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To what extent do psychological distance and knowledge mediate the impact of algae blooms on cultural ecosystem services in the Lake Champlain Basin?

Gemma L. Del Rossi

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Gemma Del Rossi

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Advisors:
Dr. Rachelle Gould, Assistant Professor, RSENR, University of Vermont
Dr. Brendan Fisher, Associate Professor, RSENR, University of Vermont
Kelly Hamshaw, Research Specialist, Lecturer, CDAE, University of Vermont

Abstract

This research examines the relationships between psychological distance and knowledge of blue green algae on cultural ecosystem services with the hope of understanding how to better incorporate these values into managing the issue of harmful blue-green algae blooms within Lake Champlain. A questionnaire was developed and conducted to characterize the relationships between the three concepts. I hypothesized there would be a significant relationship between both people's knowledge of algae blooms, their psychological distance from algae blooms, and the corresponding impact on cultural ecosystem services from Lake Champlain. In order to test this hypothesis, a mediation model was created and run to determine the relationship between the three variables. Although there was a significant relationship between psychological distance and CES, knowledge of blue-green algae blooms failed to significantly mediate the primary relationship, with the exceptions of the Bequest and Heritage variables. By understanding these relationships, one can better frame the tradeoff between valuable ecosystem services and environmental degradation in decision-making. Additionally, applying the concept of psychological distance to cultural ecosystem services can motivate individuals to take action against the collective problem of phosphorus management within the Lake Champlain Basin.

Keywords: Cultural ecosystem services, psychological distance, blue-green algae, knowledge, harmful algae blooms, mediation model

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INTRODUCTION

In my last four years living in Burlington, Vermont, I have become familiar with Lake Champlain through educational field trips, sunsets at Waterfront Park, swimming at North Beach, and kayaking and boating in South Hero. The lake has played a central role in my time here in Burlington and has contributed greatly to what I view as Burlington's sense of place. I receive many additional non-material benefits, or cultural ecosystem services (CES) from Lake Champlain. Cultural ecosystem services are defined as "ecosystems' contributions to the non-material benefits (e.g., capabilities and experiences) that arise from human–ecosystem relationships" (Chan, Satterfield & Goldstein, 2012, p. 9).

My personal experiences and interactions with Lake Champlain have undoubtedly increased my wellbeing. But how do we capture and quantify (or even qualify) these non-material benefits? That is a central question and issue within research on cultural ecosystem services. The goal of this research project is to further elucidate the CES people receive from Lake Champlain. Additionally, I want to illustrate how the ongoing issue of phosphorus management and harmful algae blooms (HABs) potentially threaten the flow of those services. Further, by understanding the CES individuals derive from Lake Champlain will lead to improved understanding of how to influence individual's decision-making and communication strategies that could improve collective phosphorus management across the basin.

Additionally, this study seeks to understand how psychological distance and knowledge of blue-green algae blooms relate to CES. Psychological distance is defined as "an index of how near or far from one's self a concept seems through temporal, geographic, social group and uncertainty dimensions" (Millarhouse, 2017). It is important to consider the impact of psychological distance on non-material benefits derived from ecosystems because it can be

linked to people's environmental motivations and behavior. If algae blooms are psychologically distant, then a person is less concretely connected to that particular concept. It is critical to determine the relationship of psychological distance of an environmental "bad" (HABs) and CES in order to understand how HABs impact individuals CES.

The importance of this research is that no one has studied the impact of psychological distance on cultural ecosystem services. Cultural ecosystem services can be values that are deeply held and personal, but are often left out of the decision-making sphere (Daniel et al., 2012). If we are better able to understand how to apply the concept of psychological distance and environmental behavior to cultural ecosystem services, it can lead to better informed decisions regarding environmental management of Lake Champlain.

The Lake Champlain Basin and the surrounding states of Vermont, New York and the province of Quebec have been struggling with phosphorus management and harmful blue-green algae blooms for several decades. In 2002, the U.S. EPA created a Total Maximum Daily Load (TMDL) for Vermont's segments of Lake Champlain to reduce phosphorus loading into the Lake (U.S. EPA, 2016). Despite the existing TMDL, in 2008 the Conservation Law Foundation (CLF) sued the EPA, claiming that Vermont failed to adequately reduce nutrient loading and that the TMDL was insufficient in addressing the issue (U.S. EPA, 2011). In 2011 the EPA rejected the Vermont TMDL and mandated a new TMDL be implemented that addressed the CLF's concerns (U.S. EPA, 2011). By 2016, a new phosphorus TMDL was implemented across Vermont's segments of Lake Champlain, and ongoing efforts are being made to meet the TMDL's goals (U.S. EPA, 2016).

I position this study in the context of blue-green HABs and phosphorus management within Lake Champlain as it is uniquely situated to relate individual's psychological distances

and existing knowledge of blue-green HABs with CES. My interest in both Lake Champlain and CES lead me to consider the following question: how do algae blooms impact the wellbeing and cultural ecosystem services people obtain from Lake Champlain? I will explore this relationship through relating CES to psychological distance and knowledge of blue-green HABs. In order to define these relationships, I conducted a questionnaire over the Summer and Fall of 2018 in Burlington, Vermont targeting residents of Vermont. Using the data gathered from the questionnaire, I ran a mediation model to determine the relationships between psychological distance and knowledge of blue green algae blooms and individual's cultural ecosystem services.

LITERATURE REVIEW

Ecosystem Services

The concept of ecosystem services (ES) was founded in the late 1970's as a way to increase public support of biodiversity conservation during a time of rapid growth in environmental awareness, support, and corresponding policies (Gómez-Baggethun et al., 2010; de Groot et al., 2010). The goal was to frame natural ecosystems in such a way that highlighted human dependency upon these ecosystems outside of resource provision and consumption (Gómez-Baggethun et al., 2010). It was not until the 1990's, however, that the concept of ES was mainstreamed with the growth of the academic field of ecological economics (de Groot et al., 2010).

The conversations existing around ecosystem services largely remained in the academic sphere until the publishing of the Millennium Ecosystem Assessment by the United Nations in 2005, which pushed this framework into environmental policy and decisionmaking (de Groot et al., 2010; Gómez-Baggethun et al., 2010). Gómez-Baggethun et al. (2010) argues that as use of this environmental framework became increasingly incorporated into political arenas ecosystem services as a concept have moved from "a pedagogical concept designed to raise public interest for biodiversity conservation, towards [sic] increased emphasis on how to cash ecosystem services as commodities on potential markets" (p. 1).

A great many definitions exist for the concept of ecosystem services. For example, Daily (1997) defined ecosystem services as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (p. 645), while Costanza et al. (1997) defined them as, "the benefits human populations derive, directly or indirectly, from ecosystem functions" (p. 645), and the Millennium Ecosystem Assessment (2005) defined them as, "the benefits people obtain from ecosystems" (as cited in Fisher, Turner

& Morling, 2009, p. 645). Additionally, Fisher et al. (2009) provide yet another definition of ecosystem services, stating: "ecosystem services include ecosystem organization or structure as well as process and/or functions if they are consumed or utilized by humanity either directly or indirectly" (p. 645).

From the multiplicity of definitions, a few common themes about ecosystem services emerge. First, they are characterized as a one-way flow of benefits to humans that contribute to wellbeing. Second, they are derived from ecosystem functions, which are the processes that govern the physical characteristics of the ecosystem (de Groot et al., 2010.) An ecosystem and its functions exist regardless of whether or not humans utilize it (Fisher et al., 2009). When humans directly benefit from an ecosystem function, however, it is then providing a flow of benefits from the said function (de Groot et al., 2002). de Groot et al. (2002) list 23 separate ecosystem functions and, in turn, relate them to the ecosystem processes and services they provide.

The Millennium Ecosystem Assessment (hereafter referred to as MA) also created the framework for grouping and classifying ecosystem services. The MA separated ecosystem services into four different categories: *provisioning services*, *regulating services*, *cultural services*, and *supporting services* (MA, 2005). The main objective of the MA was to classify and define these services and show how they contribute to human wellbeing in material and nonmaterial ways (Gómez-Baggethun et al., 2010). *Provisioning services* are the raw materials obtained from ecosystems, such as food, fiber, fresh water, and fuel (MA, 2005). These are the traditional consumptive services already incorporated into market models and valued using price mechanisms. *Regulating services* are the benefits obtained from the regulation of ecosystem processes such as air quality regulation, climate regulation, erosion control, disease and pest regulation, and pollination (MA, 2005). *Cultural services* are the immaterial benefits obtained

from ecosystems such as spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (MA, 2005). Finally, the MA classified *supporting services* as the services "necessary for the production of all other ecosystem services" (p. 40). Examples of supporting services include nutrient cycling, soil formation, and photosynthesis (MA, 2005).

A majority of research into ecosystem services has been through the lens of environmental valuation. From a land-use perspective, de Groot et al. (2010) argue valuation of is necessary in order to characterize how a potential change in land use will cause a corresponding change in multiplicity of ecosystem services provided by the existing ecosystem. Additionally, de Groot et al. (2010) and Fisher et al. (2009) argue ES should be characterized through valuation to fully account for all ecosystem services, not selected services in those "bundles" that might be favored by stakeholders. Further arguments for valuing ecosystem services include using it as an educational tool and to influence market transactions and corresponding human behavior (Fisher et al., 2009). The idea behind incorporating the ES framework into the market model is it helps account for positive externalities which are currently excluded from the market transaction (de Groot et al., 2010). By including these services, the price will more accurately reflect human value and relative scarcity of the service provided (Daly & Farley, 2010). This in turn will influence environmental decisionmaking and human behavior. Certain ecosystem services have been successfully valued in market schemes such as: carbon sequestration, habitat and biodiversity protection, and hydrological functions (Gómez-Baggethun et al., 2010).

Another way of valuing ecosystem services are through payment for ecosystem services schemes (PES), which are defined as "voluntary and conditional transactions over well-defined ecosystem services between at least one supplier and one user" (Gómez-Baggethun et al., 2010

p. 6). This compensates the stakeholder's opportunity cost of maintaining an ecosystem through funding from government financed programs, third parties, or private individuals (de Groot et al., 2010; Viglizzo et al., 2012). Further economic valuations include cost-benefit analysis (CBA), national wellbeing and income accounts through natural capital stocks, taxation, cost of restoration, and willingness to pay (WTP) (de Groot et al., 2010; Phelps et al., 2017).

Most ecosystem services, however, are difficult to fit into a market model because they are considered public goods, which generally cannot be managed with conventional market techniques (Phelps et al., 2017). There are many critiques of solely valuing ecosystem services using market methods. Ludwig (2010) and Viglizzi et al. (2012) argue there are many intrinsic values of a personal and social nature that are incompatible with economic valuation.

