University of Minnesota Testimony and Statements to Congresswoman Betty McCollum's Listening Session for FY2021 Interior Department Appropriations

Bell Museum, February 24, 2020

Statement of Robert W. Sterner
On behalf of the University of Minnesota (Great Lakes science needs)
Submitted to Congresswoman Betty McCollum
February 24, 2020

Congresswoman McCollum, I am Dr. Robert W. Sterner, and I am honored to appear before you today to speak to you on the topic of Great Lakes science. I serve as the Director of the Large Lakes Observatory at the University of Minnesota Duluth where I am also a Professor of Biology. The Large Lakes Observatory has a mission to perform scientific studies on the large lakes of Earth. I myself have been active in Great Lakes research for twenty-five years. My present position at LLO gives me perspective on what we know and understand about these magnificent and critical bodies of freshwater and what efforts are being undertaken to create the knowledge that underpins our ability to manage them. My testimony today asks you to do two things. First, to recognize and act on the need for enhanced support for Great Lake science through GLRI and other funding mechanisms. And second, to provide leadership and support for high-level planning for Great Lakes science.

The Great Lakes of North America hold 20 percent of Earth's liquid, accessible fresh water -- 95% of our nation's supply. These lakes define a region with a $5 trillion economy, ~30% of the combined economic activity of the US and Canada. The lakes provide numerous ecosystem services, for example generation of more than 50,000 MW hydro- and thermoelectric power. The quality of this resource matters as much as the quantity of water. The lakes provide drinking water to 10 percent of the US population. Recreation and tourism in the Great Lakes are valued at > $6 Billion/y. These five lakes and their connecting channels are a vast and diverse ecosystem where humans and nature must prosper side by side. For us to effectively manage them, we rely on science. My argument today is first, that our current science is under-supported and further that it needs high level planning and prioritization.

The Great Lakes are under threat from many stressors, including toxins and other forms of pollution, invasive species, and climate change. Managing these ecosystems requires a major effort by both the US and Canada. But management is based on knowledge and scientific understanding needs to be the foundation to all those efforts. Science can tell us about the present state of the ecosystems, but also it has the potential to tell us about how they are changing, and about how to steer them into conditions where humans and nature both prosper. Unfortunately, large gaps in our knowledge still prevent us from achieving that potential. To illustrate, let's talk about surprises.

I'm sure you're aware that one of the major environmental issues in the Great Lakes today is the presence of cyanobacterial blooms, especially but not solely in Lake Erie. An almost forgotten fact about the well-known toxic cyanobacteria blooms in Lake Erie is that they appeared suddenly, without warning. The lake had been steadily improving following actions driven by the Clean Water Act and the Great Lakes Water Quality agreement. Nevertheless, in the mid 1990s, the lake shocked us, and cyanobacterial blooms began to appear and have continued since. These blooms have led to days without safe drinking water for half a million people in

Toledo, Ohio and nearby communities. How can we have been so unprepared for such a turn of events? Science has the basic knowledge to understand how blooms are formed, but we weren't paying enough attention to Lake Erie.

Another example is closer to home here in Minnesota. In 2012, a year infamous in Duluth because of the massive June rainstorm, an entirely unexpected cyanobacteria bloom appeared on the Lake Superior shore. It was a shock to see thick, green water in what is widely regarded as the most pristine of the Great Lakes, but there it was. Subsequent years also brought smaller examples of cyanobacterial blooms, and then in 2018, another year with a massive rainstorm, the entire shore between Duluth/Superior and the Apostle Islands turned green for about a week. This shoreline is a high value recreational area, and tourists do not come to see thick, green water. Once again, we were caught off guard and left reacting to events we should have been able to see coming. Our surprises stem mainly from the fact that our monitoring and our assembling of basic science information are inadequate.

My research now is heavily involved in trying to determine why these Lake Superior cyanobacteria blooms are occurring. I am often asked what we can do about them, but how can we answer that question without first knowing the basics of how this lake works? Once we understand the lakes better, we can begin to address what management actions may be possible to mitigate them.

The Great Lakes Restoration Initiative (GLRI) provides important federal funding to support local efforts to restore the Great Lakes ecosystems. Indeed, great progress has been made across the basin through GLRI funding. The GLRI deserves continued support, but I would like to point out again that science is needed to do better. GLRI certainly needs science, in fact the word "science" appears 25 times in the 30-page GLRI Action Plan III, which was released in October, 2019. But the Action Plan addresses that science is needed but it does not specifically provide for the creation of this science. Again we see that it is important to provide federal funding to support scientific studies to allow us better to know the state of these lakes and how they function.

But I'm not here today just asking for more support. I'm also asking for your help in steering the course of the science that we depend on. There are many parties contributing to Great Lakes science on both sides of the international border. These include federal and state agencies, academics, Tribal and First Nations interests, and NGOs. This diversity of perspectives can be a strength but at the same time, coordination and prioritization is difficult with so many voices involved. Though each of these parties, separately or in groups, contribute to the process of defining priorities, Great Lakes science as a whole lacks an overarching science plan. There is no universally accepted "roadmap" of science needs and no coordinated set of priorities for investment. There are many hands on the oars but no consensus on where to go. I note that in marine sciences there have been periodic studies that assess the state of knowledge of the world's oceans and set decadal-scale research priorities. The Great Lakes need the same direction.

I'm pleased to say that the community is awakening to this need. The need for high-level planning is beginning to be addressed both by the International Joint Commission and -- under your committee's oversight -- by the USGS. In response Congressional direction, over the past year the USGS has examined the state of Great Lakes science and in its report to you it agrees with the assessment I am conveying here that more science and better planned science are critical. The USGS is proposing to initiate a significant planning effort that would bring many, many voices to the table. I am heartened to see this, and in my view it should be supported. But this is not enough.

I want to ask specifically for your support for another planning effort, a smaller and less expensive one. I am advocating here for the commissioning of a report from The National Academy of Sciences, through its National Academy Press. As you probably already recognize, the NAS/NAP is frequently commissioned to provide expert and external perspectives into high-level science. The NAS/NAP has the striking advantage of being "outside" of the system of Great Lakes science parties. It, unlike other parties who might be involved in planning, is able to produce an overview that would be seen as an objective, non-parochial, analysis of needs and priorities. A report by a small number of top experts, viewing the state and direction of Great Lakes science would provide a much-needed perspective. Such an external view would be highly valuable no matter what other planning efforts might be undertaken.

As such, I am asking today that $500,000 be provided to an appropriate agency to contract with the National Academies of Science, Engineering, and Medicine for a binational report that identifies systemic knowledge gaps, enduring scientific research and infrastructure needs, and recommended investments within relevant agencies across the federal government. No matter whether other planning efforts are seen to completion or not, the value of such a report would be immense both to provide a roadmap but also to help raise awareness.

To close, I urge you to continue to be attentive to the need to build scientific knowledge about our Great Lakes and to support efforts to coordinate and prioritize how best to grow that knowledge. Over the years we have seen --again and again--events that show how badly prepared we are to provide effective management. Scientific research together with full funding for GLRI together are key to a long-term sustainable future for the Great Lakes.

Thank you for your long history of supporting our Great Lakes and federal funding to protect and clean up our water.

