2020 Annual Report to NOAA Regional Integrated Sciences and Assessments

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Team Members

The Great Lakes Integrated Sciences and Assessments (GLISA) is housed jointly at the University of Michigan (UM) and Michigan State University (MSU), in the School for Environment and Sustainability and at the Center for Global Change and Earth Observations, respectively. GLISA's team includes an interdisciplinary group of Principal Investigators (PIs), staff and researchers, and students. Notably in the last year, we welcomed long-time collaborator Michael Notaro at the University of Wisconsin as a Co-PI and hired a Postdoctoral Researcher (Kripa Jagannathan) and our first Practitioner in Residence (Matt Naud) for cities.

Principal Investigators	Title	Institution
Maria Carmen Lemos	Co-Director; PI	University of Michigan
Jeffrey Andresen	Co-Director; Co-PI	Michigan State University
Richard Rood	Co-Principal Investigator	University of Michigan
Kenneth Frank	Co-Principal Investigator	Michigan State University
Michael Notaro*	Co-Principal Investigator	University of Wisconsin

Staff & Researchers	Title	Institution
Sam Basile*#	Research Associate	University of Michigan
Laura Briley	Climatologist	University of Michigan
Kim Channell	Climatologist	University of Michigan
Omar Gates	Climatologist	University of Michigan
Jenna Jorns	Program Manager	University of Michigan
Kripa Jagannathan*	Postdoctoral Researcher	University of Michigan
Frank Marsik	Research Scientist	University of Michigan
Matt Naud*	Practitioner in Residence	University of Michigan
Alexia Prosperi#	Research Associate	University of Michigan
Peter Yao#	Research Associate	University of Michigan

Students	Title	Institution
William (B.J.) Baule, PhD	Geography & Spatial Science	Michigan State University
Kate Hutchens, MS*	Environmental Justice	University of Michigan
Sarah Hutchinson, MEng*	Applied Climate	University of Michigan
Catherine Kemp, MPP*	Env. Policy & Planning	University of Michigan
Karl Kirchner^	Applied Mathematics	University of Michigan
Erin Maher, BSE*	Climate & Meteorology	University of Michigan
Lisa Maillard, MS*	Behavior, Education, Comm.	University of Michigan
Joseph Parton, BS^	Meteorology	University of Louisiana
Ian Ortiz, BA^	Conservation & Env. Studies	Swarthmore College
Mark Reid, BA^	Env. & International Studies	Denison University
Raymond Surya, BSE#	Climate & Meteorology	University of Michigan
Owen Watson, MS, MPP#	Env. Policy & Planning	University of Michigan
Karlie Wells, MEng#	Applied Climate	University of Michigan

*denotes new team member
#denotes left GLISA after graduation or position ended during reporting period
^denotes summer 2019 fellowship

Accomplishments

Greatest Accomplishment This Year

Our greatest accomplishment in the last year was conducting the engagements for our NOAA Sectoral Applications Research Program (SARP) award, "Co-Producing Climate Knowledge and Sustained Engagement in the Great Lakes in Support of Stormwater Management Adaptation" in partnership with the Huron River Watershed Council and the City of Ann Arbor (MI). GLISA is engaging with 12 local governments in the Great Lakes region to: 1) co-produce climate information using an existing vulnerability assessment tool for stormwater management; and 2) assess whether the boundary chain model can reduce transaction costs for scaling-up sustained engagement through a series of social experiments that explore three forms of engagement. This project builds on an earlier effort funded by The Urban Sustainability Directors Network (USDN) with the same partners and Headwaters Economics. In the last year, the project team conducted three in-person engagements in Ferndale (MI), Toledo (OH), and Dayton (OH); four webinar engagements with Goshen (IN), Buffalo (NY), Cleveland (OH), and Grand Rapids (MI); and supported the self-guided treatments for Kalamazoo (MI), Madison (WI), and Urbana (IL). Completing these engagements over a relatively short time frame (i.e., 3 months) involved a substantial amount of teamwork to develop training materials for each treatment type, coordinate logistics, conduct the engagements, and follow-up. We also coded and analyzed 24 pre-interviews and began post-interviews. As cities complete the assessments, we format a designed report for practitioners to share with city leadership. Notably, Ferndale's (MI) City Council formally adopted their assessment and plans to use the report for the City's climate adaptation and resiliency planning (see Significant Outputs and Narrative Case Studies). However, progress in most other cities has slowed as many practitioners have been reassigned to emergency duties and/or furloughed due to the COVID-19 pandemic.

Using this project as proof of concept, we partnered with another RISA, the Southern Climate Impacts Planning Program (SCIPP), to apply to the National Academy of Sciences Engineering, and Medicine's Gulf Research Program (NAS GRP) to scale-up the vulnerability assessment and social experiment to 60 cities in the Gulf of Mexico. Winning $2.1M in funding, we are in year 1 of this three-year project applying the lessons learned in the SARP project to a new region (see below). Especially exciting is the opportunity to enhance the existing assessment tool by transforming what is currently an Excel workbook into a web-based application with a streamlined user interface. The improved tool will be easier to disseminate to city participants, be more intuitive for users, allow the project team to use web analytics tools to identify patterns in use, and be scalable to cities outside of the Great Lakes and Gulf of Mexico regions.

New Areas of Focus or Partnership

Compared to previous years, more of our new areas of focus and partnership were initiated by other organizations reaching out to GLISA for applied research and/or engagement. Instead of GLISA leading many of these collaborations, this trend shows we are increasingly becoming a sought-after partner for work in several sectors and states in the Great Lakes.

Making Gulf Communities More Resilient: Scaling-up Customized Vulnerability Assessment for Extreme Events in Gulf Cities

Team Leads: Maria Carmen Lemos, Jenna Jorns

Funder: National Academy of Sciences, Engineering, and Medicine Gulf Research Program
Partners: Southern Climate Impacts Planning Program (SCIPP, at the University of Oklahoma), Stanford University, Headwaters Economics, Adaptation International

The impact of extreme climate and weather events has increased in the Gulf region and is expected to increase in the future. Cities must urgently prepare and respond to climate impacts and grow their capacity to do so exponentially. Communities in the region, in particular small- and mid-sized coastal cities, lack information and resources to implement hazard- and climate-related action to increase their resilience to these events. Sustained engagement between producers and users of knowledge can help build this capacity by providing cities with tailored climate and socioeconomic information and decision-making tools, increase use of this information in decision-making, and build communities of practice to disseminate this information. With funding from NAS GRP, GLISA is leading this three-year project to engage with 60 Gulf coastal communities to: 1) co-create climate and socioeconomic information using a comprehensive vulnerability assessment (VA) template to increase resilience to extremes; and 2) collect quantitative and qualitative data to assess cities' current adaptive capacity and carry out randomized social experiments to explore different forms of engagement (i.e., in-person, webinar-assisted, self-guided). This project leverages GLISA's ongoing NOAA SARP project as proof of concept to apply the same methodology to a larger sample in a different region by working with another RISA team, SCIPP. Deliverables will include: a customized regional framework to assess Gulf cities' adaptive capacity; an interactive database allowing cities to overlay climate and socioeconomic variables at scales of interest (Neighborhoods at Risk tool); a web-based tool that allows Gulf cities to collaboratively conduct a stormwater VA; and completion of a stormwater VA by 60 cities with upwards of 300 officials trained on the tool.

Identifying Economic Impacts of Inundation on New York's Lake Ontario Water Resources through Research and Engagement

Team Leads: Richard Rood, Kim Channell
Funder: NOAA SARP and Coastal and Ocean Climate Applications (COCA)
Partners: Syracuse University, Cornell University, New York Sea Grant

Recent Lake Ontario flooding has left coastal communities unprepared for the immediate impacts on businesses, homes, and infrastructure. While these communities lack essential knowledge to make sound investment decisions related to flood preparedness, proactive planning and funding may reduce economic impacts of future flood events. The first step is to understand the flood risk and identify the water resources that are in jeopardy. Through a 2019-2021 SARP and COCA award to Syracuse University, GLISA is partnering with New York Sea Grant to lead the scenario development component of the project and will provide lake level scenarios, a climate and lake levels 101 presentation, scenarios workbook, and a factsheet for the workshop. The project team will collect quantitative and qualitative data through participatory research methods by hosting workshops with stakeholders; the data will be analyzed to identify vulnerabilities, estimate their economic impact, and allow the project team to provide recommendations to increase resilience to future flooding. Deliverables include: GIS layers and mapped economic and shoreline property impacts linked to flooding; a series of scenarios related to future climate changes and lake levels; two stakeholder workshops to create vulnerability matrices and proposed flood resiliency actions; a report of recommended actions; and a report of water resources-related planning opportunities.

Filling the Gaps: Climate and Weather Information for Small- and Medium-Sized Water Utilities

Team Leads: Kim Channell, Jenna Jorns
Funder: NOAA SARP
Partners: The Water Research Foundation

In response to requests from decision makers from the water resource management and city planning communities, NOAA has been developing the Water Resources Dashboard as an integrated information resource for a wide variety of federal weather, climate, and water information used throughout the water sector. The Dashboard has primarily attracted use by larger water utilities, but has a limited reach to smaller utilities. NOAA's Office of Coastal Management and Water Initiative is funding an expanded Dashboard relevant to smaller water utilities, the creation of more useful tools, and improved outreach materials for water resource managers to help in daily and long-term decision-making related to weather and climate events. As part of this effort, GLISA is planning a regional webinar for July 27, 2021 focused on stormwater, to raise awareness of the tools and assess stakeholder information needs.

