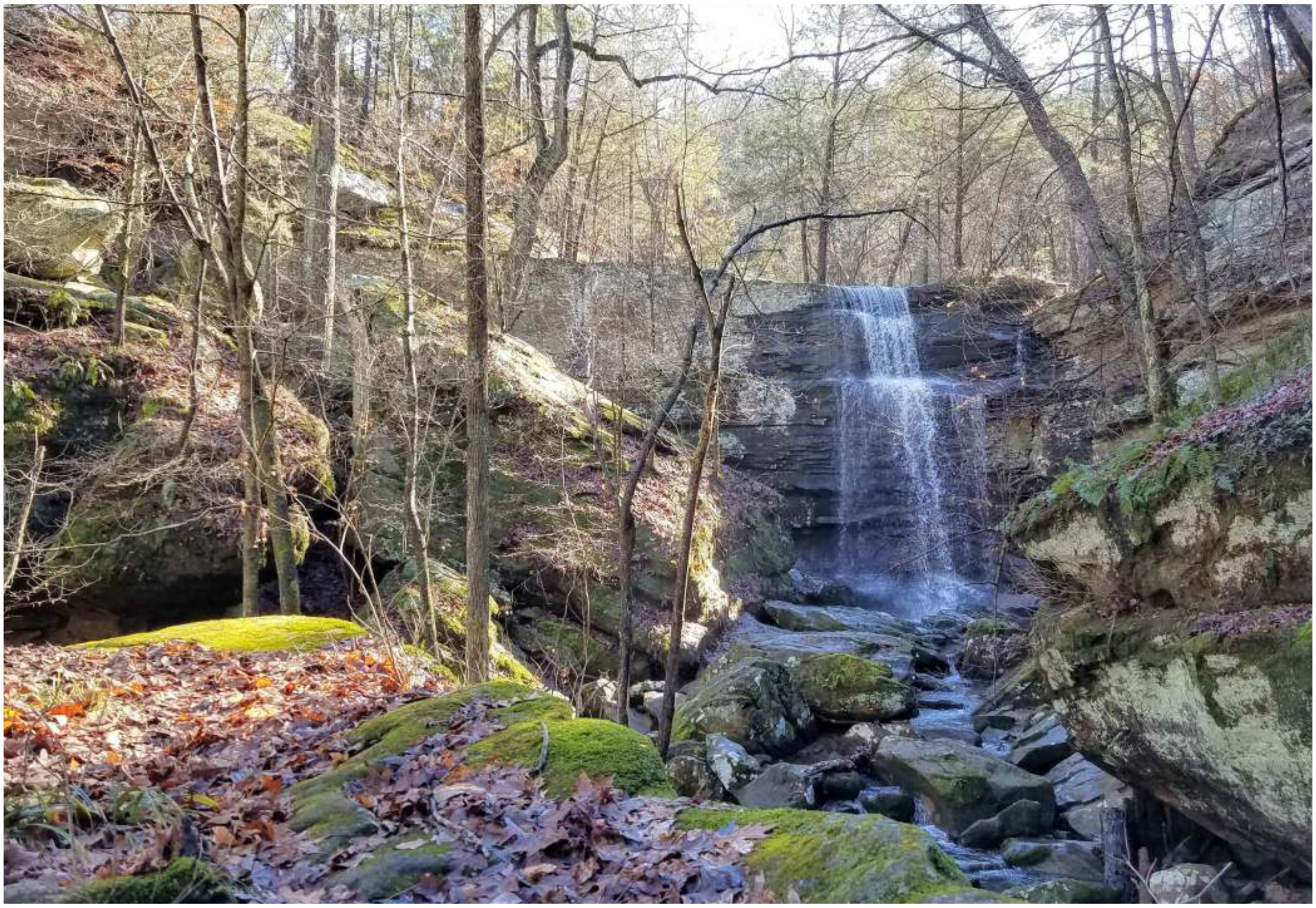
Journal of Contemporary

Water Research & Education

Issue 173
September 2021



UCOWR
UNIVERSITIES COUNCIL ON WATER RESOURCES

A publication of the Universities Council on Water Resources
with support from Southern Illinois University Carbondale

JOURNAL OF CONTEMPORARY WATER RESEARCH & EDUCATION

Universities Council on Water Resources
1231 Lincoln Drive, Mail Code 4526
Southern Illinois University
Carbondale, IL 62901
Telephone: (618) 536-7571
www.ucowr.org

ISSN 1936-7031

Cover photo: *Burden Falls, Southern Illinois*, Credit: Jackie Gillespie
Back cover photo: Reedy River Falls, Greenville, SC, Credit: Nicolas Henderson, original work, CC BY 2.0
Inside back cover photo: Downtown Greenville, Credit: Timothy J, original work, CC BY 2.0

Journal of Contemporary Water Research & Education

Issue No. 173 September 2021

Universities Council on Water Resources
Journal of Contemporary Water Research & Education
Issue 173, Pages 1-12, September 2021

Addressing Water Resources and Environmental Quality Programming Needs in Arequipa, Peru

*Laura C. Bowling[1], Katy E. Mazer[1], Edwin Bocardo-Delgado[2], Jane R. Frankenberger[3], José Pinto[4], Ruxandra Popovici[5], and Linda S. Prokopy[5]

*[1]Agronomy Department, Purdue University, USA; [2]Biology Department, Universidad Nacional de San Agustin, Arequipa, AR, Peru; [3]Agricultural & Biological Engineering Department, Purdue University, USA; [4]Agronomy Department, Universidad Nacional de San Agustin, Arequipa, AR, Peru; [5]Forestry and Natural Resources Department, Purdue University, USA; *Corresponding Author*

Abstract: Water resources in historically water scarce regions such as Arequipa, Peru are vulnerable to changing conditions. Population growth and climate change are projected to be major threats to water availability in the region, while urban growth, informal mining, and agriculture threaten water quality. To address these concerns and others, the Arequipa Nexus Institute for Food, Energy, Water, and the Environment (the Arequipa Nexus Institute) was formed as a collaboration between Purdue University and the Universidad Nacional de San Agustín to address key challenges to a sustainable future for Arequipa through research. In this work, a vision for water-related extension programming in Arequipa was developed through three phases of data collection. Phases 1 and 2 involved semi-structured interviews and focus groups with agency personnel, community leaders, and farmers in Arequipa. The water education needs of stakeholders that could be addressed by water and environmental extension programming were identified. In Phase 3, a workshop of researchers from the Arequipa Nexus Institute used the data and their knowledge of institutional capacity to identify opportunities for the Institute to serve as a boundary organization facilitating communication and collaboration between scientists and stakeholders to support water extension and engagement in Arequipa. Water resources extension services provided by this boundary organization would include education about water quality, water allocation, and water use, as well as providing resources to improve public participation in water management. Water extension services could be part of a cross-cutting extension initiative within the Arequipa Nexus Institute, which would be responsible for accumulating research data and connecting them to both formal and informal stakeholders. The dual training nature of the boundary organization will serve to both increase public understanding of water concerns and the capacity of information generators in the university and agencies to engage with the public. This study is unique in combining both sides of the boundary (community needs and scientists' perspectives) in developing the vision for this extension programming.

Keywords: *boundary organization, extension, Arequipa, water resources, engagement*

Population growth in the tropical Andes, particularly in urban centers, is projected to put additional stress on regional water resources by increasing water demand (Buytaert and De Bièvre 2012) and negatively impacting water quality (Wang et al. 2008; Liyanage and Yamada 2017). From 1993 to 2017, the Department of Arequipa has grown by more than 50%, reaching a population of approximately 1,383,000 (INEI 2017a; 2017b). Of those, 1,268,000, or 92%, were living in urban areas in 2017. These increases led to increased need for water for domestic, agricultural, and industrial uses.

In addition to local environmental concerns, climate change is projected to have several impacts in the tropical Andes and act as a threat multiplier in an already stressed region. Vuille et al. (2003) found some decreases in seasonal precipitation in southern Peru since the 1950s, a trend that is expected to continue (Urrutia and Vuille 2009), reducing water availability in some locations during the rainy season. A decrease

Research Implications

- Identified need to develop capacity for public participation in water resources management in Arequipa, based on understanding of both community needs and scientists' perspectives.
- A boundary organization can facilitate communication and collaboration between scientists and stakeholders, supporting end-user participation in water governance.
- The main goals of this organization should be bi-directional to support stakeholders while also informing a culture of applied research. This organization would increase the capacity of information generators at the university and agencies to engage with the public.

in water availability will be compounded by increased evapotranspiration as a result of higher temperatures (Buytaert and Beven 2011). In the Peruvian Andes region, glaciers provide the majority of dry season flow in many watersheds (Viviroli et al. 2011) and have been greatly reduced in recent decades (Racoviteanu et al. 2007; Silverio and Jaquet 2012).

These changing social and environmental conditions mean that local ecological knowledge is less able to support water management decision-making than in the past (Popovici et al. 2020a). Though many farmers have made efforts to adapt, smaller rural and upland communities often do not have the resources or knowledge to utilize the newest information or technology to make effective water management decisions.

The term extension education dates to the mid-1800s, and here we use it in the broad sense to refer to any program of continuing education whose purpose is to share applied, practical information to adult populations (Wu et al. 2011; Prokopy et al. 2017). Extension education has its roots in agricultural extension programs centered on farming practices for smallholder farmers, but here we are specifically exploring programs that help with water management decisions in water scarce environments. Although increased knowledge does not always lead to behavior changes, Dean et al. (2016) and Bowe and van der Horst (2015) found that increased knowledge can increase adoption of water-saving and pollution-reduction behaviors by farmers and homemakers in water-scarce environments.

Globally, there are many different models of extension, depending on the institutional home of extension networks and centers; extension can be tied to public universities, federal or regional government, or the private sector or non-governmental organizations (Prokopy et al. 2017). All models provide technical information in some way, although the method and reach of these services vary. In the U.S. land grant model, extension is tied to public universities, with extension serving as a bridge between university research and community needs (Prokopy et al. 2017). This structure has evolved over time, and increasingly, university extension serves as a boundary organization where scientists and citizens can exchange information needs and techniques to develop new knowledge and management tools together (Cash 2001; Guston 2001). Boundary organizations are entities that facilitate communication among multiple stakeholder groups (including scientists and citizens) and are considered important in generating effective solutions to pressing environmental issues (Cash et al. 2003; Beier et al. 2017). Prokopy et al. (2017) provide multiple examples of the potential for extension boundary organizations to create community-driven approaches to improve community climate resiliency through regional technical advisors that provide technical help, resources, and educational programs to inform decision-making.

The purpose of this paper is to evaluate the requirements and provide a vision for a boundary organization to inform applied water-related research and to extend research results and water resources information to institutions and communities in Arequipa, Peru. To address this goal, we looked at both sides (community needs and scientists' perspectives) in developing the vision for this extension programming by asking the following two questions:

1. What water-related information do local populations and agencies need access to that they currently do not have to make water management decisions? (i.e., What are the unmet needs of stakeholders?); and
2. What is the current institutional capacity

(agency and university) in Arequipa for conducting research and supporting water resources extension programming?

We then discuss how a new boundary organization could fit within the context of current water governance and research in Arequipa. This vision evolved through a three phase, iterative process between extension experts and university personnel in the U.S., collaborators at the Universidad Nacional de San Agustín (UNSA), and stakeholder input.

Background

The Arequipa Nexus Institute

In 2018, UNSA partnered with Purdue University, a land grant institution, to establish the Arequipa Nexus Institute for Food, Energy, Water, and the Environment, a multi-year, multi-phase technical cooperative agreement that will progressively transform UNSA to a regional leader in sustainability and resilience thinking through collaborative research and technical development programs. The Arequipa Nexus Institute's mission includes building university capacity and collaborations needed to address key challenges to create a sustainable future for Arequipa. Research focuses around five centers established at UNSA in 2020 and overseen by UNSA administrators – Sustainable Watershed Management, Soil and Water Quality, Social Sciences and the Environment, Agricultural Innovation and Demonstration, and Sustainable and Adaptive Energy Systems – designed to support UNSA and its mission.

Current Regulatory Structure in Arequipa

In Peru, prior to 2009, water was managed by separate sectors. Water governance fell primarily under the Ministry of Agriculture, which loosely collaborated with the Ministries of Health and Defense (Budds and Hinojosa-Valencia 2012; Pérez 2016). These three Ministries did not work together in a coordinated way. The Water Resource Law of 2009 codified the idea of integrated water resources management with support from the World Bank and Inter-American Development Bank (Congreso de la Republica 2009), which shifted water management from being directly tied to agriculture to explicitly representing other water use sectors. Specifically, the Water Resources Law of 2009 prioritizes water allocation by sector according to the following hierarchy: 1) protecting biodiversity, 2) domestic use, 3) agricultural use, and 4) industrial use and mining. It also defined the river basin as the primary unit of management, within a decentralized national authority. Currently there are 29 river basin units in Peru. River basin councils (*los Consejos de Recursos Hídricos de Cuenca*) are being established, which include regional representatives, as well as members of smaller, local groups. The river basin councils have round table discussions to deliberate and make water resources decisions. Thirteen of the 29 councils are already in place (August 2020), including one in the Quilca-Chili basin in the Arequipa Department.

The National Water Authority (ANA), which is under the Ministry of Agriculture, is the "decentralized national authority" for water management. The Administrative Water Authority (AAA) and the Local Water Authorities (ALA) are entities under the ANA. The AAA and ALA do not have any power to make local rules, as they are set centrally by the ANA. However, the AAA creates water resources plans for local river basins with the assistance of the river basin council. ALA offices implement the plans locally, disseminate information regarding ANA regulations, and help answer questions related to water management from citizens. Additionally, other groups have their own authority over water at some capacity. For example, the Autonomous Authority of Majes (AUTODEMA) was created to develop the Majes Irrigation Project and is now primarily in charge of management and maintenance of its water infrastructure, including collecting, storing, treating, and delivering water from the Colca River to the Majes Irrigation Project. Water users' associations and irrigation commissions are private, non-governmental organizations that operate based on fees from producers. A water users' association may oversee several irrigation commissions, which then work with land-owners. Urban water provisioning and treatment are the responsibility of the Potable Water and Sewage System Service of Arequipa (SEDAPAR), part of the National Superintendence of Sanitation

Services (SUNASS). Through a unique public-private agreement between the Cerro Verde mine and the provincial municipality of Arequipa, Cerro Verde constructed and operates the wastewater treatment plant “La Enlozada” for municipal waste, and in exchange, on average about one half of the treated water (1 m^3/s) is diverted for use by the mine (ANA 2020; ICMM 2020).

Current Extension Programming in Arequipa

While U.S. land grant universities have a three-part mission for research, teaching, and extension, Peruvian public universities have a four-part mission. These four missions include education, research, extension, and social projection. Social projection refers to university participation in the resolution of problems and proposals for societal development, among other activities. Multiple forms of extension programming are in use at UNSA, including expert presentations and training programs, both in person and utilizing the campus television and radio stations. Such methods of delivery are often preferred; written training materials are limited since much of the target population may not be literate, and in-person demonstrations require extensive travel to remote locations. However, despite a mission and experience with extension programming, UNSA currently has limited capacity to transform its science into terms that people can understand to support societal development. Similarly, many local and regional agencies have an interest or role in developing water-related extension materials, with mixed success. The 2009 Water Resources Law establishes the principle of public participation that requires the ANA to create mechanisms for the population to participate in decisions related to the quantity, quality, and opportunity for use of the water, and to strengthen water users’ associations (Congreso de la Republica 2009). However, no specific extension programs led by the ANA have been identified.

The National Meteorology and Hydrology Service of Peru (SENAMHI) maintains a station network to monitor meteorological and hydrological data. They also conduct internal research and develop many products, including gridded weather station data, analysis of El Niño/La Niña climate extremes, and analysis of ecological zones. They have created K-12 outreach materials related to climate change and El Niño. These materials are available online and in print, although in some cases they must be purchased, and they reportedly have some programs for farmer outreach.

At a more regional level, AUTODEMA is involved in the economic development of the Majes region. They conduct internal research and use different methods of extension delivery to help farmers increase farm profitability. For example, AUTODEMA worked together with the water users’ associations to develop pamphlets with information on calculating growing degree days for some crops. They have also developed an online tool to estimate irrigation water requirements for specific crops.

Methods

This work involved three phases of qualitative data collection. In Phases 1 and 2, semi-structured interviews and focus groups with agency personnel, community leaders and farmers in Arequipa allowed direct questioning regarding the unmet needs of stakeholders and the institutional capacity of agencies to support water and environmental extension programming to address our two primary research questions. These qualitative data collection approaches are appropriate as they allow the collection of a high level of detail from which to gain insight into experiences based on context (Hammarberg et al. 2016). In Phase 3, a workshop of researchers from the Arequipa Nexus Institute used the data and their knowledge of institutional capacity to identify opportunities to facilitate communication and collaboration between scientists and stakeholders to support water extension and engagement in Arequipa.

The initial research phase consisted of 139 semi-structured interviews conducted in 2018 and 2019 with agency personnel and farmers in the districts of Caylloma, Lari, Yanque, Cabanaconde, and Majes in the province of Caylloma, Department of Arequipa, Peru. As described in more detail by Popovici et al. (2020a), a purposive sampling strategy was used to select interviewees from key organizations involved in water management (Ritchie et al. 2014). Snowball sampling was used to identify additional people and organizations to interview based on the information collected in previous interviews, until data saturation was reached (Fusch and Ness 2015).

Phase 2 focus groups were conducted in 2019 by members of the Sustainable Water Management (SWM) team of the Arequipa Nexus Institute. A total of eight focus groups were conducted with agency personnel and farmers, including five in the rural districts of Lari, Yanque, Cabanaconde, Chivay, and Majes, and three with different agency audiences in the city of Arequipa. Attendance ranged from one to 40 participants, see Popovici et al. (2020b) for details. During the focus groups, SWM members reported the research findings they had obtained through semi-structured interviews and presented a preliminary set of research ideas to support development of tools for water and crop management. These tools included calculation methods for estimating crop water use and irrigation scheduling; fact sheets on 30-year historic climate trends; information on regional crop quantities, growth stage, and water use using remote sensing; and water quality testing kits.

Researchers from the Arequipa Nexus Institute for Food, Water, Energy, and the Environment who are investigating topics related to water issues in Arequipa convened for a two-day workshop on August 1 and 2, 2019. In this workshop, approximately 40 researchers discussed needs to support diffusion of water and environmental management information in Arequipa, Peru. Content for the workshop included presentations on recent research on water governance and community needs in Arequipa based on the semi-structured interviews and focus groups to provide a common basis of understanding. A trained facilitator led the large group discussion on the target audience for extension programming, appropriate programming structures for Arequipa, and methods of delivery. In addition, participants could opt into a specific small group discussion with a defined purpose, including extension support needs (financial/intellectual/staffing), funding models, advantages and disadvantages of physical centers, and centralized delivery. Volunteer bi-lingual facilitators encouraged and re-directed discussion and note takers participated in each small group break-out section to help recap key discussion points.

