The Perceived Threat of Aquatic Invasive Species: Exploring the Influence of Social Norms and the Social Perception of Threat on Public Attitudes Towards (Un)Controversial Scientific Issues

by

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Dedication

This dissertation is dedicated to my parents, Richard and Judy Heinrich, and my stepmother, Denise Heinrich.

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Abstract

Using invasive species as the contextual background, this dissertation explores the social factors that influence how people make decisions about science issues. The main idea that underpins this dissertation is that effective science communication is contingent upon understanding the beliefs, values, attitudes, and norms of the general public. Without such an understanding, science communication is merely the dissemination of information. Moreover, understanding the psychological forces underpinning the public's attitudes towards science issues enables science communicators to craft more effective messaging, outreach efforts, or intervention strategies.

In Chapter 2, this dissertation explores factors that influence how lakeshore property owners in Wisconsin perceive chemical management of aquatic invasive species (AIS). In this chapter, psychosocial factors like emotion, trust, and perceived presence of AIS are explored as influences on homeowners' preferences for chemical management strategies. Understanding why homeowners may prefer to use chemical management strategies is particularly important given that these methods, while effective, could have unintended consequences for native plant and animal species.

In Chapter 3, this dissertation extends the findings from Chapter 2 by directly comparing the influence of the perceived presence of invasive species to the actual presence of invasive species in a homeowner's lake. Using natural resources data obtained from the Wisconsin Department of Natural Resources, it is revealed that the actual presence of invasive species has no statistically significant influence on whether people prefer to use chemical treatment options. Rather, the perceived presence of AIS exerts the greatest influence on preference for chemical treatment.

In Chapter 4, this dissertation discusses the role of social norms in shaping how people think about management of invasive species. Using data derived from a statewide survey of Wisconsin boaters and anglers, it is discovered that, across all dependent variables, social approval is one of the most significant factors influencing how people think about invasive species management and prevention.

Table of Contents

List of Abbreviations

AIS	Aquatic Invasive Species
IS	Invasive Species
WDNR	Wisconsin Department of Natural Resources
FAO	Food and Agriculture Organization of the United Nations

Chapter 1: Introduction

Despite what many in the general public might consider a relatively low-profile issue, invasive species pose a serious problem, both in the United States and globally. In North America, for instance, invasive species have been estimated to have cost the North American economy some $1.26 trillion between 1960 and 2017, with annual costs estimated to have risen to $26 billion per year in the 2010s (Crystal-Ornella et al., 2021). The United States had the highest recorded overall costs associated with invasive species, with $1.21 trillion in economic output lost to invasive species from 1960-2017 (Crystal-Ornella et al., 2021). While many of these costs are agricultural (Leistritz, Bangsund & Hodur, 2004), others, such as the zebra mussel (*Dreissena polymorpha*) can cause economic damages by blocking intake pipes in power generation plants or water treatment facilities (Rosaen, Grover & Spencer, 2016). The United States Department of Agriculture has also noted that, while only a subset of introduced species become invasive, those that become invasive can cause significant economic damage (Warziniack et al., 2021) and costs associated with aquatic invasive species specifically were estimated to be about $14.69 billion from 1960-2017 (Crystal-Ornella et al., 2021).

Additionally, the Food and Agriculture Organization of the United Nations (FAO) released a report detailing the impacts of climate change on the spread of invasive species and the future risks to agriculture, biodiversity, and human health (IPPC Secretariat, 2021). In particular, the FAO notes that, as the climate warms in some areas and cools in other areas, these changes can have substantial impacts on the ability of invasive species to establish themselves in areas where they are not wanted and could pose significant risks to agricultural capacities, particularly in the developing world. At the same time, there is growing interest in the human and social dimensions of invasive species, with researchers increasingly interested in

understanding the ways in which individuals and communities perceive invasive species and how they feel about particular methods of control (e.g., Kueffler, 2010; Woolford et al., 2016; Eiswerth et al., 2011). Indeed, people's attitudes towards invasive species and their eradication are often informed by social factors, such as whether a particular methodology is convenient or easy for individuals or communities to employ (Aslan et al., 2009), or based on personal values or beliefs (e.g., Lake, 2009).

This dissertation further explores the social factors influencing decision making about invasive species among a hitherto understudied population: lakeshore property owners in the U.S. state of Wisconsin. Effective science communication hinges on a detailed and nuanced understanding of the various social factors and motivations informing people's decision-making on scientific issues. With a comprehensive level of such knowledge, science communicators are better able to craft detailed, salient, messaging and reach out to impacted communities more effectively. Indeed, the data upon which this dissertation is based is derived from such an effort, yet the implications of this research extend beyond state and local issues to science issues more broadly. Wisconsin lakeshore property owners are in an interesting, yet unfortunate, position with regards to invasive species in that they are not primarily responsible for the introduction or dissemination of invasive species throughout waterways in the state (Rothlisberger, Chadderton & McNulty, 2010; Witzling, Shaw & Seiler, 2016), yet they must deal with the consequences of invasive species introduced by others. Additionally, lakeshore property owners dealing with invasive species infestations must frequently engage in community decision making and collaborative group effort to effectively manage invasive species outbreaks. Indeed, the incentive to do so is significant, as invasive species have been found to significantly reduce property values (Horsch & Lewis, 2009; Johnson & Meder, 2013; Zhang & Boyle, 2010). Consequently,

community-based decision making can often be highly influenced by social factors like social norms and social identity, so this population represents an interesting context with which to study the social influences on environmental management decisions.

This dissertation threads together literatures on risk perception, environmental management, and social psychology to understand how people perceive and evaluate threats invasive species may pose, and what implications this may have as a result of a changing climate. The issue of invasive species represents a suitable avenue for this vein of inquiry because, as of yet, invasive species, unlike climate change, is not considered by many to be a politically contentious issue. Additionally, it also offers the opportunity to better understand how individuals make decisions in situations with relative uncertainty with regards to "best practices." Unlike COVID-19, for example, in which a series of mitigation recommendations are issued by the U.S. Centers for Disease Control and Prevention (CDC), what is considered a "best practice" for invasive species depends on the lake ecosystem, the type of invasive species being treated and, more pragmatically, money. Fluoridone for example, a common chemical used to treat invasive species, has been found to have initial success in reducing invasive species density though invasive species often reappear after several years, thus requiring further treatments that can have negative impacts on native plant species (Mikulyuk et al., 2020). Other research has found that some aquatic invasive species can develop a resistance to fluoridone (Gettys & Leon, 2021), suggesting a need for caution when considering these treatment types.

While some may argue that economic losses or scientific information demonstrating environmental harm is sufficient motivation for individuals to participate in invasive species control measures, I argue that, in fact, social factors are often *more* important than scientific facts when it comes to understanding human behavior. Indeed, there are often situations in which an

individual's perception of reality is more salient than the "on the ground" reality in terms of how people make decisions (explored in more depth in Chapter 2). In the sections below, I provide some background information on key concepts that I will argue are crucial to understanding how people make decisions about scientific issues more broadly, and invasive species management specifically.

Threat Perception

The degree to which individuals view something as a threat depends on a multitude of factors, many of them unrelated to the actual threat of the object itself. Personal experience, for example, frequently influences an individual's assessment of risk through the "availability heuristic," in which information that is more easily accessible weighs more heavily in decision making (Johnson, 1983). The framing of an issue (Putnam, 1992) can impact the degree to which people consider something a threat by interacting with an individual's pre-existing values, which can then shift over time (Ho, Brossard, & Scheufele, 2008). Additionally, factors completely exogenous to environmental threat can significantly alter how individuals perceive an invasive species. Research has demonstrated, for instance, that individuals tend to avoid potentially lethal or harsher treatments for invasive species that are more aesthetically pleasing (i.e., have a high "cuddliness factor") compared to those that are less aesthetically pleasing (Verbrugge, Van den Born & Lenders, 2013. Additionally, there is often a discrepancy between what the lay public believes about risks posed by invasive or non-native species and what environmental management professionals assess the risks to be (Selge & Fischer, 2011), suggesting that members of the public use different criteria to assess environmental threat than those who are more academically or scientifically trained to do so. Moreover, people may view invasive

species as a threat in an abstract sense, but not so immediate a threat that it warrants significant attention. A study of public attitudes towards invasive species in Cape Town, South Africa, for instance, revealed that, while most people believed that managing biological invasions was important, only 39% of people considered it to be a "high management priority" (Potgieter et al., 2019).

Perceived Knowledge, Perceived Familiarity, and Actual Knowledge

Due to necessary constraints (e.g., time, inclination, information accessibility) on one's ability to fully understand the scale and scope of a particular issue, one's understanding of a topic may be a mix of both perceived knowledge (also referred to as perceived familiarity) and actual, or measurable, knowledge. Scholars have argued that knowledge should not be construed as a single, broad, construct (e.g., Rose et al., 2019). For one, assessing an individual's level of knowledge often depends on the way in which it is assessed. Factual, or "textbook" knowledge of a topic is frequently assessed through a battery of questions on a given issue or scientific fact (i.e., Brossard & Shanahan, 2006; Johnson, 2003; Stoutenborough & Vedlitz, 2016). However, some scholars question whether this is the only conceptualization of knowledge given what people are exposed to in everyday life via the media. Brossard and Shanahan (2006), for instance, propose that assessments of knowledge that include themes or information prominent in media more accurately represent what individuals are "expected" to know about a given topic rather than what subject matter experts (e.g., scientists) think the lay public should know. Importantly, however, is research finding that perceived knowledge (or perceived familiarity) and factual knowledge have different correlates (Ladwig et al., 2012). For instance, television

use, and sex (i.e., being male) was a significant predictor of perceived familiarity with nanotechnology, but not factual knowledge of nanotechnology (Ladwig et al., 2012).

Factual, or textbook, knowledge is also less subject to social forces than perceived knowledge. For one, research has found that individuals can be quite overconfident in estimating their level of self-reported knowledge on a given topic (Banwart, 2007; Kruger & Dunning, 1999; Mabe & West, 1982; Malka et al., 2009). Indeed, the "Dunning-Kruger effect" was coined after discovering that individuals with higher levels of self-reported knowledge were more likely to have lower levels of factual knowledge of the same topic (Kruger & Dunning, 1999). When it comes to managing invasive species, understanding the differences between perceived knowledge and factual knowledge is an important part in understanding how people make decisions about methods of treatment. Ideally, one might hope that individuals would make decisions based only on what they know to be true rather than merely what they *think* to be true. In Chapter 3, I compare these perceptions with the "on the ground" reality of whether invasive species are present in an individual's lake in order to ascertain which type of knowledge exerts a stronger influence on preference for chemical management of invasive species.

Social Norms and Social Identity

Social norms have been referred to as, essentially, a set of informal rules that govern how an individual is expected to behave in a given social context (Sharif, 1936). Social norms serve many purposes in social settings, but one important function of social norms is that they serve to provide a "social template" that individuals can use to guide them in navigating more complex social behaviors. Moreover, social norms can convey information about how popular or unpopular certain behaviors are among a specific social group, and these perceptions of

endorsement or sanction of behavior can influence how people make decisions. This subjective understanding of socially acceptable behavior is often referred to as a "perceived norm" (Lapinski & Rimmel, 2005). Injunctive norms, on the other hand, are beliefs about what individuals "ought to do" in a given situation (Cialdini, Reno, & Kallren, 1990), and are often contrasted with descriptive norms, which simply describe what is "commonly done" (Reno, Cialdini, & Kallgren, 1993). For example, in an educational setting (at least in the United States and many Western, industrialized, developed, countries) descriptive norms suggest that it is expected that students sit in desks while instructors stand at the front of the class. Injunctive norms for violating this expectation may include the belief that they will receive a reprimand from the instructor. When thinking about social norms, however, it is important to keep in mind that social norms are only as influential as an individual's desire to avoid social sanction. A student who does not care about receiving a reprimand or detention is unlikely to be phased by violating the social norm that students seat in desks and do not speak when the instructor is delivering lectures.

Descriptive and injunctive norms often align, but not always. For example, research on college alcohol consumption found that many college students perceive that their peers frequently drink alcohol (a descriptive norm) and that they may lose friendships if they do not drink alcohol (an injunctive norm) (Perkins & Berkowitz, 1986; Cox et al., 2019). Likewise, research on social norms has found they can influence how people approach environmental or land management issues. Sharing information about descriptive norms has been found to increase pro-environmental behavior (Farrow, Grolleau & Inbanez, 2017), while an individual's participation in an invasive species management program can be influenced by the desire to avoid social sanction via gossip (Curtis & Allen, 2010).

Norms, however, are not universal constructs. Individual communities can have norms that conflict with broader group norms, or individual families may have norms that do not align with their own community. However, people are linked through the values they hold (Abrams & Hogg, 1990), which is a key component of the social identity approach (SIA). Social identity can indeed influence behavior if the identity is salient enough for an individual. For example, some research has found that individuals who derive some sense of personal identity from driving a car are less likely to reduce the amount of driving they do (and thus reduce emissions) if their "car owner" identity is sufficiently salient (Stradling et al., 1999). Conversely, individuals who have a more salient "environmental identity" are more likely to be compliant with pro-environmental actions like reducing electricity usage (Van der Werff et al., 2011). Understanding social identity is important because how a person identifies can increase the salience of perceived social norms (Terry & Hogg, 1996). Therefore, the influence of social norms on behavior may be partially or completely attenuated by an individual's self-identification.

Rationale and Motivation

I have outlined above several significant factors that have been found to significantly impact how people approach invasive species specifically, but also science issues more generally. Two primary motivations guide this dissertation: an applied motivation and a theoretical one. In an applied sense, understanding how individuals think or perceive invasive species, and what social factors influence those thoughts or perceptions can lead to better management outcomes. Chemical treatments, for example, might be highly effective in some circumstances but are not risk free. Therefore, it would be in the public's best interest to understand what factors guide the decision to use potentially harmful chemicals, particularly

given the extensive economic costs associated with invasive species outlined earlier (Crystal-Ornella et al., 2021; Leistritz, Bangsund & Hodur, 2004; Warziniack et al., 2021). Moreover, it is critically important for natural resources managers and government officials to view citizens as partners in management programs because doing so is more likely to build community trust, which can, in turn, result in more community funding or participation for management activities (Nguyen et al., 2020). This is particularly important given that some research has found that, while individuals are willing to coordinate with community members on invasive species management, they are much less willing to do so with government agencies or government officials (Clarke et al., 2019). Land managers, as scientific experts in invasive species and land management issues, must also recognize that lay individuals do not have the same level of expertise on these issues, but they have a certain level of knowledge about their own communities, properties, and situations about which outsiders are necessarily ignorant.

In a more theoretical sense, this dissertation is concerned with the process by which social factors influence how individuals make decisions about science more broadly. According to the Food and Agriculture Organization of the United Nations, climate change is increasingly changing the native habitats of invasive species across the world (IPPC Secretariat, 2021). As climate change continues to shift the habitable landscape of invasive species, it is important to understand how individuals think and feel about invasive species so that effective mitigation and management strategies can be implemented, particularly those strategies that involve impacted communities. The treatment of invasive species is often a community-driven issue because individuals often have differing beliefs and values when it comes to the natural environment. For instance, many people value certain types of plants because they perceive them to be contributing to the "landscape character" of a particular place (Kendle & Rose, 2000), whether

these plants are native or invasive, and such people may be less likely to favor removal of particular plant species based on their individual values. Furthermore, research has found that individuals who move to rural areas for lifestyle reasons based on their perceived vision of "rural nature" often remove plants that do not comport with their idiosyncratic vision of nature (Lake, 2009). Consequently, it is critically important to understand these social factors driving perceptions of invasive species so mitigation strategies can be crafted that involve impacted communities and that value their active input and participation.

Preview of Chapters

As described above, I will argue that social factors like threat perception, social norms, and perceived knowledge are key components in understanding how individuals make decisions about science issues in which best practices are uncertain, while also discussing implications for politicized science and future directions for research.

In Chapter 2, I focus on factors influencing lakeshore property owner preferences for chemical management of aquatic invasive species (AIS). I argue that lakeshore property owners' preference for chemical management methods is primarily driven by social forces rather than scientific ones, specifically property owner's perception of AIS threat and negative emotions about invasive species in general. This chapter threads together literature on risk perception, trust in scientists, and the psychology of emotion to understand how these factors interact and influence individual decision making. I find that, contrary to previous research on the importance of trust, the most important factors in influencing Wisconsin lakeshore property owners preferences for chemical treatment was their assessment of the threat posed by AIS and their

negative feelings towards AIS. Moreover, I find that social conservatism, but not economic conservatism, was a significant predictor for preference for chemical treatment of AIS.

In Chapter 3, I use the same data from the previous chapter to explore in more depth the distinction between perceived and actual knowledge of AIS in order to compare which of these factors exerts a greater influence on lakeshore property owner preference for chemical management. Key to this chapter is the distinction between factual and perceived knowledge and to this effect I incorporate natural resources data provided by the Wisconsin Department of Natural Resources to the Statewide Parcel Map Initiative at the University of Wisconsin-Stevens Point (https://www.sco.wisc.edu/parcels/data/). In this study, I find that an individual's perceived presence of AIS exerts a far greater influence on whether they prefer chemical management than whether AIS are actually present in their lake. Specifically, I find that actual AIS presence is a significant predictor of preference for chemical treatment *only until* perceived presence is added into the regression model, after which actual presence becomes nonsignificant.

