

## RESEARCH REPORT

JULY, 2023

# *Evaluating Illinois's Organisms in Trade Outreach Impacts on Hobbyists and Informing Future Efforts*

### **PREPARED BY:**

Elizabeth Golebie<sup>1</sup>, Sofia Ford<sup>1</sup>, Juan Carlos Martinez<sup>1</sup>, North Joffe-Nelson<sup>1</sup>, Greg Hitzroth<sup>2</sup>, Amanda Huegelmann<sup>2</sup>, & Carena J. van Riper<sup>1</sup>

<sup>1</sup>Department of Natural Resources and Environmental Sciences  
University of Illinois at Urbana-Champaign

<sup>2</sup>Illinois-Indiana Sea Grant

## EXECUTIVE SUMMARY

The spread of aquatic invasive species (AIS) by aquarium and water garden hobbyists is of great concern throughout freshwater ecosystems. To teach hobbyists about the dangers of AIS and how individuals can prevent their spread, numerous outreach campaigns have been developed. In the U.S. state of Illinois, the Illinois – Indiana Sea Grant (IISG) developed the *Be A Hero – Release Zero* outreach campaign in 2013, and has since promoted that campaign as well as *Take AIM: Aquatic Invaders in the Marketplace*, *What’s in your water garden?* and *What’s in your aquarium?* The present study was developed to assess the impact of IISG outreach by examining familiarity with these campaigns, as well as AIS-related beliefs and behaviors.

This report synthesizes key findings and shares management implications to support invasive species outreach initiatives for organism-in-trade hobbyists across the state of Illinois. A mixed methods study was employed, starting with informal interviews followed by on-site data collection efforts at an aquarium trade show, and resulting in an online pilot test. A state-wide survey was then administered to ask questions about Illinois hobbyists’ awareness, beliefs, and behavior regarding AIS. Results are organized into four sub-sections corresponding to the objectives that guided the study.

Objective 1: Develop descriptive information about Illinois organism-in-trade hobbyists

Objective 2: Evaluate hobbyists’ information sources for aquatic invasive species, their levels of awareness and use of Illinois-Indiana Sea Grant outreach campaigns

Objective 3: Determine the factors that contribute to aquatic invasive species-prevention behaviors among organism-in-trade hobbyists

Objective 4: Examine attitudes toward management of aquatic invasive species, and the conservation worldviews of organism-in-trade hobbyists

## Key Findings and Management Recommendations

### Objective 1: Develop descriptive information about Illinois organism-in-trade hobbyists

- Respondents included aquarium hobbyists (74%), outdoor pond or water garden hobbyists (9%), and those who engaged in both types of activities (17%).
- **Freshwater aquariums of five gallons or more were most common** (57%), with smaller proportions of hobbyists owning aquariums of five gallons or less (42%), indoor aquatic pets (27%), and water gardens (12%).
- Three types of hobbyists were identified on the basis of their self-identified skill levels. Therefore, results are presented for the pooled sample and for these three types of hobbyists:
  - 1) **Novice hobbyists** were those who reported below average expertise;
  - 2) **Intermediate hobbyists** were those who reported average expertise;
  - 3) **Expert hobbyists** were those who reported higher than average expertise.
- Average years of experience ranged from approximately four years for novice hobbyists to approximately 11 years for expert hobbyists.
- A majority of novice hobbyists (75%) owned just one tank, 58% of intermediate hobbyists owned one tank, while a majority of expert hobbyists (65%) owned two or more tanks.
- Hobbyists obtained their aquatic species from a variety of sources. **Purchasing species from a chain store was most common.** In contrast to less experienced groups, **expert hobbyists reported a more diverse suite of species sources**, frequently purchasing species over the internet, through fish club events or meetings, and from other hobbyists.
- Awareness of aquatic invasive species was moderate and varied significantly by expertise level. Expert hobbyists had the highest level of awareness, followed by intermediate and novice hobbyists.
- Familiarity with ecological features (e.g., ways that invasive species affect the environment) and social features (e.g., how hobbyists can spread invasive species) of aquatic invasive species was low to moderate. Experts exhibited higher familiarity than intermediate hobbyists, who exhibited higher familiarity than novice hobbyists.
- Most respondents (78%) were White, 75% were women, and a majority (67%) reported an annual household income less than \$75,000 before taxes. Educational experiences varied, with intermediate and expert hobbyists having higher levels of education than novice hobbyists.

### Objective 2: Evaluate hobbyists' information sources for aquatic invasive species, their levels of awareness and use of Illinois-Indiana Sea Grant outreach campaigns.

- We evaluated familiarity with four outreach campaigns: Be a Hero, Release Zero, Take AIM, What's in Your Water Garden, and What's in Your Aquarium.
- **Familiarity was low across all campaigns**; most respondents reported being either "not at all familiar" or "slightly familiar" with each campaign.
  - Novice hobbyists had lower familiarity with each campaign than expert hobbyists.
- Respondents reported low use of campaign resources, such as websites, lists of invasive and non-invasive species, and veterinarian and rehoming networks.

- Expert hobbyists used each resource more frequently than novice hobbyists, and reported particularly high use of lists of invasive and non-invasive species.
- Respondents reported learning about AIS through a variety of sources.
- **Half of respondents (50%) used at least one online source**, which included online hobbyist forums, online ads, and social media.
  - Experts most commonly learned about AIS through online water hobbyist forums (42%), and intermediate hobbyists most commonly learned about AIS via social media (33%).
  - Novice hobbyists had been exposed to AIS through fewer modes, and most commonly learned about AIS in school (29%).
  - A total of 14 respondents (6%) indicated that this survey was the first time they had heard about AIS.
- Respondents frequently consulted several sources for advice about their hobby. **Retailers were commonly consulted by all three groups** and were among the most frequently consulted source by novice and intermediate hobbyists. Expert hobbyists consulted veterinarians more frequently than both intermediate and novice hobbyists.

Objective 3: Determine the factors that contribute to aquatic invasive species-prevention behaviors among organism-in-trade hobbyists

- We observed **moderate levels of intended behavior** to prevent the spread of AIS, such as purchasing only native species and sterilizing aquarium water prior to disposal.
  - Expert hobbyists had higher intentions to engage in these behaviors compared with intermediate and novice hobbyists.
- Respondents report several disposal methods used in the past 12 months.
  - Bagging plants and placing them in the trash was the most common plant disposal method (42%), and rehoming animals with a sanctuary or rescue group was the most common disposal method for animals (37%).
  - Experts had higher engagement with each recommended disposal type in contrast to the other two groups; over half of experts (52%) reported rehoming animals with a sanctuary or rescue group, and 36% reported giving, trading, or selling animals to another hobbyist.
- Three types of risk perceptions were evaluated: environmental (i.e., the perceived level of threat posed to the environment), personal (i.e., the perceived level of threat posed to individuals), and social (i.e., the perceived level of threat posed to communities).
  - Respondents were **most concerned with environmental risks** and least concerned with personal risks.
  - Novice hobbyists reported lower risk perceptions than both intermediate and expert hobbyists for all three types of risk.
  - Higher risk perceptions were associated with higher levels of intended behavior.
- Benefits, defined as beliefs that following purchasing and disposal guidelines will have positive outcomes, were high among hobbyists, and did not differ by skill level.
  - Higher perceived benefits were associated with higher levels of intended behavior.
- Self-efficacy (i.e., beliefs that one has the ability to take action) was moderate, and stronger among expert hobbyists than novice and intermediate hobbyists.

- Self-efficacy positively predicted intended behavior; the more confident hobbyists felt in their ability to follow prevention guidelines, the more likely they were to do so.
- Response-efficacy (i.e., beliefs that a recommended action will be effective) was high among hobbyists.
  - Expert hobbyists reported higher response-efficacy than novice and intermediate hobbyists.
  - No statistical relationship was observed between response-efficacy and intended behavior.
- We evaluated barriers, defined as internal or external factors that prevent someone from taking action.
  - Novice hobbyists were particularly susceptible to barriers such as being unsure of the disposal guidelines, not knowing who to ask for advice and not having the necessary resources or equipment.

Objective 4: Examine attitudes toward management of aquatic invasive species, and the conservation worldviews of organism-in-trade hobbyists

- Hobbyists were supportive of AIS management actions characterized by two dimensions
  - Support for outreach (e.g., providing educational materials, offering public programs) was high.
  - Laws and enforcement (e.g., monitoring waterways and fining people who release AIS) were also supported, though to a lesser degree than outreach.
- Four conservation worldviews were evaluated
  - Respondents exhibited the most agreement with the *compassionate conservation* worldview, focused on the intrinsic value of animals and moral prescriptions to protect them.
  - *Nature without people*, reflecting a focus on conserving biological diversity and natural habitats through human exclusion, was moderately supported.
  - Moderate support was observed for *nature and people*, defined as a worldview focused on the interdependence of humans and nature that lead to compromises in environmental conservation.
  - *Nature for people* received the least agreement, meaning that fewer respondents believed that managers should focus on conserving the components of nature that are beneficial to humans.
- Conservation worldviews were related to management attitudes
  - Stronger agreement with *nature without people*, *nature and people*, and *compassionate conservation* corresponded to stronger support for management activity related to both outreach and enforcement.
  - Stronger agreement with *nature for people* was associated with weaker support for management activity.

## ACKNOWLEDGMENTS

Thanks are extended to the individuals who shared their experiences and knowledge in support of this research process. Funding for this study was provided by the USFWS, Illinois Department of Natural Resources Grant (# CAFWS-150B).

### **Cite this report as:**

Golebie, E., Ford, S., Martinez, J.C, Joffe-Nelson, N., Hitzroth, G., Huegelmann, A., & van Riper, C.J. (2023). Evaluating Illinois' organisms in trade outreach impacts on hobbyists and informing future efforts. Report prepared for the Illinois Department of Natural Resources. DOI: 10.5281/zenodo.8125476.

### **For additional information, please contact:**

Carena J. van Riper, PhD  
Department of Natural Resources and Environmental Sciences  
University of Illinois Urbana-Champaign  
1102 S Goodwin Ave, Urbana, IL 61801  
Phone: 217-244-9317  
Email: [cvanripe@illinois.edu](mailto:cvanripe@illinois.edu)

**This report is available electronically at:** <http://dx.doi.org/10.5281/zenodo.8125476>

# Contents

<b>Executive Summary .....</b>	<b>ii</b>
<b>Acknowledgments .....</b>	<b>vi</b>
<b>List of Tables.....</b>	<b>ix</b>
<b>List of Figures .....</b>	<b>x</b>
<b>Background.....</b>	<b>1</b>
<b>Methodology.....</b>	<b>1</b>
<b>Preliminary research .....</b>	<b>1</b>
Interviews.....	1
On-site survey .....	2
Pilot test .....	2
<b>State-wide survey.....</b>	<b>3</b>
Data collection and sampling .....	3
Sampling bias assessment .....	3
<b>Results from state-wide survey.....</b>	<b>5</b>
<b>Process for identifying subgroups and organizing research results .....</b>	<b>6</b>
Hobby experience subgroups .....	6
<b>Descriptive information about organism-in-trade hobbyists .....</b>	<b>7</b>
History of hobby participation .....	7
Awareness and familiarity with aquatic invasive species .....	10
Socio-demographic characteristics.....	12
<b>Evaluation of outreach campaigns .....</b>	<b>14</b>
Use of campaign resources.....	15
Primary information sources .....	17
<b>Factors contributing to AIS-prevention behaviors.....</b>	<b>19</b>
Drivers of behavior .....	21
Modeling Results .....	27
<b>Management attitudes and conservation worldviews .....</b>	<b>28</b>
<b>Literature Cited .....</b>	<b>34</b>
<b>Appendix A: Interview Agenda.....</b>	<b>36</b>
<b>Appendix B: Research Results from On-Site Survey .....</b>	<b>38</b>
<b>Descriptive information about organism-in-trade hobbyists .....</b>	<b>38</b>
History of hobby participation .....	38
Awareness and familiarity with aquatic invasive species .....	42
Socio-demographic characteristics.....	42

<b>Evaluation of outreach campaigns .....</b>	<b>44</b>
Use of campaign resources.....	44
Primary information sources .....	45
<b>Factors contributing to AIS-prevention behaviors.....</b>	<b>47</b>
Drivers of behavior .....	48
<b>Appendix C: Survey Questionnaire.....</b>	<b>53</b>
<b>Appendix D: Spatial Assessment of Outreach Campaigns .....</b>	<b>64</b>



## LIST OF TABLES

<i>Table 1. Sociodemographics of OIT hobbyists surveyed in different studies.....</i>	<i>4</i>
<i>Table 2. Self-reported expertise.....</i>	<i>6</i>
<i>Table 3. Reported ownership of aquatic species .....</i>	<i>7</i>
<i>Table 4. Self-identified hobby type .....</i>	<i>8</i>
<i>Table 5. Hobby experience .....</i>	<i>8</i>
<i>Table 6. Source of aquatic species .....</i>	<i>10</i>
<i>Table 7. Familiarity with topics related to aquatic invasive species.....</i>	<i>12</i>
<i>Table 8. Socio-demographics of survey respondents.....</i>	<i>13</i>
<i>Table 9. Familiarity with outreach campaigns.....</i>	<i>15</i>
<i>Table 10. Use of campaign resources.....</i>	<i>15</i>
<i>Table 11. Information channels for learning about aquatic invasive species .....</i>	<i>18</i>
<i>Table 12. Sources for advice about aquatic invasive species .....</i>	<i>19</i>
<i>Table 13. Intended behaviors to prevent aquatic invasive species spread .....</i>	<i>20</i>
<i>Table 14. Methods used to dispose of organisms .....</i>	<i>21</i>
<i>Table 15. Perceived risk of aquatic invasive species.....</i>	<i>23</i>
<i>Table 16. Perceived benefits of taking preventative action .....</i>	<i>24</i>
<i>Table 17. Self-efficacy and response-efficacy of taking preventative action .....</i>	<i>25</i>
<i>Table 18. Perceived barriers to taking preventative action.....</i>	<i>26</i>
<i>Table 19. Attitudes towards invasive species management .....</i>	<i>29</i>
<i>Table 20. Conservation worldviews.....</i>	<i>30</i>
<i>Table 21. Appendix B: Reported ownership of aquatic species (on-site survey).....</i>	<i>39</i>
<i>Table 22. Appendix B: Self-identified hobby type (on-site survey).....</i>	<i>39</i>
<i>Table 23. Appendix B: Hobby experience (on-site survey) .....</i>	<i>39</i>
<i>Table 24. Appendix B: Self-reported expertise (on-site survey).....</i>	<i>41</i>
<i>Table 25. Appendix B: Source of aquatic species (on-site survey).....</i>	<i>41</i>
<i>Table 26. Appendix B: Familiarity with topics related to aquatic invasive species (on-site survey) .....</i>	<i>42</i>
<i>Table 27. Appendix B: Socio-demographics of survey respondents (on-site survey) .....</i>	<i>43</i>
<i>Table 28. Appendix B: Use of campaign resources (on-site survey).....</i>	<i>44</i>
<i>Table 29. Appendix B: Information channels for learning about aquatic invasive species (on-site survey).....</i>	<i>46</i>
<i>Table 30. Appendix B: Sources for advice about aquatic invasive species (on-site survey).....</i>	<i>47</i>
<i>Table 31. Appendix B: Intended behaviors to prevent aquatic invasive species spread (on-site survey).....</i>	<i>47</i>
<i>Table 32. Appendix B: Methods used to dispose of organisms (on-site survey).....</i>	<i>48</i>
<i>Table 33. Appendix B: Perceived risk of aquatic invasive species (on-site survey) .....</i>	<i>49</i>
<i>Table 34. Appendix B: Perceived benefits of taking preventative action (on-site survey).....</i>	<i>49</i>
<i>Table 35. Appendix B: Self-efficacy and response-efficacy of taking preventative action (on-site survey).....</i>	<i>50</i>
<i>Table 36. Appendix B: Perceived barriers to taking preventative action (on-site survey).....</i>	<i>51</i>

## LIST OF FIGURES

Figure 1. Photo of on-site data collection .....	2
Figure 2. Map of the approximate locations of survey respondent. ....	5
Figure 3. Years of experience.....	9
Figure 4. Number of tanks owned.....	9
Figure 5. Awareness of aquatic invasive species.....	11
Figure 6. Age of survey respondents .....	13
Figure 7. Logos representing the evaluated outreach campaigns. ....	14
Figure 8. Relevance of the Health Belief Model to aquatic invasive species prevention .....	22
Figure 9. Drivers of invasive species prevention behavior among hobbyists.....	28
Figure 10. Conservation worldviews.....	31
Figure 11. Relationships among management attitudes and conservation worldviews .....	32
Figure 12. Appendix B: Years of experience (on-site survey) .....	40
Figure 13. Appendix B: Number of tanks owned (on-site survey).....	40
Figure 14. Appendix B: Age of survey respondents (on-site survey).....	43
Figure 15. Appendix D: Illinois Department of Natural Resources Management Regions.....	64
Figure 16. Appendix D: Self-reported expertise.....	65
Figure 17. Appendix D: Familiarity with aquatic invasive species.....	67
Figure 18. Appendix D: Familiarity with the “Be a Hero” campaign .....	68
Figure 19. Appendix D: Familiarity with the “Take AIM” campaign .....	69
Figure 20. Appendix D: Familiarity with the “What’s in your aquarium?” campaign .....	70
Figure 21. Appendix D: Familiarity with the “What’s in your water garden?” campaign .....	71
Figure 22. Appendix D: Use of pet re-homing network.....	72
Figure 23. Appendix D: Use of exotic pet veterinarian network .....	73
Figure 24. Appendix D: Use of disposal guidelines .....	74
Figure 25. Appendix D: Use of campaign websites.....	75
Figure 26. Appendix D: Use of regulations database .....	76
Figure 27. Appendix D: Use of lists of expert contacts .....	77
Figure 28. Appendix D: Use of lists of invasive and non-invasive species.....	78

## BACKGROUND

Numerous aquatic invasive species (AIS) are spread via the aquatic organism trade and may be introduced to Illinois waterways by aquarium and water garden hobbyists. Illinois-Indiana Sea Grant has developed and implemented several outreach campaigns to inform hobbyists of the risks posed by AIS and share resources that can be used to help avert their spread. These campaigns include Be a Hero – Release Zero, Take AIM: Aquatic Invaders in the Marketplace, What’s in Your Water Garden, and What’s in Your Aquarium. Although these campaigns began in 2013, there has been minimal research to evaluate their success. Therefore, **we sought to identify organism-in-trade hobbyist’s awareness of outreach campaigns and their beliefs and behaviors regarding AIS to improve efficacy in communication between resource management agencies and Illinois recreational water users** through a mixed methods study.

## METHODOLOGY

### Preliminary research

#### Interviews

As a first step in the research process, we conducted informal interviews with key stakeholders in the aquarium and water gardening hobbies in August 2022. These stakeholders included an individual with several decades of aquarium experience, two individuals who have been involved in local and regional fishing clubs, an individual with experience in the pond industry, and a researcher with experience in the human dimensions of invasive species. Our key objectives were to inform survey development by: 1) understanding how aquarium and water garden hobbyists characterize the risks posed by AIS; 2) identifying the key steps hobbyists can take to safely purchase and dispose of aquatic organisms; and 3) exploring the positive and negative consequences hobbyists might experience from behavioral engagement. Conversations loosely followed an agenda, available in Appendix A. A formal thematic analysis of interview data was outside the scope of this project. Rather, the information shared during interviews was used to refine survey questions pertaining to the risks posed by AIS, and the benefits and barriers associated with taking action.

## **On-site survey**

As a first step in the research process, we conducted an on-site survey of hobbyists attending the Aquashella Aquarium Festival in Schaumburg, Illinois on October 8<sup>th</sup> and 9<sup>th</sup>, 2022. The research team was present at a booth sponsored by Illinois-Indiana Sea Grant (see Figure 1) from 10am-7pm on October 8<sup>th</sup> and 10am-5pm on October 9<sup>th</sup>.

Individuals who approached the booth were invited to participate in the survey and offered pencils and notepads as tokens of appreciation.

A total of 43 hobbyists completed the survey (response rate = 66%). Non-response bias was not detected on the basis of group size ( $t = -0.241, p = 0.810$ ) or assumed gender ( $\chi^2 = 1.4452, p = 0.229$ ). Participants were 60% male, 36% female, and 5% other, with an average age of 29 years. The median number of tanks owned was 4, and the average years of experience was 7.62. Full results from this data collection initiative are available in Appendix B. Based on these results, we were able to tune the wording of survey questions to improve clarity.

## **Pilot test**

An online pilot test was conducted October 17-22, 2022. A total of 19 respondents were recruited to participate in the study through a Qualtrics panel. The results generated from this online pilot survey were used to modify the questionnaire. This feedback enabled us to: a) tune the wording of survey questions; b) diagnose any potential methodological problems (e.g., completion rates, item interpretation); and c) increase the likelihood of science transfer at the conclusion of the project in response to stakeholder needs and management concerns. The final questionnaire is presented in Appendix C.



**Figure 1.** Undergraduate Research Assistant, Sofia Ford, interacts with research participants during the on-site survey at the Aquashella Aquarium Festival.

## **State-wide survey**

### **Data collection and sampling**

During October-November 2022, we conducted an online survey of Illinois recreational water users using the Qualtrics platform. Respondents were recruited from an online panel and compensated for their participation. All respondents were at least 18 years old and lived in the U.S. state of Illinois. To take the survey, potential respondents had to be an OIT hobbyist, defined as meeting at least one of the following screening requirements:

- Keep a fish bowl or small freshwater aquarium of 5 gallons or less
- Keep a large freshwater aquarium of 5 gallons or more
- Keep a saltwater aquarium
- Keep a koi pond or water garden
- Keep indoor aquatic pets (turtles, frogs, etc.)

Responses were discarded and replaced when participants did not complete the entire survey, failed at least one of two “attention check” questions (Berinsky et al., 2014) or had response patterns that indicated extreme inattention or possible use of bots. This process continued until a final sample size of 219 was attained.

### **Sampling bias assessment**

Analyses were performed to test how well the data collected in this study represented the target population of organism-in-trade hobbyists in Illinois. Few studies have surveyed aquarium and water garden hobbyists in the U.S. Midwest. We identified two recent studies (Seekamp et al., 2016; Fitzgerald et al., 2021) to serve as a point of comparison for our research and allow us to consider potential sources of bias that may have emerged from our sampling methods (see Table 1). Seekamp et al. (2016) conducted on-site surveys at 16 aquarium and water garden events and trade shows in the Great Lakes region. Fitzgerald et al. (2021) recruited aquarium and water garden hobbyists from Minnesota to their online survey via online hobbyist forums, social media, and in-store flyers. In contrast to the sampling efforts by Seekamp et al. (2016) and Fitzgerald et al. (2021), the present study used an online panel provided by Qualtrics. This method resulted in a distribution of respondents that skewed younger ( $\chi^2 = 50.725$ ,  $p < .001$ ;  $\chi^2 = 35.120$ ,  $p < .001$ ) and more female ( $\chi^2 = 84.435$ ,  $p < .001$ ;  $\chi^2 = 74.646$ ,  $p < .001$ ) than both studies. Previous research has shown that women report stronger environmental attitudes and are

more likely to engage in pro-environmental behavior (Lynn & Longhi, 2011; Blankenberg & Alhusen, 2019), thus it is possible that respondents in our study reported higher levels of beliefs and behavior than other comparable populations.

**Table 1**

*Comparison with studies that used different sampling methods to organism-in-trade hobbyists*

Variables	Golebie et al. (2023): Qualtrics survey n=219	Golebie et al. (2023): On-site survey n=43	Seekamp et al. (2016) n=496	Fitzgerald et al. (2021) n=479
Age (M, SD)	40.19 (15.60)	28.61 (8.97)	--	--
18-29	31% (68)	68% (28)	12% (58)	15% (67)
30-49	39% (85)	29% (12)	34% (165)	35% (158)
50 or above	26% (65)	2% (1)	54% (261)	51% (230)
Gender (% , N)				
Male	24% (53)	60% (25)	62% (301)	54% (259)
Female	75% (164)	36% (15)	38% (185)	37% (177)
Other	1% (2)	5% (2)	--	3% (14)
Income (% , N)				
Less than \$100,000	83% (172)	75% (27)	75% (346)	--
\$100,000 or more	17% (34)	25% (9)	25% (115)	--
Race (% , N)				
White	78% (171)	63% (27)	--	87% (327)
Black or African American	10% (21)	2% (1)	--	0.3% (1)
Descriptive statistics (M, SD)				
Number of tanks owned	2.86 (16.93)	6.86 (9.33)	--	--
Years of experience	8.14 (8.67)	7.62 (6.64)	--	--
Hobbyist type (% , N)				
Aquarium hobbyist	74% (162)	83% (35)	48% (238)	49% (236)
Outdoor pond / water garden owner	9% (20)	2% (1)	21% (104)	14% (69)
Both	17% (36)	14% (6)	31% (154)	32% (157)

*Note.* Some columns may not add up to 100%

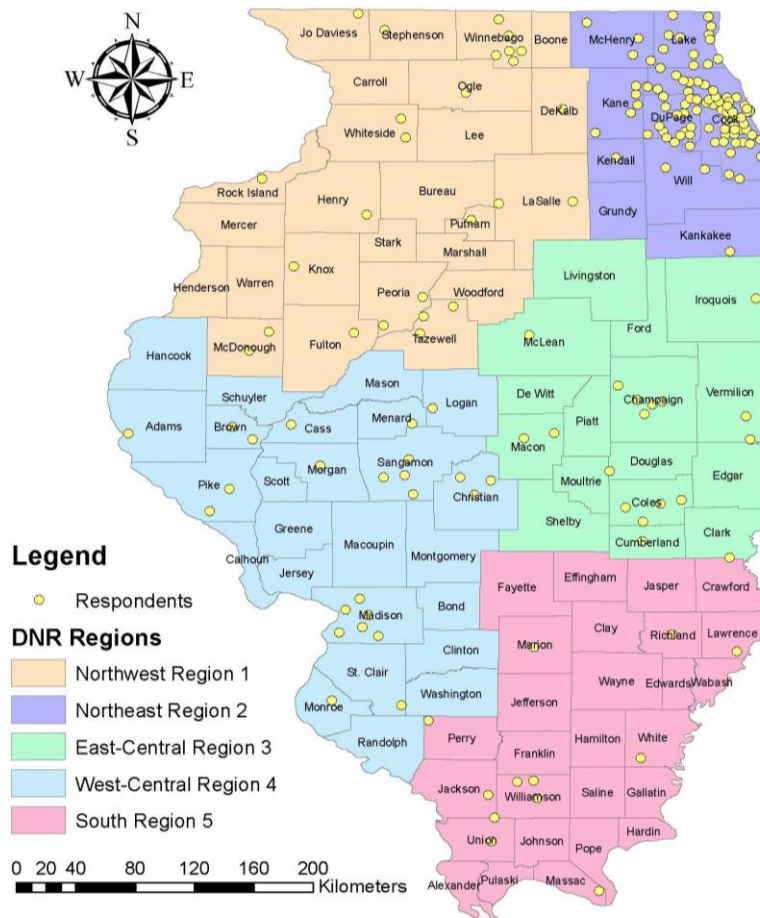
*Note.* Some values are missing because of survey differences

### **Data entry and analysis**

All survey data were cleaned and analyzed by the research team following data collection that was facilitated by Qualtrics. Descriptive statistics and tests for normality were estimated in SPSS version 28, while more advanced modeling took place in R Studio packages. All survey data used were drawn from respondents who lived across the state of Illinois (see Figure 2).

