems, and sustainability. At IREES we focus our efforts on mobilizing a convergence of perspectives, knowledge, and expertise to work on solutions across these key research areas.

2 Grow research projects and programs

IREES research development resources and services span a wide range, from team building to seed funding to project management. Our efforts are focused on advancing research and creative activity and designed to meet the needs of OU researchers.

3 Spark and sustain partnerships

We believe partnerships are built on a foundation of trust. They are reciprocal, and they take time. IREES focuses on creating partnerships that start with a compelling purpose, are integrated into a strong team, and are appropriately resourced.

IREES VALUE PROPOSITION

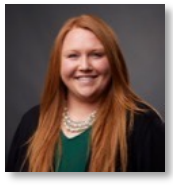
- ☑ **Opportunity**
  Create opportunity spaces for integration and engagement in the Environment, Energy and Sustainability research vertical.
- ☑ **Continuum Of Support**
  Provide parallel effort for rapid response and long-term planning.
- ☑ **Engagement**
  Create and apply new models for local to global engagement.
- ☑ **Infrastructure Investments**
  Supercharge research with infrastructure investments.
- ☑ **Student Experiences**
  Expand student research opportunities and experiences.
- ☑ **STEAM**
  Expand focus on science, technology, engineering and math (STEM) to integrate "arts" into projects and proposals.

MEET THE TEAM

Tim Filley
IREES Director
Professor, DGES and SOG

Steven Crossley
Associate Director
Low-C Energy and Infrastructure
Professor, CSBME

Royce Floyd
Faculty Fellow
Associate Professor, CEES



Mikayla Foreman
Operations Manger

Bruce Hoagland
Faculty Fellow
Professor, DGES

Victor Maqque
LASI Managing Director
Adjunct professor, HIST

Li Song
Faculty Fellow
Professor, AME

Katarina Tsetsura
Faculty Fellow
Professor, GCJMC

Jacqueline Vadjunec
Associate Director
Sustainable Societies
Professor, DGES

Kamisha Walker
Senior Administrative Coordinator and Assistant to the Director

Binbin Weng
Faculty Fellow
Associate Professor, ECE

Xiangming Xiao
Associate Director
Earth Systems and Global Change
Professor, SBS

Undergraduate Research Interns
Donovon Berotte (CEES)
Luke Christensen (CAGS)
Cole Hicks (CEES)
Jordan Jones (CAGS)
Smith Paul (CEES)
Rocky Underwood (CEES)
Bailey Williams (CAGS)
Yang Yan (CEES)

Graduate Student Interns
Adam Anwar (CAGS)
Aliana Head (GCJMC)
Carrie Leslie (CAS)
Nicole Colque Romero (GCJMC)

Postdoctoral Research Associates
Gregory Newman (CAS)
Jorge A. Celis Rodriguez (CAGS)

See Abbreviations Glossary on page 27.

IREES Tribal and Indigenous Advisory Board

M. Alexander Pearl, J.D.
Professor of Law; Citizen of the Chickasaw Nation; nationally recognized scholar in the field of Federal Indian Law.

Jim Collard, Ph.D.
Director, Planning and Economic Development for the Citizen Potawatomi Nation; Co-founder and Chair of the Tribal-Municipal Dialogue; Professor, GCOA.

Tana Fitzpatrick, J.D.
Associate Vice President, Tribal Relations; Director, Native Nations Center; Member of the Crow Tribe of Montana, and a Sioux, Ponca, and Chickasaw descendent.

Victor Maqque, Ph.D.
Managing Director, LASI; Affiliate Faculty, Department of History; Quechua Native from Peru.

The Year in Review

BY THE NUMBERS

13 RESEARCH TEAMS INITIATED

55 AFFILIATED PROPOSALS SUBMITTED

16 EXTERNALLY FUNDED PROJECTS

$194,500
INVESTED IN OU RESEARCHERS & INFRASTRUCTURE

$91.8M
AFFILIATED PROPOSAL SUBMISSIONS

$24.1M
EXTERNALLY FUNDED GRANT AWARDS

47
STUDENTS SUPPORTED

1ST
OU'S FIRST PARTNERSHIP WITH EPA KERR LAB

23
INDUSTRY PARTNERSHIPS

9
NEW MOUs and NDAs

14
TRIBAL NATIONS & INDIGENOUS COMMUNITIES ENGAGED

4
POSITION PAPERS CO-AUTHORED

6
FACULTY FELLOWS

6
INTERNATIONAL SCHOLAR RESEARCH VISITS

13
OKLAHOMA COMMUNITIES ENGAGED

29
WORKSHOPS & SPECIAL EVENTS HOSTED

MAKING PROGRESS

1. Build A Culture Of Convergence Research

Observing and Predicting Earth Systems

Earth Systems and Global Change

Extraordinary advances in science and technology have enabled the collection, storage, and analysis of massive streams of observational data monitoring the Earth's systems, improving our understanding of the impacts of human development across scales. The data show a global environment shifting from a steady-state toward a one that is less predictable, less stable, with fewer natural resources. Addressing this trajectory and guiding society toward a more sustainable, resilient future will rely on our ability to observe, understand, and predict the complex interactions among Earth's coupled systems. Here, we include examples of our efforts to address this challenge using convergence approaches that maximize the social value of our research.

Frontiers in Ecology and Evolution of Infectious Diseases

Infectious diseases outbreaks are emerging at increased rates and with significant impacts on lives and livelihoods around the world. COVID-19, H5N1, H7N9, H5N8, Ebola virus and Zika virus epidemics all resulted in high morbidity and mortality while spreading across borders to infect people in multiple countries. Emergence, transmission, spread, and persistence of infectious diseases in connected pathogen-host-environmental systems is complex and dynamic, as most of these infectious diseases involve multiple hosts and transmission pathways, which are affected by many rapidly changing socio-economic and environmental factors—all highlighting the need for a collaborative, convergence framework for infectious disease research.

Addressing this challenge, a team of international researchers from the U.S., U.K., China, and Israel, led by IREES Associate Director and Professor Xiangming Xiao (SBS), were funded by the National Science Foundation (NSF) to identify and assess major gaps in data, information, and knowledge in the ecology and evolution of infectious diseases. The group also explored advanced modeling capabilities that integrate across prediction of pathogen evolution, host dynamics, and environmental change.

NASA's Terrestrial Ecology Field Campaigns

How are climate change and land-use change impacting the vulnerability and resilience of tropical forests and dryland ecosystems across space and time? This is the overarching question guiding work to scope the next NASA decadal Terrestrial Ecology campaigns. The PAN tropical investigation of bioGeochemistry and Ecological Adaptation (PANGEA) and the the Adaptation and Response in Drylands (ARID) are two scoping projects funded by NASA to work with stakeholders and the remote sensing science community to create a research agenda for the next generation of NASA's Terrestrial Ecology field campaigns. The OU affiliated members, Xiangming Xiao, a member of the core PANGEA leadership team, along with IREES Director and Professor Tim Filley (DGES and SOG) and LASI Managing Director and Adjunct Professor Victor Maqque (HIST) have focused on integrating additional OU expertise into both scoping projects to help define the science questions, geographic domain, and priorities for submission of final proposals to NASA in December 2024.

Global Grassland Ecosystems in Crisis

Constituting almost 40% of the terrestrial biosphere, grasslands provide habitat for a diversity of animals and plants and contribute to the livelihoods of more than 1 billion people worldwide. Climate change and land-use change affect these important ecosystems and a growing number of OU researchers are working to better understand the impacts. IREES has supported 5 research teams in the development of proposals and related activities, including the upgrade of the Kessler Atmospheric and Ecological Field station and contributions to the NASA ARID project.

Co-generating Community Resilience

Sustainable Communities

Two global trends similar in speed, scale, and systems impact are changing the way we live, work, and relate to one another. The first is technology-based. Digitization, artificial intelligence, robotics, advanced materials, 3D printing, and biotechnology are reshaping industries and creating entirely new ones—online learning, genetic editing, e-commerce. The second trend is Earth systems-based. Climate change, resource depletion, loss of biodiversity, and chemical pollution are straining the planet's life-sustaining services. These two trends are tightly linked, and on their current trajectory, they are neither sustainable nor equitable. Here we include examples of how IREES is connecting stakeholders and scholars in research endeavors that seek to understand the multiple interacting dimensions of transformational change.

A Research Coordination Network in Sustainable Communities

Despite losing nearly 32 million acres since 2012, the Great Plains hosts some of the most intact remaining grasslands globally and is considered the "Bread Basket" of the U.S. and World. This complex socio-ecological system (SES) which houses diverse peoples is at risk, exacerbated by threat multipliers linked to climate change. With a grant from the NSF, IREES Associate Director and Professor Jacqueline Vadjunec (DGES) is building a community of practice for co-producing resilient socio-ecological systems in grasslands. The project will advance knowledge gaps in multiple transdisciplinary and convergent literatures around resilient SES that include climate change as a threat multiplier, holistic water and land systems studies, and coproduction and adaptive management for increasing community resilience.

Developing Oklahoma's Priority Climate Action Plan

With funding from the U.S. EPA, through the Oklahoma DEQ, a team of 15 OU researchers and students helped develop a statewide Priority Action Plan (PAP) in partnerships with scientists at DEQ. The goal of the Climate Pollution Reduction Grant (CPRG) to OU, led by Tim Filley along with Professors Scott Greene (DGES), John Harrison (GCOA), and Lauren Mullenbach (DGES), was to identify and meaningfully engage low income and disadvantaged communities in Oklahoma that have a stake in GHG reduction to support creation of the PAP. The team identified 27 tracts with the highest vulnerability to climate and environmental risks, and engagement efforts were centered on these communities. Focus group sessions and survey responses showed that Oklahoma's low income and disadvantaged communities experience climate impacts in serious ways that are negatively impacting everyday life. Survey data, fielded and analyzed by graduate students in OU's Regional + City Planning Program indicate 91% of respondents think about local environmental challenges and the impact on their community at least daily to weekly. Of most concern are extreme heat events, severe weather, drought, high energy costs, and increasing power outages. See page 21 for more details.

