Project Title:	Expanding Collaborative Capacity to Address Climate Resiliency in the Great Lakes Region
Award #:	DE-SC0023215
Project period:	09/01/2022 to 12/31/2024
Report submission date:	04/18/2025

PI:	Wendy Robertson (ORC ID: 0000-0002-8798-6188) Department of Earth and Atmospheric Sciences Central Michigan University rober2w@cmich.edu
Co-PIs:	Dr. Daria B. Kluver, Central Michigan University Dr. Rod Lammers, Central Michigan University Dr. John Allen, Central Michigan University
Collaborators:	Dr. Amanda Suchy, Central Michigan University Dr. Natalie Griffiths, Oak Ridge National Laboratory Dr. Rob Hetland, Pacific Northwest National Laboratory

Distribution:	This report contains no patentable material or protected data.

Executive Summary

U.S. Department of Energy (DOE), Office of Science, Award DE-SC0023215, *Expanding Collaborative Capacity to Address Climate Resiliency in the Great Lakes Region*, supported capacity and partnership building between researchers at Central Michigan University (CMU) and scientists at DOE laboratories. The work involved identifying potential collaborations both internal to CMU and between CMU researchers and DOE staff, developing collaborative research proposals, and partnering on pilot-scale research projects focused on enhancing resilience of Great Lakes communities, ecosystems, and infrastructure to global change and environmental stressors. DOE funds supported travel, time to develop collaborations, investigate new research pathways, and draft grant proposals, and a loan of DOE equipment to collect pilot data in support of future work. The project achieved its goal of strengthening research collaborations between interdisciplinary researchers at CMU and establishing new collaborations and partnerships between CMU and DOE scientists. These collaborations resulted in 5 pre-applications and 4 full applications for funding to DOE BER Funding Opportunities, a successfully funded DOE BER award (DE-SC0025260), a new pilot project that leveraged DOE resources (AquaBOT) to improve understanding of water quality conditions in Michigan rivers, and two presentations of preliminary results at national scientific conferences. This project's outcomes will benefit the Great Lakes Region via new lines of collaborative research focused on improving the resilience of Michigan communities, ecosystems, and infrastructure.

Highlighted Project Outcomes

- 2 poster presentations (American Geophysical Union Fall Meeting, 2024 and American Meteorological Society Annual Meeting, 2025) presenting outcomes from new interdisciplinary collaborations established with support from this project.
- New collaborations between Central Michigan University researchers and Department of Energy projects including COMPASS-GLM, Pacific Northwest National Laboratory, and Oak Ridge National Laboratory.
- A successfully funded DOE Office of Science, Biological and Environmental Research Award (DE-SC0025260) to PI Robertson in 2024, a direct outcome of support from this RDPP project.
- A robust, interdisciplinary network of 11 CMU researchers, their students, and DOE scientists investigating how Michigan ecosystems, infrastructure, and communities can become more resilient to extreme weather and environmental stressors.

Expanding Collaborative Capacity to Address Climate Resiliency in the Great Lakes Region – Final Report

This report presents the work undertaken and tasks performed to complete the four project objectives of our efforts to expand collaborative capacity to investigate stressors, threats, and opportunities for resilience of Great Lakes ecosystems, infrastructure, and communities. This project will benefit Michigan and Great Lakes communities through translational research focused on regional challenges and synergistic collaborations between Central Michigan University (CMU) and U.S. Department of Energy (DOE). The project objectives were:

1. To foster an interdisciplinary network of resiliency experts at CMU
2. To identify where the investigators' research programs and expertise align with DOE funding and research priorities
3. To identify opportunities and develop partnerships with resilience-focused DOE researchers and projects
4. To position the investigators to prepare one or more proposal submissions to DOE BER ESS for resilience-related research in the Great Lakes region

The work was performed between September 2022 and December 2024. The efforts to support each project objective and their outcomes are described below. We have included links to products and outcomes partially or fully supported by this project in the Products and Outcomes section following the description of Project Objective activities.

Project Objective 1: To foster an interdisciplinary network of resiliency experts at CMU

Researchers at Central Michigan University (CMU) possess a broad range of expertise that positions them to effectively address the complex and interconnected challenges faced by Great Lakes ecosystems, infrastructure, and communities. However, impactful interdisciplinary collaboration requires time. With support from this project, we expanded our networks, established partnerships, and formed internal working groups with CMU researchers that identified synergies across research groups and departments, resulting in new areas of interdisciplinary research, pilot projects, and funding requests for future work on Great Lakes resilience priorities.