**Figure 2.**

*Graphical representation of the approximate locations of survey respondents*



## RESULTS FROM STATE-WIDE SURVEY

This section presents results using tables and figures, particularly frequency distributions for each variable included in the questionnaire. Data presented are typically valid percentages in each response category (i.e., percentages excluding missing values). Descriptive statistics, such as mean values and standard deviations are also included for appropriate variables. Per disciplinary standards within the environmental social sciences, Likert scale questions with five points or greater were treated as interval-level measures. Data are displayed for the pooled sample of survey respondents as well as subgroups defined by hobby expertise.

## Process for identifying subgroups and organizing research results

### Hobby experience subgroups

All respondents ( $N = 219$ ) were asked to report their perceived level of expertise compared to other hobbyists (see Table 2). Reported skill was more normally distributed ( $skewness = -0.245$ ) and respondents reported their skills were “average” ( $M = 2.98, SD = 0.88$ ).

**Table 2.**

*Self-reported expertise by organism-in-trade hobbyists*

<b>Recreation type</b>	<b>Pooled sample</b> N (%)	<b>Novice</b> n (%)	<b>Intermediate</b> n (%)	<b>Expert</b> n (%)
Level of expertise compared to other hobbyists <sup>1</sup> (M, SD)	2.98 (0.88)	1.69 (0.47)	3.00 (0.00)	4.16 (0.37)
Much lower than average	15 (16.9)	15 (16.9)	-	-
Lower than average	33 (15.1)	33 (15.1)	-	-
Average	120 (55.0)	-	120 (55.0)	-
Higher than average	42 (19.3)	-	-	42 (19.3)
Much higher than average	8 (3.7)	-	-	8 (3.7)

<sup>1</sup>Measured on a 5-point Likert scale ranging from 1 (Much lower than average) to 5 (Much higher than average)

Based on responses to the self-reported expertise question, we identified three subgroups defined as novice, intermediate, and expert hobbyists. Specifically, respondents who answered ‘1: Much lower than average’ or ‘2: Lower than average’ were deemed novices; those who answered ‘3: Average’ were deemed intermediate, and those who answered ‘4: Higher than average’ or ‘5: Much higher than average’ were deemed expert. This delineation resulted in following subgroups: novice hobbyists ( $n=48$ ), intermediate hobbyists ( $n=120$ ), and expert hobbyists ( $n=50$ ). One respondent did not answer the skill question and was thus not assigned a group or included in group analyses. This approach to segmenting the survey sample was adopted due to the managerial relevance of these subgroups, the different strategies that would be needed to reach these groups, and empirical differences that emerged through exploratory analyses.



## Descriptive information about organism-in-trade hobbyists

### History of hobby participation

All respondents were asked to provide information on the type of hobby pursued (see Table 3). In order to participate in the survey, respondents must have owned at least one of the aquariums or water gardens listed in Table 3 within the past three years. **More than half of respondents (57.1%) reported owning a large freshwater aquarium of five gallons or more, with smaller proportions owning aquariums of five gallons or less (41.6%), indoor aquatic pets (26.9%), and water gardens (11.9%).**

**Table 3.**

*Reported ownership of aquatic species*

<b>Recreation type</b>	<b>Pooled sample N (%)</b>	<b>Novice n (%)</b>	<b>Intermediate n (%)</b>	<b>Expert n (%)</b>
Fish bowl or small freshwater aquarium of 5 gallons or less	91 (41.6)	26 (54.2)	47 (39.2)	18 (36.0)
Large freshwater aquarium of 5 gallons or more	125 (57.1)	17 (35.4)	72 (60.0)	36 (72.0)
Saltwater aquarium	18 (8.2)	0 (0.0)	10 (8.3)	8 (16.0)
Koi pond or water garden	26 (11.9)	2 (4.2)	14 (11.7)	10 (20.0)
Indoor aquatic pets (turtles, frogs, etc.)	59 (26.9)	11 (22.9)	27 (22.5)	20 (40.0)

*Note.* Respondents could check all that applied so column totals may not equal 100%.

Respondents were also asked to identify as a particular type of hobbyist (see Table 4). A majority of respondents identified as an aquarium hobbyist (74.3%), which was consistent across all three subgroups. A smaller proportion of respondents identified as both aquarium hobbyists and outdoor pond or water gardeners (16.5%), whereas few respondents identified as solely an outdoor pond hobbyist (5%) or just a water gardener (4.1%).

**Table 4.***Self-identified hobby type*

<b>Hobby type</b>	<b>Pooled sample</b>	<b>Novice</b>	<b>Intermediate</b>	<b>Expert</b>
	N (%)	n (%)	n (%)	n (%)
Aquarium hobbyist	162 (74.3)	35 (72.9)	88 (73.3)	39 (78.0)
Outdoor pond hobbyist	11 (5.0)	4 (8.3)	6 (5.0)	1 (2.0)
Water gardener	9 (4.1)	4 (8.3)	4 (3.3)	1 (2.0)
Both aquarium hobbyist and outdoor pond or water gardener	36 (16.5)	5 (10.4)	22 (18.3)	9 (18.0)

Hobbyists reported an average of 8.14 years of experience with their activity (see Table 5; Figure 3). Novice hobbyists ( $M = 3.71$ ,  $SD = 4.32$ ) had significantly fewer years of experience compared with intermediate ( $M=8.90$ ,  $SD = 9.53$ ) and expert hobbyists ( $M=10.63$ ;  $SD=8.20$ ;  $F(2, 214) = 9.449$ ,  $p<0.001$ ). The average number of tanks each hobbyist owned was 2.86 ( $SD = 16.93$ ), and the majority of respondents (56.7%) owned just one tank (see Figure 4). Both years of experience and number of tanks owned were right skewed ( $skewness = 2.599$ ,  $14.548$ ).

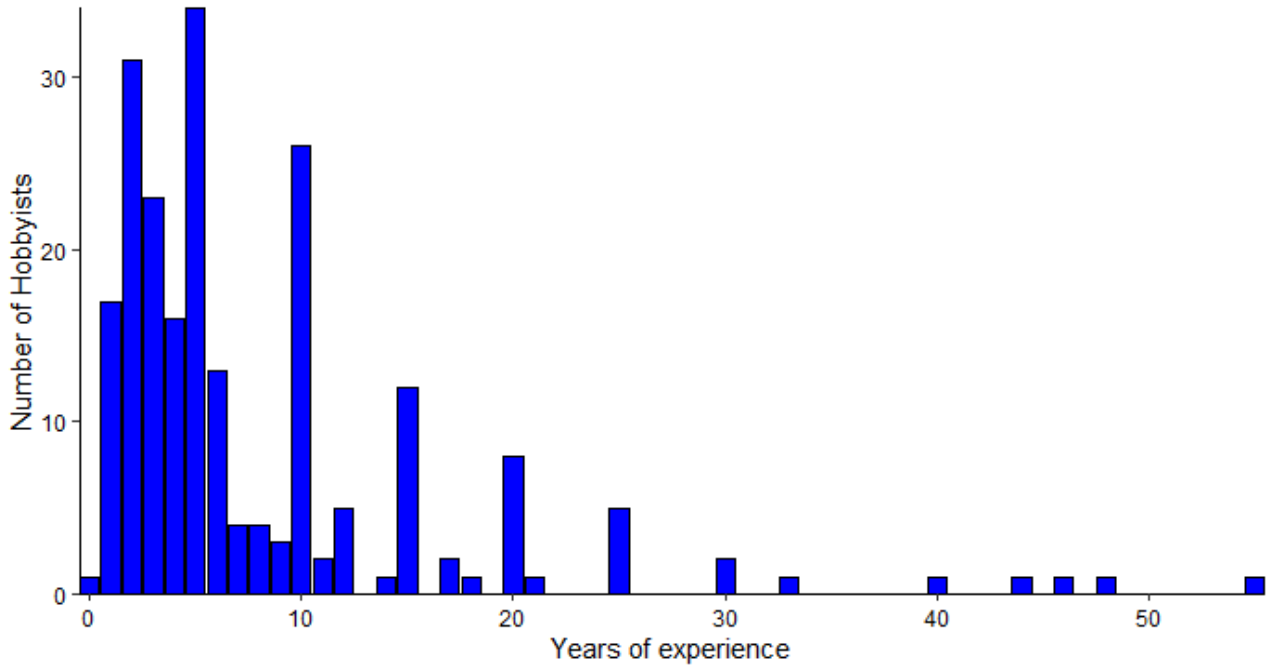
**Table 5.***Previous experiences among organism-in-trade hobbyists*

<b>Previous experience</b>	<b>Pooled sample</b> M (SD)	<b>Novice</b> M (SD)	<b>Intermediate</b> M (SD)	<b>Expert</b> M (SD)
Total number of years having maintained an aquarium or water garden	8.14 (8.67)	3.71 (4.32)	8.90 (9.53)	10.63 (8.20)
Number of aquarium tanks maintained	2.86 (16.93)	1.13 (0.49)	3.78 (22.73)	2.33 (1.52)
0 tanks	4 (1.8%)	3 (6.3%)	1 (0.8%)	0 (0.0%)
1 tank	123 (56.7%)	36 (75.0%)	70 (58.3%)	17 (34.7%)
2 tanks	59 (27.2%)	9 (18.8%)	33 (27.5%)	17 (34.7%)
3 tanks	18 (8.3%)	0 (0.0%)	11 (9.2%)	7 (14.3%)
More than 3 tanks	13 (6.0%)	0 (0.0%)	5 (4.2%)	8 (16.3%)

<sup>1</sup>Estimate included hobby activities in 2022

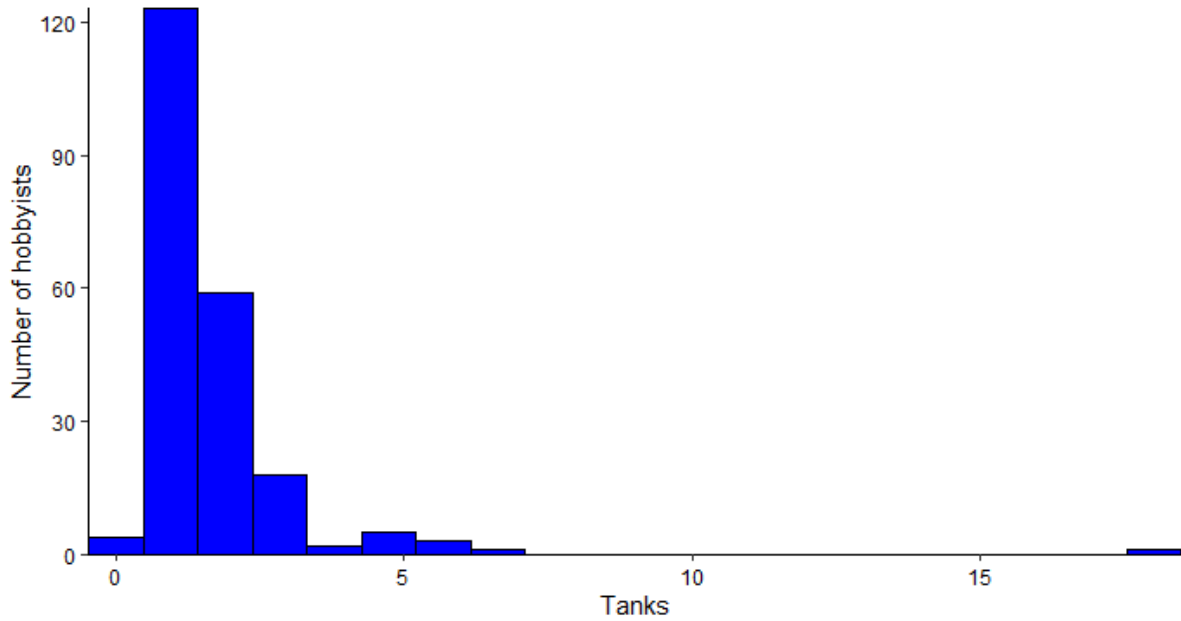
**Figure 3.**

*Total years of experience including 2022 for aquarium and water garden hobbyists across the state of Illinois*



**Figure 4.**

*Number of tanks owned by aquarium and water garden hobbyists across the state of Illinois. One outlier (250 tanks) was removed for this visualization.*



Several questions were asked to determine the source of the aquatic species owned by respondents (see Table 6). **Purchasing species from a chain store ( $M = 3.01$ ,  $SD = 1.30$ ) and local fish stores ( $M = 2.59$ ,  $SD = 1.22$ ) were the most frequent methods of obtaining new species among respondents.** Experts exhibited a more diverse suite of species sources, more frequently purchasing species over the internet, through fish club events or meetings, local classified system, or other hobbyists, in contrast to less experienced groups.

**Table 6.**

*Source of aquatic species owned by hobbyists in the state of Illinois*

<b>Source of species<sup>1</sup></b>	<b>Pooled sample M (SD)</b>	<b>Novice M (SD)</b>	<b>Intermediate M (SD)</b>	<b>Expert M (SD)</b>
Buy aquatic species over the internet	1.49 (0.84)	1.35 (0.78) <sup>a</sup>	1.41 (0.70) <sup>a</sup>	1.82 (1.08) <sup>b</sup>
Buy aquatic species from a chain store (PetCo, PetSmart, etc.)	3.02 (1.30)	3.04 (1.37) <sup>a</sup>	3.15 (1.23) <sup>a</sup>	2.72 (1.34) <sup>a</sup>
Buy aquatic species from a local fish store	2.59 (1.22)	2.33 (1.34) <sup>a</sup>	2.62 (1.19) <sup>a</sup>	2.82 (1.12) <sup>a</sup>
Buy aquatic species through fish club events or meetings	1.38 (0.82)	1.08 (0.35) <sup>a</sup>	1.34 (0.75) <sup>a</sup>	1.76 (1.12) <sup>b</sup>
Accept aquatic species from another hobbyist	1.65 (0.94)	1.38 (0.67) <sup>a</sup>	1.61 (0.89) <sup>a</sup>	2.02 (1.17) <sup>b</sup>
Find fish species through a local classified system	1.41 (0.81)	1.13 (0.39) <sup>a</sup>	1.38 (0.81) <sup>a</sup>	1.74 (0.99) <sup>b</sup>
Buy aquatic species from a reputable breeder	1.59 (0.97)	1.33 (0.60) <sup>a</sup>	1.57 (0.99) <sup>ab</sup>	1.92 (1.12) <sup>b</sup>
Personally collect species that I find in aquatic environments	1.51 (0.98)	1.25 (0.67) <sup>a</sup>	1.51 (0.92) <sup>ab</sup>	1.76 (1.29) <sup>b</sup>

<sup>1</sup>Measured on a 5-point Likert scale from 1 (never) to 5 (every time)

Note. Like superscript indicates no significant differences at  $p < 0.05$

### **Awareness and familiarity with aquatic invasive species**

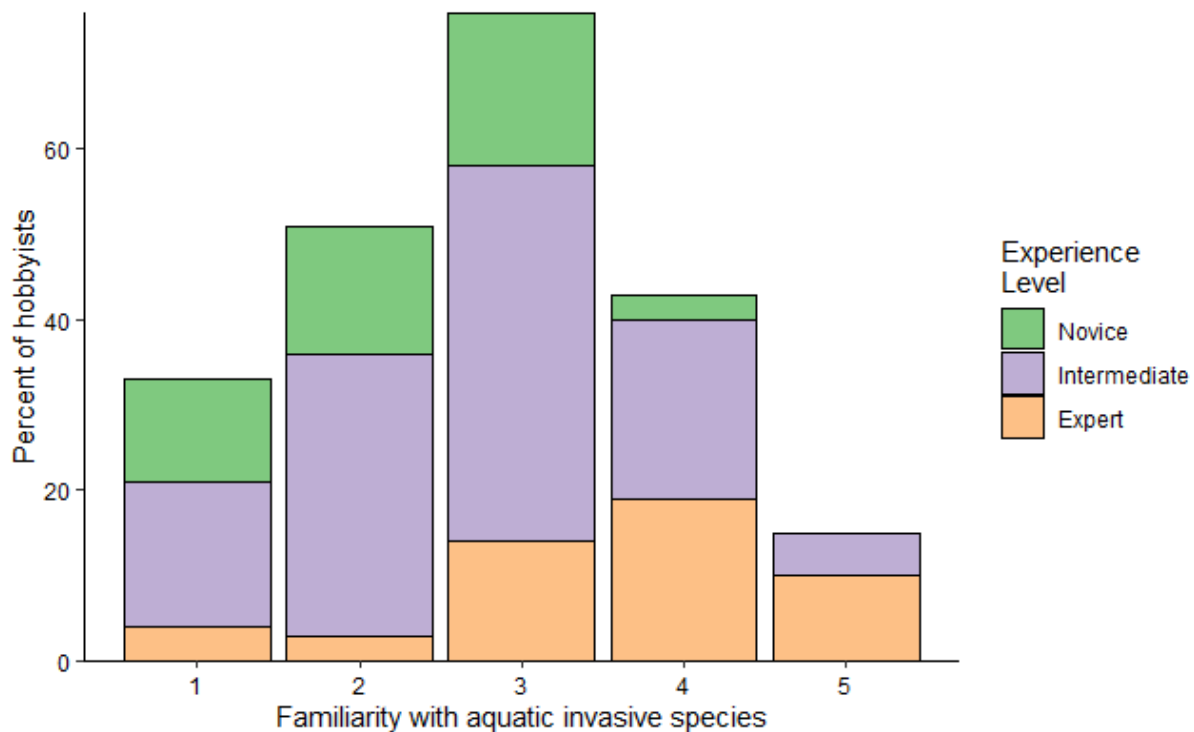
In direct alignment with past work (Seekamp et al., 2016), respondents were presented with the following definition of AIS and asked to report their awareness:

*Aquatic invasive species (AIS), also known as aquatic nuisance species, are aquatic plants or animals that are introduced to an area where they are not native, outcompete native species and establish abundant populations in the wild, and are difficult to control or eradicate. Based on the given definition, to what extent are you aware of AIS (aquatic invasive species)?*

Responses indicated that awareness was moderate ( $M = 2.79$  on a 5-point scale;  $SD = 1.13$ ). Awareness varied by experience ( $F(2, 215) = 20.619, p < 0.001$ ; see Figure 5). Novice hobbyists had the lowest awareness ( $M = 2.25, SD = 0.91$ ), followed by intermediate ( $M = 2.70, SD = 1.05$ ) and expert hobbyists ( $M = 3.56, SD = 1.13$ ).

**Figure 5.**

*Illinois aquarium and water garden hobbyists' awareness of aquatic invasive species*



Respondents were also asked to report their level of familiarity with ecological and social aspects of AIS (see Table 7), to align with sources of knowledge assessed in past work (van Riper et al. 2020). This approach to measuring familiarity was reliable given high internal consistency that was measured using a “Cronbach’s alpha coefficient” that ranged from 0 – 1. Values above 0.6 were deemed acceptable in this study, and this applied to the questions that indicated familiarity with ecological ( $\alpha = 0.855$ ) and social ( $\alpha = 0.925$ ) facets of AIS. We also confirmed that the relationships among these groupings of survey questions were more closely related with one another than with the broader types of familiarity we were trying to understand by estimating factor loading scores.

**Table 7.***Familiarity with topics related to aquatic invasive species*

<b>Familiarity<sup>1</sup></b>	<b>Pooled sample M (SD)</b>	<b>Novice M (SD)</b>	<b>Intermediate M (SD)</b>	<b>Expert M (SD)</b>
<b><i>Ecological</i> (<math>\alpha = .855</math>, <math>\Omega = .858</math>, <math>AVE = .671</math>)</b>	<b>2.54 (0.99)</b>	<b>1.94 (0.72)<sup>a</sup></b>	<b>2.47 (0.89)<sup>b</sup></b>	<b>3.29 (1.01)<sup>c</sup></b>
The biological characteristics that make a species “invasive”	2.61 (1.14)	1.98 (0.89)	2.54 (1.04)	3.38 (1.18)
Names of species that are considered invasive	2.20 (1.03)	1.62 (0.79)	2.13 (0.91)	2.92 (1.12)
Ways that invasive species affect the environment	2.81 (1.20)	2.23 (0.99)	2.74 (1.12)	3.56 (1.22)
<b><i>Social</i> (<math>\alpha = .925</math>, <math>\Omega = .927</math>, <math>AVE = .810</math>)</b>	<b>2.58 (1.17)</b>	<b>1.88 (0.85)<sup>a</sup></b>	<b>2.53 (1.09)<sup>b</sup></b>	<b>3.38 (1.17)<sup>c</sup></b>
How aquarium and garden hobbyists can spread invasive species	2.72 (1.31)	2.04 (1.01)	2.67 (1.25)	3.52 (1.30)
Types of actions you can take to prevent invasive species from spreading	2.57 (1.24)	1.90 (1.02)	2.53 (1.13)	3.36 (1.26)
How to complete recommended preventative actions	2.42 (1.24)	1.71 (0.87)	2.37 (1.17)	3.26 (1.23)

*Fit statistics:  $\chi^2 = 29.573$ ,  $df = 8$ ,  $p < .001$ ; CFI = .980; TLI = .963; RMSEA = .111, SRMR = .020*

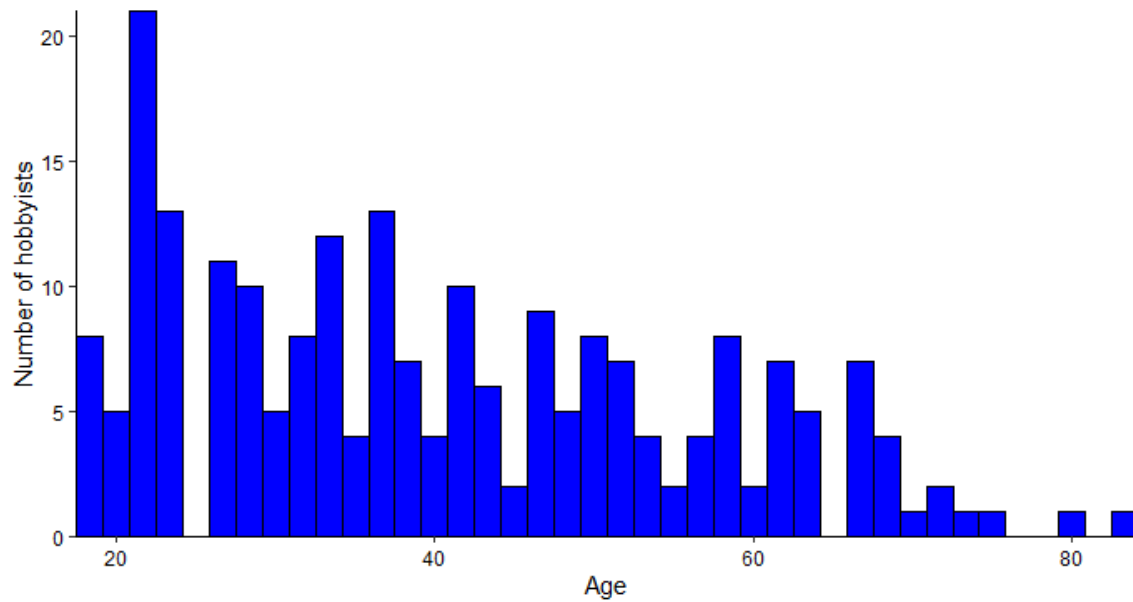
<sup>1</sup>Measured on a 5-point Likert scale ranging from 1 (Not at all familiar) to 5 (Extremely familiar)

*Note.* Like superscript indicates no significant differences at  $p < 0.05$

On average, **respondents were slightly to moderately familiar** with ecological ( $M = 2.54$ ,  $SD = 0.99$ ) and social ( $M = 2.58$ ,  $SD = 1.17$ ) facets of AIS. Familiarity differed by experience level for both ecological familiarity ( $F(2, 215) = 29.047$ ,  $p < 0.001$ ) and social familiarity ( $F(2, 215) = 24.627$ ,  $p < 0.001$ ). That is, experts exhibited higher familiarity than intermediate hobbyists, who in turn exhibited higher familiarity than novice hobbyists.

### **Socio-demographic characteristics**

Survey respondents were mostly White (78.1%), with an average age of 38.19 ( $SD = 15.60$ ) (see Table 8, Figure 6). A total of 74.9% of respondents were women. Educational experiences varied; 43.4% earned a high school diploma, another 25.6% held a bachelor’s degree, and an additional 7.3% earned a graduate degree. A majority of respondents (66.6%) reported an annual household income less than \$75,000 before taxes. Intermediate and expert hobbyists had higher levels of education than novice hobbyists ( $\chi^2 = 21.687$ ,  $p = 0.006$ ).