Economics of Wind Machine-Based Frost Control for Tree Fruit Production in the Great Lakes Region

Team Leads: Jeff Andresen
Funder: GLISA internal (NOAA RISA)
Partners: MSU Extension, MSU Department of Agricultural, Food, and Resource Economics

The primary objective of this project is an evaluation of the economics of wind machine-based technology for mitigating the impact of frost on apple and cherry production in Michigan. The economic approach used is a capital partial budgeting model with two strategies; the first calculates the annual use cost of capital as a reference point while the other uses a net present value approach. Both start with estimating the capital investment in the wind machine and infrastructure. Frost events are simulated on a daily basis with a temperature-based model to estimate the frequency and severity of cold damage for a given location. Using literature-based assumptions about the expected effectiveness of the frost protection technology, we will develop a series of simulated years with estimated crop yields. We will then compare the difference in net revenues above the costs considered between management approaches including none, wind machine frost protection, crop yield insurance, and the combination of wind machine frost protection and crop insurance. The simulations will be run with climate data from both historical (1981-present) and projected future (2041-2060) time frames. Results from the project should help growers better quantify their current weather and climate-related production risks and help inform decisions regarding capital investment in a common adaptive strategy.

Development of Ontario Climate Divisions

Team Leads: Laura Briley, Omar Gates, Frank Marsik
Funder: Great Lakes Observing System (GLOS)
Partners: Environment and Climate Change Canada (ECCC), Aquanty, Ouranos

Consistent, standardized analysis of historical climate changes and future projections are critical to all of our work. In our experience, climate stations (location-based) and climate divisions (multi-county scale) are useful spatial scales for presenting summaries of past, current, and future climate changes. The climate divisions, as defined by NOAA for the U.S., represent an

intermediate spatial scale that has proven valuable to many of GLISA's partners and are often a good starting point for describing sub-regional climate changes. But, there is no equivalent set of boundaries for Canada. As part of our Great Lakes Adaptation Data Suite (GLADS), we are convening a working group of Canadian partners to develop the spatial boundaries for climate divisions in Ontario to better serve stakeholders in Canada. We will share the new boundaries with other organizations, packaging Ontario climate data as a new, vetted, spatial scale for local and regional climate change analysis and adaptation.

Expanding Green Infrastructure as a Response to Environmental Injustice and Climate Change

Team Leads: Richard Rood, Omar Gates
Funder: USDA McIntyre Stennis
Partners: UM SEAS, UM Taubman College; Southeast Michigan Council of Governments (SEMCOG), Tetratech

This project responds to an urgent and timely opportunity to transform vacant, neglected, and underutilized land into a matrix of green infrastructure (GI) for the residents and ecology of the Detroit area. The objective is to advance the science necessary to make informed decisions about how to maintain the existing forestry as well as expand urban forest ecosystems as part of a broader GI strategy. The project has three specific objectives: 1) quantify changes in Detroit's GI over 25 years (1992-2018); 2) develop and deploy robust sustainability criteria to identify optimal sites for maintaining and expanding GI in Detroit; and 3) delineate future climate resilient pathways reflecting different climatic realities and the multidimensionality of GI. GLISA contributed regional historical observations and model projections for southeast Michigan and presented the historical trends via webinar. GLISA's work will continue in the coming months with possible development of scenarios focusing on the climate impacts on GI.

Moving Michigan Farms towards Climate and Weather Resilience: the Creation of a "Weather and Climate Ready" Assessment Tool

Teams Lead: Jeff Andresen
Funder: GLISA internal (NOAA RISA)
Partners: MSU Extension, MSU W.K. Kellogg Biological Station

Michigan farmers are both struggling with and adapting to regional changes in climate including increases in the frequency and severity of extreme weather events. Other than conventional crop insurance, there is little support for farmers to help manage weather and climate related risks. Based on a system created by the University of Nebraska-Lincoln, the team will develop and evaluate a prototype of a new assessment tool for Michigan cropping systems on weather-related vulnerability and sustainability, including key short-term weather and longer-term climate variables and indicators. We will create two versions, one for annual field crops and one for perennial tree fruit crops, with the hope that these will be adapted for the diverse range of agricultural production systems across the region. Using the framework set forth by Lengnick (2015), we will create the assessments to help farmers identify their climate risk and adaptive capacity. The assessment will ask about farm management and operational conditions and produce a vulnerability map for each farm. Potential management and conditions include: insurance and financial consideration, weather and climate indicators (frost/freeze, rainfall, etc.), temporal trends, detailed soil information, drainage installation, site growing season information,

nitrogen and phosphorus management, disease incidence, diversity of crop rotation, and changes in variety selection or maturity groups.

Towards High-Resolution Climate Projections for the Great Lakes Region

Team Leads: Michael Notaro
Funder: GLISA internal (NOAA RISA)
Partners: NASA, University of Illinois, Michigan Tech University, University of Wisconsin

GLISA and its partners are developing, testing, and evaluating a high-resolution (single kilometers) regional climate model, coupled to a 3D lake model, for the Great Lakes region. The model will be capable of representing complex lake-atmosphere interactions, ice motion, lake circulation and local-scale features of lake-effect snow and extreme rainfall. This will better represent complex 3D lake processes (e.g., lake circulation, ice motion) and lake-atmosphere exchanges of heat and moisture, while reducing biases in lake-surface temperature (LST), overturning, and ice cover associated with 1D lake models. The work entails: 1) producing reanalysis-driven historical simulations of the new model configuration, namely the NASA Unified Weather Research and Forecasting Model coupled to the 3D Finite Volume Community Ocean Model, to evaluate the mean simulated air temperature, precipitation, snowfall, and lake evaporation; seasonal cycles of LST and lake ice cover; and the frequency and intensity of extremes; 2) producing identical historical simulations using NU-WRF coupled to a 1D model to demonstrate the necessity and improvements of 3D versus 1D lake model coupling; and 3) dynamically downscaling one Coupled Model Intercomparison Project version 6 (CMIP6) global climate model (GCM) using 3-km NU-WRF/FVCOM for the past, present, and future as a case for additional downscaling. This aims to establish proof of concept of the value of RCM coupling to a 3D lake model and of high-resolution, non-hydrostatic modeling, motivating the need for a high-resolution ensemble, which would be highly valuable to GLISA's practitioners.

Freeze/Thaw Cycle Analysis for the Great Lakes Region

Team Leads: Richard Rood, Laura Briley, Sarah Hutchinson
Funder: GLISA internal (NOAA RISA)

Practitioners in the region have expressed a need for updated information on how freeze-thaw cycles (FTCs) are changing across the region. Current trends are only available up to 2010, so GLISA is expanding the analysis to include data to present day. Quantifying FTC patterns is important to GLISA's stakeholders because it can provide them with valuable information to aid in planning across several industries including tourism, transportation, and agriculture. Anticipated products from the synthesis of this work include updated trend information to include in GLISA's Climate Change in the Great Lakes Region Fact Sheet and Climate 101 presentation as well as a more in-depth summary page on GLISA's new website.

The next new areas of focus and partnership are the 2019 GLISA small grant projects, our largest cohort ever. The six projects that began in November 2019 are described below, and the five that started in April 2020 are in Appendix A (and will be included in more detail in next year's report). To accommodate delays encountered by the project teams and/or stakeholders due to the COVID-19 pandemic, all projects have been granted a one-year no cost extension.

GLISA Small Grant: Bringing For-Profit Companies into the Boundary Chain Model

Teams Leads: Laura Briley, Jenna Jorns
Partners: American Society of Adaptation Professionals (ASAP, grantee), Adaptation International

Private sector service providers are entering the adaptation field at an increased rate. Through integration into the boundary chain model, private sector businesses have the opportunity to play a critical role scaling equitable, ethical, and actionable adaptation. This project will provide the foundational steps to ensure private sector service providers have access to and support in implementing the best available climate information for the Great Lakes region by surveying their existing data needs and applied services and developing a replicable training program for service providers that highlights GLISA resources, tools, and methods. Deliverables include: a contact list of climate adaptation service providers operating in the region; a report documenting the practices and needs of climate adaptation service providers operating in the region; a workshop series for climate adaptation service providers; a report documenting the workshop proceedings, conversations that take place at the workshop, and workshop feedback. GLISA is providing an overview of our products and services during the workshop, presenting a live demonstration of the GLISA station climatologies, and meeting one-on-one with participants.

GLISA Small Grant: Calumet Connect: Modernizing the Calumet River Industrial Corridor

Team Lead: Omar Gates, Ken Frank
Partners: Alliance for the Great Lakes (grantee); Calumet Industrial Corridor Working Group

Chicago's Southeast Side faces some of the City's worst economic and health conditions including lack of public infrastructure investments, industrial pollution, and health inequities. Massive storms have caused extreme flooding and combined sewer overflows in the nearby Calumet River, exposing residents to contaminated water-based illnesses, toxic chemicals from nearby industries, and poor quality air that is exacerbated by extreme heat. This project will support the work of the Calumet Connect partners on the Southeast Side, who are working with the Chicago Department of Planning and Development and the Chicago Public Health Department on two initiatives: the Calumet River industrial corridor modernization plan and a city-wide stormwater management strategy and maintenance program. They are developing a multi-year strategy focused on passing and ensuring equitable implementation of policies that integrate equity, health, and climate and will identify a portfolio of funding and financing to ensure the strategy being developed can be implemented and maintained. The Calumet Connect partners have also incorporated the current issues of the COVID-19 pandemic, economic threats, and racial injustice, recognizing that immediate challenges reinforce previous social inequalities around water and air quality. Deliverables include: presentations describing the historical and projected trends; a climate and health fact sheet; and an evaluation of the ways residents have adapted. GLISA is working with the Alliance and Calumet Connect to survey the members regarding their level of political advocacy (as an indicator of expertise) and their social networks. GLISA is analyzing these data to support a network intervention to better facilitate knowledge flows about political advocacy and environmental health risks.

