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Human-Nature Relationships and Normative Beliefs Influence Behaviors that Reduce the Spread of Aquatic Invasive Species

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Abstract

Human behaviors that contribute to the spread of aquatic invasive species are influenced by myriad social psychological factors that vary across contexts and populations. Understanding such behavior is crucial for forming successful management strategies that minimize environmental impacts while generating support and cooperation among stakeholders. We identify several reasons why recreational anglers and boaters make decisions that benefit the environment. Specifically, our study addresses the following objectives: (1) examine reported behaviors that minimize the spread of aquatic invasive species, (2) test the effects of social normative beliefs on reported behaviors, and (3) determine the role of human-nature relationships in explaining behavioral patterns. Drawing on a path model of the decisions made by respondents who completed an on-site survey at two nature-based case study sites in Illinois, we observed that reported behavior was positively influenced by normative beliefs about those behaviors and human-nature relationships. Specifically, the Participant in Nature and Partner with Nature orientations were positively and negatively correlated with norms, respectively. In turn, norms positively predicted reported stewardship behaviors. These findings advance research on the human dimensions of aquatic invasive species by providing insights on the role of stable psychological processes that shape behavior, while informing management decisions aimed at minimizing biological invasions in freshwater ecosystems.

Keywords Invasive species · Pro-environmental behavior · Social psychology · Freshwater ecosystems

Environmental Behavior and Aquatic Invasive Apecies

Aquatic invasive species (AIS) are transforming the face of waterways in the United States and abroad (Pagnucco et al. 2015; Stiers et al. 2011). Illinois waters in particular, including inland waterways and Lake Michigan, are impacted by numerous AIS, most notably Asian carp (*Hypophthalmichthys* genus), zebra mussels (*Dreissena polymorpha*), Eurasian watermilfoil (*Myriophyllum spicatum)*, and the spiny water flea (*Bythotrephes longimanus*) (Cole et al. 2016). Asian carp threaten to displace native sportfishes and change the species composition of valuable recreational and commercial fisheries (Hintertheur 2012; Irons et al. 2007). Zebra mussels have reached high densities and filtered large volumes of water, resulting in substantive change in water quality and disruption of food webs (Higgins and Vander Zanden 2010). Eurasian watermilfoil growth has also crowded out native plants, interfered with recreational activities, and lowered the value of lakefront properties (Zhang and Boyle 2010). Moreover, large numbers of spiny water fleas can accumulate on fishing lines, hindering angler activity, in addition to unbalancing the ecosystem by displacing native zooplankton (Yan et al. 2011). Once these AIS establish, reversing their effects is difficult and often cost-prohibitive (Leung et al. 2002). Therefore, the prevailing management strategy has been to adopt practices that prevent the introduction and spread of

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AIS rather than trying to remove them following establishment (Mack et al. 2000; Vander Zanden and Olden 2008).

Water-based recreationists have directly contributed to the spread of AIS by transporting plants and animals from one waterway to another via uncleaned boats (Rothlisberger et al. 2010), sediments on fishing equipment (Gates et al. 2009), and dumped bait or fishing waste (Drake and Mandrak 2014). In response, management agencies have designed and implemented numerous educational programs at local and national scales (e.g., "Stop Aquatic Hitchhikers" campaign; see Seekamp et al 2016), and taken steps to reach broad audiences through outlets, such as advertisements at movie theaters (Shaw et al. 2014). Previous research has assessed factors, such as awareness, concern, and the perceived threats of biological invasions (e.g., Cole et al. 2016; Seekamp et al. 2016), and indicated that angler awareness of AIS is increasing (Nanayakkara et al. 2017). However, behaviors that distribute AIS persist (Cole et al. 2016). Several examples include dumping unwanted live bait fish into waterways in Maryland (Kilian et al. 2012), not always washing boats after exiting waterways in Wisconsin (Rothlisberger et al. 2010), and not cleaning equipment to remove AIS in Montana (Gates et al. 2009). In these contexts, simply informing recreationists of the effects of their actions on the environment have not translated into behavior change (Connelly et al. 2016; Eiswerth et al. 2011; Prinbeck Lach and Chan 2011).