**Figure 6.***Age of survey respondents included in this research***Table 8.***Socio-demographic profile of organism-in-trade hobbyists included in this research*

<b>Variables</b>	<b>Pooled sample N (%)</b>	<b>Novice N (%)</b>	<b>Intermediate N (%)</b>	<b>Expert N (%)</b>
<i>Age [M, SD]</i>	[38.19, 15.60]			
<i>Gender</i>				
Male	53 (24.2)	8 (16.7)	31 (25.8)	13 (26.0)
Female	164 (74.9)	40 (83.3)	87 (72.5)	37 (74.0)
Other	2 (0.9)	0 (0.0)	2 (1.7)	0 (0.0)
<i>Education</i>				
Some high school	8 (3.7)	0 (0.0)	7 (5.8)	0 (0.0)
High school graduate or GED	95 (43.4)	28 (58.3)	51 (42.5)	16 (32.0)
Associate's degree	44 (20.1)	10 (20.8)	18 (15.0)	16 (32.0)
Bachelor's degree	56 (25.6)	9 (18.8)	36 (30.0)	11 (2.0)
Graduate degree (MA, MS, PhD, JD, MD, etc.)	16 (7.3)	1 (2.1)	8 (6.7)	7 (14.0)
<i>Income</i>				
Less than \$24,999	32 (14.6)	9 (18.8)	18 (15.0)	5 (10.0)
\$25,000 to \$49,999	55 (25.1)	12 (25.0)	25 (20.8)	18 (36.0)
\$50,000 to \$74,999	59 (26.9)	11 (22.9)	38 (31.7)	9 (18.0)
\$75,000 to \$99,999	26 (11.9)	4 (8.3)	14 (11.7)	8 (16.0)
\$100,000 to \$149,999	21 (9.6)	3 (6.3)	12 (10.0)	6 (12.0)
\$150,000 and over	13 (6.0)	3 (6.3)	3 (2.5)	2 (4.0)
Prefer not to answer	13 (5.9)	6 (12.5)	5 (4.2)	2 (4.0)

Variables	Pooled sample N (%)	Novice N (%)	Intermediate N (%)	Expert N (%)
<i>Race &amp; Ethnicity<sup>1</sup></i>				
American Indian	14 (6.4)	0 (0.0)	8 (6.7)	6 (12.0)
Asian	9 (4.1)	3 (6.3)	3 (2.5)	3 (6.0)
Black or African American	21 (9.6)	5 (10.4)	12 (10.0)	4 (8.0)
Hispanic or Latino	22 (10.0)	5 (10.4)	13 (10.8)	4 (8.0)
Native Hawaiian or other Pacific Islander	1 (0.5)	0 (0.0)	1 (0.8)	0 (0.0)
White	171 (78.1)	38 (79.2)	95 (79.2)	37 (74.0)
Other	5	1 (2.1)	3 (2.5)	1 (2.0)

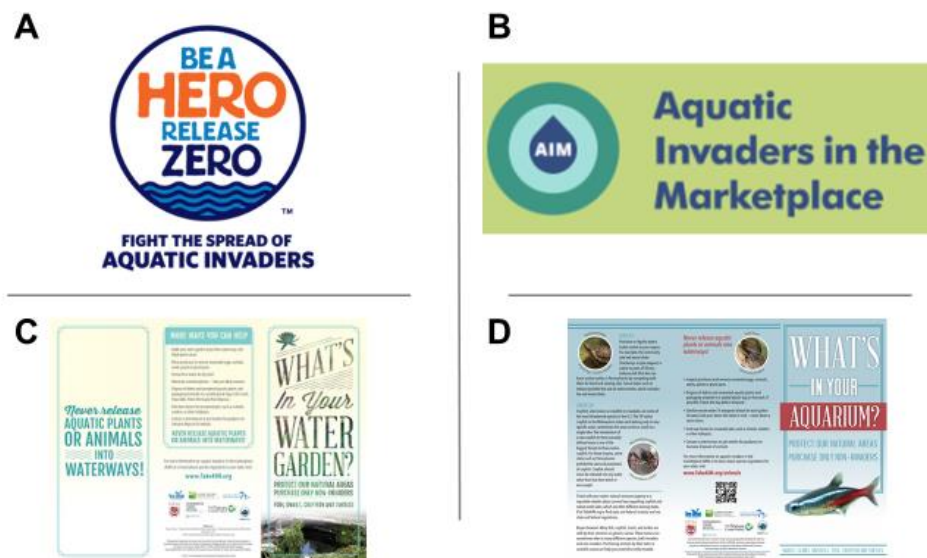
<sup>1</sup>Respondents could check all that applied so column totals may not equal 100%.

## Evaluation of outreach campaigns

This project evaluated four campaigns that were in use by Illinois-Indiana Sea Grant as of 2022 (see Figure 7). Respondents were presented with the logo and name of each campaign and asked to report their familiarity with the campaign. Average familiarity for each campaign ranged from ‘not at all familiar’ to ‘slightly familiar’ (See Table 9). Familiarity differed by experience level, in that novice hobbyists had lower familiarity with each campaign than expert hobbyists.

**Figure 7.**

Logos representing the four outreach campaigns, including A) *Be a Hero, Release Zero*; B) *Take AIM*; C) *What’s in your water garden?*; and D) *What’s in your aquarium?*





**Table 9.***Participant familiarity with outreach campaigns*

<b>Familiarity with campaigns</b>	<b>Pooled sample</b> M (SD)	<b>Novice</b> M (SD)	<b>Intermediate</b> M (SD)	<b>Expert</b> M (SD)
Be a Hero Release Zero	1.66 (1.04)	1.17 (0.52) <sup>a</sup>	1.70 (1.02) <sup>b</sup>	2.06 (1.28) <sup>b</sup>
Take AIM	1.59 (0.95)	1.21 (0.54) <sup>a</sup>	1.60 (0.91) <sup>ab</sup>	1.94 (1.19) <sup>b</sup>
What's in your water garden?	1.61 (1.01)	1.31 (0.72) <sup>a</sup>	1.57 (0.97) <sup>a</sup>	2.00 (1.21) <sup>b</sup>
What's in your aquarium?	1.78 (1.05)	1.31 (0.66) <sup>a</sup>	1.75 (0.99) <sup>b</sup>	2.30 (1.28) <sup>c</sup>

*Note.* Measured on a 5-point Likert scale from 1 (not at all familiar) to 5 (extremely familiar)

*Note.* Like superscript indicates no significant differences at  $p < 0.05$

**Use of campaign resources**

We asked respondents how often they had used a selection of resources that these campaigns offer. Due to the low campaign familiarity identified during pilot testing, we asked about resource use in general, rather than use specific to each campaign. On average, respondents indicated having used each resource ‘at least once,’ though use varied by experience level. Expert hobbyists used each resource more frequently than novice hobbyists, and reported particularly high use of lists of invasive and non-invasive species ( $M = 3.08$ ,  $SD = 1.55$ ) which was more than both intermediate and novice anglers ( $F(2, 214) = 19.461$ ,  $p < 0.001$ ).

**Table 10.***Use of campaign resources by organism-in-trade hobbyists*

<b>Use of campaign resources</b>	<b>Pooled sample</b> M (SD)	<b>Novice</b> M (SD)	<b>Intermediate</b> M (SD)	<b>Expert</b> M (SD)
Pet re-homing network	1.63 (1.03)	1.23 (0.69) <sup>a</sup>	1.57 (0.88) <sup>a</sup>	2.16 (1.39) <sup>b</sup>
Exotic pet veterinarian network	1.58 (1.06)	1.17 (0.63) <sup>a</sup>	1.55 (0.93) <sup>a</sup>	2.08 (1.44) <sup>b</sup>
Disposal guidelines	2.11 (1.29)	1.48 (0.97) <sup>a</sup>	2.17 (1.21) <sup>b</sup>	2.60 (1.51) <sup>b</sup>
Campaign websites (ReleaseZero.org, TakeAIM.org, etc.)	1.71 (1.17)	1.27 (0.87) <sup>a</sup>	1.70 (1.10) <sup>ab</sup>	2.16 (1.42) <sup>b</sup>
Regulations database	1.83 (1.18)	1.33 (0.88) <sup>a</sup>	1.79 (1.07) <sup>a</sup>	2.46 (1.43) <sup>b</sup>
Lists of expert contacts	1.78 (1.24)	1.23 (0.69) <sup>a</sup>	1.74 (1.11) <sup>b</sup>	2.45 (1.63) <sup>c</sup>
Lists of invasive and non-invasive species	2.28 (1.40)	1.44 (0.85) <sup>a</sup>	2.30 (1.33) <sup>b</sup>	3.08 (1.55) <sup>c</sup>

<sup>1</sup>Measured on a 5-point Likert scale from 1 (never) to 5 (very often)

*Note.* Like superscript indicates no significant differences at  $p < 0.05$

A spatial assessment of respondent familiarity with outreach campaigns and use of campaign resources is available in Appendix D.

## **Open-ended responses to outreach messages**

Respondents were asked to provide open-ended feedback on outreach campaigns, in response to the following prompt: *The organizations developing these informational campaigns (Be a Hero, Transport Zero, Take AIM, What's in your water garden, What's in your aquarium) would value your feedback. What, if any, changes would you recommend?* A total of 170 hobbyists out of the 219 survey participants provided input in response to this question.

The most common response, shared by 68 respondents, is that they **would not make any changes**. Of these respondents, 14 provided specific positive feedback, including recommendations to continue current efforts.

- “None! They do a very good job of informing everyone. If you pay attention!”
- “None. Now that I’m aware of them they look useful with a lot of information and guidance.

Sixty-one respondents **recommended different strategies for disseminating campaign materials**. These suggestions included: pet stores (20 respondents), veterinarian offices (3 respondents), social media or online (9 respondents), print media (5 respondents), radio or television (3 respondents), and targeting younger audiences (2 respondents). A few representative comments are below:

- “Make information more available at pet stores”
- “Make the information available in more places. Pamphlets at pet stores or veterinary offices maybe.”
- “Promote more, whether it be through social media or radio commercials.”
- “I think I'd try to work with pet stores more. Maybe have some posters or something that can be hung up. Have training for employees so they can pass on info.”
- “Find a way to put more advertising out there about these campaigns more frequently for people who aren't aware of them. Either by social media, local broadcasting, magazines, or radio, that way your sure to spread the knowledge needed to keep or aquariums safe, as well as our natural resources, and community.”

Three respondents recommended **specific changes to campaign materials**.

- “I would add brighter colors to make it all more eye catching brighter”
- “I would not try to be clever with. different campaigns but focus on a consistent "planet health" message that focuses on the environmental benefits of maintaining natural environments and where to look for further information, like websites with information on species and connecting with solutions.”
- “Take a lighter attitude and insert a little fun”

Eight respondents shared their **preferences for invasive species management** more broadly.

- “Stricter guidelines for local pet stores for selling invasive species”
- “Continuous research equals early intervention”
- “let them live (bring them to there natural habitat)”
- “I would recommend to never heart fishes in the wild.”

Many respondents indicated that they **did not know what to suggest**. Thirteen simply responded with a brief comment of “I don’t know” (or similar), and twelve respondents explicitly mentioned that they were **too unfamiliar with these campaigns** to make a recommendation.

- “Don’t know enough bout them to recommend changes”
- “I have no feedback since I have never heard of them.”
- “I don’t know since this is the first time I have been made aware of these campaigns.”

### **Primary information sources**

Respondents reported learning about AIS through a variety of sources (see Table 11). The most common sources included social media (28.8%) and school (26.9%). Experts most commonly learned about AIS through online water hobbyist forums (42.0%), social media (30.0%), school (30.0%), and magazines (28.0%). The most common sources for intermediate hobbyists were social media (32.5%), school (25.0%), magazines (24.2%), television (24.2%), and brochures (24.2%). Novice hobbyists had been exposed to AIS through fewer modes. Their most common learning sources were school (29.2%) and brochures (20.8%). A total of 14 respondents (6.4%) indicated that this survey was their first time hearing about AIS.

Three categories of information sources were identified via a principal components analysis: traditional sources, online sources, and live events. Approximately one third of respondents (36.7%) used at least one traditional source, including magazines, television, and newspapers. Use of these sources was more common among expert and intermediate hobbyists in contrast to novices ( $\chi^2 = 10.635, p = 0.005$ ). Half of respondents (50.0%) used at least one online source, which included online hobbyist forums, online ads, and social media. Experts more commonly used online sources than novice hobbyists ( $\chi^2 = 9.287, p = 0.010$ ), largely due to their use of online forums. Although the individual online sources were less commonly used by novice hobbyists, 33.3% of hobbyists in this group used at least one online source. Finally, 32.6% of respondents had learned about AIS through a live event: school, presentations, and/or tradeshow.

**Table 11.***Information channels through which Illinois hobbyists have learned about AIS*

<b>AIS learning mode (select all that apply)</b>	<b>Pooled sample N (%)</b>	<b>Novice n (%)</b>	<b>Intermediate n (%)</b>	<b>Expert n (%)</b>
<b><i>Traditional sources</i></b>	<b>80 (36.7)</b>	<b>8 (16.7)</b>	<b>51 (42.5)</b>	<b>21 (42.0)</b>
Read about AIS in magazines	47 (21.5)	4 (8.3)	29 (24.2)	14 (28.0)
Learned about AIS through a television program	45 (20.5)	3 (6.3)	29 (24.2)	13 (26.0)
Read about AIS in the newspaper	22 (10.0)	2 (4.2)	12 (10.0)	8 (16.0)
<b><i>Online sources</i></b>	<b>109 (50.0)</b>	<b>16 (33.3)</b>	<b>61 (50.8)</b>	<b>32 (64.0)</b>
Read about AIS in online water hobbyist forums	49 (22.4)	5 (10.4)	23 (19.2%)	21 (42.0)
Saw information about AIS in an online ad	46 (21.0)	8 (16.7)	28 (23.3)	10 (20.0)
Learned about AIS through social media posts or videos	63 (28.8)	9 (18.8)	39 (32.5)	15 (30.0)
<b><i>Live events</i></b>	<b>71 (32.6)</b>	<b>14 (29.2)</b>	<b>37 (30.8)</b>	<b>20 (40.0)</b>
Learned about AIS in school	59 (26.9)	14 (29.2)	30 (25.0)	15 (30.0)
Attended presentations about AIS	13 (5.9)	1 (2.1)	5 (4.2)	7 (14.0)
Learned about AIS in tradeshow	13 (5.9)	0 (0.0)	9 (7.5)	4 (8.0)
<b><i>Miscellaneous</i></b>				
Read about AIS in brochures	51 (23.3)	10 (20.8)	29 (24.2)	12 (24.0)
Information about AIS came with the purchase of my aquatic plant or animal	41 (18.7)	6 (12.5)	25 (20.8)	10 (20.0)
Saw information about AIS on posters	33 (15.1)	5 (10.4)	23 (19.2)	5 (10.0)
Received giveaways from an AIS organization (pencils, garden kneelers, screen wipes, stick-on thermometers, fish bags, magnets, etc.)	10 (4.6)	1 (2.1)	6 (5.0)	3 (6.0)
Saw AIS wrapped vehicles (cars or trucks displaying logos or information about AIS)	4 (1.8)	0 (0.0)	2 (1.7)	2 (4.0)
Other <sup>1</sup>	37 (16.9)	11 (22.9)	18 (15.0)	7 (14.0)

<sup>1</sup>Common responses included “none” (n = 7), “do not recall” (n = 3), had not heard of AIS before taking the survey (n = 14), and personal experiences including work, volunteering, or encounters with AIS in daily life (n = 5).

*Note:* A majority of respondents (n = 121; 55.2%) reported being confident or very confident in their responses to this question. A proportion of respondents (n = 75, 34.2%) reported being somewhat confident, whereas only 10.5% (n = 23) reported being not at all confident.

Aquarium and water garden hobbyists reported **several frequently consulted sources for advice about their hobby** (see Table 12). Retailers were commonly consulted by all three groups and were among the most frequently consulted source by novice ( $M = 2.77$ ,  $SD = 1.17$ ) and intermediate ( $M = 3.04$ ,  $SD = 1.02$ ) hobbyists. Expert hobbyists consulted veterinarians ( $M = 3.58$ ,  $SD = 1.31$ ) more frequently than both intermediate and novice hobbyists ( $F(2,215) = 10.400$ ,  $p < 0.001$ ).

**Table 12.**

*Sources that Illinois aquarium and water garden hobbyists frequently consult for advice about their hobby*

Frequently consulted sources <sup>1</sup>	Pooled sample M (SD)	Novice M (SD)	Intermediate M (SD)	Expert M (SD)
Family members, friends, or neighbors	2.90 (1.07)	2.54 (1.09) <sup>a</sup>	3.06 (0.94) <sup>ab</sup>	2.92 (1.24) <sup>b</sup>
Other hobbyists	2.74 (1.26)	2.08 (1.18) <sup>a</sup>	2.79 (1.19) <sup>b</sup>	3.28 (1.23) <sup>b</sup>
Retailers	2.99 (1.10)	2.77 (1.17) <sup>a</sup>	3.04 (1.02) <sup>a</sup>	3.10 (1.17) <sup>a</sup>
Breeders	2.26 (1.27)	1.65 (0.98) <sup>a</sup>	2.27 (1.27) <sup>b</sup>	2.84 (1.27) <sup>c</sup>
Veterinarians	2.88 (1.42)	2.35 (1.33) <sup>a</sup>	2.80 (1.39) <sup>a</sup>	3.58 (1.31) <sup>b</sup>

<sup>1</sup>Measured on a 5-point Likert scale from 1 (never) to 5 (very often).

Note. Like superscript indicates no significant differences at  $p < 0.05$

## Factors contributing to AIS-prevention behaviors

The outreach programs developed by Illinois-Indiana Sea Grant encourage aquarium and water garden hobbyists to prevent the spread of AIS by purchasing non-invasive species, quarantining species before introducing to pond or aquarium, and sterilizing water prior to disposal to avoid accidentally spreading small organisms. We asked survey respondents how likely they were to engage in these behaviors over the next 12 months (see Table 13). The questions were based on Seekamp et al. (2016) but modified to match the current aims of Illinois-Indiana Sea Grant's campaigns, and to present a simplified list to respondents. Likelihood of engaging in preventative behaviors were moderate ( $M = 3.16$ ,  $SD = 1.00$ ). Compared with the other two groups, experts were more likely to purchase species based on scientific names ( $F(2, 215) = 23.596$ ,  $p < 0.001$ ) and quarantine species before introducing to pond and aquarium ( $F(2,214)=10.253$ ,  $p < 0.001$ ).

**Table 13.***Behaviors that organism-in-trade hobbyists intend to perform in the next 12 months*

<b>Intended Behavior</b>	<b>Pooled sample M (SD)</b>	<b>Novice M (SD)</b>	<b>Intermediate M (SD)</b>	<b>Expert M (SD)</b>
<b><i>Intended behavior (<math>\alpha = .740</math>, <math>\Omega = .745</math>, <math>AVE = .424</math>)</i></b>	<b>3.16 (1.00)</b>	<b>2.61 (0.90)<sup>a</sup></b>	<b>3.14 (0.94)<sup>b</sup></b>	<b>3.77 (0.86)<sup>c</sup></b>
Purchase species based on scientific names	2.57 (1.34)	1.77 (0.97) <sup>a</sup>	2.53 (1.28) <sup>b</sup>	3.46 (1.30) <sup>c</sup>
Purchase only native or non-invasive species	3.45 (1.26)	2.96 (1.30) <sup>a</sup>	3.47 (1.19) <sup>ab</sup>	3.92 (1.19) <sup>b</sup>
Quarantine species before introducing to pond or aquarium	3.60 (1.28)	3.09 (1.35) <sup>a</sup>	3.57 (1.27) <sup>a</sup>	4.20 (0.95) <sup>b</sup>
Sterilize water (add bleach) used in an aquarium or water garden prior to disposal	3.01 (1.43)	2.64 (1.41) <sup>a</sup>	2.97 (1.37) <sup>ab</sup>	3.50 (1.49) <sup>b</sup>

<sup>1</sup>*Measured on a 5-point Likert scale from 1 (not at all likely) to 5 (extremely likely)**Note.* Like superscript indicates no significant differences at  $p < 0.05$ 

Releasing unwanted species into local waterways is one pathway for species invasions. Sea Grant’s campaigns encourage hobbyists to use alternative methods of disposing of or rehoming unwanted species. We asked respondents to report which disposal methods they have used in the past 12 months (see Table 14). Bagging plants and placing them in the trash was the most common plant disposal method (42.0%), and rehoming animals with a sanctuary or rescue group was the most common disposal method for animals (37.4%). Experts had higher engagement with each recommended disposal type in contrast to the other two groups; over half of experts (52.0%) reported rehoming animals with a sanctuary or rescue group, and 36.0% reported giving, trading, or selling animals to another hobbyist. The majority of respondents who selected ‘other’ (n=21) indicated that they either had not disposed of any species in the past 12 months, or simply indicated ‘N/A’ or ‘none of the above.’ The remaining six respondents listed the following methods: composting (n=1), burning (n=1), throwing fish in the trash (n=1), flushing down the toilet (n=1), releasing in the wild (n=1), and ‘let them die by themselves’ (n=1). We did not include ‘release into the wild’ as one of the choices in the list of disposal methods, because we wanted to avoid promoting release or inadvertently communicate that release was an appropriate disposal method. However, because we did not specifically ask about release, it is possible that additional respondents had also released species into the wild and did not report this behavior.

**Table 14.***Methods that hobbyists have used to dispose of organisms in the past 12 months*

<b>Disposal methods (select all that apply)</b>	<b>Pooled sample N (%)</b>	<b>Novice n (%)</b>	<b>Intermediate n (%)</b>	<b>Expert n (%)</b>
<b>Plants</b>				
Give, trade, or sell plants to another hobbyist	55 (25.1)	9 (18.8)	29 (24.2)	16 (32.0)
Donate plants to a school, business, zoo, or other organization	43 (19.6)	7 (14.6)	25 (20.8)	11 (22.0)
Bag plants and place them in the trash	92 (42.0)	20 (41.7)	50 (41.7)	22 (44.0)
<b>Animals</b>				
Give, trade, or sell animals to another hobbyist <sup>1</sup>	56 (25.6)	7 (14.6)	31 (25.8)	18 (36.0)
Donate animals to a school, business, zoo, or other organization	52 (23.7)	9 (18.8)	30 (25.0)	13 (26.0)
Rehome animals with a sanctuary or rescue group <sup>2</sup>	82 (37.4)	16 (33.3)	40 (33.3)	26 (52.0)
Euthanize animal species	30 (13.7)	5 (10.4)	15 (12.5)	10 (20.0)
<b>Other<sup>3</sup></b>	27 (12.3)	9 (18.8)	14 (11.7)	4 (8.0)

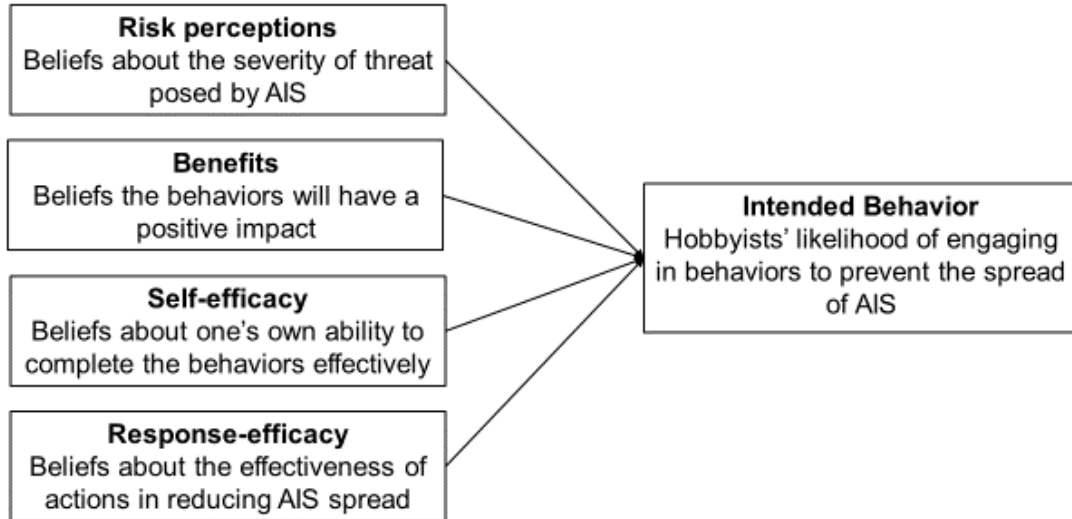
<sup>1</sup>Significant differences identified at  $p=.053$  ( $\chi^2=5.887$ )<sup>2</sup>Significant differences identified at  $p=.057$  ( $\chi^2=5.722$ )<sup>3</sup>The majority of respondents who selected 'other' ( $n=21$ ) indicated that they either had not disposed of any species in the past 12 months, or simply wrote 'N/A' or 'none of the above.'

### **Drivers of behavior**

Psychological models such as the Health Belief Model (Rosenstock, 1974) can be used to understand why hobbyists take action to help prevent the spread of AIS. The Health Belief Model considers the role of benefits, barriers, risk perceptions, and efficacy in predicting desirable behaviors (see Figure 8) and has been applied to understand a variety of behaviors that promote environmental sustainability (Carpenter, 2010), including behaviors relevant to AIS (Golebie et al., 2023). Therefore, this study sought to understand each of these variables among Illinois hobbyists and understand their relevance in predicting AIS-prevention behaviors.

**Figure 8.**

*Relevant variables for predicting hobbyist participation in behaviors that minimize the spread of aquatic invasive species, according to the Health Belief Model.*



The first key concept from the Health Belief Model included in this study was perception of the risks posed by AIS. Three types of risk perceptions were examined, including environmental (i.e., the level of threat posed to the environment) ( $\alpha = 0.832$ ); personal (i.e., the level of threat posed to individuals) ( $\alpha = 0.846$ ); and social (i.e., the level of threat posed to communities) ( $\alpha = 0.883$ ). We found acceptable model fit and factor loading scores exceeding minimum acceptable thresholds.

**Respondents reported moderate risk perceptions and were more concerned with environmental risks and least concerned with personal risks** (see Table 16). Specifically, environmental risk perceptions ( $M = 3.43$ ,  $SD = 0.82$ ) were higher than social ( $M = 3.16$ ,  $SD = 1.04$ ;  $t(218) = 4.739$ ,  $p < 0.001$ ), and social risk perceptions were higher than personal ( $M = 3.01$ ,  $SD = 1.03$ ;  $t(218) = -2.868$ ,  $p = 0.005$ ). Novice hobbyists reported lower risk perceptions than intermediate and expert hobbyists for three types of risk: environmental ( $F(2, 215) = 8.957$ ,  $p < 0.001$ ), personal ( $F(2, 215) = 10.897$ ,  $p < 0.001$ ), and social ( $F(2, 215) = 8.093$ ,  $p < 0.001$ ).