GLISA Small Grant: Great Lakes State Climate Change Summaries for Agriculture

Team Lead: Jeff Andresen, William (B.J.) Baule
Partners: Michigan Technological University (grantee), USDA Midwest Climate Hub

Agricultural producers recognize and are concerned with the increased frequency of climate extremes, such as flooding, droughts, and late freezes. Timely communication of regionally-specific information on relevant agricultural commodities (crops, livestock, forestry) is critical for both increasing understanding of these changes as well as reducing the risks to producers. This project will create state-level agriculture-climate summaries for the eight states in the USDA Midwest Climate Hub region (MN, WI, IA, MO, IL, IN, MI, OH). Stakeholders will be involved in developing these summaries, which will ensure the relevance of information on existing climate change issues and future potential problems to crops/livestock in each state. The products will be subsequently distributed to technical service providers, producers, and state entities via coordinated efforts between the Climate Hubs and State and University staff, including extension and agriculture experiment station partners. Impact will be assessed using download numbers and shares on various web sites. Surveys will be conducted at conferences when the document is introduced to determine the usefulness and likelihood to share the information with others. Deliverables will be state-specific agriculture-climate summaries for the eight states. GLISA will provide downscaled historical and projected climate information to the team for the project area and analysis/visualization of agro-climatic variables.

GLISA Small Grant: Responding to Climate Change in the Diverse Shiawassee River Watershed

Team Lead: Frank Marsik
Partners: Friends of the Shiawassee River (grantee), The Nature Conservancy, Saginaw Bay Watershed Initiative Network

The impacts of climate change manifest in the Shiawassee River in two significant ways: 1) extreme storm events that cause a rapid rise in water volume/levels; and 2) summer droughts that lower water levels, presenting a stress to aquatic life and a challenge to recreational users. The Friends of the Shiawassee River will hold three workshops focusing in distinct categories of stakeholders in the watershed: 1) Agricultural Impacts of Climate Change (partnering with the Shiawassee Conservation District); 2) Urban Impacts of Climate Change (partnering with the Michigan Association of Planning); and 3) Wildlife Impacts of Climate Change (partnering with the USDA Fish and Wildlife Service/Shiawassee National Wildlife Refuge). The Friends' goal is to serve as a climate change information "hub" – surveying populations about their observations of local impacts of climate change, connecting those impacts with observed climate trends in the watershed, and helping to foster conversations about what potential changes in practices might be helpful in mitigating those effects. The Shiawassee River will ultimately serve as a common thread to tie diverse interest groups together for both climate change awareness and action. GLISA is assisting with workshop planning and creating a historical climatology for the Shiawassee River watershed. The first workshop is anticipated to be held virtually in early 2021.

GLISA Small Grant: Using Climate Data to Better Manage Within-Field Unstable Yield Zones in Row-Crops

Team Leads: William (B.J.) Baule, Jeff Andresen, Kim Channell
Partners: MSU Department of Earth and Environmental Sciences (grantee)

This project aims to analyze the effect of climate variability and change on crop yields in yield stability zones (particularly the unstable zones) in the Great Lakes region and to develop improved strategies for tactical (within season) and strategic nitrogen management decisions using climate data and information. We propose to examine this with a combination of remotely-sensed data and detailed output from deterministic crop simulation models for historical and projected future time frames at test sites in Michigan. The proposed management protocol would increase the climate resilience of growers and the economic and environmental sustainability of the agricultural sector. Our partnership with these groups has given us the opportunity to work hands-on with farmers' applications through the analysis of their geospatial data. As a result of this project, stakeholders will be able to make better management decisions on the unstable zones of the field. GLISA will provide gridded and historical climate data to the team, provide analysis, and support preparing publications.

GLISA Small Grant: Using Impact Scenarios and Dialogue to Enhance the Climate Resilience of Organic Dry Bean Production Systems in Michigan

Team Leads: Jeff Andresen, Omar Gates
Partners: MSU Extension and AgBioResearch (grantee), MSU Department of Plant, Soil,& Micro Sciences, MSU Bean Breeding and Genetics Laboratory

Increasingly erratic weather due to climate change is causing more uncertainty and expanding risk for Michigan farmers. However, climate risk is not equal across cropping systems. Pulse crops, like dry beans, are expected to be relatively resilient under projected climate changes due to their genetic diversity, developmental flexibility, C3 photosynthesis, and capacity for nitrogen fixation. Michigan is the second-largest producer of dry edible beans in the U.S. and research suggests Michigan may be a 'climate haven' for dry beans where climate risk is low and dry bean production may even benefit. There will likely be barriers to growers capitalizing on climate change, such as variable precipitation and more frequent summer droughts. This project aims to help the Michigan dry bean industry understand and adapt to climate change by developing climate impact scenarios in three phases: 1) a needs assessment with industry stakeholders; 2) modeling and impact scenario development; and 3) presentation of a scenario report and potential adaptation strategies to industry stakeholders for evaluation. With this information, the Michigan dry bean industry will be better equipped to leverage climate change for the benefit of the entire value chain, consumers, and environment. Deliverables include: four stakeholder meetings in the geographic centers of Huron, Kent, Alpena, and Delta counties and climate scenarios for each region in Michigan based on UW-RegCM4 model projections.

Significant Outputs

While GLISA formally serves the Great Lakes basin, in practice, we serve all states and provinces that border a Great Lake, including central and southern Illinois, Indiana, and Ohio, western Minnesota, New York, Pennsylvania, and Wisconsin, as well as Ontario. The following are our outputs from the last year that are already being used by stakeholders, as well as older resources that are still being used today.

Regional

- Great Lakes Water Quality Agreement Executive Committee and Annexes are using the 2019 Annual Climate Trends and Impacts Summary for the Great Lakes Basin to inform

research priorities and future GLWQA updates. The 2019 summary has also been of interest to NOAA's Great Lakes Environmental Research Laboratory (GLERL), the International Joint Commission, and the Great Lakes and St. Lawrence Cities Initiative.
- More than 20 municipal, county, and state staff meet regularly to discuss local climate adaptation work, share best practices, and co-develop new initiatives as part of the Great Lakes Climate Adaptation Network (GLCAN), which GLISA funds and administers.
- The USDA Forest Service used our Climate Change in the Great Lakes Region 2-pager to analyze air quality and its effects on the forest ecosystem in the upper Great Lakes.
- The American Planning Association used GLISA's boundary chain model of stakeholder engagement, regional 2-pager, and station climatologies in their guidebook to help planners to incorporate climate data into comprehensive and capital improvement plans.
- The National Weather Service is using GLISA's Great Lakes Adaptation Data Suite (GLADS) to host its binational precipitation dataset. GLADS is now hosted on the Great Lakes Observing System's Cloud server and continues to be updated monthly.

Illinois

- At Illinois Beach State Park and Waukegan Beach, beach managers are using climate information and skills gained from a scenario planning workshop GLISA co-facilitated with the Illinois State Geological Survey to better prepare for lake level variations.
- The City of Urbana is using localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment.
- The City of Evanston began a city-wide vulnerability assessment using the template and customized city climatology GLISA provided in 2017. The City's Climate Action Resilience Plan working group was already using the customized climate information from this template as a first source of information, and are now evaluating how to pursue the full vulnerability assessment in a way that engages all municipal departments.
- In northwestern Illinois, the Alliance for the Great Lakes used GLISA's network visualization to inform how they engaged stakeholders to better cultivate the flow of expertise about managing ravines.
- The Chicago Metropolitan Agency for Planning (CMAP) is using GLISA's boundary chain model of stakeholder engagement, regional 2-pager, and station climatologies included in the American Planning Association's guidebook for planners to incorporate climate data into comprehensive and capital improvement plans.

Indiana

- The City of Goshen is using localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment.
- The City of Indianapolis used a localized climatology co-produced with GLISA and USDN in a city-wide climate hazard and social vulnerability assessment.

Michigan

- Four Inter-Tribal Council of Michigan member Tribes are using a stormwater assessment report produced by GLISA to guide decision making on vulnerability of key Tribal assets to extreme precipitation events after we provided training on EPA's National Stormwater Calculator.
- The Fort Custer Training Center (FCTC), operated by the Michigan Army National Guard, used climate information and scenarios co-produced by GLISA to finish their updated Integrated Natural Resources Management Plan. FCTC won the 2020

Department of Defense Environmental Award for Natural Resource Conservation for the Plan, partly for being the first installation to include climate information.
- The City of Ferndale used localized climate and socioeconomic information and professionally designed assessment report provided by GLISA to conduct a stormwater vulnerability assessment. So far, the assessment has been used to guide capital improvement planning discussions and the City Council formally adopted the assessment so it can inform their anticipated Climate Action Plan.
- Grand Rapids and Kalamazoo are using localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment.
- Detroit and Ypsilanti public high school students at Martin Luther King, Ypsilanti, Communication and Media Arts, and Academy of the Americas High Schools are implementing community resilience projects focusing on climate change and adaptation based on GLISA data and guidance.
- The Michigan State Police are using GLISA data, figures, and expertise to update the new 'Climate Trends' chapter in the updated Michigan Hazard Mitigation Plan.
- The Southeast Michigan Council of Governments (SEMCOG) and the Michigan Department of Transportation (MDOT) is using raw projection data and our climate model report card in their Climate Resiliency and Flood Mitigation Study.
- The City of Ann Arbor used historical observations and future projections of extreme precipitation to justify proposing higher building standards within the floodplain to minimize public and private losses due to flooding.
- Allison Steiner, a regional climate expert at the University of Michigan, has been using GLISA's CMIP5 lake evaluation to understand prior CMIP5 results, specifically, looking at changes in snow to understand and explain model behavior.
- The University of Michigan School for Environment and Sustainability faculty are using a teaching case on GLISA's work with the Great Lakes Climate Adaptation Network (GLCAN) to teach graduate level courses in adaptation.
- Washtenaw County revised their 'Rules and Guidelines: Procedures & Design Criteria for Stormwater Managements Systems' to use updated NOAA Atlas 14 data for design storms (rather than FEMA flood maps) on GLISA's recommendation. *This was adopted in 2016, but we learned about this outcome during the 2020 reporting period.*
- The Detroit Land Bank Authority and the University of Detroit School of Architecture are using GLISA's regional maps in an educational book on how to incorporate climate change into restoration and design decisions.
- The City of Detroit is using GLISA's updated city climatology for Detroit, specifically indicators on days over 90 and 100 degrees, in their Sustainability Action Agenda.
- A Detroit middle school science teacher uses GLISA's information and resources in her classroom to teach them about applied science.