Non-monetary valuation includes mapping and visualizing ecosystems services, modelling changes in ecosystem services, and integrated cost-benefit analysis (de Groot et al., 2010). Further, Wainger et al. (2010) call for a "multi-objective optimization model," which is a non-monetary approach to valuing various tradeoffs between actions, concluding conceptual models can improve decision-making regarding land or natural resource management.

Cultural Ecosystem Services

As discussed earlier, the concept of ecosystem services has been defined in literature since the 1980s. It was not until the publishing of the Millennium Ecosystem Assessment (MA), however, that cultural ecosystem services (CES) described the "nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (MA, 2005, p. 40). Within this broad definition of nonmaterial benefits cultural ecosystem services are broken down and further defined. They are as follows: *cultural diversity* is the diversity of ecosystems being a factor in diversity of a

culture; *spiritual values* that are attached to an ecosystem; *knowledge systems* influenced by ecosystems that are developed by different cultures; formal and informal *education* from ecosystems; *artistic inspiration* in the form of art, music, or folklore; the *aesthetic* beauty found in various ecosystems; *social relations* that are established and influenced by ecosystems across cultures; one's *sense of place* or recognized features in the environment; *cultural heritage*, which is historically important landscapes or culturally important species; and finally *recreation*, defined as characteristics of an ecosystem where leisure activities can take place (MA, 2005).

Recently, there have been attempts to further expand the definitions of CES from the original definitions provided by the MA. Church et al. (2014) expanded the CES suite of definitions based on specific identities, experiences, and capabilities from ecosystems. Additional CES derived from Church et al. (2014) include belonging, rootedness, tranquility, escape, discovery, health, dexterity, and judgement. Gould et al. (2015) developed an interview protocol for eliciting a suite of CES asking questions regarding place value, heritage, nonphysical value of activities, spirituality, artistic inspiration, ceremony, education, and bequest/intergenerational services. Further, Gould & Lincoln (2017) argue that we should expand upon the definitions of CES to include ingenuity, life teaching, and perspective.

The ability to link a specific ecosystem function to improving a human's wellbeing, whether material or immaterial, is an essential characteristic of ecosystem services. Much of the research to date has described the links between CES and human wellbeing. Russell et al.'s (2013) review of ecosystems' nonmaterial contributions to wellbeing to date highlighted research that has been done linking human wellbeing to CES and identified gaps needing further research. For example, they found the published research "provides a rich set of examples of the importance of sacred places and the wilderness experience for the spirituality of some

individuals and groups" (Russell et al., 2013, p. 483). Further, they found research validating the idea of ecocentric identity, or that one's identity is formed by cultural activities found in ecosystems (Russell et al., 2013). Overall, they conclude that "connectedness to nature significantly predicts the participants' degree of life satisfaction and overall happiness and perspective-taking ability" (Russell et al., 2013, p. 491).

Additional examples of cultural ecosystem services contributing to human wellbeing include a study by Brown & Raymond (2007) that found individuals and communities with a strong sense of place or place attachment are able to distinguish more "landscape values" and have a higher quality of life than those with a weaker place attachment. A psychological study by Kaplan (2001) found those living in apartments with views of the natural environment had more "micro-restorative opportunities" which led to a greater sense of tranquility, relaxation, effectiveness, energy and satisfaction with the surrounding residential environment. Laband (2013) found that certain oak trees on Auburn University's campus are integral to a football ceremony and a shared sense of community which, as Laband argued, enriches life. Russell et al. (2013) conclude further academic research is needed to better identify the benefits of learning and inspiration from ecosystems as well as how ecosystem functions create flows of services to create a sense of identity, self-sufficiency and belonging.

Despite the amount of literature surrounding cultural ecosystem services, they have largely been ignored by the mainstream framework of ecosystem services, which has gained rapid popularity since the publishing of the Millennium Assessment (Satz et al., 2013). One reason why CES has been relatively neglected is due to current methods of environmental valuation, which generally focus on the quantifiable biophysical or economic metrics of certain

ecosystem services (Satz et al., 2013). Due to the complex, intangible nature of most CES, they are not easily characterizable and generally elude such assessment.

Furthermore, CES generally do not fit into the market paradigm unlike other ES such as provisioning or regulating services. Many cultural ecosystem services are considered pure public goods, unlike market goods, because they are nonrival and nonexcludable; nonrival means that one person's use does not prevent another from using it, and non-excludable means one cannot legally or feasibly prevent another person from using it or gaining access to the good, or in this case, ecosystem service (Daly & Farley, 2010; Fisher et al., 2009). Since many CES are defined as public goods, they do not fit into the traditional market framework, hence there is "under-provision by private property owners of valuable aesthetic environmental services…. because of the implied free rider problems. Cultural environmental services result from experiences shared with others" (Laband, 2013, p. 42). This concept applies to many other CES besides aesthetics.

The additional argument exists that CES should not be monetized for moral and/or ethical reasons (Ludwig, 2010). For example, how do you put a price tag on the value of a sacred forest to a local indigenous community? Or how one's identity is shaped by the surrounding ecosystem? Chan et al. (2012) argues that there is a need for alternative forms of valuation for CES because there needs to be a way to capture the ethical, political, or spiritual aspects alongside the economic ones for a more comprehensive decision making regarding natural resource issues. Daniel et al. (2012) propose that CES are largely absent from the framework because of their transdisciplinary nature and consequently fall into other fields. Fields related to CES include, but are not limited to, anthropology, economics, traditional ecological knowledge, psychology, religious studies, sociology, geography, and natural resources (Gould, 2013).

Cultural ecosystem services tend to be left out of the decision-making realm due to difficulties in valuing them. There are, however, many convincing arguments as to why cultural ecosystem services need to be explicitly recognized in policy. Satz et al. (2013) makes an ethical argument for incorporating CES in policy: "ignoring the cultural services that ecosystems provide excludes considerations that often matter to vulnerable and otherwise underrepresented communities" (p. 676). Those underrepresented communities are often the ones who bear the brunt of negative externalities regarding damage done to ecosystem functions (Fisher et al., 2009). For underrepresented communities who are often low income, values generated by CES are an important part in "peoples' sense of their own lives," (p. 681) and are often the product of generations of interactions by people and their surrounding environment (Satz et al., 2013).

Daniel et al. (2012) believe CES contribute to public support for ecosystem protection and conservation. Further arguments for incorporating CES into policy include educational purposes (i.e. to make people more aware of the interconnectedness of the social-ecological system), decisions regarding place attachment and land-use change, and to give decisionmakers a comprehensive analysis of the potential impacts of a decision outside the common cost-benefit analysis framework (Fisher et al., 2009; Brown & Raymond, 2007; Daniel et al., 2012).

A common trend is using GIS and participatory mapping to convey cultural ecosystem services, which can then be used to influence policy decisions. As Brown & Raymond (2007) state in their study on place attachment, mapping landscape values can provide enough context to decision makers to minimize conflict in land use planning. Mapping can give context as to how the ecosystem is valued by various stakeholders without necessarily using monetary valuation. Other suggested methods include ecosystem-based management (EBM), integrated conservation schemes, and payment for ecosystem services (PES) (Chan et al., 2012). Daniel et al. (2012)

recommends both qualitative and quantitative methods of valuation for incorporating into policy such as focus groups, participatory scenario planning, surveys, economic valuation techniques (willingness-to-pay, hedonic pricing, travel-cost methodology, etc.). In doing this, the hope is to "forge more explicit links between social and ecological systems and to improve the integration of knowledge from scientists, policy makers, and stakeholders" (Daniel et al., 2012).

Psychological Distance

Psychological distance is a theoretical concept that has been developed over the last several decades in conjunction with the construct of Construal Level Theory (hereafter referred to as CLT). It was largely developed through the work of Trope & Liberman (2003; 2010). CLT is a psychological construct regarding how individuals view the world using mental models, and is the underlying theory of psychological distance. They theorize that individuals view the world through construals which represent varying levels of abstraction or concreteness of events or ideas. Higher-level construals represent abstract features that convey the basis of the event, idea, or occurrence. Conversely, low-level construals represent concrete, defined details surrounding the particular occurrence (Trope & Liberman, 2003). Depending upon which level construal individuals view a particular idea or event, the psychological distance individuals perceive these events from changes.

According to CLT, "people use increasingly higher levels of construal to represent an object as the psychological distance from the object increases" (Trope & Liberman, 2010, p. 3). Therefore, more concrete, detailed events and ideas (low-level construals) are less psychologically distant than highly abstract, conceptual ideas (higher-level construals). There are four different dimensions of psychological distance: temporal, spatial, social, and

hypothetically/uncertainty (Tope & Liberman, 2010). Each dimension can have different psychological distances depending on the event and personal experience.

Psychological distance can be found in a variety of academic literature; its roots are in psychology, but this theoretical construct has been applied to the fields of decision-making behaviors, risk analysis and communication, and climate change. In her study of risk communication and psychological distance, Millarhouse (2017) argues a smaller psychological distance creates a stronger emotional response to threats, which could encourage individuals to take preventative actions to reduce the perceived threat. McDonald et al.'s (2015) literature review suggests decreasing psychological distance increases personal concern for the issue/event at hand depending on the severity of the event. They find highly severe or threatening events, when combined with increased psychological distance, may be more effective at promoting action-oriented behaviors. However, Pronin et al. (2008) find that when perceived events are more psychologically distant, they are less likely to influence decision-making, since it is our "future selves or others who will experience them" (p. 233).

In the environmental field, most research on psychological distance has been in regards to individual's perceptions of climate change and climate resilience. In their seminal work, Spence et al. (2012) found overall lower levels of psychological distance was strongly related to higher levels of concern when surveying residents of Britain. Likewise, a study conducted in the U.S. found not only a strong positive relationship between decreased psychological distance and concern about climate change, but also the decreased distance increases individual's support for climate adaptation policies (Singh et al., 2017).

Environmental psychology research conducted by Sacchi et al. (2016) further confirmed the relationship by climate change psychological distance and environmentalism (pro-

environmental behaviors). They additionally found that an analytical cognitive style related strongly to the psychological distance of climate change; whereas those with a holistic cognitive style (think on a global scale) had a further psychological distance from climate change and were less likely to take pro-environmental behaviors. In their literature review of psychological distance and climate change, McDonald et al. (2015) identified several common themes of research. First, when climate change is perceived as psychologically distant, individuals could either view it as a high level construal, impeding action-oriented behavior, or it can lead to a holistic perspective, leading individuals to realize the need for immediate action (McDonald et al., 2015). However, the study concludes that as climate change impacts are going to be increasingly felt, individual's psychological distance will be forcefully reduced and hopefully motivating increased action.