The actions of anglers, boaters, and other water-based recreationists can be attributed to diverse and complex causes that include beliefs (Connelly et al. 2016), knowledge and awareness of AIS (Eiswerth et al. 2011), and environmental attitudes (Cottrell 2003; Pradhananga et al. 2015). These psychological processes influence "pro-environmental behavior," which is a multi-dimensional concept spanning public, private, and social domains (Steg and Vlek 2009; Van Riper and Kyle 2014; Larson et al. 2015). Gaining empirical insights on the relationship between behavior and other influential variables such as environmental worldviews or 'human-nature relationships' is also a priority, because these are psychologically stable processes that transcend contexts and are formed early in a person's life (Dietz et al. 2005). This lies in contrast to the current focus of literature on concepts like beliefs that shift with new information and in particular management contexts. Despite the benefits that would emerge from better understanding and shifting 'long-term' drivers of behavior, they are absent from the literature evaluating the drivers of angler behavior. Greater knowledge of the empirical relationships between human-nature relationships and environmental behavior will provide management agencies with guidance on how to frame information in a way that resonates with stakeholders' underlying orientations, and in turn, stimulate lasting changes in behavior (Manfredo et al. 2017).

The primary objective of this study was to engage with relevant stakeholder groups including recreationists and organism-in-trade hobbyists (Kemp et al. 2017), and advance theoretical knowledge of the role of multiple dependent variables that influenced behavior tied to the spread of AIS (Pradhananga et al. 2015). Specifically, we quantified how human-nature relationships influenced social normative beliefs that in turn predicted reported behaviors. We also aimed to provide guidance on how environmental management agencies could target a range of psychological processes, including short- and long-term drivers, to more effectively prevent impacts of biological invasions in freshwater ecosystems.

Conceptual Framework of the Relationship Among Drivers of Behaviors

Pro-environmental Behavior

Actions that aim to minimize degradation and benefit the environment are referred to as "pro-environmental behaviors" (Stern 2000). These actions are performed in relation to an array of environmental issues, from aquatic invasive species (Kemp et al. 2017) to resource consumption (Poortinga et al. 2004; Steg et al. 2005) and natural area conservation (Halpenny 2010; Van Riper and Kyle 2014). Given the importance of understanding how anglers interact with fishery resources (Ward et al. 2013; Heck et al. 2015), previous research has examined behaviors such as removing aquatic plants and sediments from boats, trailers, and equipment, throwing away unused bait and fish waste in trash facilities rather than in waterways, and draining water in boats, livewells, and buckets before leaving recreation settings (Seekamp et al. 2016).

Previous research, including work guided by the value-belief-norm model of environmentalism (Stern et al. 1999), has converged on the assumption that behavior is a multi-dimensional construct. For example, Larson et al. (2015) identified four types of pro-environmental behavior that rural landowners adopted to enhanced environmental quality in New York, including social environmentalism (e.g., talking to others about environmental issues), land stewardship (e.g., private land habitat enhancement), conservation lifestyle (e.g., recycling), and environmental citizenship (e.g., petitioning about environmental issues). In this vein, social advocacy behaviors have also stimulated environmentalism and therefore warrant consideration in environmental social science research (Lewandowski and Oberhauser 2016), especially in freshwater ecosystmes where social pressures are relevant for predicting angler

behavior (Drake et al. 2015). In response to this growing body of literature, behavior can be considered in terms of three dimensions that represent public, private, and social stewardship activities (Landon et al. 2016). Theoretically, these behaviors are linked to predictors, such as social norms (Cialdini and Trost 1998) and human-nature relationships (Kemp et al. 2017); however, previous research has yet to engage with these concepts and determine their combined effects on angler behavior.

Social Normative Beliefs

Norms are behavioral and ethical standards imposed by society that play an important role in explaining human behavior (Cialdini and Trost 1998; Schultz et al. 2007; Heywood et al. 2000). The norm activation model (Schwartz 1977) is a guiding framework that describes the major factors contributing to norms and the influence of norms on an individual's decisions (Cialdini et al. 1990; Stern et al. 1999; De Groot and Steg 2009). The premise of this model is that people are compelled by moral obligations and feelings of guilt, worry, and pride. When activated, these "personal norms" are powerful predictors of behavior (Heberlein 2013) that work in tandem with normative beliefs (termed "social norms") indicating how an individual believes other people are acting. A growing body of research has drawn on social norms to better understand behaviors, such as outdoor water use (Landon et al. 2016) and the control of AIS (Prinbeck et al. 2011). Water-based recreationists, in particular, tend to conform to the expected behaviors within recreational communities at boat ramps due to the presence of other people (Seekamp et al. 2016). Thus, exploring the role of social normative beliefs in behavior change tied to AIS can identify avenues for management agencies to encourage pro-environmental outcomes.