In Chapter 4, I explore the influence of social norms on recreational boaters and angler's attitudes towards invasive species management. Using a data set combined from surveys administered in 2018 and again in 2019, I find that, across all dependent variables, social approval is one of the strongest predictors. Social approval strongly influences whether individuals report following AIS prevention steps, whether they believe it is important to stop the spread of AIS, and their beliefs about how effective AIS prevention steps are at slowing the spread of AIS. In this chapter, I also compare perceived and actual knowledge of AIS laws, finding that, in some cases, an individual's perception of their knowledge of AIS laws is a stronger predictor of attitudes or behavior than their factual knowledge of these laws.

Chapter 2: Lakeshore Property Owner Perceptions of Aquatic Invasive Species

Lakeshore property owners are a significant stakeholder group in terms of management of invasive species, in part because they often some of the most impacted groups, dealing with potentially significant economic and ecological impacts of aquatic invasive species. Coordination among stakeholder groups, including individual homeowners who may have competing goals and interests, is therefore an important management goal. Indeed, property owners who opt not to "do their part" to manage an invasive species can increase costs of control efforts for neighboring property owners, even if the parcel of land they own or manage is small, because doing so could allow for invasive species to use these untreated areas as "invader propagule sources" (Epanchin-Niell et al., 2010). This problem could potentially be compounded given that private decision-makers (including homeowners) may "under control" invasions, compared to established management objectives, because they take into consideration their individual costs and benefits (Epanchin-Niell, 2017). In other words, if a homeowner does not perceive an invasive species to have a particularly negative impact on *their* plot of land, they may be inclined to do less than what is necessary if IS management activities become burdensome in terms of time and cost.

The current study seeks to fill a gap in the existing literature by exploring the perceptions of aquatic invasive species that lakeshore property owners in the state of Wisconsin (United States) have, and how they perceive the risks and benefits of common herbicide treatment strategies for managing AIS. This is particularly important given that the use of chemical management strategies to manage AIS could have unintended consequences, which may not be immediately evident to impacted communities. While transient boaters and anglers have been identified as the primary transporters of aquatic invasive species across Wisconsin lakes (Rothlisberger,

Chadderton & McNulty, 2010; Witzling, Shaw & Seiler, 2016), property owners are often the ones who are left dealing with the consequences of aquatic invasive species introductions on their lakes. Although lakeshore property owners may be aware of AIS on their lake, efforts to remove invasive species can be a diffuse, hard to manage activity often undertaken by a plethora of independent actors—these concurrent efforts can have cumulative effects on the lake ecosystem, resulting in a "commons dilemma", in which individual stakeholders act in accordance with their own self-interest rather than working together to reduce invasive species populations leading to a multitude of ineffective actions (Radomski & Goeman, 2001). Moreover, there is often a disconnect among lakeshore property owners between their beliefs about personal responsibility and sense of moral obligation to "do the right thing" regarding invasive species and behavioral intentions towards native aquatic plant protection (Schroeder & Fulton, 2013). This suggests that, while homeowners may believe that managing invasive species is the "right" thing to do, they may not know much about what actions they can take to further this goal. Moreover, effective management plans can often be coordinated, community-involved projects, which have their own unique challenges.

Unfortunately, despite effective interventions that can reduce the risk of transporting aquatic invasive species by transient anglers and boaters (Wallen & Kyle, 2018; Holden, Nyrop and Ellner, 2016; Venette et al., 2021), new and existing invasions still require management. Within the state of Wisconsin (USA) alone, Eurasian watermilfoil (*Myriophyllum spicatum*) has been observed in 864 lakes and rivers, while curly-leaf pondweed has been observed in 802 (WDNR, 2021). Wisconsin, according to the Wisconsin Department of Natural Resources (WDNR, 2009) has over 15,000 lakes, though approximately 60% of these are less than 10 acres and remain

unnamed. These plants are found in many more lakes and rivers across the Upper Midwest (USGS NAS, 2021).

Literature Review

Aquatic Invasive Plants and their impacts

Invasive species can have undesirable impacts on the ecosystems they inhabit, including large ecological impacts (Walsh et al., 2017), impacts on flood mitigation and climate regulation that the invaded environments provide (Pejchar & Mooney, 2009, Walsh et al., 2016), impacts on human health (Daou, 1998), and local ecology (Larkin et al., 2018). Eurasian watermilfoil has specifically been linked to decreases in lakefront property values (Horsch & Lewis, 2009; Johnson & Meder, 2013; Olden & Tamayo, 2014; Zhang & Boyle, 2010) and impacts to recreation (Horsch & Lewis, 2009; Eiswerth et al. 2000; Rothlisberger et al., 2010) due to its ability to create dense canopies in the lakes it inhabits (Madsen et al., 1991). Additionally, Eurasian watermilfoil has been found to negatively impact recreational qualities of lakes, such as fishing (Schultz & Dribble, 2012). Water hyacinth, another aquatic invasive plant, has posed considerable challenges to governments in California, Texas, and Florida by disrupting irrigation system and flood control systems (U.S. Department of State, 2001; Florida Fish and Wildlife Commission, 2019). In other words, the impacts of invasive species differ widely. So, too, does the way they are perceived by people.

As important as understanding the biology of a particular invasive species may be, scholars have stressed that one of the most important elements in managing the spread of invasive species is understanding the specific management problem (i.e., introduction pathways, or habitat management challenges) (Kueffler, 2013) as well as taking into account that biological invasions

are driven by human factors (Kueffler, 2010). Additionally, in some cases, particular stakeholders' goals may compete with conservation goals, and people may be disinclined to go along with management strategies that conflict with these goals if they feel their concerns are not taken seriously (Woodford et al.,2016), or they may even deliberately hinder conservation efforts in some cases (Rotheram & Lambert, 2012). Other social elements influencing perceptions of invasive species include stakeholders' knowledge (Eiswerth et al., 2011), economic impacts (Osteen & Livingston, 2011; Shackelton et al., 2011), as well as cultural beliefs and values of communities in which invasive species may be found (Coates, 2011; Notzke, 2013). The perception of the risk posed by an invasive species has also been found to contribute to the actions individuals take to manage them (Requier et al., 2000). For example, stakeholders have been found to rely on personal assessments of risk and their own observations rather than scientifically informed recommendations in determining their behavior towards managing an invasive species (Requier et al., 2020).

Unintended consequences of chemical management

One challenge facing stakeholders in managing invasive species is that their unique physiology, reproduction patterns or growth patterns may mean that they cannot all be managed in the same way. For instance, fluoridone, a chemical commonly used to manage invasive plants was initially found to be successful in reducing the amount of Eurasian watermill foil, but also contributed to the decline of several native plant species as well and can have impacts on the life cycle of native fish, potentially undesirable side effects of using chemical treatments to manage invasive species (Crowell, Proulx & Welling, 2006). Other scholars studying the effects of fluoridone treatments found similar results, finding that invasive species often reappeared several

years after fluoridone treatments (Wagner et al., 2017). Because of the negative impacts some chemical treatments have on native plants, some researchers have questioned whether chemical control methods are worse for the environment than invasive plants themselves. A survey of 173 Wisconsin lakes found that lake wide treatment for Eurasian watermilfoil using chemical control methods resulted in 82% of lakes experiencing a decline in native aquatic plant populations. Interestingly, this study also found that Eurasian watermilfoil was, in some cases, positively associated with native plant species abundance, leading the researchers to suggest that Eurasian watermilfoil does not always act by displacing or outcompeting native plants the same way in every lake it inhabits (Mikulyuk et al., 2020). This finding has important implications for the management of invasive species because, if an invasive plant does not pose an immediate threat to native ecosystems, it might be more prudent for stakeholders to adopt a "wait and see" approach before proceeding with a chemical management strategy. In fact, Blossey (1999) notes that monitoring the development of an invasive species in a lake before, during and after both invasion and treatment can lead to more comprehensively informed policies for managing invasive plants. Due to the ways in which invasive species can negatively impact their surrounding environments by decreasing desirable lake qualities like water clarity and the quality of the lake for fishing, I propose the following hypothesis:

H1: The more lakeshore property owners perceive aquatic invasive species will have a negative impact on their lake, the more they prefer chemical treatment.

Values and AIS Management

Due to the differential impact invasive plants can have on different communities, some of which can be severe, researchers have sought to study the perceptions of individuals living in

communities impacted by invasive species. Some non-native species have an economic benefit. The honeybee, for instance, was unknown to the Americas before it was introduced in the 17th century (Hardy, 2016). However, not all non-native species provide an economic benefit to the ecosystems they inhabit, and people generally favor the eradication of invasive species if they are perceived to be economically disadvantageous. In fact, individuals may be motivated to downplay the risk of an invasive species if they perceive that species to have some desirable quality (Humair, Kueffer & Siegrist, 2014). Depending on an individual's values, they may be more likely to support harsher management practices, like the application of chemical herbicides, as long as clear progress is being made to remove the problematic invasive species (Gobster, 2011). Attitudes on AIS and perceptions of their risk may influence aquatic plant management actions by lake stakeholders as well. In a 2007 survey of attitudes towards invasive species in Scotland, researchers found that between 73% and 84% of respondents favored the eradication of invasive species found to cause economic damage or harm threatened or endangered native species (Bremner & Park, 2007).

Results like these can illustrate the need for a more cautious, evidence-based approach to managing invasive species, given that an aggressive treatment regime is not necessarily appropriate every time an invasive species is found in a lake or waterway. While the authors found that not as many people favored the complete eradication of *all* invasive, non-native species, these species are often perceived negatively due to the potential negative impacts they have on surrounding ecosystems. Considering some research (e.g., Mikulyuk et al., 2020) suggests chemical treatment may have unintended negative consequences for other native aquatic lake life, and that AIS are rarely present in highly abundant levels (Hansen et al., 2013), decision makers should also consider alternative methods to chemical treatment. In fact,

individuals who are more familiar with invasive plants have been found to be more likely to favor less lethal management strategies (Japeji & colleagues, 2019). Relevant stakeholders, therefore, have an interest in managing these invasives, particularly those that are economically disadvantageous.

Because it is difficult for communities to manage invasive species on their own, partnerships with local and state government institutions are often necessary, not only to secure the relevant permits to conduct management protocols on a particular lake, but also to ensure effective treatment. Stakeholders who believe they are cut out of the decision-making process could feel a lack of institutional trust, leading to a disinclination to participate in any sort of outreach, education, or management efforts by local governments (Mackenzie & Larson, 2010). Because increased levels of trust have been found to be negatively related to risk perception of technological, societal, or natural hazards (Siegrist, Gutscher, & Earle, 2005), homeowners with higher levels of trust in government officials may be more inclined to adopt a monitoring approach to managing invasive species if such an approach is the recommended strategy to manage invasive species in that location. They may view invasive species as less risky or threatening and have confidence that the relevant authorities will make good decisions related to issues such as the management of AIS on their lake.

Furthermore, organizations that prioritize building trust with local communities can establish effective working relationships, even if organizational and community values do not always align (Leahy & Anderson, 2008). However, the ways in which invasive species are framed could also impact how individuals view treatment of invasive species. Framing, how information is packaged or presented (Putnam, 1992), may also significantly impact an individual's perception of risk by interacting with an individual's pre-existing value dispositions to shift attitudes over

time (Ho, Brossard, & Scheufele, 2008). How invasive species are framed in news media has also been found to impact behavioral intentions towards AIS management (Hart & Larson, 2014; Wallen & Kyle, 2018) by increasing the perception of risk of an invasive species, as well as the actions people take to learn more about invasive species (Shaw, Campbell & Radler, 2021).

The management of invasive species can pose a challenge to both government agencies and local communities., Therefore, it is important to understand the ways people approach the management of invasive species. For example, Aslan and colleagues (2009) found that, when it comes to treatment methods for invasive species identified on their land, many ranchers in California could be described as "satisficers"—finding a handful of control methods that work sufficiently and sticking to them, while not devoting more time to considering alternative management strategies. Other scholars found that some landowners simply did not want to spend much time dealing with invasive plants, preferring to administer a treatment and then move on (Aslan, 2009; Head et al., 2015). In fact, attitudes towards managing invasive species can often involve factors far removed from environmental impacts of the species themselves, such as the belief systems or value dispositions of the property owners.

Political Ideology and Environmental Worldviews

While the above research has shown that individual values can have an influence on a person's attitude towards nature and the environment, political ideology has also been demonstrated to influence environmental attitudes as well. For example, research has shown that liberals tend to score more highly on measures of environmental concern than conservatives (Cruz, 2017) and has been shown to be correlated with responsible environmental behavior (Cottrell, 2003). Moreover, political ideology has been found to influence attitudes towards

scientific topics like conservation (Coffey & Joseph, 2012). Pro-environment behaviors, such as recycling, the boycotting of environmentally unfriendly companies, and conservation behaviors have been linked to an individual's values (Mainieri et al., 1997; Stolle, Hooghe & Micheletti, 2005). Other research has found that political ideology can also influence support for conservation efforts, like laws designed to protect endangered species (Czech and Borkhataria 2001). The role of political ideology on trust in science is a topic of much debate. Some research has found that conservatives tend to have a greater distrust of science than liberals, particularly with regards to topics like climate change, attitudes towards energy efficiency, and overall attitudes towards environmentalism in general (Gauchat, 2012; Lewandowsky & Oberauer, 2017; Gromet, Kunreuther & Larrick, 2013; Dunlap, Xiao & McCright, 2001).

Other studies, however, have found that differences in partisan trust in the scientific community is more nuanced. For instance, Krause and colleagues (2019) point out that an increase in individuals identifying as Independents, coupled with increases in the gap in trust in scientists between religious and non-religious individuals, and between urban and rural residents might account for some of the relationship between conservatism and skepticism towards science. In other words, traditional notions of conservatives as opposed to science may be more driven by divides in strength of religiosity and geographic location rather than political ideology alone. Still, trust in scientists remains quite high, and has remained so even for controversial topics like global warming and nuclear energy (Krause et al., 2019). Although invasive species as a general science issue (there is, however, much debate over the various *solutions* to the spread of invasive species) may not be controversial in the same way that climate change, vaccines, or GMOs are, there is some evidence that skepticism of the scientific consensus on invasive species is growing, increasing uncertainty among the public on this issue (Russell &

Blackburn, 2017). Still, support for invasive species management is high in some populations (Bremner & Park, 2007), particularly among stakeholders who are primarily impacted by invasive species (Oxley, Waliczek, & Williamson, 2016).

One explanation, some scholars suggest, for this difference in partisan trust could be that environmental appeals tend to be framed in ways that are more appealing to political liberals (Feinberg & Willer, 2013) and that the frames used in this messaging may not be highly appealing to political conservatives as it relies more strongly on notions of care and harm (Graham et al., 2013; Clayton, Koehn, & Grover, 2013). When environmental issues are framed in a way that are more likely to resonate with conservatives (i.e., by emphasizing loyalty, patriotism, authority, or personal responsibility) political conservatives and political liberals had roughly equivalent levels of pro-environmental attitudes (Wolsko, 2017). There is currently little research on the impact of political ideology on attitudes towards invasive species management strategies. However, because political ideology has been shown to influence environmental attitudes (Gromet, Kunreuther, & Larrick, 2013), attitudes towards environmental issues like climate change (Kellstedt, Zahran & Vedlitz, 2008), and influences trust in sources of scientific information about the environment (Brewer & Ley, 2013), the following hypothesis are proposed:

H2: There is a positive relationship between political ideology and chemical treatment preferences among lakeshore homeowners, such that conservatives are more likely to prefer chemical treatment than liberals.

Environmental values

Kendle and Rose (2000) discussed how many people perceive native plants to being essential to defining the "landscape character" of a particular region and, while this is true to some extent, many non-native species manage to integrate well with local ecosystems, with some even having beneficial effects (Ewel et al., 1999). For example, non-native tamarisk trees provide shelter to native Willow Flycatcher (*Empidonax traillii extimus*) in the Southwestern United States, while other non-native species can serve as substitutes for extinct native species (Schlaepfer, Sax & Olden, 2011). Moreover, non-native plants can also serve as protective habitats for native waterfowl (Hershner & Havens, 2008). Despite the benefits some non-native species may provide, however, an individual's environmental values often influence how they perceive non-native species (Lake, 2009). For example, some individuals who moved to rural areas for lifestyle reasons made decisions about managing invasive species, in part, based on what their perceived vision of "rural nature" was, sometimes removing native plants that did not accord with that vision while keeping invasives that did (Lake, 2009).

Other researchers have discussed the role that value predispositions play in how people perceive invasive species (Fischer et al., 2011). Perceptions of the relationship between humans and nature play a role in people's attitudes towards managing invasive species, often influenced by factors that have little to do with the environmental impact of the species themselves. For example, individuals' attitudes towards treating a lake with chemical pesticides differed depending on the "cuddliness factor" of the various invasives present in the lake: while respondents generally avoided the use of pesticides in aquatic environments due to potential impacts on more aesthetically pleasing mammals, exceptions were made for undesirable, less

"cuddly", insect species (Verbrugge, Van den Born & Lenders, 2013). Additionally, individuals who had a "pristine" vision of nature, perceived higher risk of invasive species.