Despite the wealth of research on the psychological distance of climate change, very little research has been done in other environmental fields, including pollution and water quality (Zhang et al., 2014). Zhang et al. (2014) conducted perhaps the only study looking at the impacts of psychological distance on pollution and water quality. They argue that water pollution is subject to high dimensions of uncertainty, costs borne by other people, and impacts of pollution that cannot be forecast ahead of time, making the topic area very applicable to be studied under the lens of psychological distance. When comparing the different dimensions – social, temporal, geographic, and uncertainty – of psychological distance the researchers found that temporal distance was not significant in respondent's assessment of the severity of water pollution, but when psychological distance increased for uncertainty and social dimensions, the pollution was assessed as less severe (Zheng et al., 2014). Further, they found the most significant dimension

of psychological distance was uncertainty in having individuals assess the severity of water pollution.

Algae Blooms in Lake Champlain

Harmful algae blooms (HABs) blooms occur across many aquatic ecosystems - from the red tide along the beaches of Florida to blue-green algae blooms in Vermont. Cyanobacteria are small bacteria that occupy water bodies and only become HABs when there is a proliferation of the bacteria due to certain conditions, causing a "bloom" to occur and creating a visible presence in the water (Lake Champlain Basin Program, 2018a). The HAB events that occur in Vermont are blue-green algae blooms, and when they occur, the surface of the water becomes coated with a thick, green "pea soup" substance.

There are a variety of causes and conditions that form HABs. Certain biophysical characteristics such as shallow lakes and bays, large basin catchment areas to lake volume, and accessibility of benthic nutrients create a disposition towards HABs (Isles et al., 2015). Other lake conditions such as vertical stratification, salinization, warmer water temperatures, and high nutrient loading all create strong conditions for the presence of HABs (Chapra et al., 2017; Isles et al., 2015; Paerl & Huisman, 2008). Nutrient loading in Lake Champlain is a major cause of HABs occurrence; as phosphorus is a limiting factor for cyanobacteria growth, when more nutrients enter the water body they are more likely to grow rapidly into a bloom (Lake Champlain Basin Program, 2018a).

When HABs do occur there are a variety of impacts to the ecosystem as well as human health. HABs lead to a loss in water clarity, which suppresses the growth of both plant and animal aquatic life (Chapra et al., 2017). As algae grows into a bloom and eventually decomposes, reduced dissolved oxygen content and can lead to aquatic "dead-zones" where no

plant or animal life can survive from the lack of oxygen (Heisler et al., 2008). From a human health perspective, "cyanobacterial algal toxins were also responsible for nearly half of all reported waterborne disease outbreaks in U.S. untreated recreational freshwater in 2009 and 2010" (Chapra et al., 2017, p. 8933). HABs impact aesthetic and recreational activities, and can even reduce the property values of homes where they occur (Chapra et al., 2017, Lake Champlain Basin Program, 2018a).

Further, climate change is likely to exacerbate the impacts and frequency of cyanobacteria HABs in the coming decades. A study by Chapra et al. (2017) model the impact of climate change on HAB scenarios across the United States and find the Northeastern U.S. will be the hardest hit. Within Lake Champlain, Zia et al. (2016) find that cyanobacteria HAB increased for all climate change scenarios modelled within their research. They conclude that current management efforts under the U.S. EPA TMDL may be inadequate in the face of climate change.

In the last few decades Lake Champlain and the surrounding states (Vermont, New York, and the province of Quebec) have been struggling to manage blue-green algae blooms caused not only by the biogeochemical conditions within the lake but the excess of nutrient loading into the basin as well. Isles et al. (2015) argue the largest contributor to eutrophic conditions caused by HABs within Lake Champlain is the nutrient loading, especially of phosphorus, from the agricultural sector. Zia et al. (2016) further expand upon this, stating that "changes in agricultural activity resulting from evolving socio-economic pressures have resulted in increased nutrient loads to the lake" (p. 2). Additionally, the high basin catchment area to lake volume poses significant challenges in limiting nutrient loading, as land-based activities have an outsized impact on Lake Champlain (Lake Champlain Basin Program, 2018a).

Due to the ongoing issues of phosphorus management and HABs, in 2002 the U.S. EPA implemented a Total Maximum Daily Load (hereafter referred to as TMDL) on segments of Lake Champlain for phosphorus pollution (Lake Champlain Basin Program, 2018b; U.S. EPA, 2016). A TMDL is defined as an "estimate of the amount of a pollutant that a body of water can receive without impairing vital uses, such as drinking water supply or support of aquatic life" (Lake Champlain Basin Program, 2018b, n.p.). However, in 2008 the Conservation Law Foundation (CLF) sued the U.S. EPA for the 2002 TMDL having inadequate waste load allocations and margin of safety, and failing to consider the impacts of nutrient loading with climate change (U.S. EPA, 2011). By 2011, the U.S. EPA disapproved the Vermont TMDL and mandated the creation of a new one (U.S. EPA, 2016; U.S. EPA, 2011). In 2016 the U.S. EPA approved a new TMDL for 12 segments of Lake Champlain, and management efforts have been underway since to reduce the nutrient loading into the waterbody.

GOALS AND OBJECTIVES

The goal of this research is to apply the concept of psychological distance and knowledge of blue-green HABs to cultural ecosystem services in order to better inform decisions regarding environmental management of Lake Champlain. To draw these connections, the questions motivating this research are as follows:

1. How do algae blooms impact the wellbeing and cultural ecosystem services people obtain from Lake Champlain?
    a. To what extent does individuals' psychological distance from algae blooms impact people's cultural ecosystem services from Lake Champlain?
    b. To what extent does individuals' knowledge of algae blooms impact the cultural ecosystem services people derive from Lake Champlain?

To test these research questions, the following hypotheses were developed:

$H1_a$: There are significant relationships for *both* people's knowledge and psychological distance of algae blooms in predicting the corresponding impact on cultural ecosystem services from Lake Champlain.

$H2_a$: There is a significant relationship between people's CES from Lake Champlain and their knowledge of algae blooms.

$H3_a$: There is a significant relationship between people's CES from Lake Champlain and their psychological distance of algae blooms.

$H1_0$: There is no relationship between people's knowledge of algae blooms and their psychological distance from algae blooms, and cultural ecosystem services.

$H2_0$: There is no relationship between people's CES and knowledge of algae blooms.

$H3_0$: There is no relationship between people's CES and their psychological distance from algae blooms.

METHODS

Questionnaire Design

In order to capture the impacts of algae blooms on individual's CES, a questionnaire was developed using previously validated questionnaires from other studies (Spence et al., 2012; Bryce et al., 2016; Gould et al., 2014). Permission to adopt each survey for the purpose of this project was granted by all corresponding authors. Since there has been no research to date looking at CES from a psychological distance lens, sections of several questionnaires were integrated into the survey instrument used for this project. To see the full list of survey questions initially developed, please see Appendix A. From this beginning list, questions were selected based on their applicability to the research project and formatted into two pilot questionnaires; one pilot containing a "True/False" section, while the other question contained a short written free response section. The pilot questionnaires were conducted in the summer of 2018 on 10 individuals with varying levels of familiarity on the subject matter. Of the two pilot options, participants responded more favorably to the pilot questionnaire containing the free response section in terms of question clarity. Additionally, I felt the free response yielded more interesting and meaningful data than the "True/False section." Other changes to the pilot questionnaires were regarding word choice and formatting, which were integrated into the final questionnaire (Appendix B.1).

The questionnaire is broken into four separate sections. To see the questionnaire codebook, please refer to Appendix C. The first question, 1a. and 1b. screen individuals on their familiarity with blue-green algae blooms and are included in the knowledge index (discussed below). If the respondent answers "NO" to both 1a. and 1b. then their questionnaire was not included in the analysis. Questions 2 and 3 address individuals' psychological distance to blue-green algae blooms. This set of question ask individuals to rank statements using a 7-point Likert

scale ranging from "strongly disagree" to "strongly agree," for geographic, social, and uncertainty distances, and "never" to "we are already feeling the effects," for temporal distance. Each statement addresses a different metric of psychological distance (geographic, social, uncertainty, and temporal, respectively). Individuals who score lower (e.g. 1, 2, 3) are more psychologically "distant" than those who score higher (e.g. 5, 6, 7) who are psychologically "closer" to algae blooms. These questions were averaged to come up with a psychological distance "index" per respondent.

The goal of Question 4 is to elicit respondents' true knowledge of blue-green algae blooms. By having the sub-questions be free-response, individuals are less likely to be biased or primed towards a particular answer but can instead list their knowledge about blue-green algae blooms. This question addresses individuals' baseline knowledge of algae blooms by asking people freely respond. The aim of this question is for individuals to attempt to identify land-based causes of algae blooms (e.g. runoff or pollution), lake-based causes of algae blooms (e.g. still water, shallow bays, or warm temperatures), and identify health risks they may have heard about (e.g. gastro-intestinal issues or rashes).

From the free-response questions I coded individual's self-reported knowledge of algae blooms. Following a standard coding process, I began by identifying a large list of potential themes, and then reorganized these codes into larger common themes. From there, I re-examined and re-coded the knowledge themes into final knowledge themes for each sub-question within Question 4. To see the full coding analysis and justification, please see Table 1. The knowledge "index" will be created by summing 1a., 1b., (both coded 1 or 0 for YES/NO) and the short-answer responses thematically coded as 1 = theme present, 0 = theme absent.

Table 1. Thematic coding for blue-green algae knowledge index of respondents.