Statement of Jessica J. Hellmann
On behalf of the University of Minnesota (Institute on the Environment)
Submitted to Congresswoman Betty McCollum
February 24, 2020

Congresswoman McCollum, I am Dr. Jessica Hellmann, and I am honored to provide this testimony as director of the Institute on the Environment, a campus-wide interdisciplinary research, education and outreach institute that I have led since 2015. I also am a chaired professor in the Department of Ecology, Evolution and Behavior at the University of Minnesota.

The Institute on the Environment is responsible for promoting interdisciplinary, environmental scholarship. It brings thought-leaders together from across and outside the University to help lead the way toward a future in which people and planet prosper together. Common goals, a sense of shared purpose, and innovative programming attract hundreds of faculty, students, staff and external partners to tackle complex sustainability challenges. The Institute is just one of several units at the University of Minnesota doing cutting-edge work on Department of Interior (DOI) priorities. Today I speak for the institute and other units that work at the intersection of climate change and natural resource management.

I want to start by thanking you for funding in the FY20 Interior Appropriations bill for the USGS Climate Adaptation Science Centers (CASC) and for directing the USGS to create a new Midwest CASC. I urge you to continue those efforts, with additional funding that enlivens that new Center. A Midwest Center is critical to helping our region confront the challenges of a changing climate, and the University of Minnesota has a set of unique assets that will make an important contribution to that Center.

The Climate Adaptation Science Centers

There are currently 8 regional CASCs that work with natural resources stakeholders, managers and academics to identify and gather the scientific information and tools necessary to help fish, wildlife, and natural and human-dominated ecosystems adapt to the impacts of a changing climate.

Regional CASCs are housed at host universities, involving a consortium of Universities and non-university partners within the region, including federal research centers. Research is conducted through calls for research proposals that address regional needs in adaptation science. Standard protocol allows for principal investigators (PIs; i.e., lead researchers) to come from one of the CASC consortium institutions or from a USGS employee. Non-consortium researchers can participate through subawards on projects led by CASC-affiliated partners.

Unmet need for adaptation research in the Midwest

The regional CASCs provide a platform for adaptation decision-making across the US: identifying key research needed to improve those decisions and facilitating collaboration between universities, the government, and key stakeholders confronting climate challenges. The first CASC was formed in 2008; since then, several host arrangements have come and gone, and some Centers have changed host universities.

Despite the many successes of the CASC system, there are two problems with the program's application in Minnesota and the broader Midwest region. First, our region is underserved because we did not have a dedicated Center focused on the unique concerns and stakeholders of our region. And, second, the University of Minnesota (and many other universities in the Midwest) have nominal opportunity to engage with the current regional CASC because the host, the Northeast (NE) CASC, lies outside the

Midwest and institutional participation within the Midwest is limited. NE CASC Midwestern members currently include the University of Wisconsin, the University of Missouri, and Michigan State University. The Northern Forest Research Center of the US Forest Service is based at the University of Minnesota campus and is a consortium member, but affiliation with the CASC does not extend to University employees.

The NE CASC currently serves 21 states from its base at the University of Massachusetts (most CASCs serve between one and eight states). In 2016, the USGS sought to remedy this situation by establishing a new Midwest CASC, but review and selection was suspended when funds were not appropriated.

Thanks in large part to your leadership, $4 million of funding was appropriated for Midwest adaptation work in FY2020, reversing the 2016 course and enabling Midwest participation in the CASC network to grow. Three-quarters of that funding was recently made available for Midwestern projects, administered by the NE CASC. The USGS decided that PIs from the University of Minnesota can use the Great Lakes-Northern Forest Cooperative Ecosystem Studies Unit agreement to apply for funding this year. Happily, University of Minnesota PIs will be able to access this new pool of research resources. One concern, however, is that these funded projects will lack the coordination and stewardship of the forthcoming Midwest Center.

Formation of a new Midwestern CASC

The insufficiency of the NE CASC to meet Midwestern needs and the awkward accessibility of Midwestern institutions to funding through the NE CASC consortium will be remedied with the creation of a new CASC in the Midwest region.

The Midwest CASC will recognize specific climate drivers that are important in the Midwest, including floods, drought, extreme heat, and the shifting of seasons. These drivers lead to distinct issues and concerns in our region, including disease spread (e.g., Chronic Wasting Disease), mortality of key species with economic and ecosystem significance, and infrastructure damage that affects our natural environment. It will allow for focus on the value of traditional ecological knowledge and tribal data sovereignty that is important in our region. And it will allow for focused research on the most endangered ecosystem in the world—Midwestern native prairie—and the world's greatest freshwater ecosystems, the Great Lakes and Mississippi River basin.

Projects funded by the new Midwest CASC will fall to a diverse set of Midwestern institutions within the new CASC, rather than the limited consortium of the NE region. In the long term, this will create alignment between research needs and the responsiveness of regional institutions to those research needs.

Univ of MN as an ideal hub for the Midwest CASC

Researchers at the University of Minnesota were eager to propose projects in response to the recent call for projects in the Midwest region. I am aware of at least a dozen letters of intent that were submitted by University of Minnesota PIs, for example, arising from the College of Food, Agriculture and Natural Resource Sciences, the Natural Resource Research Institute, and the Institute on the Environment. We know of others submitted as subawards with NE CASC investigators. These projects demonstrate a wide range of expertise among University of Minnesota researchers and their readiness to take action in our region. They address key climate risks and adaptation decisions that are pending in the Midwest: from

manoomin (wild rice), to coastal wetlands along the Great Lakes, to sport fisheries, to techniques for forest regeneration, to habitat management underneath rapidly expanding solar installations.

Today, the University of Minnesota is preparing to lead a proposal to host the Midwest CASC (as we did in 2016). Our proposal will involve research teams that collaborate with stakeholders to identify essential research questions in the region and then generate data, findings, and tools that support key adaptation decisions. Our proposal will evaluate the efficacy and side effects of adaptation decisions, identify substitutes and alternative actions to proposed adaptation solutions, and deploy adaptive management to correct and steer adaptation actions so that they improve over time. We will focus on critical adaptation concerns as they apply to climate drivers, biomes, and constituencies of the Midwest. During the next several months we are forming a consortium of partners that comprehensively covers the region and its issues. We also plan to conduct workshops to refine the themes, priorities, and methods that form our proposal.

Complementary proposals and requests

Our proposal to host the Midwest CASC is complementary to several other proposals the University is pursuing with federal granting agencies. For example, we have a proposal pending to the NSF to create a Science and Technology Center for ecological forecasting, that aims to dramatically increase the capacity for generating societally and economically relevant forecasts for ecological phenomena. The University's vision for research around the Laurentian Great Lakes also focuses on ecological forecasting. Third, the University expects to apply in Topic Area 6 to the DOE's Solar Energy Technology Office for research on ecosystem services under solar arrays. That office expects to fund 4-6 projects, but additional funding is needed to pursue critical natural resource research in an industry that is booming in our region.

Request for FY21

I urge you to consider appropriating $6 million in FY2021 to support the creation of Midwest CASC Center. I also urge you to hold the USGS accountable for developing the new Midwest CASC, as soon as possible. The Center will support critical climate adaptation decisions in Minnesota and the Midwest region. We believe the University of Minnesota is an ideal host for the center, but regardless which university is chosen, it is critical that the University of Minnesota and other large public Midwestern universities be able to participate in Midwest CASC activities and access its resources, to conduct essential adaptation research.