Familiarity and Attitudes towards Aquatic Invasive Species

Although invasive species have been identified as a threat to native plants and wildlife, there is often a disconnect between expert and lay attitudes towards invasive species. Several studies have identified the importance of understanding an individual's attitudes towards environmental issues as important components of the management of invasive species (Bremner & Park, 2007; Jetter & Paine, 2004). Research on familiarity with AIS among lakeshore property owners has found that individuals who are college educated, own boats, and enjoy lake-related recreational activities are more likely to be aware of the potential environmental harm caused by AIS compared to those who do not enjoy lake-related recreational activities (Eisworth, 2011). Other research has found that familiarity with the impacts of invasive animals, like fish, tends to be higher than familiarity with the impacts of invasive plants (Nanayakkara et al., 2018). While scholars have found that AIS knowledge tends to the positively related to an individual's adopting behaviors that help prevent the spread of AIS, (Gates et al., 2009), other research has found that higher levels of knowledge of AIS does not necessarily translate into compliance with management recommendations (Witzling et al., 2016). Individuals who live on a lake may be more likely to dock their boats on their own property and use their own lake for recreational purposes rather than travel to other lakes. Despite this, lakeshore property owners often must deal with the consequences of aquatic invasive species, which can be financially burdensome (e.g., Zhang & Boyle, 2010). Furthermore, research has also found that lakeshore property

owners tend to be more motivated by personal benefit rather than environmental concerns when thinking about managing AIS on their lakes (Schroeder & Fulton, 2013).

Attitudes towards AIS management strategies

Although it has been well documented that invasive species can have a negative impact on local ecosystems, it is also evident that factors that go beyond the biology of an invasive species play clear, significant, roles in determining whether people are willing to aid in management efforts and, consequently, contribute to the spread or decline of an invasive species population. For instance, one of the main barriers to reducing or controlling the spread of invasives among individuals having expressed concern about them was a lack of information on management approaches (Ansong & Pickering, 2015). For example, while visitors to parks expressed concerns about the impact of invasive weeds on the park ecosystem, they often disposed of seeds found on their person in a way that would contribute to the spread, not the management, of these invasive weeds (Ansong & Pickering, 2015). Due to the ways in which familiarity with an invasive species can impact attitudes towards their management, the following hypothesis is proposed:

H3: The more familiar lakeshore property owners are with invasive species, the more likely they are to prefer chemical treatment.

Negative Affect and Attitudes

Studies in human behavior have found that the threat of undesirable risks, especially those that can trigger negative emotions like frustration or anger, can influence human behavior (Loewenstein & Lerner, 2003; Sunstein & Zeckhauser 2000). Additionally, some research

suggests that when individuals use more emotionally laden phrases to describe an invasive species, it is linked to the perception that it is a more immediate, tangible threat (Cottet et al., 2015). Interactions with nature can also contribute both positively and negatively to the emotions an individual feels. For instance, positive interactions with wildlife influenced a feeling of "wonder" in some respondents (Schänzel & McIntosh, 2000). Negative interactions, too, can influence an individual's attitudes and behaviors towards wildlife. For example, individuals who reported feelings of anger towards house sparrows were more likely to favor lethal management methods than those who felt positively about house sparrows (Larson, Cooper & Hauber, 2016). Like interactions with wildlife, positive or negative interactions with management officials may contribute to the way individuals perceive invasive species management. Because invasive species management is a collective effort, it is important that individuals trust those involved in AIS management decisions.

Trust in science and scientists

For a particular management strategy to be effective, coordination between local government officials and impacted stakeholders must be present: those impacted by invasive species must be able to trust that something will be done and that their partnership is valued. In another context, it has been established that individuals reporting higher levels of general trust reduced perceived risks of technologies like genetically modified foods and medical x-rays (Siegrist, Gutscher & Earle, 2005). In an invasive species context, homeowners with higher levels of trust in local government officials may be more inclined to consider recommendations about managing invasive species, such as monitoring whether the species are spreading in a manner that poses real threats to the ecological integrity of their lake and avoid using chemicals that may harm

native plants that are present. Additionally, individuals tend to be more supportive of management activities they can take part in directly, even favoring more funding for activities like community invasive pulls and native species planting (Nguyen et al., 2020).

Being able to take part in invasive species management decisions could help give important stakeholder groups a sense of having some agency and a voice in issues that impact their community, serving to build trust between stakeholders and decision makers. However, other research with property owners has found that while awareness and knowledge of invasive species is moderate, interest in coordinating with government officials on invasive species management is low. For example, a study of family farm owners in the United States (FFOs) found that, while these individuals were likely to take initiative in inspecting their properties for invasive species, coordinating with friends, other families, or other FFOs on the removal of invasive species, or removing invasive species themselves, many expressed little to no experience or interest in partnering with government officials on invasive species issues (Clarke et al., 2019). A study on public attitudes towards invasive species management and trust in management officials in Guam found that individuals who expressed greater confidence in the ability of officials to effectively manage invasive species were more supportive of management activities, had greater interest in management initiatives, and an increased desire to participate in invasive species management compared to those with lower levels of trust (Wald et al., 2019). Although this study sheds light on *public* attitudes about invasive species management and trust, managing invasive species in waterways and on land are often different processes and there may be significant differences in attitudes between lakeshore property owners and other types of property owners. Because the attitudes of lakeshore property owners, specifically, have received relatively less attention in the academic literature, the following research question is proposed:

RQ1: What is the relationship between trust in scientists and an individual's preference for chemical management of invasive species?

Familiarity and management preferences

Personal experience has long been described as contributing to layperson assessment of risks, including through the "availability heuristic," where examples that are more mentally accessible are weighted more heavily when constructing attitudes (Johnson, 1983). With regards to invasive species, individuals are often less familiar with invasive plants than they are with invasive animals or fish (Nanayakkara et al., 2018), suggesting that attitudes about invasive plants may be, in part, influenced by attitudes towards other invasives more broadly. It seems likely that familiarity with AIS is a prerequisite for forming an opinion about how to manage them, but potentially more familiarity with AIS could also mean that AIS are perceived as more threatening and the more threatening the AIS appears to be, the more negative the emotional reaction is to it. Given that individuals are unlikely to view invasive animals and invasive plants the same way (Nanayakkara et al., 2018), individuals who have invasive plants on their properties may be more likely to engage in chemical control measures compared to those with invasive animals, which are often associated with more humanistic values (Fitzgerald, Fitzgerald, & Davidson, 2007).

Although invasive species may not be a topic that is highly emotionally salient for many people, negative emotions surrounding invasive species could be an effect of the way they are presented in outreach materials, campaigns, or the media (Otieno et al., 2014). Due to the potentially negative consequences associated with invasive species, it may, however, be a salient issue for lakeshore property owners. Consequently, it is important to explore the impact of

emotions on preferences for chemical treatment of AIS, the application of which could have unintended environmental consequences, leading us to propose the following hypothesis:

H4: The more negatively about AIS a lakeshore homeowner feels, the more they will favor chemical treatment options to manage them.

Data and Methods

A survey was developed to assess lakeshore owners' attitudes towards various AIS management approaches. The University of Wisconsin-Madison's Survey Center (UWSC) administered the paper mail survey using the Dillman (Dillman, Smyth & Christian, 2014) method, where the survey, a description of the study, and a self-addressed, stamped envelope were mailed with a reminder sent several weeks later to a sample of 1200 individuals identified through public records as owning a lakeshore property in Wisconsin, USA. The original data set, provided by the Statewide Parcel Map Initiative at the University of Wisconsin-Stevens Point (https://www.sco.wisc.edu/parcels/data/), used surface water layer data from the Wisconsin Department of Natural Resources to match individuals identified as owning a property on a Wisconsin lake with a specific water body identification code (WBIC).

After this initial data set was compiled, properties identified as belonging to businesses, organizations, or other non-individual entities were removed from the sampling frame. Furthermore, natural resources data, which indicates whether a particular water body was identified as having an invasive species and, if so, which specific invasive species, was obtained by the Wisconsin Department of Natural Resources and merged with the Statewide Parcel Map Initiative data based on the WBIC. After the final sampling frame was identified, a $1 incentive was included in the mailing of each survey as an indication of appreciation for the participant's

time. Four individuals contacted the research team to notify them that they no longer owned the property and were removed from response rate calculations. The response rate was 63% (as calculated with the AAPOR Outcome Rate Calculator Version 4.0). This research was approved for human research subjects by the Institutional Review Board at the University of Wisconsin-Madison.

Independent variables

Sample demographics. The sample was mostly White (92.5%), with an average age of 65 years (*SD* = 11.36). With regards to gender, the sample was mostly male (66.9%). Regarding level of education, few participants (.7%) completed some high school, 13.2% completed high school or received a GED, 27% had some college, technical, or trade school education, 31.4% completed a four-year college with a bachelor's degree and 27.8% completed a graduate or professional degree. Politically, on economic issues, 3.2% of participants described themselves as "very liberal," 8.2% as "somewhat liberal," 25.9% as "moderate," 28% as "somewhat conservative", 29.7% as "very conservative" and 5% of respondents reported they "don't know". With regards to social issues, 10.3% described themselves as "very liberal," 17.9% as "somewhat liberal," 27.6% as "moderate," 20.9% as "somewhat conservative" and 18.1% as "very conservative," with 5.2% reporting they "don't know."

Political ideology: Two questions assessed an individual's position on economic and social issues. The first question, which asked individuals to rate their level of conservatism or liberalism on economic issues (*M* = 3.88, *SD* = 1.17) asked, "In terms of economic issues, would you say that you are…", and asked individuals to rate their level of economic conservatism (*M* = 3.34, *SD* = 1.37) on a scale ranging from 1 (Very Liberal) to 5 (Very Conservative). The second

question asked participants "In terms of social issues, would you say that you are…" and asked participants to rate themselves on the same 5-point Likert scale.

Perceived Familiarity: Perceived familiarity was measured (M = 3.12, SD = .88) by combining and averaging responses to three survey questions: (1) "How much have you heard about aquatic invasive species?", (2) "How familiar are you with ways to prevent the spread of invasive species?", and (3) "How familiar are you with ways to manage invasive species once present?". Each question was measured on a 5-point scale. The response options for the first item were "Nothing at all," "A little," "Some," "Quite a bit" and "A great deal," while the response options for the remaining two questions were "Not at all familiar," "A little familiar," "Somewhat familiar", "Very familiar" and "Extremely familiar". Cronbach's alpha coefficient, which measures the consistency of items that comprise a variable, was used to measure the reliability of this three-item scale and was calculated to be .82. A minimum coefficient of .70 is generally considered to be acceptable (Rovai et al. 2014).

Perception of AIS presence in lake. This item measured a participant's perception of the presence of aquatic invasive species in their lake. The question asked respondents "To your knowledge, does your lake currently have any invasive plants?" with response options "Yes," "No" and "Don't Know." If participants selected either of the latter two options, they were directed to skip to the next set of questions. For analysis purposes, this question was transformed into a dummy variable with the reference group being participants who selected the "Don't Know" option. About half (51.6%) of respondents perceived AIS in their lake, with 16.4% perceiving no AIS and 32% of respondents reported they "don't know" whether their lake has AIS or not. The "don't know" group was chosen as the reference group based on the assumption

that there are differences with regards to treatment approaches between people who perceive AIS and their lake and those who do not.

Trust. The trust variable (M = 5.65, SD = 1.40) was created by averaging responses to two questions that measured a participant's level of trust in scientists. The first question asked, "How much do you trust university staff and scientists?," while the second question asked, "How much do you trust Wisconsin Department of Natural Resources staff and scientists?". Both questions were measured on a 7-point Likert scale, with response options "Strongly distrust", "Moderately distrust", "Slightly distrust", "Neither trust nor distrust", "Slightly trust", "Moderately trust" and "Strongly trust". Because this scale consisted of two items, the Spearman-Brown coefficient, which is commonly used to calculate reliability for two-item scales, (Eisinga, Te Grotenhuis, & Pelzer 2013) was calculated to be .85.

Negative Affect. Negative affect was assessed with three survey items, all part of the same question stem which read "When you think about preventing or managing invasive plants on your lake, how strongly do you feel any of the following emotions, if at all?." The 5-point options were "Not at all", "Slightly", "Somewhat", "Very" and "Extremely". The emotions used to create the negative affect scale included "Angry," "Sad" and "Frustrated." The responses to these items were averaged to form the scale (M = 2.29, SD = 1.09) and the Cronbach's alpha was calculated to be .87.

Dependent variables:

Preference for chemical treatment: A participant's preference for chemical treatment of AIS was measured using two items from the survey, which were combined and averaged into a scale (M = 3.00, SD = 1.20). The first survey item asked participants to rate their perception of

the risks and benefits of the chemical approach to managing AIS on a 5-point scale ranging from "Risks greatly outweigh the benefits" to "Benefits greatly outweigh the risks". The second survey item asked respondents to rate their agreement with the statement "If an herbicide can temporarily reduce the amount of an invasive plant in a lake, it is worth using" on a 5-point scale ranging from "strongly disagree" to "strongly agree". The Spearman-Brown reliability coefficient for this scale was found to be .80.

To examine the research questions and hypotheses, hierarchical ordinary least squares (OLS) regression was used to test the relationship between independent and dependent variables by fitting a linear model to the date. Independent variables were entered in blocks according to their assumed causal order. The initial regression model started with Block 1, which only included demographics variables. Block 2 included social and economic political ideology variables. Block 3 was perceived familiarity with invasive species. Block 4 included perceived presence of invasive species on the participant's lake. Block 5 included a scale measuring trust in scientists. Block 6 included a scale measuring negative affect (emotions).

Results

H1 suggested that the perceived impacts of AIS would be positively correlated with preference for using chemical treatment methods. Support for this hypothesis was not found in the final model, as the perceived AIS impact variable was not significant at the $p < .05$ level, ($B = -.022$, $p > .05$). With regards to political ideology (H2), social conservatism ($B = .153$, $p < .01$) was related to preference for chemical treatment, but not economic conservatism. However, there is a trend with economic ideology that trends towards significance, such that individuals who are more economically conservative may be more inclined to support chemical treatment.

Table 1: Hierarchical Multiple regression model predicting support for chemical treatment approach (unstandardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Block 1 - Demographics							
Age	.006	.010	.008*	.008	.007	.007	.006
Education	.061	.044	.091	.078	.053	.052	.061
Incremental R2 (%)		.009					
Block 2 – Political Orientation							
Ideology - Social	.153*		.169**	.169**	.145**	.146**	.153**
Ideology- Economic	.082		.059	.059	.070	.072	.082
Incremental R2 (%)			.044***				
Block 3 – Familiarity							
Perceived AIS Familiarity	.085*			.196***	.090	.089	.085
Incremental R2 (%)				.020***			
Block 4 – Perception of AIS in Lake							
Perceived AIS Impact	-.022				-.040	-.039	-.022
AIS in Lake = Yes	.673***				.782***	.781***	.673***
AIS in Lake = Don't Know	.216*				.249	.250	.216
Incremental R2 (%)					.065***		
Block 5 - Trust							
Trust in Scientists	.017					.008	.017
Incremental R2 (%)						.000	
Block 6 - Emotions							
Negative Affect	.049***						.049**
Incremental R2 (%)							.015***
Total adjusted R2 (%)							13.9

*p< .05, ** p < .01 *** P < .001

The third hypothesis (H3), which suggested that familiarity with AIS would also be positively associated with preferences for chemical management strategies was similarly not supported. A non-significant result for trust in scientists (RQ1) was also found. While previous research has demonstrated a relationship between trust and AIS management behavior, these results suggest that the preference for chemical treatment appeared to be primarily driven by negative emotions towards AIS.

The fourth hypothesis (H4), that greater negative affect predicts chemical treatment attitudes while controlling for demographics (age, education), political ideology, trust in scientists, and familiarity with invasive species, however, was supported ($B = .049$, $p < .01$), suggesting that the more negatively a person feels towards AIS, the more likely they are to support chemical management strategies. Compared to people who did not perceive their lake currently had AIS, people who perceived their lake had AIS were also more likely to support chemical management strategies.

Discussion

The results of our study suggest that Wisconsin lakeshore owners' negative feelings about aquatic invasive species serve as a main driver in influencing preferences for chemical AIS management approaches. One implication of this finding is that natural resources managers creating AIS outreach materials should avoid sensational language, which has been associated with an increase in negative emotions (Otieno et al., 2014). Although it may be tempting to create attention-grabbing messages in a media environment characterized by competition for attention, sensationalized framing has not been found to perform better than more straight-forward, science-focused framing (Shaw, Campbell & Radler, 2021). Negative affect, which included anger, sadness, and frustration, was statistically significant in our model after

controlling for other potential factors, suggesting that when individuals feel negatively about an invasive species, they have a strong desire to remove them from their lakes and an increased willingness to use chemical management strategies. It is possible that this might be the result of some spillover effects of outreach campaigns aimed at transient anglers or boaters, which may use sensational messages. These messages may also reach lakeshore property owners, amplify their perception of risk, and exacerbate negative emotions influencing them to support chemical treatment options to eradicate an AIS from their lake. Although lakeshore property owners may not themselves be transient anglers or boaters who are spreading AIS, they may nevertheless still be exposed to these materials at community meetings, signage at boat landings, lake association meetings, print or online newsletters, online information, or bait shops.