Human-Nature Relationships

Human-nature relationships are psychologically stable worldviews about the complex relationships that form between people and places (Bauer et al. 2009; Mace 2014; Van den Born 2008). The longest-standing and most widely used measure of human-nature relationships is the New Ecological Paradigm (NEP) scale that considers the degree to which a person believes the human race should dominate over the natural world (Dunlap et al. 2000). The NEP scale has advanced knowledge in diverse cultural and environmental contexts; however, it has been criticized due to its reduction of human-nature relationships into two diametrically opposing worldviews (i.e., anthropocentric vs. biocentric), varied empirical interpretations, and antiquated language (Hawcraft and Milfont 2010). A growing body of research characterizes people's relationship with nature as more complex than what is posited by the NEP scale (for a review see Flint et al. 2013). Therefore, other scales have been developed to measure human-nature relationships.

One promising measure of the different facets of human-nature relationships is the Visions of Nature framework (Van den Born 2008). Like the NEP, this framework shares a rich history of use and development, albeit largely in European countries (Flint et al. 2013). The Visions of Nature framework also accounts for some of the disadvantages of previous measures like the NEP by including multiple dimensions (Hawcroft and Milfont 2010). The Visions of Nature framework posits that a person's relationship with nature can be divided into four non-mutually exclusive dimensions (de Groot et al. 2011). The Master over Nature dimension describes the level of importance a person assigns to the human race. High levels indicate a person believes the natural world is subordinate to human beings. The Participant in Nature dimension indicates the extent to which a person feels that humans are spiritually connected with the natural world. This dimension is the most biocentric of the four dimensions. The Partner with Nature dimension describes how much a person feels the natural world and the human race are equals. Finally, the Steward of Nature dimension indicates whether a person believes that human beings are responsible for the management and preservation of nature. Because, these dimensions are not mutually exclusive, a given individual could report similar results for several of these dimensions. Consequently, several studies have found little statistical support for distinguishing between Partner with Nature and Participant in Nature (Van Heel et al. 2017; Flint et al. 2013). Therefore, further research on the dimensional structure of this scale and the extent to which its four components can be distinguished from one another is warranted (Muhar and Bock 2017).

Previous research has suggested there is a linkage between human-nature relationships and pro-environmental behavior (Verbrugge et al. 2013; Pradhananga et al. 2015), yet empirical evidence of this relationship is scant. One exception is a qualitative study that explored the role of human-nature relationships in angler and organism-in-trade hobbyists' evaluations of AIS outreach campaigns (Kemp et al. 2017). These authors suggested a variety of relationships were formed between people and nature, all of which differentially influenced environmental behavior. Moreover, these authors indicated perceived responsibility and a sense of moral obligation factored into decisions about the spread of AIS. Better understanding the role of human-nature relationships and normative processes in behavior change will thus provide a basis for incorporating individual and group decisions into broader frameworks that guide conservation action and social-ecological systems research

(Muhar et al. 2018). This information can be leveraged by management agencies to determine how best to frame information in a way that aligns with the worldviews of key stakeholders.

Hypotheses

Building from a review of past work, five hypotheses about the effects of social normative beliefs and four dimensions of human-nature relationships on pro-environmental behavior that influenced the spread of AIS were developed. First, as Social Normative Beliefs increased, so too would the degree to which people reported engagement in Pro-Environmental Behavior. Second, as the Master over Nature orientation increased, it was hypothesized that respondents would be less likely to hold Social Normative Beliefs. The third, fourth, and fifth hypotheses indicated that as Participant in Nature, Partner with Nature, and Steward of Nature orientations increased, levels of Social Normative Beliefs would also become more pronounced.

Methods

Study Contexts

We conducted this research at two nature-based recreational areas in Illinois, including Chain O'Lakes State Park and the North Point Marina on Lake Michigan. These sites were selected in consultation with the Aquatic Invasive Species team of the Illinois-Indiana Sea Grant. Our rationale was to select two sites that reflected the water-based recreational opportunities provided within the state. These two case study sites represented one inland waterway and one access point on Lake Michigan.

