University at Buffalo
Department of Geology
College of Arts and Sciences

Dear Friends of the Boyne River,

Thank you for being such incredible partners in managing and supporting the CrowdHydrology gauges on the Boyne River. Expressing how much your support has meant to our research team is tough. You have not only supported a group of, at the time, young scientists on a quest to build their scientific research groups, but you have also been a model for so many other organizations on what can be done by a dedicated group of people.

To provide some historical background on the start of our partnership, I may need to correct some facts here, but I will do my best. The first gauges on the Boyne River went in late May of 2014. I believe Ed was contacted by some folks with connections to the USGS water science center office asking if your group might be willing to put in some gauges. I have looked back to see if I could find that original e-mail from Ed, but apparently, the e-mail does not last that long. The gauges became popular, and the Friends of the Boyne stayed in close contact with us. A few years later, we were looking for a field site to test whether we could use citizen science gauges to run a numerical stream flow and temperature model. We contacted two groups, the Friends of the Boyne and another group on the Betsy River. I can't remember if Ed or Adam got back to us with some positive feedback. After a lot of grant writing and a letter of support from the Friends of the Boyne River, four young scientists got a grant from the National Science Foundation, and a true partnership was born. This partnership has genuinely helped accelerate the careers of myself, Darren and Damon (Jason was already a superstar). We really can't thank you folks enough.

In an attempt to fully describe the impact of your support, I would like to provide a few metrics to quantify the support the Friends of the Boyne River have provided. The Friends of the Boyne River has supported five gauges for the last ten years. Your gauges have collected 1,892 observations of water levels. These gauges have supported the research of four faculty members from five Universities. Two of us have gotten tenure while working on the Boyne River. In addition, it has supported one post-doctoral student, summer support for one PhD student, and a half dozen undergraduates. It has supported the publication of seven papers in the scientific literature. We have given talks at local and national scientific conferences on the work on the Boyne River. We have used the Boyne River as a case study for undergraduate and graduate courses at multiple Universities. In short, the impact of the research on the Boyne River has been exceptional.

On a personal note, you have invited us to meetings and picnics. We have enjoyed talking with you all in the field. You have left pie on the hood of our car after a long day in the field. While Ed was our first contact, he introduced us to your community and led us to a long list of people who have helped carry the load. In particular, we would not have been here without Ed, Adam, Mike, and Gow, who helped us set up the gauges in the early days. Poor Mike has had multiple packages shipped to his house with spare parts. Koz has been a master of pushing the CrowdHydrology gauges in the community. Sheri was the one who, I

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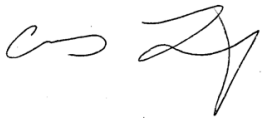
believe, put several articles in your newsletter and, I think, at least one story in the paper. We have had wonderful interactions with the Friends of the Boyne River through meetings at the public library and at least one potluck down by the water. All I can say is you folks are wonderful. Science, at times, can be dry and a little solitary, our work on the Boyne has been anything but dry and solitary.

In closing, I feel a bit of sadness that the shutting down of the gauges on the Boyne marks the end of an era. At the same time, this was the start of an experiment that showed that you can use citizen science data to run numerical models to forecast hydrologic events. It would have been impossible without the Friends of the Boyne River and your willingness to allow a group of young scientists to try something new. We are truly grateful for your support and encouragement.

Below is a list of all the publications that have been written as a result of our work on the Boyne River. These papers are a direct result of your help.

Thank you for everything,



Chris Lowry
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Hall, D. M., Avellaneda-Lopez, P. M., Ficklin, D. L., Knouft, J. H., & Lowry, C. (2024). How to close the loop with citizen scientists to advance meaningful science. *Sustainability Science*, 1-16.

Hall, D.M., P.M. Avellaneda-Lopez D.L. Ficklin, J.H. Knouft, C.S. Lowry (2024) Citizen Silence in Citizen Science: Towards an inclusive social contract with society, BioScience biae020, DOI:10.1093/biosci/biae020

Lowry, C.S. and K.F. Stepenuck (2021) Is Citizen Science Dead? Environmental Science and Technology doi:10.1021/acs.et.0c07873 (Scientific opinion paper non-peer reviewed)

Hall, D.M., S.J. Gilbertz, M.B. Anderson, P.M. Avellaneda, D.L. Ficklin, J.H. Knouft, and C.S. Lowry (2021) Mechanisms for Engaging Social Systems in Freshwater Science Research, *Freshwater Science* doi:10.1086/713039

Wu, D[‡]., E.A. Del Rosario[‡], and C.S. Lowry (2021) Exploring the Use of Decision Tree Methodology in Hydrology Using Crowdsourced Data. *Journal of the American Water Resources Association* doi:10.1111/1752-1688.12882

Avellaneda, P.M., D.L. Ficklin, C.S. Lowry, J. Knouft, and D. Hall (2020) Improving Hydrological Models with the Assimilation of Crowdsourced Data. *Water Resources Research* doi.org/10.1029/2019WR026325