This suggests a need for a more tailored communications approach targeting the diverse needs of these two distinct groups of stakeholders which has also been suggested elsewhere (i.e., Witzling, Shaw & Seiler, 2016). While transient anglers and boaters may be primarily responsible for the spread of AIS, the homeowners living on these lakes must deal with the consequences. At the same time, however, it is important to recognize the unintended consequences of chemical treatments, like the application of herbicides, can have on the lake ecosystem. Lake associations may have good intentions by using herbicides to prevent the spread of aquatic invasive species but may not be aware that some chemical treatments may harm indigenous plants and pave the way for regrowth of AIS at the expense of native plant species. A statistically significant effect of familiarity with AIS on preference for chemical treatment was not found, suggesting that increasing homeowner's familiarity with invasive species may not have a significant impact on their willingness to use chemical applications to manage invasive species. Instead, it seems more prudent for lake managers to work more closely with lakeshore

property owners on the development and implementation of management strategies, given that community involvement can have a significant impact on support and participation in these programs (Nguyen et al., 2020). Additionally, an individual's perceived level of familiarity with aquatic invasive species did not significantly influence their attitudes towards preferring chemical management. suggesting that educational campaigns aimed at helping property owners identify and prevent the spread of invasive species can coexist with efforts to promote evidence-based management strategies. Moreover, lake managers may also consider stressing the importance of a monitoring approach as a viable management strategy, given that invasive species may not be present in quantities that warrant chemical application.

Future research should more closely examine the attitudes and behaviors of lakeshore property owners as an important stakeholder group and influential partner of community or governmental organizations in the management of invasive species. Furthermore, outreach campaigns that focus only on increasing knowledge of AIS are not likely to be effective, as multiple factors can influence adherence to management recommendations (Koob & McGuire, 2013). Factors such as the inability to remember campaign messaging or the use of overly complex, technical, language could hinder the ability to effectively communicate with relevant stakeholders (Seekamp et al., 2016; Koob & McGuire, 2013). If lake managers and other decision makers understand what sorts of strategies lakeshore property owners prefer, which they regularly use, and their perceptions of the effectiveness of various management approaches, more comprehensive outreach strategies could be tailored towards these specific needs. Moreover, while agency-led and research-driven invasive species surveillance programs detected the highest percentage of new invasives, independent sources, such as homeowners or farm operators, also contributed significantly to the detection of new invasive pests (Epanchin-Niell,

Thompson, & Treakle 2021). This suggests that growing partnerships between agencies and lakeshore property owners in citizen science can be a fruitful mechanism for monitoring and detecting emerging invasive species. Moreover, such partnerships could be a valuable tool in evaluating the risk that a particular invasive species poses and what, if any, treatment plan is appropriate.

As for the finding that social conservatives were more likely to favor treatment, natural resources managers can gauge the general political leanings of lakeshore properties in the areas they serve by examining voting patterns in the local area. However, it is also true that many lakeshore property owners may own their property as a second home and do not vote in the local area. Still, to the extent that natural resources managers can infer the political climate of their local constituents, they may prioritize their outreach to more conservative areas to communicate about how chemical treatments can sometimes have unintended consequences and do more harm than good. Therefore, if resource managers identify local constituencies as stakeholders in aquatic invasive management decisions, they should be aware of values that have been found to resonate with conservatives regarding pro-environmental behavior, such as deference to authority, patriotism, and the purity of nature, especially when messages are perceived as coming from within the group (Wolsko, Ariceaga, & Seiden, 2016). If non-native plants are perceived as diminishing the "purity" of an ecosystem, prompting a preference for eradication efforts, that concern could be directed towards the impacts of chemical treatments on the integrity of existing plant and animal communities. For example, chemical treatments may not eradicate aquatic invasive species as planned, but rather create more resistant hybrid varieties (Mikulyuk et al., 2020).

Furthermore, social media sites such as Facebook and search platforms such as Google allow groups and organizations the unique ability to pay to microtarget specific populations of individuals efficiently based on their interests, allowing for the possibility of creating tailored messaging designed to be most persuasive to each audience. Local government agencies and lake association leaders seeking to engage relevant stakeholder groups, or raise awareness about the impact of AIS, could consider the unique technological affordances inherent to social media sites as effective tools for outreach. Natural resources managers should also be aware that those who perceive they have AIS on their lake were more likely to prefer a chemical management strategy. While this is intuitive at some level, it is still valuable to know that lakeshore property owners have this disposition. It points toward the need for outreach that explains the potentially damaging effects of chemical treatments and the benefits of ecologically informed decision-making.

Trust in scientists did not play a major role in attitudes towards chemical management approaches. This could potentially be due to AIS not being a particularly controversial topic for lakeshore property owners, as attitudes towards aquatic invasive species were almost uniformly negative in this sample.

To date, there is little research on the attitudes lakeshore property owners have towards AIS, despite these property owners being a significant stakeholder group that face unique challenges and impacts from AIS being present in their lakes. This research helps fill this gap by showing that, for lakeshore property owners, negative feelings about AIS seem to drive their preference for chemical treatment. More research is needed on lakeshore property owners' attitudes towards AIS management, their preferences for treatment and their perception of the risks and benefits of different treatment approaches. Future research could examine the

difference between perceived or actual knowledge of AIS and its role in risk perception of management approaches, or more in-depth analyses of their attitudes towards chemical treatments along with other management strategies. Finally, future research should also examine what messaging strategies are most effective in encouraging lakeshore property owners to take a more deliberate, methodical approach to managing invasive species that maintain the ecological integrity of the lakes they live on.

Chapter 3: Perceived and Actual Knowledge of Aquatic Invasive Species

Biological invasions significantly negatively impact the economy, costing around $1.2 trillion worth of damage between 1960 and 2020, with an annual average cost of $19 billion (Fantle-Lepczyk et al., 2022). Invasive species can interfere with a water body's ability to provide clean drinking water, serve as habitats for fish or other wildlife, and negatively impact recreational qualities of lakes (Walsh, Carpenter & Vander Zanden, 2016). Moreover, invasive species can also threaten or endanger native species, many of which serve essential functions in their native ecosystems (Blackburn et al., 2019). The physiology of invasive species has been studied extensively in order to better inform natural resources managers seeking to more effectively manage biological invasions (e.g., Smith & Barko, 1990; Williamson, 1996; Kolar & Lodge, 2001; Lee, Park & Leskey, 2019; Larson et al., 2020; Mikulyuk et al., 2020). At the same time, however, researchers understand that managing invasive species is a social, as well as biological, issue and have explored the social dimensions of invasive species management. In South Africa, for example, Shackleton and colleagues (2007) found that many people viewed the presence of an invasive cactus as a positive, due to economic value of its fruits (Shackleton et al., 2007).

Moreover, many people may refuse to participate in invasive species management programs if their needs, values, or opinions are ignored (Simberloff, 2011; Woodford et al., 2016). As a consequence, the social perception of invasive species is an equally important factor in determining how willing individuals are to engage with environmental management practices. Factors such as knowledge of invasive species have been found to be a key factor influencing people's perception of invasive species (Eiswerth et al., 2011; Colton & Alpert, 1998; Schreck Reis et al., 2011; Shackleton & Shackleton, 2016; Novoa et al., 2017). For instance, Garcia-

Llorente and colleagues (2008) conducted a cluster analysis to identify distinct stakeholder groups impacted by invasive species in Spain. They found that the level of knowledge of invasive species differed across stakeholder groups such that conservation professionals and "nature tourists" were more knowledgeable about invasive species than members of the general public. Moreover, individuals with more knowledge of invasive species were more likely to favor eradication, suggesting that knowledge of invasive species or their ecological impacts could influence how individuals perceive the risk they pose to the native ecosystem. Additionally, when many of these studies ask respondents questions about invasive species, their level of knowledge is determined by the number of correct answers (e.g., Eiswerth, Yen & Van Kooten, 2011), or whether they were aware of specific AIS-related impacts (Nanayakkara et al., 2017). However, to the best of my knowledge, no studies have directly explored perceived and actual knowledge of invasive species. Some research suggests that this distinction is important for health behaviors (Crosby & Yarber, 2001) and that there is often a difference in terms of what people *say* they know versus what they *actually* know (Naughton & Freisner, 2012; Alotaibi et al., 2012; Ladwig et al., 2012; Rose, Howell & Scheufele, 2019).

Literature Review

Management of Aquatic Invasive Species

While understanding an invasive species' biology and introduction pathway(s) is important (Kueffler, 2013), management of biological invasions is as much a social issue as a biological one and human factors influencing biological invasions are equally important (Kueffler, 2010). This is because, in some instances, those impacted by invasive species may have values or goals that conflict with those of natural resources managers or decision makers

(Woolford et al., 2016). Indeed, managing invasive species has been referred to as a "wicked problem" by some scholars (e.g., Woolford et al., 2016) because of its complex nature. A "wicked problem" (Rittel & Weber, 1973; Conklin, 2005) is one in which, among other criteria, there is no right or wrong solution, and each solution is unique. The ambiguity surrounding the management of invasive species could help explain why some individuals deliberately hinder invasive species management or conservation efforts (Rotheram & Lambert, 2012). Because invasive species management is, in part, a social problem, it can be significantly influenced by stakeholder knowledge (Eiswerth et al., 2011) and the cultural beliefs and values of the communities in which invasive species may establish themselves (Coates, 2012; Notzke, 2013).

Because the management of invasive species is, in some way, a "wicked problem," there is no singular way to effectively manage them. Chemical treatments, like fluoridone, are popular and effective but come with potential unintended consequences. Crowell and colleagues (2006), for example, found that, while fluoridone treatment was effective in reducing the concentration of invasive Eurasian watermilfoil, it also contributed significantly to the decline of native plant populations. Moreover, researchers studying the impact of fluoridone treatments found that invasive species reappeared years after initial treatment, suggesting that chemical applications will need to be ongoing in order to be effective (Wagner et al., 2017). To further illustrate the complex nature of this issue, there is some debate over whether chemical treatment of invasive species is worse for the environment than the invasive species themselves. Mikulyuk and colleagues (2020) found, for example, that in a survey of 173 Wisconsin lakes approximately 82% of these lakes experienced a decline in native plant populations after chemical treatment but, in some of these lakes, Eurasian watermilfoil was *positively* associated with native plant abundance.

There is a plethora of information available online about best practices regarding the *prevention* of aquatic invasive species. The Minnesota Department of Natural Resources, for instance, publishes a document emphasizing the importance of regular inspection and cleaning of boats, properly disposing of aquatic plants and the display of adequate signage around waterways to inform lake users about relevant state laws (Minnesota Department of Natural Resources, 2012). The state of Wisconsin contains similar resources available online, however these resources emphasize *prevention* of invasive species spread whereas individuals currently impacted by invasive species might be more interested in how to appropriately *manage* them once they are already established. While prevention is an important part of management, the uncertainty surrounding the "best practice" of managing invasive species could result in a decision-making environment in which an individual's values, knowledge, and perceptions (c.f. Witzling, Shaw & Amato, 2015) play a greater role than they would in situations with more clear-cut best practices.

Types of Knowledge: Perceived and Factual

Researchers have long acknowledged the importance of knowledge in influencing individuals' problem-solving processes when confronted with complex information. Simon (1947, 1965) proposed the idea that people do not operate in situations with complete knowledge of a topic and, therefore, their decisions cannot be purely rational and thus coined the term "bounded rationality". Scholars have also recognized that increased knowledge of an issue increases the quality of public debate and improves the ability of decision-making bodies to adequately represent the will of the people (Delli Carpini & Keeter, 1996). Additionally, treating knowledge as a single, broad, concept has led some research to argue that such a conflation

results in conflicting findings in regard to science attitudes (Rose et al., 2019). Moreover, the idea that simply increasing an individual's level of knowledge about a topic is sufficient for attitude change (i.e., the "knowledge deficit model") has been criticized as an incomplete conceptualization of the relationship between knowledge, attitudes, and behavior (Brossard & Lewenstein, 2010; Eveland & Cooper, 2013).

In terms of attitudes towards scientific topics, knowledge has been operationalized in many different ways. Some have distinguished between knowledge on a broader level, and knowledge of a specific issue or specific scientific technology (i.e., Allum et al., 2008). In some cases, knowledge of a scientific issue correlates weakly with positive attitudes towards science (Sturgis & Allum, 2000; Sturgis & Allum, 2001) and in other cases, knowledge correlates negatively with attitudes towards specific science issues. For example, Evans and Durant (1995) found that while general "textbook" knowledge of science issues was positively correlated with attitudes towards general science, it correlated negatively with attitudes towards specific technologies that might be considered controversial, like embryonic stem cell research. Thus, while knowledge about science can make people more favorable to science in an abstract sense, it can also lead to them feeling more negatively about more controversial topics. Other researchers have distinguished between other common conceptualizations of knowledge: factual knowledge versus perceived familiarity. Factual knowledge is considered to be a measure that assesses the amount of "textbook" information an individual possesses about a specific scientific issue. For instance, it has been assessed via a battery of informational questions that ask respondents about specific scientific facts (i.e., Brossard & Shanahan, 2006; Johnson, 2003; Stoutenborough & Vedlitz, 2016).

On the other hand, some researchers questioned whether this view of knowledge adequately captures the range of knowledge of respondents, given that the scope of the questions are extremely narrow and specific. For instance, Brossard and Shanahan (2006) argued that measures of knowledge that incorporate elements prominent in media are more representative of what ordinary people are "expected" to know about a given scientific issue, rather than questions taken from what scientific experts believe constitutes sufficient scientific knowledge.

Another common form of knowledge is based on a self-reported measure which asks respondents to rate how knowledgeable they believe themselves to be on a given scientific issue or, alternatively, rate their level of familiarity with the given scientific issue. Stoutenberg and Vedlitz (2016), for instance, explored the difference between respondents' assessed and perceived knowledge of the risk of various scientific technologies finding that, while respondents who scored higher on assessed knowledge mirrored scientists perception of risk for these technologies, greater perceived knowledge was often related to *elevated* perception of risk, suggesting that these are fundamentally different constructs. Ladwig and colleagues (2012) argued that such a measure is more adequately referred to as perceived familiarity, finding that assessed knowledge about nanotechnology and a respondent's perception of their knowledge reflected different underlying knowledge structures and had different correlates. For instance, reading science newspapers and viewing science television were significant predictors for perceived familiarity of nanotechnology, viewing science media online was a significant predictor of factual knowledge (Ladwig et al., 2012).

Perceived familiarity or perceived knowledge is also more subject to a variety of social or psychological impacts than assessed science knowledge. People can be overconfident in estimating their level of self-reported knowledge of a topic (Banwart, 2007; Kruger & Dunning,

1999; Mabe & West, 1982; Malka et al., 2009) and that there can be gender differences in terms of people's self-reported knowledge, with men (particularly younger men) consistently more likely to rate themselves as "well-informed" than women (Banwart, 2007). Other evidence that these are distinct constructs comes from research finding that individuals with lower levels of factual knowledge may be the most likely to self-report higher levels of factual knowledge (Kruger & Dunning, 1999). That perceived familiarity is fundamentally distinct from factual knowledge, and that perceived familiarity has been found to influence an individual's attitude towards science issues has led to the following hypothesis:

H1: Perceived familiarity with AIS is positively correlated with support for chemical management of AIS.

Perceived threat of AIS

Biological invasions are increasingly recognized as a threat to biological diversity because of their significant social or economic impacts (Pejchar & Mooney, 2009; Pimental et al., 2005). Additionally, many invasive species can alter the function of local ecosystems and/or disrupt ecosystem services, and reduce biodiversity (Pejchar & Mooney, 2009; Shackleton et al., 2016; Jeschke et al., 2014). The specific threat posed by invasive species can also be different in the minds of many people. For example, Sharp and colleagues (2011) found that visitors to Cumberland Island National Seashore perceived feral pigs to be the greatest threat to local ecosystems, while visitors were more unsure of the threat posed by insects or plants. Other research has found that the non-nativeness of a particular species was not a factor the general public or conservation volunteers used in judgements about the impacts of biological invasions,

suggesting that lay people may have different perceptions of the threat posed by invasive species than scientists or natural resources managers (Selge & Fischer, 2011; Gozlan et al., 2013).

Moreover, there can be discrepancies between management professionals and the lay public in terms of how these groups view the threats posed by invasive species. Gozlan and colleagues (2013) surveyed both conservation managers and members of the public on perceptions of ecological threat and knowledge of invasive species in the United Kingdom. They found that not only did conservation managers have higher levels of perceived knowledge of invasive species compared to members of the public, but they were also more likely to perceive a greater ecological risk of invasive species in general. Members of the public perceived similar levels of ecological risk for some invasive species (e.g., Japanese knotweed) but not others (e.g., harlequin ladybird) (Gozlan et al., 2013). These findings suggest that, perhaps, there is a link between knowledge of invasive species and the degree to which one perceives them as an ecological threat. The more familiar one is with a particular invasive species, the more accurate one may be in evaluating its potential threat to the environment and, therefore, more likely to support invasive management policies.