Heat Watch in Oklahoma City

IREES staff and affiliates joined other local partners to complete a heat mapping campaign organized by the OKC Office of Sustainability. In this endeavor, OKC was one of 18 cities worldwide collecting data for NOAA's Urban Heat Island Mapping Campaign. Volunteers collected thousands of ground-level temperature and humidity data points in a long, hot day on August 12th, 2023. These data were documented in a report produced by the OKC Office of Sustainability and used to create a guidebook outlining heat mitigation and adaptation strategies for OKC communities.

Waste carbon-based emissions from energy and infrastructure systems are among the largest sources of greenhouse gases that are contributing to climate change. The impacts of climate change—increasing heat extremes, changing rainfall patterns, rising sea level, declining snowpack, and worsening air quality—are, in turn, increasing the vulnerability of our critical infrastructure. The IREES community of scholars combines their expertise with external partners and stakeholders to drive innovation, better understand decision-making, and accelerate implementation of solutions. Here are a few examples of efforts in this area.

OK Tribal Clean Energy Summit and Symposium

With the goals of relationship building and information sharing, IREES co-hosted the first Oklahoma Tribal Clean Energy Summit and Symposium on September 27-29, 2023. Convened in partnership with Oklahoma State Senator Mary Boren, the OU Office of the Associate Vice President for Tribal Relations, and the OU Native Nations Center, the Summit was designed as a Nation-to-Nation discussion exploring how Tribes can harness clean energy to enhance energy sovereignty, address climate resilience, and build stronger economies. The accompanying symposium highlighted OU expertise across the clean energy space with poster sessions, tours of clean energy laboratories, one-on-one engagement, and networking events with Tribal representatives. The events brought together representatives from seven Tribal Nations, local sustainability-focused community organizations, and over 25 OU faculty and students presented posters on clean energy technologies, examples of existing OU-Tribal Nation energy partnerships, and perspectives on co-creation of energy solutions.

Great Plains Catalysis Society Fall Symposium

Led by IREES Associate Director and Professor Steven Crossley and in partnership with OU's School of Sustainable Chemical, Biological and Materials Engineering, IREES co-convened the 2024 Great Plains Catalysis Society (GPCS) Symposium on August 23-24, 2024. The GPCS is a local chapter of the North American Catalysis Society and seeks to promote fellowship and collaborations among the chemists, chemical engineers, material scientists, and other scientists in the Great Plains region who are interested in catalysis and related fields. At the symposium over 150 participants from across the region gathered at OU to present the latest in research on the role of catalysis in the changing energy and materials landscape with a thematic emphasis on sustainable catalysis, electrocatalysis, oxide and zeolite catalysis, the net zero transition, and upcycling plastics and biomass. Additionally, a special session was convened in honor of the career achievements of OU Professor Daniel Resasco in catalysis and carbon-based nanomaterials.

Reducing Methane Emissions

The Inflation Reduction Act provides new authorities under the Clean Air Act to tackle methane emissions from the oil and natural gas sector through the creation of the Methane Emissions Reduction Program (MERP). Oil and natural gas facilities are the nation's largest industrial source of methane, a GHG more potent than carbon dioxide and responsible for approximately one third of the warming occurring today. IREES convened a series of teaming workshops including a day-long event with the Western Oklahoma Tribal Environmental Coalition to discuss and develop proposals to the MERP. In collaboration with DISC, two IREES affiliated proposals were ultimately submitted to the DOE including one focused on creating a University-Community-Industry-Tribal Nation Collaborative to understand and reduce emissions and impacts of methane and co-emitted chemicals for the environmental, health, and economic sustainability of disadvantaged communities.

A Cross-Cutting Research Platform

Latin America Sustainability Initiative

The Latin America Sustainability Initiative (LASI) is a cross-cutting IREES program developed to catalyze, support, and scale collaborations with partners in Latin America to address complex environmental, human health, and societal challenges across the Western Hemisphere. LASI connects universities, companies, research institutions, non-profit organizations, and government entities to identify sustainable development challenges and build interdisciplinary, inclusive teams to work on solutions that improve human well-being and the environments in which we live.

Actionable Information for Climate Security in Latin America

A new project led by Associate Professor Kathy Pegion (SOM), and funded by an OVPRP BIC 2.0 grant, explores the challenge of climate change as a threat multiplier to global security. BIC 2.0 grants are intended to incentivize the formation of convergent research teams focused on global grand challenges with high potential for future extramural support and significant societal impact—this project is well positioned to meet both expectations. The project team includes researchers with expertise in regional weather, geography, politics, and cultures, and leverages LASI's extensive network of governmental and university partnerships in Peru and Brazil. Using sub-seasonal to multi-year weather-climate forecasts the researchers aim to improve understanding of the current and near-term impacts of climate change on the vulnerability of food, energy, and water infrastructure, while working towards developing a co-production framework to reduce insecurity within impacted communities.

A Sustainable Lake Titicaca

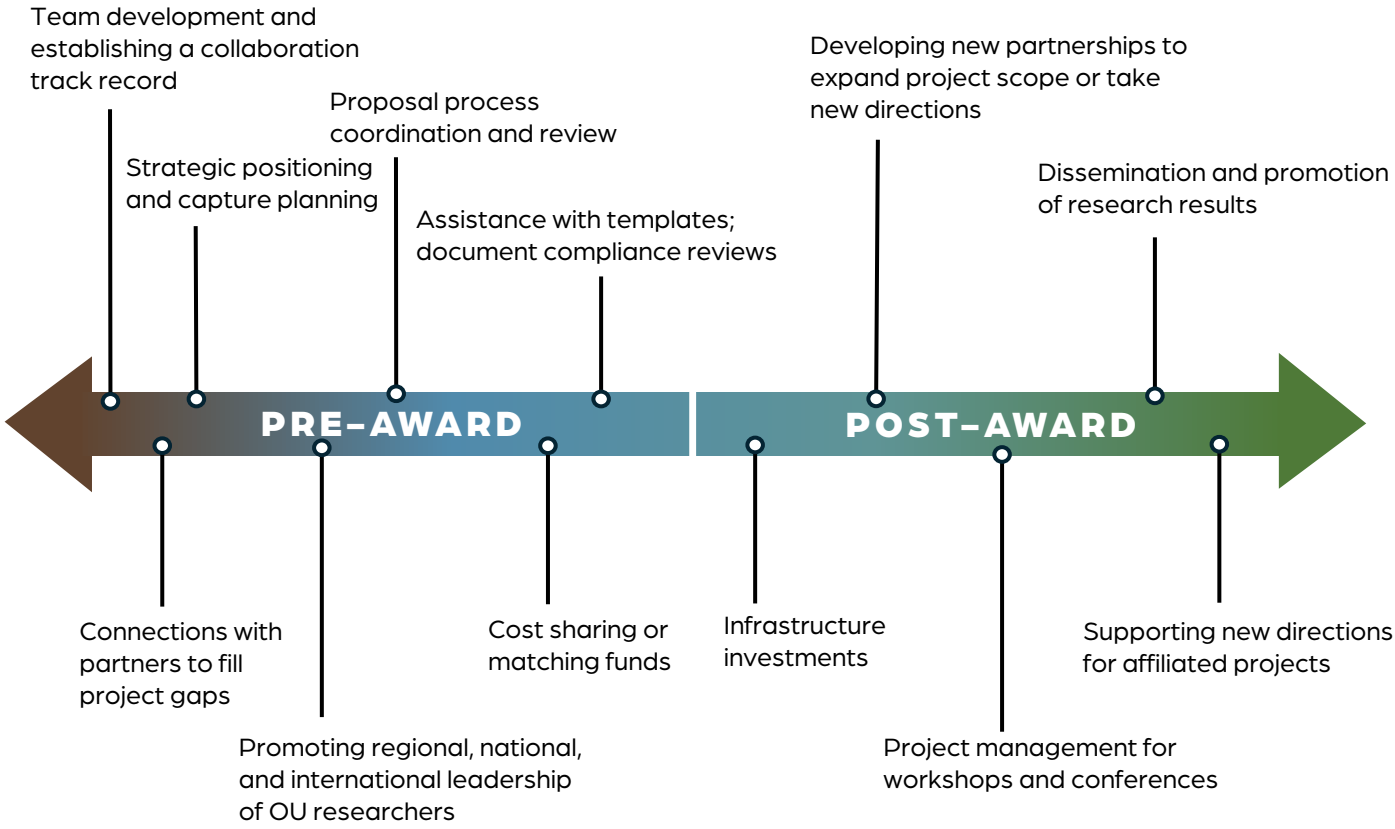
Lake Titicaca is the largest freshwater lake in South America and sits at the highest elevation (at 12,850 feet) of the world's large lakes. It is a critical food and water resource to the growing coastal cities of Puno and Juliaca. However, the diverse terrain and ecology, regional population growth, and the rich mineral reserves and biodiversity of the Lake Titicaca Basin (LTB) present both challenges and opportunities to the development of the Region of Puno, particularly in the context of changing pressures from economic, climate, and environmental drivers. A new 3-year project integrating the expertise of OU faculty from DGES (Yang, Hoagland, and Filley), CEES (Vogel and Hong) and DFCAS (Maqque) with faculty from the Universidad Nacional del Altiplano in Puno (UNAP) has been recommended for funding. The project will explore collaborative research projects with the goal of building research capacity at UNAP and co-creating a conceptual framework for research infrastructure to support sustainable environmental management of the LTB.