Theme	Codes	Definition	Intermediate codes	Beginning codes
Land conditions that cause blue-green algae blooms:	Agricultural Sources	Agricultural sources are defined as causes from farms or farmland that cause nutrient loading as a factor contributing to blue-green algae blooms.	Agricultural Runoff	-Farming
				-Runoff from farms
				-Livestock in streams
	Nutrients & Runoff	This is defined as when respondents specifically identify particular nutrients or runoff contributing to blue-green algae. All of the intermediate codes contribute to nutrient loading, which was why they were grouped together.	Nutrients	-Phosphorus, nitrogen
				-Nutrient loading
				-Fertilizer
			Runoff	-Excess rainwater
				-Inadequate drainage
				-Runoff
			Soil Erosion	-Soil erosion
				-Lack of vegetated buffers
	Pollution (on own)	Pollution on its own is considered a category because it shows the respondents have a bit of knowledge that something negative contributes to blue-green algae, but they weren't able to specifically define it beyond general terms.	Pollution (on own)	-Contaminated
				-Pollution
				-Toxins
				-Waste
	Urban Sources	Urban sources are defined as when respondents specifically identified manmade causes that contribute to nutrient loading (outside of agricultural activities) that are largely due to urban populations and development.	Urban Runoff	-Storm-water
				-Lawns
				-Roadway residue
				-Infrastructure/ industry
				-City runoff
			Sewage	-Waste-water treatment

				-Sewer
				-Sewage
	Lake Conditions	This is a category as respondents would mistakenly identify lake conditions instead of land-based activities as a cause for blue-green algae blooms. Rather than marking it as incorrect, we grouped these responses together broadly according to the lake conditions coding below.	Lake Conditions	See lake conditions below.
Lake conditions that cause blue-green algae blooms:	Climate Change & Warming	This category of knowledge is grouped together as respondents identified warming (whether it be the air/climate/water) as a factor contributing to lake conditions causing blue-green algae blooms.	Warmer Air Temperatures	-High temperatures
				-Sunny days
				-Heat
				-Warm waters
				-Global warming
	Lack of Wind	Enough respondents specifically identified calm water, due to a lack of wind, as a category causing blue-green algae blooms that we grouped these responses together.	Lack of Wind	-Calm winds
				-Calm water
				-Lack of wind
	Lake Conditions	We broadly grouped lake conditions into a major theme because this exhibited respondents having an in-depth amount of knowledge as to the specific lake conditions causing blue-green algae blooms. They were able to specifically identify a biophysical lake factor contributing towards B/G algae.	Lake Conditions	-Lake patterns
				-Stratification
				-Smaller bays
				-Poor circulation
				-Low/shallow waters
				-Stagnant water/still water
	Land conditions	This is a category as respondents would mistakenly identify land-based activities instead of lake conditions as a cause for blue-green algae blooms. Rather than marking it as incorrect, we grouped these responses together broadly according to the land-based activities coded above.	Land Conditions	See land conditions listed above.

Health impacts of blue-green algae are:	Neurotoxins	This group is defined as specific neurological degenerative diseases caused by blue-green algae blooms. These are grouped together because it exhibits a specific, in-depth, knowledge about the health impacts of blue-green algae separate from more physical illnesses.	Neurotoxins	-Parkinson's
				-ALS
				-Neurotoxins
	Specific health issue	I grouped these into three separate sub-categories since responds provided many distinct responses for the health effects of blue-green algae blooms. Additionally, by identifying a health impact more specific than general illness this shows the respondent has a slightly greater understanding and knowledge of blue-green algae blooms.	Skin Irritations	-Rashes
				-Skin irritation
				-Allergic reactions
			GI Issues	-Ingestion
				-Stomach problems
				-Nausea
				-Vomiting
				-Diarrhea
				-Fever
			Respiratory issues	-Breathing issues
				-Respiratory issues
				-Cough
	Sickness (general)	This is defined a theme because it shows the respondents have a bit of knowledge that blue-green algae has a negative health impact, but they weren't able to specifically define it beyond general terms.	Sickness (general)	-Sickness (general)
				-Illness
				-Unsafe to drink
				-Diseases (general)
Wrong answers	Wrong	For each of three knowledge themes, there were a manner of incorrect answers. We define wrong as either they do not cause blue-green algae blooms (even if they contribute to other lake water-quality concerns) or are not a health impact of blue-green algae.	Biologically incorrect	-Invasive species
				-Dying/dead fish
				-Dogs
				-Bacteria

			Not a cause of blue-green algae	-CO2
				-pH Balance
				-Pesticides
				-Salt on road/salt runoff
			Not a health impact	-Toxic Air
				-E coli
				-Cancer
				-Death
I don't know	I don't know	If the respondents said they had heard of blue-green algae, but were unable to respond to the knowledge questions, many put I don't know, unsure, or left the question blank. All of these (including non-responses) are coded as "I don't know."	I don't know	-Unsure
				-Left blank
				-I don't know

The next set of statements address a suite of CES. Respondents are again asked to rank statements using a 7-point Likert scale ranging from "strongly disagree" to "strongly agree." Each statement corresponds with a particular CES. Individuals who score lower (e.g. 1, 2, 3) have relatively "weaker" CES derived from Lake Champlain than those who score higher (e.g. 5, 6, 7) and thus have "stronger" CES. Listed below are the CES questions and what concept they represent (Bryce et al., 2016; Gould et al., 2014).

Visiting Lake Champlain clears my head. - *Reflection*
Lake Champlain makes me feel part of something greater than myself. - *Spirituality*
Lake Champlain feels almost like a part of me. - *Identity*
I feel a sense of belonging by Lake Champlain. - *Sense of place*
There are places in/near Lake Champlain that remind me of past events or past experiences that are important to me or my community. - *Heritage*
Lake Champlain helps me learn about nature. - *Education/knowledge*
Lake Champlain helps me to make or strengthen bonds with other people. - *Social bonds*
There are particular experiences associated with Lake Champlain that I hope my kids and/or kids in my community will experience. - *Bequest*
I have felt touched by Lake Champlain's beauty. - *Aesthetics*

Lake Champlain has provided me with ideas or images for what some people might call art. - *Artistic inspiration*

Data Collection Process

Data collection occurred from August 2018-October 2018 within the city of Burlington, Vermont. The questionnaire was administered in person in public spaces across the city. The sample locations included Burlington's Waterfront Park, Fletcher Free Library, and City Hall Park. Each location was selected due to its varying proximity from the waterfront (one right on Lake Champlain, two a further distance away), and the diversity of potential respondents.

I screened potential respondents by asking if they were residents of Vermont or lived in Vermont at this present time. This was to ensure I was not surveying tourists visiting Burlington from out of state to reduce any potential bias. If the participant responded they were a Vermont resident, I asked for their informed consent (in addition to providing an information sheet; see Appendix B.2), briefly explained the context of my research, and proceeded to administer the survey in-person.

The sampling method using for this research was quota sampling, which is a form of nonprobability sampling (Fink, 1995). Quotas for age, gender, and race (white vs non-white) were created using the 2017 American Community Survey 1-Year Estimates provided by the U.S. Census Bureau. Please refer to Tables 2 and 3 to see the quotas set for Chittenden county (county in which Burlington is located).

Table 2. Quotas for Age based on the American Community Survey 1-Year Estimates for Chittenden County.

Age (18+)	Percent (%) of Total	Percent (%) of population that is female

18 to 24 years	19.50%	50.70%
25 to 34 years	17.81%	48.23%
35 to 49 years	21.09%	52.03%
50 to 64 years	23.99%	50.40%
65 years and older	17.62%	57.15%
Total	100.00%	51.60%

Table 3. Quotas for Race based on the American Community Survey 1-Year Estimates for Chittenden County.

Race	Percent (%) of Total
White, over 18	91.54%
Non-white, over 18	8.46%
Total	100.00%

Data Analysis

As the questionnaires were completed, they were entered into an Excel spreadsheet and the data were cleaned and coded as needed. Descriptive statistics were generated to determine demographic representation of the survey sample. The data was then transferred into IBM SPSS Statistics for Windows (Version 25.0) (IBM Corp., 2017) for further analysis.

In order to best analyze the data, I chose to run a mediation model, following the work of Baron & Kenny (1986), Kenny (2014), and Kenny (2018). Mediation is a simple path analysis that tests the relationship between two variables (psychological distance and CES), and then introduces a third variable (knowledge) as a mediator to determine the extent to which it influences the relationship between the primary independent and dependent variables. To see a diagram representing the mediation model applied to this project, please see Figure 1.

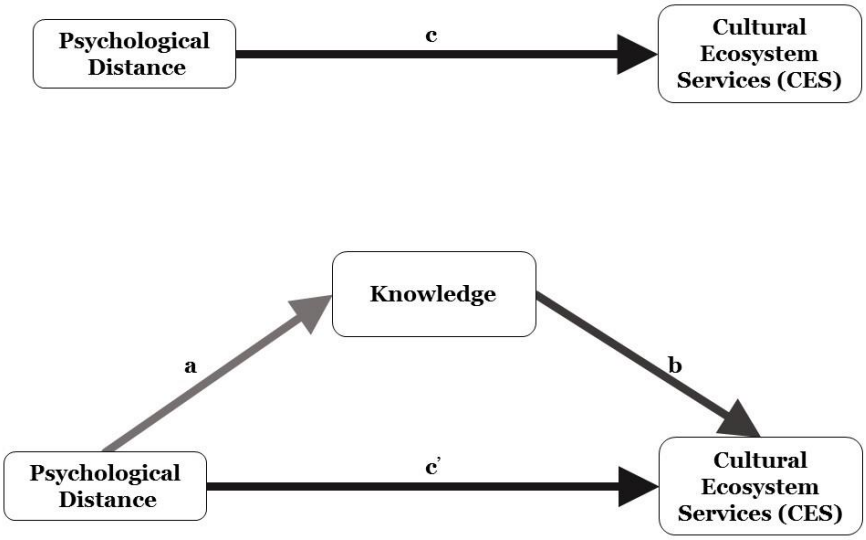

Figure 1. Diagram of the proposed mediation model showing the total effect between psychological distance and CES (path c), the indirect effects of psychological distance and knowledge (paths a and b), and the direct effect of psychological distance on CES mediated by knowledge (path c').

A major goal of using a mediation model is to show a causal path relationship between a suite of variables. If a significant relationship exists between two variables, one independent and one dependent (path c) then a mediation variable is introduced to see if there is a significant impact on the relationship between the primary variables. The pathway from the primary independent variable, psychological distance for the purpose of this research, to the dependent variable of interest (CES) is known as the total effect, or path c. When a mediator variable is introduced (knowledge), a suite of pathways are created to find the relationship between the independent variables, and the impact of the mediating variable on the dependent variable pathway. The path from psychological distance to knowledge is known as path a; the path from knowledge to CES is known as path b; and when the two are multiplied (a*b) we are presented with the indirect effect which is the amount of mediation occurring. The final pathway is from

psychological distance to CES with the indirect effect present and that is known as c', or the direct effect. In a mediation model, the pathways form the following formula:

$$c = c' + a*b \quad \textbf{OR} \quad \text{total effect} = \text{direct effect} + \text{indirect effect}$$

So in sum, the total effect from the primary independent variable to the dependent variable (path c) equals the total effect (path c') plus the indirect effect (paths a*b). The difference between the direct effect and the total effect (c and c')'s regression coefficients are how one tells if a significant mediation effect has occurred (Baron & Kenny, 1986). If c' = 0, then what is known as complete mediation has occurred (Kenny, 2018). If c' is not equal to zero but is a reduced coefficient from c, then what is known as partial mediation has occurred, or that the mediating variable "indicates the operation of multiple mediating factors" (Baron & Kenny, 1986, p. 1176).

