Closing the Human-Nature Feedback Loop

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Understanding people's responses to changing lakes

Introduction

Humans are entwined in reciprocal – and often complex – relationships with lakes. When a community, agency, or individual makes a land management decision, it can impact lake water quality by affecting drinking water supplies, ecosystem health, and recreation opportunities. When negative impacts become great enough that the public begins to observe them, it can inspire individuals and communities to act to protect the lakes they love and rely upon. We think of this relationship as a feedback loop, in which people affect lakes, and lakes in turn affect people (see Figure 1).

The scientific community has made great progress in understanding the relationship between human decisions and lake water quality, but there is still much to learn about this feedback loop. A great deal of research has focused on lakes' chemical, physical, and biological responses to people's actions. Yet significantly less attention has been paid to how people respond to changes in lakes, and how their responses can influence lake water quality in the future. The way that lake ecology affects human decisionmaking represents a considerable gap in our knowledge (Troy et al. 2015).

This knowledge gap, which is captured by the brown and yellow arrows in Figure 1, represents the ways in which people respond to changes in water quality. Our team is currently conducting research to better understand this response by working to model the relationship between people and lakes. We are a team of social scientists, ecologists, and physical scientists, who collaborate by sharing our disciplinary knowledge about components of the human-lake relationship, and work to link those components together to understand the complete feedback loop.

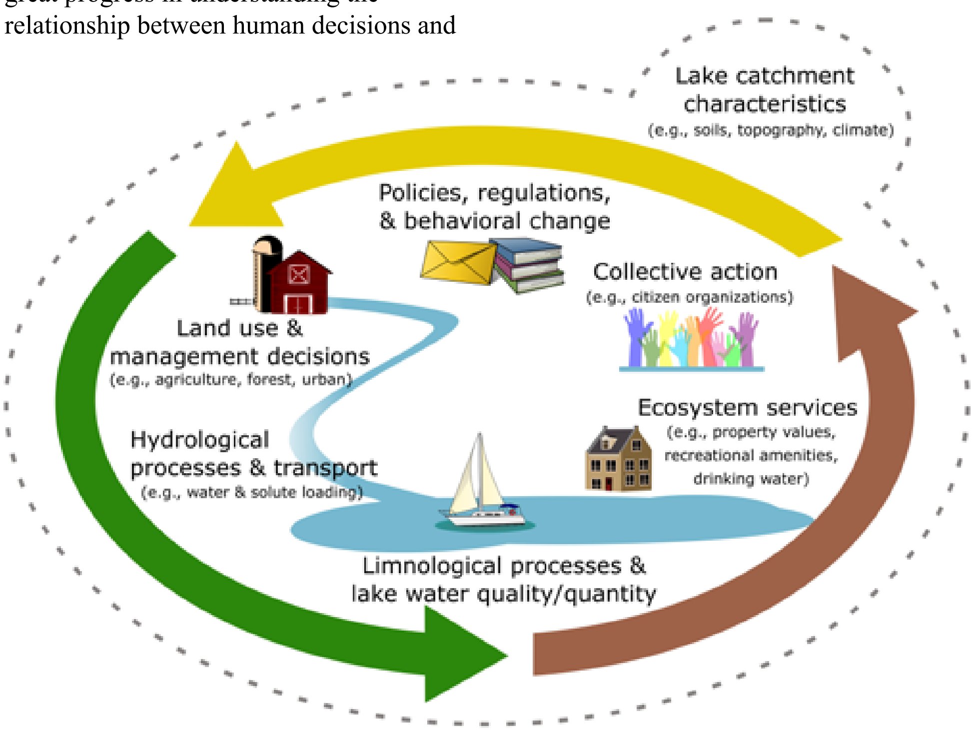

Figure 1. An illustration of how our project conceptualizes the feedback loop between lakes and people.

The importance of understanding behavior

Understanding the feedback loop between people and their environment is critical to achieving environmental, social, and economic goals over the long term (Matson et al. 2016). However, decisionmaking and policies usually address only one part of the feedback loop (a single arrow in Figure 1), which can result in unintended, often negative consequences (Matson et al. 2016). For example, if a policy requiring erosion control on personal property does not improve water quality the way that people expect, people may reject future policies under the assumption that they are ineffective.

The overarching goal of our project is to understand the full feedback loop between people and lakes, paying particular attention to the human behavioral response to changes in a lake ecosystem. This behavioral response occurs when people make decisions based on knowledge gained from past experiences, as well as predictions they make about the future. For instance, if residents observe cloudy lake water near shoreline areas with sparse vegetation after storms, they may choose to add plants or other features to reduce erosion, either individually or by working together to implement a policy. By understanding what kinds of changes in a lake inspire behavioral response, and how those behavioral responses in turn influence lakes, our research supports lake management decisions that are more likely to achieve short and long-term goals.