Results

Stakeholder Needs for Water-Related Information

It is clear from interviews and focus groups that water scarcity is felt by farmers throughout Arequipa. Additionally, there are issues with proper use of irrigation, whether it be by over-irrigating or lack of knowledge of how to best implement irrigation technology to meet specific needs. Many people believe that water quality is a concern, both from an agricultural and a domestic use perspective. However, some would almost rather not know the quality of their water, for fear of knowing about a problem that they have no control over. Nevertheless, participants in focus groups consistently expressed interest in products that will help to establish risk and best practices, including: information about drinking water quality standards and impacts to human health, a system to communicate water risks to the public using a phone app, and methods for testing irrigation water quality and understanding the limitations of use.

Farmers in traditional high-altitude farming communities such as the Colca Valley are experiencing numerous biophysical and socioeconomic changes that influence their water information needs. Because of the proximity to glaciers (Buytaert and De Bièvre 2012) and more extreme increases in temperature predicted at higher elevations (Bradley et al. 2006), rural and upland indigenous communities are most vulnerable to climate change impacts. Some of these impacts have already been seen; for example, there are reports of small springs drying up and changes in crop performance. It is sometimes unclear if these changes are due to climate change, human influence from mining, or other infrastructure developments.

In addition, the current generation of workers are becoming more individualistic, and have less of a sense of helping others in their community (Popovici et al. 2020a). People are migrating out of the Colca Valley into larger cities like Arequipa to find work, and many have multiple jobs. These factors contribute to a less informed population. For example, they do not have time to attend irrigation commission meetings and become informed of water management policies and their rights in the new integrated water management system. ANA staff also told us that when they travel to communities to schedule training, there is a lack of participation, but they attributed it to lack of motivation from farmers. The need is perhaps greater than ever, but the current training does not accommodate changing lifestyles.

Across all focus groups, a recurrent theme was whether the participants had the knowledge necessary to use the products being discussed. For example, local farmers in Majes expressed interest in testing water sediment load themselves, but at the regional level, agency staff had little confidence that this was possible. For example, one agency representative said:

> *"De nada me sirve a mí llegar con mis unidades de medida, mis cases y todos mis métodos de investigación, si el agricultor no me va a captar absolutamente nada de lo que yo le estoy diciendo."* Translated: *"It is useless for me to arrive with my units of measurement, my containers and all my research methods, if the farmer is not going to retain absolutely anything that I am telling him."*

Focus group participants cited low literacy as a major barrier to use existing data and concepts above the level of what farmers understand from their experiential training/learning. For example, another participant said:

> *"Se han hecho muchas capacitaciones, se han repartido folletos, boletines, gráficos, fotos, pero agricultores que sí lo han captado por el nivel de alfabetización…. Entonces, es complejo la situación... ha traído mucha problemática."* Translated: *"Many trainings have been carried out, brochures, newsletters, graphics, photos have been distributed, but farmers have understood it up to the level of their literacy… So, the situation is complex ... it has brought a lot of problems."*

In many cases it was felt that local community members need basic education on the topic areas but may never use decision support products themselves.

Institutional Capacity to Provide Water-Related Information

Participants in the workshop shared that research at UNSA has historically been siloed with little collaboration between professors or with people in the community. As a result, the research undertaken does not necessarily meet the needs of the country and the people impacted are not receiving research results. UNSA does not have the capacity to transform their science into terms that people can understand to support societal development. To move toward impactful, collaborative research, UNSA looked to develop partnerships with established, collaborative research universities, experienced in translating research to application, such as Purdue University. UNSA would like to coordinate their research so that they can better deliver information to citizens.

Many workshop participants had ties to agencies in Arequipa and corroborated what was found in focus groups. Local and regional agencies have developed online products to help users make water management decisions. A common theme across focus groups with regional and municipal agencies was that they wanted support to generate products themselves. So, although the agencies are information generators and extension providers themselves, they are also stakeholders who could benefit from educational programming. For example, they expressed interest in receiving training to run hydrology and hydraulic models, rather than receiving analysis products from research groups. As one focus group participant said:

> *"O sea, la herramienta existe, más que el modelo lo que necesitamos es un poco de capacitación para que haya más gente que pueda tener la idea de cómo se modela y cómo se planifica."* Translated: *"In other words, the tool exists, more than the model what we need is a little training so that there are more people who can have the idea of how to model and how to plan."*

However, there was also a large sense of frustration expressed on both sides regarding the ability of agencies to share information with their target populations. For example, farmers expressed that a tool to predict irrigation water needs would be useful, but we learned through the agency focus groups that AUTODEMA developed a similar tool and tried to promote it through workshop training, but farmers have not adopted it. It is unclear if the tool did not meet farmer needs, if the training materials were poorly suited to the audience, or if it was the wrong audience (targeting the farm owners rather than the irrigation operators, for example (see e.g., Erwin et al. in review)).

Representatives from the ANA, AUTODEMA, and water users' associations all had examples of challenges in distributing pamphlets, training, and tools with farmers and expressed interest in help with outreach materials. Agency personal admitted that:

> *"...el problema es la difusión de esta información, o sea, hay material de años atrás que hasta ahora no se logra difundir, no logramos, o AUTODEMA como entidad no logra llegar al agricultor."* Translated: *"...the problem is the dissemination of this information, that is, there is material from years ago that until now has not been disseminated, we have not succeeded, or AUTODEMA as an entity has not managed to reach the farmer."*

The ALA and water users' association offices are understaffed and do not have sufficient resources and appropriate training to support communities with a local presence. Another limitation of agencies is the frequent leadership changes which minimizes continuity in outreach programs.

In addition to the outreach, another challenge may exist in the creation of the products themselves. Multiple times in focus groups and interviews we heard that the SENAMHI was working on related products, but they did not meet user needs or were not readily 'shared' with users. For example, products included regional gridded climate data that were at too coarse a resolution for decision-making, compiled extreme weather information that did not incorporate predictions of risk, and projections that did not have consumer confidence. Other complaints included difficulty in accessing data products, access fees, and low quality control. It seems that some of these products could benefit from a boundary organization that could facilitate co-production of the products to better address user needs. Co-production refers to the joint creation of information and collaborative decision-making (Djenontin and Meadow 2018).

Discussion: A Vision for the Boundary Organization

Based on findings from existing programming, stakeholder needs, and institutional capacity, it was determined at the workshop that there is an opportunity for a boundary organization to provide water resources extension services in Arequipa. This boundary organization could be created through the development of an extension hub that operates through the Arequipa Nexus Institute.

The Hub's Role

At the workshop, a broad discussion was held of the different target audiences in Arequipa and the types of programming that are appropriate. It was agreed that a boundary organization needs to support the differing needs of both informal and formal actors. Formal actors include national and regional agencies, such as the SENAMHI, AUTODEMA and ANA, and the university, while informal actors include farmers, individual communities, and community groups, such as irrigation commissions, livestock and product associations, women's groups, and water users' associations. The type of information needed by informal actors varies depending on the geographic location, level of urbanization, and income generation methods, among others, but will include training and information to support personal water management decisions, such as when irrigation water is safe to use. Formal actors can consult with the boundary organization to guide their applied research initiatives and learn how to effectively co-produce information products and tools.

During the workshop, different extension models were discussed involving different primary information generators and different information distributors. It was expressed that information distributed by a university-affiliated organization would be perceived with higher validity by the end users than information from agencies. Given distrust of government agencies, and past inability of agencies to allocate resources to community education, a university-affiliated extension office may be more effective at working directly with community level organizations.

The Arequipa Nexus Institute is uniquely poised to fill the current shortcomings of extension education in Arequipa. As a part of UNSA, a public institution, it can simultaneously interact with high level agencies, businesses, not for profit organizations, and local populations, and it has also already begun to deepen its relationship with many institutions. However, to function as a boundary organization, the extension hub would need to expand the Arequipa Nexus Institute's current efforts of research and innovation to include extension as an additional role. This extension hub would be cross-cutting throughout the Arequipa Nexus Institute, addressing aspects of all five of the established Nexus Research Centers.

This relationship would function by UNSA (including the Arequipa Nexus Institute) generating new information from current research (Figure 1). This information could be passed to the water extension hub to be shared with formal institutions (agencies) at both regional and local levels as end users for in-house decision-making. However, these agencies are also substantial generators of information. This audience would benefit from training and consultation provided by the extension hub on *how* to co-produce and disseminate information and products themselves to better meet the needs of target audiences.

By allowing the extension hub to be an intermediary of information, data and research generated by UNSA and agencies can be evaluated for applicability before being shared with end users. The extension hub can play the role of transforming information into a form that stakeholders can understand and facilitate the relationship between content generators and end users. Products can be distributed directly from the hub, through agencies such as AUTODEMA that are equipped for extension, but also through existing local users' groups and organizations, which can provide a targeted method of reaching individuals.

Extension Hub Needs

As described above, a bi-directional boundary organization can help to translate generated information into useful tools, trainings and products, and to guide future directions of inquiry. The primary need is to build the capacity to co-produce water management products between UNSA, agencies, and society to allow Arequipa to fully embrace the integrated water management approach mandated by federal law. A new boundary organization would greatly benefit from staff trained in social science techniques who can provide training and resources on increasing participation in integrated water management. In addition, there is need to increase capacity for extension within the water agencies, and increase access to hands-on training programs.

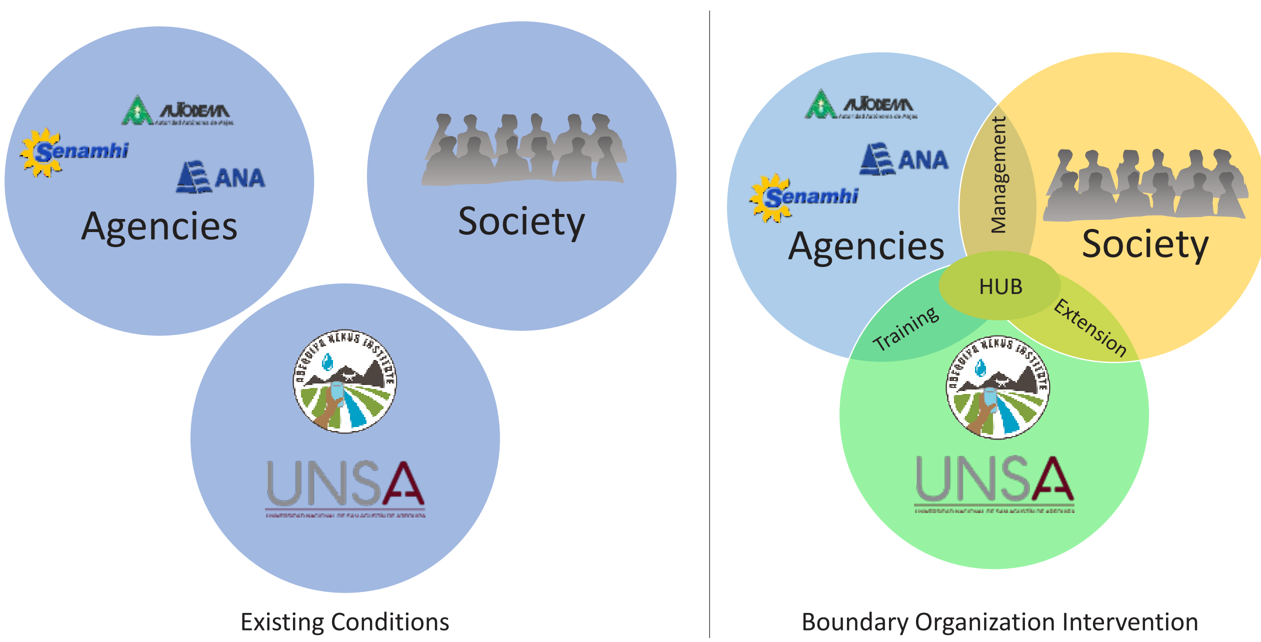


Figure 1. The situation of the Water Resources Extension Hub as a boundary organization that closes the gaps between researchers in the university, information generators in government agencies in Arequipa, Peru, and society.

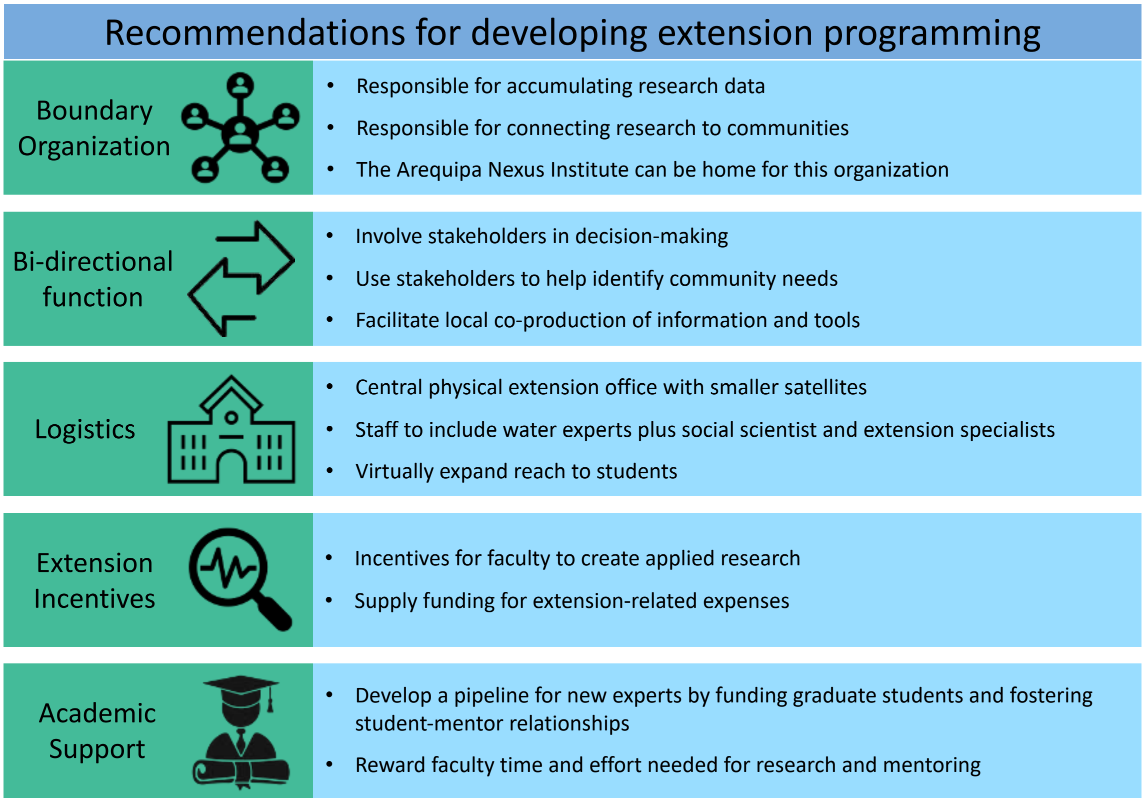


Figure 2. Recommendations for needs to develop effective extension programming were identified at the two-day workshop. These include the creation of a boundary organization with a bi-directional function, a dedicated office and staff, and incentives and academic support for faculty to develop applied research.

To create the research pipeline to support an extension program, it is necessary to continue to develop internal university incentives and infrastructure for applied research and to increase collaboration between the university and water agencies (Figure 2). Research projects should be developed involving UNSA students who can use the research to work toward their theses. This mentored development of research products involving faculty and students working together is not the norm at UNSA. Although research theses are required at the bachelor, professional, and graduate levels, there is no formal support or supervision of this research. There should be a reliable graduate student funding source, as these students are the basis of research in many places. Support for developing advisor-student relationships is needed to create reliable research that is carried out by graduate students. Lines of research need to be defined to have clearer goals based on the five Nexus research centers. An extension hub can develop research capacity by helping to identify research needs that are relevant to local communities, in addition to translating research results to make them understandable for lay people.

Participants in the workshop voiced support for both physical, in-person programming and virtual models, both of which have benefits and drawbacks. Physical centers have more value for locally relevant hands-on learning and local access, and the visual presence will increase awareness of the center. On the other hand, virtual centers provide a broader reach, especially in a geographically diverse region such as Arequipa in which travel can be difficult. In addition, virtual centers are less costly to start up, and can better reach new audiences (Dromgoole and Boleman 2006). An OECD survey of virtual learning has shown that almost a quarter of adults in Latin American countries who wanted to participate in training were unable to, but new technologies may provide new opportunities to engage adults who find traditional in-person training difficult to access or ineffective. However, it was also found that in Latin America virtual adult education tended to reinforce and potentially amplify existing knowledge gaps, with more educated individuals more likely to benefit. Given that the proposed extension hubs will have two types of stakeholders, both trained, agency personnel and untrained community members creating a model that combines physical centers and virtual information seems desirable in Arequipa (OECD 2021).

Conclusions

There is a great need to develop capacity for public participation in water resources management in Arequipa to support management decisions at all level and scales. The 2009 Water Resources Law charges the ANA with the goal of creating mechanisms for public participation in integrated water management, but this service has not yet been implemented. Similarly, other agencies and university researchers are developing research and services that may help communities, but they lack the resources and knowledge to engage with these communities and provide training and resources that will be utilized. Although many entities put at least some effort into extension, community education needs are not being fully met. There is a need for a boundary organization that can support end-user participation in water governance, while helping to disseminate materials from agencies and universities.

To more effectively share water resources research with local stakeholders, efforts should be consolidated by allowing the boundary organization to act as a central extension entity. The main goals of this extension hub should be bi-directional to support and inform stakeholders while informing research and management. Stakeholders' needs should be further explored to steer research and problem-solving in the region, while UNSA and the Arequipa Nexus Institute continue to develop a culture of applied research to support the information needs of the extension center. Extension programming will focus on the co-production of water resources knowledge to involve end-users in water resources decision-making. In Arequipa, a model that combines physical hubs and virtual information is the most logical. Staff should include both biophysical water experts, as well as social scientists and extension specialists to support the co-production needs.

Acknowledgements

Funds to support research in the Arequipa Nexus Institute for Food, Energy, Water, and the Environment were provided by the Universidad Nacional de San Agustín.

Author Bio and Contact Information

Laura C. Bowling (corresponding author) is a Professor of hydrology in the Department of Agronomy at Purdue University. Her research investigates the water resources impact of environmental change across multiple scales, climate regimes, and ecosystems and communicates these findings to stakeholders. She can be contacted at bowling@purdue.edu or 915 W. State St., West Lafayette, IN 47907.

Katy E. Mazer is coordinator of the Sustainable Water Management team of The Nexus Institute at Purdue University. She engages with stakeholder groups in Arequipa, Peru to coproduce water management decision-making tools. She can be contacted at kmazer@purdue.edu or 920 W. State St., West Lafayette, IN 47907.