Lowry CS, Fienen MN, Hall DM and Stepenuck KF (2019) Growing Pains of Crowdsourced Stream Stage Monitoring Using Mobile Phones: The Development of CrowdHydrology. *Front. Earth Sci.* 7:128. doi: 10.3389/feart.2019.00128

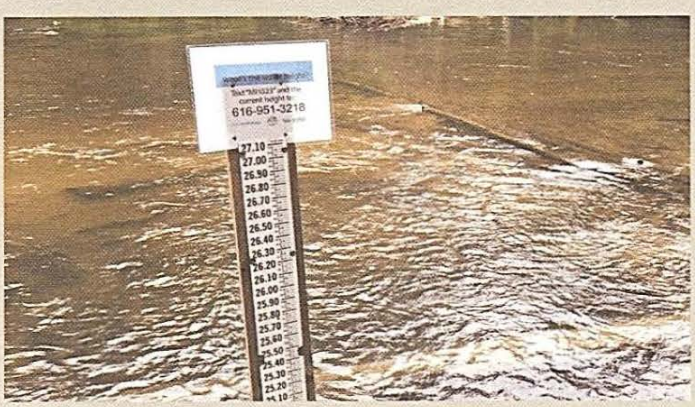
FROM ROAD KILL TO RIVERS:

CITIZEN-SUPPLIED SCIENTIFIC DATA

Damon Hall, Center for Sustainability, Department of Biology, Saint Louis University, Chris Lowry, Department of Geology, University at Buffalo, Darren Ficklin, Department of Geography, Indiana University, Jason Knouft, Department of Biology, Saint Louis University

In the early 2000s, a researcher in California wanted to better understand the wildlife population. He asked citizens to report observations about wildlife-vehicle collisions, also known as, roadkill. People passing through would notice what animals were struck and where. This was all input into a computer model of wildlife movement used to improve understanding of wildlife populations, migration, and habitat.

Could the same be done for streams where there are no USGS stream gauges; could citizens supply necessary stream-flow data? Chris Lowry from the University at Buffalo and Mike Fienen from the USGS wanted to know if they could solicit citizen scientists to collect water-level data. To test this, they put a water-level height gauge, basically a large ruler (Figure 1), at the Buffalo Audubon Society nature center in North Java New York in 2010 and asked people who passed by the gauge to use their phones to text message the readings (data) to the researchers. These data were then used to model the hydrology of a stream and wetland. People provided information where there was none. This "crowd-sourced" data and the network of gauges was dubbed CrowdHydrology and given a website (www.crowdhydrology.com). Within seven years, CrowdHydrology had installed over 100 gauges in 11 US states.



Super Friends Meet Super Computers

IN 2014, IN AN EFFORT TO LEARN MORE ABOUT their river, the Friends of the Boyne River (FoBR) installed five CrowdHydroogy gauges. Over two years, these five gauges were receiving a high number of readings suggesting that people were actively visiting these gauges. These readings were impressive because, like USGS gauges, readings were also being taken during crummy weather conditions. Readings in inclement weather are essential for understanding the overall water system. Because of the community of river users' commitment to delivering consistent high-quality data, the Boyne River merits further study.

A team of water researchers including a hydrologist, a hydrological modeler, a fisheries biologist, and social scientist was pulled together to use the citizen-generated data to develop a hydrological model of the Boyne River that uses real-time data input into a super-computer. The model uses citizen readings of stream height and water temperature (temperature gauges to be added in October 2017), enabling the prediction of high and low-water events as well as fishing and boating conditions three to seven days in advance. With the citizen-supplied data, the model will be able to improve itself in real time.

A National Science Foundation Study

TO CONSTRUCT THIS MODEL, WE ARE CONDUCTing field research to develop and calibrate the model with citizen readings. Our biologist is working with local organizations to assess aquatic life in the Boyne River.

For the social science, we are interested in who is texting information to the super computer. We are particularly interested in why people participate? How could we increase participation? And what can we make this model do that is of interest to those persons texting readings to the super computer?

We are carrying out this work in the Lake Charlevoix watershed for the next two years. Through the simple task of Boyne River users texting information to the server, this crowdsourced data supplies information that otherwise is unavailable. The Boyne River model will serve as an example to the nation that the quality of local streams and natural systems as well as the ability to protect these resources does not have to fluctuate as state and federal funding and priorities change. For those persons who care about the health of their waterways, lakes, and oceans, small collaborations can have large impacts. We have seen this with the Boyne River and its many friends including the FoBR, Michigan Department of Natural Resources, Michigan Trout Unlimited, Boyne Area Chamber of Commerce, Boyne Outfitters, Boyne City, Boyne USA, Little Traverse Bay Bands of Odawa Indians, Tip of the Mitt Watershed Council, the Lake Charlevoix Association, and others.

For individuals who wish to help, please text us your readings from any and all stations in the rain, snow, or sunshine.