The first site, Chain o' Lakes State Park (www.dnr.illinois.gov/Parks/Pages/ChainOLakes.aspx), provided access to the largest concentration of natural lakes in Illinois. As such, it was a prime location to sample boaters looking for recreational opportunities in a nature-based, yet accessible context outside of an urban area (i.e., Chicago). Situated in northeast Illinois in McHenry and Lake Counties, the park contains an 18-hectare lake within its boundaries and connects to seven other lakes that make up its lake "chain". In total, boaters can access nearly 2630 hectares of water from its boat ramp. Other recreational facilities include over 26 km of trails available to hikers, bikers, and horseback riders and 230 campsites and cabins. The second case study site, North Point Marina State Recreation Area (www.dnr.illinois.gov/Parks/Pages/NorthPointMarina.aspx), is the largest marina on the Great Lakes. Located 1 h north of Chicago, this recreation area provides access to Lake Michigan and extensive boating services, including a floating fuel dock, convenience store, and a protected dock system of 1500 slips from 9 to 18 meters in length. It also hosts fishing tournaments that attract people from the broader Great Lakes region. In addition to boating opportunities, the area includes a conference venue and camping facilities.

The Mississippi and Great Lakes basins where our two sites were located are at high risk for AIS transfer, as reflected by previous research that found 254 different AIS within the region (Veraldi et al. 2011). In this list of fish, plants, mollusks, crustaceans, and protozoans, 35 species were confined to only one basin and were at high risk for causing harm if transferred into the other basin (GLMRIS 2012). Some of these species (e.g., silver carp *Hypophthalmichthys molitrix*, ruffe *Gymnochephalus cernuus*) could swim between basins, while others (e.g., Eurasian watermilfoil *Myriophyllum spicatum*, spiny water flea *Bythotrephes longimanus*, zebra mussel *Dreissena polymorpha*) could be inadvertently transferred by recreational anglers and boaters. The impacts of these AIS on ecosystems include, but are not limited to restructuring food webs, reducing the abundance and diversity of native communities, and reducing ecosystem services (Havel et al. 2015; Gallardo et al. 2016; Walsh et al. 2016).

Data Collection

On-site self-administered surveys were distributed to a random sample of adult visitors (18 years or older) by a team of trained survey administrators on boat ramps at the two case study sites. The survey schedule was stratified by day of the week (equal numbers of weekend days and weekdays) and time of day (equal numbers of morning and afternoon sessions) to reflect the high use season (June–September, 2016). Respondents were asked to participate in the study when they exited the water and/or parked near the boat ramp before leaving the recreational area. Every third group was approached during times of high use while every group was approached during times of low use. Researchers collected data using a Qualtrics offline survey application loaded onto Samsung Galaxy (8.0) Active Tablets. Paper copies of the questionnaires were available to select respondents. All on-site encounters were recorded in contact logs to estimate response rates and non-response bias. Decisions about data collection and sampling design were informed by preliminary on-site visits to the two sites in the summers of 2015 and 2016, and in consultation with site staff. In total, 260 people were asked to participate in the study, 104 of whom agreed, resulting in a response rate of 40%. There were no significant differences between respondents and non-respondents on the basis of group size ($t = 1.00$, $df = 98$, $p \geq 0.05$); however, males were more

Table 1 Scaled items that measured pro-environmental behaviors and social normative beliefs, including factor loading scores (λ), mean values (M), standard error (SE), and standard deviations (SD) ($n = 104$)