Types of behavioral responses

Changes in lake water quality can affect people through a variety of mechanisms, and people respond to changes in a variety of ways (see Figure 2). These mechanisms – such as changing property values and effects on an individual's personal connection with a lake – may interact with one another, producing complex social and economic dynamics. Behavioral responses can take place at an individual or group level, or some combination of the two. An example of group behavior might be the formation of a civic organization whose mission is to protect lakes; an example of individual action would be if a resident reduced the amount of fertilizer applied to their yard in the hopes of reducing runoff into the lake.

The most pronounced behavioral changes occur in response to lake water quality degradation, which is often due to eutrophication. That could mean, for example, that the water becomes cloudier, there are longer periods of hypoxia (low oxygen) that lead to fish kills, or that algal blooms become more frequent. Identifying the mechanisms by which these changes affect people is a key step in studying the relationship between people and lakes. One such mechanism is that decreased water quality can reduce the monetary value of nearby properties. This is a phenomenon that economists study by analyzing trends in property prices. Another way people respond to degradation is to organize efforts to sustain lake water quality, which social scientists study by examining the types of action people take as a group to protect lakes, as well as their motivations for acting. Studying responses from these different disciplinary perspectives leads to a richer, more complete understanding than any one scientific discipline can provide.

Changes in property values

When water quality noticeably decreases, it can make lakefront homes less desirable, and nearby businesses may suffer if people do not visit the lake for recreation (Nichols and Crompton 2018). Property values decline due to diminished lake aesthetics, recreation quality, and other negative conditions. By using data on changes in property values alongside water quality data, it is possible to measure how strongly a decrease in water quality negatively influences property prices. Conceptually, this measures how much property owners are willing to pay to avoid a decline in water quality. This "willingness to pay" is often a helpful figure when making policy and management decisions, because it provides an economic justification for protecting lake water quality.

More complicated behavioral dynamics can also occur when a lake exhibits a pronounced shift in water quality. For instance, as water quality declines, people living near the lake who value water quality may decide to move away. The people who move in after them may tend to be more accepting of low water quality, making them less likely to actively protect the lake. This dynamic has been observed in some contexts, such as with amenities like open space, though more research is needed on its occurrence specifically around lakes.

Though scientists most often study how degradation in water quality affects people, improvements in lake water quality also affect human decisionmaking in potentially unexpected ways. For example, improvements in water quality make the lake and surrounding landscape more attractive to developers, who build housing, businesses, and other structures. As more land in the watershed is developed, the increase in impervious surface and changes in land-use practices (e.g., lawn fertilization) may create a new source of nutrient loading that degrades water quality anew. Through our research, we aim to understand and anticipate more of the unexpected responses to changes in lake water quality, including how those unexpected responses may affect the full feedback loop between people and lakes.

Changes in recreation

Just as property values tend to decrease with poorer water quality, so do tourism and recreation. When people visit from out of town to fish, boat, or sightsee, they often spend money at local businesses, including restaurants, recreational supply stores, and more. This boosts the economy of the community surrounding the lake. When decreased water quality causes these people to visit less often (perhaps choosing to visit a different lake instead), the community loses this economic benefit, providing yet another economic incentive to protect lakes (Keeler et al. 2015).

Additionally, if lower water quality reduces the number of people who visit the lake for recreation, it may contribute to a public perception that the lake is only an amenity for lakefront property owners. This will further reduce the amount of support for lake protection in the broader community, potentially reducing the degree to which land and lake managers adopt best practices for water quality.

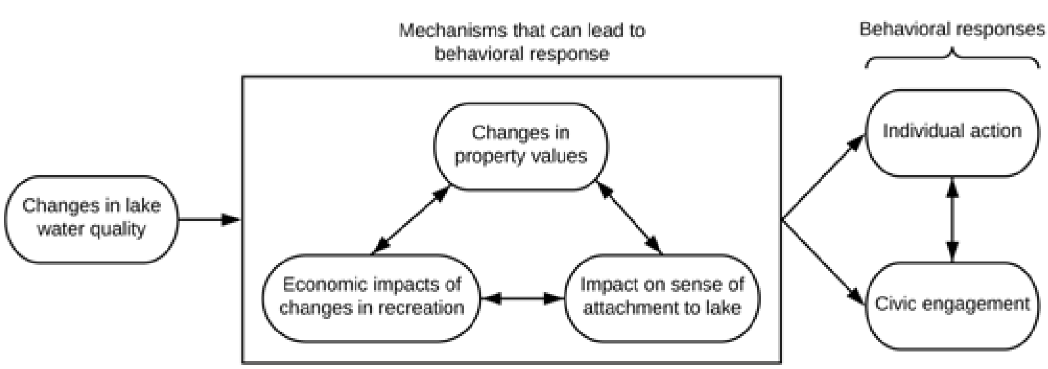

Figure 2. Examples of mechanisms by which changes in water quality can lead to behavioral responses.