Statement of Peter A. Larsen
On behalf of the University of Minnesota
(Minnesota Center for Prion Research and Outreach, College of Veterinary Medicine)
Submitted to Congresswoman Betty McCollum
February 24, 2020

Congresswoman McCollum, I am pleased to share a statement with you today on behalf of the Minnesota Center for Prion Research and Outreach, College of Veterinary Medicine, University of Minnesota.

I am an Assistant Professor in the Department of Veterinary and Biomedical Sciences. I have over 18 years of research experience in molecular biology and genomics and my research program is highly interdisciplinary. My lab group focuses on the discovery of emerging zoonotic diseases, development of field-based molecular diagnostics, and the mechanisms that underlie the origin of neurodegenerative disease. I am leading an effort at the University of Minnesota to develop new diagnostics for and to expand the scientific understanding of Chronic Wasting Disease (CWD), while also educating students and the public about the biology of CWD.

Background

A wide variety of protein-misfolding diseases (PMDs) negatively impact the health of humans, domesticated animals and wildlife. These diseases include Alzheimer's, Parkinson's, and Creutzfeldt-Jakob diseases in humans, scrapie in sheep, and CWD in cervids, the family of mammals that includes deer. When considering Alzheimer's alone, it is estimated that at least 8.4 million Americans will have the disease by 2030 with an annual economic burden of approximately $200 billion. At the same time, CWD is spreading throughout cervid populations in North America and the disease is an immediate threat to the rich heritage that surrounds cervids and all cervid-related industries in the United States. The pathogenetic misfolded CWD prion protein is an environmental contaminate, and human-health concerns are mounting with respect to exposure to unique CWD prion strains. Despite decades of research on human and animal PMDs, effective diagnostics and therapeutics have yet to be developed. However, recent research has identified common features across human and animal PMDs suggesting that a One Health approach to investigating the spectrum of PMDs has the potential to yield transformative diagnostic and therapeutic insights. For these reasons, we strongly believe that novel and cutting-edge One Health research that crosses and intersects species lines must be conducted in order to advance our understanding of all PMDs and to develop key innovations that will help to detect and disrupt their progression.

The Minnesota Center for Prion Research and Outreach

To meet the current and future challenges posed by PMDs, we have formed the Minnesota Center for Prion Research and Outreach (MNPRO). Our transdisciplinary MNPRO team leverages the world-class research and education expertise at the University of Minnesota. The team currently spans ten U of M colleges and institutes

and has established collaborative relationships with multiple state, federal, tribal and academic partners. MNPRO is committed to improving human health, protecting connections to heritage, safeguarding the environment, and relieving the economic burden posed by PMDs. We will accomplish these goals through a combination of innovative and unparalleled One Health research and outreach efforts having state, national and global impacts.

Chronic Wasting Disease

Our first research and outreach priority centers on CWD. The hazards posed by CWD are far-ranging, not limited to cervid health, and are capable of permanently altering our relationship with cervids and the environment we share. The biology and ecology of CWD is incredibly complex, and this complexity makes managing the spread of the disease extremely difficult. It is abundantly clear that the scientific community must mobilize to protect the rich heritage that surrounds cervids. The complexity of this prion disease requires a fresh and intensive transdisciplinary One Health research effort. Our MNPRO team is ready to collaborate directly with federal partners including the USGS, US Fish and Wildlife Service, and USDA to advance key CWD research areas, including:

- developing next-generation diagnostic tools for rapid detection of prions in biological and environmental samples;
- identifying key prion transmission pathways across diverse ecological settings;
- devising novel remediation strategies for the targeted disruption, destruction, removal, or neutralization of infectious prions in the environment;
- and, establishing genomic and genetic resources to elucidate CWD prion strain variation in cervid populations over time and across North America.

Our team has already mobilized to develop advanced CWD diagnostic tools and, through collaboration with NIH Rocky Mountain Laboratories, we have recently successfully adapted a molecular assay used for Alzheimer's and Parkinson's diagnostics for the rapid detection of CWD prions. This research advancement is rooted in a One Health approach and helps document the benefit of cross-disciplinary collaborations.

In addition to scientific research efforts focused on CWD, we must also expand CWD related educational and outreach efforts across the United States. We have initiated an educational campaign aimed at connecting with communities and stakeholders impacted by CWD across the state of Minnesota. These CWD education and outreach efforts integrate specialized and translated science communications structured to reach many diverse communities across Minnesota using a web-based interface and in-person events featuring augmented reality displays, 3D models, and unique animations. Our MNPRO team has directly connected with over 3,100 Minnesotans in the past 6 months through one-on-one interactions as well as countless others through the web-based materials. We have learned that there is a great deal of fear and misunderstanding about CWD, especially within regions where CWD is found in resident deer herds. Our team has become aware that Minnesota's culturally-diverse hunting populations have missed critical information regarding CWD biology, management and potential human health risks, and we have responded accordingly with specific materials, events and future aims engaging Amish, SE Asian (including

Hmong, Korean, and Khmer translated materials), and Tribal communities. Still, as a scientific community, we need to expand our efforts to engage the public and relevant stakeholders across the United States on the science of CWD and share with them all that we know about prion biology and deer natural history. These outreach activities will help to increase awareness and could prevent un-intentional spread of the disease due to human activities that threaten and counter state, federal and tribal CWD management efforts.

Conclusion

The looming crisis surrounding the economic, health and environmental impact of human and animal PMDs requires a novel, transdisciplinary approach that can only be achieved through the creation of a transformative center: MNPRO. Specifically related to CWD, the success of state, regional, national and international efforts to control this disease hinges on the ability of government agencies, researchers, policy makers and stakeholders to work together. MNPRO and the University of Minnesota are uniquely positioned to take paramount action in making positive changes to the current trajectory of CWD in Minnesota, the broader United States, and beyond. Congresswoman McCollum, we thank you for the necessary DOI appropriations addressing CWD across the country and recommend continued support to the USGS, USDA and USFWS efforts on this front.

Statement of Susan M. Galatowitsch
On behalf of the University of Minnesota
(Department of Fisheries, Wildlife, and Conservation Biology)
Submitted to Congresswoman Betty McCollum
February 24, 2020

Congresswoman Betty McCollum, I am Dr. Susan Galatowitsch and I am pleased to provide this statement regarding the U.S. Geological Survey's (USGS) Cooperative Research Units (CRU) Program, one of which is hosted by the University of Minnesota. I am Professor and Head of the University of Minnesota's Department of Fisheries, Wildlife and Conservation Biology, the academic unit that works most closely with the Minnesota CRU, as one of the cooperators. The unique model of the CRU Program allows all cooperators, host universities, together with state and federal natural resource agencies and the Wildlife Management Institute, to benefit from each other's strengths and pursue research priorities based on regional conservation needs.