To determine the mediation effects, bivariate correlations were conducted, as well as linear multiple regression analysis. Following these analyses, the Sobel Test of significance was conducted (Preacher & Leonardelli, 2018; Baron & Kenny, 1986; Sobel, 1982) to see if there was any significant mediation effect of the mediator variable (knowledge) on the dependent variables (CES). The results are detailed in the following section.

RESULTS AND OUTCOMES

Demographics Details

Overall, 110 surveys were distributed and filled out during the data collection process. Of the 110 surveys, 4 were left incomplete, 3 of which marked they had never heard of blue-green algae, and therefore are not included in the final sample of 106 respondents and the corresponding analyses. Of the 106 respondents (Table 4), 55 identified as female (51.89%), 2 identified as non-binary (1.89%), and the remaining 49 identified as male (46.22%). As seen from Table 2 in the methods section regarding quotas, the gender breakdown is close to representative. Respondents came from across Vermont, with the vast majority (86.8%) living within Chittenden County (Appendix D. Table F). When asked about race, a large majority identified as white (91.51%), with the remaining respondents identifying as other races (Table 5). This reflects Chittenden County's quota, but it is not representative of Vermont as the rest of the state is less diverse.

The largest age group of respondents fell under the age category of 50-64 years old (26.42% of the sample), followed by 18-24 years, and 25-34 years; 24.53% and 17.92%, respectively. Please refer to Table 4 for the full age and gender demographic quota. While this sample fails to reflect the demographics of Vermont as a whole, it accurately reflects the quota of Chittenden County, particularly when capturing the 25-34 years and 50-64 age range. I under sampled the 35-49 year old age range and oversampled the 18-24 years old. However, this sample largely reflects the demographic breakdown of Chittenden County, whose population over the age of 18 is 133,304.

There are several limitations of the quota sampling method. First, it is prone to bias as individuals self-select whether to engage with the questionnaire or not (Davies & Hughes, 2014; Fink, 1995). Additionally, one must be able to access up-to-date information and records to best

represent accurate proportions (Fink, 1995). Despite these limitations, the quota method for the purposes of this research was suitable and created an approximate representation of Chittenden County residents.

Table 4. Survey demographics relating to age.

	Sample Demographics			Chittenden County Demographics	
Age	**Number of respondents (n)**	**Percent (%) of total**	**Percent (%) of sample that is female**	**Percent (%) of Total**	**Percent (%) of population that is female**
18 to 24 years	26	24.53%	61.54%	19.50%	50.70%
25 to 34 years	19	17.92%	68.42%	17.81%	48.23%
35 to 49 years	18	16.98%	44.44%	21.09%	52.03%
50 to 64 years	28	26.42%	46.43%	23.99%	50.40%
65 years and older	15	14.15%	33.33%	17.62%	57.15%
Total	106	100.00%	51.89%	100.00%	51.60%

Table 5. Survey demographics relating to race.

	Sample Demographics		Chittenden County Demographics
Race	**Frequency**	**Percent (%) of total**	**Percent (%) of Total**
White, over 18	97	91.51%	91.54%
Non-white, over 18	9	8.49%	8.46%
Total	106	100.00%	100.00%

Mediation Model

Before creating the mediation model, bivariate correlations were run in order to ensure the data was suitable and had the presence of a mediation effect. This is determined by whether or not they are significantly correlated, which in turn signifies there is a "path" to create the model. Table 6 shows the bivariate correlations where psychological distance and knowledge are run as independent variables to all measures of CES.

Table 6. Testing for bivariate correlations between psychological distance, knowledge, the CES index, and all other independent measures of CES.

	Psychological Distance Index		**Knowledge Index**	
	Pearson Correlation	**Sig. (2-tailed)**	**Pearson Correlation**	**Sig. (2-tailed)**
Psychological Distance Index	1	-	.468**	0
Knowledge Index	.468**	0	1	-
CES Index	.298**	.002	.246*	.011
Reflection	.237*	0.015	.241*	0.013
Spirituality	0.139	0.156	0.058	0.557
Identity	0.131	0.182	0.168	0.085
Sense of Place	.193*	0.048	0.152	0.119
Heritage	.204*	0.036	.276**	0.004
Education	.282**	0.003	0.176	0.07
Social Relations	.242*	0.013	0.179	0.066
Bequest	.267**	0.006	.310**	0.001
Aesthetics	.387**	0	.251**	0.009
Artistic Inspiration	.217*	0.025	0.053	0.591

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The three main indices, psychological distance, knowledge, and CES index all correlated significantly with each other. This signifies that there is a significant path effect from each variable, creating the possibility for a mediation effect. When broken down, different dimensions of CES are not significantly correlated and therefore will not create a mediation effect. Those that are not significantly correlated with psychological distance are Spirituality ($p = 0.156$) and Identity ($p = 0.182$). CES dimensions that are not significantly correlated with knowledge are Spirituality ($p = 0.557$), Identity ($p = 0.085$), Sense of Place ($p = 0.119$), Education ($p = 0.07$), Social Relationships ($p = 0.066$), and Artistic Inspiration ($p = 0.591$). As these variables are not significantly correlated, a complete mediation pathway cannot form and they are therefore not included in the following analyses.

Using the remaining dependent variables (CES Index, Reflection, Heritage, Bequest, and Aesthetics), I ran multiple regressions to create a mediation model following the work of Kenny (2014; 2018) in IBM SPSS for Statistics. The final mediation model is presented in Figure 2. It is important to remember that while correlation coefficients might be individually significant, the main focus of statistical significance to see how much the mediator reduces the correlation between c and c' using the Sobel Test.

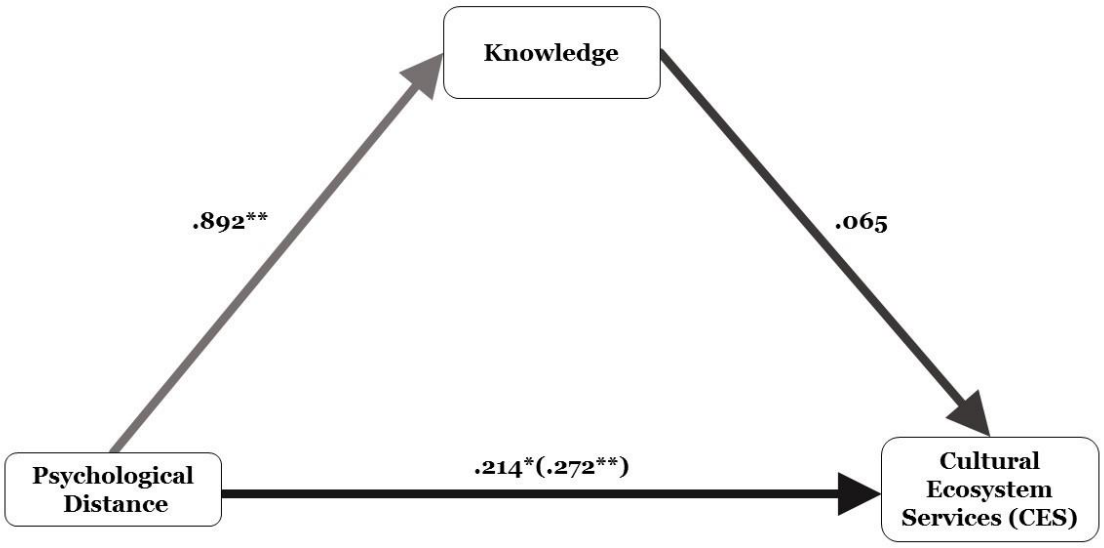

Figure 2. Diagram of mediation model results. Total effects = 0.272** (path c), direct effects = 0.214* (path c'), indirect effects = .892** and .065 (paths a and b, respectively).

As one can see, there was a slight mediation effect from knowledge by reducing the correlation coefficient of c to c' from 0.272 to 0.214. There is a strongly correlated coefficient between psychological distance and knowledge (path a), and a weak correlation from knowledge to CES (path b). To get these path effects, I followed the work of Kenny (2014; 2018) and Baron & Kenny (1986) who defined four steps in a mediation model. First, one has to run regressions for path c to determine the total effect of psychological distance on CES. The results of step one (determining path c) are found in Table 7.

Table 7. Total effects of the psychological distance index predicting the following CES (path c).

Dependent Variable	**B**	**Std. Error**	**Significance**	**95% CI**		**R^2**
				Lower Bound	Upper Bound	
CES Index	.272	.085	.002**	.102	.441	.089

(Constant)	4.369	.508	.000	3.361	5.377	-
Reflection	.257	.615	.015*	.052	.462	.056
(Constant)	4.746	.103	.000	3.527	5.964	-
Heritage	.288	.135	.036*	.019	.556	.042
(Constant)	4.300	.806	.000	2.702	5.898	-
Bequest	.283	.100	.006**	.084	.481	.071
(Constant)	4.668	.596	.000	3.486	5.851	
Aesthetics	.253	.059	.000**	.136	.370	.150
(Constant)	5.115	.352	.000	4.418	5.813	-

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

All of the regression coefficients for path c are statistically significant. Of all the dependent CES variables being tested, Aesthetics has the strongest R^2 value, with 15% of the variation being correlated with psychological distance. Heritage overall has the strongest relationship path to psychological distance, with a correlation coefficient of 0.288.

The next outlined step is to determine the regressions between psychological distance and knowledge, the two dependent variables to form path a, a partial indirect effect. Table 8 outlines the regression results for path a. Knowledge and psychological distance are strongly related. The R^2 value for regressing path a explains 21% of the variation of knowledge correlated with psychological distance. The correlation coefficient is highly significant ($p = 0.000$), and $B = 0.892$, suggesting potential multicollinearity of the variables psychological distance and knowledge.

Table 8. Partial indirect effect of psychological distance predicting knowledge as an outcome (path a) for the mediation model.

Dependent Variable	B	Std. Error	Significance	95% CI		R^2
				Lower Bound	Upper Bound	
Knowledge Index	.892	.165	.000**	.565	1.220	.219
(Constant)	-.869	.984	.379	-2.820	1.082	-

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Path b, or step three, is predicted by running a multiple regression with knowledge and psychological distance as independent variables with CES dimensions as the dependent variable, with a specific focus on the correlation coefficient of knowledge acting on CES. Table 9 details the results of this partial indirect effect.

Table 9. Partial indirect effect of knowledge (path b) in predicting the following CES.