**Table 15.***Risk perceptions of organism-in-trade hobbyists*

<b>Risk perceptions<sup>1</sup></b>	<b>Pooled sample M (SD)</b>	<b>Novice M (SD)</b>	<b>Intermediate M (SD)</b>	<b>Expert M (SD)</b>
<b><i>Environmental</i> (<math>\alpha = .832</math>, <math>\Omega = .832</math>, <math>AVE = .623</math>)</b>	<b>3.43 (0.82)</b>	<b>3.07 (0.92)<sup>a</sup></b>	<b>3.43 (0.78)<sup>b</sup></b>	<b>3.75 (0.69)<sup>b</sup></b>
Quality of habitat and natural environments	3.45 (.93)	3.25 (1.00)	3.42 (0.89)	3.76 (0.89)
Environmental processes (e.g., water cycle)	3.26 (.93)	2.71 (1.05)	3.32 (0.85)	3.62 (0.73)
Survival of plants and animals	3.57 (.98)	3.27 (1.07)	3.55 (0.95)	3.88 (0.87)
<b><i>Personal</i> (<math>\alpha = .846</math>, <math>\Omega = .853</math>, <math>AVE = .660</math>)</b>	<b>3.01 (1.03)</b>	<b>2.47 (1.02)<sup>a</sup></b>	<b>3.08 (0.8)<sup>b</sup></b>	<b>3.36 (0.95)<sup>b</sup></b>
Your appreciation of the beauty of the landscape	3.12 (1.12)	2.48 (1.17)	3.14 (1.01)	3.65 (1.03)
Your own enjoyment of recreational activities	3.98 (1.18)	2.35 (1.16)	3.09 (1.11)	3.28 (1.18)
Your own access to waterbodies	2.94 (1.20)	2.56 (1.20)	3.00 (1.15)	3.18 (1.22)
<b><i>Social</i> (<math>\alpha = .883</math>, <math>\Omega = .883</math>, <math>AVE = .715</math>)</b>	<b>3.16 (1.04)</b>	<b>2.67 (1.16)<sup>a</sup></b>	<b>3.22 (0.99)<sup>b</sup></b>	<b>3.47 (0.89)<sup>b</sup></b>
The local economy	3.04 (1.17)	2.69 (1.22)	3.08 (1.15)	3.24 (1.12)
The community in the region	3.06 (1.15)	2.54 (1.29)	3.13 (1.06)	3.38 (1.07)
Recreational opportunities for future generations	3.39 (1.16)	2.79 (1.24)	3.45 (1.11)	3.78 (0.98)

*Fit statistics:  $\chi^2 = 74.866$ ,  $df = 24$ ,  $p < .001$ ;  $CFI = .958$ ;  $TLI = .937$ ;  $RMSEA = .098$ ,  $SRMR = .042$*

<sup>1</sup>*Measured on a 5-point Likert scale from 1 (no impacts) to 5 (very severe impacts)*

*Note.* Like superscript indicates no significant differences at  $p < 0.05$

The second key concept from the Health Belief Model that was tested in this study pertained to benefits, defined as beliefs that following purchasing and disposal guidelines will have positive outcomes. The survey questions were drawn from past research (Golebie et al., 2021), and reviewed and refined during interviews with experts. Results of a confirmatory factor analysis showed good model fit and reliability across benefits to the self ( $\alpha = 0.844$ ) and to the community ( $\alpha = 0.790$ ).

Respondents agreed that AIS prevention has both personal and social benefits (see Table 15). Perceived benefits to the self ( $M = 4.20$ ,  $SD = 0.63$ ) were slightly higher than perceived benefits to the community ( $M = 3.97$ ,  $SD = 0.75$ ) ( $t(218) = 5.382$ ,  $p < 0.001$ ). There were no significant differences between the experience subgroups for either benefits to the self ( $F(2, 215) = 2.307$ ,  $p$

= 0.102) or benefits to the community ( $F(2, 215) = 1.863, p = 0.158$ ). In other words, hobby expertise did not significantly influence the level of perceived benefits of AIS prevention.

**Table 16.**

*Perceived benefits of taking action to prevent the spread of aquatic invasive species*

<b>Benefits</b>	<b>Pooled sample M (SD)</b>	<b>Novice M (SD)</b>	<b>Intermediate M (SD)</b>	<b>Expert M (SD)</b>
<b><i>Benefits to the self</i></b> ( $\alpha = .844, \Omega = .850, AVE = .655$ )	<b>4.27 (0.62)</b>	<b>4.20 (0.63)<sup>a</sup></b>	<b>4.23 (0.64)<sup>a</sup></b>	<b>4.43 (0.56)<sup>a</sup></b>
Increasing my own knowledge and understanding of the ecosystem	4.22 (0.72)	4.21 (0.71)	4.19 (0.71)	4.32 (0.71)
Maintaining a healthy aquarium or water garden	4.31 (0.71)	4.23 (0.72)	4.24 (0.72)	4.58 (0.56)
Knowing that I have done the right thing to be a successful hobbyist	4.26 (0.74)	4.17 (0.83)	4.25 (0.71)	4.40 (0.67)
<b><i>Benefits to the community</i></b> ( $\alpha = .790, \Omega = .792, AVE = .560$ )	<b>4.09 (0.69)</b>	<b>3.97 (0.75)<sup>a</sup></b>	<b>4.09 (0.70)<sup>a</sup></b>	<b>4.23 (0.58)<sup>a</sup></b>
A sense of community among hobbyists	3.87 (0.85)	3.77 (0.85)	3.85 (0.89)	4.02 (0.80)
Teaching younger generations about the impact of our behaviors on the environment	4.21 (0.81)	4.04 (0.90)	4.25 (0.79)	4.30 (0.76)
Preserving aquatic resources for my community	4.19 (0.82)	4.08 (0.87)	4.17 (0.81)	4.38 (0.75)

*Fit statistics*  $\chi^2 = 18.339, df = 8, p = .019; CFI = .984; TLI = .971; RMSEA = .077, SRMR = .025$

*Note.* Measured on a Likert scale where 1 = “Strongly Disagree” and 5 = “Strongly Agree”.

*Note.* Like superscript indicates no significant differences at  $p < 0.05$

Additional variables from the Health Belief model included **self-efficacy** (i.e., beliefs that one has the ability to take a particular action) and **response-efficacy** (i.e., beliefs that a recommended action will effectively achieve a particular goal). These questions were adapted from past work (Bandura, 1977; Landon et al., 2018), refined through previous research (Golebie et al., 2021), and tailored to be most relevant to hobbyists. Both self-efficacy ( $\alpha = 0.843$ ) and response-efficacy ( $\alpha = 0.773$ ) were reliable and there was good model fit.

Hobbyists reported moderate levels of self-efficacy ( $M = 3.81, SD = 0.76$ ) and high levels of response efficacy ( $M = 4.12, SD = 0.69$ ), indicating beliefs that they had the ability to take preventative actions, and that their actions would help prevent AIS spread (see Table 17). Response-efficacy was higher than self-efficacy ( $t(218) = -7.287, p < 0.001$ ), indicating

respondents had more confidence that the guidelines had the potential to be successful than they did about their ability to follow the guidelines effectively. Expert hobbyists reported higher levels of self-efficacy ( $F(2, 215) = 19.589, p < 0.001$ ) and response-efficacy ( $F(2, 215) = 5.409, p = 0.005$ ) than novice and intermediate hobbyists.

**Table 17.**

*Self-efficacy and response-efficacy related to behaviors that prevent the spread of aquatic invasive species*

<b>Efficacy<sup>1</sup></b>	<b>Pooled sample M (SD)</b>	<b>Novice M (SD)</b>	<b>Intermediate M (SD)</b>	<b>Expert M (SD)</b>
<b><i>Self-efficacy</i> (<math>\alpha = .843, \Omega = .846, AVE = .647</math>)</b>	<b>3.81 (0.76)</b>	<b>3.36 (0.87)<sup>a</sup></b>	<b>3.80 (0.64)<sup>b</sup></b>	<b>4.25 (0.67)<sup>c</sup></b>
I understand what I need to do in order to minimize the risk of AIS	3.62 (.92)	3.19 (1.00)	3.61 (0.77)	4.06 (0.98)
I am capable of performing the tasks required to minimize the risk of AIS	3.95 (.82)	3.46 (0.99)	3.97 (0.70)	4.38 (0.64)
I feel confident in performing the steps necessary to minimize the risk of AIS	3.84 (.90)	3.44 (1.07)	3.83 (0.77)	4.32 (0.74)
<b><i>Response-efficacy</i> (<math>\alpha = .773, \Omega = .794, AVE = .567</math>)</b>	<b>4.12 (0.69)</b>	<b>3.95 (0.65)<sup>a</sup></b>	<b>4.08 (0.72)<sup>a</sup></b>	<b>4.38 (0.59)<sup>b</sup></b>
My own actions will prevent the spread of AIS	3.89 (.87)	3.63 (0.87)	3.88 (0.83)	4.20 (0.90)
If everyone followed purchase and disposal guidelines, we could significantly lower the risk of spreading AIS	4.25 (.80)	4.21 (0.74)	4.18 (0.83)	4.42 (0.79)
Following recommended purchasing and disposal guidelines helps to prevent AIS from spreading	4.22 (.81)	4.02 (0.81)	4.18 (0.83)	4.52 (0.68)

*Fit statistics:  $\chi^2 = 57.876, df = 8, p < .001$ ; CFI = .919; TLI = .849; RMSEA = .169, SRMR = .087*

*Note.* Measured on a Likert scale where 1= “Strongly disagree” and 5= “Strongly agree”

<sup>1</sup>Like superscript indicates no significant differences at  $p < 0.05$

Finally, we measured perceived barriers, which are internal or external factors that prevent someone from taking action. We considered three types of barriers theorized in past work (Crawford & Godbey, 1987): 1) intrapersonal barriers, which are barriers based on one’s personal beliefs; 2) interpersonal barriers, which are based on social pressures, connections, or interactions; and 3) structural barriers, which are external contextual factors. The specific items representing each type of barrier were identified during informal interviews. Perceived barriers

were generally moderate (see Table 18). Structural barriers ( $M = 2.30$ ,  $SD = 0.89$ ) were lower than both intrapersonal barriers ( $M = 2.79$ ,  $SD = 0.81$ ;  $t(218) = 9.450$ ,  $p < 0.001$ ) and interpersonal barriers ( $M = 2.86$ ,  $SD = 0.91$ ;  $t(218) = 10.290$ ,  $p < 0.001$ ). Novice hobbyists exhibited the highest barriers across all three types, and were particularly susceptible to the following barriers: being unsure of the disposal guidelines ( $F(2,215) = 10.043$ ,  $p < 0.001$ ), not knowing who to ask for advice ( $F(2, 215) = 8.728$ ,  $p < 0.001$ ), and not having the necessary resources or equipment ( $F(2, 214) = 14.722$ ,  $p < 0.001$ ).

**Table 18.**

*Perceived barriers to taking action to prevent the spread of aquatic invasive species*

<b>Barriers<sup>1</sup></b>	<b>Pooled sample M (SD)</b>	<b>Novice M (SD)</b>	<b>Intermediate M (SD)</b>	<b>Expert M (SD)</b>
<b><i>Intrapersonal</i></b>	<b>2.79 (0.81)</b>	<b>3.03 (0.65)<sup>a</sup></b>	<b>2.78 (0.77)<sup>ab</sup></b>	<b>2.60 (0.99)<sup>b</sup></b>
I am unsure of the guidelines for how to dispose of my plants and animals	2.88 (1.09)	3.42 (0.96) <sup>a</sup>	2.82 (0.98) <sup>b</sup>	2.48 (1.28) <sup>b</sup>
The guidelines do not seem relevant to my own engagement with the hobby	2.70 (1.09)	2.87 (0.98) <sup>a</sup>	2.71 (1.02) <sup>a</sup>	2.52 (1.31) <sup>a</sup>
I am unwilling to euthanize the plants and animals that I need to dispose of	2.80 (1.12)	2.81 (0.98) <sup>a</sup>	2.79 (1.11) <sup>a</sup>	2.80 (1.29) <sup>a</sup>
<b><i>Interpersonal</i></b>	<b>2.86 (0.91)</b>	<b>3.21 (0.76)<sup>a</sup></b>	<b>2.83 (0.88)<sup>ab</sup></b>	<b>2.58 (1.03)<sup>b</sup></b>
I do not know who to ask for advice on recommended guidelines	2.84 (1.18)	3.38 (1.08) <sup>a</sup>	2.79 (1.08) <sup>b</sup>	2.42 (1.33) <sup>b</sup>
I cannot find anyone to accept an organism I am trying to rehome	2.58 (1.06)	2.73 (1.05) <sup>a</sup>	2.61 (0.99) <sup>a</sup>	2.34 (1.21) <sup>a</sup>
I am not connected with other hobbyists who could help	3.17 (1.26)	3.52 (1.11) <sup>a</sup>	3.10 (1.19) <sup>ab</sup>	2.98 (1.49) <sup>b</sup>
<b><i>Structural</i></b>	<b>2.30 (0.89)</b>	<b>2.64 (0.64)<sup>a</sup></b>	<b>2.30 (0.85)<sup>ab</sup></b>	<b>1.99 (1.06)<sup>b</sup></b>
I lack the necessary resources or equipment	2.72 (1.09)	3.27 (0.94) <sup>a</sup>	2.74 (1.05) <sup>b</sup>	2.14 (1.09) <sup>c</sup>
I do not have enough time to follow recommended guidelines	2.19 (1.01)	2.54 (0.87) <sup>a</sup>	2.16 (0.93) <sup>ab</sup>	1.92 (1.21) <sup>b</sup>
My health or physical abilities make following recommended guidelines difficult	2.02 (1.02)	2.10 (0.88) <sup>a</sup>	2.03 (1.04) <sup>a</sup>	1.92 (1.10) <sup>a</sup>

<sup>1</sup>Measured on a Likert scale where 1 = “Strongly Disagree” and 5 = “Strongly Agree”.

Note. Like superscript indicates no significant differences at  $p < 0.05$

## **Modeling Results**

This study identified the most important drivers of AIS-prevention behavior among Illinois aquarium and water garden hobbyists using multiple regression (see Figure 9). Several variables played a significant role in hobbyist behaviors. **As risk perceptions increased, so did respondents' intended behavior** ( $\beta = 0.268$ ). That is, the more hobbyists believed that AIS threaten the environment, their community, and their own lives, the more likely they were to follow AIS prevention guidelines.

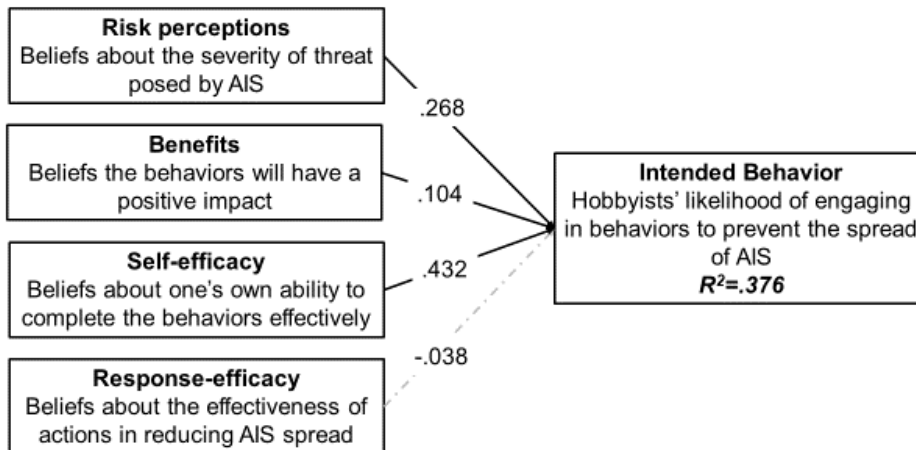
**Perceived benefits moderately predicted intended behavior** ( $\beta = 0.104$ ). Campaigns should continue to highlight the positive outcomes of invasive species prevention in order to raise perceived benefits and in turn increase behavior. Given that perceived benefits to the community were lower than perceived benefits to the self, campaigns should boost the idea of social benefits by speaking to outcomes such as a sense of community among hobbyists, teaching younger generations about the impact of our behaviors on the environment, and preserving community resources.

**Self-efficacy was the strongest predictor of intended behavior** ( $\beta = 0.432$ ), meaning that as hobbyists' confidence in their ability to take action increased, they were more likely to do so. This finding highlights the importance of providing resources to hobbyists to support their ability to take action. In particular, self-efficacy was moderately low among novice hobbyists, meaning this group is most in need of resources to support their efforts in AIS prevention. Resources such as purchasing and disposal guidelines and information about hobbyist and veterinarian networks should be disseminated via avenues novice hobbyists are most likely to access, such as pamphlets and brochures at aquatic species retailers, and advertisements disseminated via social media.

Finally, response-efficacy was not significantly related to intended behavior. Response-efficacy was high among respondents, meaning there are widespread beliefs that following purchasing and disposal guidelines will effectively reduce the spread of AIS. These findings indicate that response-efficacy does not need to be emphasized in outreach campaigns.

**Figure 9.**

*Drivers of prevention behavior of aquarium and water garden hobbyists in Illinois. Regression coefficients are placed on the paths leading from variables that were hypothesized to predict intended behavior according to the Health Belief Model. Non-significant relationships are shown in grey dotted lines*



## **Management attitudes and conservation worldviews**

Attitudes towards invasive species management were measured. The scale was developed by first identifying five key management priorities from past research (McLeod, 2015), creating one item to measure each of these priorities, and assessing item performance during pilot testing. Results from the pilot test indicated that there were two distinct dimensions: 1) management actions pertaining to laws and enforcement, and 2) management actions pertaining to outreach and education. To create the final scale, one item that did not relate to either dimension was dropped, and two new items were created, resulting in a total of three items for each dimension. The two dimensions were found to be reliable ( $\alpha = 0.828, 0.830$ ) and exhibited acceptable model fit (see Table 19). Support for AIS management was high among respondents, with a small but significant difference between the two dimensions ( $t = -3.987, p < 0.001$ ). Specifically, although there was broad support for both types of management, there was stronger support for management providing education and outreach resources ( $M = 4.35, SD = 0.64$ ) than management enacting and enforcing laws ( $M = 4.22, SD = 0.72$ ).

**Table 19.***Illinois hobbyist attitudes towards management of aquatic invasive species*

Management attitudes	Pooled sample M (SD)
<b><i>Laws &amp; Enforcement</i> (<math>\alpha = .828, \Omega=.833, AVE=.626</math>)</b>	<b>4.22 (0.72)</b>
Releasing invasive species should be illegal	4.11 (.90)
People should be fined for releasing invasive species in Illinois waterways	4.34 (.74)
Waterways should be monitored to ensure compliance with regulations	4.20 (.80)
<b><i>Outreach resources</i> (<math>\alpha = .830, \Omega=.835, AVE=.630</math>)</b>	<b>4.35 (0.64)</b>
Educational outreach materials should be developed to teach people about invasive species prevention	4.37 (.74)
Communication should be used to persuade people to take action	4.31 (.69)
Public programs should be available to raise awareness about invasive species	4.36 (.78)

*Fit statistics:  $\chi^2=25.092, df=8, p<.001; CFI=.975; TLI=.953; RMSEA=.099, SRMR=.028$*

<sup>1</sup>*Measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree)*

Conservation worldviews were measured in this study (see Table 20). Four dimensions of worldviews were conceptualized from past work (Mace, 2014; Latombe et al., 2022), including 1) *nature without people*; 2) *nature for people*; 3) *nature and people*; and 4) *compassionate conservation*. The first worldview, *nature without people* was defined as a focus on conserving biological diversity and natural habitats through human exclusion. The second worldview, *nature for people* was defined as a focus on conserving the components of nature that are beneficial to humans. Third, *nature and people* was defined as a worldview focused on the interdependence of humans and nature that lead to compromises in environmental conservation. Finally, *compassionate conservation* was defined as a worldview focused on the intrinsic value of animals and moral prescriptions to protect them. Three items were developed to measure each worldview and were evaluated through pilot testing. The scales used in the final version of the survey were reliable ( $\alpha = 0.813, 0.776, 0.642, 0.652$ ). Respondents exhibited the most agreement with the *compassionate conservation* worldview ( $M = 4.10, SD = 0.69$ ), and the least agreement with the *nature for people* worldview ( $M = 3.12, SD = 0.94$ )<sup>1</sup>. Respondents also on average agreed with the *nature without people* ( $M = 3.94, SD = .82$ ) and *nature and people* ( $M = 3.68, SD = 0.73$ ) worldviews.

<sup>1</sup> *Compassionate Conservation* was higher than *Nature and People* ( $t(218) = -6.947, p < 0.001$ ), *Nature without People* ( $t(218) = -0.2686, p = 0.008$ ), and *Nature for People* ( $t(218) = -13.014, p < 0.001$ ). *Nature for People* was also lower than *Nature without People* ( $t(218) = 9.723, p < 0.001$ ) and *Nature and People* ( $t(218) = -0.9054, p < 0.001$ ). *Nature without People* was higher than *Nature and People* ( $t(218) = 3.688, p < 0.001$ ).

**Table 20.***Conservation worldviews among aquarium and water garden hobbyists*

Conservation worldviews	Pooled sample M (SD)
<b><i>Nature without people</i> (<math>\alpha = .813, \Omega = .813, AVE = .593</math>)</b>	<b>3.94 (0.82)</b>
We should set aside protected areas (parks, preserves, wilderness) to be kept safe from people	4.05 (0.96)
Plants and animals in nature should be protected by limiting human use	4.01 (0.91)
Protected areas should exclude people to preserve their stability	3.76 (1.02)
<b><i>Nature for people</i> (<math>\alpha = .776, \Omega = .779, AVE = .540</math>)</b>	<b>3.12 (0.94)</b>
The aspects of nature that are most important are the ones that can be utilized by people	3.28 (1.11)
The primary goal of conservation should be to ensure that people have access to food and raw materials	3.29 (1.08)
All protected areas should be accessible to people for recreational activities (fishing, hiking, hunting)	2.80 (1.20)
<b><i>Nature and people</i> (<math>\alpha = .642, \Omega = .646, AVE = .379</math>)</b>	<b>3.68 (0.73)</b>
Within protected areas, human communities can co-exist with nature	3.60 (0.96)
The needs of humans and the environment should be equally weighed	3.62 (0.99)
The primary goal of conservation should be to seek compromises that balance the well-being of human and non-human species	3.82 (0.92)
<b><i>Compassionate conservation</i> (<math>\alpha = .652, \Omega = .661, AVE = .404</math>)</b>	<b>4.10 (0.69)</b>
It is wrong to harm animals even to achieve conservation goals	3.76 (1.04)
The life of every living animal, including human and non-human species, has value	4.26 (0.83)
Humans should minimize the suffering of animals whether they are wild or domesticated, invasive or native, or endangered or common	4.28 (0.82)

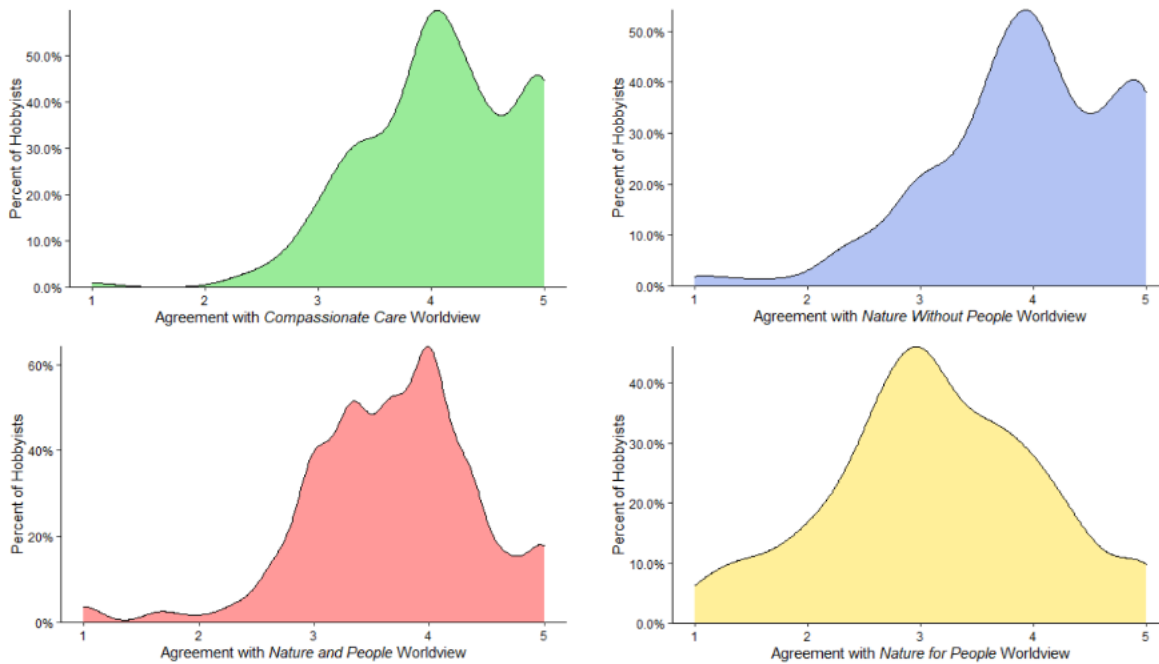
*Fit statistics:  $\chi^2=132.680, df=48, p<001; CFI=.890.; TLI=.849; RMSEA=.090, SRMR=.068$*

<sup>1</sup>*Measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree)*



**Figure 10.**

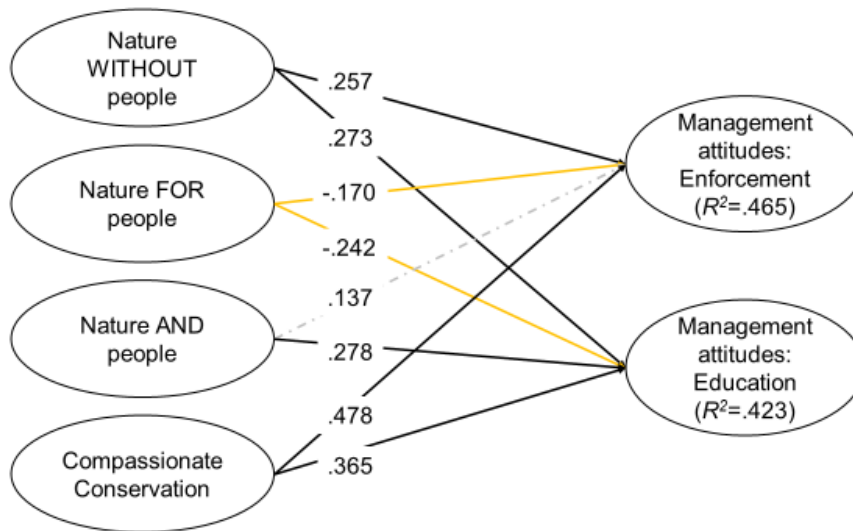
*Distribution of responses to the four conservation worldviews. In each graph, responses range from 1 = strong disagreement to 5 = strong agreement.*



We examined relationships among attitudes towards AIS management and conservation worldviews with structural equation modeling (see Figure 10). All four worldviews significantly predicted management attitudes. Stronger agreement with the *nature without people* worldview was associated with higher support for both enforcement ( $\beta = 0.257$ ) and outreach ( $\beta = 0.273$ ) management activities. Stronger agreement with the *nature for people* worldview was associated with lower support for both enforcement ( $\beta = -0.170$ ) and outreach ( $\beta = -0.242$ ) management activities. Agreement with the *nature and people* worldview positively predicted support for outreach ( $\beta = 0.278$ ) but not enforcement activities. Finally, agreement with *compassionate conservation* strongly predicted support for both enforcement ( $\beta = 0.478$ ) and outreach ( $\beta = 0.365$ ) activities. These results highlight the relevance of worldviews in shaping preferences for AIS management and the potential for conflict when diverse worldviews are present but not acknowledged.