Because biological invasions are an ongoing process, people's perception of the threat posed by invasive species may also shift over time. Shackleton and colleagues (2019) noted that perceptions can shift in relation to an "invasion gradient", in which an invasive species is seen as more threatening as it becomes more abundant. Research has also demonstrated how media issues can significantly impact an individual's perception of risk by interacting with pre-existing value dispositions, shifting attitudes over time (e.g., Ho, Brossard & Scheufele, 2008). Additionally, other research illustrates the role of news media in increasing the public's

perception of risk of invasive species and the actions they take to learn more about them (Clarke, Roman & Conway, 2020).

To further complicate matters, people may hold negative attitudes about invasive species, yet not view them as threatening enough to favor eradication or lethal control measures (García-Quijano et al., 2011; Gardener et al., 2010). Additionally, people may have different perceptions about the threat posed by invasive plants compared to invasive animals. A survey of public attitudes towards invasive alien plants (IAP) in Cape Town, South Africa, showed that, while most people viewed managing IAPs as a necessary action to protect the environment, only 39% considered it to be a "high management priority" (Potgieter et al., 2019). Some non-native species have an economic benefit. The honeybee, for example, was brought to North America by European colonists and has since become an important pollinator of native plants (Hardy, 2016). However, not all non-native species provide an economic benefit to the ecosystems they inhabit, and people generally favor the eradication of invasive species if they are perceived to be economically disadvantageous. In a survey of attitudes towards invasive species, researchers found that between 73% and 84% of respondents favored the eradication of invasive species found to cause economic damage or harm, or that threatened or endangered native species. Interestingly, 45% of respondents in this study favored the eradication of *all* invasive, non-native species (Bremner & Park, 2017). With this in mind, people's perceptions of the value of an invasive species might depend on what kind of value can be derived from it. Invasive species that are unlikely to yield any positive economic value, or that negatively impact recreational values of a water body (e.g., Eurasian watermilfoil) may be perceived as more threatening. Given the role perceptions play in shaping individual attitudes towards invasive species, the following hypotheses are proposed:

H2a: Individuals who perceive AIS in their lake are more likely to support chemical management of AIS.

H2b: The actual presence of AIS in one's lake is positively associated with greater support for chemical management of AIS.

Attitudes towards Aquatic Invasive Species (AIS)

Despite being regarded by experts as a threat to native plants and animals, there is often a disconnect between experts and the public when it comes to managing invasive species. Although invasive species may not be as controversial as climate change, or as high profile a science issue as genetically modified foods, an individual's understanding of invasive species is a key component in effective management (Bremner & Park, 2007; Jetter & Paine, 2004). Additionally, people who are more familiar with invasive species tend to be more familiar with their impacts (Nanayakkara et al., 2018) and that individuals higher in AIS familiarity tend to be more supportive of preventing the spread of AIS (Gates et al., 2009). However, other research has found that AIS knowledge does not always translate into adherence with management recommendations (Witzling et al., 2016). Moreover, some research suggests that being familiar with invasive species is related to an individual's sense that they can do something about the problems posed by invasive species. Clarke and colleagues (2021) found that individuals who rated highly on measures of self-efficacy (i.e., confidence in their ability to manage invasives on their own), and who were more likely to perceive invasive species as a threat were more likely to take action to manage invasive species on their property.

In addition to individual level factors, social factors also influence people's attitudes towards invasive species. The way people evaluate the value or perceived threat of a particular

invasive species can be influenced by factors that have little to do with the invasive species itself, but rather social or emotional factors unrelated to environmental impact. For example, Verbrugge, Van den Born, and Lenders (2013) examined the lay public's perceptions of invasive species and invasive species management in the Netherlands. They found that people were generally opposed to eradication of invasive species that had a high "cuddliness factor", such as mammals or birds, leading the authors to conclude that people's attitudes towards environmental management is highly influenced by factors other than scientific calculation. Other studies further illustrate the importance of people's value predispositions in informing how they approach invasive species management. Fisher and colleagues (2011) conducted a survey across eight different countries in Europe in order to explore how people's value dispositions and mental representations of individual species inform their attitudes towards management practices. They found that people were more likely to report wanting a particular species' population to increase if they perceived it to be harmless and there was a decline in the species' population previously. In other words, the perception that a species was harmless was strongly related to the desire to see the population of the species increase, regardless of whether the species in question a large mammal, a spider, or an invasive plant was. These findings suggest that notions of desirability or undesirability of a particular species, invasive or not, are complex and influenced heavily by an individual's values, beliefs, culture, or community norms.

Another key social factor influencing attitudes towards the environment in general is political ideology. At present, there is little research examining the influence of political ideology on individual attitudes towards invasive species management specifically. However, there is research that shows political ideology has an influence on environmental attitudes. Political conservatives, for example, have been found to place less importance on reducing

carbon emissions and, therefore, were less likely to support investment in energy efficient technologies (Gromet, Kunreuther, & Larrick, 2013). Moreover, research has shown that liberals tend to score more highly on measures of environmental concern than conservatives (Cruz, 2017) and has been shown to be correlated with responsible environmental behavior (Cottrell, 2003). Moreover, political ideology has been found to influence attitudes towards scientific topics like conservation (Coffey & Joseph, 2012). Pro-environmental behaviors, such as recycling, the boycotting of environmentally unfriendly companies, and conservation behaviors has been linked to an individual's values such that people alter purchasing decisions if they feel a company or organization's values do not align with their own (Mainieri et al., 1997; Stolle, Hooghe & Micheletti, 2005).

Other research has found that political ideology can also influence support for conservation efforts, like laws designed to protect endangered species (Czech & Borkhataria, 2001). The role of political ideology on trust in science is a topic of much debate. Some research has found that conservatives tend to have a greater distrust of science than liberals, particularly with regards to topics like climate change, attitudes towards energy efficiency, and overall attitudes towards environmentalism in general (Gauchat, 2012; Lewandowsky & Oberauer, 2017; Gromet, Kunreuther & Larrick, 2013; Dunlap, Xiao & McCright, 2001). Other studies, however, have found that differences in partisan trust in the scientific community is more nuanced. For instance, Krause and colleagues (2019) point out that an increase in individuals identifying as Independents, coupled with increases in the gap in trust in scientists between religious and non-religious individuals, and between urban and rural residents might account for some of the relationship between conservatism and skepticism towards science. In other words, traditional notions of conservatives as opposed to science may be more driven by divides in

strength of religiosity and geographic location rather than political ideology alone. Still, trust in scientists remains quite high, and has remained so even for controversial topics like global warming and nuclear energy (Krause et al., 2019). Although invasive species may not be controversial in the same way that climate change, vaccines, or GMOs are, there is some evidence that skepticism of the scientific consensus on invasive species is growing, increasing uncertainty among the public on this issue (Russell & Blackburn, 2017). Still, support for invasive species management is high in some populations (Bremner & Park, 2007), particularly among stakeholders who are most impacted by invasive species (Oxley, Waliczek, & Williamson, 2016).

One explanation, some scholars suggest, for this difference in partisan trust could be that environmental appeals tend to be framed in ways that are more appealing to political liberals (Feinberg & Willer, 2013) and that the frames used in this messaging may not be highly appealing to political conservatives as it relies more strongly on notions of care and harm (Graham et al., 2013; Clayton, Koehn & Grover, 2013). When environmental issues are framed in a way that are more likely to resonate with conservatives (i.e., by emphasizing loyalty, patriotism, authority, or personal responsibility) political conservatives and political liberals had roughly equivalent levels of pro-environmental attitudes (Wolsko, 2017). There is currently little research on the impact of political ideology on attitudes towards invasive species management strategies.

Data and Methods

The data used for this study is derived from the same data set used for study 1, with one modification. The Wisconsin Department of Natural Resources (WDNR) provided surface water

layer data with each water body indicated by a unique water body identification code (WBIC). This data was combined with other data provided by the WDNR which indicated the presence of specific invasive species in each water body using this WBIC. These data were merged with the data set from study 1 using the WBIC as reference.

Independent Variables:

Political Ideology. This variable is identical to the political ideology variable used in study 1.

AIS Familiarity. This variable is identical to the AIS familiarity variable used in study 1.

Presence of AIS in lake. This variable is designed to measure the actual presence of AIS in an individual's lake. In the data set, each individual invasive species is coded as 1 (present in the water body) or 0 (not present in the water body). This variable is constructed by adding all of the values that indicate a water body contains an invasive plant and transforming it into a binary variable where 1 indicates an invasive plant is present and 0 indicates a water body has no invasive plants. If a water body had both invasive plants and animals, it was treated as having invasive plants. If a water body had invasive animals but no invasive plants, it was excluded from the analysis. In total, 217 (29%) respondents resided on water bodies that contained at least one invasive plant, while 530 (71%) resided on water bodies that did not include any invasive plants.

Perception of AIS presence in lake. This variable is identical to the variable used in study 1.

Perceived Knowledge of AIS management. This variable is identical to the variable used in study 1.

Dependent Variables:

The dependent variable for study 2 is identical to the dependent variable in study 1.

Results

With regards to the first hypothesis (H1), it was not supported by the analysis ($B = -.063$, $p > .05$). Interestingly, however, perceived familiarity was significant in Model 4, after which the perceived presence of AIS variable was added.

The second hypothesis (2a) was, however, supported by the model. Individuals who reported that their lake had invasive species were significantly more likely ($B = .650$, $p < .001$) to support chemical management of AIS compared to those who did not report that their lake had AIS. Interestingly, there was no difference between individuals who did not know whether their lake had AIS or not, and those who reported their lake had no AIS ($B = .189$, $p > .05$). The second part of the hypothesis (2b) was not supported. The actual presence of AIS in one's lake showed no impact on an individual's support for chemical management of AIS ($B = .219$, $p > .05$).

The third hypothesis (H3) was also supported by the model. Individuals who were more socially conservative were more likely to support chemical management than individuals who were more socially liberal ($B = .147$, $p < .05$). Interestingly, however, economic conservatism showed no relationship to support for chemical management.

Table 5: Hierarchical Multiple regression model predicting support for chemical approach to AIS management (unstandardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Block 1 - Demographics							
Age	.007	.010	.008	.008	.008	.007	.007
Education	.062	.091	.093*	.078	.068	.057	.062
Incremental R^2 (%)		.005					
Block 2 – Political Orientation							
Economic Ideology	.061		.059	.059	.044	.059	.061
Social Ideology	.147*		.169**	.169**	.163**	.150**	.147**
Incremental R^2 (%)			.046				
Block 3 – AIS Familiarity							
Perceived AIS Familiarity	-.063			.196**	.180**	.104	-.063
Incremental R^2 (%)				.065			
Block 4 – Presence of AIS in lake							
AIS in lake = Yes	.219				.466***	.226	.219
Incremental R^2 (%)					.094		
Block 5 – Perceived Presence of AIS in lake							
Perceived presence of AIS = YES	.650***					.649***	.650***
Perceived presence of AIS = Don't know	.189					.191	.189
Incremental R^2 (%)						.129	
Block 6 – Perceived Knowledge							
Perceived knowledge of AIS Management	.159						.159
Incremental R^2 (%)							.128
Total adjusted R^2 (%)							12.8

*p< .05, ** p < .01 *** P < .001

Discussion

This study is one of the first to shed light on whether an individual's perception of AIS presence is more or less influential than the "on the ground" reality in influencing how people think about managing invasive species. While this study specifically examines perceptions versus reality in an invasive species context, it could help shed light on people's approach to environmental conservation more broadly. For example, in communicating to people about the importance of climate change mitigation, it might be most constructive to focus on what is happening in their community versus what they might think is happening elsewhere. For instance, individuals might be more motivated to engage with management practices if they can see evidence of biological invasions in their own backyard and understand the potential consequences such invasions might have for them personally.

The results of this study suggest that, at least in an invasive species context, perceptions play a strong role in determining how people choose to react to a perceived threat. An important implication of these findings is that science communicators and natural resources managers should be cognizant of the role perceptions play in people's minds and avoid over-emphasizing the threat invasive species causes because it could lead to unintended consequences (i.e., overuse of chemical treatments). Research has shown, for instance, that sensational language has a strong association with negative emotions (Otieno, 2014), and the results of study 1 demonstrate the importance of negative affect in influencing people's preference for chemical management of AIS. Other research (e.g., Shaw et al., 2021) has found that sensationalized language in science messaging does not perform any better or worse than straightforward, fact-based, communications.

Moreover, the finding that social conservatism, but not economic conservatism, impacted people's support for chemical management suggests that researchers and science communicators would do well to take a more nuanced approach to understanding the impact of political ideology on attitudes towards invasive species. For instance, some research has found that political ideology itself has no relation to attitudes towards some scientific issues, but it becomes significant in interactions with other variables like attention to news (Nardi et al., 2020). Other scholars have suggested the relationship between political ideology and trust in science is best understood as a distinction between attitudes towards governments, and attitudes towards corporations, (Pechar et al., 2018), suggesting that political ideology can be a complex factor with multiple components, each becoming salient depending on the specific context or issue under consideration. Consequently, natural resources managers interested in engaging in intervention or outreach activities might want to be cognizant of ways in which issue framing might inadvertently increase the salience of partisan identity when it might not be the most constructive to do so.

In the digital era, it is also important to acknowledge the role of social media in shaping perceptions and attitudes of various publics on different issues. Although this study did not examine the role of social media in this study, future research could take into account the impact of social media and social media use on shaping people's perception of scientific issues that receive less attention from mainstream media. While invasive species might not be a politicized topic like stem cell research, climate change, or COVID-19 vaccination, it is not guaranteed to stay that way. It may also be important for relevant stakeholders to acknowledge that, while the issue of invasive species may not be a politicized issue in a broader sense, how one manages invasive species once present may be political.

Chapter 4: Social Norms and Invasive Species Attitudes

Invasive species pose significant risks to native ecosystems and biodiversity (Vitousek et al., 1996, Asner et al., 2008) and have been suggested to be the cause of about half of extinctions with a known cause (Clavero & García-Berthou, 2005; Bellard et al., 2016). Although much research has been devoted to the investigation of impacts of invasive species on economically generative industries like agriculture and forestry (Vilà et al., 2010), the consequences of biological invasions can be far-reaching, including impacting human health by acting as vectors for disease (Medlock & Leach, 2015). At the same time, effectively managing invasive species can be costly and controversial. For example, individuals may oppose management of a particular invasive species if it has acquired a significant economic value or cultural significance (Roberts, Cresswell, & Hanley, 2018). Increasingly, scholarly attention is being given to beliefs, attitudes, and norms around people's relationship to the environment and the impact this may have on their approach to invasive species management. For example, individuals whose environmental values were assessed to be more "absolute ecocentric" (i.e., the belief that all living things have the right to coexist) were more likely to support a "hands off" management style with regards to invasive species compared to individuals with an "adaptive ecocentric" view of the environment (Sharp et al., 2011). However, while environmental attitudes, knowledge of invasive species and behavioral intention to engage with invasive species management may be influential in *informing* an individual's behavior, it is not sufficient to actually change an individual's behavior (Kollmuss & Agyeman, 2002).

Because invasive species management is a complex process, requiring coordination between private property owners, community members, and government agencies, the management of invasive species has been conceptualized by some scholars to be a problem of

collective action (Epanchin-Niell et al., 2010; McLeod & Saunders, 2011; Yung et al., 2015; Graham et al., 2018). One key challenge in many collective action problems is ensuring that individuals "do their part" to ensure that the organizational goal or objective is met or at least not hindered. With invasive species management, for instance, this could take the form of attending community meetings on invasive species or being aware of invasive species currently residing in their community and taking steps to avoid spreading them further. Social norms have been found to be an important aspect of invasive species management, both because they can help or hinder effective management of biological invasions. For example, Niemiec and colleagues (2016) found that the subjective social norm that others in one's community expect that an individual take action to control invasive species was positively associated with invasive species control behavior. This mirrors previous findings in that scholars have found that subjective social norms in which invasive species control behavior is uncommon was a common barrier to engaging in invasive species management (Prinbeck et al., 2011). Additionally, Witzling, Shaw and Amato (2015) found that subjective norms, but not descriptive norms, were positively correlated with compliance with AIS prevention steps. Other scholars have similarly suggested that using social norms to increase people's perception that others care about invasive species control could be influential in motivating individuals to support invasive species management (Graham, 2013). Conversely, social norms can also hinder invasive species control efforts. Ravnborg and Westermann (2002), for instance, found that, in some rural areas, social norms against approaching neighbors regarding land management decisions inhibited cooperation in invasive species management programs. While social norms can have a considerable influence on individual beliefs and behavior, context is important. Nevertheless, the role of social norms in influencing people's attitudes about environmental management cannot be ignored.