The Global Change and Human Health Institute: Phase 2

In partnership with the OU Office of Research Services, IREES conducted an internal request for proposals for a funding opportunity created by the Universidad Nacional de San Agustin (UNSA) of Arequipa, Peru. The funding opportunity sought new research and capacity-building projects in support of the Global Change and Human Health Institute (GCHH)—a bilateral research and capacity-building ecosystem housed at UNSA and designed to facilitate collaboration between the University of Oklahoma and UNSA. The GCHH was established in 2021 and is jointly administered by the Office of the Vice Rector for Research at UNSA and IREES. Research projects supported by the GCHH are focused on three key areas: building resilience to climate change, advancing One Health, and designing adaptive social systems. Six collaborative, multidisciplinary projects were recommended for funding.

2. Grow Research Projects

IREES provides OU researchers with proposal and project development support for large-scale, interdisciplinary, and transdisciplinary opportunities with an emphasis on using a convergence framework to advance understanding of the complex, dynamic interactions of people and the planet, train the next generation of resilience researchers and leaders, and engage in collaborations with change makers.



LASI Connections and Team Building

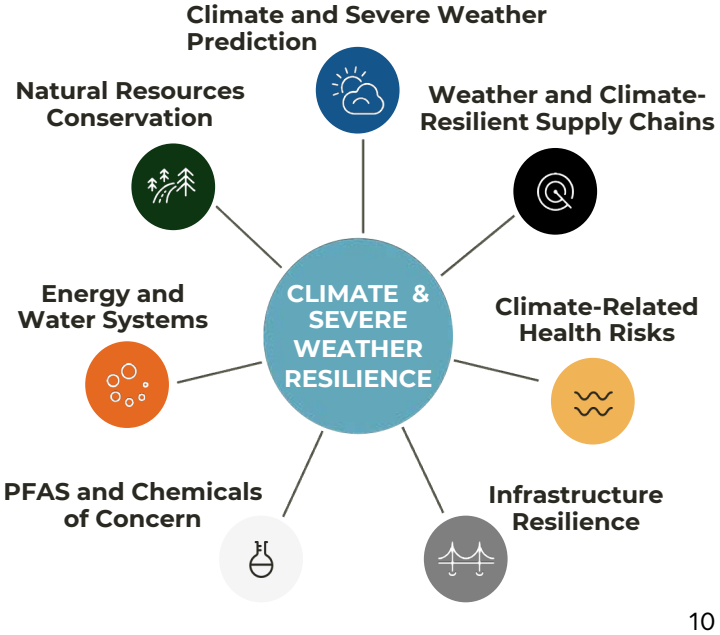
OU's expertise in weather and climate prediction, co-production, and LASI's extensive network of governmental and university partnerships in Peru and Brazil were brought together to investigate the current and near-term impacts of climate change on security risks in Latin America. The research team, funded by a BIC 2.0 grant and supported by IREES, will explore specific risks related to food, water, and infrastructure security. LASI hosted remote research development meetings and led a visit to Peru to connect the U.S. team with research partners at Piura University and Peru's Institute of Geophysics.

A First: Partnership with the EPA Kerr Lab

Members of the IREES leadership team are working with Professor Robert Nairn (CEES) and Dr. Saba Tahmassebi, director of the EPA's Robert S. Kerr Environmental Research Center lab in Ada, Oklahoma to create a framework agreement that will enable greater OU-Kerr Lab collaboration. With help from OU's Office of Corporate Partnerships and Regional Economic Development, an MOU is in review and will outline the details of this first-of-its-kind relationship with the Kerr Lab.

Toward Climate Readiness

IREES works closely with government relations firm Lewis Burke and Associates to identify and promote opportunities for OU. This year, in collaboration with OADII, IREES facilitated the creation of seven research teams focused on developing research projects in support of enhancing military installation resilience and addressing threats to operational and war readiness. Guiding all seven teams is the understanding that climate change is an urgent and growing threat to national security, with far-reaching impacts both domestically and internationally.



Convergent Clean Energy Research in Support of Tribal Nations

A two-day, invitation-only workshop led by the Navajo Technical University and supported with funding by NSF, was convened in March 2024 in Santa Ana Pueblo, New Mexico to co-create a research and workforce development agenda supporting clean energy transitions in Tribal communities. Tim Filley attended the workshop and contributed to the subsequent white paper outlining challenges and opportunities that Tribes encounter, and a research agenda to address the challenges and capitalize on the opportunities going forward.

Workshop on Frontiers in Ecology and Evolution of Infectious Diseases

An international workshop, supported with funding from the NSF and led by Xiangming Xiao, brought together leading researchers from the U.S., U.K., China, and Israel to review progress, identify gaps, and discuss priorities for joint collaborations in areas related to the ecology and evolution of infectious diseases. IREES provided project management support for this two-day workshop held at the Wellcome Trust, London, United Kingdom in March 2024.

SEED FUNDING CONVERGENCE RESEARCH TEAMS

To encourage cross-institute collaborations and convergence research approaches in the environment, energy and sustainability research vertical, IREES collaborated with DISC, ICAST, and SPTC to seed-fund four new projects in 2024. IREES provided nearly $52,900 for teams investigating socio-ecological systems (SES), including those focused on weather and climate-related threats to SES, nature-based solutions, and development of bio-based energy and products. Often, a modest amount of internal funding can help researchers get projects off the ground and collect preliminary data to secure external funding. It can also provide opportunity for investigators to explore approaches that may be unfamiliar (convergence) or high-risk/high-reward.

A Deep Learning Approach to Identify Irrigation in the High Plains Aquifer (HPA) and Quantify Hydrological Dynamics

The world's drylands are home to ~2 billion people and provide multiple key ecosystem services, not least among them supplying food and fiber to the world. In these regions, agriculture is fraught with vulnerabilities associated with infrequent, seasonal, and highly variable precipitation, cyclic drought, and land degradation. One method used to decrease vulnerability while increasing agriculture productivity in these ecosystems is irrigation. While helping "drought proof" agricultural operations and expanding the production of crops once limited to wetter climates, adverse ecological effects accompanied the deployment of irrigation technologies and subsequent land use/land cover changes, among them groundwater drawdown, soil salinization, changes in surface water flow, waterlogging, changes in biogeochemical cycles, and even alterations in local and regional climate. Despite these ongoing changes, accurate estimates of the quantity and distribution of irrigated lands and, more specifically, center pivot irrigation technologies, in the HPA are limited. In this seed project, led by Lecturer Todd Fagin (DGES and CSA) and Professor Jason Vogel (OK Water Survey, CEES), the research team will expand on fifteen years of socio-ecological research in the Southern Great Plains to refine deep learning models trained with remotely sensed data to estimate extent of irrigation in the HPA over the past 20 years. The work will produce a robust data set and improve understanding of dryland land use/land cover dynamics that is paramount to fostering socio-ecological resilience in these ecosystems.

The HPA is the largest aquifer system in the U.S., underlying 174,000 square miles and bisecting 237 counties across eight states. The region is among the most productive cropland areas in the country.

Structural Health Monitoring For Shear-critical Prestressed Concrete Girders

All elements of a bridge—from footings and foundations to beams and girders —are expected to deteriorate over time, but in many regions, climate change is causing them to age prematurely. Through advanced sensor technologies, data analytics, and predictive modeling, structural health monitoring (SHM) systems can detect potential structural issues in bridges in the early stages of damage in structures. A seed project led by Associate Professor Jin-Song Pei (CEES) and Professor Dean Hougen (CS) will apply a state-of-the-art SHM that uses machine learning to study shear-critical prestressed concrete girders in the five-state region supported by the Southern Plains Transportation Center, a hub for weather-related infrastructure expertise.

Producer Knowledge and Perceptions of Biochar: Improving Soil Health and Combating Invasive Eastern Red Cedar in Rural OK

Biochar is a multi-purpose, multi-benefit bio-based product created through the pyrolysis of biomass. Its use as a soil amendment increases soil health and retains water. When properly applied to land, biochar can be a powerful carbon sequestration tool that also mitigates the effects of floods and droughts. It can be made from agricultural wastes as well as invasive species, contributing to material upcycling as well as ecosystem restoration. Biochar can be made on-site by agricultural producers with relatively inexpensive and easy to use equipment. In a project led by Assistant Professor Lori Han (CEES), the research team will conduct focus groups and a pilot survey with the goal of better understanding agricultural producer knowledge and perceptions of biochar, with the central objective of discovering the barriers to adoption of this nature-based solution.

Developing an OU Microplastic Research Center

Microplastics (MPs), polymeric contaminants ranging in size from 1-5000 microns, originate from the physical and chemical decay of polymers used in every aspect of modern life. The current state of knowledge regarding MPs is that they are pervasive, persistent, and a highly heterogenous contaminant varying in size, morphology, and chemical composition. MPs can adsorb organic chemicals, heavy metals, bacteria, and viruses thereby making MPs a transport vector for these contaminants. It is also known that these physical, chemical, and microbial parameters can cause MPs to detrimentally target specific ecological or biochemical processes. Led by Assistant Professor Tingting Gu (CEES), the research team will focus on filling two research gaps: standardizing extraction methods for MPs in complex samples and developing a high throughput analytical method for quantitative characterization of MP concentration, size, morphology, and composition. In parallel, the team will expand the group with experts in remote sensing and microbiology.

3. Spark and Sustain Partnerships

Partnering with Native Nations and Tribal Communities

Native American Indian Tribes in the U.S. hold unique status as sovereign, self-governing nations. While the meaning of energy sovereignty varies among Tribes, there is a growing consensus on the importance of renewable energy technologies in building an energy system that aligns with Tribal cultural values, supports economic goals, and reinforces Tribal self-determination. Tribal communities are also among the most vulnerable to climate change and legacy environmental degradation. As the IREES research community works to build the capacity to anticipate, manage, and drive change for a more sustainable, inclusive and prosperous future, we believe guidance from and partnerships with Tribal Nations and those with Tribal identity is essential. The following examples illustrate some of the activities we have recently undertaken.