Minnesota

- NOAA's Office for Coastal Management is using GLISA's downscaling guidance to advise communities on integrating resilience principles into their Capital Improvement Planning process.

New York

- The City of Buffalo is using localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment.

- The New York Department of State Planning Office is using the scenario planning documents GLISA and New York Sea Grant developed as part of a 2014 GLISA small grant for a state-wide planning initiative for high water levels.
- Dr. Lowry at the University at Buffalo is using GLISA's Great Lakes Ensemble climate projections to develop an integrated surface water-groundwater model to analyze the effects of future climate change and human activities in Western New York.

Ohio

- The City of Toledo used localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment. So far, the City's stormwater engineers are using the assessment to improve on the identification and tracking of stormwater system components to inform future monitoring and their storm capacity design standards. It has been put in the Public Utilities 2019 Highlights and Accomplishments report. It has also been referenced in their EPA Section 319 grant to demonstrate a need for certain stormwater projects and practices.
- The City of Dayton used localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment. So far, the assessment received an unexpected amount of buy-in from workshop participants (e.g., city manager's office), and will be handed over to the new Sustainability Manager to include in Dayton's climate strategic plan and its city-wide corporate mission.
- Cleveland and Columbus are using localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment.

Ontario

- The Ontario Climate Consortium used GLISA's assessment of the CMIP5 models for their representation of the Great Lakes in preparation for and summary of the June 2019 workshop for climate modeling in the Great Lakes Basin for Annexes 7 and 9 of the GLWQA. GLISA's CMIP5 evaluations are included in their State of Climate Modeling in the Great Lakes Basin report.
- The City of St. John's is using GLISA's CMIP5 lake evaluation to communicate to their constituents how GCMs represent the lakes and provide guidance on selecting GCMs when conducting impact assessments.
- The State of the Strait is using indicator narratives written by GLISA in their most recent update to the Detroit River-Western Lake Erie Basin Indicator Project to communicate trends for policy-makers and resource managers in order to identify data gaps and comprehensively assess the state of this ecosystem.
- Environment and Climate Change Canada's Boundary Water Issues Unit is using GLISA's climate stations and quality control standards to model Great Lakes water supplies and water level forecasts.
- Regional climate modeling experts are using GLISA's Great Lakes Ensemble guidance in the Ontario Climate Consortium's 'The State of Climate Modeling in the Great Lakes Basin' report to develop the best available climate projections for the region.

Wisconsin

- The City of Madison used localized climate and socioeconomic information and a template provided by GLISA to conduct a stormwater vulnerability assessment. So far, the engineering and sustainability departments are using the assessment to inform a broader City initiative for their Climate Resilience Planning Partnership project.

- The Lac du Flambeau Tribe of Lake Superior Chippewa Indians used customized historical observations and future projections in their Climate-Smart Hazard Mitigation Plan. The plan was adopted by their Tribal Council and approved by FEMA in September 2019. GLISA co-developed this climate information as part of a larger vulnerability assessment process, led by Adaptation International.
- The Apostle Islands National Lakeshore is using climate projections provided by GLISA for a climate change vulnerability assessment for terrestrial ecosystems (published May 2020) led by the Northern Institute of Applied Climate Science (NIACS).

Outside of our region via a UM SEAS masters student project led by GLISA Co-PI Richard Rood, GLISA's scenario planning approach was applied in the Seychelles (Africa) to evaluate the impacts of sea level rise and storm surge on the island's critical infrastructure.

Engagement & Outreach

We engage a broad network of stakeholders including local, state, and regional decision makers in many sectors, the media, educators and students, and the public. This section summarizes our engagement and outreach to specific audiences, as well as our general outreach and engagement through conferences, workshops, presentations and leadership in peer networks. We are continuing to redesign our website to better highlight our impact and to make our most popular products and projects more accessible. In the last year, we installed a professional video conferencing system for remote engagement (with funding from UM SEAS) and built up our social media presence on Twitter (@GreatLakes GLISA).

Elected Officials

GLISA has continued to conduct Congressional outreach through individual briefings and by partnering with other NOAA entities. This outreach has not only provided an avenue to share our work with leaders in Congress, but it has also strengthened our ability to tailor and effectively communicate our message to specific issues and geographic interests:

- Presentation to 17 congressional staffers as part of UM's Annual University Research Corridor Tour on 8/20/19; presented alongside NOAA partners the Cooperative Institute for Great Lakes Research (CIGLR), Michigan Sea Grant, and the National Estuarine Research Reserve System (NERRS).
- Provided information and our logo to 'The Climate Crisis in Michigan,' a 2019 report prepared by Debbie Stabenow, U.S. Senator for Michigan
- Shared information on GLISA's municipal vulnerability assessment process to U.S. Senator Tammy Baldwin's office.

Educators & Students

In the last year, our work with students at many educational levels has continued. We are still working directly with K-12 educators on climate change curriculum for the classrooms in Detroit. We have continued our long-term relationship with the University of Michigan Department of Climate and Space Sciences and Engineering. Over the last year, GLISA has worked with five graduate and undergraduate students on real-world, applied climate projects to contribute to GLISA's research efforts, provide usable climate information for stakeholders in the region, and

train the students on stakeholder engagement and how to communicate climate science to a broad audience. These students contributed to much of the work highlighted in this report and continue to find excellent employment opportunities, often citing their time with us as critical in gaining skills and experience (see Testimonials). Furthermore, we supported several graduate student research assistantships through cost share from both universities and hired additional graduate students hourly to support specific projects. We also continued to mentor two undergraduate students through the summer Doris Duke Conservation Scholars Program at the University of Michigan (see Testimonials). Furthermore, GLISA's Michigan Sustainability Case for co-development of climate knowledge featuring the Great Lakes Climate Adaptation Network (GLCAN) was used by PI Lemos in two courses and accessed by 31 users outside UM.

NOAA & Federal Partners

Our long-term partnerships with other UM NOAA Great Lakes programs continue to translate into tangible projects. GLISA is a subcontractor to Michigan Sea Grant on a 3-year NOAA Environmental Literacy Grant and we continue to partner with CIGLR and GLERL to improve ice forecasting information. Two of our 2019 small grants involve Pennsylvania and New York Sea Grant (see New Areas of Focus or Partnership). These projects allow us to leverage each other's expertise and relationships to build adaptive capacity in the region, and we continue to seek opportunities to continue working with these, and other, NOAA entities and partners.

Through our participation in the NOAA Great Lakes Regional Collaboration team and the new Climate sub-group, we interact regularly with GLERL and other NOAA line offices. The regional team funded GLISA's contribution to the 2018 annual climate summary and Co-PI Andresen regularly joins NOAA partners to present on public webinars on lake levels. We presented a 'Climate 101' and a summary of our Great Lakes Ensemble to the NOAA Office of Coastal Management's Coastal Resilience grant project with the Association of State Floodplain Managers and the American Planning Association and participated in the June 2019 Ohio Climate Services Summit (co-hosted by NOAA and USDA). Finally, a case study on GLISA's boundary chain model was added to NOAA's U.S. Climate Resilience Toolkit.

Outside NOAA, GLISA engages with other federal climate partners. One of our 2019 GLISA small grants includes a partnership with the USDA Midwest Climate Hub (see New Areas of Focus or Partnership) and we are part of a new Midwest Climate Partners Group, led by the Department of Interior's new Mid-Continent Climate Adaptation Science Center. By serving on the Great Lakes Water Quality Agreement Annex 9 Subcommittee, we have a long-term relationship with ECCC and work with them on several projects and discuss new ideas.

As a regional convener and content expert, we serve on a number of local and regional committees. The following activities allow GLISA to broaden our impact by communicating our work to a larger group of stakeholders and lend our expertise to new projects. See Appendix B: Complete List of Presentations for a complete list of peer networks.

Media

GLISA interacts with the media often either to promote upcoming events and publications, or by request to discuss a recent climate or weather event. The following list highlights particularly noteworthy coverage. For a complete list of media mentions, see Appendix C: Complete List of Media Mentions:

- New monthly blog for Michigan Today by co-PI Richard Rood
- The Conversation, 6/4/19; article on climate change and lake levels
- The Guardian, 9/3/19; article on flooding in the Great Lakes
- Washington Post, 3/5/20; article on usually late lake effect snow
- National Geographic, 3/24/20; article on changing ice cover
- Huffington Post, 3/28/20; article on the impact of changing ice cover on ice fishing

Conferences, Workshops, & Presentations

Engaging stakeholders through conferences, workshops, and webinars allows us to interact directly with decision makers and to work through exercises to jointly develop data and resources. In the last year, we engaged stakeholders primarily as co-leaders of workshops to facilitate individual sessions or make presentations. We were a co-facilitator in partnership with the Illinois State Geological Survey at the August 2019 Illinois State Beach Park and Waukegan Beach Climate Scenario Workshop. GLISA walked six key beach managers through five exercises to operationalize customized climate and lake level scenarios and think through how to adapt their practices to varying lake levels. We also co-hosted a June 2019 Climate Modeling Experts Workshop in Ann Arbor (MI) with the Ontario Climate Consortium, resulting in a workshop report and plans to co-host another workshop together in spring 2021.

GLISA team members have also made presentations in a number of other contexts to reach a broad audience. We attended a number of local, regional, and national conferences to formally present our work and we regularly present a 'Climate 101' for the Great Lakes region, tailoring our presentation to any unique information needs or topics. Finally, GLISA is often invited to attend regional stakeholder meetings or webinars and present an overview of our program or a specific project. See Appendix B: Complete List of Presentations.

Program Evaluation & Impact

GLISA continues to prioritize understanding how our information and resources inform decision making in our region, and how we can better increase communities' adaptive capacity to respond to climate variability and change. We continue to track the metrics first presented in our Phase I report for 2010-2016, including sectors and number of entities engaged, number of organizations engaged at different levels of government, grants awarded, and funds leveraged.