**Figure 11.**

*Relationships among management attitudes and conservation worldviews of aquarium and water garden hobbyists in Illinois (N=507). Regression coefficients are placed on the paths. Non-significant relationships are shown as grey dotted lines; negative relationships are indicated in yellow. Model fit was acceptable ( $\chi^2 = 230.394$ ,  $df = 120$ ,  $p < .001$ ;  $CFI = .929$ ;  $TLI = .909$ ;  $RMSEA = .065$ ;  $SRMR = .058$ ).*



**Open-ended comments on survey**

Respondents had the opportunity to provide additional thoughts at the end of the questionnaire. Out of 219 survey participants, 40 chose to leave a comment. Common trends, as well as a selection of representative comments, are presented below.

Ten respondents shared suggestions or preferences for invasive species management.

- “I give animals and environment priority over human population and greed. Humans act pretty stupid in nation parks. They should be more heavily fibed or jailed for pollution or animal harassment.”
- “I think more should have been.said about species keeping other species alive. If they die off more than just they will die. Also doing.stuff like releasing invasive species into our waterways is why we can't have nice things.”
- “I know red ear sliders are commonly released I have one that someone got rid of making people aware of the commitment they are getting themselves into”
- “More public education needed”
- “should reach out to people more”
- “The internet is currently the best place to get the public involved and talking, and it gets the message across fast.”

Six respondents commented that the survey was educational, including mentioning that they were inspired to continue learning about invasive species.

- “This study has encouraged me to study and become more knowledgeable on invasive species and things I can do to prevent contributing in any way to the spread of invasive species”
- “This survey gave me a lot to think about pertaining to our environment (plants and animals)and wanting to do more.”
- “this survey was very informative and peaks my interest to learn more”

Twelve respondents offered positive feedback on the survey or commented that they enjoyed participating in the survey.

- “Good straightforward survey”
- “This was a great survey and I’m glad that I completed it”

Two respondents offered critical feedback on the contents of the survey.

- “There were a few typos, and I think it would also be wise to not assume people are already familiar with this organization.”
- “Too technical”

There were 179 respondents who chose not to leave a comment, and an additional 10 respondents who added brief general comments (e.g. “thank you” or “have a great day”).

## LITERATURE CITED

- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological review*, 84(2), 191.
- Berinsky, A. J., Margolis, M. F., & Sances, M. W. (2014). Separating the shirkers from the workers? Making sure respondents pay attention on self-administered surveys. *American journal of Political Science*, 58(3), 739-753.
- Blankenberg, A. K., & Alhusen, H. (2019). On the determinants of pro-environmental behavior: A literature review and guide for the empirical economist. cege Discussion Papers, No. 350, University of Göttingen, Center for European, Governance and Economic Development Research (cege), Göttingen.
- Carpenter, C. J. (2010). A meta-analysis of the effectiveness of health belief model variables in predicting behavior. *Health communication*, 25(8), 661-669.
- Crawford, D. W., & Godbey, G. (1987). Reconceptualizing barriers to family leisure. *Leisure Sciences*, 9, 119–127.
- Fitzgerald, T., Blanke, C., Donnelly, K. (2021). Pond and aquarium hobbyists survey summary report. *Minnesota Department of Natural Resources Aquatic Invasive Species Community-Based Social Marketing Project*.  
[https://files.dnr.state.mn.us/natural\\_resources/invasives/prevention/ais-community-based-social-marketing-report.pdf](https://files.dnr.state.mn.us/natural_resources/invasives/prevention/ais-community-based-social-marketing-report.pdf)
- Golebie, E. J., van Riper, C. J., Hitzroth, G., Huegelmann, A., & Joffe-Nelson, N. (2023). Barriers to participation in aquatic invasive species prevention among Illinois, USA recreational water users. *Biological Invasions*, 1-17.
- Golebie, E., Joffe-Nelson, N., Siever, A., Hitzroth, G., Huegelmann, A., & C.J. van Riper. (2021). *Addressing barriers to aquatic invasive species prevention behaviors among Illinois recreational water users*. Report prepared for the Illinois Department of Natural Resources.
- Landon, A. C., Kyle, G. T., van Riper, C. J., Schuett, M. A., & Park, J. (2018). Exploring the psychological dimensions of stewardship in recreational fisheries. *North American Journal of Fisheries Management*, 38(3), 579-591.
- Lynn, P., & Longhi, S. (2011). Environmental attitudes and behaviour: who cares about climate change. In McFall, S. L. & Garrington, C. (Eds.). *Early findings from the first wave of the UK's household longitudinal study* (pp. 109-116). Colchester: Institute for Social and Economic Research, University of Essex.
- Mayer, J., Seekamp, E., Casper, J., & Blank, G. (2015). An examination of behavior change theories to predict behavioral intentions of organisms-in-trade hobbyists. *Human ecology review*, 21(2), 65-92.
- McLeod, L. J., Hine, D. W., Please, P. M., & Driver, A. B. (2015). Applying behavioral theories to invasive animal management: towards an integrated framework. *Journal of Environmental Management*, 161, 63-71.
- Rosenstock, I. M. (1974). Historical origins of the Health Belief Model. *Health Education & Behavior*, 2(4), 328–335.
- Seekamp, E., Mayer, J. E., Charlebois, P., & Hitzroth, G. (2016). Effects of outreach on the prevention of aquatic invasive species spread among organism-in-trade hobbyists. *Environmental Management*, 58, 797-809.

van Riper, C.J., E.J. Golebie, S. Shin, M. Eriksson, A. Smith, C. Suski, & R. Stedman. (2020). *A study of angler behavior and the spread of aquatic invasive species in the Great Lakes region*. Series 20-7 Dept. of Nat. Resources., Coll. Agric. and Life Sci., Cornell Univ., Ithaca, NY. 94 pp.

# APPENDIX A: INTERVIEW AGENDA



## Interview Agenda

The purpose of this meeting is to discuss how Illinois aquarists and water gardeners characterize aquatic invasive species and identify the benefits and barriers to taking precautions during purchasing and disposal. We are interested in your own perspectives, as well as your insights on how hobbyists across the state may feel about these topics. Insights gained from this interview will be used to inform a survey that will be disseminated to a larger group of hobbyists in the state of Illinois.

### Introductions: 5 minutes

- *Project Introduction:* A research project examining hobbyists' perspectives of aquatic invasive species with a focus on understanding benefits and barriers to preventative behaviors
- *Overview of agenda:* Review the scope of the conversation
- *Participant Introductions:*
  - Could you tell me a little about your position and organization?
  - Describe your experience with aquariums and/or water gardens

### Risks of aquatic invasive species and opportunities for mitigating risks: 15 minutes

- *Risks:* What are some of the most concerning ways that invasive species may impact the environment? The community? Your own life and daily experiences?
  - Which species pose the greatest threats to freshwater environments?
  - How have AIS risks changed over time?
- *Behaviors:* What steps can aquarium and water garden hobbyists take to stop the spread of invasive species? Do you have anything to add to the list below?
  - How effective are those steps at reducing environmental impacts?
  - Which steps are most essential?

#### Recommendations for purchasing

- Buy aquatic species from...
  - a licensed, local dealer
  - a reputable, local dealer
  - a licensed, online dealer
  - a reputable, online dealer
- Accept aquatic species from another hobbyist

#### Recommendations for disposal

- Contact another hobbyist to give or trade
- Donate aquatic species to a school or business
- Contact a retailer for possible returns
- Contact a retailer or vet for advice on humane disposals



### Positive and negative consequences of taking action: 20 minutes

- **Barriers:** There are many reasons people are unable to make purchasing and disposal decisions that prioritize AIS mitigation. For these questions, we are interested both in your own experiences and what you have observed or heard about from others.
  - What are the key reasons people are unable to take these steps?
  - Which of these are most difficult?
  - How might the most challenging barriers be overcome?
- **Benefits:** There are many positive outcomes associated with taking precautions during purchasing and disposal of species. For these questions, we are interested both in your own experiences and what you have observed or heard about from others.
  - In addition to mitigating the spread of AIS, what benefits might you experience?
  - Which benefits are the most important?

### Closing: 5 minutes

- Researchers provide a summary of what has been covered during the conversation
- Participants have the opportunity to share closing remarks or other final points that they would like to discuss.
- Could you recommend another person for us to contact? Particularly someone who works with invasive species issues that has a different perspective than you?
- Would you like to receive a copy of the interview transcript and/or a copy of the survey results (in early 2023)?

**Thank you for your time.**

## APPENDIX B: RESEARCH RESULTS FROM ON-SITE SURVEY

This section presents information about Illinois aquarium and water garden hobbyists who were engaged in a survey at the Aquashella Aquarium Festival in Schaumburg, Illinois on October 8<sup>th</sup> and 9<sup>th</sup>, 2022. A full description of methods is available at the beginning of this document (page 2). To summarize, a total of 43 hobbyists participated in the on-site survey (response rate = 66%). This sample size is typical for an on-site survey conducted over a few days; for comparison, see Mayer et al. (2015) who collected an average of 41 responses per event across a total of 16 events attended by organism-in-trade hobbyists in the Great Lakes region. Although this sample size is typical, and non-response bias was not detected on the basis of group size ( $t = -0.241, p = 0.810$ ) or assumed gender ( $\chi^2 = 1.4452, p = 0.229$ ), it is still important to be aware of this sample size when interpreting results.

We reiterate that this phase of research was used to pilot the survey, and to provide information on the relatively homogenous group of avid aquarists who attended Aquashella. These results do not necessarily reflect the diverse experiences, beliefs, and behaviors of all organism-in-trade hobbyists across the state of Illinois; rather, that information is provided in the main section of this report based on data drawn from a larger online survey.

In this appendix, we share results from the on-site survey using tables and figures, particularly frequency distributions for each variable included in the questionnaire. Data presented are typically valid percentages in each response category (i.e., percentages excluding missing values). Descriptive statistics, such as mean values and standard deviations are also included for appropriate variables. Per disciplinary standards within the environmental social sciences, Likert scale questions with five points or greater were treated as interval-level measures.

### **Descriptive information about organism-in-trade hobbyists**

#### **History of hobby participation**

Respondents were asked to provide information on the type of hobby they engaged in (see Table 21). **A majority of respondents (86.0%) reported owning a large freshwater aquarium of 5 gallons or more, with smaller proportions saltwater aquariums (30.2%) and indoor aquatic pets (30.2%).**



**Table 21.***Reported ownership of aquatic species by organism-in-trade hobbyists*

Recreation type	State-wide survey	On-site survey
	N (%)	N (%)
Fish bowl or small freshwater aquarium of 5 gallons or less	91 (41.6)	10 (23.3)
Large freshwater aquarium of 5 gallons or more	125 (57.1)	37 (86.0)
Saltwater aquarium	18 (8.2)	13 (30.2)
Koi pond or water garden	26 (11.9)	3 (7.0)
Indoor aquatic pets (turtles, frogs, etc.)	59 (26.9)	13 (30.2)

*Note.* Respondents could check all that applied so column totals may not equal 100%.

Respondents were also asked what type of hobbyist they best identify as (see Table 22). A majority of respondents identified as an aquarium hobbyist (83.3%). A smaller proportion of respondents identified as both aquarium hobbyists and outdoor pond or water gardeners (14.3%).

**Table 22.***Self-identified hobby type by organism-in-trade hobbyists*

Hobby type	State-wide survey	On-site survey
	N (%)	N (%)
Aquarium hobbyist	162 (74.3)	35 (83.3)
Outdoor pond hobbyist	11 (5.0)	0 (0.0)
Water gardener	9 (4.1)	1 (2.4)
Both aquarium hobbyist and outdoor pond or water gardener	36 (16.5)	6 (14.3)

Hobbyists reported an average of 7.62 years of experience with their activity (see Table 23; Figure 11). The average number of tanks each hobbyist owned was 6.86 ( $SD = 9.33$ ), and the majority of respondents (61.9%) owned more than three tanks. Both years of experience and number of tanks owned were right skewed ( $skewness = 1.323, 3.140$ ).

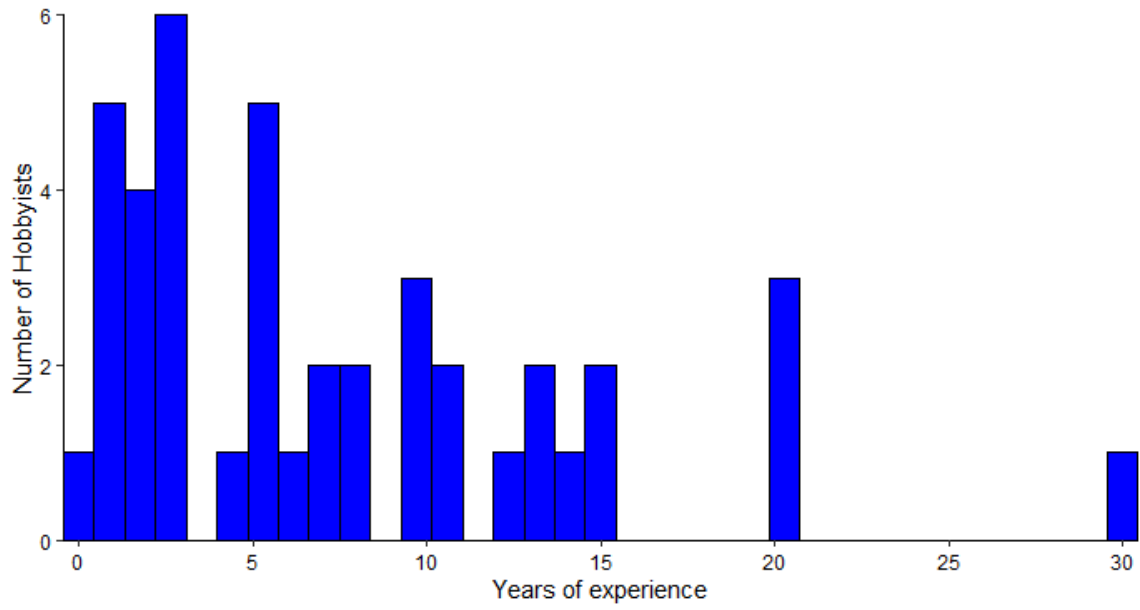
**Table 23.***Previous experiences and self-reported skill levels among organism-in-trade hobbyists*

Previous experience	State-wide survey	On-site survey
	N (%)	N (%)
Total number of years having maintained an aquarium or water garden	8.14 (8.67)	7.62 (6.64)
Number of aquarium tanks maintained	2.86 (16.93)	6.86 (9.33)
0 tanks	4 (1.8%)	1 (2.4%)
1 tank	123 (56.7%)	5 (11.9%)
2 tanks	59 (27.2%)	4 (9.5%)
3 tanks	18 (8.3%)	6 (14.3%)
More than 3 tanks	13 (6.0%)	26 (61.9%)

<sup>1</sup>Estimate included hobby activities in 2022

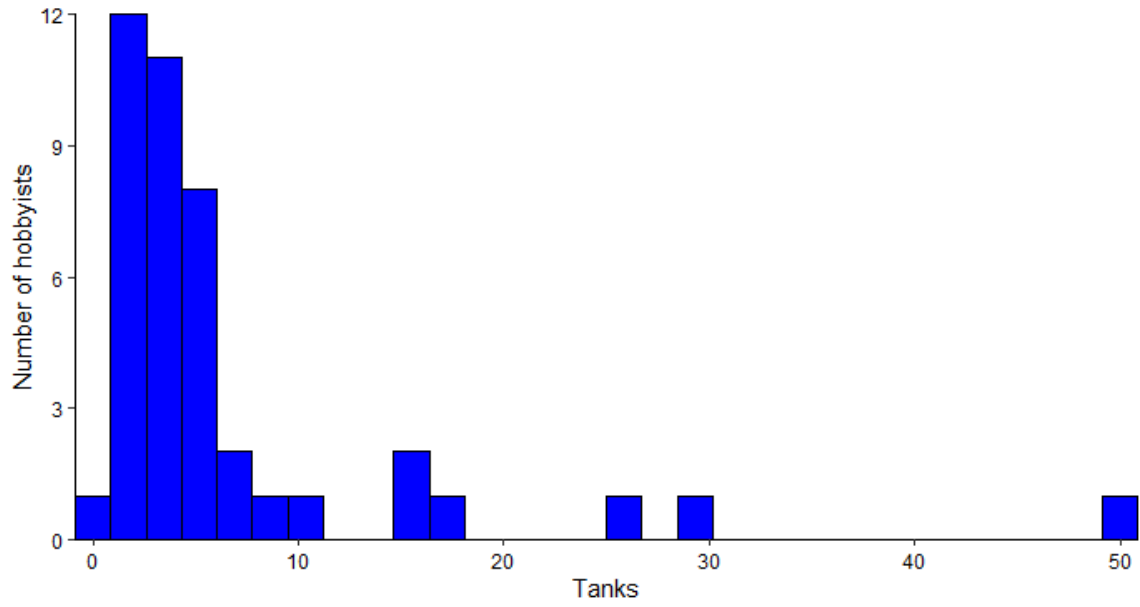
**Figure 12.**

*Total years of experience including 2022 for organism-in-trade hobbyists attending Aquashella*



**Figure 13.**

*Number of tanks owned by organism-in-trade hobbyists attending Aquashella*



Respondents were asked to report their perceived level of expertise compared to other hobbyists (see Table 24). Reported skill was more normally distributed (*skewness* = 0.209) and **respondents reported their skills were “average” to “higher than average”** ( $M = 3.55$ ,  $SD = 0.74$ ).

**Table 24.**

*Self-reported expertise by organism-in-trade hobbyists attending Aquashella*

Recreation type	State-wide survey	On-site survey
	N (%)	N (%)
Level of expertise compared to other hobbyists <sup>1</sup> (M, SD)	2.98 (0.88)	3.55 (0.74)
Much lower than average	15 (16.9)	0 (0.0)
Lower than average	33 (15.1)	2 (4.7)
Average	120 (55.0)	19 (44.2)
Higher than average	42 (19.3)	17 (39.5)
Much higher than average	8 (3.7)	4 (9.3)

<sup>1</sup>Measured on a Likert scale ranging from 1 (Much lower than average) to 5 (Much higher than average)

Several questions were asked to determine the source of the aquatic species owned by respondents (see Table 25). **Purchasing species from a local fish store ( $M = 3.44$ ,  $SD = 1.03$ ) and from a reputable breeder ( $M = 2.40$ ,  $SD = 1.34$ ) were the most frequent methods of obtaining new species among respondents.**

**Table 25.**

*Source of aquatic species owned by organism-in-trade hobbyists attending Aquashella*

Source of species <sup>1</sup>	State-wide survey	On-site survey
	M (SD)	M (SD)
Buy aquatic species over the internet	1.49 (0.84)	2.20 (1.01)
Buy aquatic species from a chain store (PetCo, PetSmart, etc.)	3.02 (1.30)	2.03 (0.97)
Buy aquatic species from a local fish store	2.59 (1.22)	3.44 (1.03)
Buy aquatic species through fish club events or meetings	1.38 (0.82)	1.93 (1.05)
Accept aquatic species from another hobbyist	1.65 (0.94)	2.23 (1.10)
Find fish species through a local classified system	1.41 (0.81)	1.46 (0.95)
Buy aquatic species from a reputable breeder	1.59 (0.97)	2.40 (1.34)
Personally collect species that I find in aquatic environments	1.51 (0.98)	1.49 (0.95)

<sup>1</sup>Measured on a 5-point Likert scale from 1 (never) to 5 (every time)

## **Awareness and familiarity with aquatic invasive species**

In direct alignment with past work (Seekamp et al., 2016), respondents were presented with the following definition of AIS and asked to report their awareness:

*Aquatic invasive species (AIS), also known as aquatic nuisance species, are aquatic plants or animals that are introduced to an area where they are not native, outcompete native species and establish abundant populations in the wild, and are difficult to control or eradicate.*

*Based on the given definition, to what extent are you aware of AIS (aquatic invasive species)?*

Responses indicated that awareness was moderately high ( $M = 3.74$  on a 5-point scale;  $SD = 1.15$ ). Respondents were also asked to report their level of familiarity with ecological and social aspects of AIS (see Table 26). On average, **respondents were moderately familiar** with ecological ( $M = 3.48$ ,  $SD = 0.93$ ) and social ( $M = 3.60$ ,  $SD = 1.01$ ) facets of AIS.

**Table 26.**

*Familiarity with topics related to aquatic invasive species*

<b>Familiarity<sup>1</sup></b>	<b>State-wide survey M (SD)</b>	<b>On-site survey M (SD)</b>
<b><i>Ecological (<math>\alpha = .855</math>, <math>\Omega = .858</math>, <math>AVE = .671</math>)</i></b>	<b><i>2.54 (0.99)</i></b>	<b><i>3.48 (0.93)</i></b>
The biological characteristics that make a species “invasive”	2.61 (1.14)	3.57 (1.17)
Names of species that are considered invasive	2.20 (1.03)	2.98 (1.12)
Ways that invasive species affect the environment	2.81 (1.20)	3.88 (0.92)
<b><i>Social (<math>\alpha = .925</math>, <math>\Omega = .927</math>, <math>AVE = .810</math>)</i></b>	<b><i>2.58 (1.17)</i></b>	<b><i>3.60 (1.01)</i></b>
How aquarium and garden hobbyists can spread invasive species	2.72 (1.31)	3.98 (1.07)
Types of actions you can take to prevent invasive species from spreading	2.57 (1.24)	3.52 (1.09)
How to complete recommended preventative actions	2.42 (1.24)	3.29 (1.18)

*Fit statistics:  $\chi^2 = 29.573$ ,  $df = 8$ ,  $p < .001$ ;  $CFI = .980$ ;  $TLI = .963$ ;  $RMSEA = .111$ ,  $SRMR = .020$*

<sup>1</sup>Measured on a 5-point Likert scale ranging from 1 (Not at all familiar) to 5 (Extremely familiar)

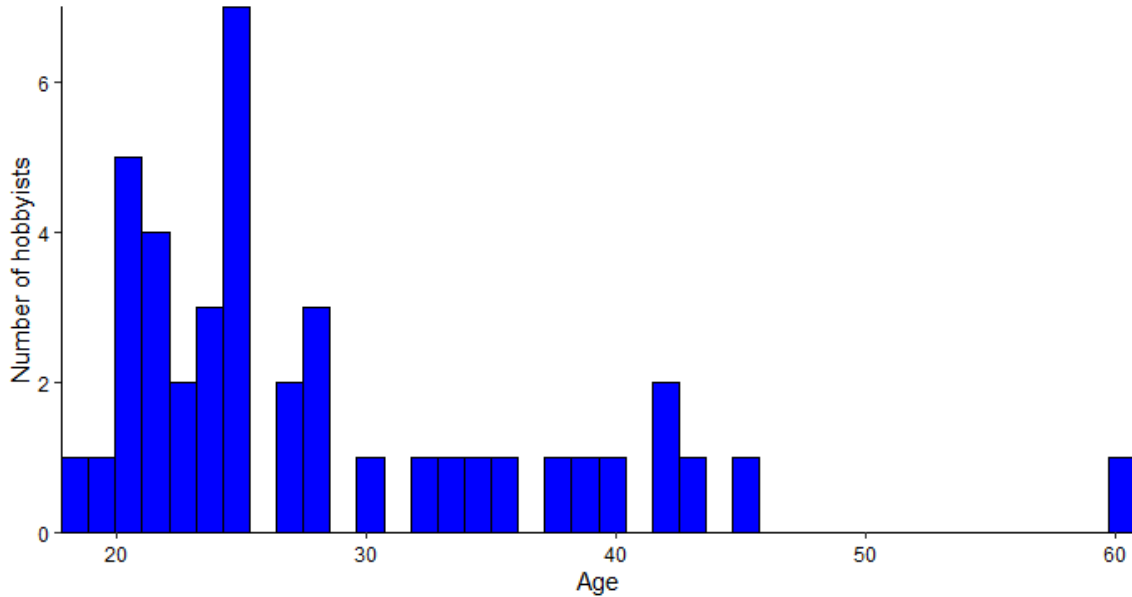
## **Socio-demographic characteristics**

Survey respondents were predominantly White (62.8%) and Latino (20.9), with an average age of 28.61 ( $SD = 8.97$ ) (see Table 27, Figure 13). Genders included male (59.5%), female (35.7%), and other (4.8%). Educational experiences varied; 31.6% earned a high school diploma, another

34.2% held a bachelor’s degree, and an additional 21.2% earned a graduate degree. A majority of respondents (63.2%) reported an annual household income less than \$75,000 before taxes.