- IREES co-convened the **Oklahoma Tribal Clean Energy Summit and Symposium** (September 27-29, 2023) in partnership with Oklahoma State Senator Mary Boren, the OU Office of the Associate Vice President for Tribal Relations, and the OU Native Nations Center. The events were designed as a Nation-to-Nation discussion exploring how Tribes can harness clean energy to enhance energy sovereignty, address climate resilience, and build stronger economies; and an introduction to the OU energy research community.
- IREES hosted members of the **Muscogee (Creek) Nation** (January 11, 2024) Office of Environmental Services for a day long visit that included tours of labs/facilities and a working lunch to outline research interests and potential collaborations leading to multiple collaborative proposals and OU participation in the advisory of the Muscogee Creek Nation EPA CPRG proposal.
- IREES and the **Kiowa Tribe** Office of Natural Resources established biweekly research engagement meetings beginning in October 2023 to explore research opportunities related to challenges from legacy oil and gas infrastructure. The team from the **Kiowa Tribe** visited OU (March 8, 2024) for a half-day visit focused on tours of labs focusing on near surface geophysics labs, gas monitoring, stable isotopes and and biogeochemistry, and well integrity.
- IREES director Tim Filley participated in the **Workshop on Convergent Clean Energy Research in Support of Sovereign and Prosperous Tribal Nations**, a two-day, invitation-only workshop led by Navajo Technical University and convened in Santa Ana Pueblo, New Mexico (March 2024). The workshop participants worked to co-create a research and workforce development agenda supporting clean energy transitions in Tribal communities and published their recommendations in a white paper.
- At the invitation of the Inter-Tribal Environmental Council, Tim Filley co-designed a panel discussion on collaboration and partnerships for climate pollution reduction grants at the **27th Annual Tribal Environmental Summit** held in Tulsa, OK (April 17-19, 2024).
- IREES hosted a group of 15 students and faculty from the **Pawnee Nation College** (May 6, 2024) to discuss soil health and toolkits form carbon monitoring as part of a project led by OU Assistant Professor Dianna Denham (DGES).
- IREES convened a day-long workshop with the **Western Oklahoma Tribal Environmental Coalition** (July 29, 2024). Members from the Kiowa Tribe, Caddo Nation, Fort Sill Apache Tribe, Delaware Nation, Cheyenne and Arapaho Tribes, Wichita and Affiliated Tribes, and the Apache Tribe of Oklahoma participated in a day-long workshop focused on the DOE Methane Emissions Reduction Program funding opportunities. The workshop included time for tours of key research laboratories and facilities.

Partnering for sustainable, responsible, and productive development of critical resources

The Chilean mining firm SQM has partnered with IREES in a collaboration aimed at discovering more sustainable, responsible, and productive ways to harvest critical resources driving the global economy while also preparing students for rewarding, impactful careers. The partnership with SQM, a global leader in industries critical for sustainable development, was launched in September 2023 with a Mutual Recognition Agreement outlining the partnership.

The first joint venture, funded in February 2024, is exploring challenges related to the production and purification of nitrate and iodate. These soluble salts that accumulate almost exclusively in the arid environments of Chile's Atacama Desert are extracted as high salinity brines which are particularly difficult to analyze due to the highly corrosive nature of these kinds of aqueous solutions. This complicates real-time, inline monitoring of solute concentrations within the production process.

A NOVEL TECHNOLOGICAL APPROACH

To overcome this challenge, a new Raman spectroscopic method developed by Professor Megan Elwood Madden's (SOG) research group will be used to measure trace amounts of solutes within extremely salty brines, even in solutions made of more than 50 weight percent salt. If the team can achieve high enough analytical sensitivity with the method, the next step would be to install optical windows into the pipes at the production facility and collect Raman spectra through the window with a fiber optic Raman spectrometer. These windows, made of Raman transparent material, would allow SQM to directly monitor solute concentrations in the flowing brines within the plant in real time, helping to conserve water and other resources while also producing a purer product.

NEXT STEPS

This new partnership with SQM is an exciting addition to the portfolio of IREES-initiated projects that supports development of resilient solutions to sustainability challenges. With broad and deep expertise across the Earth and environmental sciences and engineering, and particular strengths in geochemistry and mineralogy, soil science, microscopy, hydrology, and industrial systems engineering, we are exploring projects that could help SQM develop more efficient mining processes, initiating scientist exchanges between SQM and OU, and working to facilitate stronger collaborations and other opportunities for innovation. We are also co-developing study abroad and internship programs for OU students. These high-impact learning opportunities would allow students to become immersed in Chile's natural resources and sustainability issues while gaining real-world work experience with a global leader in sustainable, responsible, and resilient development of critical mineral resources.

PHOTO ABOVE: SQM representatives visit OU.

9 NEW MOUs DRAFTED

- EPA's Robert S. Kerr Environmental Research Center Lab, Ada, OK
- SQM Corporation, Santiago, Chile
- Muscogee Creek Nation, Okmulgee, OK
- Kiowa Tribe, Carnegie, OK
- Universidad Politecnica de Madrid, Madrid, Spain
- Universidad Nacional de Trujillo, Trujillo, Peru
- Universidad Nacional Jorge Basadre Groghmann, Tacna, Peru
- Universidade Federal do Oeste do Para , Para, Brazil
- Universidade Sao Paulo, Piracicaba, Sao Paulo, Brazil

6 INTERNATIONAL SCHOLARS HOSTED

- Yony Chavez, UNAP, Peru
- Antonio Florentino, CENA, Brazil
- Yuri Arevalo, UNALM, Peru
- Ruby Vega, UNALM, Peru
- David Briceno, UNALM, Peru
- Nana Wu, Shenyang Jianzhu University, China

Spark and Sustain Partnerships

Strategic Partnerships for OU in Brazil

The tropical forests of Brazil's Amazon play a critical role in the global carbon cycle. Climate change and large-scale land use and land cover changes have altered the region's carbon balance, with potential impacts to the global climate as well as South America's hydrological cycle. IREES, in collaboration with OU's Center for Brazil Studies and School of Meteorology helped support two delegations of OU faculty to Brazil (July 2023 and May 2024) to engage international teams of scientists, state and national agencies with the goal of outlining joint research studies aimed at protecting and understanding threats to the Amazon rainforests. Professor and CAGS Dean Petra Klein (SOM), with Professors Otavio Costa Acevedo (SOM), Victor Maqque, Xiangming Xiao, Fabio Costa Morais de sa Silva (CIS), and Tim Filley traveled to Brazil and developed collaborative research agreements with the Federal University of Western Para, the University of Sao Paulo, the Ministry of Agrarian Development, EMBRAPA (Brazilian Agricultural Research Corporation) and the National Institute for Amazon Research. Additionally, members of the team took part in a joint NASA/NSF workshop in Manaus, Brazil, on impacts of unusual weather events and climate anomalies on the Amazon rainforest, co-lead by Otavio Costa Acevedo.

The AndesFlux Western Amazonia Connection

Peru's rainforests hold some of the greatest biodiversity on Earth and one way to determine how these tropical forest ecosystems respond to climate and land use disturbances is to assess how they flip between being sources or sinks of carbon to the atmosphere. Doing so requires a detailed accounting of carbon dioxide and methane over large spatial scales using advanced monitoring systems called flux towers. Along the western Amazon, Ponitifica Catolica University maintains four high precision, 50-meters tall gas flux towers (AndesFlux). The AndesFlux principal investigator, Professor Eric Cosio, shown above, invited OU Professors Filley and Xiao to one of the tower sites in Tambopata, Peru. Over a week-long visit in July 2024, they discussed adoption of OU research methods, data sharing, and collaborative proposal development. A trip is scheduled for late 2024 to visit the AndesFlux tower in San Martin, Peru which is near the OU PERU Hub research sites to explore linking the two project's goals.

Expanding Stable Isotope Measurement Networks

Linking existing monitoring and analysis capability across Peru is a key LASI strategy designed to enable leading-edge modeling of ecosystem processes and responses to climate and land use change in the Andes and the Western Amazon. In partnership with the Universidad Nacional de San Agustín de Arequipa (UNSA) and Pontifica Catolica University (PUCP), LASI is working to create a network of environmental stable isotope analysis facilities that links OU's Stable Isotope Measurement Facility (SIMF), the UNSA Stable Isotope Lab (LABISOP) and the new stable isotope and food quality monitoring laboratory of the Center for Productive Innovation and Technology Transfer Centers (CITE) which is part of Peru's Ministry of Production. CITE promotes innovation and encourages the use of new technologies among producers, companies, associations and cooperatives. An agreement between CITE, PUCP, and OU is being drafted which will include open access of CITE instrumentation to regional university-led climate and environmental monitoring research, building capacity to monitor climate impacts to food security in Peru's Ica valley.

Supporting NASA PANGEA in Peru

LASI leadership was invited to attend a 2-day workshop (June 3-4, 2024) in Lima, Peru to support networking and integration of existing monitoring and research sites in Peru into the framework of the NASA PANGEA proposal (see page 5). The purpose of the workshop, co-hosted by Pontificia Universidad Católica del Perú, the Governors' Climate and Forests Task Force, and the University of California, Los Angeles, was to share information about the scoping process with the Amazonian research community early enough in the process for feedback and engagement. The workshop sought to engage with regional and national civil-servants, practitioners, and scientists from Amazonian countries to determine research priorities for end-user needs in tropical communities, solicit feedback on the campaign design, including the science questions and geographic scope, and identify and discuss existing efforts that align with the potential campaign. Filley and Maqque presented opportunities related to integrating work from their exiting USAID-funded PERU Hub grant in the Amazonian region of San Martin, Peru.