Literature Review

Social Norms

Social norms have been extensively studied for many decades. Sherif (1936) conceived of social norms as a, more or less, set of informal rules that regulate an individual's behavior or activities within a group. Individuals can then use the information conveyed by social norms to evaluate their own behavior relative to the social reality in which they exist (Festinger, 1954). Not only do norms regulate behavior, but social norms can also provide a sort of mental template for individuals navigating complex social information. Informally, social norms convey information about the acceptability of certain behaviors, beliefs, or attitudes within a group or social setting. At the same time, it is also important to distinguish between group or social-level social norms and an individual's understanding of these norms. The latter is often referred to as a perceived norm (e.g., Lapinski & Rimmel, 2005), and operates at the individual, rather than group, level. This distinction has led some scholars to conclude that norms are only meaningful if an individual perceives the violation of social norms to result in some sanction or other undesirable consequence (Bendor & Swistak, 2001). These injunctive norms refer to people's perception of "what ought to be done" in a given social circumstance (Cialdini, Reno, & Kallren, 1990). Descriptive norms, on the other hand, refer to beliefs about what is commonly done by group members (Reno, Cialdini, & Kallgren, 1993). Thus, descriptive norms simply provide information about how individuals tend to act in a given social situation (i.e., the prevalence of a certain behavior), whereas injunctive social norms come with a sanction (or perceived sanction) for violation (Reno, Cialdini & Kallgren, 1993). In many cases, descriptive and injunctive social norms can align. For instance, research on college student attitudes about alcohol consumption shows that many college students perceive that their peers commonly drink alcohol (Perkins &

Berkowitz, 1986; Cox et al., 2019), a descriptive social norm, and that they may lose friendships if they do not also drink alcohol (Rimal & Real, 2003; Yang & Nan, 2019). The differential impact of descriptive or injunctive norms on human behavior, however, can be complex.

Some qualitative studies have found that social norms in general can motivate people to engage in pro-environmental behavior, like sustainable harvesting of plants and animals or participating in invasive species management (Jones, Andriamarovololona, & Hockley, 2008; McKiernan, 2018). Additionally, sharing information about normative behavior (i.e., descriptive norms) has been found to encourage pro-environmental behavior, such as reducing electricity use, recycling, or behavioral intention to conserve energy (Farrow, Grolleau, & Inbanez, 2017). One possibility for this effect is that many pro-environmental behaviors are observable by others, leading to the establishment of a descriptive norm that can influence other people's perceptions of what is commonly done. Recycling, for example, in many municipalities is frequently a public behavior. Homeowners receive specific containers to deposit their recycling, which is then collected by the city on a set collection cycle. A homeowner who chooses not to put out their recycling in a neighborhood of recyclers would stand out. Other studies examining the influence of various types of social norms (e.g., personal, descriptive, and subjective) found that descriptive social norms played a significant role in behavioral intention to engage in pro-environmental behavior like recycling and household waste reduction (Niemiec, Champine, Vaske & Mertens, 2020).

Social norms and invasive species management

The United States Department of Agriculture (USDA) considers prevention of invasive species to be the safest and least expensive method of management (USDA, 2023). Some studies

recognize the importance of prevention strategies as a critical first step in a comprehensive management plan (e.g., Vander Zanden et al., 2010)

In addition to pro-environmental behavior, the role of social norms has also been studied in the context of managing invasive species (IS), which represent a growing concern to many communities as the effects of climate change continue to alternative ecosystems (IPPC Secretariat, 2021). Indeed, invasive species management is a collective action problem, requiring coordination and participation from a variety of actors, although much research on invasive species management has explored individual-level factors that influence attitudes towards invasive species. Attitudes towards specific species have been found to influence beliefs about the appropriateness of particular management practices (Marshall et al., 2011), for example, and studies point out that other individual-level factors like a lack of invasive species knowledge can impact whether people treat invasive species at all, as individuals who have little or no knowledge of invasive species may be unaware of the risk they pose to the local ecosystem (Fischer & Charnley, 2012).

However, other researchers also mention collective-level factors (i.e., social norms) warrant further exploration. For instance, Niemiec and colleagues (2016) found that many individuals in Hawai'i became discouraged in their efforts to combat an invasive tree when they perceived a lack of participation or coordination among others within their community. In this context, a descriptive norm was implicitly established that individuals in this community do not engage in IS control efforts, hindering the ability of the community to effectively manage the invasive species. At the same time, there is some research showing that norms themselves can influence an individual's behavior in managing invasive species. Minato, Curtis, and Allen (2010) studied a rural Australian community dealing with invasive weeds, finding that weed

control mechanisms can be enforced through norm-reinforcing social control mechanisms like gossiping. Furthermore, a study among landowners in Montana found that injunctive norms about how noticeable their weed control efforts are by neighbors positively correlated with the use of herbicides to control invasive weeds (Lubeck et al., 2019).

Injunctive norms can function as a way to motivate individuals to engage in invasive species management through, for example, the anticipation of recognition or praise for engaging in control efforts or for social or other sanctions for not participating in control efforts (Ostrom, 2000; Simpson & Willer, 2014). The social context in which individuals exist can play an influential role in motivating or demotivating behavior. A study in New Zealand examining landowner and land manager attitudes towards a predator control program, for example, found that the perception of others' participation in the predator control program was significantly related to their participation in the program and their perception of its efficacy (Niemiec et al., 2017). Specifically, individuals who believed that others did not participate in predator control, were much less likely to engage in predator control, finding it "pointless" to do so (Niemiec et al., 2017). A social norm can be established encouraging action towards a specific collective action goal, but it can also be established against such participation depending on the values and cultural context of the local community. Moreover, in Niemiec and colleagues' (2017) study, the perception of a social norm against participating in predator control programs was sufficient to inhibit participation, though it is unclear whether such a norm existed within the community. Thus, it is not just a matter of interrogating community-level social norms that matters when looking at social influences on invasive species control, but individual-level perceptions of these norms.

This is also particularly noteworthy given that some research found that community-level social norms were more influential than norms from natural resources agencies in motivating invasive species management behaviors. Coon and colleagues (2020a) investigated landowner attitudes towards non-native grasses and behavioral intentions to control them in the Great Plains region of the United States. They found that, while institutional norms (i.e., norms from government agencies) played some role in how people felt about their responsibility for managing non-native grasses, the effect was much weaker compared to social norms from peers. This, as the researchers postulated, could be partially due to a lack of trust towards government institutions in some rural communities, which is in line with prior research in this area (e.g., Coon et al., 2020b). Alternatively, it could also be that individuals in communities impacted by invasive species look to community-based opinion leaders for guidance and information about these issues rather than government officials or agencies.

Social norms, environmental values, and identity

As influential as social norms and normative beliefs may be within an individual or specific social group, it is important to recognize that norms are not universal. Different groups or communities have different normative beliefs about which behaviors are acceptable and in which contexts. One manifestation of this difference is through different social identity groups. The social identity approach (SIA) suggests that people within a particular identity group are linked through the values they hold (Abrams & Hogg, 1990), which in turn form normative beliefs about acceptable behaviors (Manfredo et al., 2016). Values, in this case, being the concepts or beliefs about desirable behavior, which "guide the selection or evaluation of behavior and are ordered by relative importance" (Schwartz & Bilsky, 1990). Unsurprisingly,

values, identity, and normative beliefs have been found to play a significant role in environmental behavior. Research has found, for instance, that people who drive cars may be less likely to reduce the amount of driving they do if they derive a sense of personal identity from driving a car (Stradling et al., 1999), and that an "environmental identity" increases compliance with pro-environmental actions like conserving energy (Van der Werff et al., 2011).

How a person identifies (e.g., as an environmentalist, anti-environmentalist, etc.) can also play a significant role in how they approach issues related to the environment because self-identification can increase the relative importance of perceived social norms (Terry & Hogg, 1996). Social identity is also thought to be generally stable and generalize to different contexts. For instance, a person who conceives of themselves as an environmentalist may make purchasing decisions about whether to buy environmentally conscious products, conserve energy usage at home, or engage in recycling. Gatersleben, Murtagh and Abrahamse (2014) conducted a study on over 2,600 UK residents and their attitudes towards sustainable lifestyles. They found a strong link between how an individual identified (i.e., as a health-conscious consumer, price conscious consumer, or environmentally conscious consumer) and personal norms surrounding pro-environmental behavior.

In particular, identity and personal norms played a greater role in specific behaviors in which an individual is more likely to feel they have greater freedom to act (i.e., in purchasing decisions like buying Fair Trade products) and that both factors played a significant role in behavioral intention to engage in pro-environmental behavior. Importantly, the link between individual values and pro-environmental behavior was often fully or partially mediated by social identity (Gatersleben, Murtagh & Abrahamse, 2014), suggesting that the influence of social norms imposed by self-categorization in an identity group might play a greater role than

individual values for some specific environmental behaviors. Additionally, other research has shown that not only can social identification moderate the relationship between values and behavioral intention, but it can also have a direct impact (Fishbein & Ajzen, 2010). In light of these findings on the role of social norms and their influence on environmental attitudes, the following hypotheses are proposed:

H1: Individuals who perceive greater social approval for following AIS prevention behaviors are less likely to perceive barriers to engaging in AIS prevention.

H2a: Individuals who perceive greater social approval for managing invasive species are more likely to believe that it is important to prevent the spread of AIS.

H2b: Individuals who perceive greater social approval for managing invasive species are more likely to believe that following AIS prevention behaviors can slow the spread of AIS than individuals with less social approval.

H3: Individuals with greater social approval are more likely to follow AIS prevention steps in the future than those without such social approval.

H4: Individuals who perceive AIS to be a greater threat are more likely to follow AIS prevention steps, more likely to believe that preventing the spread of AIS is important, and more likely to report following AIS prevention steps.

H5: Individuals who have more factual knowledge of AIS laws are more likely to believe that it is important to prevent the spread of AIS and are more likely to report following AIS prevention steps.

Political Ideology and environmental attitudes

Political ideology has long been known to play a role in how people approach science issues. From contentious and controversial issues like stem cell research and climate change, to more "under the radar" topics like invasive species management, an individual's level of conservatism or liberalism can factor significantly into how they think about environmental issues. For example, research has found that the more conservative a person is, the less likely they favor investing in energy efficient technology (Gromet, Kunruether, & Larrick, 2012); that liberals tend to score higher on measures for environmental concern (Cruz, 2017); or that political ideology has an impact on an individual's support for laws designed to protect endangered species (Czech & Borkhataria, 2001). Moreover, other research has found that conservatives are generally distrustful of science in general compared to liberals, particularly with controversial issues like climate change, although the degree to which conservatives can be considered "anti-science" is subject to empirical debate and may not be empirically accurate (Gauchat, 2012; Lewandowsky & Oberauer, 2017; Dunlap, Xiao & McCright, 2001, Krause et al., 2019). For example, Krause and colleagues (2019) point out that overall trust in science has remained relatively high over the decades and that the role of political partisanship in science attitudes is becoming increasingly complex as political partisans become more ideologically consistent (i.e., hold individual beliefs that are consistent with their party's platform) so the relationship between science attitudes and political identification less a function of political party identification and more a function of urban versus rural divides, religiosity, and individual values.

The relationship between political ideology and science issues like invasive species is less clear, largely because invasive species does not feature as prominently in partisan rhetoric as

issues like climate change and energy (Dunlap, Xiao & McCright, 2010; Feygina, Jost & Goldsmith, 2010). Previous research on message framing of invasive species management found that both liberals and conservatives were supportive of invasive species management, although it largely depended on whether the message was framed in ecological or economic terms (DeGolia, Hiroyasu & Anderson, 2019). Other research on invasive species found that political attitudes were related to attitudes about climate change, but not invasive species (Seidl & Klepeis, 2011), suggesting that it would be much too simplistic and inaccurate to assume general partisan trends applies to the issues of invasive species management. Based on these findings, the following research question is proposed:

R1: What is the relationship between political ideology and AIS prevention behavior?

Data and Methods

The data for this study comes from two surveys of Wisconsin boaters and anglers. The first distributed in 2018, in order to better understand Wisconsin boater and angler attitudes towards invasive species and related prevention behaviors. The second survey was a nearly identical survey distributed among Wisconsin boaters and anglers in 2019, also designed to assess boater and angler attitudes towards invasive species management and prevention behaviors. For the purpose of this study, data from the two surveys were combined. Because respondents did not provide answers for several survey items, resulting in missing data, missing data was imputed via the “automatic” procedure in SPSS version 28.

Data imputed via the "automatic" procedure is scanned automatically to determine whether the pattern of missing data has a monotone pattern or an arbitrary one, and data will be imputed via either the monotone method or Markov Chain Monte Carlo (MCMC) method

depending on which imputation method fits the pattern of missing data. For this analysis, a total of five imputed data sets were generated, with missing values being generated via linear regression. The values reported in each of the regression models represent the pooled coefficients from each of the five generated data sets.

Independent Variables

Demographics: The sample was mostly White (97.2%), with an average age of 56 years (*SD* = 11.36). With regards to gender, the sample was mostly male (64.9%). Regarding level of education, few participants (1.7%) completed some high school, 14.0% completed high school or received a GED, 39.3% had some college, technical, or trade school education, 28.5% completed a four-year college with a bachelor's degree and 16.6% completed a graduate or professional degree. Politically, on economic issues, 4.4% of participants described themselves as "very liberal," 10.2% as "somewhat liberal," 29.7% as "moderate," 28.8% as "somewhat conservative," 26.3% as "very conservative" and 2.4% of respondents reported they "don't know." With regards to social issues, 8.9% described themselves as "very liberal," 16.4% as "somewhat liberal," 29.3% as "moderate," 22.5% as "somewhat conservative" and 23% as "very conservative", with 2% reporting they "don't know".

Political ideology: This item asked respondents to rate how conservative or liberal they were on economic and social issues. The first question asked respondents "In terms of economic issues, would you say you are…," with response options presented on a 5-point Likert scale ranging from "Very liberal" to "Very conservative" (*M* = 3.60, *SD* = 1.13). The second question asked respondents "In terms of social issues, would you say you are…" with response options

presented on a 5-point Likert scale ranging from "Very liberal" to "Very conservative" (*M* = 3.34, *SD* = 1.25).

Perceived AIS threat: This item asked respondents directly "In your opinion, how much of a threat are AIS to the quality of fishing in Wisconsin?" with respondents presented response options on a 5-point Likert scale ranging from "No threat" to "Extreme threat" (*M* = 4.07, *SD* = .86).

Knowledge of AIS laws: This survey asked respondents to rate whether it was legal or illegal to engage in various invasive species behaviors. Respondents were asked whether it was "legal", "illegal" or "don't know" to engage in the following behaviors: "launch a boat trailer with plants or animals attached", "use the same boat on more than one body of water without prior power washing or other disinfection, such as drying for 5 days", "Leave a boat landing with any water onboard a boat or in equipment with the exception of bait buckets and drinking water", "Leave a boat landing with plants or animals attached to a boat or trailer", "Leave a boat landing with your catch in water", and "Use leftover minnows on another water body if they have had contact with lake or river water". To create the dependent variable, the binary responses for each item were summed up and recoded such that respondents who indicated they "didn't know" whether a specific action was legal, or illegal were coded as "0" (i.e., not having that specific knowledge). Thus, final knowledge of AIS laws scale ranged from 0 to 5 (*M* = 3.83, *SD* = 1.12).

Perceived knowledge of AIS laws: This item also asked respondents to rate their level of knowledge of AIS laws, asking respondents "How knowledgeable are you about the laws and regulations related to AIS?". Respondents indicated how knowledgeable they felt they were of AIS laws and regulations on a 5-point Likert scale ranging from "Not at all knowledgeable" to "Extremely knowledgeable" (*M* = 2.78, *SD* = .883).

Information seeking about AIS: This item asked respondents to rate how often they heard or seen information about AIS from various sources of information. The information source options presented to respondents were as follows: "In television news stories", "In television public service announcements or advertisements", "In a newspaper", "On the Internet", "On radio news shows", "On radio advertisements or public service announcements", "Signs at boat landings", "A person stationed at a boat landing", "Bait shop owners or their employees", "Fishing clubs or organizations", "Lake Associations", "Other anglers", and "Other boaters". Respondents were asked to rate how frequently they seen or heard information about AIS from these sources on a 5-point Likert scale ranging from "Not at all" to "A lot". These 13 items were combined to create a scale with Cronbach's alpha coefficient calculated to be .87.

Social Approval: Respondents were also asked to rate how much their friends, family, and other boaters or anglers would approve of them following AIS prevention steps. Respondents were directed to indicate their responses to the following questions: "How much will your friends approve if you follow the AIS steps?", "How much will your family approve if you follow the AIS steps?", and "How much do you think other boaters or anglers will approve if you follow the AIS steps?" with response options presented on a 5-point Likert scale ranging from "Not at all" to "Extremely". These three items were then combined into the social approval scale, with Cronbach's alpha calculated to be .88.

Dependent Variables

Perceived Barriers to AIS Prevention: This item is designed to measure a respondent's perception of barriers to engage in AIS prevention behaviors. The survey presented respondents with a list of reasons he or she may not engage in AIS prevention steps and asked respondents to

rate how strongly they agree or disagree with the following statements on a 5-point Likert scale ranging from "Strongly disagree" to "Strongly Agree": "There often is not enough time to do the steps"; "The steps are too physically difficult for me"; "I do not believe the steps will be effective at stopping the spread of AIS"; "I have a hard time understanding the steps"; "The boat launch is usually too crowded to perform all the steps"; "I would rather do the steps at home"; "There is no punishment if I do not follow the steps"; "Other boaters at the launch do not perform the steps"; "It is too dangerous to do the steps at my launch, e.g. due to high traffic or other reasons"; and "I don't have the tools I need to perform the steps at the launch". These 10 items were then combined into a scale, with Cronbach's alpha coefficient calculated to be .86.