Dependent Variable	B	Std. Error	Significance	95% CI		R^2
				Lower Bound	Upper Bound	
CES Index	.065	.050	.200	-.035	.165	.103
(Constant)	4.425	.509	.000	3.417	5.434	-
Reflection	.095	.061	.123	-.026	.215	.078
(Constant)	4.828	.613	.000	3.612	6.043	-
Heritage	.171	.079	.032*	.015	.328	.083
(Constant)	4.449	.795	.000	2.873	6.025	-
Bequest	.132	.058	.025*	.017	.248	.115
(Constant)	4.783	.587	.000	3.619	5.947	-
Aesthetics	.031	.035	.383	-.039	.100	.156
(Constant)	5.142	.354	.000	4.441	5.843	-

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Of all correlations, knowledge had the strongest relationship with Heritage (B = 0.171). For the overall CES index, there is a weak and statistically insignificant correlation between knowledge CES (B = 0.065). Specific CES variables that were statistically significant when regressed by the knowledge index are Heritage (p = 0.032) and Bequest (p = 0.025), respectively. Of all variables, knowledge had the strongest R^2 value in predicting Aesthetics, with the regression correlating with 15.6% of the variation within the data.

The final step details the results of path c', or the impact of psychological distance on CES when mediated by knowledge. Results were generated from a multiple regression with psychological distance and knowledge. To see the direct effect results, please refer to Table 10.

Table 10. Direct effects of psychological distance on CES, mediated by knowledge (path c').

Dependent Variable	**B**	**Std. Error**	**Significance**	**95% CI**		**R^2**
				Lower Bound	Upper Bound	
CES Index	.214	.096	.029*	.023	.405	.103
(Constant)	4.425	.509	.000	3.417	5.434	-
Reflection	.172	.116	.141	-.058	.403	.078
(Constant)	4.828	.613	.000	3.612	6.043	-
Heritage	.135	.151	.372	-.164	.433	.083
(Constant)	4.449	.795	.000	2.873	6.025	-
Bequest	.165	.111	.141	-.056	.385	.115
(Constant)	4.783	.587	.000	3.619	5.947	-
Aesthetics	.226	.067	.001**	.093	.359	.156
(Constant)	5.142	.354	.000	4.441	5.843	-

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

As previously discussed, the correlation coefficient for path c' with the CES index is slightly smaller than path c, suggesting a mediation effect did occur. Whether the mediation was significant, however, is yet to be determined. Of all dependent variables, psychological distance had the strongest correlation with Aesthetics (B = 0.226) that was highly significant (p = 0.001). All dependent variables tested had a reasonably strong relationship with knowledge with B > 0.1. Since Tables 9 and 10 were generated from the same multiple regression, Aesthetics again has the largest R^2 value of 15.6%. As compared to Table 7, or the total effect, all dependent CES variable correlations were reduced when psychological distance was mediated by knowledge in this regression.

Now that the results for the mediation model are generated, the Sobel test can be performed to determine if statistically significant mediation occurs when knowledge was introduced into the regression. Table 11 presents the results of the Sobel test.

Table 11. Sobel Test of mediation significance

Dependent Variable	Test Statistic	Std. Error	P-value
CES Index	1.2639	0.0458	0.2062
Reflection	1.4965	0.05662	0.1345
Heritage	2.0094	0.0759	0.0444*
Bequest	2.0975	0.0561	0.0359*
Aesthetics	0.8740	0.0316	0.3820

* Correlation is significant at the 0.05 level (2-tailed).

As one can see, there was no significant mediation by knowledge when regressed on psychological knowledge and the CES index. Significant mediation did occur on the variables of

Heritage ($p = 0.0444$) and Bequest ($p = 0.0359$). This means the knowledge index reduced the correlation from psychological distance to these particular CES dimensions. Of all the CES tested, Aesthetics had the smallest test statistic when the Sobel test of mediation was performed and hence also had the largest p-value.

To see the frequencies of the knowledge index, as well as descriptive statistics for each measured variable, please refer to Appendix D.

Decomposition of effects

Another approach to showing the impact of mediation is by breaking down the effects and explaining how the indirect effects explain a portion of the total effect. Recall from the methods that the formula stating the relationship of a mediation model is as follows:

$$c = c' + ab$$

By isolating the indirect effects generated by the model, one can explain the mediation occurred using the following formula:

$$(ab/c) * 100$$

Where the indirect effect (ab) is divided by the total effect and multiplied by 100, which generates the percentage of the total effect explained by the mediator. Following this logic, I calculated the decomposition percentages of knowledge explaining the relationship to the overall CES Index, as well as the Bequest and Heritage, as the Sobel test proved them to be statistically significant.

When the CES Index is the dependent variable, the introduction of knowledge as a mediator explained 21.32% of the total effect of the regression from psychological distance to CES. Comparing that decomposition effect to the two significant mediation effects that occur on Bequest and Heritage, however, highlights the strength of mediation. For psychological distance

regressed on Bequest, knowledge as a mediator explained 52.96% of the total effect. Whereas, for psychological distance regressed on Heritage, knowledge explained 41.61% of the total regression. The variable most insulated from knowledge's mediation was Aesthetics, with knowledge only explaining 10.93% of the relationship. Decomposing the effects to explain the total effect is another useful way to understand how a third variable, knowledge, can augment the relationship between psychological distance and CES.

Additional Results

To address the second hypothesis, additional regressions were run between knowledge of blue-green HABs and cultural ecosystem services to determine their relationship without the influence of psychological distance. The results are detailed in Table 12.

Table 12. Regressions of knowledge acting on CES.

Dependent Variable	**B**	**Std. Error**	**Significance**	**95% CI**		**R^2**
				Lower Bound	Upper Bound	
CES Index	.118	.045	.011*	.027	.208	.060
(Constant)	5.452	.215	.000	5.026	5.877	-
Reflection	.137	.054	.013*	.030	.244	.058
(Constant)	5.656	.255	.000	5.149	6.163	-
Heritage	.204	.070	.004**	.066	.342	.076
(Constant)	5.097	.329	.000	4.444	5.750	-
Bequest	.173	.052	.001**	.070	.275	.096
(Constant)	5.575	.245	.000	5.089	6.060	-
Aesthetics	.086	.033	.009**	.022	.151	.063
(Constant)	6.227	.154	.000	5.922	6.532	-

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

There is a significant linear relationship between knowledge and several CES dimensions. Overall, the relationship between knowledge and the CES index is significantly correlated at B = 0.118 (p = 0.011). However, the R^2 value is relatively small, with knowledge as an independent variable only regressing approximately 6% of the variability within CES. Other significant relationships between knowledge of blue green algae blooms and CES dimensions are Reflection, Heritage, Bequest, and Aesthetics, with Bequest being the most significant (p = 0.001). However, knowledge has the largest correlation coefficient with Heritage, which is the largest of all CES dimensions.

Hypothesis Testing

The goal of conducting this research was to determine whether the hypotheses I generated regarding knowledge of algae blooms, psychological distance, and cultural ecosystem services are validated. The main hypothesis, $H1_a$, predicted there would be a significant relationship between *both* people's knowledge of algae blooms, their psychological distance from algae blooms, and the impact on cultural ecosystem services from Lake Champlain. The validity of this hypothesis was tested using the mediation model.

When looking at just the bivariate correlations (see Table 6), there is a statistically significant relationship between CES, psychological distance, and knowledge of blue-green HABs. If I were to base my project off the bivariate correlations, I would reject $H1_0$ in favor of $H1_a$. What bivariate correlations do not show, however, is how the three variables are related to one another and causal impacts, which is where the mediation model is useful.

As the mediation model characterizes linear pathways among the three variables, both the direct and the indirect effect pathways need to be significant, as well as the mediation effect of knowledge, to reject the null hypothesis in favor of the alternative hypothesis. While there is a significant relationship between cultural ecosystem services and psychological distance (p = 0.029*), there is not a significant linear relationship between the CES index and knowledge (p = 0.200). Additionally, the mediation effect knowledge has on the relationship between CES and psychological distance is not significant (p = 0.206). For these reasons, I ultimately fail to reject null hypothesis $H1_0$.

The CES variables of Bequest and Heritage had significant bivariate correlations with both knowledge and psychological distance. Knowledge played a significant mediation effect on the relationship between psychological distance and these two variables. Interestingly, Bequest and Heritage (when regressed by both psychological distance and knowledge) had a significant relationship with knowledge (p = .025*, p = .032*), but not psychological distance (p = .141, p = .372). Additionally, both of these dimensions were statistically significant when knowledge was introduced as the mediator on the relationship between Bequest or Heritage and psychological distance. Despite the significant mediation effect, I still fail to reject null $H1_0$ hypothesis, as the relationship between both knowledge and psychological distance failed to be significant.

After characterizing the relationship between both knowledge and psychological distance on CES, I wanted to evaluate the individual impact of each directly. $H2_a$ predicts there is a significant relationship between people's CES from Lake Champlain and their knowledge of blue-green algae blooms. According to the mediation model, there is not a significant relationship between knowledge and CES overall. However, when looking at knowledge regressed directly onto the CES index (Table 12), we see there is a significant relationship (p

= .011*). Within specific CES dimensions, knowledge significantly correlates with Reflection, Heritage, Bequest, and Aesthetics. Therefore, the null $H2_0$ is rejected.

My final hypothesis, $H3_a$, tests the direct relationship between CES and the psychological distance of algae blooms. Within the mediation model, there is a significant relationship with both path c (p = .002**) and path c' (p = .029*) when psychological distance is regressed on CES. Additionally, all CES dimensions used in the mediation model are statistically significant when regressed by psychological distance (Table 7) for path c, but only Aesthetics is statistically significant (p = .001**) when regressed by psychological distance with knowledge mediating the relationship. So for the overall CES Index, the null $H3_0$ is rejected in favor of the alternative hypothesis. When looking specifically at the total effect, the null $H3_0$ for all CES dimensions can also be rejected. However, when evaluating the relationship between psychological distance and specific CES mediated by knowledge, the null $H3_0$ hypothesis can only be conclusively be rejected for Aesthetics. This suggests that Aesthetics was the variable most insulated from knowledge's mediation effect.

DISCUSSION

As shown from the decomposition effects detailed in the results, knowledge explains 21.32% of the relationship between psychological distance and CES, which itself is a significant relationship. Understanding these relationships, while not statistically significant using the mediation model, is useful because it explains *how* the three variables are related, rather than simply stating the strength of relationships. Bequest and Heritage, the two significant dimensions in the mediation model, were better explained by knowledge than by psychological distance. This is significant because it highlights knowledge of blue-green algae blooms strongly influences these dimensions for individuals. For example, one who knows a lot about Lake Champlain and blue-green HAB's influence on the ecosystem may feel strongly about the water quality for future generations. Conversely, Aesthetics was least influenced by knowledge and most determined by psychological distance. Those with the highest psychological distance scores had a concrete, detailed view of Lake Champlain (psychologically "close") and therefore can explain strong aesthetic connections to Lake Champlain.