	λ	$M \pm$ SE	SD
Public stewardship behavior ($\alpha = 0.876$)		2.17 ± 0.14	1.40
Volunteered to enhance and/or improve habitat affected by AIS	0.905	1.98 ± 0.15	1.45
Advocated for an organization that helps to manage AIS	0.889	2.29 ± 0.16	1.64
Participated in scientific research and/or monitoring about AIS	0.743	2.22 ± 0.16	1.58
Private Stewardship Behavior ($\alpha = 0.861$)		2.17 ± 0.14	1.40
Engaged in a policy (e.g., voting) that would affect the AIS	0.803	2.39 ± 0.16	1.64
Donated money for conservation that reduces impacts from AIS	0.876	2.30 ± 0.16	1.58
Wrote a letter or email about AIS issues	0.778	1.83 ± 0.15	1.54
Social stewardship behaviors ($\alpha = .925$)		2.56 ± 0.14	1.44
Taught others about how to minimize the spread of AIS	0.906	2.54 ± 0.15	1.52
Spoke with other people about problems related to AIS	0.907	2.71 ± 0.16	1.55
Worked with others to minimize impacts on the environment from AIS	0.882	2.43 ± 0.16	1.58
Social normative beliefs about public behavior ($\alpha = 0.840$)		2.15 ± 0.08	0.84
Volunteered to enhance and/or improve habitat affected by AIS	0.774	2.22 ± 0.10	0.96
Advocated for an organization that helps to manage AIS	0.848	2.25 ± 0.10	0.99
Participated in scientific research and/or monitoring about AIS	0.749	2.07 ± 0.10	1.03
Social normative beliefs about private behavior ($\alpha = 0.777$)		2.05 ± 0.80	0.78
Engaged in a policy (e.g., voting) that would affect the spread of AIS	0.705	2.13 ± 0.10	0.96
Donated money for conservation that reduces impacts from AIS	0.809	2.27 ± 0.10	1.04
Wrote a letter or email about AIS issues	0.745	1.82 ± 0.90	0.89
Social normative beliefs about social behaviors ($\alpha = 0.913$)		2.42 ± 0.30	1.29
Taught others about how to minimize the spread of AIS	0.776	2.26 ± 0.10	1.01
Spoke with other people about problems related to AIS	0.817	2.42 ± 0.11	1.07
Worked with others to minimize impacts on the environment from AIS	0.920	2.22 ± 0.11	1.08

Survey response scale ranged from 1 (never) to 5 (very often)

likely than females to refuse to participate in the study ($\chi^2 = 60.232$, $p \leq 0.05$).

Survey Measures

To assess Pro-environmental Behavior, respondents were asked to report their engagement in activities during the previous year that reduced the spread of AIS. A suite of survey items were drawn from past research (Larson et al. 2015; Landon et al. 2016), tailored to address problems related to the spread of AIS, and designed to reflect the dimensions of public, private, and social stewardship behaviors. One mean value score was created for analysis by calculating the average of all survey items to ensure model identification. Social Normative Beliefs were measured using the same battery of questions that assessed self-reported pro-environmental behaviors. Respondents were asked how often they believed other people (rather than themselves) engaged in these activities. Similar to our analysis of Pro-environmental Behavior survey items, one mean value score was created to reflect the variation in Social Normative Beliefs held by survey respondents. Human-nature relationships were measured using the Human and Nature Relationship scale (De Groot and Van Den Born 2003) that included 19 items reflecting four dimensions: (1) Participant in Nature, (2) Master over Nature, (3) Partner with Nature, and (4) Steward of Nature. Tables 1 and 2 include each of the mean values, standard deviations (SD), factor loading scores for all survey items, and statistical uncertainties in the mean values due to the finite sample size.

Analysis

To test our hypotheses, we first examined the measurement properties of our scales and the internal consistency of survey items within each dimension (Anderson and Gerbing 1988). All scales were reliable given Cronbach's alpha scores greater than 0.70 (Aiken 1997). Also, all factor loading scores were above 0.40 (Hair et al. 1998). To examine model fit, we used a χ^2-test of significance, though given this statistic's sensitivity to sample size (Bryne et al. 1998), we used three other fit indices to determine the fit of the model to the sample data (Kline 2011). Root mean square error of approximation (RMSEA) values less than 0.08 (Steiger 2007), Comparative Fit Index (CFI) values over 0.90 (Bentler 1978), and standardized root mean

Table 2 Scaled items measuring human-nature relationships, including factor loading scores (λ), mean values (M), standard error (SE), and standard deviations (SD) ($n = 104$)

	λ	$M \pm$ SE	SD
Master over nature ($\alpha = 0.759$)		2.30 ± 0.15	1.45
Humans have more value than nature	0.688	2.68 ± 0.13	1.32
Because I can think, I am more important than nature	0.808	2.43 ± 0.13	1.29
Nature should not hamper economic development	0.607	2.81 ± 0.13	1.28
Human beings have the right to alter nature radically	0.577	2.30 ± 0.15	1.45
Steward of nature ($\alpha = 0.698$)		4.35 ± 0.05	0.55
Human beings have responsibility to conserve the natural environment	0.650	4.47 ± 0.08	0.78
I have the obligation to protect nature	0.732	4.36 ± 0.08	0.76
We have to ensure that we leave enough nature for future generations	0.709	4.47 ± 0.08	0.78
Partner with nature ($\alpha = 0.792$)		3.73 ± 0.08	0.78
I would like a relationship with nature just like I have with my friends	0.921	3.42 ± 0.11	1.07
I can have a relationship with nature just like I have with my friends	0.874	3.40 ± 0.11	1.14
Humans and nature deserve to be treated in the same way	0.579	3.76 ± 0.11	1.11
Participant in nature ($\alpha = 0.705$)		3.51 ± 0.08	0.78
I would like to spend a week alone in forest	0.593	3.71 ± 0.13	1.32
It would be wonderful to join wild geese on their journey	0.410	2.76 ± 0.14	1.35
I often feel an intense connection with nature	0.669	3.87 ± 0.09	0.90
When I am surrounded by nature I experience something greater than mankind	0.607	4.03 ± 0.10	1.02