Edwin F. Bocardo-Delgado is a principal professor in the Department of Biological Sciences and a graduate Environmental Science professor at the Universidad Nacional de San Agustín de Arequipa. He also works as an environmental consultant for several companies and a natural resource management specialist. He can be contacted at ebocardo@unsa.edu.pe or Av. Sánchez Carreón s/n, Cercado Arequipa.

Jane R. Frankenberger is a Professor of Agricultural and Biological Engineering at Purdue University. She conducts model-based analyses and engages stakeholders to improve management of watersheds and water quality. She can be contacted at frankenb@purdue.edu or 225 S. University St., West Lafayette, IN 47907.

José P. Pinto Cáceres is a professor in the Department of Agronomy at the Universidad Nacional de San Agustín de Arequipa. He conducts agricultural research and connects with interested associations to improve natural resource management. He can be contacted at jpinto2@unsa.edu.pe or Urb. Aurora s/n (costado Estadio UNSA) Arequipa - Perú.

Ruxandra Popovici was a Postdoctoral Researcher in the Department of Forestry and Natural Resources at Purdue University. Her work focuses on environmental governance, where she researches the various rules and norms through which people on the ground manage their natural resources. She can be contacted at ruxandra.popovici1@gmail.com.

Linda S. Prokopy is a Professor in the Forestry and Natural Resources Department at Purdue University. She conducts research on the social dimensions of watershed management. She can be contacted at lprokopy@purdue.edu or 195 Marsteller St., West Lafayette, IN 47907.

References

Autoridad Nacional de Agua (ANA). 2020. Visor de Estaciones. Available at: http://snirh.ana.gob.pe/visors2/. Accessed October 6, 2020.

Beier, P., L.J. Hansen, L. Helbrecht, and D. Behar. 2017. A how-to guide for coproduction of actionable science. *Conservation Letters* 10(3): 288-296.

Bowe, C. and D. van der Horst. 2015. Positive externalities, knowledge exchange and corporate farm extension services; A case study on creating shared value in a water scarce area. *Ecosystem Services* 15(C): 1-10.

Bradley, R.S., M. Vuille, H.F. Diaz, and W. Vergara. 2006. Threats to water supplies in the tropical Andes. *Science* 312(5781): 1755-1756.

Budds, J. and L. Hinojosa-Valencia. 2012. Las industrias extractivas y los paisajes hídricos en transición en los países andinos: Análisis de la gobernanza de recursos y formación de territorios en Perú. In: *Agua, Injusticia y Conflictos*, R. Boelens, E. Isch, F. Peña (Eds.). Lima, Peru, CBC.

Buytaert, W. and K. Beven. 2011. Models as multiple working hypotheses: Hydrological simulation of tropical alpine wetlands. *Hydrological Processes* 25(11): 1784-1799.

Buytaert, W. and B. De Bièvre. 2012. Water for cities: The impact of climate change and demographic growth in the tropical Andes. *Water Resources Research* 48(8): W08503.

Cash, D.W. 2001. "In order to aid in diffusing useful and practical information": Agricultural extension and boundary organizations. *Science, Technology, & Human Values* 26(4): 431-453.

Cash, D.W., W.C. Clark, F. Alcock, N.M. Dickson, N. Eckley,…and R.B. Mitchell. 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences of the USA* 100(14): 8086-8091.

Congreso de la Republica del Perú. 2009. Ley de Recursos Hídricos N° 29338. Lima, Peru. Available at: https://leyes.congreso.gob.pe/Documentos/Leyes/29338.pdf. Accessed September 8, 2021.

Dean, A.J., K.S. Fielding, and F.J. Newton. 2016. Community knowledge about water: Who has better knowledge and is this associated with water-related behaviors and support for water-related policies? *PLoS ONE* 11(7): e0159063. Available at: https://doi.org/10.1371/journal.pone.0159063. Accessed October 8, 2020.

Djenontin, I.N.S. and A.M. Meadow. 2018. The art of co-production of knowledge in environmental sciences and management: Lessons from international practice. *Environmental Management* 61(6): 885-903. Available at: https://doi.org/10.1007/s00267-018-1028-3. Accessed September 16, 2020.

Dromgoole, D.A. and C.T. Boleman. 2006. Distance education: Perceived barriers and opportunities related to extension program delivery. *Journal of Extension* 44(5): 5RIB1. Available at: https://archives.joe.org/joe/2006october/rb1.php. Accessed September 8, 2021.

Erwin, A., Z. Ma, R. Popovici, P. Salas, L. Zanotti,…and G. Arce. In review. Integrating migration into community resilience: A case of the Majes Canal. *Land Use Policy.*

Fusch, P.I. and L.R. Ness. 2015. Are we there yet? Data saturation in qualitative research. *The Qualitative Report* 20(9): 1408-1416.

Guston, D.H. 2001. Boundary organizations in environmental policy and science: An introduction. *Science, Technology, & Human Values* 26(4): 399-408.

Hammarberg, K., M. Kirkman, and S. de Lacey. 2016. Qualitative research methods: When to use them and how to judge them. *Human Reproduction* 31(3): 498-501.

Instituto Nacional de Estadistica e Informatica (INEI). 2017a. Evolución de la Población Censada Urbana, Según Departamento y Año Censal. Censos Nacionales de Población y Vivienda 30 Aug. 2019.

Instituto Nacional de Estadistica e Informatica (INEI). 2017b. Población Censada, Según Departamento y Año Censal. Censos Nacionales de Población y Vivienda 30 Aug. 2019.

International Council on Mining & Materials (ICMM). 2020. Creating Shared Value for Business and Communities. ICMM Guidance

Case Studies. Available at: https://guidance.miningwithprinciples.com/case_study/creating-shared-value-for-business-and-communities/. Accessed October 6, 2020.

Liyanage, C.P. and K. Yamada. 2017. Impact of population growth on the water quality of natural water bodies. *Sustainability* 9(8): 1405.

Organization for Economic Cooperation and Development (OECD). 2021. Making the Most of Technology for Learning and Training in Latin America. Available at: https://doi.org/10.1787/ce2b1a62-en. Accessed September 5, 2021.

Pérez, E.G. 2016. Evolución histórica de la gestión de los recursos hídricos en el Perú. *Revista Iberoamericana del Agua* 2(i–iv).

Popovici, R., A. Erwin, Z. Ma, L. Prokopy, L. Zanotti,…and G.R.A. Larrea. 2020a. Outsourcing governance in Peru's integrated water resources management. *Land Use Policy* 101:105105. Available at: https://doi.org/10.1016/j.landusepol.2020.105105. Accessed September 9, 2021.

Popovici, R., K.E. Mazer, A. Erwin, Z. Ma, J.P. Pinto Cáceres,…and L.S. Prokopy. 2020b. Coproduction challenges in the context of changing rural livelihoods. *Journal of Contemporary Water Research and Education* 171: 111-126. Available at: https://doi.org/10.1111/j.1936-704X.2020.3348.x. Accessed September 8, 2021.

Prokopy, L., W.-L. Bartels, G. Burniske, and R. Power. 2017. Agricultural extension and climate change communication. *Oxford Research Encyclopedia of Climate* Science. Available at: https://doi.org/10.1093/acrefore/9780190228620.013.429. Accessed September 8, 2021.

Racoviteanu, A.E., W. Manley, Y. Arnaud, and M.W. Williams. 2007. Evaluating digital elevation models for glaciologic applications: An example from Nevado Coropuna, Peruvian Andes. *Global and Planetary Change* 59(1): 110-125.

Ritchie, J., J. Lewis, C.M. Nicholls, and R. Ormston (Eds.). 2014. *Qualitative Research Practice: A Guide for Social Science Students and Researchers*. SAGE, Los Angeles, California.

Silverio, W. and J.-M. Jaquet. 2012. Multi-temporal and multi-source cartography of the glacial cover of Nevado Coropuna (Arequipa, Peru) between 1955 and 2003. *International Journal of Remote Sensing* 33(18): 5876-5888.

Urrutia, R. and M. Vuille. 2009. Climate change projections for the tropical Andes using a regional climate model: Temperature and precipitation simulations for the end of the 21st century. *Journal of Geophysical Research* 114: D02108.

Viviroli, D., D. Archer, W. Buytaert, H.J. Fowler, G.B. Greenwood,…and R. Woods. 2011. Climate change and mountain water resources: Overview and recommendations for research, management and policy. *Hydrology and Earth System Sciences* 15(2): 471-504.

Vuille, M., R.S. Bradley, M. Werner, and F. Keimig. 2003. 20th century climate change in the tropical Andes: Observations and model results. *Climatic Change* 59: 75-99.

Wang, J., L. Da, K. Song, and B.-L. Li. 2008. Temporal variations of surface water quality in urban, suburban and rural areas during rapid urbanization in Shanghai, China. *Environmental Pollution* 152(2): 387-393.

Wu, H.-Y., Y.-K. Lin, and C.-H. Chang. 2011. Performance evaluation of extension education centers in universities based on the balanced scorecard. *Evaluation and Program Planning* 34: 37-50.

Universities Council on Water Resources
Journal of Contemporary Water Research & Education
Issue 173, Pages 13-28, September 2021

Engaging the Public in Water Policy: Do Political Affiliation and Ideology Matter?

*Kristin E. Gibson, Alexa J. Lamm, Kyle Maurice Woosnam, and D. Barry Croom

All authors affiliated with University of Georgia
**Corresponding Author*

Abstract: Unsustainable human activities are rapidly depleting freshwater resources in many parts of the United States. Public policy surrounding water conservation is arguably one of the most essential strategies for targeting the preservation of water. Increased public engagement in environmental policy may bolster sustainable consumption of water resources if nuances in human behavior are targeted through communication messages. A quantitative research design using an online survey of the general United States public was used to explore if political affiliation and political ideology predicted how respondents prepared to vote on a policy that impacts water. The study revealed that respondents neither agreed nor disagreed on the level to which they would take specific actions to become prepared to vote on a policy that impacts water, indicating there is room for improvement. Results from a multiple linear regression revealed political affiliation and political ideology significantly predicted how respondents prepared to vote on a policy that impacts water; however, they accounted for a small amount of variance in the models. Future studies should identify additional predictors to determine how respondents prepare to vote on a policy that impacts water since political affiliation and political ideology were not a major influence on how respondents prepare to vote. Environmental communicators should focus their outreach efforts on increasing public preparedness to vote on polices that impact water.

Keywords: *environmental communication, political affiliation, political ideology, water resource engagement*

Water resources around the globe are rapidly depleting and degrading due to increasing demands for freshwater (Araya and Moyer 2006). In the United States (U.S.), freshwater resources are locally and regionally strained in many parts of the country (Sankarasubramanian et al. 2017). For example, extreme long-term drought conditions exist in southern California and many parts of the western U.S. (NDMC 2021). Environmental pollution also poses a serious threat to water resources (Pimentel et al. 2004). For example, the Red River, which supplies drinking water for many residents in Moorhead, Minnesota and Fargo, North Dakota, experiences nitrate spikes that are unsafe for human consumption (MPCA 2019). The freshwater supply will continue to diminish unless the public is demonstrably committed to water resource protection, creating sustainable human consumption of water resources (Araya and Moyer 2006; Eck et al. 2020). Thus, environmental communicators are tasked with engaging the public in a way that promotes water resource protection behaviors while also empowering the public to engage in policies that protect their water (Araya and Moyer 2006; Warner et al. 2020).

Research Implications

- Political affiliation and ideology accounted for a small amount of variance in the multiple linear regression models; thus, future studies should identify additional predictors to determine how respondents prepare to vote on a policy that impacts water.
- The mean public preparedness to vote on polices that impacts water can be improved as it indicated respondents neither agreed nor disagreed on the level to which they prepared to vote on a policy that impacts water.

Information-driven environmental campaigns that aim to promote sustainability are often unsuccessful in generating long-term public behavior changes (Kollmuss and Agyeman 2002; Steg and Vlek 2009; Cote and Wolfe 2018). The assumption behind information-only campaigns is that awareness of a problem will lead to positive behavioral change (Dickinson 2009; Cote and Wolfe 2018); however, this assumption is problematic as there are numerous factors that contribute to changes in behavior (Kahneman 2011). In order for environmental campaigns to promote pro-environmental behavior they must strategically target nuances in human behavior (Cote and Wolfe 2018). Mmojieje (2015) examined the effect of major principals from different theoretical models on public learning from environmental campaigns, finding that political climate, environmental knowledge, infrastructure, technology, habits, social norms, values, motivation, and self-efficacy influenced pro-environmental behavior change.

The political climate in the U.S. surrounding environmental protection has shifted since the 1980s, causing environmental issues to no longer be viewed as a non-partisan issue but rather as harmful to the free market and economic growth by the Republican party (Hejny 2018). Recently, political viewpoints on environmental issues have become increasingly polarized (Antonio and Brulle 2011; Hejny 2018). Political viewpoints may dictate how individuals vote on policies that protect water (e.g., Pew Research Center 2019b), regardless of the long-term impact on human health. In addition, the public may ignore issues related to the environment for policies they consider more pressing (e.g., Novacek 2008). Thus, it is important that the public is knowledgeable about policies that impact water so they make informed decisions when voting.

Literature Review

A need exists for greater public engagement with environmental issues so that policy decisions are more aligned with public interests (Parkins et al. 2017). For example, numerous studies have found that increasing public knowledge on the benefits of protecting freshwater ecosystems through educational activities increased public acceptance and policy support (Johnson and Pflugh 2008; Wagner 2008; Davenport et al. 2010; Mann et al. 2013). Davenport et al. (2010) investigated community support for a wetland restoration project in southern Illinois and found local engagement in project planning may benefit community commitment for the restoration project. Huang and Lamm (2015) explored Florida residents' water conservation behavior engagement and found civic engagement in water conservation behaviors was predicted by residents' experiences with water policies and issues.

Political affiliation and ideology have historically been strong indicators of environmental protection efforts (Owens and Lamm 2017), especially related to climate change (Bieniek-Tobasco et al. 2020). For the purpose of this study, political affiliation was defined as an individual's "political party identification" (Botzen et al. 2016, 354) and political ideology was defined as the principals, beliefs, and values that people use to view the world around them (Botzen et al. 2016). Recent studies examining political affiliation and/or political ideology in the U.S. explore water conservation behavior (e.g., Owens and Lamm 2017; Holland et al. 2019) or attitude (e.g., Callison and Holland 2017), indicating research that encompasses water conservation voting behavior in relation to political affiliation and ideology is needed.

The Democratic (31% of the public) and Republican (26% of the public) Parties are the two major political affiliations within the U.S. (Pew Research Center 2019a). Independent voters account for 38% of the U.S. public (Pew Research Center 2019c). Democratic Party members are generally concerned about environmental protection, and their political agenda contains environmental issues (Botzen et al. 2016). The Democratic Party has made substantial efforts to preserve and protect natural resources for future generations in the U.S. (Owens and Lamm 2017). Conversely, Republican Party members are generally not as concerned with environmental protection as the Democratic Party and think government spending for environmental issues is too high (McCright et al. 2014; Owens and Lamm 2017). Republican Party members believe the protection of natural resources harms the U.S. economy and threatens numerous jobs (Owens and Lamm 2017). In addition, water conservation behaviors are more likely to be adopted by Democrats than Republicans (Pew Research Center 2013).

Political ideology broadly divides the public into conservatives, moderates, and liberals. Individuals who identify as liberal are more likely to engage in pro-environmental behavior than individuals who identify as conservative (Callison and Holland 2017). Literature on environmental relationships with political affiliation and ideology indicates they should be examined separately (Cruz 2017). Historically, scholars hypothesized environmental concern may be a nonpartisan issue (see Dunlap 1975); however, early studies contradicted this hypothesis, with conflicting findings on how political affiliation predicts environmental concern (e.g., Dillman and Christenson 1972; Buttel and Flinn 1974; Dunlap 1975; Buttel and Johnson 1977; Mazmanian and Sabatier 1981). For example, Mazmanian and Sabatier (1981) found political affiliation explained minimal amounts of environmental behavior and policy preferences. Dunlap (1975) found Democrats were more concerned about the environment than Republicans. More recent studies have found a "widening gap" (p. 27) between Republicans and Democrats in regard to environmental concern (Dunlap and McCright 2008). Findings concerning political ideology, however, have remained consistent in the literature, with liberalism consistently positive and significant in relation to environmental concern (e.g., Constantini and Hanf 1972; Dillman and Christenson 1972; Buttel and Flinn 1978; Van Liere and Dunlap 1980).

Public policy surrounding water conservation is arguably one of the most essential strategies for targeting the preservation of water (Holland et al. 2019). Having a firm understanding of how the public interacts with issues surrounding water conservation will help educators and policy makers work with the public to benefit future water policy (Holland et al. 2019). Therefore, environmental communicators must determine if political affiliation and political ideology provide a basepoint for disseminating information about water conservation to the public to inform the development and use of effective communication practices.

Purpose and Objectives

The purpose of this study was to determine if political affiliation and political ideology predicted how respondents prepared to vote on a policy that impacts water. The study was guided by the following objectives:

1. Describe respondents' political affiliation, political ideology, and how they prepared to vote on a policy that impacts water; and
2. Determine if political affiliation and political ideology predicted how respondents prepared to vote on a policy that impacts water.

Methods

The study described here, which utilized a quantitative research design, was part of a larger research effort to investigate public perceptions of water resources and climate change. Three sections of the survey were germane to this study: respondents' political affiliation, political ideology, and how respondents prepared to vote on a policy that impacts water.

Survey Measures

The instrument contained demographic and Likert scale questions. Respondents' political affiliation was determined with one multiple-choice question (Owens and Lamm 2017). Respondents were asked to indicate the option that best described their political affiliation: *Republican, Democrat, Independent, Nonaffiliated,* and *Other.* A five-point Likert-type scale (1 = *Very Liberal*; 3 = *Moderate*; 5 = *Very Conservative*) was used to determine respondents' political ideology (Ferguson et al. 2020). Political affiliation and political ideology were self-identified by respondents. Political affiliation and political ideology were subsequently coded as dichotomous variables for inferential statistics. Specifically, if a respondent indicated they aligned with a particular affiliation or ideology they were coded with one and if a respondent indicated they did not align with a particular affiliation or ideology they were coded with zero.

Five questions adapted from Patterson (2012) were used to determine how respondents prepared to vote on a policy that impacts water. The questions asked respondents when preparing to vote on policy that impacts water, if they would: seek factual information from multiple sources, seek to fully understand the policy, consider both the positive and negative implications that could result, discuss their opinion with others, and ask others what their opinions are. The respondents indicated their level of agreement or disagreement using a five-point Likert-type scale (1 = *strongly disagree*; 2 = *disagree*; 3 = *neither agree nor disagree*; 4 = *agree*; 5 = *strongly agree*). The question assumed respondents answering the survey have the ability to vote. Reliability was calculated *post hoc* and found reliable ($\alpha = .90$). An overall scale for how respondents prepared to vote on a policy that impacts water was created by taking the mean score of the responses to the five items.