Belief about the importance of preventing AIS: This item asked respondents to rate "How important do you think it is to prevent the spread of AIS?" on a 5-point Likert scale with response options ranging from "Not at all important" to "Extremely important" (M = 4.31, SD = .75).

Belief that following AIS prevention steps will slow the spread of AIS: This item asked respondents to rate how likely they believe following the AIS prevention steps will slow the spread of AIS. The question was worded as follows: "In your opinion, how likely is it that following the AIS prevention steps will slow the spread of invasive species?" with response options given on a 5-point Likert scale ranging from "Not at all likely" to "Extremely likely" (M = 3.8, SD = .88).

Likelihood of following AIS prevention steps: This item asked respondents how likely they were to follow all of the AIS prevention steps. The question was worded as follows: "How likely are you to follow all of the AIS prevention steps?," with response options given on a 5-point Likert scale ranging from "Not at all" to "Extremely" (M = 4.18, SD = .80).

Results

H1, regarding perceived barriers to AIS prevention, was supported. Social approval (B = -.325, $p < .001$) was the most significant predictor of the dependent variable. Individuals who perceived greater levels of social approval among friends, family, and other boaters or anglers were less likely to perceive significant barriers to engaging in AIS prevention steps compared to those with lower levels of social approval. Interestingly, both perceived knowledge (B = -.105, $p < .001$) and actual knowledge of AIS laws and regulations (B = -.059, $p < .01$) were also significant in the final model as well as perceived AIS threat (B = -.097, $p < .001$).

H2a, regarding the belief that it is important to prevent the spread of AIS, was also supported in the final model (model 6). In addition, social approval (B = 278, $p < .001$) was one of the largest predictors of the belief that preventing the spread of AIS is important. Interestingly, in this model, neither perceived knowledge of AIS laws (B = .047, $p < .001$) nor actual knowledge of AIS laws and regulations were significant predictors (B = .044, $p > .05$). However, the degree to which individuals perceive AIS to be a threat (B = .399, $p < .001$) was highly significant.

Additionally, H2b, regarding the relationship between social approval and the belief that engaging in AIS prevention steps can slow the spread of AIS, was supported in the final model. Social approval (B = .284, $p < .001$) was the largest predictor of this dependent variable, however AIS threat perception (B = .229, $p < .001$) was also highly significant. Moreover, there was a slight effect for gender, such that women were more likely than men to believe that engaging in AIS prevention steps can slow the spread of AIS (B = .141, $p < .05$). There was also a positive effect of actual knowledge of AIS laws (B = .058, $p < .05$) on the belief in AIS prevention efficacy.

Table 1: Hierarchical Multiple regression model predicting perceived barriers to AIS prevention (unstandardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Block 1 - Demographics								
Age	.001	.000246	.000218	.000457	.001	.001	.001	.001
Education	-.023	-.028	-.025	-.017331	-.018	-.017	-.019	-.023
Year of Survey	.000009	.075*	.000030	.000018	.000021	.000011	.000013	.000009
Gender (female)	.003	-.034	.004	-.050	-.048	-.082	-.081	.003
Incremental R^2 (%)		.003						
Block 2 – Political Orientation								
Political Ideology	.020		.038	.025	.023	.025	.026	.020
Incremental R^2 (%)			.012					
Block 3 – Threat Perception								
Perceived AIS Threat	-.097***			-.233***	-.203***	-.171***	-.165***	-.097***
Incremental R^2 (%)				.077				
Block 4 – Actual Knowledge of AIS laws								
Knowledge of AIS laws	-.059***				-.102***	-.091***	-.089***	-.059***
Incremental R^2 (%)					.096			
Block 5 – Perceived Knowledge								
Perceived Knowledge of AIS laws	-.105***					-.105***	-.095***	-.105***
Incremental R^2 (%)						.130		
Block 6 – Information Seeking								
Information seeking about AIS	.039						-.036	.039
Incremental R^2 (%)							.134	
Block 7 – Social Approval								
Social Approval	-.325***							-.325***
Incremental R^2								.253
Total adjusted R^2 (%)								25.3

*p< .05, ** p < .01 *** P < .001

Table 2: Hierarchical Multiple regression model predicting belief that it is important to prevent the spread of AIS (unstandardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Block 1 - Demographics								
Age	-.00040	-.00012	-.00018	-.000346	-.00038	-.00039	-.00042	-.00046
Education	.038	.050	.045	.029	.030	.029	.032	.035
Year of Survey (year = 2019)	.00004	.00002	.000012	.00004	.00004	.00004	.00004	.00004
Gender (female)	.125*	.148*	.126*	.186***	.185***	.201	.200***	.128*
Incremental R^2 (%)		.002						
Block 2 – Political Orientation								
Political Ideology	-.195*		-.068**	-.040*	-.040*	-.040*	-.041*	-.036
Incremental R^2 (%)			.015					
Block 3 – Threat Perception								
Perceived AIS Threat	.260***			.502***	.479***	.464***	.457***	.399***
Incremental R^2 (%)				.277				
Block 4 – Actual Knowledge of AIS laws								
Knowledge of AIS laws	.044*				.076***	.071***	.069***	.044
Incremental R^2 (%)					.282			
Block 5 – Perceived Knowledge								
Perceived Knowledge of AIS laws	.050*					.050*	.038	.047
Incremental R^2 (%)						.297		
Block 6 – Information Seeking								
Information seeking about AIS	-.021						.044	-.020
Incremental R^2 (%)							.299	
Block 7 – Social Approval								
Social Approval	.278***							.278***
Incremental R^2								.387
Total adjusted R^2 (%)								38.7

*p< .05, ** p < .01 *** P < .001

Table 3: Hierarchical Multiple regression model predicting belief that AIS prevention steps will slow the spread of AIS (unstandardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Block 1 - Demographics								
Age	-.00019	.00026	.00029	-.00004	-.00008	-.00007	-.00015	-.00018
Education	-.038	-.034	-.038	-.048	-.047	-.047	-.042	-.038
Year of Survey	-.00001	-.00001	-.00001	.000003	.000001	-.000003	-.00001	-.00001
Gender (female)	.141*	.208**	.192**	.230***	.229***	.217***	.215***	.141*
Incremental R^2 (%)		.008						
Block 2 – Political Orientation								
Political Ideology	-.026		-.050	-.032	-.031	-.030	-.031	-.026
Incremental R^2 (%)			.012					
Block 3 – Threat Perception								
Perceived AIS Threat	.229***			.318***	.293***	.304***	.288***	.229***
Incremental R^2 (%)				.095				
Block 4 – Actual Knowledge of AIS laws								
Knowledge of AIS laws	.058*				.085***	.088***	.084***	.058*
Incremental R^2 (%)					.102			
Block 5 – Perceived Knowledge								
Perceived Knowledge of AIS laws	-.055					-.037	-.064	-.055
Incremental R^2 (%)						.101		
Block 6 – Information Seeking								
Information seeking about AIS	.034						.099*	.034
Incremental R^2 (%)							.114	
Block 7 – Social Approval								.284***
Social Approval	.284***							
Incremental R^2								.180
Total adjusted R^2 (%)								18.4

*p< .05, ** p < .01 *** P < .001

Table 4: Hierarchical Multiple regression model predicting respondent's self-reported likelihood of following AIS prevention steps (unstandardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Block 1 - Demographics								
Age	-.00015	.00038	.00040	.00010	.00002	.000002	-.00011	-.00015
Education	.016	.015	.014	.004	.005	.004	.011	.016
Year of Survey	.00004	.00002	.00002	.00003	.00003	.00004	.00003	.00004
Gender (female)	.121*	.155*	.150*	.187**	.185**	.228***	.225***	.121*
Incremental R^2 (%)		.001						
Block 2 – Political Orientation								
Political Ideology	.006		-.016	.001	.003	.00009	-.001	.006
Incremental R^2 (%)			.002					
Block 3 – Threat Perception								
Perceived AIS Threat	.130***			.310***	.275***	.235***	.214***	.130***
Incremental R^2 (%)				.088				
Block 4 – Actual Knowledge of AIS laws								
Knowledge of AIS laws	.063***				.120***	.106***	.099***	.063***
Incremental R^2 (%)					.117			
Block 5 – Perceived Knowledge								
Perceived Knowledge of AIS laws	.107***					.131***	.094**	.107***
Incremental R^2 (%)						.162		
Block 6 – Information Seeking								
Information seeking about AIS	.042						.135***	.042
Incremental R^2 (%)							.182	
Block 7 – Social Approval								
Social Approval	.401***							.401***
Incremental R^2								.330
Total adjusted R^2 (%)								33.0

*p< .05, ** p < .01 *** P < .001

H3, regarding the self-reported likelihood of following AIS prevention steps, was similarly supported. Again, social approval (B = .401, p < .001) was the single largest predictor of an individual's self reported likelihood of following AIS prevention steps. Perception of AIS threat (B = .130, p < .001) and perceived knowledge of AIS laws and regulations (B = 107, p < .001) were also highly significant factors in whether individuals felt they were more likely to engage in AIS prevention steps. Additionally, more actual knowledge of AIS laws and regulations (B = .063, p <.001) also significantly predicted the likelihood of following AIS prevention steps.

Additionally, H4, regarding perceived threat, was also supported. The more an individual perceived AIS to be a threat, the more likely they were to report fewer perceived barriers to AIS prevention (B = -.097, p < .001), were more likely to report that preventing the spread of AIS is important (B = .399, p < .001) and more likely to report following AIS prevention steps (B = .130, p < .001).

Moreover, H5, regarding actual knowledge of AIS laws was somewhat supported in the final model. Individuals who had greater factual knowledge of AIS laws were more likely to report following the AIS prevention steps (B = .063, p < .001), although the relationship between factual knowledge of AIS laws and the belief that it is important to prevent the spread of AIS was non-significant (B = .044, p > .05).

The findings regarding political ideology (R1) are nonsignificant, but interesting. While political ideology was not a significant predictor in any of the final models, it was a significant negative predictor of the belief that it is important to prevent the spread of AIS until the social approval variable was added (Table 2), suggesting that what one's friends, family and other boaters and anglers think about AIS prevention might have some influence that cancels out the

influence of political ideology. No significant interaction effects with political ideology were found for any of the dependent variables.

Discussion

This study reveals some interesting insights about the relationship between social approval and various AIS beliefs about AIS prevention and behaviors. For one, social approval was highly significant for every dependent variable suggesting that, at least in Wisconsin, boaters and anglers value, to a significant degree, what their family, friends, and other boaters and anglers think of their participation in AIS management. This is in line with previous research on social norms and invasive species management or pro-environmental behavior, which finds that an individual's relationship with his or her community, as well as his or her perception of expected behavior can play a significant role in helping or hindering management actions (Witzling, Shaw & Amato, 2015).

The results of this study suggest that, for Wisconsin boaters and anglers, social approval is one of the greatest predictors of an individual's perception of the efficacy of engaging in AIS prevention as well as their self-reported likelihood of engaging in AIS prevention practices in the future. In my view, this has important implications for stakeholders engaged in AIS prevention outreach and education, because it underscores how important close relationships are in an individual's decision to adhere to best practice recommendations regarding invasive species management. While norms can indeed be imposed from the top down (i.e., from government agencies to communities), this approach may not be as effective if one's peer group or close relationships do not share the same norms. Indeed, previous research (e.g., Coon et al., 2020b) has demonstrated that many rural communities experience distrust of government agencies and

therefore may avoid compliance with government-endorsed normative behaviors unless they also align with the individual or community's own norms.

Another interesting finding is that social approval was a much stronger predictor of an individual's hesitancy to engage in AIS prevention behaviors than his or her knowledge of AIS laws, both perceived and actual. While both actual knowledge of AIS laws and regulations and the perceived knowledge of AIS laws and regulations were significant, they appeared to exert less of an influence compared to social approval. This may suggest that outreach campaigns emphasizing the legality of engaging in various AIS-spreading behaviors (e.g., releasing minnows or not cleaning one's boat properly) may have limited effect, particularly if an individual perceives others to not be following these practices themselves. While it may serve an important goal to ensure that boaters and anglers are informed of the legality of specific behaviors related to invasive species, it appears judicious to consider this a first step towards outreach with local communities, rather than a solution in and of itself.

Additionally, the findings regarding political ideology were somewhat surprising. While previous research has demonstrated that conservatives tend to be less environmentally conscious than political liberals (Gromet, Kunruether & Larrick, 2012; Czech & Borkhataria, 2001), the picture revealed in this study demonstrated no meaningful influence of political ideology on any AIS-related dependent variable. However, political ideology was a significant influence on the belief that preventing the spread of AIS is important only until social approval was added, after which political ideology became nonsignificant. Future research could examine in more depth the relationship between political ideology, social norms, and attitudes towards AIS prevention. It could be the case, for instance, that social approval mediates or moderates the influence of political ideology on AIS prevention attitudes.

It is also worth investigating, for instance, whether perhaps factors other than political ideology alone may be responsible for this effect. Krause and colleagues (2019) noted that many effects of partisanship can be explained by religious or geographical factors (i.e., urban or rural residency), and boating and angling are popular recreational activities in Wisconsin. It could be that this significant effect of political ideology is driven more by conservatives who live in more urban areas that are not primarily impacted by aquatic invasive species and therefore maintain some degree of psychological distance from the issue. Further research along these lines should explore whether there are any differences between urban and rural boaters in terms of attitudes towards AIS prevention. Findings from study 1 and study 2, for instance, suggest that conservatives do care about managing or preventing invasive species, even if they are more likely to prefer chemical methods to do so.

Chapter 5: Conclusion

The goal of this dissertation was to explore the social perception of risk and threat, particularly as it pertains to issues of AIS management and prevention. Invasive species (IS) provides a helpful context for this type of investigation because how threatening something is often informed by both what an individual knows about it, as well as how others in their community perceive it. Because invasive species can cause significant environmental damage that can be costly for communities to manage (Pimentel et al., 2005), the issue of invasive species is one in which understanding the interplay between individual beliefs, motivations, and values and those of the community is critically important. Understanding what factors influence people's decision-making with regard to these types of issues can help land managers, stakeholders, and environmentalists more appropriately reach out with impact communities while at the same time providing further insight into how people make decisions in relatively ambiguous circumstances.

Study Overviews

Study 1 examines what factors underpin lakeshore property owner preferences for chemical treatment of aquatic invasive species (AIS). While AIS may not be an inherently politically contentions issue, the use of chemical treatments in waterways can be, however, highly contentious. Research has shown that individuals are more likely to accept management methods perceived as "harsh" (i.e., chemicals) if there are clear guidelines surrounding their use and removal of AIS is evident (Gobster, 2011). Additionally, treating invasive species is a collective action problem, and individuals who opt not to participate in AIS management can cause significant problems for their neighbors and wider community. This is because AIS are

living, evolving, organisms and untreated spaces may serve as "invader propagule sources" (Epanchin-Niell, 2017) allowing AIS to multiply relatively undisturbed and then re-colonize previously treated segments of the environment.

At the same time, some research has called into question the circumstances under which chemical management of AIS is the most appropriate approach (e.g., Mikulyuk et al., 2020). One issue is that invasive species are not always present at highly abundant levels (Hansen et al., 2013), so using an environmentally risky method like chemical management may be a "nuclear option" with unintended side effects for non-target species. Glyphosate, for example, is a common chemical used to treat aquatic invasive species, but it is non-selective and will impact non-target plants of all types, both native and non-native (Helander, Saloniemi, & Saikkonen, 2012). Moreover, plants treated with glyphosate have been found to develop a resistance over time (Beckie, 2011), so further treatments will require an increasing amount of chemicals which some individuals may not find desirable. While some individuals or communities might find that using different types of chemicals to manage invasive species might be a desirable workaround, others might object to having more chemicals dumped into their lake.

In this study, an individual's preference for chemical treatment of AIS was largely driven by how they feel about invasive species (i.e., negative emotions), in addition to their perception of their lake as having AIS. Neither trust in university scientists nor trust in Wisconsin Department of Natural Resources (WDNR) scientists played a significant role in whether Wisconsin lakeshore property owners preferred chemical treatment of AIS. This may be partly due to the WDNR not taking an explicit anti-chemical stance on AIS management, rather viewing the use of chemicals to manage AIS as part of a comprehensive AIS control program. In fact, the WDNR explicitly mentions that eradication of invasive species is not realistic, and that

not all control methods are "practical, effective, economically feasible, or environmentally sound for every situation" (Wisconsin Department of Natural Resources, 2023). Thus, individuals facing an infestation of invasive species on their property are left with many options, but not so much guidance on what is considered to be "best practice".

Interestingly, although it was not a major finding, social conservatives were more likely to prefer chemical treatment of AIS than individuals who considered themselves to be socially liberal as well as both economic conservatives and economic liberals. While the precise reason this may be the case is not particularly clear, it could be due to partisan sorting. Research on party identification and political ideology with regards to environmental concern found that party identification had only a small influence on environmental concern whereas political ideology had a moderate effect (Cruz, 2017).