Survey response scale ranged from 1 (strongly disagree) to 5 (strongly agree)

square residual (SRMR) values less than 0.08 were considered acceptable (Hu and Bentler 1999).

Due to concerns over model identification, we evaluated mean value scores for all dimensions of human-nature relationships, Social Normative Beliefs and reported Pro-environmental Behaviors, as well as reported the statistical uncertainties on these quantities. These parceled items were entered into a path model that was estimated in Mplus version 7.2 (Muthén and Muthén 2012). This model was identified given six observed variables and 11 parameters (Kline 2011). All data were analyzed using a maximum likelihood estimation procedure, and missing data were accounted for using the full information maximum likelihood method. All non-significant paths were dropped from the analysis before interpreting results.

Results

Socio-Demographics and Descriptive Characteristics

The majority of respondents (76%) were male and the average age was 48 years (SD = 13.84). Respondents were highly educated, in that approximately one quarter (26%) held a graduate degree and an additional 50% had either a 2-year or 4-year college degree. The vast majority (91%) identified as White, with few respondents identifying as Hispanic (3%) or American Indian or Alaska Native (1%); no other races were represented. While respondents spanned all income brackets, data were skewed towards higher income levels; 19% reported an annual income greater than $150,000 and nearly one third (29%) reported earning between $100,000 and $149,999 annually. A total of 16% made less than $49,999 before taxes.

We examined trip characteristics to better understand respondents' skill levels and previous experiences at the two case study sites. The activities in which respondents participated were mostly boating (71%) and/or fishing (50%). A total of 8% of respondents reported participation in other activities, including during their on-site visit, including hiking, camping, hunting, biking, experiencing nature, horse rental, picnicking, painting, archery, and commercial activities. One-half traveled with one other person in their group, and 30% traveled with two or more people. The predominant group types were family (64%) or friends (32%). With regard to length of stay, 93% of respondents were day rather than overnight users. The length of stay for day-users ranged from 1 to 10 h ($M = 5.00$). The median number of visits to the site where respondents were surveyed was eight times in the past 12 months. When asked about familiarity with AIS, the vast majority (89%) reported they had heard of the term "aquatic invasive species," and 71% reported they could identify at least one non-native aquatic species in Illinois.

Modeling results

Modeling results showed partial support for the study hypotheses (Fig. 1), and the path model adequately fit the sample data ($\chi^2 = 8.58$, df = 7; RMSEA = 0.051 (90% C.I.

is 0.00–0.149), CFI = 0.947, and SRMR = 0.061). More specifically, Social Normative Beliefs positively predicted Pro-environmental Behavior ($\beta = 0.27$; t-value = 2.34). Also, the relationship between the Master over Nature human-nature relationship and Social Normative Beliefs was non-significant (Table 3). The third hypothesis was supported, in that respondents who identified as Participants in Nature were more likely to agree with statements reflecting Social Normative Beliefs ($\gamma = 0.34$; t-value = 2.8). As for the fourth hypothesis, although a significant relationship between Partner with Nature and Social Normative Beliefs emerged ($\gamma = -0.27$; t-value = −2.16), as levels of this human-nature relationship dimension increased, responses to normative pressure decreased. The final hypothesized relationship between Steward of Nature and Social Normative Beliefs was not supported.