Experts in survey design, natural resource management, educational research, and water conservation reviewed the survey for face and construct validity and the research was approved by the University of Georgia Institutional Review Board (IRB #00001893). Fifty individuals, representative of the sample, pilot-tested the survey instrument for face validity.

Data Collection

The population of interest was U.S. residents 18 years of age or older. Respondents were recruited via Qualtrics using non-probability opt-in sampling (Baker et al. 2013) with a sample of 1,049 U.S. residents obtained. Using *a priori* quotas for gender, age, race/ethnicity, and geographic location based on the 2010 Census and *post hoc* weighting techniques, the sample was deemed representative of the population of interest (Lamm and Lamm 2019). Weighting techniques were also applied to reduce bias (Baker et al. 2013). Qualtrics compensated respondents according to their standard protocols.

Opt-in sampling techniques recruit groups of people via the internet to participate in studies and often include an incentive (Baker et al. 2013; Lamm and Lamm 2019). Communication research regularly accepts and uses non-probability opt-in sampling as a sampling method (Lamm and Lamm 2019). For example, Chaudhary et al. (2018) used non-probability opt-in sampling to collect data on high-level water users to understand their lack of interest in conserving water. However, one limitation of this study is that non-probability opt-in sampling may result in a biased sample because not all types of individuals have access to the internet and not all types of individuals will answer surveys (Lamm and Lamm 2019).

Demographics

The respondents were 50.0% male and 50.0% female (Table 1). The majority of respondents were White (72.4%) and had a total family income (before taxes) of less than $149,999 (85.4%). More than half of respondents had at least a two-year college degree (59.2%). Respondents' detailed demographics are in Table 1.

Data Analysis

Objective one was analyzed descriptively. Prior to analysis of objective two, multicollinearity diagnostics were conducted and interpreted following the work of Cohen (1998) to ensure issues of high collinearity did not impact regression coefficients. Objective two was analyzed inferentially with multiple regression. The dependent variable in the regression analysis was the overall scale for how respondents prepared to vote on a policy that impacts water. Independent variables in the regression analysis included demographics (e.g., age, family income, and education level), political affiliation, and political ideology. Family income and education level were coded as dichotomous for inferential statistics. Data were analyzed via SPSS 26 (Chicago, IL).

Results

Respondents' political affiliation was mainly distributed between Republicans (33.2%), Democrats (41.3%), and Independents (19.7%; Table 2). There were very few respondents who were non-affiliated (5.1%) or Other (0.8%). Respondents' political ideology was fairly distributed among those who self-identified as Moderate (36.6%), Liberal (19.6%), or Conservative (17.9%).

Respondents were asked to indicate how they prepared to vote on a policy that impacts water (Table 3). The majority of respondents agreed

Table 1. Demographics of respondents (N = 1,049).

		n	%
Sex:	Male	525	50.0
	Female	524	50.0
Age:	18-34 years	353	33.7
	35-54 years	349	33.3
	55+ years	347	33.1
Race*:	White	759	72.4
	Black	148	14.1
	Asian	102	9.7
	American Indian or Alaska Native	33	3.1
	Other	22	2.1
Ethnicity:	Hispanic	99	9.4
	Non-Hispanic	950	90.6
Education:	Less than 12th grade	22	2.1
	High school diploma	202	19.3
	Some college	204	19.4
	2-year college degree	109	10.4
	4-year college degree	272	25.9
	Graduate or Professional degree	240	22.9
Family Income:	Less than $24,999	185	17.6
	$25,000 - $49,999	240	22.9
	$50,000 - $74,999	215	20.5
	$75,000 - $149,999	256	24.4
	$150,000 - $249,999	101	9.6
	$250,000 or more	52	5.0

*Respondents were allowed to select more than one race.

Table 2. Respondents' self-reported political affiliation and ideology (*N* = 1,049).

		n	%
Political Affiliation:	Republican	348	33.2
	Democrat	433	41.3
	Independent	207	19.7
	Non-affiliated	53	5.1
	Other	8	0.8
Political Ideology:	Very Liberal	146	13.9
	Liberal	206	19.6
	Moderate	384	36.6
	Conservative	188	17.9
	Very Conservative	125	11.9

Table 3. Respondents' self-reported preparedness to vote on policy that protects water (*N* = 1,049).

	Strongly Disagree (%)	Disagree (%)	Neither Agree nor Disagree (%)	Agree (%)	Strongly Agree (%)
I would seek factual information from multiple sources	4.9	2.8	16.6	52.7	23.1
I would seek to fully understand the policy	4.0	3.1	17.6	47.4	27.8
I would consider both the positive and negative implications that could result	3.6	2.0	17.1	50.2	27.1
I would discuss my opinion with others	5.6	6.9	27.5	39.9	20.1
I would ask others what their opinions are	6.1	8.0	24.1	41.3	20.5

or strongly agreed they would consider both the positive and negative implications that could result (77.3%), seek factual information from multiple sources (75.8%), seek to fully understand the policy (75.2%), ask others what their opinions are (61.8%), and discuss their opinion with others (60%). A notable number of respondents neither agreed nor disagreed they would discuss their opinion with others (27.5%) and ask others what their opinions are (24.1%). Respondents' self-reported actions to become prepared to vote on a policy that impacts water, which was the average response to the five items, indicated they neither agreed nor disagreed they prepared to vote on a policy that impacts water ($M = 3.80$, $SD = 0.84$).

Prior to the multiple regression analysis, correlations were used to determine any issues of multicollinearity (Table 4). The Republican political affiliation had a strong, negative relationship with the Democrat political affiliation ($r = -0.591$).

In addition, Variance of Inflation Factor (VIF) and multicollinearity tolerance coefficient (MTC) were used to assess multicollinearity (Table 5).

Table 4. Relationships between political affiliation, political ideology, and preparedness to vote variables (N = 1,049).

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Preparedness to vote	-													
2. Age	0.00	-												
3. White	-0.01	0.366**	-											
4. American Indian or Alaska Native	0.071*	-0.127**	-0.231**	-										
5. Asian	-0.05	-0.155**	-0.502**	-0.06	-									
6. Black	0.00	-0.271**	-0.643**	-0.04	-0.124**	-								
7. Other	0.04	-0.072*	-0.222**	0.01	-0.05	-0.06	-							
8. Less than $24,999	-.151**	-0.02	-0.077*	0.103**	-0.05	0.085**	0.05	-						
9. $25,000 - $49,999	0.02	0.093**	0.02	0.02	-0.03	0.01	0.02	-0.252**	-					
10. $50,000 - $74,999	-0.03	0.00	-0.04	0.00	0.03	0.02	-0.01	-0.235**	-0.277**	-				
11. $75,000 - $149,999	0.00	0.00	0.02	-0.064*	0.068*	-0.071*	-0.01	-0.263**	-0.309**	-0.288**	-			
12. $150,000 - $249,999	0.142**	-0.06	0.064*	-0.04	-0.03	-0.03	-0.05	-0.151**	-0.178**	-0.166**	-0.185**	-		
13. $250,000 or more	0.085**	-.068*	0.04	-0.04	0.00	-0.03	-0.03	-0.106**	-0.124**	-0.116**	-0.130**	-0.075*	-	
14. Less than 12th grade	-0.03	-0.03	-0.01	-0.03	0.00	0.06	-0.02	0.05	0.03	0.03	-0.05	-0.05	-0.03	-
15. High school diploma	-0.184**	0.01	0.02	0.078*	-0.079*	0.01	0.00	0.256**	0.097**	0.01	-0.171**	-0.159**	-0.100**	-0.071*
16. Some college	-0.065*	-0.02	-0.073*	0.105**	-0.02	0.078*	0.03	0.082**	0.128**	0.01	-0.089**	-0.120**	-0.079*	-0.072*
17. 2-year college degree	0.01	0.078*	0.03	-0.01	-0.05	0.02	0.02	0.03	0.082**	0.06	-0.063*	-0.090**	-0.078*	-0.05
18. 4-year college degree	0.02	-0.01	-0.03	-0.069*	0.136**	-0.06	-0.01	-0.143**	-0.069*	0.05	0.160**	0.04	-0.075*	-0.087**
19. Graduate or Professional degree	0.216**	-0.03	0.073*	-0.085**	-0.02	-0.05	-0.02	-0.210**	-0.210**	-0.125**	0.140**	0.307**	0.315**	-0.080**
20. Republican	-0.02	0.154**	0.245**	-0.069*	-0.088**	-0.210**	0.01	-0.04	-0.090**	-0.02	0.071*	0.086**	0.04	-0.02
21. Democrat	0.107**	-0.086**	-0.183**	-0.03	0.05	0.205**	-0.03	-0.03	0.03	0.01	-0.04	0.01	0.05	0.01
22. Independent	-0.05	-0.02	-0.05	0.103**	0.02	-0.01	0.03	0.02	0.05	0.05	-0.01	-.081**	-0.080**	-0.01
23. Non-affiliated	-0.064*	-0.091**	-0.03	0.03	0.03	0.02	-0.03	0.110**	0.04	-0.063*	-0.03	-0.05	-0.03	0.03
24. Other	-0.096**	-0.01	0.01	-0.02	0.01	-0.04	0.064*	0.074*	-0.02	0.04	-0.05	-0.03	-0.02	-0.01
25. Very Liberal	0.145**	-.0087**	0.00	-0.01	-0.05	0.01	0.06	-0.04	0.00	0.00	0.00	0.01	0.06	0.02
26. Liberal	0.066*	-0.074*	-0.075*	0.02	0.02	0.06	-0.02	-0.02	0.01	-0.01	-0.03	0.066*	0.01	0.01
27. Moderate	-0.096**	-0.06	-0.114**	0.06	0.078*	0.084**	0.00	0.06	0.06	0.01	0.00	-0.127**	-0.05	0.01
28. Conservative	-0.068*	0.111**	0.105**	-0.04	-0.03	-0.104**	0.00	-0.02	-0.02	-0.02	0.04	0.02	0.01	-0.02
29. Very Conservative	-0.01	0.140**	0.135**	-0.05	-0.061*	-0.081**	-0.03	0.01	-.074*	0.03	0.00	0.079*	-0.02	-0.03

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 4 Continued. Relationships between political affiliation, political ideology, and preparedness to vote variables (N = 1,049).

Variables	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1.															
2.															
3.															
4.															
5.															
6.															
7.															
8.															
9.															
10.															
11.															
12.															
13.															
14.															
15.	-														
16.	-0.240**	-													
17.	-0.166**	-0.167**	-												
18.	-0.289**	-0.291**	-0.201**	-											
19.	-0.266**	-0.268**	-0.185**	-0.322**	-										
20.	0.06	-0.106**	-0.02	-0.03	0.098**	-									
21.	-0.085**	-0.04	0.064*	0.02	0.05	-0.591**	-								
22.	-0.02	0.132**	-0.04	0.05	-0.122**	-0.349**	-0.416**	-							
23.	0.097**	0.074*	-0.02	-0.06	-0.095**	-0.163**	-0.193**	-0.114**	-						
24.	0.04	0.01	-0.03	-0.03	0.00	-0.062*	-0.073*	-0.04	-0.02	-					
25.	-0.064*	-0.05	-0.01	0.00	0.109**	-0.125**	0.250**	-0.130**	-0.04	-0.04	-				
26.	-0.071*	0.02	-0.03	0.01	0.05	-0.206**	0.283**	-0.06	-0.081**	-0.02	-0.199**	-			
27.	0.101**	0.067*	-0.01	0.01	-0.159**	-0.199**	-0.094**	0.270**	0.150**	0.00	-0.306**	-0.376**	-		
28.	-0.01	0.02	-0.01	0.01	-0.01	0.267**	-0.205**	-0.06	-0.02	0.02	-0.188**	-0.231**	-0.355**	-	
29.	0.02	-0.099**	0.077*	-0.04	0.066*	0.366**	-0.231**	-0.123**	-0.06	0.04	-0.148**	-0.182**	-0.279**	-0.172**	-

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 5. Results of Variance of Inflation Factor (*VIF*) and Multicollinearity Tolerance Coefficient (*MTC*) used to determine multicollinearity (*N* = 1,049).

		Model 1		Model 2	
		MTC	*VIF*	*MTC*	*VIF*
Age		0.82	1.22	0.80	1.25
Race:	American Indian or Alaska Native	0.93	1.08	0.93	1.08
	Asian	0.90	1.11	0.89	1.12
	Black	0.82	1.22	0.81	1.23
	Other	0.97	1.04	0.96	1.04
Family Income:	Less than $24,999	0.92	1.09	0.92	1.09
	$25,000 - $49,999	0.60	1.68	0.59	1.69
	$50,000 - $74,999	0.64	1.56	0.64	1.56
	$150,000 - $249,999	0.75	1.34	0.74	1.35
	$250,000 or more	0.59	1.69	0.59	1.70
Education Level:	Less than 12th grade	0.57	1.76	0.57	1.77
	High school diploma	0.57	1.75	0.57	1.75
	Some college	0.63	1.58	0.63	1.58
	2-year college degree	0.75	1.34	0.74	1.35
	Graduate or Professional degree	0.81	1.24	0.81	1.24
Political Affiliation:	Democrat political affiliation	0.69	1.45	0.53	1.90
	Independent political affiliation	0.73	1.38	0.63	1.59
	No political affiliation	0.86	1.16	0.82	1.22
	Other political affiliation	0.97	1.04	0.97	1.04
Political Ideology:	Very liberal political ideology			0.74	1.35
	Liberal political ideology			0.73	1.38
	Conservative political ideology			0.72	1.39
	Very conservative political ideology			0.69	1.45

Based on the results of the multicollinearity diagnostics, the regression models should not be impacted by the rate of multicollinearity.

A multiple linear regression model was used to determine if political affiliation predicted how respondents prepared to vote on a policy that impacts water (see Table 6, Model 1). The model was statistically significant ($F = 6.96$, $p < 0.001$) and predicted 11.4% of variance. Within the model, respondents who identified as American Indian or Alaska Native predicted an increased engagement in preparing to vote on a policy that impacts water as compared to respondents who identified as White. A family income of $25,000 - $49,999 and a family income of $150,000 - $249,999 predicted an increased engagement in preparing to vote on a policy that impacts water as compared to a family income of $75,000 - $149,999. A high school diploma predicted a decreased engagement in preparing to vote on a policy that impacts water as compared to a 4-year college degree. A graduate or professional degree predicted an increased engagement in preparing to vote on a policy that impacts water as compared to a 4-year college degree. The Democratic political affiliation predicted an increased engagement in preparing to vote on a policy that impacts water as compared to Republicans. The Other political affiliation predicted a decreased engagement in preparing to vote on a policy that impacts water as compared to Republicans.

Political ideology was included as a predictor in the second model (see Table 6, Model 2). The second model was statistically significant ($F = 6.41$, $p < 0.001$) and predicted 12.6% of variance. There was a significant change in R^2 from Model 1 to Model 2, indicating the second model was more effective at predicting how respondents prepared to vote on a policy that impacts water. In the second model, respondents who identified as American Indian or Alaska Native predicted an increased engagement in preparing to vote on a policy that impacts water as compared to respondents who identified as White. A family income of $25,000 - $49,999 and a family income of $150,000 - $249,999 predicted an increased engagement in preparing to vote on a policy that impacts water as compared to a family income of $75,000 - $149,999. A high school diploma predicted a decreased engagement in preparing to vote on a policy that impacts water as compared to a 4-year college degree. A graduate or professional degree predicted an increased engagement in preparing to vote on a policy that impacts water as compared to a 4-year college degree. Other political affiliation predicted a decreased engagement in preparing to vote on a policy that impacts water as compared to Republicans; the Democratic political affiliation was no longer a significant predictor. Instead, very liberal political ideology predicted an increased engagement in preparing to vote on a policy that impacts water as compared to moderates ($p < 0.05$).

Discussion and Conclusion

Arguably one of the most essential strategies for targeting the preservation of water is through public policy surrounding water conservation (Holland et al. 2019). Thus, providing water resource protection information and engagement opportunities that effectively engage the public in water issues and policy is imperative. This study examined if political affiliation and political ideology predicted how respondents prepared to vote on a policy that impacts water so that communication messages can be tailored to specific audiences.

The final regression model that examined if demographic characteristics, political affiliation, and political ideology predicted how respondents prepared to vote on a policy impacting water explained greater variance than the first model. Among additional demographic characteristics, the findings indicated that very liberal political beliefs and *Other* political affiliation predicted how respondents prepared to vote on a policy that impacts water. It is possible that liberalism is consistently positive and significant in relation to environmental concern (e.g., Constantini and Hanf 1972; Dillman and Christenson 1972; Buttel and Flinn 1978; Van Liere and Dunlap 1980; Cruz 2017) because very liberal individuals prepare to vote on policies that impact natural resources. While the findings indicated *Other* political affiliation predicted how respondents prepared to vote on a policy that impacts water, the small number of respondents indicating *Other* ($n = 8$) should be considered a limitation in interpreting this specific finding.

Table 6. Predicting how respondents prepared to vote on a policy that protects water using political affiliation and political ideology (N = 1,049).

		Model 1	Model 2
R^2:		0.114***	0.126***
ΔR^2:			0.012**
Age:		0.001	0.002
Race[a]:	American Indian or Alaska Native	0.530***	0.527***
	Asian	-0.149	-0.123
	Black	0.031	0.049
	Other	0.296	0.269
Family Income[b]:	Less than $24,999	-0.089	-0.096
	$25,000 - $49,999	0.168*	0.155*
	$50,000 - $74,999	0.049	0.038
	$150,000 - $249,999	0.239*	0.239*
	$250,000 or more	0.145	0.142
Education Level[c]:	Less than 12th grade	-0.194	-0.205
	High school diploma	-0.331***	-0.317***
	Some college	-0.160*	-0.151
	2-year college degree	-0.035	-0.022
	Graduate or Professional degree	0.258***	0.236**
Political Affiliation[d]:	Democrat political affiliation	0.127*	0.042
	Independent political affiliation	-0.020	-0.033
	No political affiliation	-0.040	-0.051
	Other political affiliation	-0.759**	-0.743**
Political Ideology[e]:	Very liberal political ideology		0.259**
	Liberal political ideology		0.106
	Conservative political ideology		-0.066
	Very conservative political ideology		0.003

Note: *p < 0.05; **p < 0.01; ***p < 0.001; [a]White was left out of the model as a comparison variable; [b]$75,000 - $149,999 was left out of the model as a comparison variable; [c]4-year college degree was left out of the model as a comparison variable; [d]Republican was left out of the model as the comparison variable; [e]Moderate was left out of the model as the comparison variable.