Evaluation

Evaluation of GLISA's impact

GLISA hired an independent external evaluator, Dr. Alison Meadow, to evaluate GLISA's impact in the Great Lakes to inform long-term strategic planning and future proposals. She is assessing the impacts of GLISA projects on regional practitioners and policy makers through the application of a societal impacts assessment framework completed within the last five years. She is currently interviewing practitioners and GLISA team members and anticipates completing an evaluation report in October 2020.

Evaluation of small grants competition

In the last year, we continued to finalize the evaluation of the first five years of our small grants competition. We conducted a second round of interviews with grantees to understand the long-term impacts associated with the projects and interviewed the GLISA Climatologists who worked on the project to learn what characteristics made a project successful. These new findings are being integrated into the existing evaluation and a report is anticipated to be finished in 2020 with a draft manuscript to follow. Preliminary research findings suggest that the embeddedness of boundary organizations with GLISA and with their end users – the strength and history of those relationships – was the most important driver in forming and maintaining lasting networks that continued operating after the project. Interestingly, grantees felt that less tangible outcomes (i.e., networks, relationship building, awareness) were the most numerous and successful long-term outcomes (compared to reports, plans, decisions) in their view.

Evaluation of Adaptation Project Impact

While adaptation professionals and other decision makers are actively implementing adaptation projects, few evaluate their projects' outcomes and impacts or obtain insights into how to improve. Based on input from an advisory group (academia, government agencies, NGOs and the American Society of Adaptation Professionals) and a session at the 2018 Great Lakes Adaptation Forum, we will launch a webpage on the GLISA website that will: 1) introduce adaptation professionals to evaluation and its potential benefits, 2) support the preparation for and execution of adaptation evaluations, 3) explain how to identify and work with evaluation consultants, and 4) provide an inventory of the most valuable adaptation evaluation resources.

Evidence of Societal Impact

We continue to focus on deepening existing relationships and work in our three main sectors: cities, tribes, and agriculture. We also continue to explore new ideas and partnerships, and started to better document capacity building in our region over the last year. We developed a standard design template for impact stories and aim to have a library of stories available on our new website by the end of 2020 highlighting partner testimonials and project outcomes.

Engagement with Cities

GLISA continues to convene and provide administrative support to the Great Lakes Climate Adaptation Network (GLCAN). To lead this work, we welcomed our first-ever Practitioner in Residence, Matt Naud, who previously worked for the City of Ann Arbor for 17 years. In addition to leading GLCAN's bimonthly calls, Naud distributed a survey and conducted interviews with select members to learn how the network can better serve the region and is using responses to develop a factsheet and a plan to expand the group. An unexpected, positive development during the COVID-19 pandemic has been the renewed strength of GLCAN. Usually meeting every 2 months, the group decided to meet every two weeks in the spring to work together to respond to the common challenges they are facing during the pandemic. The group is working collaboratively on resilient recovery plans, ideas for shovel-ready projects, and a brief on the value of sustainability and adaptation planning as it relates to pandemic recovery. We saw much higher attendance on these calls and are proud to continue to administer the group. We also plan to use the network to recruit cities for both cross-RISA collaborations (see Next Steps).

Testimonials

The following testimonials from key partners and recent graduates highlight our reach and impact. They also show the long-term benefits of our work, often years after formal projects have ended. See Appendix D: Additional Testimonials for additional quotes.

"As a climate change specialist working binationally, GLISA has provided valuable expertise and support in addressing climate change impacts across the Great Lakes. I have had the privilege of collaborating with GLISA on several initiatives over the past year, including the Great Lakes Ensemble as a scientific advisor, in identifying climate scenario planning needs and in scoping out climate divisions across Ontario in support of increased climate action and consistency. GLISA continues to play a vital role across the Great Lakes basin in driving best practices, building a broad network of climate change stakeholders, and in developing excellent guidance which enables resilient decision making by practitioners."

- Glenn Milner, Climate Change Specialist, Savanta (formerly with OCC)

"When I joined GLISA, I had relatively little climate science knowledge, as my background was primarily in engineering & programming. During my year working there I gained valuable experience working with meteorological data and climate model outputs, and I learned a great deal about climate adaptation efforts in the Great Lakes region. The skills I learned at GLISA definitely helped prepare me for my current position at Scripps Institution of Oceanography, where I write code to help conduct research on extreme precipitation events in the western U.S. The best parts of working at GLISA were the learning experiences and the opportunity to work with people who are passionate about climate science and adaptation."

- Peter Yao, former GLISA Research Associate, Scripps Institute of Oceanography

Narrative Case Studies

Lac du Flambeau Vulnerability Assessment and Adaptation Plan

GLISA previously worked with Adaptation International on the Climate Change Vulnerability Assessment and Adaptation Plan for the 1854 Ceded Territory, including the Bois Forte, Fond du Lac, and Grand Portage Reservations in Minnesota. Following this successful partnership, Adaptation International reached out to GLISA to partner on a new project to develop a climate change resilience plan for the Lac du Flambeau Tribe of Lake Superior Chippewa Indians in northern Wisconsin. As a subcontractor to Adaptation International, we led the climate change analysis portion of the assessment, providing a custom analysis of historical observations and future projections for a geographic area defined by the Tribe. Preliminary findings were presented on a site visit in May 2017, when additional topics of interest were added to our role including writing up a climate summary, identifying climate thresholds for the Climate Change Vulnerability Index (CCVI) for culturally-significant species, and providing relevant literature on groundwater, ice cover and pollen. GLISA attended another site visit in November 2018 and presented updated temperature and precipitation trends and figures to the Tribal Council and the Tribal Climate Resilience Planning (TCRP) committee. Using this information, the TCRP finalized a Climate-Smart Hazard Mitigation Plan, which was adopted by the Tribal Council and FEMA in fall 2019. With this information, Tribal member Eric Chapman Senior participated in a panel on climate-smart hazard mitigation during the National Adaptation Forum and then reprised that role for a National Adaptation Forum Webinar which had the most attendees ever for one of their webinar series events. Although the COVID-19 pandemic has delayed some of the work for their final vulnerability assessment and adaptation plan, Adaptation International

and the TCRP will wrap-up the overall project by fall 2020. Other partners include ICLEI Local Governments for Sustainability and George Haddow, Bullock & Haddow LLC and GLISA presented the collaboration at the American Meteorological Society 99th Annual Meeting.

Comprehensive Vulnerability Assessment Template for Cities

Cities require vulnerability assessments (VAs) for virtually every planning process (i.e., natural hazards, infrastructure, climate change), but they are rarely coordinated across existing planning domains. To save municipal staff time and resources that are often dedicated to duplicative VAs, GLISA worked with five Great Lakes cities, the Great Lakes Climate Adaptation Network (GLCAN), and the Huron River Watershed Council (HRWC) in 2017 to develop a comprehensive VA template with support from USDN. We then received funding from NOAA SARP to adapt the template for stormwater and implement it with 12 more cities. The City of Ferndale (MI) was the first to complete their template and their City Council formally adopted the stormwater vulnerability assessment on July 13, 2020. Erin Quetell, Ferndale's Environmental Sustainability Planner who participated in the project, used the decision matrix outcome of the assessment that compares adaptive capacity and sensitivity of city infrastructure and stormwater components to tell the story. This adoption was only three days after a severe rain event (more than 2 inches of rain/hour), generating timely interest for this discussion. Ferndale is using the assessment in their climate adaptation and resiliency planning, specifically to guide capital improvement planning discussions and their upcoming master land use plan update. In addition to developing a regional climatology and customized city-specific climatology for Ferndale, GLISA coordinated and conducted in-person training on the tool. The workshop was attended by a large group of city staff, including the city manager and representatives from public works, engineering, community and economic development, and the sustainability commission. Participating in the project has helped Ferndale support green stormwater infrastructure projects, generate ongoing city conversations about climate and social vulnerabilities, and strengthened relationships with other sustainability departments across the region. The template is now being scaled-up again, to 60 cities in the Gulf region (see New Areas of Focus or Partnership) and we are developing a web-based version of the tool with the intent to scale it up eventually beyond the Great Lakes and Gulf regions.

Economic Return

GLISA partnered with the Alliance for the Great Lakes (AGL) on 2013 and 2015 GLISA small projects. The AGL's goal was to help cultivate social network ties among those working in different communities to better manage ravines on Lake Michigan between Chicago and Milwaukee. GLISA facilitated this network intervention by helping AGL members develop, analyze, and interpret social network survey instruments to identify potential relationships that, if established, would facilitate the flow of knowledge across communities about the potential effects of climate change on ravines. GLISA also provided customized climate information for the area of interest. To estimate economic impacts, we first look to the value of improved management of the ravines in the context of climate change. Because most ravines in the area are on private property, protection of the ravines is a protection of private property. In the particular example of the GLISA-AGL project, ravines were protected if ravine managers, including municipalities and private landowners, could better anticipate and mitigate against climate change events (e.g., extreme precipitation). A recent Chicago Tribune article indicates that coastal engineers charge between "a few hundred thousand dollars to more than $2 million" to protect shoreline destruction which includes eroding ravines. Some of these costs could and were avoided by ravine managers who learned from others about practices to reduce erosion (i.e., planting of native species with deeper roots that resist erosion, how to reduce channeling

of water into ravines due to construction). The projects helped create new knowledge flows involving 20 of about 40 ravine managers. Assuming each of the 20 participants pay at least $200,000 to mitigate the effects of erosion, this totals $4 million. If the knowledge flows reduced that by 10%, they would account for $400,000 in economic impact. Second, members of the AGL used the GLISA small grants to leverage an additional $272,000 to support ravine management from foundations such as Healing our Waters - Great Lakes Coalition.