Discussion

Environmental management agencies are confronted with difficult decisions about how to address the spread of AIS and adapt to rapidly changing social-ecological conditions in freshwater ecosystems (Pagnucco et al. 2015). Human behavior is a crucial driver of biological invasions that warrants attention by environmental managers and researchers due to its multifaceted structure and complexity (Larson et al. 2015). In response, this study advanced knowledge of short- and long-term predictors of Pro-environmental Behavior relevant to AIS reduction. That is, we provided insight on the role of time unvarying processes (i.e., Human-nature Relationships) alongside more context dependent drivers of behavior (i.e., Social Normative Beliefs) to develop a more robust model of the factors influencing individual decisions (Manfredo et al. 2017). In particular, given that the Partner with Nature orientation positively influenced norms and behavior, management agencies that tailor communication strategies to suggest people are dependent on environments and vice versa, will be more likely to align with the existing worldviews of anglers included in this study. Our results also indicated that management agencies should de-emphasize the spiritual relationships formed between people and places given that respondents who held these beliefs were less likely to take action that would minimize the spread of AIS.

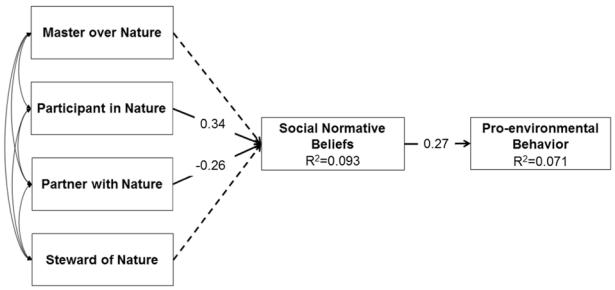

Fig. 1 Results from the manifest variable path model. Dotted lines signify non-significant results

Advancing the Study of Pro-environmental Behavior and its Antecedents

This study determined how three types of Pro-environmental Behavior—encompassing public, private, and social stewardship dimensions (Larson et al. 2015)—were influenced by several predictor variables that warrant future research attention. Our model fit the sample data using a suite of reliable scaled survey items, and we accounted for a modest degree of variation in behavioral patterns. Consequently, our analysis demonstrated a parsimonious yet revealing explanation of how specific psychological factors determined whether or not individuals practiced behaviors that affected the dispersion of AIS.

Our investigation into the human-nature relationships of recreational anglers and boaters strengthened past research that has strived to understand how and why individuals make decisions (Beardmore et al. 2014; Flint et al. 2013; Verbrugge et al. 2013). We provided support for a relatively new conceptualization of how humans view and interact with the natural world, and contend the human-nature relationships scale will afford future opportunities for researchers to test an alternative measure to the New Ecological Paradigm scale (Dunlap et al. 2000). Given several limitations of NEP such as uncertain dimensionality and dated language to represent environmentalism (Hawcroft and Milfont 2010), we suggest this scale holds promise for future research on environmental worldviews. We also

Table 3 Estimates of the path model

Dependent variable	Predictor	γ	β	SE	t-value	R^2
Pro-environmental behavior	Social normative beliefs	—	0.27	0.11	2.34*	0.093
Social normative beliefs	Participant in nature	0.34	—	0.18	2.84*	0.071
Social normative beliefs	Master over nature					—
Social normative beliefs	Steward of nature	—	—	—	—	—
Social normative beliefs	Partner with nature	−0.26	—	0.12	−2.16*	—

* Significant value at $p \leq 0.05$

assessed how Social Normative Beliefs predicted a measure of behavior that was theoretically grounded and relevant to biological invasions. Our survey measures maintained the same attitude objects and levels of specificity (Tarrant et al. 1999), and as such, may be useful in future studies into the human dimensions of AIS.

The multi-dimensional approach that was adopted to measure human-nature relationships showed differential effects of environmental worldviews on normative beliefs and subsequently reported behavior. The Participant in Nature orientation significantly influenced descriptive normative beliefs, which illustrated how this facet of respondents' core beliefs about their relationship with nature could be leveraged by agencies to foster stewardship activities. Given a negative correlation between the Partner with Nature orientation and the norm-behavior relationship, biases toward equality with the environment should be de-emphasized and existing as a part of nature should be emphasized by resource management agencies that aim to activate societal expectations of Pro-environmental Behavior tied to AIS. These findings align with past research that has pointed to difficulties in distinguishing between the dimensions of Participant in Nature and Partner with Nature (Van Heel et al. 2017). The Master over Nature and Steward of Nature orientations played non-significant roles in influencing normative processes and the reported behaviors of survey respondents. It should be noted that the Steward of Nature dimension was reflected by survey items that were rated highly by respondents. However, these orientations they did not play a significant role in explaining why anglers and boaters held normative beliefs, and in turn, reported engagement in behaviors that would benefit the environment.