**Figure 14.**

*Age of survey respondents included in this research*



**Table 27.**

*Socio-demographic profile of organism-in-trade hobbyists included in this research*

Variables	State-wide survey N (%)	On-site survey N (%)
Age [M, SD]	[38.19, 15.60]	[28.61, 8.97]
<i>Gender</i>		
Male	53 (24.2)	25 (59.5)
Female	164 (74.9)	15 (35.7)
Other	2 (0.9)	2 (4.8)
<i>Education</i>		
Some high school	8 (3.7)	0 (0.0)
High school graduate or GED	95 (43.4)	12 (31.6)
Associate’s degree	44 (20.1)	5 (13.2)
Bachelor’s degree	56 (25.6)	13 (34.2)
Graduate degree (MA, MS, PhD, JD, MD, etc.)	16 (7.3)	8 (21.2)

Variables	State-wide survey	On-site survey
	N (%)	N (%)
<i>Income</i>		
Less than \$24,999	32 (14.6)	5 (13.2)
\$25,000 to \$49,999	55 (25.1)	13 (34.2)
\$50,000 to \$74,999	59 (26.9)	6 (15.8)
\$75,000 to \$99,999	26 (11.9)	3 (7.9)
\$100,000 to \$149,999	21 (9.6)	8 (21.1)
\$150,000 and over	13 (6.0)	1 (2.6)
Prefer not to answer	13 (5.9)	2 (5.3)
<i>Race &amp; Ethnicity<sup>1</sup></i>		
American Indian	14 (6.4)	0 (0.0)
Asian	9 (4.1)	3 (7.0)
Black or African American	21 (9.6)	1 (2.3)
Hispanic or Latino	22 (10.0)	9 (2.09)
Native Hawaiian or other Pacific Islander	1 (0.5)	0 (0.0)
White	171 (78.1)	27 (62.8)
Other	5	0 (0.0)

<sup>1</sup>Respondents could check all that applied so column totals may not equal 100%.

## Evaluation of outreach campaigns

### Use of campaign resources

Respondents were asked to provide general feedback on four campaigns that were in use by Illinois-Indiana Sea Grant as of 2022. We asked respondents how often they had used a selection of resources that these campaigns offer (see Table 28). On average, respondents indicated having used each resource ‘at least once.’

**Table 28.**

*Use of campaign resources by organism-in-trade hobbyists attending Aquashella*

Use of campaign resources	State-wide survey	On-site survey
	M (SD)	M (SD)
Pet re-homing network	1.63 (1.03)	1.56 (0.90)
Exotic pet veterinarian network	1.58 (1.06)	1.47 (0.96)
Disposal guidelines	2.11 (1.29)	2.35 (1.35)
Campaign websites (ReleaseZero.org, TakeAIM.org, etc.)	1.71 (1.17)	1.68 (1.07)
Regulations database	1.83 (1.18)	1.82 (1.04)
Lists of expert contacts	1.78 (1.24)	1.73 (1.20)
Lists of invasive and non-invasive species	2.28 (1.40)	2.60 (1.48)

<sup>1</sup>Measured on a 5-pt scale from 1 (never) to 5 (very often)

### **Open-ended responses to outreach messages**

Respondents were asked to provide open-ended feedback on outreach campaigns, in response to the following prompt: *The organizations developing these informational campaigns (Be a Hero, Transport Zero, Take AIM, What's in your water garden, What's in your aquarium) would value your feedback. What, if any, changes would you recommend?*

A total of eight suggestions were provided. Three respondents commented on the need for increased exposure (e.g., “more public facing info, maybe advertisements”), and an additional three respondents provided specific suggestions for disseminating information, including:

- Create more social media content. Collab with other businesses.
- Maybe at each town/city visitor center there can be invasive species pamphlets that show what people can do to help stop / reverse the spread
- To put pamphlets or posters in pet stores

One respondent commented on the need for more involvement in middle and high school, and one respondent commented that hobbyists needed guidance on how to seek out available resources.

### **Primary information sources**

Respondents reported learning about AIS through a variety of sources (see Table 29). The most common sources were online water hobbyist forums (55.8%), school (44.2%), and tradeshow (32.6%). Three categories of information sources were identified via a principal components analysis: traditional sources, online sources, and live events. Over one third of respondents (39.5%) used at least one traditional source, including magazines, television, and newspapers. A majority of respondents (60.5%) used at least one online source, which included online hobbyist forums, online ads, and social media. Finally, 62.8% of respondents had learned about AIS through a live event: school, presentations, and/or tradeshow.

**Table 29.***Information channels through which Illinois hobbyists have learned about AIS*

<b>AIS learning mode (select all that apply)</b>	<b>State-wide survey</b>	<b>On-site survey</b>
	N (%)	N (%)
<b><i>Traditional sources</i></b>	<b>80 (36.7)</b>	<b>17 (39.5)</b>
Read about AIS in magazines	47 (21.5)	10 (23.3)
Learned about AIS through a television program	45 (20.5)	10 (23.3)
Read about AIS in the newspaper	22 (10.0)	10 (23.3)
<b><i>Online sources</i></b>	<b>109 (50.0)</b>	<b>26 (60.5)</b>
Read about AIS in online water hobbyist forums	49 (22.4)	24 (55.8)
Saw information about AIS in an online ad	46 (21.0)	4 (9.3)
Learned about AIS through social media posts or videos	63 (28.8)	11 (25.6)
<b><i>Live events</i></b>	<b>71 (32.6)</b>	<b>27 (62.8)</b>
Learned about AIS in school	59 (26.9)	19 (44.2)
Attended presentations about AIS	13 (5.9)	5 (11.6)
Learned about AIS in tradeshow	13 (5.9)	14 (32.6)
<b><i>Miscellaneous</i></b>		
Read about AIS in brochures	51 (23.3)	12 (27.9)
Information about AIS came with the purchase of my aquatic plant or animal	41 (18.7)	6 (14.0)
Saw information about AIS on posters	33 (15.1)	10 (23.3)
Received giveaways from an AIS organization (pencils, garden kneelers, screen wipes, stick-on thermometers, fish bags, magnets, etc.)	10 (4.6)	1 (2.3)
Saw AIS wrapped vehicles (cars or trucks displaying logos or information about AIS)	4 (1.8)	1 (2.3)
Other <sup>1</sup>	37 (16.9)	6 (14.0)

<sup>1</sup>Responses included work (n=2), google (n=1), books (n=1), and not having heard of AIS previously (n=2).

*Note:* A majority of respondents (n=32; 80%) reported being confident in their responses to this question. A proportion of respondents (n=7, 17.5%) reported being somewhat confident, whereas only 2.5% (n=1) reported being not at all confident.

Aquarium and water garden hobbyists reported sever users reported **several frequently consulted sources for advice about their hobby** (see Table 30). Other hobbyists were the most frequently consulted source ( $M = 4.08$ ,  $SD = 0.80$ ).



**Table 30.**

*Sources that Illinois aquarium and water garden hobbyists frequently consult for advice about their hobby*

Frequently consulted sources <sup>1</sup>	State-wide survey	On-site survey
	M (SD)	M (SD)
Family members, friends, or neighbors	2.90 (1.07)	2.79 (1.26)
Other hobbyists	2.74 (1.26)	4.08 (0.80)
Retailers	2.99 (1.10)	3.08 (1.01)
Breeders	2.26 (1.27)	3.23 (1.27)
Veterinarians	2.88 (1.42)	2.45 (1.41)

<sup>1</sup>Measured on a 5-pt scale from 1 (never) to 5 (very often).

### Factors contributing to AIS-prevention behaviors

The outreach programs developed by Illinois-Indiana Sea Grant encourage aquarium and water garden hobbyists to prevent the spread of AIS by purchasing non-invasive species, quarantining species before introducing to pond or aquarium, and sterilizing water prior to disposal to avoid accidentally spreading small organisms. We asked survey respondents how likely they were to engage in these behaviors over the next 12 months (see Table 31). The questions were based on Seekamp et al. (2016) but modified to match the current aims of Illinois-Indiana Sea Grant's campaigns, and to present a simplified list to respondents. Likelihood of engaging in preventative behaviors was moderate ( $M = 3.64$ ,  $SD = 0.93$ ).

**Table 31.**

*Behaviors that organism-in-trade hobbyists intend to perform in the next 12 months*

Intended Behavior	State-wide survey	On-site survey
	M (SD)	M (SD)
<b><i>Intended behavior</i></b> ( $\alpha = .740$ , $\Omega = .745$ , $AVE = .424$ )	<b>3.16 (1.00)</b>	<b>3.64 (0.93)</b>
Purchase species based on scientific names	2.57 (1.34)	3.58 (1.28)
Purchase only native or non-invasive species	3.45 (1.26)	3.49 (1.28)
Quarantine species before introducing to pond or aquarium	3.60 (1.28)	4.12 (1.14)
Sterilize water used in an aquarium or water garden prior to disposal	3.01 (1.43)	3.37 (1.46)

<sup>1</sup>Measured on a 5-pt scale from 1 (not at all likely) to 5 (extremely likely)

Releasing unwanted species into local waterways is one pathway for species invasions. Sea Grant's campaigns encourage hobbyists to use alternative methods of disposing of or rehoming unwanted species. We asked respondents to report which disposal methods they have used in the

past 12 months (see Table 32). Giving, trading, or selling to another hobbyist was the most common disposal method for both plant (51.2%) and animal (58.1%) species.

**Table 32.**

*Methods that hobbyists have used to dispose of organisms in the past 12 months*

Disposal methods (select all that apply)	State-wide survey N (%)	On-site survey N (%)
<i>Plants</i>		
Give, trade, or sell plants to another hobbyist	55 (25.1)	22 (51.2)
Donate plants to a school, business, zoo, or other organization	43 (19.6)	6 (14.0)
Bag plants and place them in the trash	92 (42.0)	20 (46.5)
<i>Animals</i>		
Give, trade, or sell animals to another hobbyist <sup>1</sup>	56 (25.6)	25 (58.1)
Donate animals to a school, business, zoo, or other organization	52 (23.7)	7 (16.3)
Rehome animals with a sanctuary or rescue group <sup>2</sup>	82 (37.4)	10 (23.3)
Euthanize animal species	30 (13.7)	12 (27.9)
<i>Other</i> <sup>1</sup>	27 (12.3)	5 (11.6)

<sup>1</sup>The respondents who selected 'other' reported the following disposal methods: burning plants (n=1), putting in the river (n=1), putting outside in the garden (n=1), burying deceased animals (n=1), and 'none' (n=1).

### **Drivers of behavior**

Psychological models such as the Health Belief Model (Rosenstock, 1974) can be used to understand why hobbyists take action to help prevent the spread of AIS. The Health Belief Model considers the role of benefits, barriers, risk perceptions, and efficacy in predicting desirable behaviors (see Figure 7). Therefore, this study sought to understand each of these variables among Illinois hobbyists and understand their relevance in predicting AIS-prevention behaviors.

The first key concept from the Health Belief Model included in this study was perception of the risks posed by AIS. Three types of risk perceptions were examined, including environmental (i.e., the level of threat posed to the environment); personal (i.e., the level of threat posed to individuals); and social (i.e., the level of threat posed to communities). **Respondents reported moderately high risk perceptions, and were particularly concerned with environmental risks** (see Table 33). Specifically, environmental risk perceptions ( $M = 4.05$ ,  $SD = 0.70$ ) were higher than both social ( $M = 3.71$ ,  $SD = 0.90$ ;  $t(41) = 2.964$ ,  $p = .005$ ), and personal ( $M = 3.65$ ,  $SD = 0.96$ ;  $t(41) = 3.598$ ,  $p < .001$ ).

**Table 33.***Risk perceptions of organism-in-trade hobbyists*

Risk perceptions <sup>1</sup>	State-wide survey	On-site survey
	M (SD)	M (SD)
<b>Environmental (<math>\alpha = .832, \Omega=.832, AVE=.623</math>)</b>	<b>3.43 (0.82)</b>	<b>4.05 (0.70)</b>
Quality of habitat and natural environments	3.45 (.93)	4.12 (0.77)
Environmental processes (e.g., water cycle)	3.26 (.93)	3.76 (0.96)
Survival of plants and animals	3.57 (.98)	4.29 (0.81)
<b>Personal (<math>\alpha = .846, \Omega=.853, AVE=.660</math>)</b>	<b>3.01 (1.03)</b>	<b>3.65 (0.96)</b>
Your appreciation of the beauty of the landscape	3.12 (1.12)	3.95 (0.99)
Your own enjoyment of recreational activities	3.98 (1.18)	3.76 (1.10)
Your own access to waterbodies	2.94 (1.20)	3.24 (1.25)
<b>Social (<math>\alpha =.883, \Omega=.883, AVE=.715</math>)</b>	<b>3.16 (1.04)</b>	<b>3.71 (0.90)</b>
The local economy	3.04 (1.17)	3.43 (1.11)
The community in the region	3.06 (1.15)	3.57 (1.13)
Recreational opportunities for future generations	3.39 (1.16)	4.14 (0.95)

Fit statistics:  $\chi^2=74.866, df=24, p<.001$ ; CFI=.958.; TLI=.937; RMSEA=.098, SRMR=.042

<sup>1</sup>Measured on a 5-pt scale from 1 (no impacts) to 5 (very severe impacts)

The second key concept from the Health Belief Model that was tested in this study pertained to benefits, defined as beliefs that following purchasing and disposal guidelines will have positive outcomes. Respondents exhibited agreement that AIS prevention has both personal ( $M = 4.20, SD = 0.63$ ) and social ( $M = 3.97, SD = 0.75$ ) benefits (see Table 34).

**Table 34.***Perceived benefits of taking action to prevent the spread of aquatic invasive species*

Benefits	State-wide survey	On-site survey
	M (SD)	M (SD)
<b>Benefits to the self (<math>\alpha =.844, \Omega=.850, AVE=.655</math>)</b>	<b>4.27 (0.62)</b>	<b>4.54 (0.50)</b>
Increasing my own knowledge and understanding of the ecosystem	4.22 (0.72)	4.51 (0.59)
Maintaining a healthy aquarium or water garden	4.31 (0.71)	4.58 (0.55)
Knowing that I have done the right thing to be a successful hobbyist	4.26 (0.74)	4.53 (0.55)
<b>Benefits to the community (<math>\alpha = .790, \Omega=.792, AVE=.560</math>)</b>	<b>4.09 (0.69)</b>	<b>4.58 (0.53)</b>
A sense of community among hobbyists	3.87 (0.85)	4.30 (0.86)
Teaching younger generations about the impact of our behaviors on the environment	4.21 (0.81)	4.70 (0.51)
Preserving aquatic resources for my community	4.19 (0.82)	4.76 (0.48)

Fit statistics  $\chi^2=18.339, df=8, p=.019$ ; CFI=.984; TLI=.971; RMSEA=.077, SRMR=.025

Note. Measured on a Likert scale where 1 = “Strongly Disagree” and 5 = “Strongly Agree”.

Additional variables from the Health Belief model included **self-efficacy** (i.e., beliefs that one has the ability to take a particular action) and **response-efficacy** (i.e., beliefs that a recommended

action will effectively achieve a particular goal). Hobbyists reported high levels of self-efficacy ( $M = 4.17, SD = 0.75$ ) and response efficacy ( $M = 4.43, SD = 0.55$ ), indicating beliefs that they had the ability to take preventative actions, and that their actions would help prevent AIS spread (see Table 35). Response-efficacy was higher than self-efficacy ( $t(41) = -2.707, p = 0.010$ ), indicating respondents had more confidence that the guidelines had the potential to be successful than they did about their ability to follow the guidelines effectively.

**Table 35.**

*Self-efficacy and response-efficacy related to behaviors that prevent the spread of aquatic invasive species*

Efficacy <sup>1</sup>	State-wide survey M (SD)	On-site survey M (SD)
<b><i>Self-efficacy (<math>\alpha = .843, \Omega = .846, AVE = .647</math>)</i></b>	<b><i>3.81 (0.76)</i></b>	<b><i>4.17 (0.75)</i></b>
I understand what I need to do in order to minimize the risk of AIS	3.62 (.92)	4.12 (0.80)
I am capable of performing the tasks required to minimize the risk of AIS	3.95 (.82)	4.31 (0.78)
I feel confident in performing the steps necessary to minimize the risk of AIS	3.84 (.90)	4.07 (0.89)
<b><i>Response-efficacy (<math>\alpha = .773, \Omega = .794, AVE = .567</math>)</i></b>	<b><i>4.12 (0.69)</i></b>	<b><i>4.43 (0.55)</i></b>
My own actions will prevent the spread of AIS	3.89 (.87)	4.17 (0.88)
If everyone followed purchase and disposal guidelines, we could significantly lower the risk of spreading AIS	4.25 (.80)	4.57 (0.59)
Following recommended purchasing and disposal guidelines helps to prevent AIS from spreading	4.22 (.81)	4.55 (0.55)

*Fit statistics:  $\chi^2 = 57.876, df = 8, p < .001$ ; CFI = .919; TLI = .849; RMSEA = .169, SRMR = .087*

*Note.* Measured on a Likert scale where 1 = “Strongly disagree” and 5 = “Strongly agree”

Finally, we measured perceived barriers, which are internal or external factors that prevent someone from taking action. We considered three types of barriers theorized in past work (Crawford & Godbey, 1987): 1) intrapersonal barriers, which are barriers based on one’s personal beliefs; 2) interpersonal barriers, which are based on social pressures, connections, or interactions; 3) structural barriers, which are external contextual factors. Perceived barriers were generally low; on average respondents disagreed with the barriers listed (see Table 36). Structural barriers were particularly low ( $M = 1.93, SD = 0.80$ ), and significantly lower than both intrapersonal barriers ( $M = 2.36, SD = 0.91; t(42) = 4.343, p < 0.001$ ) and interpersonal barriers ( $M = 2.36, SD = 0.90; t(42) = 4.626, p < 0.001$ ).

**Table 36.***Perceived barriers to taking action to prevent the spread of aquatic invasive species*

<b>Barriers<sup>1</sup></b>	<b>State-wide survey</b>	<b>On-site survey</b>
	<b>M (SD)</b>	<b>M (SD)</b>
<b><i>Intrapersonal</i></b>	<b>2.79 (0.81)</b>	<b>2.36 (0.91)</b>
I am unsure of the guidelines for how to dispose of my plants and animals	2.88 (1.09)	2.54 (1.14)
The guidelines do not seem relevant to my own engagement with the hobby	2.70 (1.09)	2.14 (1.05)
I am unwilling to euthanize the plants and animals that I need to dispose of	2.80 (1.12)	2.40 (1.26)
<b><i>Interpersonal</i></b>	<b>2.86 (0.91)</b>	<b>2.52 (0.90)</b>
I do not know who to ask for advice on recommended guidelines	2.84 (1.18)	2.47 (1.05)
I cannot find anyone to accept an organism I am trying to rehome	2.58 (1.06)	2.67 (1.11)
I am not connected with other hobbyists who could help	3.17 (1.26)	2.42 (1.20)
<b><i>Structural</i></b>	<b>2.30 (0.89)</b>	<b>1.93 (0.80)</b>
I lack the necessary resources or equipment	2.72 (1.09)	2.09 (1.04)
I do not have enough time to follow recommended guidelines	2.19 (1.01)	1.91 (0.95)
My health or physical abilities make following recommended guidelines difficult	2.02 (1.02)	1.79 (0.98)

<sup>1</sup>Measured on a 5-point Likert scale where 1 = “Strongly Disagree” and 5 = “Strongly Agree”.**Open-ended responses to barriers question**

Respondents were asked to think about ways of overcoming barriers, in response to the following prompt:

*We would like to know how management agencies could help you overcome the barriers listed in the previous question. For example, agencies can provide resources such as educational materials and workshops, as well as enforce rules and regulations. What would be most helpful?*

A total of 15 respondents provided suggestions:

Four respondents provided a general request for **more education**

- Educational materials would be better
- Educational resources being provided
- More advertising!
- Public information about best practices for disposal

Four respondents suggested **greater use of online platforms**:

- Provide videos through social media
- Social media, short quick TikTok-like videos on the impacts of AIS and prevention.
- Video links
- Online promotion of info

**Workshops**, among other resources, were suggested by four respondents

- Educational workshops, guest speakers, attending fish swaps/aquashella, youtube
- Workshops
- Workshops, youtube videos

Two respondents mentioned that **information could be more readily available at fish stores**

- I would recommend placing easy to access literature or videos regarding this topic in chain and local fish stores. I rarely see that information readily available there.
- Pamphlets at local fish stores, reptile stores, and parks, and natural with identification and disposal guides, and general best practices.

Remaining comments:

- Just places to get rid of them?
- Schools should have environmental classes for one month of the school year to teach the younger gen how to care for the environment.

### **Open-ended comments on survey**

Respondents had the opportunity to provide additional thoughts at the end of the questionnaire.

Comments were shared by 8 respondents. The comments are presented below:

- :)
- [email redacted]; send info about the stop and reverse preventative measures that can be taken
- Love what y'all are doing!!
- No.
- Thank you!
- Thanks for sharing! I loved learning about this!
- It's a good idea. Get it out to school and stuff like it!
- The booth at the Aquashella trade show was fantastic

# APPENDIX C: SURVEY QUESTIONNAIRE

## A survey about Aquatic Invasive Species in Illinois





You are being asked to participate in a study on aquarist and water gardener viewpoints about aquatic invasive species. This research will help enable hobbyists to participate in invasive species prevention. This survey takes 15 minutes to complete and you will not experience risks outside of those encountered in daily life. You must be 18 years or older, live in Illinois, and be physically present in the United States to participate. You will be compensated by Qualtrics and have the option to not participate.

*Please click [here](#) to review the consent information. (link to PDF for review and download).*

Check the following boxes to indicate your consent to participate in the study.

- I have read and understand the above information
- I certify that I am 18 years old or older.
- I certify that I am physically present in the United States.
- By clicking the "Submit" button to enter the survey, I indicate my willingness to voluntarily take part in this study.

 Participant must check all above boxes to proceed to the screening question.

 Prospective respondents must then respond 'yes' to at least one item in the screen question below.

**During the past 3 years, did you keep aquatic plants, fish, or other animals in an aquarium, outdoor pond, or water garden?**

- Yes, I keep a fish bowl or small freshwater aquarium of 5 gallons or less
- Yes, I keep a large freshwater aquarium of 5 gallons or more
- Yes, I keep a saltwater aquarium
- Yes, I keep a koi pond or water garden
- Yes, I keep indoor aquatic pets (turtles, frogs, etc.)
- No, I do not keep an aquarium, outdoor pond, or water garden

## Section 1 of 5: Background Information

*In this section, we ask about your hobbies and familiarity with aquatic invasive species.*

**1. How would you best identify yourself?**

- Aquarium hobbyist
- Outdoor pond hobbyist
- Water gardener
- Both aquarium hobbyist and outdoor pond or water garden owner

**2. How many years, including this one, have you maintained an aquarium or water garden? \_\_\_\_\_ Years**

**3. How many aquarium tanks do you maintain? \_\_\_\_ Tanks**

**4. How would you rate your level of expertise compared to other hobbyists?**

- |                            |                          |                          |                          |                             |
|----------------------------|--------------------------|--------------------------|--------------------------|-----------------------------|
| <input type="checkbox"/>   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>    |
| Much lower<br>than average | Lower than<br>average    | Average                  | Higher than<br>average   | Much higher<br>than average |

**5. How often do you obtain new aquatic species from each of the following sources?**

	Never	Sometimes	About half the time	Most of the time	Every time
a. Buy aquatic species over the internet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Buy aquatic species from a chain store (PetCo, PetSmart, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Buy aquatic species from a local fish store	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Buy aquatic species through fish club events or meetings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Accept aquatic species from another hobbyist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Find fish species through a local classified system	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Buy aquatic species from a reputable breeder	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Personally collect species that I find in aquatic environments	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



**6. Aquatic invasive species (AIS), also known as aquatic nuisance species, are aquatic plants or animals that are introduced to an area where they are not native, outcompete native species and establish abundant populations in the wild, and are difficult to control or eradicate.**

**Based on the given definition, to what extent are you aware of AIS (aquatic invasive species)?**

- Not at all aware     
  Slightly aware     
  Somewhat aware     
  Very aware     
  Extremely aware

**7. We would like to understand your familiarity with aquatic invasive species. How familiar are you with the following types of information?**

	Not at all familiar	Slightly familiar	Moderately familiar	Very familiar	Extremely familiar
a. The biological characteristics that make a species "invasive"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Names of species that are considered invasive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Ways that invasive species affect the environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. How aquarium and garden hobbyists could spread invasive species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Types of actions you can take to prevent invasive species from spreading	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. How to complete recommended preventative actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**8. If invasive species spread to your local ecosystem, how severe would you expect the impacts to be? Please indicate the severity of potential harm to...**

	No impacts	Mild impacts	Moderate impacts	Severe impacts	Very severe impacts
a. Quality of habitat and natural environments	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Environmental processes (e.g., water cycle)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Survival of plants and animals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Your appreciation of the beauty of the landscape	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Your own enjoyment of recreational activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Your own access to waterbodies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. The local economy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. The community in the region	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. Recreational opportunities for future generations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Section 2 of 5: Preventing the spread of aquatic invasive species

**9. There are several actions hobbyists can take to help prevent the spread of aquatic invasive species. The following actions are recommended by management agencies. Over the next year, how likely are you to:**

	Not at all likely	Slightly	Somewhat	Very	Extremely likely
a. Purchase species based on scientific names	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Purchase only native or non-invasive species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Quarantine species before introducing to pond or aquarium	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Sterilize water (add bleach) used in an aquarium or water garden prior to disposal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**10. There are many ways to dispose of species used in your aquatic hobby. Please indicate which disposal methods you have used in the past twelve months. Please check all that apply.**

- |   |  |
|---|--|
| <input type="checkbox"/> Bag plants and place them in the trash                           | <input type="checkbox"/> Euthanize animal species  |
| <input type="checkbox"/> Give, trade, or sell animals to another hobbyist                 | <input type="checkbox"/> Give, trade, or sell plants to another hobbyist                 |
| <input type="checkbox"/> Donate animals to a school, business, zoo, or other organization | <input type="checkbox"/> Donate plants to a school, business, zoo, or other organization |
| <input type="checkbox"/> Rehome animals with a sanctuary or rescue group                  | <input type="checkbox"/> Other: _____  |

**11. We would like to understand how you view your ability to prevent the spread of aquatic invasive species (AIS). How strongly do you agree or disagree with the following statements?**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. I understand what I need to do in order to minimize the risk of AIS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. I am capable of performing the tasks required to minimize the risk of AIS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. I feel confident in performing the steps necessary to minimize the risk of AIS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. My own actions will prevent the spread of AIS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. If everyone followed purchase and disposal guidelines, we could significantly lower the risk of spreading AIS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Following recommended purchasing and disposal guidelines helps to prevent AIS from spreading	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<b>12. There are many barriers that prevent people from following recommendations to prevent the spread of aquatic invasive species. Please rate your level of agreement or disagreement with the following barriers.</b>	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. I am unsure of the guidelines for how to dispose of my plants and animals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. The guidelines do not seem relevant to my own engagement with the hobby	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. I am unwilling to euthanize the plants and animals that I need to dispose of	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. I do not know who to ask for advice on recommended guidelines	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. I cannot find anyone to accept an organism I am trying to rehome	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. I am not connected with other hobbyists who could help	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. I lack the necessary resources or equipment to responsibly dispose of species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. I do not have enough time to follow recommended guidelines	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. My health or physical abilities make following recommended guidelines difficult	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<b>13. There are many reasons it may be beneficial to follow aquatic invasive species prevention guidelines. Please rate your level of agreement or disagreement regarding the following reasons.</b>	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. Increasing my own knowledge and understanding of the ecosystem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Maintaining a healthy aquarium or water garden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Knowing that I have done the right thing to be a responsible hobbyist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. A sense of community among hobbyists	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Teaching younger generations about the impact of our behaviors on the environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Preserving aquatic resources for my community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Section 3 of 5: Aquatic Invasive Species Outreach

We would like your feedback on four campaigns that provide information about aquatic invasive species.