A record level of vacancies (30 percent) affecting 70 percent of the research units nationally, including Minnesota, exists because of chronic federal shortfalls in federal base funding for the CRU system. However, because of your leadership and the additional funds in the FY20 budget for the USGS CRU program, vacancies can be filled nationwide, including here in Minnesota. Filling these vacancies is essential for restoring the base level of science research capacity needed to support state and federal fish and wildlife management responsibilities. Your support for this important program means we will be able to hire a Quantitative Fisheries Scientist, as early as this summer. To this end, I strongly encourage you to reject the Administration's proposed elimination of the CRU program and continue support for the USGS CRU program at $25 million with $6.6 million designated to fill vacancies.

CRUs

For over 70 years, the CRU system has been an efficient and effective model for focusing research efforts on the highest regional and national priorities. The CRUs became a congressionally mandated program in 1960, with passage of the Cooperative Units Research Act. The work of CRUs includes identifying proactive measures to prevent species endangerment, working to rebuild populations of those species that are already endangered, prevention and control of terrestrial and aquatic invasive species, and informing fisheries and wildlife management decisions made at the local, state, and federal levels. CRUs are based at public land-grant universities and act as a bridge between state, federal, university and tribal scientists and natural resource managers.

Nationwide, the 40 CRUs, which are located across 38 states, are currently administering over 800 ongoing research projects funded with approximately $41M in reimbursable funds. These projects are supporting an estimated 550 masters and doctoral students, who will go on to be the next generation of conservation leaders. Each host university receives two to five PhD-level Federal scientists who teach classes, advise students, provide technical expertise, and bring in Federal and State research funding. Every Federally allocated dollar is matched on about a 1:3 basis by cooperator contributions and grant funds. States benefit from CRU scientists' expertise and the

direct support of graduate student research projects that target regional concerns. The CRU program relies on the collective research and training mission of all cooperators to achieve a broad scope of scientific expertise while training students to enter the conservation workforce.

Minnesota CRU Impacts

Since its establishment in 1987, Minnesota's CRU has supported more than 80 masters and doctoral students, sponsored more than 100 research projects, and facilitated research funding to cooperating faculty that supported an additional 20 masters and doctoral students. In the most recent biennium (2017-8), 21 research projects were coordinated/conducted by the Minnesota CRU, most supporting graduate students and/or postdocs. Research teams, led by University of Minnesota faculty or by Minnesota-based federal researchers, included cooperative investigators from the UMN (7), other universities (5), federal agencies (6), state agencies (7), and tribes (1). These projects addressed issues of high importance to Minnesota, especially minimizing negative impacts to natural resources from agriculture and energy development, improving stakeholder engagement in sustaining fish and wildlife populations, and responding to threats from climate change and aquatic invasive species.

CRU Funding Status

The USGS CRU Program is now at a critical point due to a significant funding shortfall that has resulted in record vacancies of 38 CRU scientists (30 percent) due to reduced federal base funding. Because 97 percent of federal base funding for CRUs supports salaries, meeting uncontrollable rising costs associated with existing personnel has prevented filling vacancies as retirements or other departures have created open positions. While the federal government is not fulfilling its obligation to the CRUs, state and university cooperators have been left to support a system that is significantly below capacity.

In order to achieve the needs of the existing CRUs, support existing conservation partnerships, and meet the research needs to address state and federal management responsibilities, the CRU base funding of $17.3 million needed to be increased by $6.6 million to fill the current 38 CRU vacancies. The funding level of $24 million was enacted in the FY20 final budget of December 2019. Already, the CRU Program has approved the hiring of 22 of the research scientist vacancies (including the Minnesota position). These positions are expected to be posted in spring 2020. This level of enacted funding must be sustained in the FY21 budget for these and the remaining vacancies to be filled, and for the CRU Program to function at capacity. The Association of Public and Land Grant Universities has included $25 million for the CRU Program in their FY21 appropriations priorities because rebuilding this research capacity to address natural resource challenges is nationally significant.

Minnesota' CRU Science Capacity Need

Minnesota's CRU has lacked a fisheries scientist since 2016. Minnesota needs to fill this vacancy with a Quantitative Fisheries Scientist. With a quantitative fisheries scientist, the Minnesota CRU will be able to:

1) improve methods for assessing fish stocks of freshwater lakes,

2) develop fish population models that account for complex dynamics resulting from invasive species, climate change, and other environmental change,

3) assist agencies and tribal governments in model-based decision-making, and

4) strengthen the academic program in fisheries and aquatic sciences at the University of Minnesota in its mission to educate future professionals and in doing so expand the national capacity of quantitative fisheries science

Many of Minnesota's economically and culturally important fisheries are subject to shared fisheries (some combination of angling, commercial, and/or tribal fisheries), and have experienced system change due to invasive species. As demands on these fisheries continue, fishing technology improves, and effects of invasive species heighten, a quantitative fisheries scientist with "state-of-the-art" expertise in fish population modeling will be increasingly essential for management decision-making and for training future quantitative fisheries scientists.

Conclusion

I want to thank you for your past support for this important program. I urge the subcommittee to provide $25 million in FY21 to support the CRU Program so natural resource research in the 38 states supporting CRUs are not further compromised. In Minnesota, this is essential for building critical capacity in quantitative fisheries sciences.

Thank you for the opportunity to present this information to you and I look forward to working with you to help ensure that a fully functional CRU Program is again a reality.

Statement of Heather E. Koop
On behalf of the University of Minnesota
(Minnesota Invasive Terrestrial Plants & Pests Center (MITPPC))
Submitted to Congresswoman Betty McCollum
February 24, 2020

Congresswoman McCollum I am pleased to share a statement with you on behalf of the Minnesota Invasive Terrestrial Plants & Pests Center (MITPPC) at the University of Minnesota, where I serve as Associate Director. My name is Heather Koop.

MITPPC exists to generate innovative, research-driven solutions to terrestrial invasive species problems regionally, nationally and beyond.

Terrestrial Invasive Species Are a Problem

Terrestrial invasive species[1] – or any nonnative plant, animal insect or microbe that causes harm – cost Americans $150 billion each year. They threaten our food systems, wildlife, recreation spaces, food security, economy and occasionally our health.

For example: Dutch elm disease, buckthorn, oak wilt, garlic mustard, mountain pine beetle and other pests have dramatically changed the way American forests look and feel. Terrestrial invasive species threaten the diversity of native plants, pollinators and wildlife across all ecosystems. Controlling them often carries both an environmental and economic cost due to the use of pesticides and the investment of human labor. New invasive threats will continue to emerge as climate, global trade, land use and human behaviors shift over time.

Coordinated, Multi-Disciplinary Research is the Solution

MITPPC acts upon a belief that the most promising route through a tangled and growing web of invasive terrestrial threats lies in the strategic coordination of work and resources. The Center allocates competitive research grants to support urgent work on only the most high-priority invasive weeds, diseases and insects – work that will make a difference on the ground.

To do this, MITPPC attracts world-class University of Minnesota researchers and external partners working across all disciplines, including forestry, agriculture, engineering, veterinary medicine, Extension, economics and contextualizing humanities and social sciences of all kinds.