There were several limitations of the study that should be acknowledged prior to interpretation, including the measurement of political affiliation and political ideology. Respondents' political affiliation and political ideology were self-reported and therefore may vary by personal interpretation. In addition, the data for the study were collected during a politically contentious time period in the U.S. (Santucci and King 2020), which may have shifted respondents' political affiliation and political ideology in the short-term to align with their opinion of the events. The 2020 Presidential Election caused a partisan divide in the U.S. public, with the Republican incumbent having the largest partisan gap in approval rating known from polling data (Pew Research Center 2021). Moreover, the study used self-reported preparedness to vote rather than actual preparedness to vote, which may alter the study's results. Future studies should determine if political affiliation and political ideology predict actual voting behavior on issues surrounding water policy.

Despite these limitations, the findings have implications for environmental communication. First, the mean self-reported preparedness to vote on policy that impacts water indicated that respondents neither agreed nor disagreed on the level to which they would take specific actions to become prepared to vote on a policy that impacts water ($M = 3.80$, $SD = 0.84$). Thus, communicators need to better engage the public with environmental issues so the public is prepared when voting on policy impacting water resources (Johnson and Pflugh 2008; Wagner 2008; Davenport et al. 2010; Mann et al. 2013). Future research should conduct focus groups to determine the best way to prepare respondents to vote on policies that impact water. For example, to what extent were resources available that clearly and concisely explained water policies. Conducting separate focus groups with liberals, moderates, and conservatives may help determine how each group understands water resource protection engagement (Gibbs 1997), and may allow researchers to determine the best way to engage individuals whose beliefs do not always align with aspects of environmental protection.

Marketing materials such as emails or billboards that focus on water resource protection issues and policies may help enhance public understanding and awareness of the importance of preparing to vote on a policy that impacts water (Huang and Lamm 2015). Additional emphasis should be placed on shared values rather than only citing data or scientists to avoid ignored messages due to potential mistrust in science (Callison and Holland 2017). Perhaps community centers should conduct programs that discuss potential water policies without political jargon to help community members filter through complex information. Two-way communication channels may help engage individuals with new information rather than information that only confirms their existing viewpoints. Similar programs can be conducted on college campuses where students also have the opportunity to register to vote.

A notable number of respondents neither agreed nor disagreed they would discuss their opinion with others (27.5%) and ask others what their opinions are (24.1%) when taking actions to become prepared to vote on a policy that impacts water, indicating respondents may not be aware of social norms surrounding voting behavior. Social norms, which vary between cultures, influence individuals to behave in a manner that is consistent with societal expectations (Minato et al. 2010). Increasing respondents' engagement with social norms surrounding water policies may encourage increased preparation when the public votes on water policies. For example, community leaders should encourage discussion surrounding water policy at local events. Local volunteers who are trained to discuss multiple facets of water policy may help initiate conversations, which may make social norms in a community more apparent to others.

The final regression model that included both political affiliation and political ideology only predicted 12.6% of variance (see Table 6, Model 2); thus, political affiliation and ideology may not be the most effective way to segment audiences for targeted communication messages about preparing to vote on water policy. Future studies should identify additional predictors to determine how respondents prepare to vote on a policy that impacts water. For example, a cluster analysis that groups respondents into subgroups based on their water resource protection engagement may help identify important audience characteristics for developing communication messages (e.g., Warner et al. 2016). In addition, respondents may not directly vote on water policy depending on the state where they reside. Thus, communication messages about preparing to vote on water policy may benefit residents in specific states more than others. Future studies should group respondents based on geographic area to determine if locations that are water scarce (e.g., California), water locked (e.g., Florida), or otherwise impacted by water quality (e.g., the Red River in North Dakota) are more prepared to vote on a policy that impacts water when compared to all other geographic areas due to their experiences with water.

The small amount of variance accounted for in the final regression model may be attributed to the survey items used for this study as they were not contentious. For example, respondents were asked to indicate if they would seek factual information from multiple sources when preparing to vote on a policy that impacts water. What a Republican considers a factual source may be different than what a Democrat considers a factual source (Pew Research Center 2018). Moreover, survey items asked respondents how they prepared to vote rather than how they voted on policy that protects water resources, which do not always correlate with one another. Respondents may arrive at what they consider a sound solution but not have the capability to critically evaluate the sources they use to inform their political stance. Future studies should determine if respondents voting behavior on a policy that impacts water is influenced by the political party bringing forth the legislation or if the policy itself is the main factor for respondents' support.

Tailoring messages and experiences for specific audiences about water resource protection may assist in securing high-quality water resources for future generations. However, audiences grouped based on demographics, political affiliation, and political ideology are unlikely to engage in water resource policy much differently, indicating messaging strategies that investigate public characteristics beyond demographics, such as shared values, need to be explored. Nevertheless, this study provides a starting point for environmental communicators seeking to engage the public in policy surrounding water conservation.

Acknowledgements

This work was supported by the USDA National Institute of Food and Agriculture, Hatch project 1021735. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the National Institute of Food and Agriculture or the United States Department of Agriculture. The authors have no conflicts of interest to declare.

Author Bio and Contact Information

Kristin E. Gibson (corresponding author) is a doctoral student in the Department of Agricultural Leadership, Education and Communication at the University of Georgia. She may be contacted via email at kristin.gibson@uga.edu or by mail at University of Georgia, 405 College Station Road, Athens, GA 30602.

Alexa J. Lamm, Ph.D., is an associate professor in the Department of Agricultural Leadership, Education and Communication at the University of Georgia. She may be contacted via email at alamm@uga.edu or by mail at University of Georgia, 405 College Station Road, Athens, GA 30602.

Kyle M. Woosnam, Ph.D., is an associate professor in the Warnell School of Forestry and Natural Resources at the University of Georgia. He may be contacted via email at woosnam@uga.edu or by mail at University of Georgia, 1809 East Green Street, Athens, GA 30602.

D. Barry Croom, Ph.D., is a professor in the Department of Agricultural Leadership, Education and Communication at the University of Georgia. He may be contacted via email at dbcroom@uga.edu or by mail at University of Georgia, 2360 Rainwater Road, Tifton, GA 31793.

References

Antonio, R.J. and R.J. Brulle. 2011. The unbearable lightness of politics: Climate change denial and political polarization. *The Sociological Quarterly* 52(2): 195-202. Available at: https://doi.org/10.1111/j.1533-8525.2011.01199.x. Accessed August 13, 2021.

Araya, Y.N. and E.H. Moyer. 2006. Global public water education: The world water monitoring day experience. *Applied Environmental Education & Communication* 5(4): 263-267. Available at: https://doi.org/10.1080/15330150601059522. Accessed August 13, 2021.

Baker, R., J.M. Brick, N.A. Bates, M. Battaglia, M.P.

Couper, J.A. Dever, K.J. Gile, and R. Tourangeau. 2013. Summary report of the AAPOR task force on non-probability sampling. *Journal of Survey Statistics and Methodology* 1(2): 90-143. Available at: https://doi.org/10.1093/jssam/smt008. Accessed August 13, 2021.

Bieniek-Tobasco, A., R.N. Rimal, S. McCormick, and C.B. Harrington. 2020. The power of being transported: Efficacy beliefs, risk perceptions, and political affiliation in the context of climate change. *Science Communication* 42(6): 776-802. Available at: https://doi.org/10.1177/1075547020951794.

Botzen, W.J.W., E. Michel-Kerjan, H. Kunreuther, H. De Model, and J.C.J.H. Aerts. 2016. Political affiliation affects adaptation to climate risks: Evidence from New York City. *Climatic Change* 138: 353-360. Available at: https://doi.org/10.1007/s10584-016-1735-9. Accessed August 13, 2021.

Buttel, F.H. and W.L. Flinn. 1974. The structure of support for the environmental movement, 1968-1970. *Rural Society* 39(1): 56-69. Available at: https://www.proquest.com/docview/1290974288?pq-origsite=gscholar&fromopenview=true. Accessed August 13, 2021,

Buttel, F.H. and W.L. Flinn. 1978. The politics of environmental concern: The impacts of party identification and political ideology on environmental attitudes. *Environment and Behavior* 10(1): 17-36. Available at: https://doi.org/10.1177/0013916578101002. Accessed August 13, 2021.

Buttel, F.H. and D.E. Johnson. 1977. Dimensions of environmental concern: Factor structure, correlates, and implications for research. *Journal of Environmental Education* 9(2): 49-64. Available at: https://doi.org/10.1080/00958964.1977.10801872. Accessed August 13, 2021.

Callison, C. and D. Holland. 2017. Impact of political identity and past crisis experience on water attitudes. *Journal of Contemporary Water Research & Education* 161: 19-32. Available at: https://doi.org/10.1111/j.1936-704X.2017.3249.x. Accessed August 13, 2021.

Chaudhary, A.K., A.J. Lamm, and L. Warner. 2018. Using cognitive dissonance to theoretically explain water conservation intentions. *Journal of Agricultural Education* 59(4):194-210. Available at: https://doi.org/10.5032/jae.2018.04194. Accessed August 13, 2021.

Cohen, J. 1988. Set correlation and contingency tables. *Applied Psychological Measurement* 12(4): 425-434. Available at: https://doi.org/10.1177/014662168801200410. Accessed August 13, 2021.

Constantini, E. and K. Hanf. 1972. Environmental concern and Lake Tahoe: A study of elite perceptions, backgrounds, and attitudes. *Environment and Behavior* 4(2): 209-242. Available at: https://doi.org/10.1177/001391657200400204. Accessed August 13, 2021.

Cote, S. and S.E. Wolfe. 2018. Evidence of mortality salience and psychological defenses in bottled water campaigns. *Applied Environmental Education & Communication* 17(4): 281-298. Available at: https://doi.org/10.1080/1533015X.2017.1399836. Accessed August 13, 2021.

Cruz, S.M. 2017. The relationships of political ideology and party affiliation with environmental concern: A meta-analysis. *Journal of Environmental Psychology* 53: 81-91. Available at: https://doi.org/10.1016/j.jenvp.2017.06.010. Accessed August 13, 2021.

Davenport, M.A., C.A. Bridges, J.C. Mangun, A.D. Carver, K.W.J. Williard, and E.O. Jones. 2010. Building local community commitment to wetlands restoration: A case study of the Cache River Wetlands in southern Illinois, USA. *Environmental Management* 45: 711-722. Available at: https://doi.org/10.1007/s00267-010-9446-x. Accessed August 13, 2021.

Dickinson, J.L. 2009. The people paradox: Self-esteem striving, immortality ideologies, and human response to climate change. *Ecology and Society* 14(1): 34. Available at: http://www.ecologyandsociety.org/vol14/iss1/art34/. Accessed August 13, 2021.

Dillman, D.A. and J.A. Christenson. 1972. The public value for pollution control. In: *Social Behavior, Natural Resources, and the Environment*, W.R. Burch, N.H. Cheek, L. Taylor (Eds.). Harper & Row, New York, pp. 237-256.

Dunlap, R.E. 1975. The impact of political orientation on environmental attitudes and actions. *Environment and Behavior* 7(4): 3-18. Available at: https://doi.org/10.1177%2F001391657500700402. Accessed August 13, 2021.

Dunlap, R.E. and A.M. McCright. 2008. A widening gap: Republican and Democratic views on climate change. *Environment: Science and Policy for Sustainable Development* 50(5): 26-35. Available at: https://doi.org/10.3200/ENVT.50.5.26-35. Accessed August 13, 2021.

Eck, C.J., K.L. Wagner, B. Chapagain, and O. Joshi. (2020). A survey of perceptions and attitudes about water issues in Oklahoma: A comparative study. *Journal of Contemporary Water Research & Education* 168: 66-77. Available at: https://doi.org/10.1111/j.1936-704X.2019.03321.x. Accessed August 13, 2021.

Ferguson, M.D., M.L. Lynch, Z.D. Miller, L.A. Ferguson, and P. Newman. 2020. What do outdoor recreationists think of fracking? Politics, ideology, and perceptions of shale gas energy development in Pennsylvania State Forests. *Energy Research & Social Science* 62: 101384. Available at: https://doi.org/10.1016/j.erss.2019.101384. Accessed August 13, 2021.

Gibbs, A. 1997. Focus Groups. *Social Research Update* 19. Available at: https://sru.soc.surrey.ac.uk/SRU19.html. Accessed August 13, 2021.

Hejny, J. 2018. The Trump administration and environmental policy: Reagan redux? *Journal of Environmental Studies and Sciences* 8: 197-211. Available at: https://doi.org/10.1007/s13412-018-0470-0. Accessed August 13, 2021.

Holland, D., K. Janét, and A. Landrum. 2019. Experience is key: Examining the relative importance of factors influencing individuals' water conservation. *Water* 11(9): 1870. Available at: http://dx.doi.org/10.3390/w11091870. Accessed August 13, 2021.

Huang, P-W. and A.J. Lamm. 2015. Understanding public engagement in water conservation behaviors and knowledge of water policy: Promising hints for extension. *Journal of Extension* 53(6). Available at: https://www.joe.org/joe/2015december/pdf/JOE_v53_6rb1.pdf. Accessed August 13, 2021.

Johnson, B.B. and K.K. Pflugh. 2008. Local officials' and citizens' views on freshwater wetlands. *Society & Natural Resources* 21(5): 387-403. Available at: https://doi.org/10.1080/08941920801967468. Accessed August 13, 2021.

Kahneman, D. 2011. *Thinking, Fast and Slow*. Random House of Canada, Toronto.

Kollmuss, A. and J. Agyeman. 2002. Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research* 8(3): 239-260. Available at: https://doi.org/10.1080/13504620220145401. Accessed August 13, 2021.

Lamm, A.J. and K.W. Lamm. 2019. Using non-probability sampling methods in agricultural and extension education research. *Journal of International Agricultural and Extension Education* 26(1): 52-59. Available at: https://www.aiaee.org/index.php/vol-26-1-april-19/1742-using-non-probability-sampling-methods-in-agricultural-and-extension-education-research.

Mann, K.B., K.A. Berry, S. Bassett, and S. Chandra. 2013. Voting on floodplain conservation: The role of public values and interactions along the Carson River, Nevada. *Society & Natural Resources* 26(5): 568-585. Available at: https://doi.org/10.1080/08941920.2012.713449. Accessed August 13, 2021.

Mazmanian, D. and P. Sabatier. 1981. Liberalism, environmentalism, and partisanship in public policy-making: The California coastal commissions. *Environment and Behavior* 13(3): 361-384. Available at: https://doi.org/10.1177/0013916581133007. Accessed August 13, 2021.

McCright, A.M., C. Xiao, and R.E. Dunlap. 2014. Political polarization on support for government spending on environmental protection in the USA, 1974–2012. *Social Science Research* 48: 251-260. Available at: https://doi.org/10.1016/j.ssresearch.2014.06.008. Accessed August 13, 2021.

Minato, W., A. Curtis, and C. Allan. 2010. Social norms and natural resource management in a changing rural community. *Journal of Environmental Policy & Planning* 12(4): 381-403. Available at: https://doi.org/10.1080/1523908X.2010.531084. Accessed August 13, 2021.

Minnesota Pollution Control Agency (MPCA). 2019. The Red River of the North: Evaluating its Health. Available at: https://www.pca.state.mn.us/water/red-river-north-evaluating-its-health. Accessed August 13, 2021.

Mmojieje, J. 2015. Strategies for public engagement on environmental matters: You can lead a horse to water, but can you make it drink? *Applied Environmental Education & Communication* 14(4): 232-245. Available at: https://doi.org/10.1080/1533015X.2015.1109485. Accessed August 13, 2021.

National Drought Mitigation Center (NDMC). 2021. U.S. Drought Monitor. Available at: https://droughtmonitor.unl.edu. Accessed August 13, 2021.

Novacek, M.J. 2008. Engaging the public in biodiversity issues. *Proceedings of the National Academy of Sciences* 105(1): 11571-11578. Available at: https://doi.org/10.1073/pnas.0802599105. Accessed August 13, 2021.

Owens, C. and A.J. Lamm. 2017. The politics of extension water programming: Determining if affiliation impacts participation. *Journal of Agricultural Education* 58(1): 54-68. Available at: https://doi.org/10.5032/jae.2017.01054. Accessed August 13, 2021.

Parkins, J.R., T. Beckley, L. Comeau, R.C. Stedman, C.L. Rollins, and A. Kessler. 2017. Can distrust enhance public engagement? Insights from a national survey on energy issues in Canada. *Society & Natural Resources* 30(8): 934-948. Available at: https://doi.org/10.1080/08941920.2017.1283076. Accessed August 13, 2021.

Patterson, L. 2012. 2012 RBC Canadian Water Attitudes Study. Available at: http://www.rbc.com/community-sustainability/_assets-custom/pdf/CWAS-2012-report.pdf. Accessed August 13, 2021.

Pew Research Center. 2013. Many More Democrats than Republicans Say Protecting Environment a Top Priority. Available at: http://www.pewresearch.org/daily-number/many-more-democrats-than-republicans-say-protecting-environment-a-top-priority/. Accessed August 13, 2021.

Pew Research Center. 2018. Distinguishing between Factual and Opinion Statements in the News. Available at: https://www.journalism.org/2018/06/18/republicans-and-democrats-more-likely-to-classify-a-news-statement-as-factual-if-it-favors-their-side-whether-it-is-factual-or-opinion/. Accessed August 13, 2021.

Pew Research Center. 2019a. State of the Union 2019: How Americans See Major National Issues. Available at: https://www.pewresearch.org/fact-tank/2019/02/04/state-of-the-union-2019-how-americans-see-major-national-issues/. Accessed August 13, 2021.

Pew Research Center. 2019b. U.S. Public Views on Climate and Energy. Available at: https://www.pewresearch.org/science/2019/11/25/u-s-public-views-on-climate-and-energy/. Accessed August 13, 2021.

Pew Research Center. 2019c. Political Independents: Who They Are, What They Think. Available at: https://www.people-press.org/2019/03/14/political-independents-who-they-are-what-they-think/. Accessed August 13, 2021.

Pew Research Center. 2021. How America Changed during Donald Trump's Presidency. Available at: https://www.pewresearch.org/2021/01/29/how-america-changed-during-donald-trumps-presidency/. Accessed August 13, 2021.

Pimentel, D., B. Berger, D. Filiberto, M. Newton, B. Wolfe, E. Karabinakis, S. Clark, E. Poon, E. Abbett, and S. Nandagopal. 2004. Water resources: Agricultural and environmental issues. *BioScience* 54(10): 909-918. Available at: https://doi.org/10.1641/0006-3568(2004)054[0909:WRAAEI]2.0.CO;2. Accessed August 13, 2021.