Next Steps

Advancing CMIP Knowledge for the Great Lakes Region

GLISA will leverage an existing NOAA project (PI Notaro, University of Wisconsin) that is a process-based evaluation of the representation of lake-effect snowstorms in CMIP6 High Resolution Model Intercomparison Project (HighResMIP) experiments. The project aims to assess the representation of lake-atmosphere interactions and resulting regional climate in the Great Lakes among high-resolution GCMs in HighResMIP. GLISA will synthesize the model evaluations for regional practitioners using our existing framework of consumer report-style resources, such as our Climate Model Report Card. This work builds on our assessment of CMIP 3 and 5 for the region and provides important updates to and messaging around the general use of CMIP, supping the ongoing development of stakeholder resources as part of the Great Lakes Ensemble project (see Appendix E: Ensemble Stakeholder Partners).

Cross-RISA Collaboration Projects

In the next year, we will work with three peer Regional Integrated Sciences and Assessments (RISA) teams on dedicated cross-RISA projects. In the first, we will work with Western Water Assessment (WWA) on the project, “Supporting Flood Planning in the Great Lakes and Intermountain West Regions in the Context of Climate Change Impact, Future Growth, and Migration.” GLISA will lead the development of an integrated spatial model to visualize urban growth patterns and flooding and then in coordination with WWA, will hold workshops with two cities in each region to co-produce scenarios and get feedback on the model. In the second, we will work with the Mid-Atlantic RISA (MARISA) and the Carolinas RISA (CISA) on the project, “Co-development of a Nationally Relevant Hazard Mitigation Planning Portal and Visualization Tool.” GLISA will contribute data from the Great Lakes region and engage Tribes and to co-develop a nationally relevant Hazard Mitigation Planning Portal and Visualization Tool with USDN to provide users with a single point of entry to community- and region-specific historical and projected data visualizations of climate-related metrics and impacts.

2021 Climate Experts Modeling Workshop

With support from the NOAA Great Lakes Regional Collaboration Team and ECCC, GLISA will co-host a second Climate Experts Modeling Workshop in March 2021 to: 1) review the existing Great Lakes regional climate modeling efforts, including the strengths, limitations and credibility of climate change projections; 2) share preliminary results from relevant work and models in Canada and the U.S.; 3) identify gaps and areas of greatest uncertainty; and, 4) develop recommendations for future work. A workshop report will follow to summarize discussions and opportunities so that climate modelers and practitioners can work together to improve these models through funding, collaboration, and engagement activities. We anticipate the workshop will be held remotely due to the COVID-19 pandemic.

Appendix A: April 2020 GLISA Small Grant Projects

GLISA Small Grant: Applying Climate Information to Build Resilience - Translating Technical Results into Practical Tools for Community Decision Makers

Team Lead: Laura Briley, Michael Notaro
Partners: Ontario Climate Consortium (OCC, grantee), Toronto Region Conservation Authority, Durham Region

Communities and watershed management agencies in Ontario are increasingly expected to address climate change at the local scale and need to integrate the best available climate data into their research, planning and decision making to build resilience. This project aims to mobilize regional climate projections into four training sessions across the Region of Durham with stakeholders including municipal and conservation authority planners, engineers, GIS experts and other technical staff. GLISA and OCC will co-produce training materials along with key messages relating to climate data and future projections around how they can be applied to research, planning, and decision making related to natural environment projects (e.g., watershed plans, running impact models to assess watershed conditions and resilience). Anticipated project outcomes include: 1) improved understanding and the "mainstreaming" of climate data for use in natural environment-related applications, 2) use of consistent climate data and messaging around climate projections, and 3) improved awareness and availability of visuals and materials for practitioners on how to use climate data. Deliverables include: climate impact scenarios; a suite of key messages related to climate data and its application to human health and the natural environment; a suite of four training modules; an infographic that illustrate how climate projections can be translated and/or applied for practical applications; and a scenario planning workshop with staff and relevant stakeholders on climate change and human health.

GLISA Small Grant: Climate Change Opportunities Phase I: Creating Two Methodologies for Anticipating Growth in the Great Lakes Region

Team Lead: Kim Channell, Sarah Hutshinson
Partners: American Society of Adaptation Professionals (grantee), Florida State University, City of Ann Arbor, National League of Cities

Working together with leading practitioners and researchers from the City of Ann Arbor (MI), the National League of Cities, and Florida State University, the American Society of Adaptation Professionals will coordinate a two-year project to create methodologies for projecting human migration that integrate future climate projections and to gather stakeholder perspectives on the topic of climate-induced in-migration to the region. Additionally, the proposed year 2 activities will provide an opportunity to pilot the developed methodology with two communities from the Great Lakes region. The project will include a mixed approach of desk research, qualitative research, and quantitative data analysis. Key project outputs will include: 1) a rigorous and replicable methodology for projecting migration that integrates future climate projections which municipalities can use to inform capital, operational, and management decisions; 2) an annotated list of stakeholders ready to pursue future work with GLISA on in-migration to the Great Lakes region including local, state, and tribal leaders; industry representatives; and applied researchers; 3) a typology of issues, opportunities, and stakeholder needs for climate-

related migration into the Great Lakes region that can inform future research agendas; and 4) a review of peer-reviewed papers and white/gray literature related to migration into the Great Lakes region in response to climate change. This project is anticipated to build foundational knowledge on the topic of in-migration, create new tools that can be applied in other climate-receiving regions, catalyze additional investment and research into this critical area of adaptation and resilience work, and cultivate a narrative around the importance of preparing for climate-related opportunities in addition to climate risks. By building a robust project team and engaging representatives of industries and sectors from across the region, this project will ensure that there is a strong group of leaders prepared to collaborate on a sustained effort to develop case studies and model practices to ensure the Great Lakes region is poised for sustainable and just economic growth into the next century.

GLISA Small Grant: Expanding Capacity to Utilize Public Health Law to Advance Climate Adaptation in the Great Lakes Region

Team Lead: Omar Gates
Partners: Network for Public Health Law and TSNE MissionWorks (grantee), The Wisconsin Public Health Association, The Wisconsin Association of Local Health Departments and Boards, The Northern Michigan Environmental Health Directors, The Michigan Department of Health and Human Services, The Great Lakes Public Health Coalition

This project aims to enhance the capacity of public health practitioners to utilize public health law to address climate change in the Great Lakes region. The project will consist of online webinars and a small number of in-depth, in-person training. The trainers will share historical and projected climate information relevant to the region and local area and will map the pathways through which these changes are likely to produce adverse health impacts (e.g., extreme heat may contribute to heatstroke or even death, wildfires and air pollution may exacerbate respiratory illnesses). Trainers and participants will then examine state and local health departments' current legal authority to address the human health impacts of climate change. Additionally, trainers will describe emerging opportunities to mitigate and adapt to climate change through law and policy. This review of existing legal authority, relevant legal strategies, and case studies from around the country will increase public health leaders' readiness to serve as their communities' "chief health strategist" in the face of climate change. The Principal attorneys will offer limited legal technical assistance to public health leaders to further amplify their capacity to protect, promote, and improve health by enforcing and implementing current laws and working with partners to introduce innovative, evidence-based laws and policies. Deliverables include: climate information for the states of Michigan and Wisconsin; co-facilitation of four workshops to train participants on linking climate impacts to health impacts; and 3) legal assistance to public health leaders. GLISA will work with health practitioners to identify health impacts from extreme heat and precipitation, and air pollution.

GLISA Small Grant: Preparing Duluth Community Sectors for the Changing Climate

Team Leads: Kim Channell
Partners: Minnesota (MN) Department of Natural Resources (grantee), Minnesota Department of Public Safety-Homeland Security and Emergency Management, University of Minnesota Duluth, Northern Institute of Applied Climate Science, Minnesota Department of Health

Duluth (MN) is a city on the coast of Lake Superior that has experienced significant flooding and damage from extreme precipitation events and high Lake Superior winds and waves in recent years. This project has the goal of preparing to maintain public health and safety during extreme precipitation and storm events, while also taking a preventive approach to reduce risk for the community. This project aims to improve local understanding and application of climate projections and potential impacts through the use of scenarios. Stakeholders will learn about climate projections for Minnesota and participate in multi-disciplinary scenario exercises of potential extreme precipitation and storm events. Project outcomes include: increased knowledge and understanding of sector-specific impacts of the changing climate; actionable knowledge of gaps, needs, and action steps to support and maintain a resilient community within the context of Minnesota's changing climate; increased awareness of other sector's activities, concerns, personnel, and challenges toward maintaining a resilient community within the context of a changing climate; and, summary sheets with highlights and recommendations from educational presentations and scenario exercises that can be built into plans. GLISA will provide climate scenarios and scenario planning facilitation at stakeholder workshops.

GLISA Small Grant: Preparing Erie, Pennsylvania for Extreme Weather - What to Do and Where to Start

Teams Leads: Kim Channell, Erin Maher
Partners: Pennsylvania Sea Grant (grantee), Erie County Department of Planning and Community Development, Environment Erie, Green Building Alliance, Erie County Department of Planning, Department of Environmental Protection

Erie County, Pennsylvania, which includes 76 miles of Lake Erie shoreline, is becoming increasingly vulnerable to the short and long-term impacts of extreme weather and climate variability. To build resilience in Erie, Pennsylvania Sea Grant is working collaboratively with the Community Resilience Action Network of Erie and GLISA to engage community stakeholders within various sectors of Erie County to discover and document local climate hazards and develop workable solutions to address these climate and weather-related risks. This project is following the 'Steps to Resilience' from the U.S. Climate Resilience Toolkit to: 1) explore Erie's hazards by hosting community engagement workshops to determine most relevant community assets and concerns, 2) assess vulnerability and risk by conducting a community vulnerability assessment to assign risk to each of the identified assets and, 3) investigate response options by compiling and prioritizing possible solutions. Deliverables include a framing document containing localized information on Erie's climate and a list of local assets potentially at risk; a set of possible climate scenarios describing future conditions; a completed vulnerability assessment for Erie with a Resilient Index score; a list of assets of community concern and level of risk from climate change; a master list of all possible actions strategies that could improve resilient in Erie; and a best management practices document. GLISA will provide climate information including historic trends and future projections in the form of a regional summary, present this information at a stakeholder workshop, and help facilitate scenario planning exercises.