With the generous support of the Minnesota legislature, these experts have invested thousands of hours and more than $17 million to date on ground-breaking research with practical outcomes

[1] 1 Executive Order 13112: Section 1. Definitions defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health."

towards:

- Predicting and preventing the arrival of new terrestrial invasive species pests
- Detecting and rapidly responding to newly arrived pests
- Mitigating the negative impacts of well-established pests
- Quantifying the economic consequences of new and established invasive species and identifying socioeconomic barriers to management

In five years, we have been able to demonstrate how a Center-based approach to research with strong community engagement can accelerate applied research that remains true to the land-grant mission. The continued priority of MITPPC is to protect American forests, prairies, wetlands and farmlands from harm by invasive species. We believe that the approach and work of MITPPC could be expanded to include research institutions and cooperators throughout the Upper Midwest.

The Center is physically located in the Twin Cities metro area, which rests at a unique cross-section of surrounding North American ecosystems most vulnerable to invasive species. In the span of just 300 miles, our experts have direct access to tall grass prairies, boreal and broadleaf forests, oak savannas, wetlands and urban green spaces of all kinds.

MITPPC also benefits from well-established regional, national and international partnerships along with strong support from the State of Minnesota. Because of the region's unique connection to forestland and other valuable habitats, MITPPC has established a particularly strong partnership with the United States Forest Service (USFS). In turn, USFS has provided in-kind staff and administrative and laboratory space in support of terrestrial invasive species research.

Conclusion

The proven MITPPC approach of research topic prioritization and innovative, cross-disciplinary coordination towards applied solutions has made it a model in the terrestrial invasive species field – one that is poised for major expansion beyond Minnesota's borders. The environmental and economic stakes are simply too high to continue to approach terrestrial invasive species problems in a less strategic manner.

We respectfully recommend and request that the Subcommittee support the appropriation of $5 million within the U.S Forest Service's Forest and Rangeland Research account for research activities that will holistically address the growing threat of terrestrial invasive species, and through an interdisciplinary model that coordinates expertise in areas including forestry, veterinary medicine, aerospace engineering, biotechnology, agronomy and applied economics.

I thank you for the opportunity to share our Center's views and we look forward to working with the Subcommittee in charting a new path forward with the Interior Department.

Statement of Paul J. Morin

On Behalf of the University of Minnesota (Polar Geospatial Center and the EarthDEM Project)

Submitted to Congresswoman Betty McCollum

February 24, 2020

Congresswoman McCollum, I am Paul Morin and I'm honored to submit this statement to you today on behalf of the University of Minnesota's Polar Geospatial Center (PGC) and the EarthDEM Project.

EarthDEM

Over the past 4 years a collaboration between government agencies including the National Science Foundation (NSF), National Geospatial-Intelligence Agency (NGA), and NASA, and Universities of Minnesota, Illinois, Texas, Washington and the Ohio State University has developed techniques for producing EarthDEM, global scale topographic data using high-resolution, time-dependent, optical imagery, open-source software and U.S. Government-funded high-performance computing to produce a large volume of high-quality, publicly distributed geospatial data.

As part of the EarthDEM project, our group is producing and distributing high-resolution repeat Digital Surface Models (DSMs) covering a substantial portion of the Earth's landmass and focusing on areas of change, including coastlines, glaciers, volcanoes, tectonically active zones and key ecological areas. EarthDEM responds to many requirements including the finding of the National Research Council Decadal Survey, which states "the coarse resolution of topographic mapping has been a major impediment to understanding the forces and dynamic processes that shape the Earth's surface". The PGC has been working with the NGA and other agencies for nearly a decade to collect sub-meter commercial imagery globally and transfer it to PGC's University of Minnesota facility.

Now, with increased federal support, we are scaling this effort to encompass the entire planet and are including other datasets including coastline and changes in permafrost. The key component of this expansion is to work with the USGS to produce this data for the United States and territories on an ongoing basis.

Benefits

When released, the U.S. elevation data will be mostly continuous across the entire country and territories. EarthDEM follows on the successes of the ArcticDEM and Reference Elevation Model of Antarctica (REMA). These publicly available DSMs are beginning to transform polar science by providing insight into surface processes regardless of proximity to infrastructure or aircraft logistics. We believe this work can have the same transformative impact for the United States and territories, and further the important mission of the USGS. EarthDEM data will be produced with

the identical methodology that the NGA/PGC collaboration is using for the rest of the Earth. In addition, since the imagery for EarthDEM is continuously and repeatedly collected, elevation change can be quantified including landslides, coastal erosion and the removal of trees through harvesting or wildfires.

Funding Status

The production of Digital Surface Models for the U.S. and territories is ideally a continuous process that requires imagery collection by NGA and NRO as well as technology development by the University of Minnesota, Ohio State University, University of Illinois, and University of Alaska. These key partners all contribute in their own way through funding, compute resources, satellite data, personnel, and their unique expertise.

The current funding agreement for FY 2020 includes:

> *"The National Geospatial program is funded at $79,454,000 which includes $7,722,000 for the Alaska mapping initiative and the following increases: $5,000,000 for the 30 Elevation program (3DEP) to accelerate achievement of l00 percent coverage of the Great Lakes region; $2,000,000 for the US Topo program to procure product-on-demand updates;* ***and $3,000,000 to produce digital surface models using unclassified satellite optical data for the U.S. and territories not mapped with LiDAR in 2021****. It is expected that any funding awarded outside the Federal sector will undergo a competitive review process."*

We request that the $3 million funding continue for the FY 2021 budget, which would enable the continued production of elevation for the U.S. as well as technology development that would improve the quality of the product and the reductions of time to public delivery.

Conclusion

We are grateful for your continued support of mapping throughout the Federal Government, and of the University of Minnesota's Polar Geospatial Center in particular. PGC will continue our work to map and measure the earth for our partners in the Federal Government, the State of Minnesota, and the scientific community.

Statement of Jeffrey Peterson
On behalf of the University of Minnesota (Water Resources Center)
Submitted to Congresswoman Betty McCollum
February 24, 2020

Congresswoman McCollum, I am pleased to share a statement with you today on behalf of the Water Resources Center (WRC) at the University of Minnesota. The WRC is one of 54 centers and institutes comprising the National Institutes for Water Resources, all of which receive base funding from the Water Resources Research Act (WRRA) program administered by the U.S. Geological Survey.

The National Institutes for Water Resources (NIWR) are interconnected water science hubs distributed across the States, territories, and the District of Columbia. Housed in the nation's land-grant universities, NIWR centers and institutes leverage university expertise to find solutions for the water management challenges we face. Water professionals and researchers receive support for the creation of local tools and policies to better manage our water. These successes start at the local level and have the ability to grow and make an impact across the nation.

Recent and Requested Funding

The federal appropriation for the WRRA program was increased from $6.5 million in Fiscal Year 2019 to $10 million in Fiscal Year 2020. The 2020 appropriation includes $1 million for research on aquatic invasive species (AIS) in the Upper Mississippi River basin to address a critical multistate need. The overall increase in funding to $10 million responds to the nation's mounting water resource challenges and will enhance the capacity of NIWR centers and institutes to address local and national needs.

NIWR proposes a funding level in Fiscal Year 2021 that would sustain this momentum. The request is $11 million for WRRA, which includes $10 million for underlying programs and $1 million for research on the links between AIS and water resources in the Upper Mississippi River basin. This funding request would support three WRRA activities: annual base grants, national competitive grants, and Upper Mississippi AIS research. I will briefly describe each, highlighting some recent successes and the future impacts of sustained funding.