Sankarasubramanian, A., J.L. Sabo, K.L. Larson, S.B. Seo, T. Sinha, R. Bhowmik, A.R. Vidal, K. Kunkel, G. Mahinthakumar, E.Z. Berglund, and J. Kominoski. 2017. Synthesis of public water supply use in the United States: Spatio-temporal patterns and socio-economic controls. *Earth's Future* 5(7): 771-788. Available at: https://doi.org/10.1002/2016EF000511. Accessed August 13, 2021.

Santucci, J. and L. King. 2020. Election Results Updates: Joe Biden, Kamala Harris Speak to Nation after Election Win. USA Today. Available at: https://www.usatoday.com/story/news/politics/elections/2020/11/07/election-results-biden-trump-pennsylvania-georgia-nevada/6196451002/. Accessed August 13, 2021.

Steg, L. and C. Vlek. 2009. Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology* 29(3): 309-317. Available at: https://doi.org/10.1016/j.jenvp.2008.10.004. Accessed August 13, 2021.

Van Liere, K.D. and R.E. Dunlap. 1980. The social bases of environmental concern: A review of hypotheses, explanations and empirical evidence. *Public Opinion Quarterly* 44(2): 181-197. Available at: https://www.researchgate.net/deref/http%3A%2F%2Fwww.jstor.org%2Fstable%2F2748427%3Forigin%3DJSTOR-pdf. Accessed August 13, 2021.

Wagner, M.M. 2008. Acceptance by knowing? The social context of urban riparian buffers as a stormwater best management practice. *Society & Natural Resources* 21(10): 908-920. Available at: https://doi.org/10.1080/08941920802183339. Accessed August 13, 2021.

Warner, L.A., A.J. Lamm, J.N. Rumble, E. Martin, and R. Cantrell. 2016. Classifying residents who use landscape irrigation: Implications for encouraging water conservation behavior. *Environmental Management* 58(2): 238–253. Available at: https://doi.org/10.1007/s00267-016-0706-2. Accessed August 13, 2021.

Warner, L.A., J.M. Diaz, and C. Gusto. 2020. Exploring blue space as a tool for promoting good fertilizer practices among Florida residential fertilizer users. *Applied Environmental Education & Communication* 19(3): 274-286. Available at: https://doi.org/10.1080/1533015X.2019.1586597. Accessed August 13, 2021.

Universities Council on Water Resources
Journal of Contemporary Water Research & Education
Issue 173, Pages 29-41, September 2021

Potential Health Hazards of Roadside Springs: Results from Central New York

*Christopher W. Sinton, Matthew Olivieri, Tara Perry, Katherine Stoddard, and Ryan Kresge

Department of Environmental Studies and Sciences, Ithaca College, Ithaca, NY
**Corresponding Author*

Abstract: Across the United States, groundwater springs adjacent to roadways have been developed as unregulated drinking water sources. We attempted to address two basic questions: 1) why do people collect water at these springs; and 2) is the water safe to drink? We conducted a study during 2015-2019 of seven springs in central New York State that included a survey of 199 users and analysis of the water for common dissolved constituents and bacteria. The survey of water users showed that over 70% of respondents use the springs at least multiple times per month for drinking water and the majority collect more than five gallons per visit. More than 80% of the users live farther than three miles from the springs and a recurring reason for drinking the spring water is that the taste is better than the water available at their homes. However, all the springs at some point tested positive for total coliform bacteria and all but one tested positive at least once for fecal coliform bacteria, meaning that 86% of the springs at some point did not meet U.S. municipal drinking water standards. None of the measured dissolved constituents exceeded drinking water standards, but one spring that exhibited elevated nitrate is downslope from a small cattle operation which may be affecting nutrient values in the water. Most of these springs appear to be fed by shallow, unconfined aquifers that are susceptible to contamination from nearby land uses that are not readily apparent from the roadside collection locations.

Keywords: *springs, drinking water, water quality, pathogens, environmental health*

Access to safe, clean water is a global requirement for healthy and sustainable societies. In the United States, advancements in providing sanitary municipal water are a major reason for the overall improvement in human health and a reduction of water-borne diseases in the past century (Cutler and Miller 2005). Much of this progress can be attributed to the passage of the Safe Drinking Water Act (SDWA) of 1974. This law, and its amendments in 1986 and 1996, created enforceable standards for municipal drinking water to reduce contaminants posing risks to human health, and requires the protection of drinking water sources. As a result, the majority of U.S. citizens have access to clean municipal water, although these regulations do not pertain to the approximately 40 million people that rely on private wells (Johnson et al. 2019).

Despite this progress, a recent survey of U.S. residents on perceptions of tap water showed that slightly more than 50% were not totally confident that their municipal water supply or their private well water is safe (Water Quality Association 2019). This lack of trust can lead some consumers

Research Implications

- Roadside springs pose potential health risks to users.
- Roadside springs can be fed by shallow, unconfined aquifers that are susceptible to contamination.
- The presence of total and fecal coliform bacteria in a single spring can vary over time so multiple analyses are needed to fully assess contamination.
- Users of roadside springs appear to be influenced mainly by organoleptic and aesthetic properties such as taste compared to their available tap water at home.

to buy bottled water (Hu et al. 2011). In the U.S., 78% of residents regularly consume bottled water (Water Quality Association 2019). An alternative to tap or bottled water is unregulated roadside or community springs. These can be broadly defined as "improved" springs located near a public roadway where the water flow has been channeled into a pipe, allowing easy water collection. Roadside springs are not monitored or regulated by state or governmental institutions although some have use-at-your-own risk warning signs that are placed by local governments or landowners. As a result, water from the springs has the potential to contain dissolved constituents or host micro-organisms that can pose threats to human health. Our understanding of roadside spring use and water quality is not well documented and only recently have there been any published studies (Swistock et al. 2015; Westhues 2017; Krometis et al. 2019; Patton et al. 2020). There has been at least one parasitic outbreak linked to a spring in upstate New York (Bedard et al. 2016). These studies indicate that roadside springs can pose potential threats to human health yet are the preferred source of water for some people.

In central New York State, as in many other rural regions of the United States, roadside springs are used as drinking water sources. Some of these springs seem quite popular based on the authors' seeing people filling multiple large containers and reviewing findaspring.com, a wiki website that collects the locations of roadside springs globally. In this study, we attempted to answer several overarching questions about these roadside springs:

- What is in the water?
- Does drinking the water pose a hazard to human health?
- What are the reasons people have for collecting water at these sites?

Site Descriptions

The project began with observations of people gathering water at two springs close to the authors' institution. Field measurements and sampling of these two springs began in 2014 and, in 2017, five more springs were located either by word of mouth or from findaspring.com. The sites (Figure 1) are described as follows.

Lisle Spring

The Lisle spring (Broome County) consists of a bifurcated PVC pipe that is embedded into a wooded hillslope of glacial till on the south side of the Dudley Creek Valley. A large pull-off allows easy vehicle access from NY 79. Satellite imagery shows that about 500 meters to the south and upslope, the topography flattens and there are several houses, a sawmill, and a small cattle operation with agricultural fields and a manure lagoon. The imagery history (Google Earth) shows that the manure lagoon was installed between 2015 and 2017.

DiRisio Spring

The DiRisio spring (the name comes from findaspring.com) is located on NY 38 about 200 meters south of Port Byron (Cayuga County). At the site, a black PVC pipe is embedded into the west side of a hill that appears to be glacial till of the Mapleton Formation (Kozlowski et al. 2018) and is possibly the eroded flank of a drumlin. Satellite imagery shows the area upslope is mostly forested with some agricultural fields 300-400 meters to the east. A sign from the Cayuga County Health Department warns that the spring is not regulated and "the water may not be safe to drink."

Reservation Spring

This is one of two springs we studied in the Tully Valley of Onondaga County. The spring is on Onondaga Nation land on Gibson Road west of Onondaga Creek. Water flows from an iron pipe protruding from a small hill that appears to be composed of stratified glacial sediment (Pair 2016) on the northern side of the road. Upslope to the north is forest cover and to the west there are several houses and agricultural fields. About 1 kilometer west is a steep escarpment of the Tully Valley with a "losing" stream that is likely the recharge source of the unconfined aquifer that feeds this spring (W. Kappel, pers. comm. 2021).

Nichols Road Spring

The Nichols spring is located near the western end of Nichols Road (Onondaga County) in the Tully Valley. The spring is a black plastic pipe installed in an excavation into a small hill of

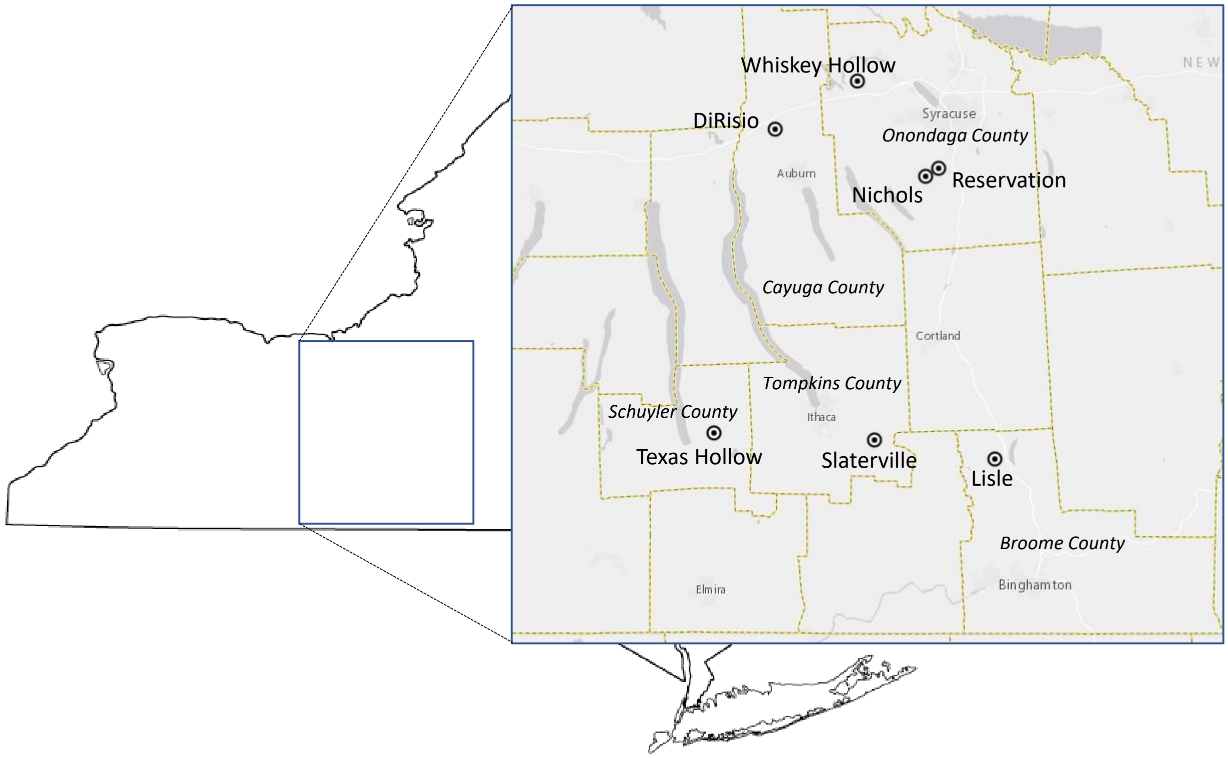


Figure 1. Map of central New York State showing the locations of the seven roadside springs in this study.

glacial sand and gravel that is partly cemented. The satellite imagery shows the area upgradient to the south is mostly forested with agricultural fields about 300 meters from the spring.

Whiskey Hollow Spring

This spring is in the forested Whiskey Hollow Nature Preserve (Onondaga County) and is part of the Central New York Land Trust. An east-west road follows the hollow, which has steep hillslopes on the northern and southern sides. A single PVC pipe is embedded into an outcrop of carbonate-cemented glacial gravel on the northern slope. These cemented gravels (Aber 1979) are the low permeability layer that creates this spring (W. Kappel, pers. comm. 2021). Satellite imagery shows the area uphill to the north is forested, but there are several tilled agricultural fields 400-500 meters upslope where the topography flattens.

Texas Hollow Spring

This spring is located on Texas Hollow Road (Schuyler County) and consists of two PVC pipes (separated by ~10 meters) placed on the west side of the road into a hill. The hill appears to be made of glacial sediments. Water seeps from the hill and flows across the soil surface before being channeled into the pipes. Satellite imagery shows the area uphill is forested, but there are agricultural fields within 500 meters upslope to the west where the topography flattens, and a cattle operation is located 1.2 kilometers to the west.

Slaterville Springs Artesian Well

This is the one artesian well in our study and is located next to the Caroline Town Hall in the village of Slaterville Springs (Tompkins County). An iron pipe protrudes from the ground and a sign advises to "use at your own risk." The land use around the site is a mix of forest, agricultural fields, and dwellings. The well was drilled 86 feet deep into a confined aquifer of sand and gravel overlain by fine, glaciolacustrine sediments (Miller 2009). The aquifer supplies the nearby Town Hall building as well as approximately 200 households, several apartment complexes, two mobile home parks, a school, and several farms. Based on chlorofluorocarbon and tritium concentrations, Miller (2009) estimated that the water in the aquifer has a residence time of about 50 years.

Methods

On-Site Water Collection and Measurement

Springs were visited on an opportunistic basis during the spring, summer, and fall with Lisle and Slaterville studied from 2015-2019 and the others from 2017-2019. At each site, water temperature and electrical conductivity were measured using an Extech EC400 meter (FLIR Commercial Systems, Nashua, NH). Flow rate was calculated by measuring the time to fill a liter bottle. Water samples for dissolved ion analysis were collected in 125 mL acid-washed, low-density polyethylene (LDPE) bottles that were rinsed three times with the sample water before collection. Samples for fecal coliform analysis were collected in sanitized 1 L LDPE bottles. All samples were placed in a cooler during transportation back to the lab where they were stored in a refrigerator until analysis.

Dissolved Ions

All samples were analyzed for common anions (chloride, nitrite, nitrate, phosphate, and sulfate) using a Dionex ICS-900 ion chromatograph at Ithaca College. Analytical methods are based on Pfaff et al. (1997). Samples from four of the springs were analyzed at Cornell University for common dissolved metals (Ca, Mg, Na, K, and Si) using inductively-coupled plasma optical emission spectroscopy. A deionized water blank was included in the analyses for quality control.

Bacteria Testing

Total coliform screening tests were conducted throughout the test period using Lamotte 5850 water test kits (Chestertown, MD). Glass vials with growth media tablets were filled onsite and incubated in the lab for 48 hours, after which they were interpreted as either positive or negative. We did not clean or sanitize the supply pipe which could result in a positive total coliform test from the supply pipe and not necessarily from the environment upstream from the pipe. Quantitative fecal coliform testing was conducted at Lisle and Slaterville from 2016-2019 and at the other sites from 2017-2019. Water samples for fecal coliform testing were analyzed within 24 hours of collection. Each sample was measured in triplicate using a membrane filtration technique (USEPA 2002) in which an aliquot of 100-300 mL of water was passed through a sterile 45 micrometer membrane under vacuum. Filter membranes were placed in sterile petri dishes on an absorbent pad that had been saturated with 2.2 mL of m-FC agar growth media. All petri dishes were incubated for 24 hours at 44.5 (±0.2)°C. After the incubation period, fecal coliform colonies were counted and reported as colony forming units (CFU) per 100 mL. Two times during summer 2019, sites that tested positive for fecal coliform bacteria were further tested for *Escherichia coli* (*E. coli*) using the same membrane filtration technique and m-ColiBlue24 (Hach) growth media and incubated at 35°C.

User Perceptions and Data

To assess the reasons why people use the springs and to gather relevant information, a sheltered box with a voluntary questionnaire was placed at Slaterville and Lisle springs in September 2015, for two weeks each. The questionnaire (Table 1) was printed on cards and participants placed the completed card in a locked collection box. The survey plan was accepted by the Ithaca College Institutional Review Board (#0216-11).

Results and Discussion

Springs are generally described as locations where groundwater discharges at the ground surface and they can be classified into several types (Kresic 2010). Slaterville is the only location in this study that is a flowing artesian well. The other sites can be classified as gravity springs or seeps at the base of hills composed of unconsolidated glacial sediments. Given their proximity to the land surface, the water from these springs likely originates in shallow, unconfined aquifers. These differences can lead to variations in the water chemistry, presence of bacteria, and ultimately the potential threat to consumers.

Spring Water Chemistry

Table 2 summarizes the range of values from the detected dissolved ions samples (a complete dataset of all the measurements is available from the corresponding author). Nitrite and phosphate were not detected in any of the samples. The composition of the artesian Slaterville spring is within the range reported in Miller (2009) and has a relatively low dissolved concentration. All locations varied in terms of dissolved load composition relative to one another. The springs with the highest dissolved concentrations, including sodium and chloride, are Reservation and Nichols. These sites are in the Tully Valley, an area known for mudboils that can contain brackish water likely derived from the salt layers in the regional bedrock (Kappel et al. 1996). At these two sites chloride can vary widely over time, but it is not clear if the source is from road salt or derived from the brackish water.

Nitrate is very soluble and tends to be the dominant form of nitrogen in water. As a result, it can move quickly into surface runoff and percolate into groundwater. Nitrate can occur naturally in water from wildlife, the decomposition of organic matter, and atmospheric deposition. As water passes through the subsoil, nitrate tends to

Table 1. User survey questions and answer options from 199 respondents in September 2015.

Question 1 **How often do you collect water here?** This is my first time coming here I come here every so often, a few times a month I frequently fill up here, multiple times a week	**Question 4** **Does your home have municipal water or well?** I have municipal water I have a well, which supplies my water Other
Question 2 **What do you use this spring water for?** Drinking Household use Storage or surplus water	**Question 5** **How much do you normally collect here?** Usually only a water bottle full 1-3 gallons 3-5 gallons 5-10 gallons 10+ gallons
Question 3 **How far do you travel to get here?** Less than 2-3 miles More than 3 miles How many miles or minutes?	**Question 6** **Is this your primary source of drinking water?** Yes No

Table 2. Minimum and maximum values of discharge, temperature, and measured dissolved components spring data.