One campaign is “Be a Hero, Release Zero”, whose logo is depicted below:



14a. How familiar are you with the “Be a Hero, Release Zero” campaign?

- Not at all familiar       Slightly familiar       Moderately familiar       Very familiar       Extremely familiar

Next, we are interested in the “Take AIM” campaign, whose logo is depicted below:



15a. How familiar are you with the “Take AIM” campaign?

- Not at all familiar       Slightly familiar       Moderately familiar       Very familiar       Extremely familiar

Next, we are interested in the “What’s in your water garden” campaign, depicted below:



16a. How familiar are you with the “What’s in your water garden” campaign?

- Not at all familiar       Slightly familiar       Moderately familiar       Very familiar       Extremely familiar

Finally, we are interested in the “What’s in your aquarium” campaign, depicted below:



17a. How familiar are you with the “What’s in your aquarium” campaign?

- Not at all familiar    
  Slightly familiar    
  Moderately familiar    
  Very familiar    
  Extremely familiar

14b. How often have you used the following resources from aquatic invasive species outreach campaigns, such as the ones you just considered (Be a Hero, Take AIM, What’s in your water garden?, What’s in your aquarium?)?

	Never	At least once	Several times	Often	Very often
a. Pet re-homing network	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Exotic pet veterinarian network	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Disposal guidelines	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Campaign websites (ReleaseZero.org, TakeAIM.org, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Regulations database	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Lists of expert contacts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Lists of invasive and non-invasive species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

18. The organizations developing these informational campaigns (Be a Hero, Transport Zero, Take AIM, What’s in your water garden, What’s in your aquarium) would value your feedback. What, if any, changes would you recommend?

**19. How have you learned about aquatic invasive species (AIS) in the past?  
(please check all that apply)**

- |   |   |
|---|---|
| <input type="checkbox"/> Read about AIS in <b>magazines</b>   | <input type="checkbox"/> Learned about AIS in <b>school</b>   |
| <input type="checkbox"/> Read about AIS in <b>online water hobbyist forums</b>                                      | <input type="checkbox"/> Learned about AIS through a <b>television program</b>  |
| <input type="checkbox"/> Read about AIS in <b>brochures</b>   | <input type="checkbox"/> Attended <b>presentations</b> about AIS  |
| <input type="checkbox"/> Read about AIS in the <b>newspaper</b>   | <input type="checkbox"/> Saw information about AIS on <b>posters</b>  |
| <input type="checkbox"/> Saw AIS <b>wrapped vehicles</b> (cars or trucks displaying logos or information about AIS) | <input type="checkbox"/> Received <b>giveaways</b> from an AIS organization (pencils, garden kneelers, screen wipes, stick-on thermometers, fish bags, magnets, etc.) |
| <input type="checkbox"/> Saw information about AIS in an <b>online ad</b>   | <input type="checkbox"/> Learned about AIS at <b>tradeshows</b>   |
| <input type="checkbox"/> Learned about AIS through <b>social media</b> posts or videos                              | <input type="checkbox"/> Information about AIS came <b>with the purchase of my aquatic plant or animal</b>  |
| <input type="checkbox"/> Other: _____   |   |

**19b. Some people easily recall where they learned about AIS, whereas others find it difficult to remember. How confident are you in your responses to the above question?**

- |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Not at all confident     | Somewhat confident       | Moderately confident     | Confident                | Very confident           |

**20. We are also interested in the sources of information that you rely on the most. How often do you consult the following sources for advice about your hobby?**

	Never	Rarely	Sometimes	Often	Very often
Family members, friends, or neighbors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other hobbyists	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Retailers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Breeders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Veterinarians	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Section 4 of 5: Your views on management of invasive species

**21. There are multiple ways that management agencies can intervene to prevent the spread of aquatic invasive species. We would like to understand how much you would support these interventions. Please rate your level of agreement or disagreement with the following statements.**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. Releasing invasive species should be illegal.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. People should be fined for releasing invasive species in Illinois waterways	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Waterways should be monitored to ensure compliance with regulations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Educational outreach materials should be developed to teach people about invasive species prevention	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Communication should be used to persuade people to take action	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Public programs should be available to raise awareness about invasive species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**22. In the questions below, we describe different ways that people view their relationship with nature. Please rate your level of agreement or disagreement with the following statements.**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a. We should set aside protected areas (parks, preserves, wilderness) to be kept safe from people	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Plants and animals in nature should be protected by limiting human use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Protected areas should exclude people to preserve their stability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. The aspects of nature that are most important are the ones that can be utilized by people	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. The primary goal of conservation should be to ensure that people have access to food and raw materials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. All protected areas should be accessible to people for recreational activities (fishing, hunting, hiking)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Within protected areas, human communities can co-exist with nature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. The needs of humans and the environment should be equally weighed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

i. The primary goal of conservation should be to seek compromises that balance the well-being of human and non-human species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
j. It is wrong to harm animals even to achieve conservation goals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
k. The life of every living animal, including human and non-human species, has value	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
l. Humans should minimize the suffering of animals whether they are wild or domesticated, invasive or native, or endangered or common	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

---



## Section 5 of 5: About You

23. What is your gender?  Male  Female  Other

24. In what year were you born? \_\_\_\_\_

25. What is your annual household income (in USD) before taxes?

- Less than \$24,999  \$25,000-\$49,999  \$50,000-\$74,999  
 \$75,000-\$99,999  \$100,000-\$124,999  \$125,000-\$149,999  
 \$150,000-\$174,999  \$175,000-\$199,999  \$200,000 and over  
 Prefer not to answer

26. What is the highest level of education you have completed? (Please ✓ one)

- Some high school  High school graduate or GED  Associate's degree  
 Bachelor's degree  Graduate degree (MA, MS, PhD, JD, MD, etc.)

27. With which racial or ethnic group(s) do you identify? (Please ✓ all that apply)

- White  Black or African American  
 Asian  Native Hawaiian or other Pacific Islander  
 American Indian  Hispanic or Latino  
 Other: \_\_\_\_\_

28. What is your zip code? \_\_\_\_\_

## Thanks for your help!

If you have any additional thoughts about this study, please share them here.

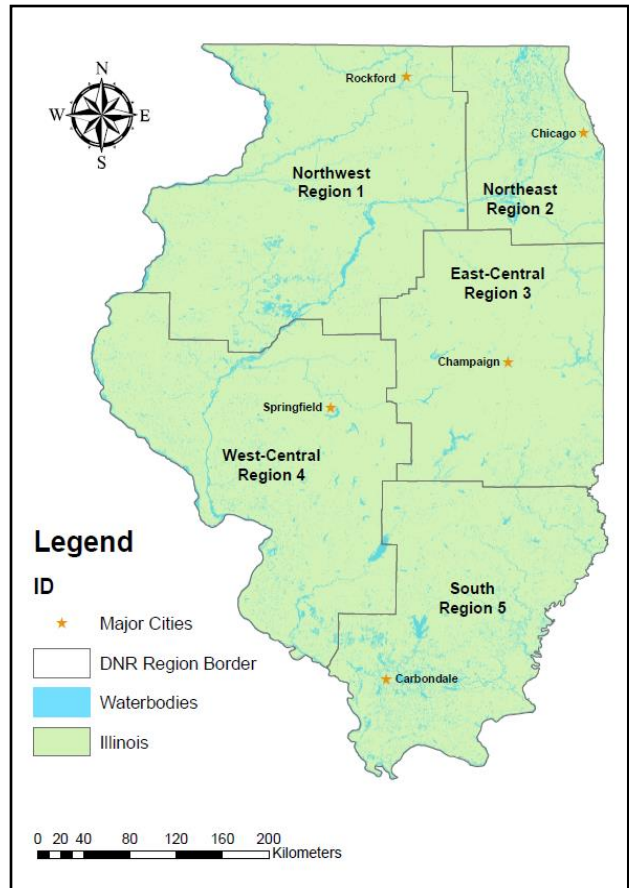
Elizabeth Golebie, Ph.D.  
Department of Natural Resources and Environmental Sciences  
University of Illinois at Urbana-Champaign  
Email: [golebie2@illinois.edu](mailto:golebie2@illinois.edu)

## APPENDIX D: SPATIAL ASSESSMENT OF OUTREACH CAMPAIGNS

In this section, we share spatial visualizations of responses to several survey questions, including awareness with the definition of aquatic invasive species, familiarity with invasive species outreach campaigns that have been ongoing in Illinois, and use of resources that these campaigns provide. The series of maps reported in this appendix was created using ESRI ArcMap and Microsoft Access software.

In each map, the approximate locations of each respondent are represented as dots. To create the shapefile with respondent locations, we first extracted relevant variables from the survey dataset (zip code, responses to the awareness, familiarity, and resource use questions) and converted to a geodatabase. Next, to plot respondents spatially, the geodatabase was joined with an Illinois Zip Code shapefile from the US Census Bureau; the zip code acted as the primary ID for the join command. Each map shows responses to a particular survey question; the shading of each dot reflects how that individual responded to the question.

Average responses are reported for each of the five regions characterized by the Illinois Department of Natural Resources (ILDNR). To create the ILDNR region shapefiles, counties within each ILDNR region were selected and were given an attribute according to their respective region. Each region was converted to its own shapefile (see Figure 15). The individual points from the respondent shapefile were assigned to the ILDNR region within which their centroids fell using the “Select by Location” command. Finally, average responses for each ILDNR region were calculated with the Statistics function.



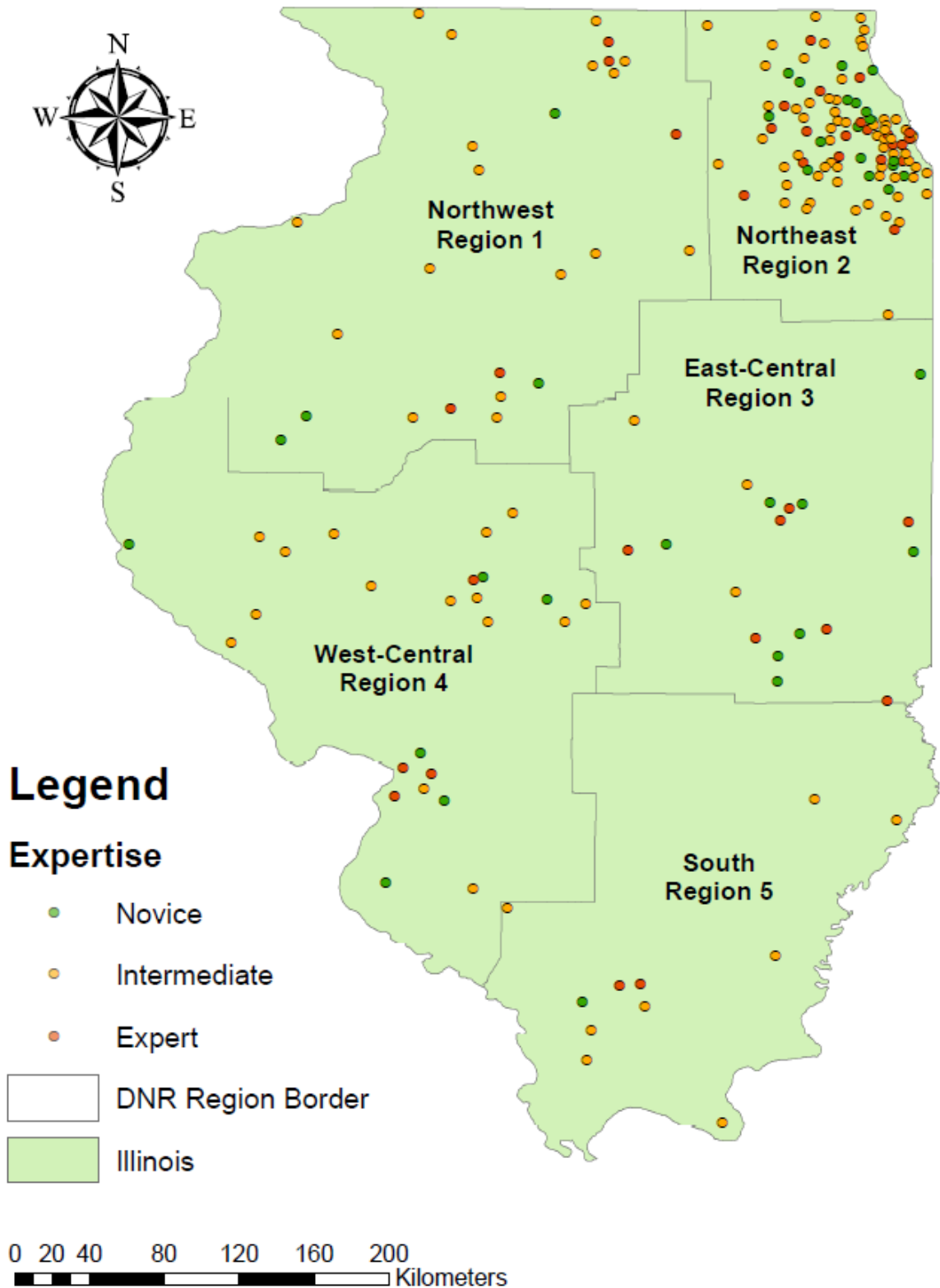
**Figure 15.** Regions of the state of Illinois in use by the Illinois Department of Natural Resources

As a point of reference, we also mapped the approximate locations of respondents categorized as ‘novice,’ ‘intermediate,’ and ‘expert’ (see Figure 16), as those categories served as a point of analysis throughout this report.

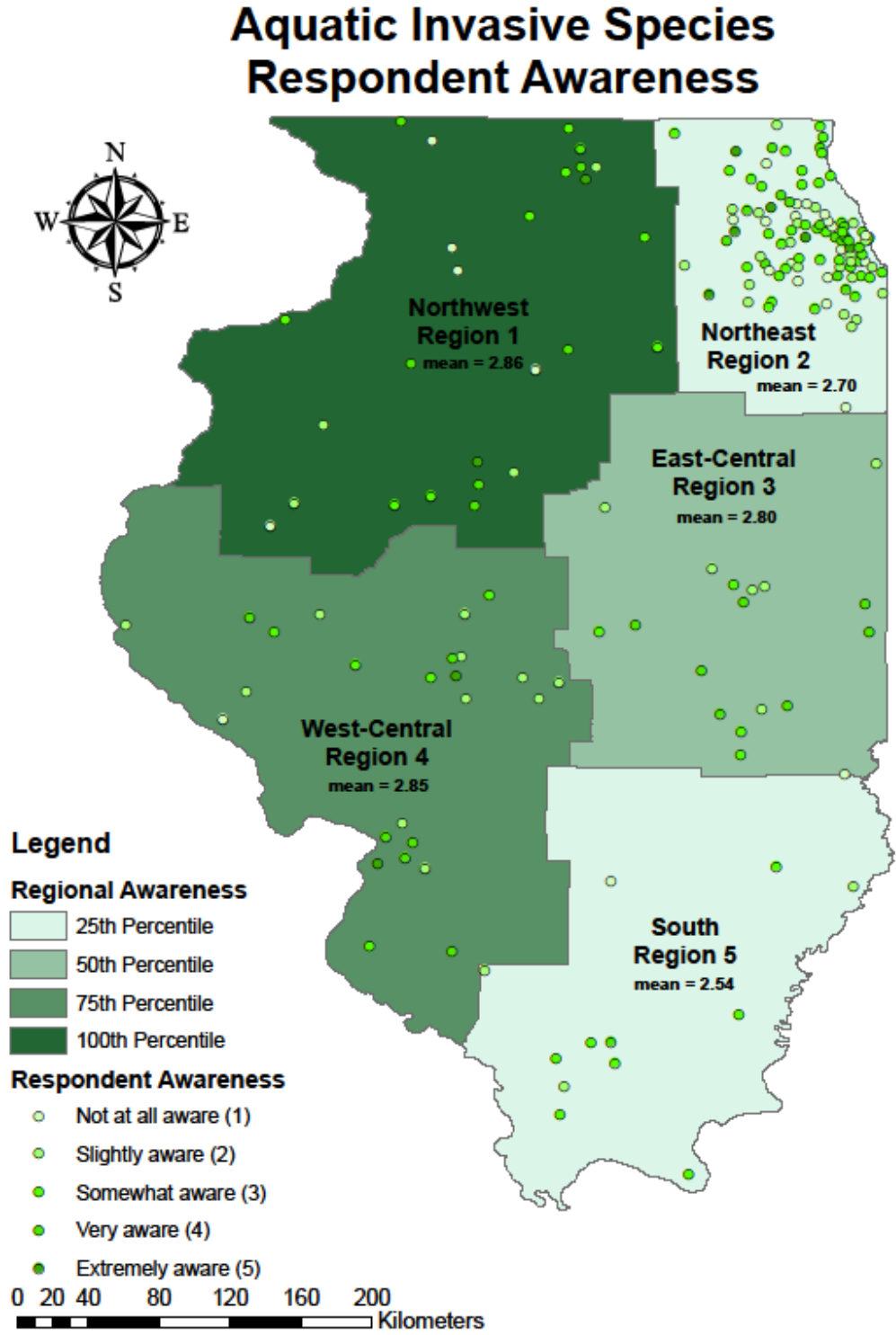
Spatial trends shown across these maps are summarized below:

- **Awareness with the definition of aquatic invasive species** (see Figure 17) was highest in the northwest and west-central regions and lowest in the south region.
  - Past work has indicated that familiarity with invasive fish is higher than familiarity with other invasive species (Golebie et al., 2021); it may be the case that residents in the western regions of the state are more aware of invasive species given their proximity to invasive carp in the Illinois river
- **Familiarity with outreach campaigns** was generally highest in the west-central region, and lowest in the east-central and southern regions.
  - In the northeast region, familiarity was relatively high for three campaigns: Be a Hero, Release Zero (see Figure 18), Take AIM (see Figure 19), and What’s in your water garden? (see Figure 21); this result may reflect Illinois-Indiana Sea Grant outreach activity in the Chicago area.
  - In the northwest region, familiarity with What’s in your aquarium? (see Figure 20) was also relatively high.
- **Use of campaign resources** generally aligned with campaign familiarity, in that resource use tended to be high in the west-central and low in the east-central and southern regions
  - Pet-rehoming networks (see Figure 22) and exotic veterinarian networks (see Figure 23) were uncommon among those living in the northwest region
  - Use of disposal guidelines (see Figure 24), campaign websites (see Figure 25), Regulations databases (see Figure 26), and lists of expert contacts (see Figure 27) was highest in the west-central and lowest in the east-central and south regions
  - Respondents living in the south region had notably higher use of lists of invasive and non-invasive species (see Figure 28)

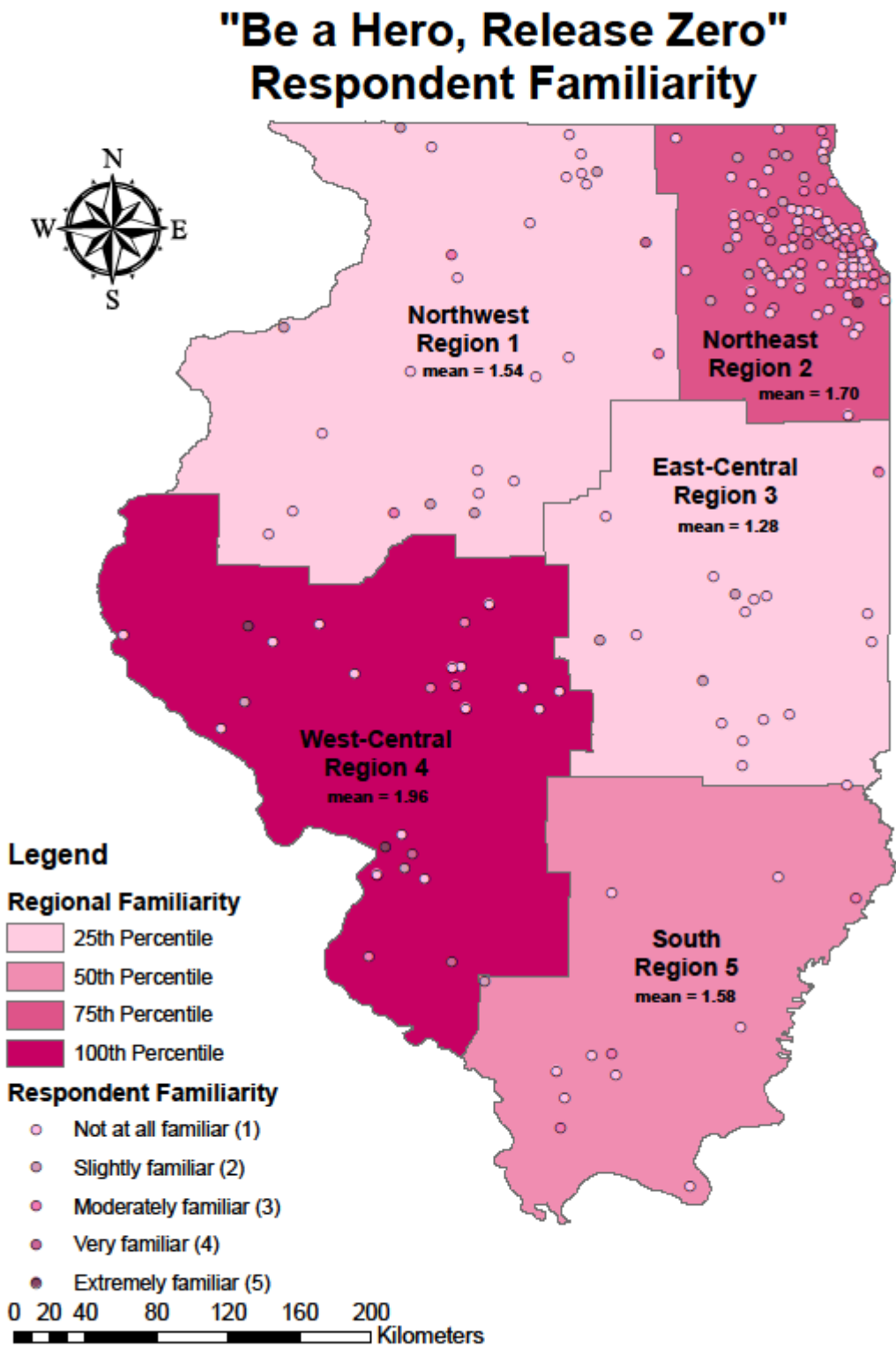
**Figure 16.** Approximate location of respondents who reported 'novice' (lower or much lower than average), intermediate (average), and expert (higher or much higher than average) levels of expertise with their aquarium or water gardening hobby.