Citizen engagement through lake associations

Sometimes people react to the observed change in water quality on an emotional, psychological, and even spiritual level, which occurs when people form an attachment to lakes because of the meaning the lake holds for them. For instance, a person who grew up near a lake may consider that lake to represent who they are as a person, their family heritage, or their livelihood. When people feel strongly connected to a lake in this way, it makes them more likely to take action when their lake is threatened (Stedman 2002). These bonds that people form with lakes and their communities, along with reductions in property values and diminished recreation opportunities, can motivate homeowners and people who recreate on a lake to join in civic action. Often, this action is in the form of citizen-formed lake associations.

Our project uses data on water quality, along with observations of lake associations, to examine how changes in a lake coincide with levels of civic engagement over the course of years or even decades. Lake associations can represent a variety of stakeholders, missions, and activities, often serving to educate the public, advocate for policies, and even help to bring science into community land-use planning and lake management. To understand what lake associations do, as well as how and why they do it, our project tracks their efforts over time using their newsletters, websites, and mission statements. By systematically searching for key themes and events, researchers compare changes in lake associations with changes in the lakes themselves over a given time period.

Challenges to studying behavioral responses

An interesting challenge arises when aligning ecological changes with human responses. It can take a long time for people to perceive the effects of a change in water quality, because changes are often gradual. It can take even longer for people to formulate and enact a response to these changes. This requires them to work together at multiple levels (local, state, and even national) to agree upon and implement actions. Sometimes different stakeholders' interests are not aligned with each other, or there may not be enough available scientific information, which can delay response further. To address this, our project focuses on lakes that have extensive, long-term data, meaning that a change in the lake could still be linked to a behavioral response, even many years later. This approach can provide insights for other lakes, where less information may be available, about how proactive actions to protect lakes unfold.

Conclusion

People's behavioral responses to changes in lakes can be complex, to say the least. Yet understanding these responses is critical to revealing the full dynamic relationship between humans and lakes. The better we understand coupled human-lake systems, the greater our ability to predict what management actions will work best, and when. Our project demonstrates a way to incorporate multiple disciplines to better understand human behavior, and this type of work is becoming more widespread in the scientific community. As this work progresses, we will better understand the complex human-lake relationship, which will directly inform improved lake management.

Acknowledgements

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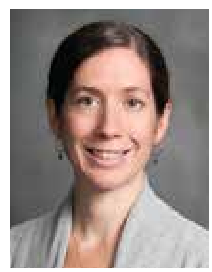
V. Reilly Henson works as a project manager for the research team. Her primary focus is on communicating the science, and helping to make information about the project – including its data – accessible to researchers and public audiences alike.



Kelly M. Cobourn studies natural resource economics from a variety of angles, including water quality degradation, land use, and invasive species management. She leads the development of this project's economic model of land use and management, which draws connections between environmental conditions and agricultural decisionmaking.

Cayelan C. Carey studies nutrient pathways and microbial communities in lake ecosystems. Her main focus is on how humans affect freshwater systems. In her role on this project, she uses software to model lake dynamics, including the causes and effects of eutrophication.

Kevin J. Boyle's research evaluates the best methods for economists to measure the value people place on environmental resources. He develops hedonic property value models for this project, which investigate the relationship between water quality and home prices.

Michael G. Sorice investigates how and why people engage in pro-environmental behaviors, and why humans tend to prioritize short-term benefits over long-term sustainability. As part of this project, he studies civic engagement in the form of lake associations.

Nicole K. Ward studies human-freshwater interactions. She is particularly interested in the intersection of decisionmaking, land use, and water quantity and quality. In this project, she uses a lake ecosystem model to simulate water quality outcomes of land use decisions.

Kathleen C. Weathers studies the ways in which living organisms influence biogeochemical cycling, especially across multiple landscapes and systems. She leads this project's efforts to work closely with lake associations, and to communicate its results to related organizations.

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