Participants – This work involved:

- **Eleven faculty researchers** across three departments and schools at CMU (Wendy Robertson (Earth and Atmospheric Sciences, EAS), Daria Kluver (EAS), Rod Lammers (School of Engineering and Technology, ET), John Allen (EAS), Amanda Suchy (Biology, BIO and EAS), Scott McNaught (BIO), Greg Colores (BIO), Kevin Pangle (BIO), Don Uzarski (BIO), Daelynn Woolnough (BIO), and Matthew Cooper (BIO, joint appointment with GVSU))
- **One graduate student** (Marta Singer, MS, BIO)
- **Six undergraduate students** (Chloe Majeske-Neal, Ainsley Reser, Julia Shablin, Alexis Jones, Jeremiah Little, and Laura Ann Moore)

Activities and Outcomes

- Monthly meetings with the core project team (Robertson, Kluver, Lammers, Allen) dedicated to developing project ideas, forming new partnerships, and drafting proposals
- 2-day workshop and training (May 2024) for CMU researchers (7 faculty and 5 students) on the use of AquaBOT (Oak Ridge National Laboratory, see objective 3) in investigations of surface water quality monitoring in the Great Lakes region.
- 5 pre-applications and 4 full applications for funding submitted to DOE Office of Science Biological and Environmental Research by PIs and Co-PIs involved in this project, with one successfully awarded (see objective 4 for more detail).
- Inland lake and wetlands water quality monitoring project on Beaver Island utilizing AquaBOT – As a part of a CMU Research Experience for Undergraduates (REU) on Beaver Island, three undergraduate students (Alexis Jones, Jeremiah Little, and Laura Ann Moore) mentored by two faculty (Suchy and Colores) investigated on the spatial variations in water quality of Beaver Island inland lakes and their wetlands. This project provided pilot data for future investigations of the physical and biogeochemical controls on trophic state changes in these systems and provided the students an opportunity to work with: 1) aquatic drone technology and field-based water quality sensors, 2) tools and applications of spatial data analysis, and 3) development of research questions and

methods for investigation as part of their professional development as future scientists and researchers.

- Spatial variability of water quality in managed wetlands at Shiawassee State Game Area – Drs. Lammers and Suchy used AquaBOT to gather additional insights into spatial variations in wetland water quality for an ongoing partnership with the Shiawassee State Game Area to improve ecosystem services and function in managed wetlands. As part of this work, two undergraduate students (Ainsley Reser and Julia Shablin) received training on AquaBOT operation, use, and data analysis.
- Assessing Michigan communities' awareness of threats and priorities for resilience planning – this project, which grew from peer-review feedback to an unsuccessful DOE full proposal submission (Robertson et al. 2023, see project objective 4) is an ongoing collaboration between five CMU faculty (Robertson, Lammers, Kluver, Suchy, and Allen) and an undergraduate student (Chloe Majeske-Neal) to assess public planning documents for Michigan municipalities, counties, and government entities as a way to understand how Michigan communities recognize and plan for resilience to severe weather-driven and environmental stressor-driven threats such as extreme heat, precipitation, flooding, and water quality impairments. Understanding where knowledge, data, and priority gaps in resilience planning exist is critical to effective translational science efforts. Preliminary results from this work were presented at the American Meteorological Society Meeting in January 2025 by undergraduate student, Chloe Majeske-Neal. This project is ongoing as the collaborators conduct additional analyses to develop the preliminary results into a manuscript and seek funding for future efforts.

Project Objective 2: To identify where the investigators' research programs and expertise align with DOE funding and research priorities

The expertise of CMU researchers, their geographical setting in the Great Lakes region, and their strong collaborations with local, state, and regional partners mean that we are well positioned to support and enhance collaborative research where DOE priorities and CMU expertise overlap. With support from this project, we spent time traveling to DOE laboratories, speaking with project staff, and identifying opportunities for synergistic collaboration, funding, and research.

Participants – this work involved five CMU researchers (Robertson, Kluver, Lammers, Allen, and Suchy).