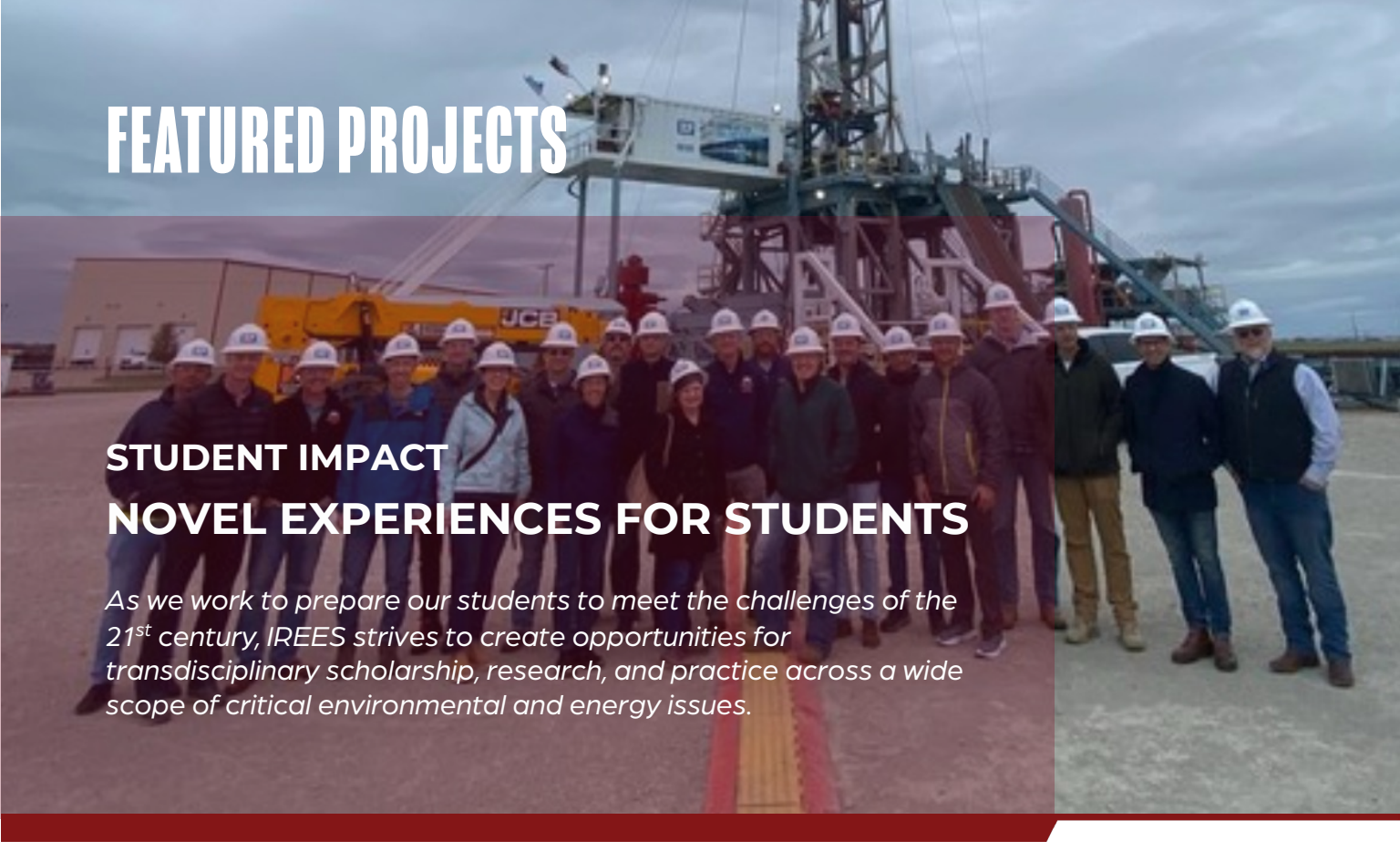
Oklahoma Career Tech Centers

Oklahoma's system of 29 career and technology education center districts, part of the Oklahoma Department of Career and Technology Education, improves Oklahoma's economy by offering individuals the training and skills necessary to be successful in the workplace, providing companies with the workforce necessary to compete globally, and anticipating future workforce needs of the state. In FY 24 IREES maintained its close affiliation with the career techs to address emerging industry needs in environmental, fugitive natural gas, and meteorological monitoring by creating a workforce development program for urban, rural, and Tribal nation communities in support of several U.S. DOE proposals submitted in a collaboration between IREES and DISC. In the photo to the right are CEO and Superintendent Gayla Lutts, campus director Jennie Croslin, Director of Business & Industry Services and Workforce Development Angie Lewis, IREES Director Tim Filley, IREES graduate student intern Carrie Leslie and IREES Faculty Fellow Binbin Weng.

OU–UNSA Research Infrastructure Partnerships

As part of the long-standing relationship between OU and the National University of San Agustin of Arequipa (UNSA), Filley has served as advisor to the development of research infrastructure at UNSA. In the summer of 2023, Filley was appointed co-director of the new stable isotope measurement facility, LABISOP, a facility he co-designed with UNSA professor Juan Lopa (Chemistry). Additionally, he was appointed as an honorary senior faculty scholar in the UNSA Department of Chemistry. In September 2024 LABISOP was officially opened as a core facility in the new five-story Center for Applied Research and Specialized Laboratories (CIALE) building. CIALE is home to 24 new laboratories dedicated to the development of knowledge and technological innovation – a $20 million public-private partnership project. The building was inaugurated September 26, 2024 with the presence of university leadership and representatives of the Southern Peru company. Filley and Maqque were invited to Arequipa by the Rector of UNSA, Hugo Jose Rojas Flores, to take part in the ribbon cutting and offer their thoughts on the progress of UNSA's research capacity.

FEATURED PROJECTS



STUDENT IMPACT

NOVEL EXPERIENCES FOR STUDENTS

As we work to prepare our students to meet the challenges of the 21st century, IREES strives to create opportunities for transdisciplinary scholarship, research, and practice across a wide scope of critical environmental and energy issues.

ANNUAL STUDY TOUR: National Defense University's Energy Studies Traveling Classroom Revisits OU

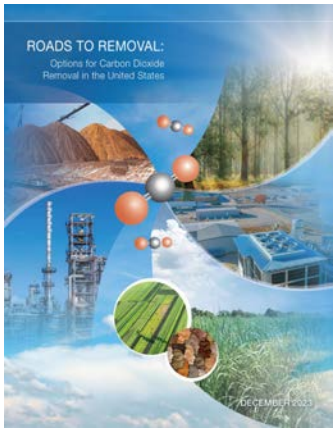
In what has become an annual study tour, a group of Masters students from the National Defense University visited IREES in April 2024 as part of their Energy Studies traveling classroom. Course instructors, Lieutenant Colonel (P) Timothy Wyant and Dr. Anita Kellogg, worked with IREES Faculty Fellow and Professor Li Song to develop a 2-day immersive learning experience featuring a series of seminars, lab tours, and field trips highlighting energy technologies, challenges related to today's energy system, and opportunities in energy efficiency and new, low-carbon technologies.

NDU, a higher education institution funded by the U.S. Department of Defense, facilitates education, training, and professional development opportunities for national security leaders. This year, the 15 visiting students are all active military in the U.S. and our international allies, ranging in rank from brigadier general, colonel, lieutenant colonel, and commander, in the U.S. Air Force, U.S. Army, U.S. Army National Guard, U.S. Navy, U.S. Space Force, and the International Forces.

The students toured Professor Catalin Teodoriu's (MCEE) Well Integrity Laboratory, Professor Chandra Rai's (MCEE) Integrated Core Characterization Laboratory Energy, and Song's Smart House—a 1940s-era home transformed into a research lab to study energy efficient heating and cooling systems. Teodoriu also led a full-day tour of Helmerich & Payne International Drilling Company's Rig 918 in Tulsa, OK to demonstrate the real-world impact of oil and gas engineering research (photo above).

> *"Our goal is to provide these leaders with a program that covers energy technologies, the challenges and opportunities they present, and the role of policy in crafting solutions."*
>
> *— Li Song*

NEW COURSE: Addressing Climate Change Through Atmosphere Carbon Dioxide Removal (CDR) Strategies



To minimize future impacts of climate change, the world needs to dramatically cut GHG emissions through implementation of decarbonization strategies in the energy, housing, agricultural, transportation, and manufacturing sectors. However, climate science has demonstrated that emissions reduction alone is not enough to prevent worsening and potentially irreversible effects of climate change—that will require the addition of carbon dioxide removal (CDR) approaches. A new course exploring the national and regional scale analysis of CO_2 removal strategies as outlined in the U.S. DOE Roads to Removal plan was offered in Spring 2024, with an emphasis on what it means for Oklahoma. In this course, offered by Tim Filley, students studied how regional differences in climate, geology, soil, water availability, and infrastructure influence the potential for CDR technologies that include direct air capture (DAC), durable storage, soil carbon sequestration, biomass carbon removal and storage or inclusion into durable construction materials, enhanced mineralization and conversion to stable "rock," ocean-based solutions, and afforestation/ reforestation. Guest speakers, including OU Professors Lance Lobban (CSBME), Catalin Teodoriou, and OGS director Nick Hayman, were invited to address different technical aspects of CO_2 sequestration. Students engaged with an industrial provider of DAC solutions, Heimdal Inc., for a student-led analysis project related to Heimdal's new Bantam DAC facility in north central Oklahoma. At 5,000 tons of CO_2 capturable from the atmosphere annually, Bantam will be the largest constructed DAC project in the U.S. and the second largest in the world.

JTAP SUMMER INTERNSHIPS: Monitoring Methane

This summer, as part of a new DOE grant led by IREES Faculty Fellow and Associate Professor Binbin Weng (ECE), the Institute welcomed seven undergraduate student interns from historically under-represented backgrounds, including two students with Chickasaw Nation heritage. The internship program was designed using the IREES Just Transitions Assessment Platform, a student-centered framework that builds capacity to 1) assess how the regional deployment of new technologies impacts communities, and 2) accelerate investments in the technologies that strengthen communities. An overarching emphasis is placed on understanding the importance of inclusive decision-making and fair distribution of benefits and burdens when considering new technologies.