Annual Base Grants

Through annual grants, USGS distributes base support to each NIWR center and institute. This funding is foundational to the WRRA program. WRRA charges each supported center or institute to respond to locally relevant issues by conducting and organizing research, engagement with local stakeholders, and education and training of the water resources workforce. WRRA also requires that centers and institutes obtain at least two dollars of non-federal support for each dollar of federal base funds. Federal base support was steady at $92,355 for each center and institute for several years through fiscal 2019, increasing to $125,000 in fiscal 2020.

The WRC and our peer centers have maintained relationships with the science and stakeholder communities to gather input on science needs, target our federal base funds, and seek additional funding from other sources. Through this process, I have seen how modest investments of federal base support can leverage other funding to build high-impact programs. I will highlight a few examples in the WRC where WRRA base support has enabled programmatic growth in recent years. In all these examples, WRRA funds have supported a small percentage of WRC staff time, with nearly all operational funding coming from university and external sources.

- The **Stormwater Research and Technology Transfer Program** has funded over $1.3 million in research projects involving more than 40 scientists, with an additional $1 million to be awarded in 2020. The program also funds a new seminar series bringing nationally known experts to interact with local stormwater professionals. The stormwater program is designed to improve the management of urban stormwater and develop new technologies suited to Upper Midwest conditions. Primary sources of funding are a state appropriation from Minnesota's Clean Water Fund and pooled contributions from the Minnesota Stormwater Research Council.

- The **Minnesota Office for Soil Health** is a collaboration of the WRC and the Minnesota Board of Water and Soil Resources (BWSR). Operational funding from WRC and BWSR support a newly created State Soil Health Specialist position and a part-time program coordinator. The program works to improve soil resources and water quality by developing the knowledge, skills and abilities of local government staff and agriculture professionals to more effectively promote sustainable soil and land management. The program obtained an $885,000 grant from the USDA-NRCS Conservation Innovation Grant program to collect soil health measurements and develop an online database to analyze and share soil health information.

- The **Digital Water Initiative** is a cluster of activities in the WRC that harness the "data revolution" to advance water research, education, and outreach. Recent research funded by the state Environment and Natural Resources Trust Fund is developing new techniques to process satellite imagery that detects changes in lake water quality. Results are being made available to the public on a recently upgraded Minnesota Lake Browser. The WRC, in collaboration with the Minnesota Supercomputing Institute and the Department of Computer Science and Engineering, recently became part of the Midwest Big Data Hub through funding from the National Science Foundation. The University of Minnesota leads the Hub's water quality priority area.

Overall, for each dollar of federal WRRA base support the WRC received in 2019, our programs generated over $40 in additional funding (with more than $30 of this support from non-federal sources). While funding levels are not direct measures of programmatic results, our available impact measures tell us that a wide range of stakeholders are finding value from WRC programs. In 2019, for example, the WRC hosted over 100 education and training events drawing over 6,000

participants from diverse sectors. The single largest of these events was our signature Minnesota Water Resources Conference, which drew a record 926 participants.

Many other NIWR institutes have similar stories to tell, collectively pointing to a high return on the federal investment in WRRA. The NIWR network has a proven record of translating limited funding into problem-driven science. Centers and institutes are investing their enlarged base funds in fiscal 2020 into new activities that will address our growing water research needs.

National Competitive Grants

A portion of WRRA funding supports a nationally competitive grants program. USGS issues a nationwide request for proposals (RFP) annually with the NIWR Board of Directors providing input on research priorities. Water researchers from any accredited institution of higher learning in the United States are eligible to apply, with applications in each state and territory submitted to USGS by the designated center or institute. The program is meant to address regional or national needs and to encourage collaboration between university and USGS scientists.

The national grants program is highly selective, with under 10% of proposals receiving funding in each of the past several years. A large number of quality submissions reflects a growing set of water science needs across the nation. Recent funding levels have supported about $1 million for 3-4 grants each year. The increased funding in fiscal 2020 is expected to support up to $1.5 million in grants, generating more collaborative projects to address the growing knowledge gaps.

Aquatic Invasive Species (AIS) Research in the Upper Mississippi River Basin

In fiscal 2020, $1 million was designated for research on AIS in the Upper Mississippi River Basin. This funding will address a critical multi-state need and will accelerate research on our emerging understanding of the links between AIS and water resources. USGS will distribute the funds based on the National Competitive Grants model, with proposals submitted in response to an RFP and projects selected on a competitive, peer-reviewed basis. USGS has reached out to NIWR directors in the Upper Mississippi region for input on research priorities. Given the expertise and needs in Minnesota, multiple research teams in our state are well-positioned to respond to this RFP.

Looking Ahead

We thank Congresswoman McCollum for her influential support of the WRRA program. While our water resources challenges are as pressing as ever, I am optimistic about our ability to address them when I see the energy, skill, and commitment of the water scientists and professionals I work with every day. Sustained funding for the WRRA program will help the WRC and our peer centers access this network, organize work around key priorities, and discover new solutions.

Statement of Nicholas B. D. Phelps
On behalf of the University of Minnesota (Minnesota Aquatic Invasive Species Research Center)
Submitted to Congresswoman Betty McCollum
February 24, 2020

Representative McCollum, I am Dr. Nicholas Phelps and I am honored to provide this testimony on behalf of the Minnesota Aquatic Invasive Species Research Center (MAISRC). I have been the Director of MAISRC since 2016 and a researcher with the Center since its creation in 2012. Our mission is to develop research-based solutions that can reduce the impacts of aquatic invasive species (AIS) in Minnesota by preventing spread, controlling populations, and managing ecosystems; and to inspire action by others. We currently have more than 60 affiliated researchers working across taxa and disciplines – an incredible team, making incredible progress. I am very proud of the work we have been able to do in a short amount of time, but we have not, and cannot, do it alone. We rely on partnerships to inform, conduct and implement our research activities, including formal collaborations with the U.S. Geological Survey (USGS). To that end, I enthusiastically support a budget increase of $5,000,000 to the USGS Invasive Species Program in the Ecosystems Mission Area to conduct critical multi-state collaborative research on AIS in the Upper Mississippi River region.

In the FY 2021 budget request, USGS proposes a significant reduction to the Invasive Species program and also would move it, along with other programs, under a new Biological Threats account. As this restructuring was only just proposed, my testimony refers to the Invasive Species Program as it currently operates within the Ecosystems Mission Area of USGS.

Minnesota Aquatic Invasive Species Research Center

Aquatic invasive species are non-native introduced aquatic species that cause, or have the potential to cause, harm to the ecosystem, economy or human health. Invasive species have been identified by many organizations and agencies to be among the most serious global Grand Challenges of our time, in some cases causing extinctions of native species and costing billions of dollars in ongoing management costs. Minnesota is unfortunately no exception, with notable invaders including invasive bigheaded carp, zebra mussels and Eurasian watermilfoil wreaking havoc on the state's water resources and way of life. As ecosystems and economies are being re-engineered, many millions of dollars are spent each year to control existing populations, yet the problem is getting worse.