Activities and Outcomes:

- Travel to Oak Ridge National Laboratory (ORNL): Drs. Robertson, Lammers, Kluver, and Allen traveled to ORNL in Spring 2023 and spent three days meeting with Oak Ridge scientists, visiting facilities and labs, presenting their work, and sharing ideas. This opportunity resulted in identifying several areas of alignment including use of drone technology to monitor spatial variation in environmental stressors and ecosystem resilience (AquaBOT), process-based modeling of hydrologic flow and reactive transport (Amanzi-ATS), and approaches for multi-modal downscaling and bias correction of atmospheric model output (RegCM and DayMET).
- Travel to Pacific Northwest National Laboratory (PNNL): Drs. Robertson, Kluver, and Allen (with Dr. Lammers participating remotely) traveled to PNNL in Summer 2023 and spent three days meeting with PNNL scientists, visiting facilities and labs, presenting their work, and sharing ideas. This opportunity resulted in identifying several areas of alignment including using coupled lake-atmosphere-land surface-hydrology models to improve understanding of the role of extreme weather in flood risk (COMPASS-GLM) and using coupled vegetation-biogeochemical models with flow and reactive transport models to understand linkages between environmental stressors and ecosystem resilience (ELM-FATES, ATS-PFLOTRAN, and COMPASS-FME).
- Participation in 2023 DOE ESS-PI Meeting: Dr. Robertson attended (virtual) the DOE ESS-PI meeting held in May 2023 to learn more about ongoing DOE research, priorities, and programs.
- Participation in the 2023 COMPASS-GLM all hands project meeting: Drs. Robertson and Kluver participated in the COMPASS-GLM all hands project meeting in September 2023. While at the meeting, they engaged in working groups, presented research, and discussed collaborative opportunities.
- Travel to AGU Fall Meeting 2024: Drs. Robertson and Suchy traveled to the AGU Fall Meeting in Washington, D.C. in December 2024 to engage with DOE Office of Science and Laboratory staff and learn more about ongoing projects, funding opportunities, priorities, and collaborations.

- Travel to AMS Annual Meetings in 2024 and 2025: Dr. Kluver traveled to the AMS National Meeting in New Orleans in January 2024 and January 2025 to engage with DOE Office of Science and Laboratory staff and learn more about ongoing projects, funding opportunities, priorities, and collaboration opportunities with Argonne National Laboratory and the Atmospheric Radiation Measurement User Facility (ARM).

Project Objective 3: To identify opportunities and develop partnerships with resilience-focused DOE staff and projects

After identifying synergistic opportunities for collaborative research (objective 3), CMU researchers spent time developing partnerships and collaborations that combined our area of expertise with the research, capabilities and priorities of DOE. This has resulted in several ongoing partnerships, collaborations, and affiliations that strengthen and enhance research at CMU and DOE.

Participants – this work involved five CMU researchers (Robertson, Kluver, Lammers, Allen, and Suchy).

Activities and Outcomes:

- AquaBOT: the loan of AquaBOT, an autonomous surface drone for monitoring water quality developed by scientists at ORNL, to CMU researchers is a partnership that arose directly from our visit to ORNL in spring 2023. We worked with Drs. Natalie Griffiths and Eric Pierce at ORNL to arrange the loan of AquaBOT and training for CMU researchers in 2024. The loan of AquaBOT has resulted in:
    - Expanded collaborations among CMU researchers assessing spatial variability in surface water quality of inland lakes, rivers, estuaries, and coastal systems
    - Training undergraduate and graduate students to use drone technology for water quality monitoring (7 total)
    - Collection of pilot data assessing thermal conditions of cool-water fish habitat which resulted in a presentation at the American Geophysical Union Fall Meeting (2024) and a submission of a full proposal for funding a full scale project to DOE BER (*in review,* see objective 4).
- PNNL Visiting Scientist Program: Drs. Kluver and Robertson applied and were accepted as Visiting Scientists at Pacific Northwest National Laboratory in January 2024. This opportunity to partner with PNNL scientists and leverage DOE facilities arose from our visit to PNNL in summer 2023. As visiting scientists, we are using the COMPASS High performance computer (HPC), part of the Environmental Molecular Sciences Laboratory (EMSL) user facility, to run simulations on coupled earth systems models as part of a DOE BER-funded project (see objective 4 for more detail) and in collaboration with the COMPASS-GLM project.
- COMPASS-GLM collaboration: Drs. Robertson, Kluver, Lammers, and Allen developed a new partnership with the multi-institutional COMPASS-GLM project; this opportunity arose from our visits to ORNL and PNNL in 2023. We are collaborating on basic and translational research goals that will enhance the resilience of Michigan's communities and infrastructure. This collaboration formed the basis of two funding proposals submitted to DOE BER, once of which was successfully funded in 2024 (see objective 4)

- Participation in COMPASS EXCHANGE consortium: as a result of traveling to PNNL in 2023, the CMU research team were introduced to DOE scientists working on the COMPASS EXCHANGE program. After these introductions, Drs. Robertson, Lammers, and Suchy began working EXCHANGE consortium, discussing experimental design, hypotheses, and proposing sampling locations for investigations into biogeochemical interactions at Great Lakes coastal wetland sites where CMU researchers have ongoing synergistic projects. In summer 2025, we will be contributing to the COMPASS EXCHANGE-D experiment, collecting data to assess decomposition rates at 4 Great Lakes coastal wetland sites.