It is also worthwhile to look at the relationship between knowledge of algae blooms and psychological distance. As Table 8 shows, there is a strong and significant linear relationship between psychological distance and knowledge (B = .892, p = .000**), stronger than both the relationship between CES and psychological distance, and CES and knowledge. The strength of their relationship in a multiple regression analysis suggests potential multicollinearity, which is when two or more variables are very highly correlated or because a variable is a function of several others (Shieh, 2010).

While multicollinearity can be a sign both variables are attempting to explain the same variance, I argue that the relationship between knowledge and psychological distance is essential

collinearity, where "multicollinearity exists because of actual relationships between predictor variables" (Shieh, 2010, p. 484). Therefore, the mediation model predicts that decreasing the psychological distance from blue-green algae blooms increases the knowledge individuals have surrounding the impacts of blue-green algae blooms on Lake Champlain.

Cultural ecosystem services often revolve around highly important values we as individuals hold, so it is important to understand what influences them. Characterizing the relationship between the psychological distance of blue-green algae, knowledge, and a suite of cultural ecosystem services helps answer that primary question. This research helps further the CES research agenda by bringing in a new academic concept – psychological distance – and applying it to the ecosystem services framework.

Additionally, this helps us understand what intangible values individuals hold most important to them regarding Lake Champlain, and attempting to value and explain them helps "explain what might be gained or lost through our management of ecosystems" (Gould & Lincoln, 2014, p. 123). This research brings to the forefront the value of nonmaterial benefits that Lake Champlain brings to people and can potentially motivate individuals to take action against the blue-green HABs by highlighting the values that are being threatened by the pollution occurring within Lake Champlain.

As previously discussed, Bequest and Heritage were the two CES variables that were the most significant, according to the mediation model. Outside the mediation model, both of these dimensions were significantly related with both psychological distance and knowledge independently. This further confirms the importance of these two specific CES to individuals as Gould et al. (2014) found.

Interestingly, Heritage denotes a strong attachment to a place's history or cultural values, whereas Bequest is a desire to pass on a healthy or significant ecosystem for future generations to enjoy. This could suggest that individuals strongly associate with Lake Champlain and its ecosystem as not only important for its cultural and historical value, but also to pass along those values to the next generation. For some, the past experiences had with Lake Champlain were strong enough for individuals to want their children or grandchildren to experience them.

This research also has implications for motivating individuals to engage in collective action to stop a complex issue. As McDonald et al. (2010) state, "the impacts of distance on motivational relevance may change when the collective nature of required actions means that the efficacy of an individual action may be easily undermined" (p. 115). Therefore, individuals may be motivated to take action to solve the collective problem of harmful blue-green algae blooms when psychological distance is decreased.

Additionally, Daniel et al. (2012) finds cultural ecosystem services often contribute to raising public support for ecosystem protection. I found there to be a significant relationship between psychological distance of blue-green algae blooms and cultural ecosystem services, so I argue this relationship not only encourages public support of ecosystem protection but could also motivate individuals into taking action on phosphorus management. Understanding the link between decreasing psychological distance and CES connections can help motivate individuals to act for the betterment of the whole socio-ecological system.

An individual's existing knowledge of blue-green algae blooms has not been extensively studied, so this research is useful in creating a gauge for what people understand about blue-green algae blooms and how they impact our ecosystems. As shown through my results, knowledge of blue-green algae blooms are strongly related to bequest and heritage services. The

more people know about the ecosystem they live in and interact with, the stronger the connection in the form of nonmaterial benefits. This connection has been well documented in academic areas such as traditional ecological knowledge (Daniel et al., 2012; Russell et al., 2013).

The relationship between knowledge and psychological distance is also important to consider. As psychological distance to blue-green algae blooms decreases, individual knowledge of the causes and impacts the blooms have on our health and ecosystems increases, as the results show. Decreasing psychological distance causes details to be more concrete, easily visualized, and accessible, leading to an increased understanding of what blue-green algae blooms consist of and the potential threat they have to the ecosystem of Lake Champlain. In understanding this relationship, there is potential frame outreach and risk communication surrounding blue-green algae blooms in such a way that decreases psychological distance to not only increase knowledge but increases motivation to take pro-environmental action (Millarhouse, 2017).

Finally, this research contributes to incorporating cultural ecosystem services into the broader ecosystem services framework and environmental decision-making. I was able to characterize which CES individuals view as important, and what underlying variables (psychological distance and knowledge) influence them. Further, in identifying these CES, the tradeoff between cultural ecosystem services and environmental degradation from harmful blue-green algae blooms and phosphorus pollution becomes clear. One can frame this as a communication tool for decision-making as blue-green algae blooms being a threat to important nonmaterial values we hold surrounding Lake Champlain. This framing, when combined with an understanding of psychological distance and knowledge, can potentially be used to encourage individual actions to address phosphorus runoff and blue-green algae blooms within this socio-ecological system.

CONCLUSION

While the mediation model failed to significantly explain the relationships between knowledge, psychological distance, and cultural ecosystem services overall, other important results were elicited from this research. Despite these shortcomings, using mediation as a model was a useful tool in explaining to what extent knowledge explained relationship between psychological distance and CES. There was found to be a significant mediation effect of knowledge of blue-green algae blooms on the relationship between psychological distance and the variables Bequest and Heritage. There is a significant relationship with psychological distance and CES, especially Aesthetics, which was most isolated from the mediation effect of knowledge. Further, there is a strong direct relationship between knowledge and psychological distance of blue-green algae blooms.

Understanding which cultural ecosystem services individuals feel most strongly regarding Lake Champlain is important as it furthers the ecosystem services agenda by aiding in emphasizing the tradeoffs between strong nonmaterial ecosystem services and environmental degradation from harmful blue-green algae blooms. Linking psychological distance to cultural ecosystem services can help link strongly felt, intangible values to taking concrete action on an issue that poses a threat to those values. Additionally, increasing knowledge about blue-green algae by decreasing psychological distance can serve to encourage individuals to take action against phosphorus pollution and blue-green algae blooms, which is a collective problem.

As this study's findings are not generalizable outside of Chittenden County and Vermont, more research should be conducted to further understand the link between psychological distance and cultural ecosystem services in different geographic locations. Future research should try to expand upon how and to what extent environmental degradation (e.g. pollution) influences CES,

as this research was unable to capture the link between blue-green algae blooms and CES. Additionally, a valuable contribution in the field of ecosystem services and environmental psychology could be looking into how to translate nonmaterial values from ecosystems in risk communication and framing to encourage pro-environmental behavior and actions. While this study could not specifically the address areas for further research, it successfully applied two novel frameworks, psychological distance and cultural ecosystem services, to better understand tradeoffs of an ecological issue within a complex socio-ecological system.

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APPENDICES

APPENDIX A: Full List of Potential Survey Questions

Construct	Survey Question	Measurement	Source
PD Geographic	"My local area is likely to be affected by blue-green algae blooms."	5-point Likert scale	Spence et al., 2012; 2010
PD Geographic	"Blue-green algae blooms will mostly affect areas that are far away from here."	5-point Likert scale	Spence et al., 2012; 2010
PD Social	Blue-green algae blooms will mostly affect other people.	5-point Likert scale	Spence et al., 2012; 2010
PD Social	Blue-green algae is likely to have a big impact on people like me.	5-point Likert scale	Spence et al., 2012; 2010
PD Temporal	"When, if at all, do you think Vermont will start feeling the effects of blue-green algae blooms?"	7-point scale (We are already feeling the effects–Never)	Spence et al., 2012; 2010
PD Uncertainty	"Thinking about the causes of blue-green algae blooms, which, if any, of the following best describes your opinion?"	6-point scale (Entirely natural processes–Entirely human activity)	Spence et al., 2012; 2010
PD Uncertainty	"I am uncertain that blue-green algae blooms are happening."	5-point Likert scale	Spence et al., 2012; 2010
PD Uncertainty	"The seriousness of blue-green algae blooms is exaggerated."	5-point scale	Spence et al., 2012; 2010
PD Uncertainty	"It is uncertain what the effects of blue-green algae blooms will be."	5-point scale	Spence et al., 2012; 2010
Knowledge	"Have you heard of blue-green algae?"	Yes or no	Nierenberg et al., 2010
Knowledge	"Blue-green algae are caused by tiny plankton"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms are naturally occurring"	True/False	Larkin & Adams, 2008
Knowledge	"The causes of blue-green algae are well known"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms occur mostly during fall "	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms only occur in Vermont"	True/False	Larkin & Adams, 2008

Knowledge	"Blue-green algae blooms begin in rivers and near the beach"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms never occurred until recently"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms can be predicted with total accuracy"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms never last longer than 1-2 weeks"	True/False	Larkin & Adams, 2008
Knowledge	"Locally caught fish and other aquatic species are safe to eat during a blue-green algae bloom"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae toxin is in the water and in the air"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms causes lasting health problems for people"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms can be controlled by chemical treatments"	True/False	Larkin & Adams, 2008
Knowledge	"Blue-green algae blooms only affect people in the water or on the beach"	True/False	Larkin & Adams, 2008
Knowledge	"It is safe for humans to swim in a blue-green algae bloom"	True/False	Larkin & Adams, 2018
CES Reflection	"Visiting Lake Champlain clears my head."	5-point Likert scale	Bryce, et al., 2016
CES Reflection	"I gain perspective on life during my visits to Lake Champlain."	5-point Likert scale	Bryce, et al., 2016
CES Connection to nature	"Visiting Lake Champlain makes me feel more connected to nature."	5-point Likert scale	Bryce, et al., 2016
CES Spirituality	"At Lake Champlain I feel part of something that is greater than myself."	5-point Likert scale	Bryce, et al., 2016
CES Identity	"Lake Champlain feel almost like a part of me."	5-point Likert scale	Bryce, et al., 2016
CES Sense of Place	"I feel a sense of belonging by Lake Champlain."	5-point Likert scale	Bryce, et al., 2016
CES Transformative values	"I've had a lot of memorable experiences in/around Lake Champlain."	5-point Likert scale	Bryce, et al., 2016

CES- Sense of Place/ Identity	"I miss Lake Champlain when I have been away from them for a long time."	5-point Likert scale	Bryce, et al., 2016
CES Knowledge	"Visiting Lake Champlain has made me learn more about nature."	5-point Likert scale	Bryce, et al., 2016
CES Social bonds	"I have made or strengthened bonds with others through visiting Lake Champlain."	5-point Likert scale	Bryce, et al., 2016
CES Participation	"I feel like I can contribute to taking care of Lake Champlain."	5-point Likert scale	Bryce, et al., 2016
CES Aesthetics	"I have felt touched by the beauty of Lake Champlain."	5-point Likert scale	Bryce, et al., 2016
CES Appreciation	"Lake Champlain inspires me."	5-point Likert scale	Bryce, et al., 2016
CES Health	"Visiting Lake Champlain leaves me feeling more healthy."	5-point Likert scale	Bryce, et al., 2016
CES Freedom	"Visiting Lake Champlain gives me a sense of freedom."	5-point Likert scale	Bryce, et al., 2016
CES Identity	"You identify strongly with Lake Champlain."	5-point Likert scale	Gould et al., 2014
CES Heritage	"There are places in/near Lake Champlain that remind you of past events or past experiences that are important to both you and your community."	5-point Likert scale	Gould et al., 2014
CES Spirituality	"You have a spiritual connection with Lake Champlain."	5-point Likert scale	Gould et al., 2014
CES Education	"You feel that Lake Champlain can teach you things."	5-point Likert scale	Gould et al., 2014
CES Artistic inspiration	"Lake Champlain has provided you with ideas or images for what some people might call art or some other visual or creative form."	5-point Likert scale	Gould et al., 2014
CES Bequest	"There are particular experiences associated with Lake Champlain that you hope your kids and/or kids in your community will experience."	5-point Likert scale	Gould et al., 2014

APPENDIX B.1: Final Questionnaire

Thank you in advance for your time!