During the 8-week summer program, the interns worked alongside OU faculty and researchers to tackle the real-world challenge of integrating GHG sensing technologies with computational modeling to monitor fugitive methane emissions. They received training from OU project investigators in research areas that include the fundamentals of GHG emissions and climate impacts, sensing technology, modeling, robotics, and data visualization. In addition to lectures and discussion sessions, interns participated in day trips to field-test various technologies, and they received hands-on training in laboratory sessions focused on fabricating sensing circuit boards, coding robots, and using visualization software to monitor emissions data.

The JTAP internship also strengthened direct pathways for the interns to pursue graduate training in methane monitoring or business ideation and innovation connections with the project's industry partners Devon Energy, Cortera Energy, and Flogistix, Inc.

PHOTO ABOVE: JTAP student interns with Professor Weng.

A GLOBAL COLLABORATION: Students design and build a model for sustainable, affordable housing in the Andes

Residential buildings in the highlands of Peru, as in most of the South American Andes, lack a central heating system and are typically built with baked bricks or concrete block walls that lack thermal insulation properties. In these high-altitude regions temperature at night drops to 0°F from May through October. This translates to indoor temperatures in these dwellings as low as 32°F. Low indoor temperatures are associated with cardiovascular problems, extreme discomfort, and respiratory infections. Indoor air contamination from poorly ventilated cooking smoke exacerbates health problems, especially among children and the elderly.

Funded by a grant from the 100,000 Strong in the Americas Innovation Fund, an international team of researchers from OU and the Universidad Nacional del Altiplano in Puno, Peru (UNAP) is addressing these interconnected challenges with a university-led, use-inspired research and teaching project. The project, "Knowledge and Cultural Exchange Through the Built Environment: Inti Wasi Sustainable and Affordable Cold Climate Housing," is led by Professor Ben Bigelow (GCOA) and Victor Maqque with Rene Peralta (GCOA) and UNAP Professors Yony Chavez-Perea, Jorge Villegas, and Samuel Huaquis.

The project began in the fall 2023 semester with a cohort of students from OU and UNAP (in-person and remote) participating in a graduate course focused on designing a sustainable, comfortable, and affordable model house for construction in Puno. In September, nine students and faculty from UNAP traveled to OU to work with their OU counterparts in collaborative research and design studio settings, participate in several related classes, and refine the model house design.

The final model house design incorporated a culturally-appropriate layout, locally accessible and affordable materials, and more efficient use of solar energy. With these innovations the model house, called Inti Wasi, which translates from the Quechua language as "House of the Sun," is expected to maintain a room temperature of 70°F, significantly improving the indoor climate, resident comfort and health.

PHOTO BELOW: UNAP faculty and students from the Inti Wasi model house design team on the OU campus.

As a follow up to the Fall semester's Inti Wasi course, during the Summer semester of 2024, OU students traveled to Puno, Peru through the study abroad course, "The Andes: history and cultures," taught by Maqque. This immersive study and service-learning opportunity made it possible for OU students to join their UNAP peers in the construction of the Inti Wasi model house while also taking classes on the UNAP campus and exploring Puno.

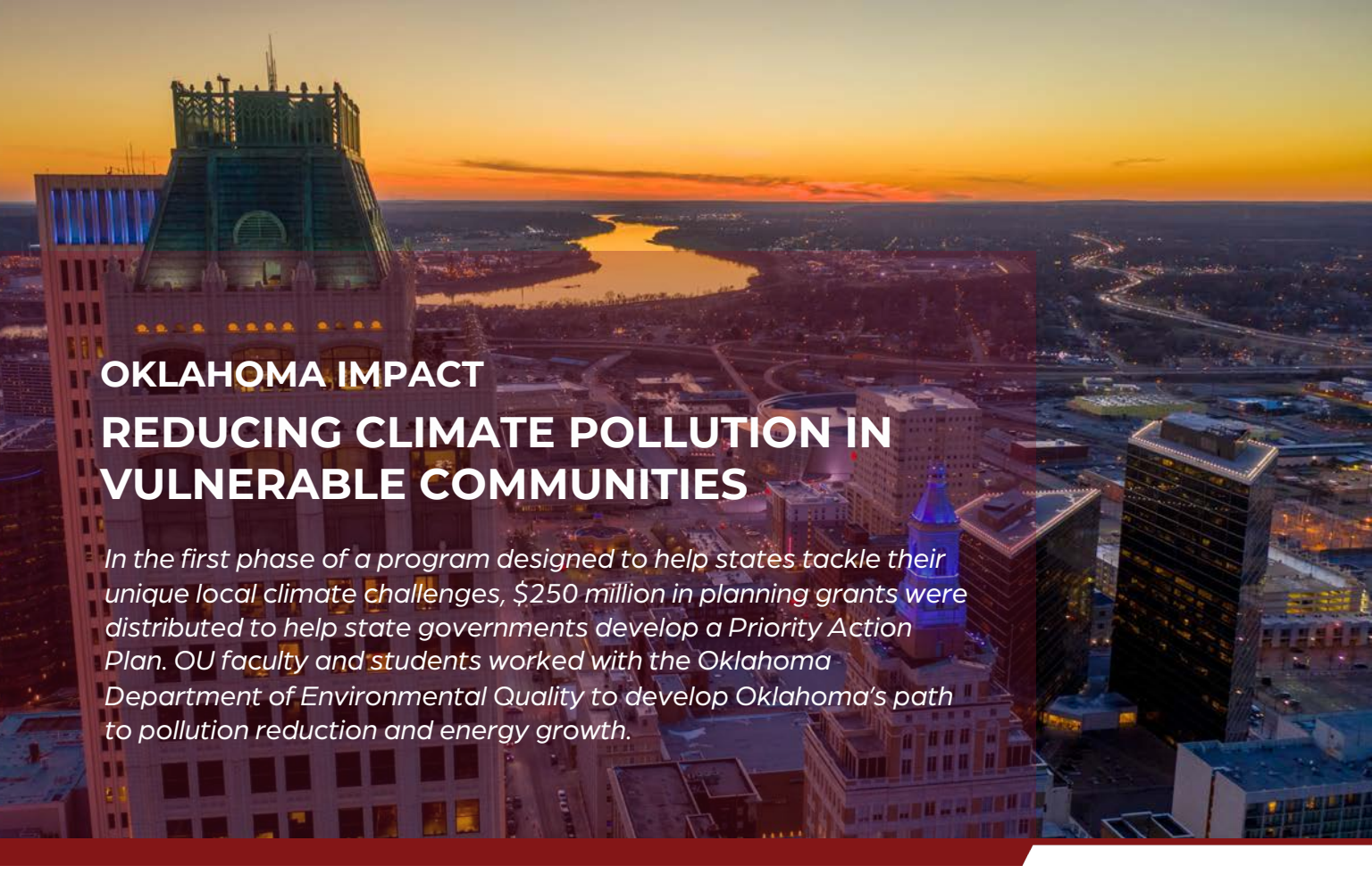
Construction of the Inti Wasi model house started in May of 2024 with UNAP and OU students working shoulder to shoulder for two weeks. Once completed, the demonstration house will be used as a research laboratory for faculty and students studying energy efficiency and sustainable housing while also serving as an innovative rural family housing design and building demonstration facility for the neighboring communities of Paucarcolla and Atuncolla. The OU and UNAP research team continues their partnership, exploring opportunities to develop and deploy new technologies and tools to monitor and analyze the indoor environment and energy efficiency of the model house.

ABOVE: Rendering of the final Inti Wasi model house design. The building is under construction at the UNAP's Illpa Research Station, located 15 miles north of Puno.

PHOTO BELOW LEFT: Construction of the Inti Wasi with UNAP and OU students working shoulder to shoulder, while the OU students were in Puno, in May of 2024

"The Inti Wasi project has been an incredible experience. It provided students the opportunity to work on a real-world problem, encouraged them to think creatively, and allowed them to collaborate with students from a different culture— all while giving them first-person experience with construction materials and methods!"

—Ben Bigelow



OKLAHOMA IMPACT

REDUCING CLIMATE POLLUTION IN VULNERABLE COMMUNITIES

In the first phase of a program designed to help states tackle their unique local climate challenges, $250 million in planning grants were distributed to help state governments develop a Priority Action Plan. OU faculty and students worked with the Oklahoma Department of Environmental Quality to develop Oklahoma's path to pollution reduction and energy growth.

Initiated in 2023, the Climate Pollution Reduction Grant (CPRG) program funded by the Inflation Reduction Action and administered by the U.S. EPA, provided $5 billion in formula grants to requesting states, Tribes, and territories to develop and implement plans to reduce greenhouse gas emissions. The first phase of the program was for recipients of the funding to develop priority action plans (PAP). In addition to identifying specific GHG reduction measures, PAPs had to include an estimation of benefits that could accrue in low-income and disadvantaged communities (LIDACs) from the implementation of the proposed GHG emission reduction measures.

In partnership with and funded by a grant from the Oklahoma Department of Environmental Quality (DEQ), OU provided the foundational research and analysis for Oklahoma's PAP. Through three projects and a comprehensive report, OU research teams led by Assistant Professor Lauren Mullenbach (DGES), Associate Professor John Harris (COA), and Professor Scott Greene (DGES) identified Oklahoma's low-income and disadvantaged communities and provided an assessment of their climate vulnerability. They also held focused workshops to support meaningful engagement with a subset of these communities and initiated a LIDAC benefits analysis of the State's proposed climate pollution reduction efforts. These activities were undertaken by a group of 11 undergraduate students in OU's Community Studio course taught by John Harris with additional mentorship provided by doctoral scholars Carrie Leslie and Olivia VanBuskirk. The students used data from EPA toolkits and the Census Bureau to identify the LIDAC Census tracts in the State and assign a vulnerability score to each using socioeconomic, demographic, and environmental indicators. In-depth community engagement was conducted in five of these tracts, with others in the top ten most vulnerable tracts profiled by the OK DEQ. The goal of the engagement strategy was to create a general sense of the experience of LIDAC communities with climate impacts and identify which priorities for action could strengthen their communities.