Location	Discharge (lpm)	Temp (°C)	Cl^-	NO_3^--N	SO_4^{2-}	Na	K	Mg	Ca	Si
Lisle	32-48	7.2-15	7.4-11.3	5.3-3.4	9.8-13	4.4-4.9	0.6-0.7	12-13	69-84	3.6-4.4
DiRisio	3.7-14	9.2-15.4	1.6-12	1.2-2	5.4-33	NA	NA	NA	NA	NA
Reservation	15-25	8.7-13.5	112-205	2.4-1.3	26-31	113-123	1.5-1.6	23-24	109-112	4.1
Whiskey Hollow	15-17	9.4-14.7	3.7-11	2.1-2.9	15-31	NA	NA	NA	NA	NA
Nichols Rd	17-28	9.3-16	33-235	1.3-1.9	10-33	25-28	1.5-1.6	21-22	104-107	3.4-3.5
Texas Holl.	6.2-20	8-18	0.7-1.8	0.1-0.2	11-17	NA	NA	NA	NA	NA
Slaterville	2.9-4.6	7-18	1.7-3.4	BDL	15-21	5.5-6.3	0-0.7	6.2-7.0	36-44	6.2-7.4

BDL= below detection limit; NA = not analyzed.

attenuate through denitrification processes (Rivett et al. 2008; Huno et al. 2018). Excess nitrate in water is that which is above background levels due to human activities. The dominant sources of excess nitrate in groundwater are agricultural activities, such as the application of synthetic fertilizers (e.g., ammonium nitrate), and animal manure (Puckett 1994; Nolan et al. 1997; Di and Cameron 2002; Williams et al. 2015). Domestic wells in agricultural areas tend to have higher nitrate concentrations compared to public supply wells and surface water (Mueller and Helsel 1996). Shallow groundwater beneath agricultural areas has higher nitrate concentrations compared to deeper aquifers away from agricultural areas (Burow et al. 2010).

In order to evaluate if the nitrate levels in the roadside springs are in excess of background levels, a threshold needs to be established. The median value for nitrate as nitrogen (NO_3-N) in central New York State groundwater is 0.32 mg/l (Reddy 2014), but this can represent water taken from deeper wells and/or confined aquifers and may not represent background levels for shallow springs. Panno et al. (2006) proposed a nitrate threshold for spring water to be 2.5 mg/l NO_3-N, and that anything above that can be attributed to anthropogenic input. Using this threshold, the Lisle spring consistently shows anthropogenic nitrate input and this is most likely due to the animal operation and agricultural fields uphill from the site. Whiskey Hollow also registered two of four measurements at or above 2.5 mg/l NO_3-N and the agricultural fields ~500 m uphill from the spring could be the source of this. The other sites did not have nitrate levels above the background threshold. The lack of measurable nitrate at the Slaterville artesian spring could be attributed to the confining layer of clay and silt that would prohibit the percolation of nitrate from nearby agricultural fields and septic systems (Miller 2009) or it could be due to denitrification in the low oxygen conditions of the deeper aquifer.

When compared to the United States Environmental Protection Agency's (USEPA) Maximum Contaminant Levels (MCLs) (USEPA 2018) for drinking water, none of the measured dissolved constituents exceeds the standards, including the nitrate concentrations at Lisle and Whiskey Hollow, which are below the 10 mg/l MCL. The Tully Valley springs (Nichols and Reservation) have maximum chloride concentrations of 235 and 205 mg/l, respectively, which approaches the chloride MCL of 250 mg/l. The previously published manganese level at Slaterville of 0.183 mg/l (Miller 2009) exceeds the USEPA secondary drinking water standard of 0.05 mg/l – this can affect taste and color but does not pose a human health hazard at these levels. Manganese is common in groundwater and almost 7% of samples from principal U.S. aquifers have concentrations exceeding 300 mg/l (DeSimone et al. 2015). Unfortunately, we did not have the resources to determine manganese concentrations of the spring water.

Bacteria and Pathogenic Organisms

Pathogenic micro-organisms in groundwater lead to millions of people globally becoming ill every year (Murphy et al. 2017). These pathogens include viruses, bacteria, and protozoans such as *Cryptosporidium parvum* and *Giardia*. Therefore, untreated natural springs pose a potential hazard, as evident from the 2009 outbreak of *Giardia duodenalis* in Rensselaer County (New York) (Bedard et al. 2016). Testing water for the presence of viruses and protozoans can be time consuming and expensive, but testing for bacteria is relatively easy. While many bacteria do not pose a threat to human health, the USEPA considers coliform bacteria to be a useful indicator organism for the presence of other pathogens.

There are a broad range of coliform bacteria types found in soil and in the gastrointestinal systems of organisms. All the springs in this study were tested often for total coliform bacteria (summarized in Figure 2) and all sites at some point had a positive result. The Slaterville spring only had one positive test (September 2018) out of a total of 23 over a four-year span and this coincided with 12.6 cm of rainfall in the area from the remnants of Hurricane Florence – the average amount for the entire month is 9.4 cm (Northeast Regional Climate Center 2020). The excess precipitation may have led to surface or near-surface water infiltrating the well casing. The MCL for total coliforms is no more than 5% samples positive in a month (USEPA 2018) but this is not relevant, considering that we generally did not test multiple times in any given month. The exception is the Lisle spring, tested four times in November of 2015, where 75% of the samples were positive for total coliform.

Fecal coliform bacteria are a subgroup of coliform bacteria that specifically reside in the gastrointestinal systems of warm-blooded animals. Federal guidelines mandate that no fecal coliform bacteria be present in municipal drinking water (USEPA 2018). Table 3 shows the results of the quantitative fecal coliform testing. The one time that the Slaterville spring tested positive for total coliform, it also tested positive for fecal coliform bacteria, although at a relatively low 2.3 CFU/100 mL. All other sites, with the exception of the Reservation spring, at some point tested positive for fecal coliform and failed to meet federal drinking water standards. *E. coli* is the most common fecal coliform bacteria and, although most *E. coli* strains are non-pathogenic, some strains, such as *E. coli* O157:H7, pose a serious health risk to humans (Jamieson et al. 2002). The sites were tested twice (June and July 2019) for *E. coli*: Nichols tested positive once and Texas Hollow tested positive both times. The low nitrate at Texas Hollow suggests little input from the nearby agricultural operation and the contamination from fecal bacteria is more likely from where the water flows about 10 m across the land surface before entering the supply pipe.

Our bacteria results are similar to the findings of two other studies of roadside springs. Testing of 21 springs in five Appalachian states (Virginia, West Virginia, North Carolina, Kentucky, and Tennessee) (Krometis et al. 2019) found that 99% of the sites

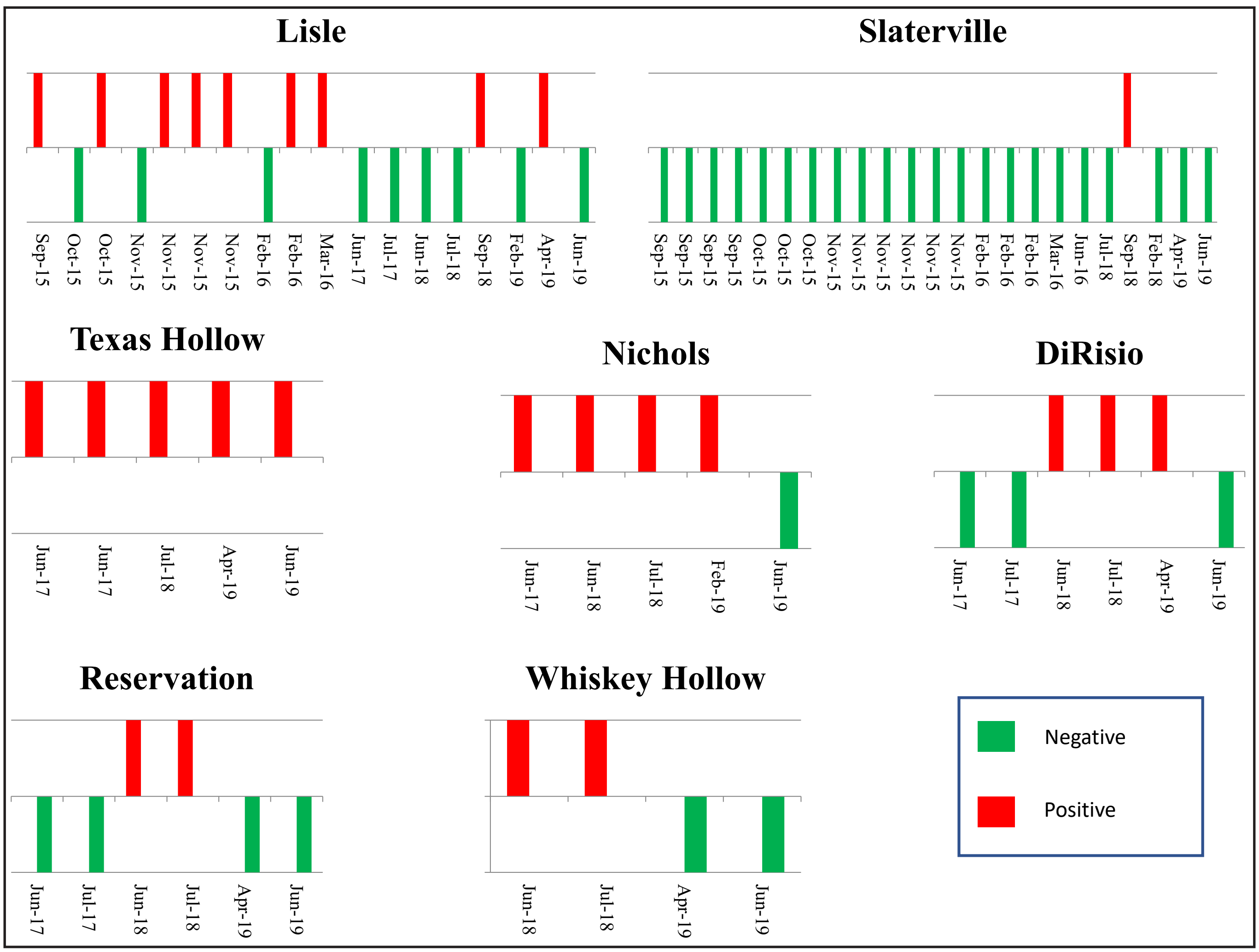


Figure 2. Compilation of the total coliform testing for the roadside springs in central New York. Red lines are positive (bacteria present) and green are negative (no bacteria present).

tested positive for total coliform bacteria and 81% of the sites tested positive for *E. coli* at least once. Swistock et al. (2015) found that 90% of the 37 roadside springs tested in Pennsylvania in 2013-2014 failed one or more health-based drinking water standards. The following year, testing of ten of those Pennsylvania springs detected bacteria, as well as the presence of both *Giardia* and *Cryptosporidium* cysts. While we did not test for any other pathogenic micro-organisms, a user of a spring in our study did contact the authors (through our informational website) to ask about *Cryptosporidium* testing because they had been diagnosed with it. Of course, this does not prove that the spring was the source of the infection, but it does indicate that testing of other pathogens at our sites may be warranted.

The combined results of our study and those referenced above demonstrate that 90% or more of roadside springs contain pathogenic micro-organisms, which is much higher than the 15% of household groundwater wells in the U.S. and Canada (Hynds et al. 2014). While there is the potential that a positive total coliform test was from the unsanitized supply pipe, the presence of fecal coliform bacteria means that the water has been contaminated by feces of warm-blooded organisms. It is generally accepted that as water passes through subsoil and into deeper strata, there is a natural attenuation of micro-organisms. Determining the survival and transport of enteric organisms such as fecal coliform bacteria into and through surface and groundwater is complex and beyond the scope of this project – the reader is referred to several papers that review this topic (e.g., Jamieson et al. 2002; John and Rose 2005; Bradford et al. 2013). Fecal coliform bacteria can come from natural organisms but can also be introduced into groundwater through agricultural practices, such as the application of animal manure to fields (Oun et al. 2014), or from residential septic systems (Lusk et al. 2017). The apparent susceptibility of the roadside springs to microbial contamination could be attributed to the water coming from shallow, unconfined aquifers or, in the case of Texas Hollow, water that has been in contact with the ground surface. Depending on the local geology, well water tends to come from deeper sources with lower susceptibility to pathogens.

User Survey

The survey resulted in 78 responses from Slaterville springs and 121 responses from Lisle (summarized in Figure 3). All respondents said that they use spring water for drinking. Almost all respondents (>96%) were regular visitors to both sites, and the proportion that visited at least weekly was 31% for Lisle and 49% for Slaterville springs.

Table 3. Fecal coliform results (colony forming units per 100 ml).

Date	Lisle	DiRisio	Whiskey Hollow	Texas Hollow	Nichols	Reservation	Slaterville
10/4/16	5.3						
11/17/16	4.8						
6/1/17				63			
6/29/18		15.5	44.6				
7/14/18		ND	ND		35	ND	
8/21/18	2.7	ND	3.8	25.5	ND		
9/30/18							2.3
4/21/19	ND	2	ND		13.4	ND	ND
6/19/19	ND	ND	ND	5.5	ND	ND	ND
7/11/19	ND	11.7	ND	27	ND	ND	ND

Values represent the average of the three replicate analyses for each date. ND = not detected.

The amount of water collected differed between the two sites, with 44% collecting 10 or more gallons per visit at Lisle compared to 8% at Slaterville. Anecdotally, this is reflected in the observation by the authors that visitors at Lisle often had five-gallon carboys. This difference could be due in part to the relatively lower discharge rate at Slaterville of 2.9-4.6 liters per minute (lpm) compared to Lisle with 32-48 lpm; a five-gallon carboy would take about 30 seconds to fill at Lisle.

The majority of respondents (62% at Lisle and 81% at Slaterville) also claimed that the springs were their primary source of drinking water. A little more than half of all respondents had a well at their home and 31-44% had municipal tap water. We were interested in how far users traveled to gather water from the springs, and the combined surveys from both Slaterville and Lisle indicated that 83% of respondents live more than three miles from the springs. We filtered out the surveys from people that had visited for the first time or that visited only occasionally, and we found that some regular (weekly) users traveled up to 30 miles each way. As an example, one user who lives 20 miles away and collects 40 gallons several times per week stated that "all water in the house must come from here."

Most of the respondents wrote comments to explain why they collect water at the spring. A common theme was that the spring water tastes good and their water at home does not – either because of a well with a sulfurous smell or the chlorine used to disinfect municipal water. Some representative comments were:

- *My water has iron - doesn't taste great, leaves stains.*
- *I live half a mile from here and have a spring in my front yard. However, my water tends towards sulfur. I think water should be free and people need to stop buying plastic water bottles.*
- *I trust it. I like it. Feels right.*

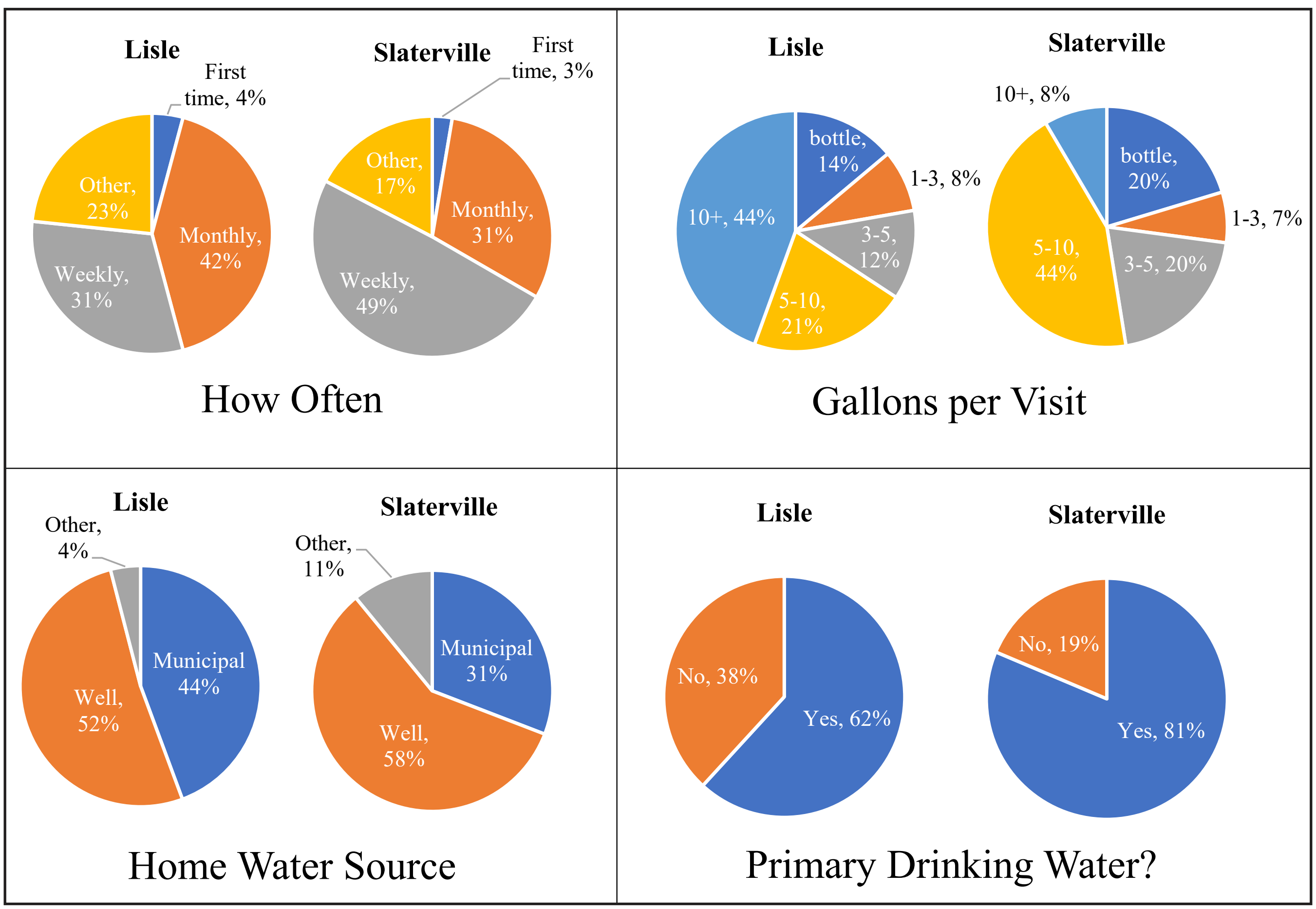


Figure 3. Results from the 2015 user survey from the Lisle and Slaterville springs.

- *So delicious, no odor, no chemicals and smells and horrible taste like the Ithaca city water that comes out of my tap.*
- *It's pure spring water clean and I do not trust any other municipal or urban source!*
- *I have been stopping here for over 50 years. Special ritual, nostalgia. I would stop here on the way to my grandmother's house as a kid.*

Our survey results are similar to the few other published studies on this topic. In the survey of the Appalachian region, Krometis et al. (2019) reported that the majority of respondents said that taste was a primary reason to collect spring water (66%) and that "quality/health" was a motivating factor. Similar to our observations, respondents in that study did not trust their water at home. A survey of roadside spring users in Indiana (Westhues 2017) reported that users generally considered spring water as "pure, natural, and good for those who consume it." Westhues (2017) further found that some water users considered any additions from natural sources preferable to elements added to municipal tap water. A survey of over 1,000 Pennsylvania residents (Swistock et al. 2015) found that 30% had consumed water from a roadside spring and 12% consumed water every year from a roadside spring, mostly because of the taste and perception that it is natural.