Study 2 expanded upon Study 1 by examining the relative impact of perceived and actual knowledge of AIS on people's preferences for chemical treatments. Increased knowledge of a situation or context is generally considered to improve decision making (Delli Carpini & Keeter, 1996), however there are different types of knowledge that may differentially impact people's perception of a given situation. For one, research has found that factual knowledge of a scientific issue only weakly correlates with positive attitudes towards science (Sturgis & Allum, 2000; Sturgis & Allum, 2001). Moreover, while "textbook" knowledge of science information may correlate with attitudes towards general science, it has also been found to negatively correlate with scientific issues that may be controversial, like stem cell research (Evans & Durant, 1995). Researchers have also distinguished between factual knowledge of an issue, and perceived knowledge (also called perceived familiarity), which represent different constructs and have different correlates (Ladwig et al., 2012; Vedlitz, 2016; Brossard & Shanahan, 2006).

In study 2, perceived knowledge of AIS (i.e., the perception of AIS presence in one's lake) was highly influential with regards to preferences for chemical management, but that the actual presence of AIS was not. Moreover, perceived knowledge of AIS management did not play a significant role in whether people preferred chemical treatment of AIS, suggesting that regardless of what people (think they) know about AIS management, treatment decisions of AIS may still be largely driven by factors examined in study 1 (e.g., negative affect, perceptions). Interestingly, actual knowledge of AIS presence (i.e., actually having invasive species in one's lake) was significant only until respondents' perceptions were taken into account, after which it remained non-significant. This suggests that, at least in Wisconsin, people's perceptions of whether their lake has AIS play a greater role in determining whether they would prefer to use chemical management methods than whether their lake actually does have AIS. Taken together with study 1, study 2 provides further evidence that, for Wisconsin lakeshore property owners, social factors like perception, emotions, and perceived knowledge of AIS and AIS management play greater roles in shaping attitudes towards management decisions than the "reality" of AIS infestation in their lakes.

Study 3, while using a different data set, explored the role of social norms and social approval in influencing how people feel about AIS management. Social norms have been found to either help or hinder IS management. Social norms can motivate people to take action because of the fear of social sanction (Niemiec et al., 2016) but social norms can also hinder IS management if norms of cooperation are not established, or if there are social norms surrounding mistrust of governmental agencies and officials (Ravnbourg & Westerman, 2002; Niemiec et al., 2017). Moreover, social norms are partly influenced by social identity because individuals are linked by values through their shared social identities (Abrams & Hogg, 1990). Pro-

environmental behavior, like reduced car use, has also been found to be informed by social identity and the values that come along with it (Stradling et al., 1999; Van der Werff et al., 2011) suggesting that these factors can be powerful motivators (or demotivators) in terms of how people approach science issues.

The findings of study 3 provide further support for the influence of social norms on people's attitudes towards invasive species management. Perhaps most relevant for land managers and government agencies charged with mitigating invasive species, study 3 showed that individuals with lower levels of social approval were much less likely to follow AIS prevention steps, even if these individuals believe that it is important to slow the spread of AIS. For individuals working with impacted populations, this could manifest in such a way that self-reported behavioral intention does not align with real-world practice (Witzling, Shaw & Amato, 2015). Understanding the various barriers people perceive to engaging in AIS prevention behaviors is a critical step in effective AIS management because, while individuals impacted by AIS might want to assist in the prevention or management of invasive species (i.e., by following prevention steps or guidelines), it must also be clear and easy for them to understand how to do so.

Across all four models, social approval was consistently one of, if not the, largest predictor of the dependent variables. Whether one's friends, family, or other boaters or anglers approve of following the AIS prevention steps greatly influenced whether a respondent reported they were likely to also follow these steps, influenced their belief that these steps were effective in slowing the spread of AIS, and influenced whether they believed that it was important to stop the spread of AIS. Additionally, this study also demonstrated that perceived threat significantly influenced how people perceived AIS prevention. Unsurprisingly, people who viewed AIS as a

threat were much more likely to follow AIS prevention steps, believe that they were effective, and endorse the idea that it is important to stop the spread of AIS.

This study also benefitted from being able to compare respondents' self-reported knowledge of AIS laws and their actual knowledge of AIS laws, which yielded some interesting findings. First, only actual knowledge of AIS laws and regulations was significant in influencing people's belief that following AIS prevention steps will slow the spread of AIS. It could be the case, for example, that people with more knowledge of AIS laws and regulations are also more knowledgeable about the impacts of AIS, how AIS are transmitted, and which behaviors are effective in preventing the spread of AIS compared to those who only perceive themselves to be knowledgeable. Additionally, both perceived and actual knowledge of AIS laws and regulations had a negative relationship with perceived barriers to AIS prevention, suggesting that, regardless of whether knowledge of AIS laws is based on measurable knowledge or not, it still results in a reduction in perceived barriers to AIS prevention. Additionally, both types of knowledge significantly influenced self-reported likelihood of engaging in AIS prevention behaviors. Interestingly, for both self-reported likelihood of engaging in AIS prevention behaviors and the belief that following AIS prevention steps will slow the spread of AIS, perceived knowledge had a greater influence than actual knowledge.

With regards to political ideology, this study demonstrates that, when it comes to invasive species prevention issues, it is not a particularly partisan issue. For example, there was no influence of political ideology in any of the models in study 3, although social conservatism did predict support for chemical management of AIS in studies 1 and 2. While invasive species might not be a politically contentious issue, it is still important for decision makers and land managers to understand the influence of political ideology in shaping people's beliefs and values

so they can create effective outreach and intervention programs without potentially alienating certain communities with contentious issue framing.

The preferences we see for chemical management in studies 1 and 2 could be driven by social norms surrounding their use or cost associated with AIS removal. Because invasive species management is a collective action problem, impacted community members must work together to decide on a treatment plan, which can be costly. In Wisconsin, for example, spending on invasive species management totaled over $8.4 million a year (Wisconsin Department of Natural Resources, 2023), so once a community decides on a management plan, it can be costly and time consuming to choose another.

Practical Implications

The influence of social forces on how people approach science issues cannot be understated. As study 1 illustrated, people's perception of AIS presence was a strong predictor of whether they were more likely to prefer chemical treatment, even after actual AIS presence was considered in study 2. At the same time, these findings also suggest avenues for future research.

First, there is no clear guidance on what constitutes a "best practice" for invasive species management, partly because it depends on species, lake, and community. Communities dealing with invasive species infestation are faced with potential economic damage to their property values (Horsch & Lewis, 2009) and a plethora of management options ranging from hand pulling to chemical treatment, each of which have varying costs and risks associated with them. The WDNR (Wisconsin Department of Natural Resources), as a governmental agency, does not advocate for any particular treatment method, even though chemical treatment may have adverse effects on the health of other lake life and humans (Wagner et al., 2007), so communities are

largely left to their own devices in terms of what management options might be best for them. Future research could explore whether providing more explicit guidance to impacted communities could influence their choice of management option. This might be particularly important given that profit-motivated companies that sell services to treat invasive species might be engaging in search engine optimization (SEO) or other targeted marketing techniques designed to place their companies and products at the top of search engine results which could then be more salient in the minds of people conducting Internet searches on how to treat invasive species.

It may be the case, for example, that chemical options are more likely to be used because they are merely *perceived* to be the most effective, even if they might not be appropriate for the particular invasive species under consideration. Research that investigates what factors influence people's decision making can be particularly informative in this type of scenario. For example, a conjoint analysis could compare various attributes of each management approach (e.g., cost, side effects, time requirement) and ask people to rate how likely they are to pick each type of management option. Such an experiment could better inform land managers about what factors impacted communities value when selecting treatments for AIS in order to better develop outreach materials and interventions.

Second, future research should consider the differences between perception of AIS presence and actual AIS presence. Given that study 2 found that the actual presence of AIS did not impact whether people preferred to use chemical treatments or not, it seems reasonable to suggest that relevant stakeholders should attempt to inform individuals about whether their property does, in fact, have invasive species in order to potentially reduce the overuse of

chemical treatments. In this way, an individual's perception and reality can align, perhaps leaving less uncertainty for those who might consider treating a lake "just in case".

Given the findings on social approval outlined in study 3, future research could expand upon these findings by further investigating the role of social identity in shaping attitudes about invasive species management. There is some research, for instance, that found social identity influences the type of control methods people use (van Eeden et al., 2020). For example, do people who conceive of themselves as environmentalists use chemical treatments with the same frequency as those who do not? Although it seems like they would not, van Eeden and colleagues (2020) found, for instance, that individuals who considered themselves to be "animal welfare activists" did not differ from other respondents in terms of methods preferred to control wild dingoes in Australia suggesting that, in some contexts, identity and behavior may be incongruent with expectations. Furthermore, future research could explore in what ways social identity or social norms might be moderated by threat perception. Although no significant interactions were found in this dissertation, this may be because respondents overwhelmingly considered AIS to be a threat, so there was little variability in terms of attitudes towards invasive species in these samples.

As an issue of science communication, many people might not consider invasive species to be a particularly "hot button" issue, yet some researchers have identified a growing trend in "invasive species denialism" that dates back to the 1990s (e.g., Ricciardi & Ryan, 2017). The contours of this debate mirror that of climate change denialism surprisingly well in that those who promote the viewpoint that invasive species are not harmful, or that the field of invasion biology is pseudoscientific, often engage in rhetorical strategies that cast doubt on the scientific consensus on invasive species (Ricciardi & Ryan, 2017) or frame invasion biology in terms of

other politically contentious social discussions like racism and xenophobia (see Simberloff, 2003). There are, indeed, legitimate criticisms of the science communication surrounding invasive species. The use of militaristic metaphors (i.e., referring to invasive plants or animals as "invaders") has long been problematic (see Larson, Nerlich & Wallis, 2005), yet the effectiveness of these metaphors, still used today, are questionable (Shaw, Campbell, & Radler, 2021). Effective science communication is, of course, contingent upon sound scientific evidence. However, I would argue that it is equally subject to the whims of social perception and, as such, highly influenced by what people see, think, and hear about these science issues. As I have shown in this dissertation, in some contexts, what people think matters much more than what science says and, as such, is heavily influenced by inherently non-scientific factors like values, norms, and ideology. With this in mind, I would argue that science communication should be conceptualized not as *communicating science* but communicating *with* science.

Theoretical Implications

Future research should also explore, in more depth, the role that social norms may have in moderating or mediating individual attitudes about AIS prevention, management, or treatment. For example, in study 3, political ideology was a significant predictor of the belief that it is important to stop the spread of AIS only until the social approval variable was added in the final model. It is possible that political ideology might initially influence individual-level beliefs or attitudes about AIS prevention, but that this effect could be somewhat attenuated by the influence of social norms. Future research could also explore in more depth the role of injunctive norms surrounding AIS prevention behaviors and people's perception of social sanctions for not engaging in such behaviors. Witzling, Shaw, and Amato (2015) for instance, suggested that signs

used by the Wisconsin Department of Natural resources could serve as a way to signal injunctive norms to individual boaters by implying that it is against the law to not follow AIS prevention steps. Additional research along these lines could explore alternative ways of framing normative AIS prevention behavior, either via signs, notices, newsletters or via other means. Additionally, while social approval, perceived knowledge of AIS laws and actual knowledge of AIS laws were all significant in reducing individual's perceived barriers to AIS prevention, future research could also further explore perceived barriers to engaging in AIS prevention behaviors. For instance, some individuals may not engage in AIS prevention behaviors because they perceive that other boaters or anglers do not engage in such behavior themselves and therefore following AIS prevention steps would not contribute significantly to slowing the spread of AIS. Future researchers could explore various interventions that boost individual self-efficacy with regards to engaging in AIS prevention steps to, hopefully, boost individuals' willingness to perform AIS prevention steps regardless of whether they perceive other boaters or anglers doing so.

Lastly, although invasive species is not generally regarded as a politically contentious issue, it is still important to understand the role political ideology plays in shaping people's beliefs and values, as well as the ways in which political ideology might interact with social norms in influencing individual behavior. The COVID-19 pandemic, for example, demonstrated how quickly a science issue can evolve into a political one, so stakeholders should be cognizant of the potential for politicization. There is some research, for example, investigating the politicizing of invasive species in the post-Brexit United Kingdom, and how these issues were co-opted by nationalist figures appealing to notions of a "pure" or "pristine" Britain in the wake of the migrant crisis in 2015 (Davies, 2022). This seems to suggest that relatively low-profile scientific issues that are not traditionally partisan can be co-opted to suit a particular narrative

goal. Moreover, there is an emerging debate on "invasive species denialism," in which elements of skepticism about the impact of invasive species, or ethical concerns surrounding invasive species management are likened to general science denialism (Frank, 2021). Given that the spread of invasive species can, in some cases, be linked to climate change (Finch et al., 2020), which *is* a politically contentious issue, it seems likely that invasive species as a science issue has the potential to become politicized. As an aside, it is important to recognize the link between conservatism and science skepticism is often confined to political contexts in the United States. Studies conducted in international contexts, for instance, have found that the link between political ideology and climate change skepticism is particularly strong in the United States, but is less so in other countries (Hornsey, Harris, & Fielding, 2018). Thus, climate skepticism and other attitudes deemed "anti-science" do not appear to be inherent to conservatism as an ideology, but rather arise from the unique cultural and media environments in which these patterns occur. It is also worth noting that economic conservatives were not always so-called "science skeptics" – in the beginning of the 21st century, for example, economic conservatives tended to have fairly positive views of science and scientists whereas social or "moral conservatives" have always had low confidence in scientists before any meaningful distinction between liberals and conservatives on this issue emerged (Kozlowski, 2021).

At the same time, invasive species have also been referred to as "commonly rare and rarely common" due to their relative lack of abundance in they inhabit (Hansen et al., 2013). This, as Hansen and colleagues (2013) point out, is often counter to the perception that invasive species quickly establish themselves, become dominant, and overwhelm native species populations. So, while I argue that it is important to understand the ways in which factors like political ideology or the process of politicization could potentially impact discourse around

invasive species, it is also important to avoid exaggerating or catastrophizing the impact invasive species has on a given ecosystem.

To conclude, as we delve deeper into the psychosocial dynamics of individual attitudes, values and behaviors involved in AIS prevention and management, the intricate interplay between social norms, political ideology, perceptions of threat, and perceptions of management efficacy becomes increasingly evident. The potential, albeit remote, for invasive species issues to become politically polarized, akin to the example of COVID-19, raises questions about how science-related topics can be co-opted for various narratives. As we navigate this terrain, it is imperative for natural resources managers, academics, and the general public to recognize both the malleability of perceptions and the nuanced balance between addressing concerns and avoiding unwarranted catastrophization in the management and prevention of invasive species and their impact on ecosystems.

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Appendix A: Standardized Regression Coefficients for Chapter 2

Table 1: Hierarchical Multiple regression model predicting support for chemical treatment approach (standardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Block 1 - Demographics							
Age	.066	.093	.074*	.072	.068	.067	.059
Education	.046	.038	.078	.066	.045	.044	.052
Incremental R2 (%)		.009					
Block 2 – Political Orientation							
Ideology - Social	.135*		.176**	.176**	.150**	.152**	.160**
Ideology- Economic	.077		.053	.053	.063	.065	.074
Incremental R2 (%)			.044***				
Block 3 – Familiarity							
Perceived AIS Familiarity	.92*			.143***	.066	.065	.062
Incremental R2 (%)				.020***			
Block 4 – Perception of AIS in Lake							
Perceived AIS Impact	.015				-.059	-.058	-.033
AIS in Lake = Yes	.284***				.324***	.324***	.279***
AIS in Lake = Don't Know	.136*				.097	.097	.084
Incremental R2 (%)					.065***		
Block 5 - Trust							
Trust in Scientists	.008					.009	.020
Incremental R2 (%)						.000	
Block 6 - Emotions							
Negative Affect	.156***						.131**
Incremental R2 (%)							.015***
Total adjusted R2 (%)							13.9

*p < .05, ** p < .01 *** P < .001

Appendix B: Standardized Regression Coefficients for Chapter 3

Table 5: Hierarchical Multiple regression model predicting support for chemical approach to AIS management (standardized coefficients)

	Zero Order correlations	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Block 1 - Demographics							
Age	.057	.082	.067	.058	.059	.053	.057
Education	.067	.056	.093*	.076	.068	.063	.067
Incremental R^2 (%)		.005					
Block 2 – Political Orientation							
Economic Ideology	.088		.090	.084	.072	.086	.088
Social Ideology	.135*		.151**	.162**	.156**	.140**	.135*
Incremental R^2 (%)			.049				
Block 3 – AIS Familiarity							
Perceived AIS Familiarity	.039			.129**	.126**	.080	.039
Incremental R^2 (%)				.063			
Block 4 – Presence of AIS in lake							
AIS in lake = Yes	.067				.155***	.069	.067
Incremental R^2 (%)					.086		
Block 5 – Perceived Presence of AIS in lake							
Perceived presence of AIS = YES	.254***					.255***	.254***
Perceived presence of AIS = Don't know	.091					.083	.091
Incremental R^2 (%)						.115	
Block 6 – Perceived Knowledge							
Perceived knowledge of AIS Management	.062						.062
Incremental R^2 (%)							.115
Total adjusted R^2 (%)							11.5

*p < .05, ** p < .01 *** P < .001