Appendix B: Complete List of Presentations

GLISA team members have attended a number of local, regional, and national conferences to formally present our work to our stakeholder groups, including academic and federal researchers, adaptation practitioners, and NOAA collaborators:

- Swiss Federal Institute of Aquatic Science and Technology (EAWAG) in Zurich, November 2019; invited lecture on the co-production of science and decision-making in the water sector
- American Geophysical Union Fall Meeting in San Francisco (CA), December 2019; poster presentation on novel modeling for ice cover predictions
- Southwest Ontario Agriculture Conference, in Guelph (ON), January 2020
- American Meteorological Society 100th Annual Meeting in Boston (MA), January 2020; oral presentation on our NOAA SARP project
- American Meteorological Society 100th Annual Meeting in Boston (MA), January 2020; oral presentation on scenario planning

Through our reputation as a trusted expert, GLISA regularly presents an overview of climate change in the Great Lakes region, a 'Climate 101.' Co-Director Jeffrey Andresen also serves as the State Climatologist for Michigan, increasing GLISA's reach through his presentations in this capacity. We typically build our presentation from a standard slide deck prepared for general audiences and tailor the talk to any unique information needs or topics not already covered. Below is a list of key meetings we participated in over the last year in-person or remotely:

- NOAA Central Region Weather Briefing webinar, 6/10/19
- Michigan Golf Course Supervisors Association webinar, 6/13/19
- NOAA Office of Coastal Management Coastal Resilience Grant project team meeting, 7/2/20
- Friendship House MSU Expert Series, 8/14/19
- Pioneer Agriculture Field Day, 9/11/19
- Weyenberg Public Library, 9/2010
- Lansing League of Women Voters, 9/26/19
- Weyenberg Public Library, 9/2019
- Michigan Department of Natural Resources, 10/22/19
- MSU Extension Fall Conference, 10/19/29
- Federation of Environmental Technologists, 10/2019
- Wisconsin Gardening Federation, 10/2019
- Michigan Water Environment Association, 12/3/19
- Midwest Food Products Association, 12/2019
- Michigan Agribusiness Association, 1/14/20
- MSU Extension Action Day, 1/31/20
- First Baptist Church, 1/2020
- Michigan Association of County Drain Commissioners, 2/12/20
- USDA Natural Resources Conservation Services Native Pollinator Workshop, 2/25/20
- Michigan Conservation District Spring Meeting, 3/4/20
- Michigan Forage Council Annual Meeting, 3/5/20
- Environmental Professionals Network webinar 'Exploring the Interactions between Water, Climate, and Communications,' 3/17/20
- Wisconsin Department of Natural Resources Bureau of Law Enforcement 2020 Statewide Meeting, 3/20/20
- MSU Master Gardener College webinar, 4/22/20
- MSU Plant Resilience Institute webinar, 4/23/20

GLISA is often invited to attend regional stakeholder meetings and present either an overview of our program or a specific project. In these cases, we tailor the presentation to share work relevant to the audience:

- Ohio Climate Services Summit, 6/4-6/5/19 in Columbus (OH); Channell presented an overview of GLISA's program
- Grand Valley State University Climate Change Summit, 6/12/2019 in Allendale (MI); Co-PI Andresen spoke on incorporating climate change into K-12 education
- 2019 Great Lakes Public Forum, 6/17/19 in Milwaukee (WI), Channell presented the *2018 Annual Climate Trends and Impacts Summary for the Great Lakes Basin*
- Great Lakes Climate Modeling Experts Workshop, 6/27/19 in Ann Arbor (MI); Briley presented the Great Lakes Ensemble project
- NSF Practitioner-Led Urban Sustainability (PLUS) workshop, 7/8-7/10/19 in Ann Arbor (MI); PI Lemos presented GLISA's work to more than 50 city practitioner and academic partners
- Blessed Trinity Global Learning and Observations to Benefit the Environment (GLOBE) workshop in Cross Plains (WI); Co-PI Notaro presented
- Illinois State Beach Park and Waukegan Beach Climate Scenario Workshop, 8/13/19 in Waukegan (IL); Gates led participants through five scenario planning exercises
- Center for Inquiry Michigan, 8/14/19 in Grand Rapids (MI); Baule gave invited talk
- Model Diagnostics Task Force, 12/2019 in Madison (WI); Co-PI Notaro presentation on lake-effect snow simulations
- Cornell University Department of Natural Resources, 1/2020 in Ithaca (NY); PI Lemos gave an invited lecture
- U.S. EPA National Stormwater Calculator: Great Lakes Applications webinar, 2/19/20; Marsik presented on our training with the Inter-Tribal Council of Michigan
- NOAA North Central and Drought Outlook Webinar for March 2020, 3/19/20; Baule and Andresen presented on short-term recent and projected climate conditions
- NOAA Great Lakes Water Levels Webinar, 4/13/20; Co-PI Andresen presented on high water levels
- 2nd Resilience Ecosystem Workshop, 4/28-5/6/20 via webinar; student Kemp attended
- U-M Biological Station Summer Lecture Series, 5/14/20; Co-PI Rood presented on applying scenario planning to climate change problem solving
- UNFCCC Filling Climate Gaps for the Lima Adaptation Knowledge Initiative webinar on 5/26/20; Maillard presented UM SEAS master's project applying GLISA's scenario planning approach in Seychelles

Leadership in Peer Networks

- Participate in the Michigan Climate Coalition
- Serve on Great Lakes Water Quality Agreement Annex 9 Subcommittee
- Represent GLISA on new Midwest Climate Partners Group
- Serve on NOAA Great Lakes Regional Collaboration Team and two working groups: Communications, Climate
- Administer & participate in Great Lakes Climate Adaptation Network (GLCAN)
- Represent the Great Lakes Adaptation Forum in adaptation forum organizers group
- Beta tester for EcoAdapt's Climate Adaptation Registry Application
- Serve on a focus group for the Northeast Climate Adaptation Science Center's five-year science plan
- Member of Wisconsin Initiative on Climate Change Impacts Working Group Council, Climate Working Group

Appendix C: Complete List of Media Mentions

The following list highlights articles featuring interviews with GLISA team members and notable mentions of our work. Italicized items are particularly noteworthy:

- Environment and Water Resources Institute (EWRI) Currents, spring 2019 issue; article by describing the capabilities of NOAA's Weather and Climate Toolkit
- Washington Post, 6/6/19; article on overflowing Great Lakes water levels
- ClimateWire, 6/6/19; article on new normal of high water levels
- Radio Ecoshock, 6/12/19; article on the bridge between disaster and climate change
- Great Lakes Echo, 6/14/19; article on how climate change is driving variation in water levels
- Crain's Business Detroit, 6/16/20; article on the wettest season on record impacting farming
- Chicago's Daily Herald, 6/17/20; article on high water levels impacting endangered birds
- MSU ANR Communications, 6/20/19; TV interview on weather and climate impacts
- MSU ANR News, 6/24/19; article on on weather and climate impacts
- NNY 360, 7/7/19; article on drivers of high Lake Ontario waters
- MSU Media Communications, 7/8/19; article on weather and climate impacts
- Michigan Public Radio, 7/11/19; radio story on weather and climate impacts
- National Geographic, 7/16/19; article on predicted heat wave
- MSUE News, 7/18/19; article on weather stations helping to reduce pesticide drift
- PBS Wisconsin, 7/19/19; TV story on Wisconsin's climate projections
- Wisconsin Public Radio, 7/31/19; interview on GLISA's work in Wisconsin
- Trade Only Today, 8/1/19; article on improving hurricane modeling
- WJR Detroit, 8/11/19; radio interview on record water levels on the Great Lakes
- MSU ANR News, 8/14/19; article on weather and climate impacts
- Michigan Radio (NPR), 8/16/19; article on cities taking the lead on climate change
- MSUE News, 8/30/19; article on estimating the first freezing temperatures of the season
- Marquette Mining Journal, 8/4/19; article on weather and climate impacts
- Michigan Radio, 8/12-8/16/19; series of articles and interviews as part of NPR's national climate change week
- E&E News, 8/22/19; article on the 2017 and 2018 annual climate summaries GLISA contributed to
- Bustle, 9/16/19; article on why individual action matters
- Badger Herald, 10/8/19; article on youth climate activism
- Michigan Radio Stateside, 10/29/19; interview on community action
- Boreal, 11/11/19; article on climate change in Marquette
- CBC Windsor, 1/7/20; radio story on weather and climate impacts
- Chicago Tribune, 1/9/20; article on rapid changes in lake levels
- Chathan-Kent This Week, 1/23/20; article on warmer and wetter conditions
- Fox 2 Detroit, 1/16/20; article on weather and climate impacts
- The Argus Press, 1/22/20; article on GLISA's small grant to Friends of the Shiawassee River
- Lansing State Journal, 1/24/20; article on warming winters
- Detroit Free Press, 2/11/20; article on fish habitats in the Great Lakes
- GoErie.com, 2/15/20; article featuring GLISA's small grant to Pennsylvania Sea Grant
- Fox 2 Detroit, 2/24/20; TV interview on rising Great Lakes water levels
- Rust to Resilience, 4/21/20; article on climate change as an opportunity for the region

- Northwestern University Medill Reports Chicago, 5/4/20; article on how two cities in different US regions are responding to climate change
- WILX 10 (NBC affiliate), 5/6/20; article on a late freeze and apple farming
- MSU ANR Communications, 5/8/20; article on weather and climate impacts
- MI Farm Radio Network, 5/18/20; radio story on an abnormally windy spring
- American Geophysical Union's EOS, 5/18/20' article on billion-year development of the Great Lakes
- Better Homes and Gardens, 5/20/20; article on gardening in a change climate
- Inside Climate News, 5/22/20; article on dams and climate change
- Michigan Farmer, 5/28/20; article on weather and climate impacts

Appendix D: Additional Testimonials

“GLISA was an indispensable part of the core project team for a recent project with the Lac du Flambeau Tribe in Wisconsin. The program is committed to the co-development of products that are both useful and usable by the project partners and that commitment came through clearly in this project. GLISA worked closely with the core team for the project to define a custom project boundary, complete detailed analysis of downscaled climate projections for that region, develop information graphics to share that information, and support the development of a science based climate change vulnerability assessment and updated hazard mitigation plan for the Tribe. Tribal staff members are using this information to help develop their annual budgets and guide investment in climate preparedness.