In 2012, Minnesota took a leadership role and created MAISRC, based at the University of Minnesota. This first-of-its-kind academic program has quickly positioned itself as a national leader for solution-oriented research on the prevention, control, and management of AIS. MAISRC researchers are working across taxa and disciplines on stakeholder identified and prioritized research needs. Significant scientific progress is being made to better understand the species and systems in which they live: Knowledge gaps are being filled, tools are being deployed, and decisions are being informed. Research highlights from recent years are many, but to highlight a few:

- Developed predictive spread models to optimize surveillance and intervention plans for zebra mussels, starry stonewort, and other high priority AIS
- Creation of a science-based statewide management plan for non-native *Phragmites*
- Improved and installed deterrent systems in the Mississippi River to reduce the upstream migration of invasive bigheaded carp
- Launched a University startup company to implement research-based management for common carp control
- Sequenced the zebra mussel genome, unlocking many possibilities for future control research

Complementing our rigorous research, MAISRC has engaged stakeholders and end users throughout the research process with active outreach and communication. This has resulted in the creation of an award-winning citizen science program, increased awareness in all corners of the state, and formed highly collaborative partnerships in Minnesota and around the world. I am regularly in awe of the personal commitment and passion Minnesotans have for protecting their lakes, rivers and wetlands, whether it is a K-12 student group, lake association or policy maker. It gives me hope that together, with innovative science, we can solve our AIS problems.

A collaborative approach to research: USGS and MAISRC

The USGS Ecosystems Mission Area is the biological research arm of the Department of Interior and includes the Invasive Species Program. This program provides essential research, management tools, and decision support to meet the science needs of resource managers to reduce or eliminate the threat of invasive species and wildlife disease. This leadership is evident in the Upper Mississippi River region, with the presence of the USGS Upper Midwest Environmental Sciences Center (UMESC). Known globally for their work on invasive fishes, invertebrates and diseases, UMESC has a reputation for strong science, productive researchers, and transitioning technologies to real world application. The University of Minnesota, and MAISRC in particular, are fortunate to have UMESC 'down the river' in La Crosse, Wisconsin.

For years there have been informal and project-based collaborations between University of Minnesota and UMESC researchers working on AIS topics. However, more recently after the creation of MAISRC, a strategic partnership has developed on the long-term control of zebra mussels. To briefly highlight this important effort, we have worked together to safely and rapidly scale up experimental laboratory trials to the largest-ever-attempted open water treatment of its kind. For more information, see here: https://twin-cities.umn.edu/discover/guardians-lake. Early results are promising, and we are currently considering plans for the next steps. Given the success of this collaboration we are currently in the process of developing an MOU that will formalize our mutual goals and research commitment.

In my opinion, there is a major opportunity not fully being realized in the Upper Mississippi River region with MAISRC, UMESC, and others well positioned to aggressively advance research that is desperately needed for science-based solutions. The aforementioned successes have the high potential to increase in both breadth and depth with additional funding support.

Investing in solutions-oriented research for aquatic invasive species

The scale of the AIS problem is massive, but insufficient funding has been dedicated for the significant and growing challenges in the Upper Mississippi River region. Dedicated federal funding and coordination to address AIS in this region would leverage the important state funding currently available in Minnesota. This would allow for an expansion of collaborative opportunities between MAISRC and USGS researchers to address high priority needs. More specifically, I support the University of Minnesota's requested FY 2021 report language:

> *"Invasive Species- The Committee includes an additional $5,000,000 for research on the control and management of aquatic invasive species in the Upper Mississippi River region to address a critical need for collaborative multi-state research."*

We deeply appreciate your consideration for this important funding and thank you for your past support. Indeed, the FY 2020 DOI Appropriations Bill included an additional $1,000,000 for the Water Institutes Program to offer competitive funding for research at the nexus of AIS and water resources. This is important funding that will significantly contribute to an understudied area and bring together new teams. Nevertheless, additional research funding focused on control and management of high priority AIS warrants full consideration.

Conclusion

Aquatic invasive species are causing significant damage to our water resources in the Upper Mississippi River region and despite the best efforts by managers to, at a minimum, maintain status quo, the problems are getting worse. It is clear that we cannot rely on the same solutions that existed when the species arrived – we need innovative research to advance the science and develop new solutions. To that end, I respectfully request additional funding for the USGS Invasive Species Program in the Ecosystems Mission Area to conduct critical multi-state collaborative research on AIS in the Upper Mississippi River region.

Thank you very much for the opportunity to share my support for this request. If I can provide any assistance to you or your staff, please do not hesitate to reach out.

Statement of Shashi Shekhar

On behalf of the University of Minnesota (collaboration to map emerald ash borer)

Submitted to Congresswoman Betty McCollum

February 24, 2020

Congresswoman McCollum, I am pleased to share a statement with you today on behalf of myself, a computer scientist at the University of Minnesota, my colleagues here in the fields of biology, forestry, and supercomputing, and community partners that include the Hennepin County Public Works Department. Together we seek to help local communities map vulnerable ash trees, combining cutting-edge hyperspectral imagery and artificial intelligence with on-the-ground verification.

The emerald ash borer: With recent climate change and warmer winters, the emerald ash borer is ravaging ash trees across Minnesota, and 21 Minnesota counties are under quarantine as a result. Minnesota has almost a billion ash trees, and they represent the majority of trees in many cities. Loss of ash trees may change forest habitats to grass and shrubbery, threatening many native plants and animals. Loss of urban ash trees may lead to reduced green space in cities, poorer air quality, and increased urban heat island effects, as well as hazards to nearby infrastructure, such as roads, power-lines, buildings, etc. Detection and removal of infected ash trees is straining the budgets of many cities. If unchecked, the emerald ash borer is projected to cost hundreds of millions of dollars to Minnesota and billions of dollars to Midwest states, as per a recent Star Tribune cover story.[1] Communities want to map ash tree locations to take preventive measures such as inoculation or tree removal and replacement to protect infrastructure (e.g., roads, powerlines) from disease-weakened trees or limbs falling during strong storms. Acquiring spatial locations of ash trees, either on private or public property, will help landowners be more proactive in ash management, preserve existing tree canopy, and reduce public safety hazards. Unfortunately, ash tree mapping is very challenging due to the large number of trees and wide distribution. Currently, locations of individual ash trees are identified by field surveys, during which tree experts and volunteers manually walk around small areas to search for these trees. This process is tedious and slow, and has mapped only a small fraction of cities after years of work.

Previous Work at the University of Minnesota: The emerald ash borer was first detected in Minnesota around 2009[2] on the UMN's St. Paul campus not far from the Bell Museum. Soon after, the entomologists[3] at the University and the Minnesota Department of Natural Resource started training[4] tree-care professionals to spot and report infected trees. In addition, a National Science Foundation Smart and Connected Communities grant[5] (2017-2020) facilitated contact with the Public Works departments of Hennepin County and cities of Minneapolis and St. Paul to identify problems needing university research. Our community partners identified the emerald ash borer problem and asked for novel scalable ways to map locations of ash Trees. They also provided high-resolution aerial imagery and tree inventory datasets

[1] E. Johnson, *Minnesota cities struggle to stay ahead of emerald ash borer's rapid spread*, Star Tribune (Cover Story), October 20, 2019.

[2] Emerald Ash Borer, Minnesota Dept. of Natural Resources (www.dnr.state.mn.us/invasives/terrestrialanimals/eab/index.html).