Some of the comments from our survey indicate that those on well water have problems with organoleptic and aesthetic properties, such as hydrogen sulfide (rotten egg) odors or staining from iron. Patton et al. (2020) surveyed homeowners near roadside springs in three Appalachian states (Kentucky, Virginia, and West Virginia) with in-home well water, and reported that over 80% of those surveyed did not trust their tap water for aesthetic reasons. The aesthetic properties of the water from the springs in our study are excellent: the water is clear, cold, and has no undesirable taste or odor. One can understand why the users with poor-quality well water would choose the springs if their decisions are based on taste, smell, and appearance. With the exception of the Slaterville artesian well, the water from the roadside springs in this study comes from near-surface, unconfined aquifers that have low turbidity because of the filtering of suspended sediment during the recharge process as surface water passes through soil and subsoil. In addition, we would not expect that this water had a long residence time in the aquifer compared to the artesian well water. A longer residence time in a confined, low oxygen aquifer could lead to higher dissolved metals and microbial generation of hydrogen sulfide. However, the shallow aquifers can have pathogenic micro-organisms and their presence has no effect on the organoleptic properties of spring water.

The users that have tap water from a regulated municipal water system appear to have slightly different reasons for drinking spring water. These center on a general lack of trust of municipal water and/or a dislike of the taste and smell of chlorine added for disinfection. Perceptions of water quality from treated municipal water sources are complex. They are commonly influenced by properties such as taste and odor but can also be a function of race, culture, income, and education level (Doria 2010; Pierce and Gonzalez 2017; Javidi and Pierce 2018; Weisner et al. 2020). We did not gather the demographic data necessary to assess the role of these variables, but we do suggest that this should be included in any future work.

Conclusions

Our study of seven roadside springs from 2015-2019 in central New York State demonstrated that each spring has its own hydrological and geochemical characteristics. In general, the chemistry of the water did not vary much at a given site and none of the dissolved species we measured exceeded federal municipal drinking water health standards. However, the presence of fecal bacteria was detected at all but one of the springs, which exceeds the drinking water standards and could signify the presence of other pathogenic micro-organisms. With the exception of the one artesian well at Slaterville, the other springs appear to be fed by shallow, unconfined aquifers that may be susceptible to contamination from nearby agricultural fields and domestic septic systems that are not readily apparent from the spring water collection outlet. The survey of water users showed that over 70% of respondents use the springs multiple times per month for drinking water and the majority collect more than five gallons per visit. More than 80% of the users live more than three miles from the springs and a recurring reason for drinking the spring water is that the taste is better than the water available at their homes. Taken together, our survey results combined with the other studies indicate that the choice to use roadside springs comes from several factors, dominated by the organoleptic and aesthetic factors (taste, smell, and color) as well as mistrust of well water and municipal tap water.

Acknowledgements

This work was supported by Ithaca College and its Summer Scholars program. We thank Cassie Schuttrumpf, Emily Horowitz, and Jake Brenner for assistance with the user survey and Bill Kappel for helpful discussions about groundwater in the region. We also thank the three reviewers for their comments to improve the manuscript.

Author Bio and Contact Information

Christopher W. Sinton (corresponding author) is an associate professor and chair of the Environmental Studies and Sciences department at Ithaca College. He teaches courses in earth and environmental sciences and conducts research in marine geology, water quality, soil carbon sequestration, and materials. He may be contacted at csinton@ithaca.edu or at 953 Danby Rd., Ithaca, NY 14850.

Matthew Olivieri recently completed his B.A. in Environmental Studies at Ithaca College and worked collaboratively to understand how the water quality of roadside springs changes over time and the implications of them being unregulated. He may be contacted at molivieri@ithaca.edu.

Tara Perry completed her B.S. in Environmental Science at Ithaca College in 2017 and is an Environmental Scientist at Foit-Albert Associates in Albany, NY. She may be contacted at tarahperry23@gmail.com.

Katherine Stoddard completed her B.S. in Environmental Science at Ithaca College and is currently a hydrologic technician for the U.S. Geologic Survey in Montgomery County, Alabama. She may be contacted at kstoddard@usgs.gov.

Ryan Kresge completed his B.A. in Environmental Studies at Ithaca College and is currently managing a small organic farm in the Hudson Valley. He may be contacted at kresgerj@gmail.com.

References

Aber, J.S. 1979. Glacial conglomerates of the Appalachian Plateau, New York. *Quaternary Research* 11(2): 185-196.

Bedard, B.A., R. Elder, L. Phillips, and M.F. Wachunas. 2016. *Giardia* outbreak associated with a roadside spring in Rensselaer County, New York. *Epidemiology & Infection* 144(14): 3013-3016. Available at: https://doi.org/10.1017/S0950268816001497. Accessed April 29, 2021.

Bradford, S.A., V.L. Morales, W. Zhang, R.W. Harvey, A.I. Packman, A. Mohanram, and C. Welty. 2013. Transport and fate of microbial pathogens in agricultural settings. *Critical Reviews in Environmental Science and Technology* 43(8): 775-893. Available at: https://doi.org/10.1080/10643389.2012.710449. Accessed April 29, 2021.

Burow, K.R., B.T. Nolan, M.G. Rupert, and N.M. Dubrovsky. 2010. Nitrate in groundwater of the United States, 1991-2003. *Environmental Science & Technology* 44(13): 4988-4997. Available at: https://doi.org/10.1021/es100546y. Accessed April 29, 2021.

Cutler, D. and G. Miller. 2005. The role of public health improvements in health advances: The twentieth-century United States. *Demography* 42(1): 1-22. Available at: https://doi.org/10.1353/dem.2005.0002. Accessed April 29, 2021.

DeSimone, L.A., P.B., McMahon, and M.R. Rosen. 2015. *The Quality of Our Nation's Waters: Water Quality in Principal Aquifers of the United States, 1991-2010*. U.S. Geological Survey Circular 1360. National Water Quality Assessment Program, Reston, VA. Available at: https://doi.org/10.3133/cir1360. Accessed April 29, 2021.

Di, H.J. and K.C. Cameron. 2002. Nitrate leaching in temperate agroecosystems: Sources, factors and mitigating strategies. *Nutrient Cycling in Agroecosystems* 64(3): 237-256. Available at: https://doi.org/10.1023/A:1021471531188. Accessed April 29, 2021.

Doria, M. de F. 2010. Factors influencing public perception of drinking water quality. *Water Policy* 12(1): 1-19. Available at: https://doi.org/10.2166/wp.2009.051. Accessed April 29, 2021.

Findaspring. n.d. Available at: https://findaspring.com/. Accessed April 29, 2021.

Google Earth. n.d. Google Earth Pro version 7.3.3.7786 (64-bit).

Hu, Z., L.W. Morton, and R.L. Mahler. 2011. Bottled water: United States consumers and their perceptions of water quality. *International Journal of Environmental Research and Public Health* 8(2): 565-578. Available at: https://doi.org/10.3390/ijerph8020565. Accessed April 29, 2021.

Huno, S.K.M., E.R. Rene, E.D. van Hullebusch, and A.P. Annachhatre. 2018. Nitrate removal from groundwater: A review of natural and engineered processes. *Journal of Water Supply: Research and Technology-Aqua* 67(8): 885-902. Available at: https://doi.org/10.2166/aqua.2018.194. Accessed April 29, 2021.

Hynds, P.D., M.K. Thomas, and K.D.M. Pintar. 2014. Contamination of groundwater systems in the US and Canada by enteric pathogens, 1990–2013: A review and pooled-analysis. *PLOS ONE* 9(5): e93301. Available at: https://doi.org/10.1371/journal.pone.0093301. Accessed April 29, 2021.

Jamieson, R.C., R.J. Gordon, K.E. Sharples, G.W. Stratton, and A. Madani. 2002. Movement and persistence of fecal bacteria in agricultural soils and subsurface drainage water: A review. *Canadian Biosystems Engineering* 44(1): 1-9.

Javidi, A. and G. Pierce. 2018. U.S. households' perception of drinking water as unsafe and its consequences: Examining alternative choices to the tap. *Water Resources Research* 54(9): 6100-6113. Available at: https://doi.org/10.1029/2017WR022186. Accessed April 29, 2021.

John, D.E. and J.B. Rose. 2005. Review of factors affecting microbial survival in groundwater. *Environmental Science & Technology* 39(19): 7345-7356. Available at: https://doi.org/10.1021/es047995w. Accessed April 29, 2021.

Johnson, T.D., K. Belitz, and M.A. Lombard. 2019. Estimating domestic well locations and populations served in the contiguous U.S. for 2000 and 2010. *Science of the Total Environment* 687: 1261-1273. Available at: https://doi.org/10.1016/j.scitotenv.2019.06.036. Accessed April 29, 2021.

Kappel, W.M., D.A. Sherwood, and W.H. Johnston. 1996. *Hydrogeology of the Tully Valley and Characterization of Mudboil Activity, Onondaga County, New York*. U.S. Geological Survey Water-Resources Investigations Report 96-4043, Ithaca, NY. Available at: https://doi.org/10.3133/wri964043. Accessed April 29, 2021.

Kozlowski, A., B. Bird, J. Leone, and A. Backhaus. 2018. Surficial Geology of Cayuga County, New York. New York State Geological Society, New York State Museum Map & Chart No. 104. Available at: http://www.nysm.nysed.gov/common/nysm/files/mc104_cayugacountysurficial.pdf. Accessed April 29, 2021.

Kresic, N. 2010. Types and classifications of springs. In: *Groundwater Hydrology of Springs*: *Engineering, Theory, Management and Sustainability*, N. Kresic and Z. Stevanovic (Eds.). Elsevier, Burlington, MA, pp. 31-85.

Krometis, L-A., H. Patton, A. Wozniak, and E. Sarver. 2019. Water scavenging from roadside springs in Appalachia. *Journal of Contemporary Water Research & Education* 166(1): 46-56. Available at: https://doi.org/10.1111/j.1936-704X.2019.03301.x. Accessed April 29, 2021.

Lusk, M.G., G.S. Toor, Y.-Y. Yang, S. Mechtensimer, M. De, and T.A. Obreza. 2017. A review of the fate and transport of nitrogen, phosphorus, pathogens, and trace organic chemicals in septic systems. *Critical Reviews in Environmental Science and Technology* 47(7): 455-541. Available at: https://doi.org/10.1080/10643389.2017.1327787. Accessed April 29, 2021.

Miller, T.S. 2009. *Geohydrology and Water Quality of the Valley-Fill Aquifer System in the Upper Sixmile Creek and West Branch Owego Creek Valleys in the Town of Caroline, Tompkins County, New York*. U.S. Geological Survey Scientific Investigations Report 2009–5173. Available at: https://pubs.usgs.gov/sir/2009/5173/pdf/sir2009-5173.pdf. Accessed April 29, 2021.

Mueller, D.K. and D.R. Helsel. 1996. *Nutrients in the Nation's Waters--Too Much of a Good Thing?* U.S. Geological Survey Numbered Series 1136. Available at: https://doi.org/10.3133/cir1136. Accessed April 29, 2021.

Murphy, H.M., M.D. Prioleau, M.A. Borchardt, and P.D. Hynds. 2017. Review: Epidemiological evidence of groundwater contribution to global enteric disease, 1948–2015. *Hydrogeology Journal* 25(4): 981-1001. Available at: https://doi.org/10.1007/s10040-017-1543-y. Accessed April 29, 2021.

Nolan, B.T., B.C. Ruddy, K.J. Hitt, and D.R. Helsel. 1997. Risk of nitrate in groundwaters of the United States - A national perspective. *Environmental Science & Technology* 31(8): 2229-2236. Available at: https://doi.org/10.1021/es960818d. Accessed April 29, 2021.

Northeast Regional Climate Center. 2020. Available at: http://www.nrcc.cornell.edu/. Accessed December 20, 2020.

Oun, A., A. Kumar, T. Harrigan, A. Angelakis, and I. Xagoraraki. 2014. Effects of biosolids and manure application on microbial water quality in rural areas in the US. *Water* 6(12): 3701-3723. Available at: https://doi.org/10.3390/w6123701. Accessed April 29, 2021.

Pair, D. 2016. Surficial Geology of Onondaga County, New York. New York State Geological Society, New York State Museum Map & Chart No. 99. Available at: http://www.nysm.nysed.gov/common/nysm/files/mc99.1_onondagacounty.pdf. Accessed April 29, 2021.

Panno, S.V., W.R. Kelly, A.T. Martinsek, and K.C. Hackley. 2006. Estimating background and threshold nitrate concentrations using probability graphs. *Groundwater* 44(5): 697-709. Available at: https://doi.org/10.1111/j.1745-6584.2006.00240.x. Accessed April 29, 2021.

Patton, H., L-A. Krometis, and E. Sarver. 2020. Springing for safe water: Drinking water quality and source selection in central Appalachian communities. *Water* 12(3): 888. Available at: https://doi.org/10.3390/w12030888. Accessed April 29, 2021.

Pfaff, J.D., D.P. Hautman, and D.J. Munch. 1997. Method 300.1 Determination of Inorganic Anions in Drinking Water by Ion Chromatography. National Exposure Research Laboratory Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH. Available at: https://www.epa.gov/sites/production/files/2015-08/documents/method_300-1_1997.pdf. Accessed April 29, 2021.

Pierce, G. and S. Gonzalez. 2017. Mistrust at the tap? Factors contributing to public drinking water (mis) perception across US households. *Water Policy* 19(1): 1–12. Available at: https://doi.org/10.2166/wp.2016.143. Accessed April 29, 2021.

Puckett, L.J. 1994. *Nonpoint and Point Sources of Nitrogen in Major Watersheds of the United States*. U.S. Geological Survey Investigations Report 94–4001. Available at: https://pubs.usgs.gov/wri/wri944001/pdf/wri94-4001.pdf. Accessed April 29, 2021.

Reddy, J.E. 2014. *Groundwater Quality in Central New York, 2012*. U.S. Geological Survey Open-File Report 2014–1226. Available at: https://dx.doi.org/10.3133/ofr20141226. Accessed April 29, 2021.

Rivett, M.O., S.R. Buss, P. Morgan, J.W.N. Smith, and C.D. Bemment. 2008. Nitrate attenuation in groundwater: A review of biogeochemical controlling processes. *Water Research* 42(16): 4215-4232. Available at: https://doi.org/10.1016/j.watres.2008.07.020. Accessed April 29, 2021.

Swistock, B., J. Clark, S. Boser, D. Oleson, A. Galford, G. Micsky, and M. Madden. 2015. Issues associated with the use of untreated roadside springs as a source of drinking water. *Journal of Contemporary Water Research & Education* 156(1): 78-85. Available at: https://doi.org/10.1111/j.1936-704X.2015.03206.x. Accessed April 29, 2021.

United States Environmental Protection Agency (USEPA). 2002. SW-846 Test Method 9132: Total Coliform: Membrane-Filter Technique. U.S. Environmental Protection Agency Office of Water (4303T). Available at: https://www.epa.gov/hw-sw846/sw-846-test-method-9132-total-coliform-membrane-filter-technique. Accessed April 29, 2021.

United States Environmental Protection Agency (USEPA). 2018. 2018 Edition of the Drinking Water Standards and Health Advisories Tables. EPA 822-F-18-001. Office of Water U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf. Accessed April 29, 2021.

Water Quality Association. 2019. National Study of Consumers' Opinions & Perceptions Regarding Water Quality. Available at; https://www.wqa.org/Portals/0/Publications/ConsumerStudy2019_Public.pdf. Accessed April 29, 2021.

Weisner, M.L., T.L. Root, M.S. Harris, D. Mitsova, and W. Liu. 2020. Tap water perceptions and socioeconomics: Assessing the dissatisfaction of the poor. *Sustainable Production and Consumption* 21: 269-278. Available at: https://doi.org/10.1016/j.spc.2019.08.008. Accessed April 29, 2021.

Westhues, K. 2017. Flowing well park: Localized water knowledge, community, and stewardship as expressed in community springs. *Southeastern Geographer* 57(2): 107-109.

Williams, M.R., A.R. Buda, H.A. Elliott, A.S Collick, C. Dell, and P.J.A. Kleinman. 2015. Linking nitrogen management, seep chemistry, and stream water quality in two agricultural headwater watersheds. *Journal of Environmental Quality* 44(3): 910-920. Available at: https://doi.org/10.2134/jeq2014.10.0412. Accessed April 29, 2021.

UCOWR UNIVERSITIES COUNCIL ON WATER RESOURCES

NIWR The National Institutes for Water Resources

2022 UCOWR/NIWR
Annual Water Resources Conference
June 14-16, 2022
Hyatt Regency, Greenville, SC

The planning committee is busy developing the 2022 conference to be held June 14-16. Please note, the health and safety of our attendees is of utmost importance. The UCOWR staff, planning committee, and hotel are working together to ensure a safe in-person conference amidst the potential pandemic impacts through June 2022. We look forward to seeing you next June!

Join us as we head to the Southeast in 2021. Nestled up against the foothills of the Blue Ridge Mountains in the heart of South Carolina's Upcountry, Greenville is a social distancing dreamland. The region's rich history, state parks, national forests, and wilderness areas provide endless opportunities for outdoor exploration. UCOWR is a family-friendly organization and we invite you to extend your conference participation and enjoy the abundance of opportunities a trip to Greenville offers.

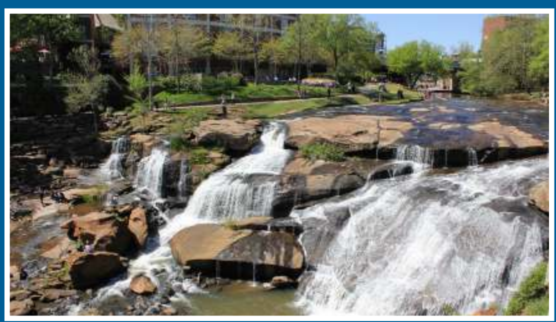
Attendees will delve into current perspectives on a range of contemporary water resources challenges and solutions (at community, watershed, regional, national, and/or global scales). In addition to the vast range of water-related topics and disciplines that are typical of a UCOWR conference, a special focus will be on Water Resilience.

Check out the Call for Special Sessions and submit proposals by October 8. The Call for Abstracts will be sent out in late October. Abstracts will be due in January.

For more information on the conference, please visit https://ucowr.org/conference/.

General questions about the conference can be directed to Karl Williard (ucowr@siu.edu), Executive Director of UCOWR.

Contents



2022 UCOWR / NIWR
Annual Water Resources Conference
Greenville, SC
June 14-16, 2022

UCOWR
UNIVERSITIES COUNCIL ON WATER RESOURCES

Universities Council on Water Resources
Mail Code 4526
Southern Illinois University Carbondale
1231 Lincoln Drive
Carbondale, IL 62901
www.ucowr.org