At Adaptation International, we work as a boundary organization connecting communities to the best available science and would absolutely partner with GLISA again in support of our work in the region.”

- Sascha Petersen, Founder & Director, Adaptation International

“The Canada-U.S. State of the Strait Conference is a biennial forum that brings stakeholders together to assess ecosystem status and provide advice to improve research, monitoring, and management programs for the Detroit River and western Lake Erie. It now has a 22-year history of transboundary cooperation to better inform ecosystem-based management. The 2019 conference performed an updated comprehensive assessment of ecosystem health based on 61 indicators. GLISA prepared four indicator reports on temperature, precipitation, ice cover, and lake levels. For each indicator, long-term trends were evaluated and management next steps and research needs identified. GLISA's work helped make the case that climate change is the most pressing environmental challenge of our time. Further, climate change has been called a “threat multiplier” where warmer, wetter, and wilder climatic conditions amplify other threats like harmful algal blooms, combined sewer overflow events, species changes, poor air quality effects on vulnerable residents, and more. Without GLISA's assistance our comprehensive assessment of ecosystem health would not have been possible.

- John H. Hartig, Visiting Scholar, Great Lakes Institute for Environmental Research, University of Windsor

“My experience with GLISA helped prepare me for work in the environmental field as it gave me a direct opportunity to work with climatologists, analyze and learn from the incredibly important national climate assessments, and allowed me to develop a better understanding of the Great Lakes' climate that I can take with me to my future jobs. I think the best part of working with GLISA was the feeling of importance the staff always gave me. The GLISA staff always made sure I knew that the work I was doing was important, and I really appreciated that validation.”

- Mark Reid, 2019 Doris Duke Conservation Scholar, Denison University

Appendix E: Ensemble Stakeholder Partners

The Ensemble Stakeholder Working Group (SWG) and Scientific Advisory Panel (SAP) are both still active groups and have been critical in developing new resources. In the last year, participants from these groups have been engaged individually on an as-needed basis to provide feedback on our draft scenario guide and downscaled data guide. This partnership was featured in a publication in the Bulletin of the American Meteorological Society (see Appendix F: 2019-2020 Publications). Bold entries are new partners or existing partners whose affiliations have changed.

Joseph Barsugli (SAP)
University of Colorado/NOAA Earth System Research Laboratory
Tim Boring (SWG)
Michigan Agri-Business Association
Devon Brock-Montgomery (SWG)
Unaffiliated, formerly with the Bad River Band
Daniel Brown (SWG)
Huron River Watershed Council
Eric Clark (SWG)
Sault Ste. Marie Tribe of Chippewa Indians
Frances Delaney (SAP)
Environment and Climate Change Canada
Ankur Desai (SWG)
University of Wisconsin-Madison
Andre Erler (SAP)
Aquanty
Rebecca Esselman (SWG)
Huron River Watershed Council
Edmundo Fausto (SWG)
City of St John's
Elizabeth Gibbons (SWG)
American Society of Adaptation Professionals
Drew Gronewold (SAP)
University of Michigan School for Environment and Sustainability
Christopher Hoving (SWG)
Michigan Department of Natural Resources/Michigan Climate Coalition
Greg Mann (SWG)
National Weather Service-Detroit
Glenn Milner (SAP)
Savanta, a GEO Company
Biljana Music (SAP)
Ouranos, Consortium on Regional Climatology and Adaptation to Climate Change
Michele Richards (SWG)
Michigan Army National Guard/Michigan Climate Coalition
Peter Snyder (SAP)
University of Minnesota

Appendix F: 2019-2020 Publications

Underlined publication titles are our most significant findings in the last year. For these, we have included a brief summary.

Peer-reviewed

Featured Publication: Increasing the Usability of Climate Models through the Use of Consumer-Report Style Resources for Decision Making

Status: Published, https://doi.org/10.1175/BAMS-D-19-0099.1
Citation: **Briley, L., Dougherty, R., Blackmer, E. D., Troncoso, A. V., Rood, R. B., Andresen, J., and Lemos, M. C.** (2020). Increasing the Usability of Climate Models through the use of Consumer-Report Style Resources for Decision Making. *Bulletin of the American Meteorological Society*.
Summary: As a knowledge broker for climate information in the Great Lakes region, GLISA developed a suite of climate model consumer-report style documents to help climate information consumers make decisions when selecting models and projections for their work. To develop the reports, GLISA reviewed examples of consumer reports from other sectors, relied on the feedback and advice of our ongoing Practitioner Working Group comprised of real-world consumers, and incorporated otherwise-unavailable information from model developers. The publications poses that climate model consumer reports, especially when developed in the context of trusted user-knowledge broker relationships, contribute to making climate information more relevant to and usable by practitioners.

Investigating Maize Subirrigation Strategies for Three Northwest Ohio Soils

Status: Published, DOI: https://doi.org/10.2489/jswc.74.2.111
Citation: Gunn, K. M., Allred, B. J., **Baule, W. J.**, and Brown, L. C. (2019). Investigating maize subirrigation strategies for three northwest Ohio soils. *Journal of Soil and Water Conservation, 74*(2), 111-125.

Development of a Gridded Reference Evapotranspiration Dataset for the Great Lakes Region

Status: Published, https://doi.org/10.1016/j.ejrh.2019.100606.
Citation: Kiefer, M. T., **Andresen, J. A.**, Doubler, D., and Pollyea, A. (2019). Development of a gridded reference evapotranspiration dataset for the Great Lakes region. *Journal of Hydrology: Regional Studies, 24*, 100606.

Water Conserving Irrigation Practices, Plant Growth, Seasonal Crop Coefficients, and Nutrition of Container-Grown Woody Ornamentals

Status: Published, **https://doi.org/10.3390/w11102070**
Citation: Fernandez, R. T., Pershey, N. A., **Andresen, J. A.**, and Cregg, B. M. (2019). Water Conserving Irrigation Practices, Plant Growth, Seasonal Crop Coefficients, and Nutrition of Container-Grown Woody Ornamentals. *Water (Basel), 11*(10), 2070.

A Perspective on Changes Across the US Corn Belt

Status: Published, DOI: https://doi.org/10.1088/1748-9326/ab9333
Citation: Hunt, E. D., Birge, H. E., Laingen, C., Licht, M. A., McMechan, J., **Baule, W. J.**, and Connor, T. (2020). A perspective on changes across the U.S. Corn Belt. *Environmental Research Letters, 15*(7), 071001.

Linking Agriculture to Climate

Status: Published, https://doi.org/10.2134/agronmonogr60.2016.0016
Citation: **Andresen, J. A., and Baule, W. J.** (2020). Perennial Systems (Temperate Fruit Trees and Grapes). *Agroclimatology, 60*, 425-452.

Actionable Knowledge and the Art of Engagement

Status: Published, https://doi.org/10.1016/j.cosust.2020.01.002
Citation: Mach, K. J., **Lemos, M. C.**, Meadow, A. M., Wyborn, C., Klenk, N., Arnott, J. C., Ardoin, N. M., Fieseler, C., Moss, R. H., Nichols, L., Stults, M., Vaughan, C., and Wong-Parodi, G. (2020). Actionable knowledge and the art of engagement. *Current Opinion in Environmental Sustainability, 42*, 30-37.

Usable Environmental Knowledge from the Perspective of Decision-Making: The Logic of Consequentiality, Appropriateness, and Meaningfulness

Status: Published, https://doi.org/10.1016/j.cosust.2019.10.003
Citation: Dewulf, A., Klenk, N., Wyborn, C., and **Lemos, M. C.** (2020). Usable environmental knowledge from the perspective of decision-making: the logics of consequentiality, appropriateness, and meaningfulness. *Current Opinion in Environmental Sustainability, 42*, 1-6.

Who Are Boundary Spanners and How Can We Support Them in Making Knowledge more Actionable in Sustainability Fields?

Status: Published, https://doi.org/10.1016/j.cosust.2020.01.001
Citation: Goodrich, K. A., Sjostrom, K. D., Vaughan, C., Nichols, L., Bednarek, A., and **Lemos, M. C.** (2020). Who are boundary spanners and how can we support them in making knowledge more actionable in sustainability fields? *Current Opinion in Environmental Sustainability, 42*, 45-51.

Non Peer-reviewed

Featured Publication: How to Use Economics to Build Support for Climate Adaptation

Status: Published on GLISA website
Citation: Great Lakes Integrated Sciences and Assessments and Headwaters Economics. (2019). *How to Use Economics to Build Support for Climate Adaptation*. Retrieved from http://glisa.umich.edu/media/files/2019HE-Economics-for-Climate-Adaptation-Full-Report-2019.pdf

Summary: Local governments face an increasingly urgent need to adapt to a changing climate in ways that reflect their unique environmental, social, and economic conditions, all on a balanced budget and with limited federal support. *How to Use Economics to Build Support for Climate Adaptation* helps cities build data-driven, economic arguments that can be presented to a diverse range of partners in arenas of competing priorities – and was written and co-produced with the specific input and needs of cities across a spectrum of conditions.

2019 Annual Climate Trends and Impacts Summary for the Great Lakes Basin

Status: Published on GLISA's website and binational.net.
Citation: Environment and Climate Change Canada and the U.S. National Oceanic and Atmospheric Administration. (2020). *2019 Annual Climate Trends and Impacts Summary for the Great Lakes Basin*. Retrieved from binational.net.