In total, ten focus groups were conducted with established groups and organizations with a history of LIDAC community embeddedness and representation. Of the ten focus groups, three were in predominantly Black communities, two in predominantly Hispanic communities, including a focus group conducted solely in Spanish, and two were conducted in rural areas outside Oklahoma's largest metropolitan regions, Oklahoma City and Tulsa. The students also fielded a survey to gauge community experiences and perceptions of severe climate conditions and events.

KEY TAKEAWAYS FROM THE REPORT

Communities experience climate impacts in ways that are negatively impacting everyday life.

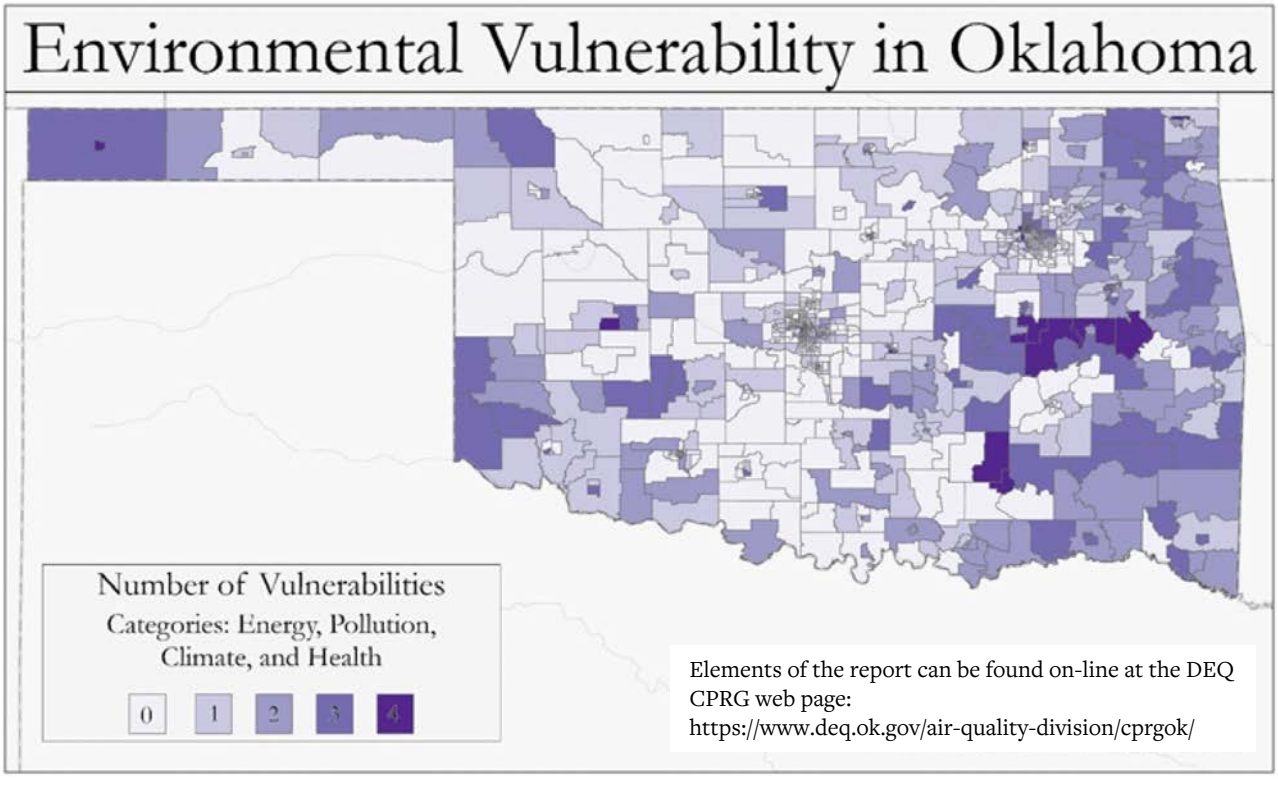
The top ways LIDAC communities in Oklahoma are experiencing climate impacts include extreme heat, severe weather, droughts and flooding, poor air quality, and increasing mosquito threats. Additionally, communities noted high energy and other critical infrastructure costs, and increasing power outages.

Climate impacts are cross-cutting interactions which worsen longstanding issues.

In LIDAC communities, climate impacts interact with and exacerbate longstanding issues communities have faced for years. For instance, LIDAC communities often have older building stock and infrastructure systems that are very expensive to retrofit or revitalize. With increasing energy and materials costs, the resources needed to take advantage of higher efficiency technologies or insulation seem inaccessible to OK's LIDAC communities. These communities also experience higher than average respiratory illnesses, such as asthma and COPD, as well as higher than average rates of cancer, depression, and high blood pressure. Each of these illnesses is associated with extreme heat and disproportionately higher exposure to air and water pollution, localized flooding, and lack of inclusion in environmental decision making.

Communities report feeling isolated or abandoned by state-wide, municipal, or regional authorities.

Oklahoma LIDAC Communities want a coordinated response where they can access resources and expertise to meet the challenges they face now and will face in the future. A common concern raised in focus group meetings centered on their limited access to information and resources from authorities, precluding the communities from responding to climate impacts with proactive projects and programs. LIDAC communities repeatedly stated the need for an organization or state entity that communities could turn to for information, resources, and accountability. Rural communities note their limited capacity even to take advantage of existing programs means they miss out and fear this pattern will continue.



Elements of the report can be found on-line at the DEQ CPRG web page: https://www.deq.ok.gov/air-quality-division/cprgok/

REGIONAL IMPACT

ANALYZING CHANGE IN SOUTHERN PLAINS ECOSYSTEMS

The central and southern great plains of the U.S. experience some of the largest climate and weather variability and extremes in the country, resulting in significant impacts to existing infrastructure and socioeconomic systems and to the ecosystem services provided by the region's diverse environments. As the climate continues to change, the risks to these systems are increasing. Yet, our understanding of the factors and mechanisms causing change and the effects of these changes remain poorly understood.

Oklahoma, with its four primary mountain ranges, temperature gradient from north to south, precipitation gradient from east to west, biotic species richness, and diverse soils is home to upwards of 12 ecoregions that are critical to the identity and economy of the region. Oklahoma also exhibits some of the largest climate and weather variability and extremes in the continental U.S., driving large interannual variations of carbon, water, and energy fluxes between the biosphere and atmosphere. Understanding the spatial and temporal controls of this exchange of matter and energy is key to predicting how ecosystems will respond to a changing and extreme climate, rising atmospheric CO_2, perturbations of nutrient budgets, and intensive land management.

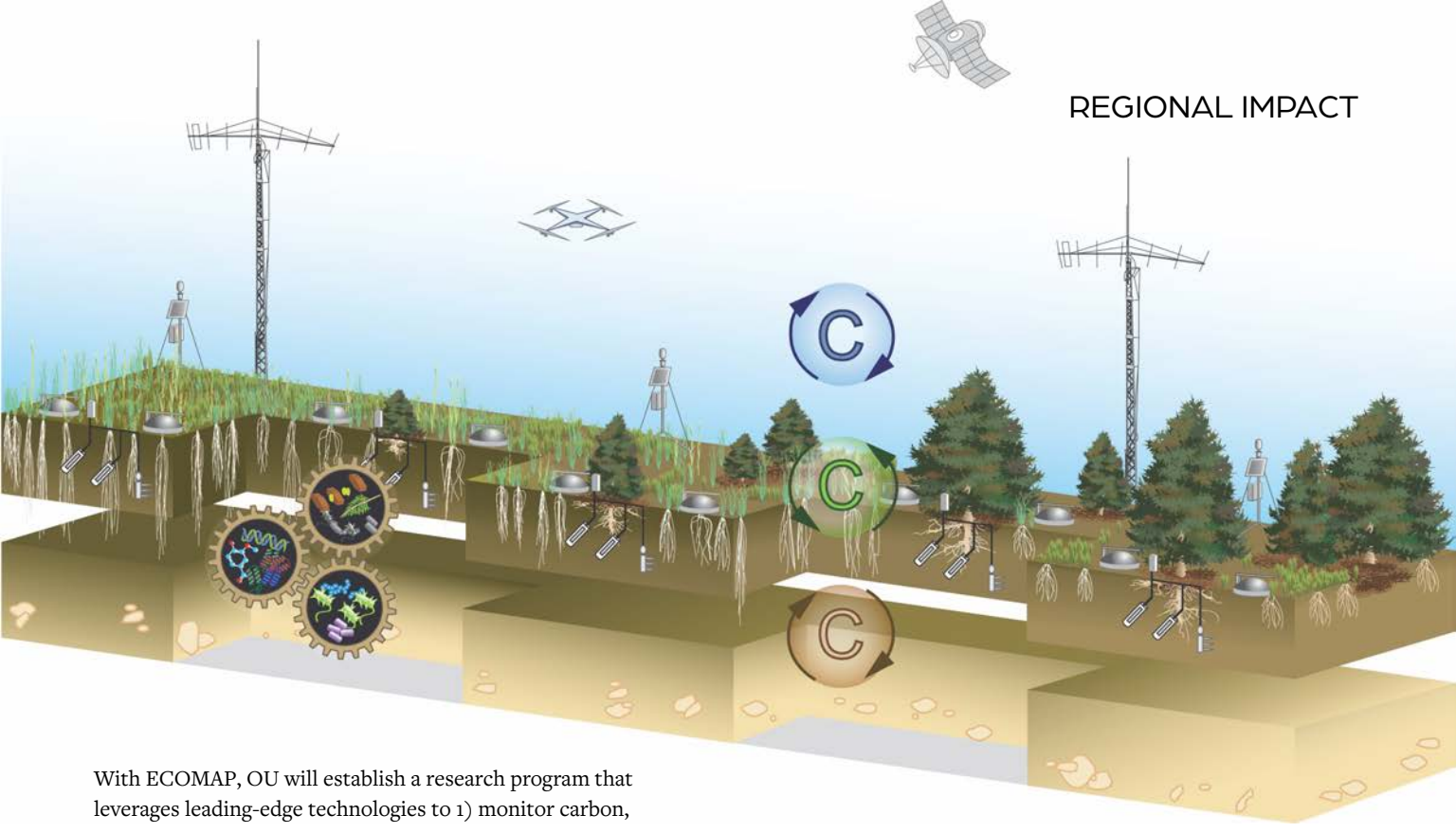
Currently, knowledge of the diurnal, seasonal, interannual variations and spatial variability of carbon, water, and energy fluxes in these regions is limited, hindering progress in nature-based climate solutions, carbon neutrality strategies, prediction of ecosystem resilience to extremes in climate and weather, and sustainable natural resource management even as we face growing threats related to drought, heatwaves, and wildfire.