1a. Have you heard of blue-green algae? 1b. What about cyanobacteria?
YES NO **YES NO**

If YES to 1a. or 1b., continue on onto question 2-4. If NO, please skip to question 5.

2. The following statements have to do with your perceptions of blue-green algae in Lake Champlain. Please circle the response that best matches how you feel.

My local area is likely to be affected by blue-green algae blooms.	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Blue-green algae is likely to have a big impact on people like me.	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I am sure that there are blue-green algae blooms in Vermont.	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

3. The following statement has to do with your perceptions of blue-green algae in Lake Champlain. Please circle the answer that best matches your perception.

When, if at all, do you think Vermont will start feeling the effects of blue-green algae blooms?	Never	Beyond the next 100 years	In the next 100 years	In the next 50 years	In the next 25 years	In the next 10 years	We are already feeling the effects

4. The following statements ask you some questions about blue-green algae. Please answer to the best of your knowledge.

What are some of the conditions on land that cause of blue-green algae blooms?

_____

_____

What are some lake conditions that cause blue-green algae blooms?

_____

_____

Human health problems from blue-green algae blooms that I might have heard about are:

_____

_____

5. The following statements describe possible connections with Lake Champlain. Please circle the response that best matches how you feel.

Being near Lake Champlain clears my head.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
Lake Champlain makes me feel part of something greater than myself.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
Lake Champlain feels almost like a part of me.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
I feel a sense of belonging when near Lake Champlain.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
There are places in/near Lake Champlain that remind me of past events or past experiences that are important to me or my community.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
Lake Champlain helps me learn about nature.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
Lake Champlain helps me to make or strengthen bonds with other people.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
There are particular experiences associated with Lake Champlain that I hope my kids and/or kids in my community will experience.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
I have felt touched by Lake Champlain's beauty.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
Lake Champlain has provided me with ideas or images for what some people might call art.	Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

6. A bit about you

Age: _____

Gender: _____

Race/Ethnicity: _____

County where you live: _____

Thank you for your time! Please list any additional thoughts and/or comments in the space below.

APPENDIX B.2: IRB Information Sheet

The following information sheet was attached to every survey in accordance with IRB guidelines:

Research Project Information
Algae blooms, non-material values and Lake Champlain
Researcher: Gemma Del Rossi (University of Vermont)

Description: This research study explores the links between algae blooms, and the aesthetic, cultural, recreational, spiritual, and other values you associate with Lake Champlain. Participation in this study will involve a short survey about algae blooms, and your perceptions and values of Lake Champlain along with collection of general demographic information about you. Your responses will be recorded in writing.
Time Involvement: I anticipate that your involvement will require 3-7 minutes.
Risks and Benefits: There are no foreseen risks to you
Confidentiality: All of your responses are completely confidential. Only the researchers conducting this study will have access to the information you provide. We are not collecting any identifying information.
Voluntary Participation: Participation in this study is completely voluntary. You are free to decline to participate, to end participation at any time for any reason, or to refuse to answer any individual question.
Contact Information: If you have any questions about this study, you may contact Gemma Del Rossi (student PI) at 315-261-9901 or gdelross@uvm.edu, or Rachelle Gould (faculty advisor) at rachelle.gould@uvm.edu.
Independent contact: If you have any questions about your rights as a research participant or concerns about the conduct of this study, you may contact the UVM Human Subjects Research Committee at 1-802-656-5040. You may also visit their website at http://www.uvm.edu/irb/?Page=participant.html.

APPENDIX C. Questionnaire Codebook

Q#	Question	Code	Response	Numerical Label
1a.	1a. Have you heard of blue-green algae?	know_intrA	YES/NO	YES = 1 NO = 0
1b.	1b. What about cyanobacteria?	know_intrB	YES/NO	YES = 1 NO = 0
2.	The following statements have to do with your perceptions of blue-green algae in Lake Champlain. Please circle the response that best matches how you feel.		7 point Likert Scale	Strongly disagree = 1 Disagree = 2 Somewhat disagree = 3 Neither agree nor disagree = 4 Somewhat agree = 5 Agree = 6 Strongly agree = 7
	My local area is likely to be affected by blue-green algae blooms.	pd_geo		
	Blue-green algae is likely to have a big impact on people like me.	pd_soc		
	I am sure that there are blue-green algae blooms in Vermont.	pd_uncert		
3.	The following statement has to do with your perceptions of blue-green algae in Lake Champlain. Please circle the answer that best matches your perception		7 point Likert Scale	Never = 1 Beyond the next 100 years = 2 In the next 100 years = 3 In the next 50 years = 4 In the next 25 years = 5 In the next 10 years = 6 We are already feeling the effects = 7
	When, if at all, do you think Vermont will start feeling the effects of blue-green algae blooms?	pd_temp		
4.	The following statements ask you some questions about blue-green algae. Please answer to the best of your knowledge.		Short Open-ended	Please see Table 1 for thematic coding
	What are some of the conditions on land that cause of blue-green algae blooms?	alg_land		

	What are some lake conditions that cause blue-green algae?	alg_lake		
	Human health problem from blue-green algae that I have heard about are:	alg_healt		
5.	The following statements describe possible connections with Lake Champlain. Please circle the response that best matches how you feel.		7 point Likert Scale	Strongly disagree = 1 Disagree = 2 Somewhat disagree = 3 Neither agree nor disagree = 4 Somewhat agree = 5 Agree = 6 Strongly agree = 7
	Visiting Lake Champlain clears my head.	ces_refl		
	Lake Champlain makes me feel part of something greater than myself.	ces_spirit		
	Lake Champlain feels almost like a part of me.	ces_ident		
	I feel a sense of belonging by Lake Champlain.	ces_sop		
	There are places in/near Lake Champlain that remind me of past events or past experiences that are important to me or my community.	ces_heri		
	Lake Champlain helps me learn about nature.	ces_edu		
	Lake Champlain helps me to make or strengthen bonds with other people.	ces_soc		
	There are particular experiences associated with Lake Champlain that I hope my kids and/or kids in my community will experience.	ces_bequ		
	I have felt touched by Lake Champlain's beauty.	ces_aesth		
	Lake Champlain has provided me with ideas or images for what some people might call art.	ces_art		

APPENDIX D. Descriptive Statistics

Table 1. Frequencies recorded for coded answers to the question "What are some of the conditions on land that cause of blue-green algae blooms?"

Category	Frequency	Percent (%)
Agricultural Sources	35	20.23
Nutrients & Runoff	52	30.06
Pollution (on own)	17	9.83
Urban Sources	26	15.03
Lake Conditions	18	10.40
I don't know	17	9.83
Wrong/incorrect	8	4.62
Total	173	100.00

Table 2. Frequencies recorded for coded answers to the question "What are some lake conditions that cause blue-green algae?"

Category	Frequency	Percent (%)
Climate Change & Warming	56	39.16
Lack of wind	3	2.10
Lake conditions	19	13.29
Land conditions	28	19.58
I don't know	24	16.78
Wrong	13	9.09
Total	143	100.00

Table 3. Frequencies recorded for coded answers to the statement "Human health problem from blue-green algae that I have heard about are: …"

Category	Frequency	Percent (%)
Neurotoxins	3	2.48
Specific Health Issues	38	31.40
Sickness (general)	17	14.05

I don’t know	45	37.19
Wrong	18	14.88
Total	121	100.00

Table 4. Descriptive Statistics for the three main indices: psychological distance, knowledge, and cultural ecosystem services.

Index	Number of respondents	Minimum	Maximum	Mean	Std. Deviation
Psychological Distance Index	106	2.50	7.00	5.8781	.93613
Knowledge Index	106	1	9	4.38	1.786
CES Index	106	3.20	7.00	5.9660	.85400

Table 5. Descriptive Statistics for all observed indices: psychological distance dimensions, knowledge dimensions, and cultural ecosystem services.

Index Dimensions	Number of respondents	Minimum	Maximum	Mean	Std. Deviation
PD Geographic	106	1	7	5.58	1.518
PD Social	106	1	7	5.25	1.346
PD Uncertainty	106	1	7	6.17	1.183
PD Temporal	105	1	7	6.53	1.020
Knowledge Land Conditions	106	0	3	1.38	.889
Knowledge Lake Conditions	106	0	3	.99	.750
Knowledge Health Impacts	106	0	2	.55	.554
CES Reflection	106	2	7	6.25	1.015
CES Spirituality	106	2	7	6.06	1.085
CES Identity	106	2	7	5.14	1.630
CES Sense of Place	106	2	7	5.67	1.336

CES Heritage	106	2	7	5.99	1.320
CES Education	106	3	7	5.95	1.055
CES Social Relations	106	2	7	5.81	1.266
CES Bequest	106	2	7	6.33	.993
CES Aesthetics	106	5	7	6.60	.612
CES Artistic Inspiration	106	1	7	5.85	1.420

Table 6. Descriptive statistics showing the spatial distribution of respondents from the questionnaire.

County	Frequency	Percent (%)
Addison	3	2.8%
Bennington	1	0.9%
Chittenden	92	86.8%
Grand Isle	3	2.8%
Lamoille	2	1.9%
Orleans	2	1.9%
Washington	3	2.8%
Total	106	100%