Limitations and Future Research Directions

We acknowledge several limitations and opportunities for future research. First, our final sample size was low, which limited the model that could be estimated in this research. To ensure model identification, we used parceled survey items rather than a full latent variable model. Moreover, our response rate was low for an on-site survey and in line with average rates for mailback surveys in the environmental social sciences (Wallen et al. 2016). A second limitation of this study is that only two sites were selected to represent the kinds of waterways recreationists experience in the state of Illinois. Given our intention to gain preliminary insights on the drivers of angler behavior in IL, this research did not reflect public opinion at the state level, but rather, provided insight on the characteristics and behaviors of boaters and anglers in two-specific areas. Further research on a larger geographic scale is needed to better understand the behaviors of recreational anglers and boaters, and align with the needs of Great Lakes managers for integrative and more comprehensive human dimensions research (Heck et al. 2016). Building on work by Connelly et al. (2016) who assessed AIS behavior of anglers across the Great Lakes, future research on the role of values (Dietz et al. 2005) and knowledge (Nathan et al. 2014) will also help link short- and long-term drivers of Pro-environmental Behavior. This area of inquiry will be particularly important to pursue in light of a diversifying world where people with varied orientations engage in nature-based activities. The study of psychologically stable orientations is particularly important given that Great Lakes stakeholders are diverse in both demographics and environmental beliefs (Breffle et al. 2013), and conservation initiatives need to be tailored to meet individual needs.

Management Implications

The results of this study were generated, in part, to inform fishery management decisions and help prevent the spread of AIS by water-based recreationists. Given the importance of norms in explaining behavior change, natural resource, and recreation managers should design or reorient AIS-management intervention programs to focus on building social normative beliefs. Establishing norms around desirable activities will help to encourage and sustain AIS reduction strategies as a routine, a key step in behavior change energized by the strong role of habits in guiding decisions (Aarts et al. 1998). For example, given that boaters are eager to remove trash from the interior of their boat and avoid the social stigma of littering on the drive home, pairing trash removal sites with boat washing stations can facilitate the widespread use of both facilities. Similarly, given that many anglers have negative attitudes toward Asian carp (Simberloff 2012; Edwards et al. 2016), managers could steer attitudes towards a social standard of harvesting carp. Signage could also depict people displaying positive attitudes while holding an Asian carp to suggest people are targeting this fish, and indicate prevalence of the activity. In general, using normative appeals (e.g., a "thumbs up" or smiley faces) on graphics that show people performing environmental behaviors can help activate feelings of guilt and promote the idea of pro-environmental behavior as a social norm (Schultz 2011).

Social psychological processes are important pieces of the behavioral puzzle and, when considered, provide valuable information that can be translated into management decisions that target different pro-environmental outcomes. This study evaluated three types of environmental behaviors including Public Stewardship Behavior, Private Stewardship Behavior, and Social Stewardship Behavior that were

folded together into one manifest variable. Managers should consider targeting all three types of behaviors investigated in this study rather than devoting resources to one at the exclusion of others. For example, while Public Stewardship Behavior, such as volunteering, advocacy, and participating in research, are often overlooked, they may play an important role in promoting other types of pro-environmental behaviors by encouraging the development of social normative beliefs and additional knowledge (Lewandowski and Oberhauser 2016). Opportunities for practicing these kinds of citizenship activities could be made available, alongside opportunities to take action in the context of one's home (e.g., donating money) and social sphere (e.g., working with committees to solve AIS-related problems). Managers could develop a variety of avenues for engaging recreationists in these activities and ensuring there is adequate publicity and communication so that stakeholders are aware that these opportunities exist.

Conclusion

Our study extends previous research and shines new light on the social psychological processes that shape individual decisions to engage in behaviors that minimize the spread of AIS. Specifically, we provide evidence of the linkages between different types of human-nature relationships and pro-environmental behavior, and underline the utility of social normative beliefs to predict (and induce) behavior change. We observed effects from both short- and long-term drivers of behavior reported by water-based recreationists, and make recommendations for how resource management agencies can advance goals focused on stewardship of the aquatic environment and build a more environmentally conscious community. This research also provided insights on how future investigations can measure a range of predictors of behavior to address the rapidly changing environments of freshwater ecosystems due to biological invasions.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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