The ECOMAP project, spearheaded by IREES this last year and located at OU's Kessler Atmospheric and Ecological Field Station (KAEFS), is designed to fill these critical research gaps with an integrated ecosystem(ECO) monitoring, analysis and prediction (MAP) platforms. Integrating empirical research (observations/monitoring and real-world experiments) with modeling (using mathematical or computational models to simulate the behavior of systems) is challenging but can shed light onto complex processes that neither method can fully explain separately.

KAEFS is home to many long-running ecosystem research projects exploring the impacts of landcover and climate change on biodiversity and carbon cycle dynamics, which has provided a detailed, albeit highly local perspective of ecological complexity in the region.

With a dedicated, enterprise-level research program leveraging KAEFS and the requisite instrumentation platforms, and a strategic teaming process that nurtures, facilitates, and supports understanding across different methodologies, disciplinary thinking, and communication methods, the ECOMAP integrated approach will advance our understanding of these complex, dynamic ecosystems across the central and western U.S.

PHOTO ABOVE: Soil erosional feature below an eastern red cedar tree at OU's KAEFS.



With ECOMAP, OU will establish a research program that leverages leading-edge technologies to 1) monitor carbon, water, and energy fluxes; 2) use environmental geonomics to assess function, interconnectedness, and diversity of the soil microbiome; 3) quantify spatial variability in soil physical and chemical properties; 4) initiate leaf-level to canopy monitoring of plant physiology and ecosystem carbon, water, and energy exchange; and 5) integrate remote sensing using UAV, airborne, and spaceborne technologies to assess changes across a wide spatial and temporal range. These new data streams will be the foundation for analysis and prediction of spatial-temporal changes through the application of data-driven models, AI and machine learning, and process-based models.

Researchers from departments across four colleges (CAS, CAGS, MCEE, GCOE) are collaborating to assess current and envision future comprehensive physical and data infrastructure, assess regional knowledge gaps that can inform future hires, and seek external funding to bring the additional instrumentation needed to make KAEFS a world-class research and education station. Current efforts, Phase 1 in the process, include equipping KAEFS with energy, water, soil, and greenhouse gas monitoring instruments and performing a detailed historical analysis of land use and land cover change at KAEFS and its surrounding watershed through digitization and analysis of historical aerial photography going back to the 1930s.

ABOVE: Illustration of proposed infrastructure at the ECOMAP observatory at KAEFS, courtesy of Drs. Jimenez and Filley.

Research questions the teams are exploring

What processes control carbon, water, and energy fluxes between the biosphere and atmosphere in the Southern Great Plains?

How can we accurately measure and monitor the carbon, water, and energy fluxes between the biosphere and atmosphere and assess their spatial-temporal variability?

Can we unravel complex biosphere-atmosphere interactions to identify and measure biosphere-atmosphere feedbacks?

How can we accurately model and predict these fluxes and processes to improve regional climate and global Earth system models?

Can data-driven artificial intelligence and machine-learning techniques help us understand how climate change is impacting biosphere-atmosphere interactions and contributing to an increase in extreme events?

How can we best use the integrated observation and modeling systems to support nature-based climate solutions, carbon neutrality strategies, sustainable natural resources management, and wildfire prevention?

GLOBAL IMPACT

AN INTEGRATED SOIL-CROP-WEATHER MONITORING SYSTEM

Climate-vulnerable populations in countries around the world are already grappling with the effects of climate change, including extreme weather events and their associated shocks and stresses. With a resilience-oriented approach and technology-enabled climate information, the PERU-Hub project is helping strengthen communities in the Amazon region to adapt and thrive.

Farmers in the Amazon region of Peru lack access to reliable, actionable information like real-time weather reports and measurements of soil quality and land use suitability, which impacts their ability to adapt to regional stresses like climate change, severe weather, legacy land degradation, and socioeconomic pressures. With the development of a custom-built, portable soil analysis kit (Pacha Kit, photo, bottom right) and installation of permanent weather and soil monitoring stations, OU researchers are contributing to sustainable agricultural development in the San Martin region of Peru, and helping farmers improve the efficiency and profitability of their land. These efforts are funded by a grant from the United States Agency for International Development (USAID) in support of the Peruvian Extension and Research Utilization project (PERU-Hub).

The soil science part of the research team, which includes postdoctoral scholars Carmen Roman Perez (DGES) and Martha Jimenez-Castaneda (DGES), together with Tim Filley and Victor Maqque, recently traveled to Peru to convene workshops focused on soil health principles coupled with hands-on field exercises demonstrating Pacha Kits in several communities across San Martin.

Derived from the Quechua term ″Pacha,” which can be roughly translated into English as “Earth,” the kits were first deployed to members of farmers′ associations who were trained remotely by experts from OU, in close partnership with collaborators Julio Alegre and Ruby Vega from PERU-Hub’s lead university, Universidad Nacional Agraria La Molina (UNALM). Analytical tools embedded in Pacha Kits measure a range of important physical, chemical, and biological soil properties directly related to soil health.

PHOTOS ABOVE: Installation of meteorological stations; Pacha Kit contents.

"Through the integrated weather and soil monitoring network provided in PERU-Hub, we can bring farmers in the Huallaga Valley actionable data to improve their livelihoods."

--Brad Illston

In the summer of 2023, the research team convened a series of field demonstrations at cacao and heart palm plantations and livestock ranches. Peru-based extension specialists are now using Pacha Kits for soils analysis across diverse sites throughout the San Martin region, providing valuable information to local farmers to improve the efficiency and profitability of their land. The OU team developed written and video-based training materials in both Spanish and Quechua languages and will provide ongoing technical support to these extensionists and the communities they serve. Negotiations are underway to expand the Pacha Kit program nationwide through a program within the National Institute of Agricultural Innovation (INIA).

Following distribution of the Pacha Kits, the OU research team turned its attention to installing a network of weather and soil monitoring stations in the San Martin region. The team traveled to Peru in May, 2024 to begin installation of the monitoring network. In this work, the team was led by Senior Research Scientist Brad Illston (Oklahoma Mesonet and OCS) and Weather Technician Kirk Wilson (Oklahoma Mesonet and OCS). They organized the siting and installation of five meteorological stations in the San Martin region including research stations operated by UNALM. The network is recording measurements of air temperature, humidity, wind speed and direction, pressure, solar radiation, and rainfall. Additionally, eight soil nodes were installed, with sensors at 20 cm and 40 cm depths. These sensors are recording soil temperature, volumetric water content, and electrical conductivity and transmit data via radio back to the meteorological stations. Detailed training exercises were conducted by Illston in coordination with instrumentation company representatives.

Going forward, the team will combine the data from this monitoring network with advanced remote sensing data to develop land use suitability models for specific high-value crops being introduced by the PERU-Hub project. The network, ultimately to be run by professors of meteorology at UNALM, will provide additional, critical information to farmers, researchers, forecasters, and climate scientists to better understand how atmospheric and hydrological processes are impacted by both changing land use and climate change.

PHOTOS ABOVE: PERU-Hub weather monitoring team setting up a new meteorological station in San Martin, Peru. Pictured left to right are: Yuri Arevalo, Martha Jimenez-Castaneda, Kirk Wilson,Victoria Calle, Henry Castaneda, Brad Illston, David Briceno, Cayo Leveau, Tim Filley, Carmen Roman, Paul Masias and Sheylla Sulca; Team members installing and field-testing the equipment.

ABBREVIATIONS GLOSSARY

AME	School of Aerospace and Mechanical Engineering
BIC	Big Idea Challenge
CAGS	College of Atmospheric and Geographic Sciences
CEES	Civil Engineering and Environmental Science
CIS	David L. Boren College of International Studies
CS	School of Computer Science
CSA	Center for Spatial Analysis
DEQ	Department of Environmental Quality
DGES	Department of Geography and Environmental Sustainability
DFCAS	Dodge Family College of Arts and Sciences
DISC	Data Institute for Societal Changes
DOE	U.S. Department of Energy
ECE	School of Electrical and Computer Engineering
ECOMAP	ECOsystem Monitoring, Analysis and Prediction project
EPA	U.S. Environmental Protection Agency
GCOA	Gibbs College of Architecture
GCOE	Gallogly College of Engineering
GHG	Greenhouse Gas
HIST	Department of History
ICAST	Institute for Community and Society Transformation
IREES	Institute of Resilient and Environmental Energy Systems
LASI	Latin America Sustainability Initiative
KAEFS	Kessler Atmospheric and Ecological Field Station
MCEE	Mewbourne College of Earth and Energy
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OADII	Oklahoma Aerospace and Defense Innovation Institute
OCS	Oklahoma Climatological Survey
OGS	Oklahoma Geological Survey
OK	Oklahoma
OKC	Oklahoma City
OU	The University of Oklahoma
OVPRP	Office of the Vice President for Research and Partnerships
PI	Principal Investigator
SBS	School of Biological Sciences
SES	Socio-Ecological Systems
SIMF	Stable Isotope Measurement Facility
SOM	School of Meteorology
SPTC	Southern Plains Transportation Center
USAID	U.S. Agency for International Development

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