[3] Experts look for signs of ash borers' spread, Jessica Mador, npr.org, May 25, 2009.

[4] Emerald ash borer in Minnesota, UMN Extension, (extension.umn.edu/tree-and-shrub-insects/emerald-ash-borers)

[5] *U of M secures $2.5 million grant to improve quality of life in cities*, University of Minnesota News, Oct. 12, 2017.

to assess the feasibility. Our preliminary work[6,7] has been able to identify locations of individual trees using available high-resolution aerial imagery and lidar data, but cannot identify tree species due to a lack of signature in the available data. Such signatures are available in high-spatial-resolution hyperspectral imagery, which is not currently available. Unfortunately, we do not have the funds to collect high-spatial-resolution hyperspectral imagery over large areas, such as Hennepin County, for ash tree mapping.

Proposed Research: To help communities quickly map ash tree locations, we propose an innovative Geospatial Artificial Intelligence (Geo-AI) based approach[8] with four components:

Data Collection: We will start with the collection of high-resolution (e.g., deci-meter) hyperspectral geo-imagery from aircrafts. Traditional imagery only contains visual bands for red, green, and blue, which are not useful in ash tree identification because the color of ash trees (i.e., green) overlaps with the colors of most other tree species in a top-down, bird's eye view. In contrast, hyperspectral imagery records additional information for hundreds of spectral bands, which, according to research literature,[9] reveal unique signatures of ash trees and can therefore be used to detect them with confidence. To scale up the approach to metropolitan areas, we need to collect high-spatial-resolution hyperspectral imagery. Fortunately, there are capable remote sensing companies such as *Quantum Spatial*.

Creation of Learning Samples: The high-resolution hyperspectral geo-imagery will be complemented with existing tree species inventories (e.g., one for the city of St. Paul and one for the University of Minnesota campuses), which will be vetted by ground truth verification to create a set of high-quality learning samples. We have already evaluated part of the St. Paul tree species inventory towards creating a set of learning samples pairing actual ash tree locations with corresponding hyperspectral imagery. Furthermore, we will leverage the elevation maps (e.g., Lidar point cloud) and high-resolution aerial imagery to enrich the information available for training Geo-AI models. In addition, we will use simple image operations (e.g., rotation) to create additional learning samples as needed. We will leverage the geographic information systems at the University of Minnesota's USpatial center to store and process the geo-imagery.

Training of Geo-AI Models: We will use the learning samples to train Geospatial Artificial Intelligence techniques (e.g., convolutional deep neural networks) to identify signatures of ash trees in the high-spatial-resolution hyperspectral data for areas covered by vetted tree species inventories. We will leverage the computational resources of the University of Minnesota's Minnesota Supercomputing Institute to train the Geo-AI models.

Prediction, Verification, and Outreach: The trained Geo-AI models will be used to predict the locations of ash trees in hyperspectral imagery over areas without tree species inventory. We will leverage the computational resources of the University of Minnesota's Minnesota Supercomputing Institute to create maps of ash Trees over large areas. The prediction will be evaluated with ground-truth verification. The technical activities will occur alongside community outreach and collaboration.

[6] S. Detor, A. Roh, Y. Xie, and S. Shekhar, *Analyzing Domain Knowledge for Big Data Analysis: A Case Study with Urban Tree Type Classification*, Proceedings of the International Conference on Big Data Analytics, Springer LNCS 11932, pp. 176-192, 2019.

[7] Y. Xie, H. Bao, S. Shekhar and J. Knight, *A TIMBER Framework for Mining Urban Tree Inventories Using Remote Sensing Datasets*, Proceedings of the IEEE International Conference on Data Mining (ICDM), pp. 1344-1349, 2018.

[8] Y. Xie, S. Shekhar, R. Feiock, J. Knight, *Revolutionizing Tree Management via Intelligent Spatial Techniques*, Best Vision Paper, Proceedings ACM SIGSPATIAL Annual Conference on Advances in GIS, 2019: 71-74. (Also highlighted as a Great Innovative Idea by the Computing Community Consortium, January 29th, 2020)

[9] J. Souci et al., *High-resolution remote sensing image analysis for early detection and response planning for emerald ash borer*, Photogrammetric Engineering & Remote Sensing, pp.905-909., ASPRS, Aug. 2009.

Partners: We have a set of partners, including the Hennepin County Public Works Department, the UMN College of Food, Agriculture, and Nutrition, the UMN College of Biological Sciences and the Research Computing Group in the University of Minnesota. Additionally, according to our Hennepin County partners, many cities would be interested in this data to use both the public tree inventory information, as well as proactively reaching out to private property owners.

Funding Request: Optimally, a $2 million fund through USGS (National Geospatial Program - Center for Excellence in Geographic Information Science) would support the collection of high-resolution hyperspectral imagery in the Twin Cities metropolitan area and the aforementioned Geo-AI research tasks for ash tree mapping.

Additional Benefits: High-spatial-resolution hyperspectral imagery and Geo-AI methods for ash tree mapping can also help with other problems faced by local communities. If the data is collected and other species can be identified, it can be used to map future pest and disease issues such as Asian longhorn beetles that kill maples and many other tree species. In addition, many communities are worried about diseases affecting Oak trees, and Prof. Jeannine Cavender-Bares would use our work to advance techniques for quickly mapping Oak trees. Similarly, Prof. Joseph Knight would use our methods for mapping wetlands and other geographic features. Our work could also help identify tree species to assess wind-damage hazards to the electric-power grid in order to protect power-lines, reducing power outages and fires started from trees falling onto power lines. This is becoming important in light of the 2018 Camp fire[10] near Paradise, CA, that claimed many lives.

Qualifications: The University of Minnesota is renowned university in many relevant research areas and has a strong track record of contributing key technologies, such as the National Historical GIS for spatio-temporal analysis of census data, the first elevation maps for polar regions, and the UMN MapServer, the first software to publish satellite imagery on the world-wide web. UMN also has USpatial, a leading research computing facility to support large scale geo-spatial analysis.

Currently, I am McKnight Distinguished University Professor and a Distinguished University Teaching Professor conducting research and teaching in the area of spatial computing and Geographic Information Science (GIS). I also serve on the board of the Computing Research Association, which serves over 250 US computing research departments spanning industry and government. Earlier, I served as the President of the University Consortium for GIS, which serves roughly 60 universities in the USA. I have also served on many National Academies' committees that have produced important reports, such as one titled “From Maps to Model: Augmenting the Nation's Geospatial Intelligence Capabilities.” Further, research from my spatial computing group produced the capacity-constrained route planning algorithm, which was used by the Minnesota Department of Transportation for evacuation route planning for the Twin Cities metropolitan area and was presented in a Congressional breakfast on GIS and homeland security in 2004. I have also had the honor of having presented at the 2015 Congressional reception on Deconstructing Precision Agriculture by invitation of the House Agriculture Committee. Moreover, my research group has contributed algorithms for mining spatial patterns (e.g., linear hotspots, colocation), an Encyclopedia of GIS, a Spatial Databases textbook, and a professional book on spatial computing.

Thank you for your continued support to the University of Minnesota and the opportunity to present our work to you.

[10] Camp fire (2018), wikipedia article (https://en.wikipedia.org/wiki/Camp_Fire_(2018))