Project Objective 4: To position the investigators to prepare one or more proposal submissions to EESSD for resilience-related research in the Great Lakes region

The CMU investigators who collaborated on this project leveraged the time, resources, connections and partnerships formed during this work to produce five pre-proposal submissions to DOE BER ESS calls between December 2022 and February 2025; four pre-proposals were invited for full submission, one was successfully funded, and one is in review.

Participants – these efforts involved six CMU researchers (Robertson, Kluver, Lammers, Allen, Suchy and Uzarski), five researchers at other academic and research institutions, and two DOE researchers (Griffiths, ORNL, and Hetland, PNNL).

- Robertson, Suchy, and Uzarski (FY 2023) Pre-proposal: Evaluating hotspots and hot moments for biogeochemical cycling and greenhouse gas emissions from Great Lakes coastal wetlands. DOE BER ESS (DE-FOA-0002849). Not encouraged for full proposal.
- Robertson, Kluver, Lammers, Allen, and Beasley (FY 2023) Center for Michigan Community Climate Resilience. DOE BER ESS (DE-FOA-0002915). Encouraged for full proposal. Not awarded.
- Suchy, Robertson, and McCullough (FY 2024) Evaluating effects of emerald ash borer on carbon and nitrogen cycling in riparian wetlands. DOE BER ESS (DE-FOA-0003196). Encouraged for full proposal. Not awarded.
- Robertson, Kluver, Lammers, Allen, Beasley, and Raubenheimer (FY 2024) Building Predictive Capacity to Enhance Stormwater Infrastructure and Flood Resilience. DOE BER ESS. **Funded** award number DE-SC0025260.
- Suchy, Robertson, Lupi, Griffiths, Kluver, Lammers, and Clark (FY 2025) Can hyper-local information improve watershed-scale resilience? Developing an Integrated Assessment Model for aquatic ecosystem resilience to stress. DOE BER ESS (DE-FOA-0003464). Invited for full submission, submitted February 2025. *In review.*

Products and Outcomes

1. Robertson, W.M., Kluver, D.B., Lammers, R.L., Allen, J.T., Beasley, W.J., and Raubenheimer, B. (FY 2024) Building Predictive Capacity to Enhance Stormwater Infrastructure and Flood Resilience. DOE BER ESS. Award number DE-SC0025260. Project period: 9/2/2024-9/1/2027. Public Abstract available at: https://pamspublic.science.energy.gov/WebPAMSExternal/Interface/Common/ViewPublicAbstract.aspx?rv=d217b21a-152c-4e06-b4ea-fc7b709027e4&rtc=24&PRoleId=10
2. Wendy Marie Robertson, Daria B Kluver, Roderick W Lammers, Chloe Majeske-Neal, Natalie Griffiths, and Amanda K. Suchy. Home Chill Home: Leveraging Aquatic Drone Technology to Understand Spatial Variation in Water Quality Parameters of Coldwater Streams (Michigan, USA). AGU Fall Meeting 2024, Washington, D.C. Abstract and Poster available via *ESS Open Archive:* DOI: 10.22541/essoar.173867564.49642022/v1
3. Chloe Majeske-Neal, Wendy M. Robertson, Daria B. Kluver, John T. Allen, Rod Lammers, and Amanda K. Suchy. How are Michigan Communities Preparing for their Climate Future? Outcomes of a Document Analysis of Municipal and County Plans for Climate Change, Risks, and Priorities. American Meteorological Society Annual Meeting 2025, New Orleans, LA. Abstract and Poster available at https://ams.confex.com/ams/105ANNUAL/meetingapp.cgi/Paper/458491
4. Robertson W.; Kluver D.; Lammers R. (2025): Water quality data collected from the Muskegon River (MI, USA) using AquaBOT June-July 2024. Expanding Collaborative Capacity to Address Climate Resiliency in the Great Lakes Region (DE-SC0023215), ESS-DIVE repository. Dataset. doi:10.15485/2530791 accessed via https://data.ess-dive.lbl.gov/datasets/doi:10.15485/2530791 on 2025-03-26