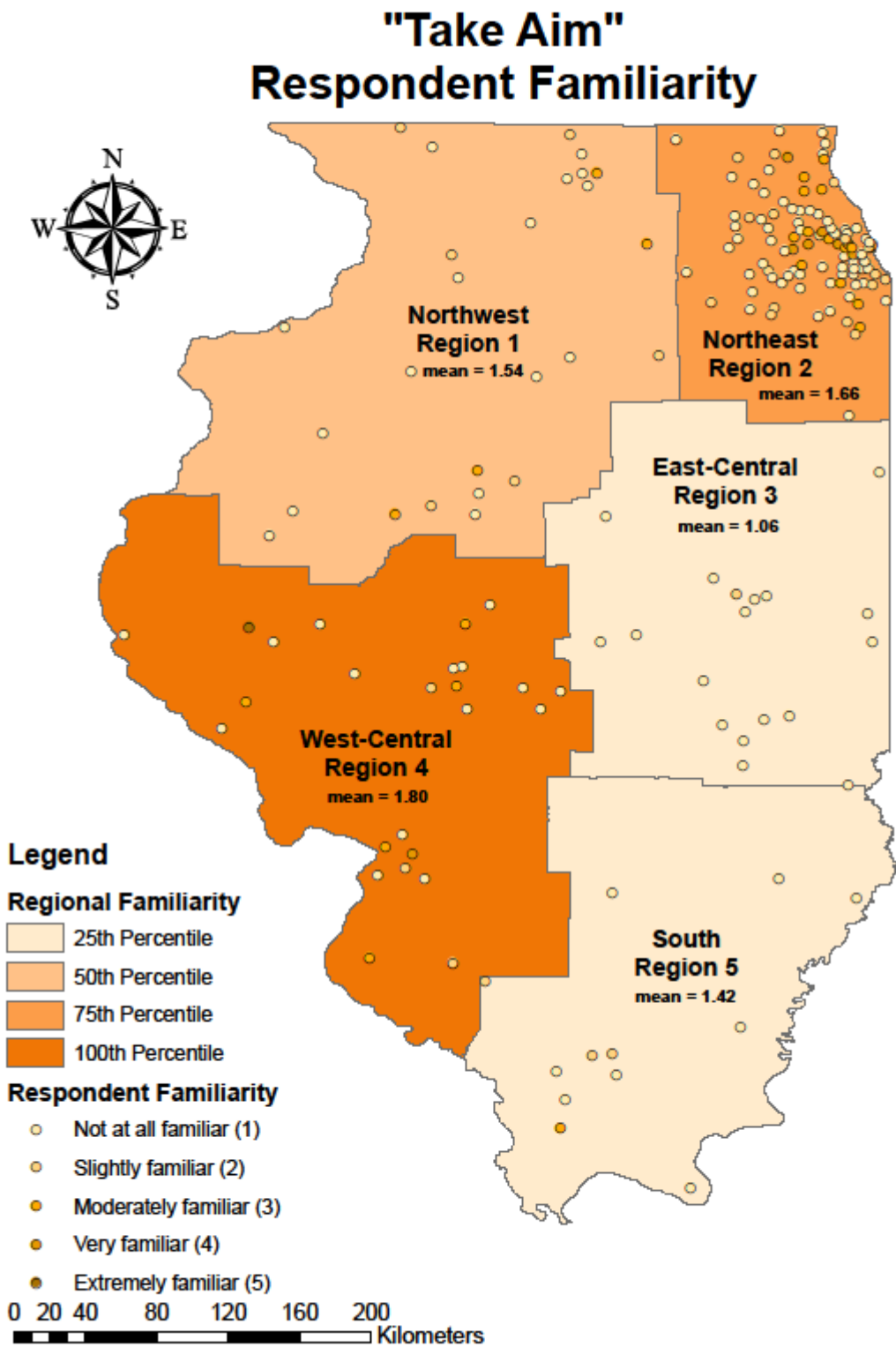
**Figure 17.** *Hobbyist Awareness of the following definition of aquatic invasive species: aquatic invasive species (AIS), also known as aquatic nuisance species, are aquatic plants or animals that are introduced to an area where they are not native, outcompete native species, and establish abundant populations in the wild, and are difficult to control or eradicate.*



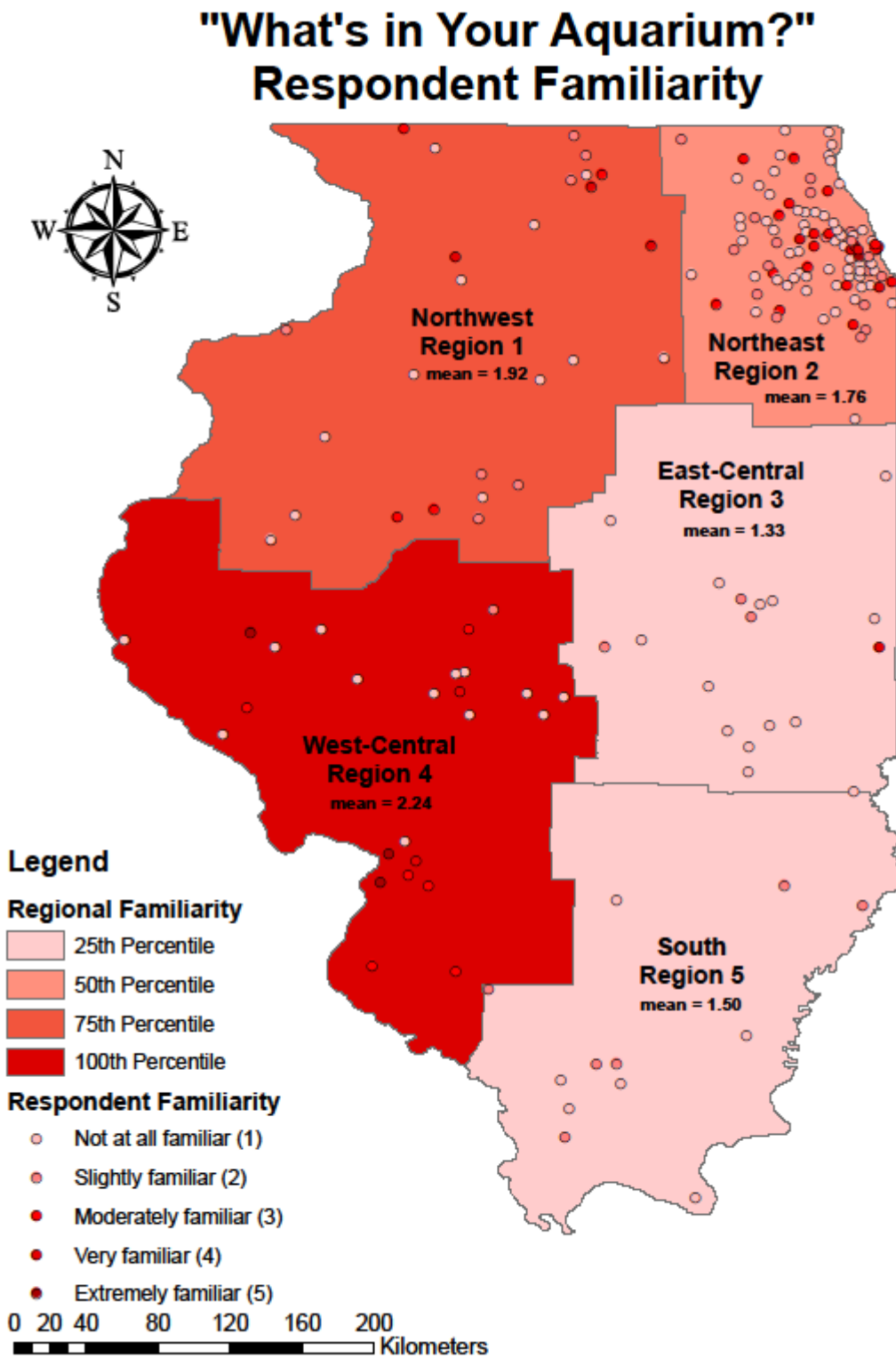
**Figure 18.** Familiarity with the “Be a Hero, Release Zero” aquatic invasive species outreach campaign among organism-in-trade hobbyists in Illinois.



**Figure 19.** Familiarity with the “Take AIM” aquatic invasive species outreach campaign among organism-in-trade hobbyists in Illinois.

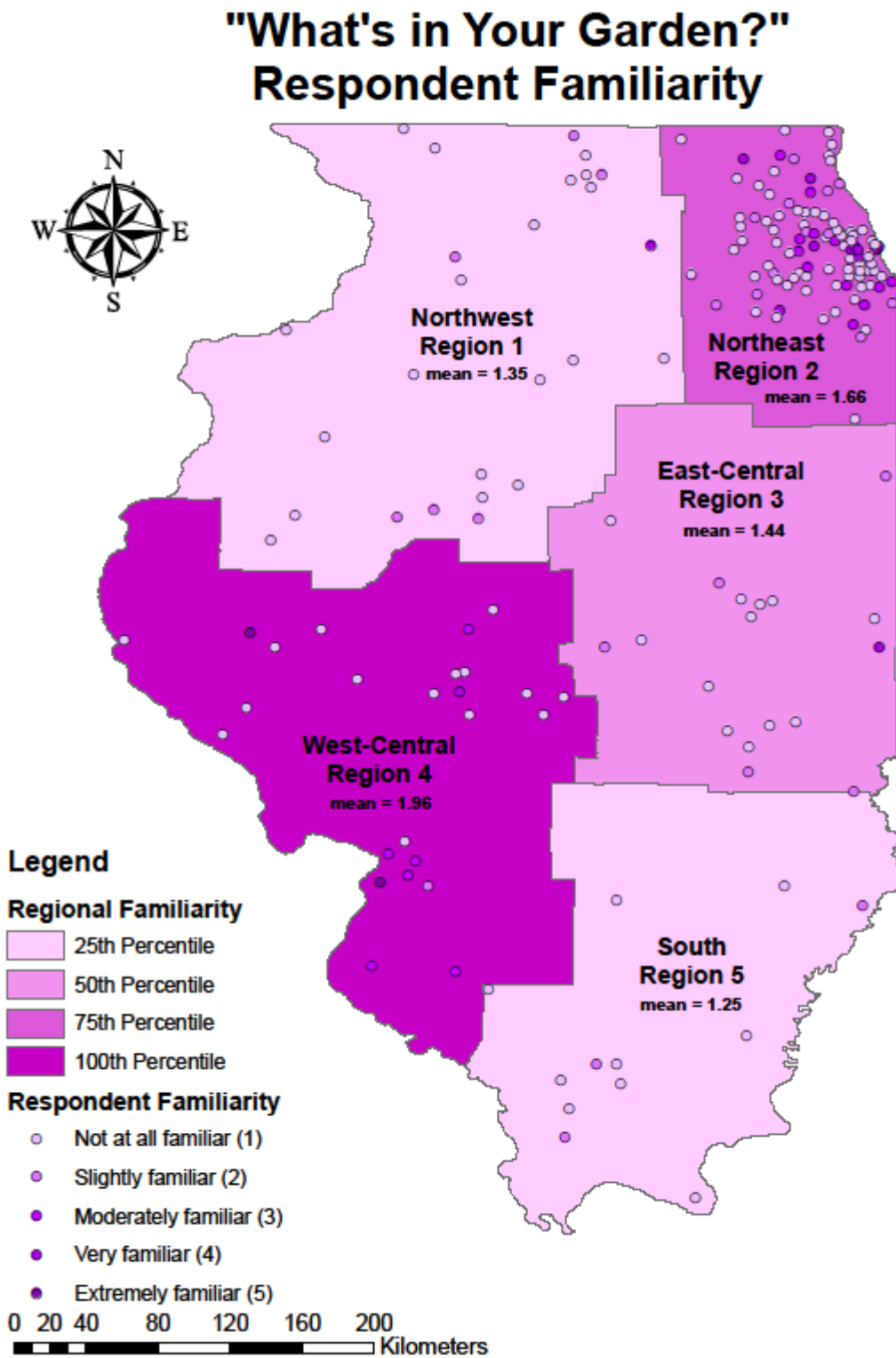


**Figure 20.** Familiarity with the “What’s in your aquarium?” aquatic invasive species outreach campaign among organism-in-trade hobbyists in Illinois.

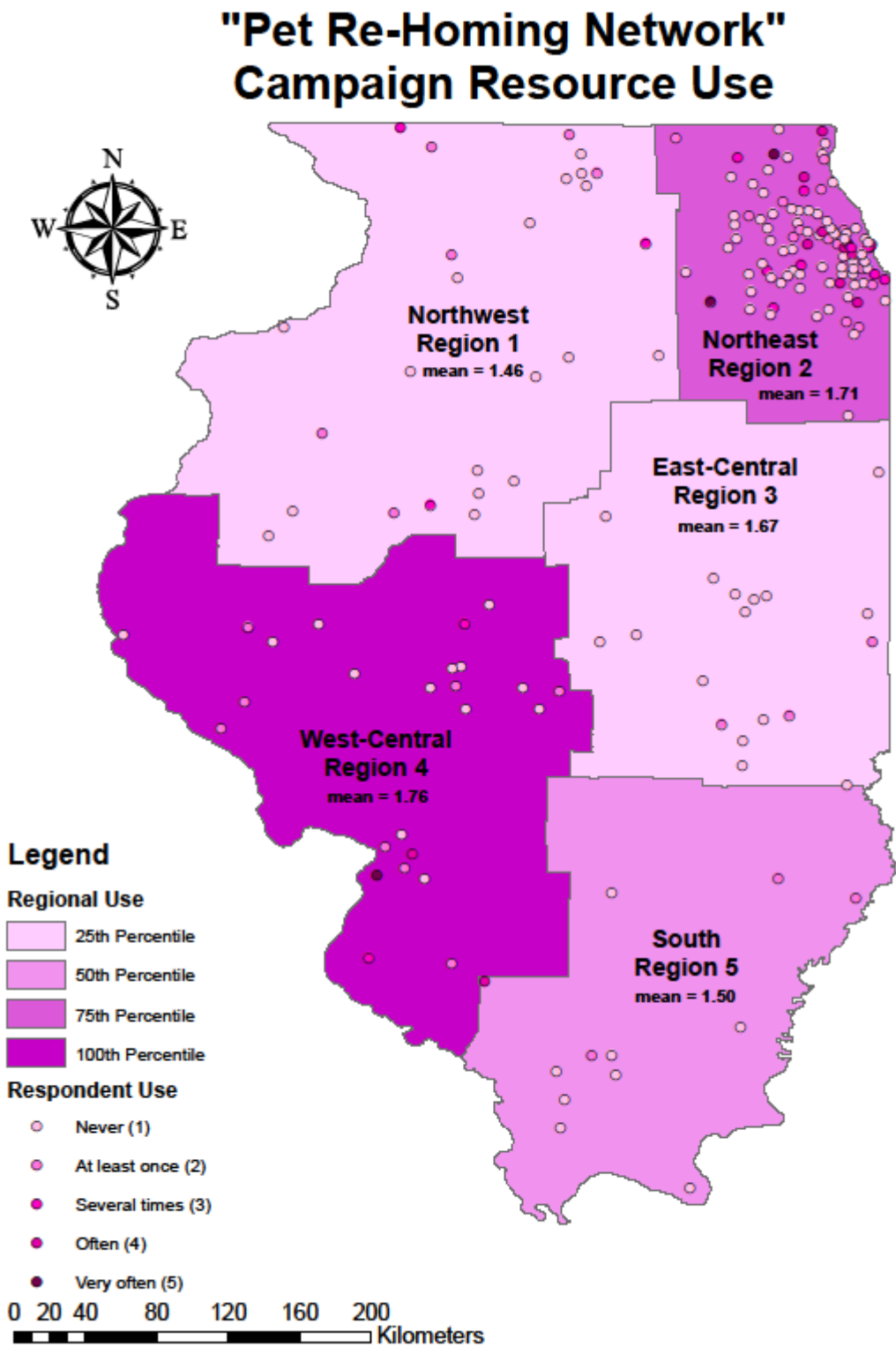




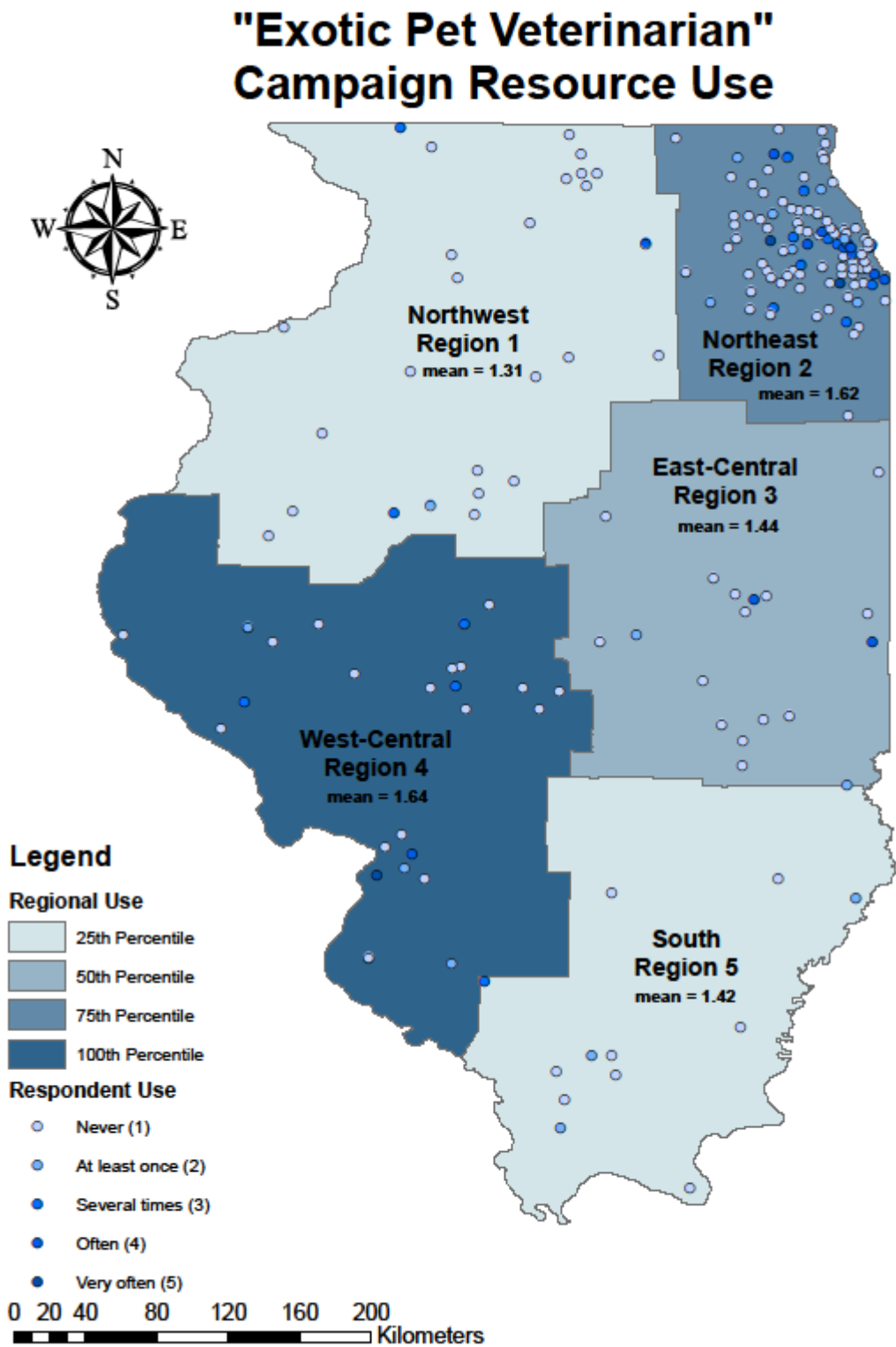
**Figure 21.** Familiarity with the “What’s in your water garden?” aquatic invasive species outreach campaign among organism-in-trade hobbyists in Illinois.



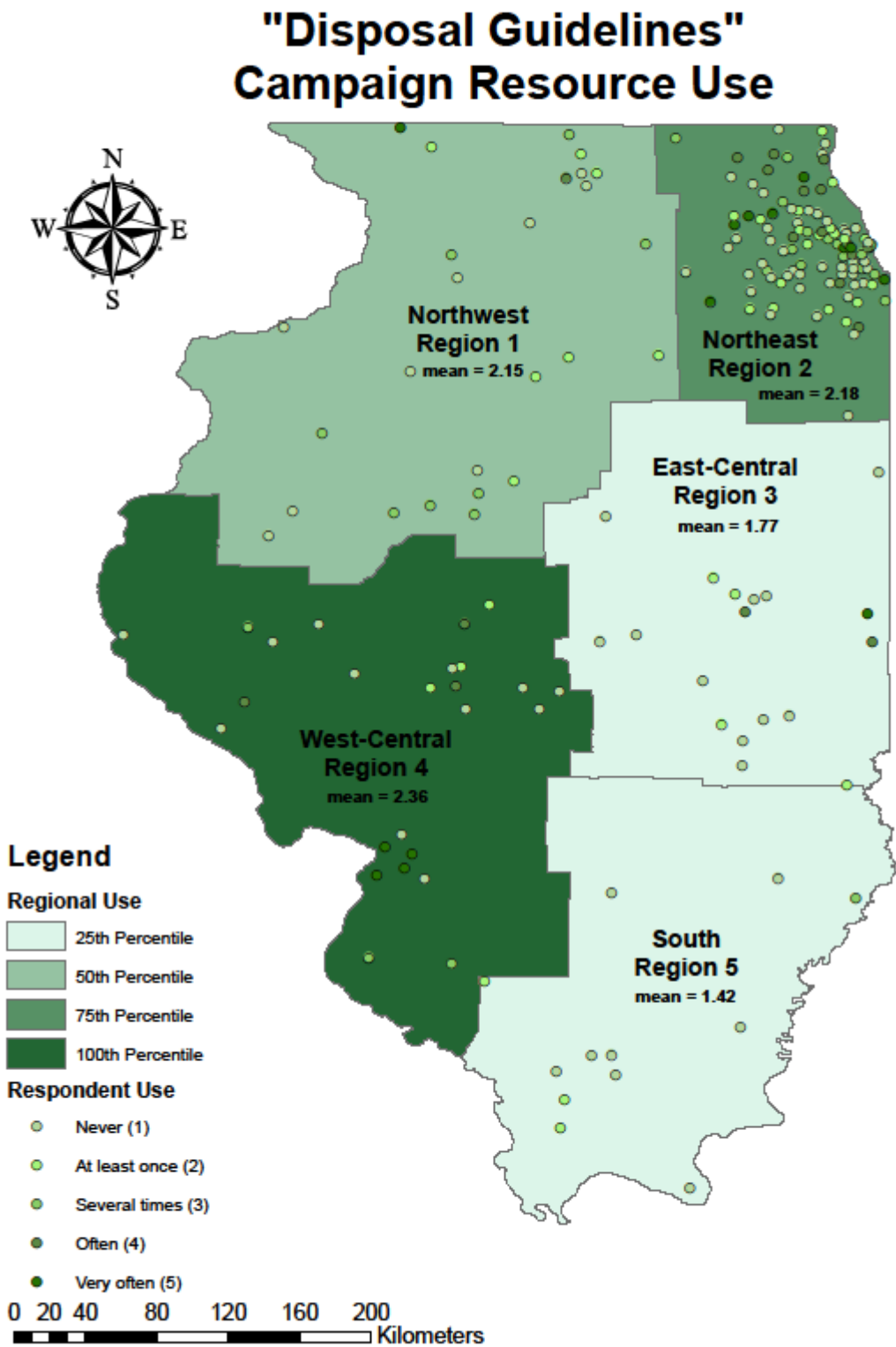
**Figure 22.** *Hobbyist use of pet re-homing networks promoted by invasive species outreach campaigns in Illinois.*



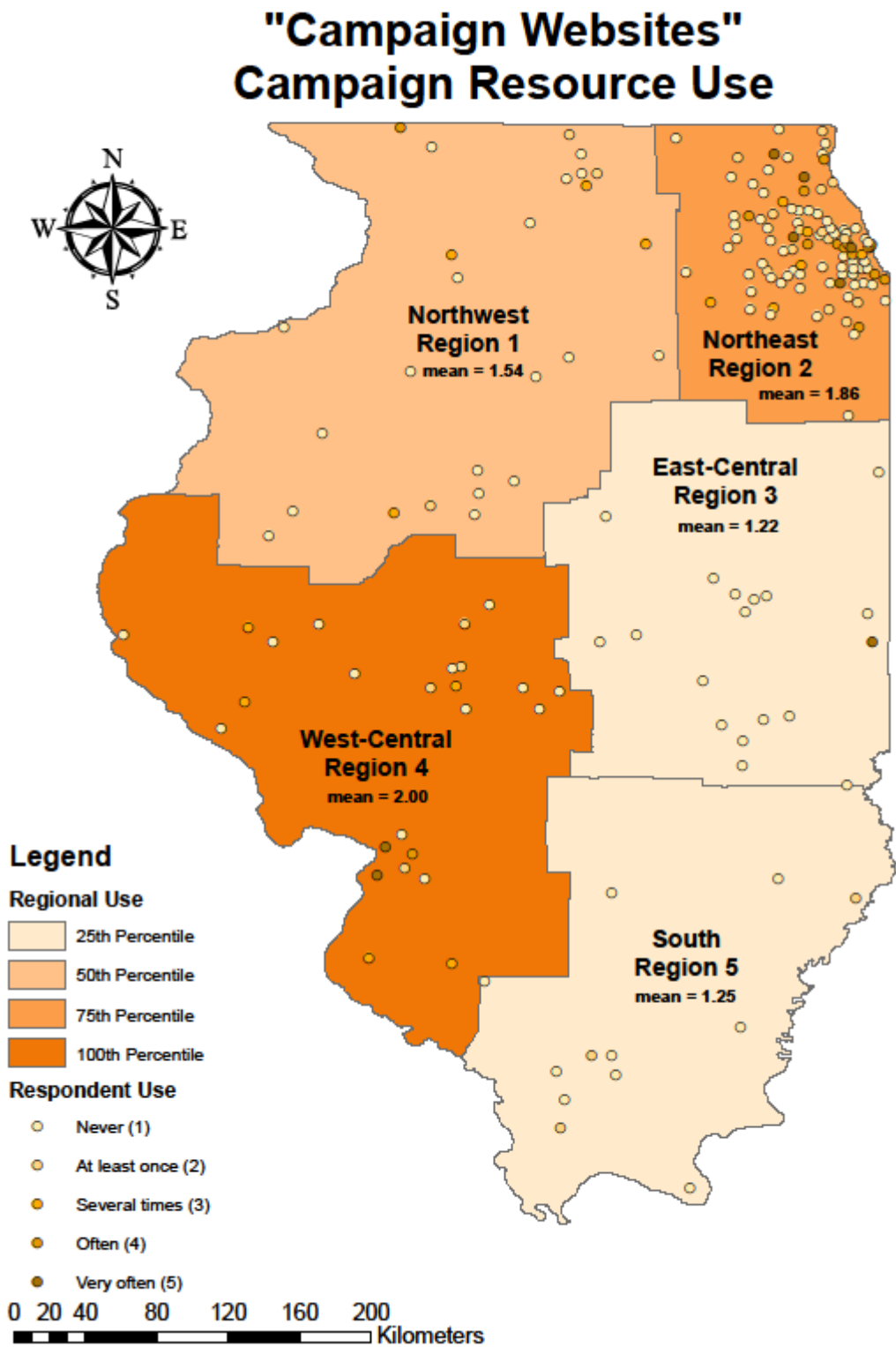
**Figure 23.** *Hobbyist use of exotic pet veterinarian networks promoted by invasive species outreach campaigns in Illinois.*



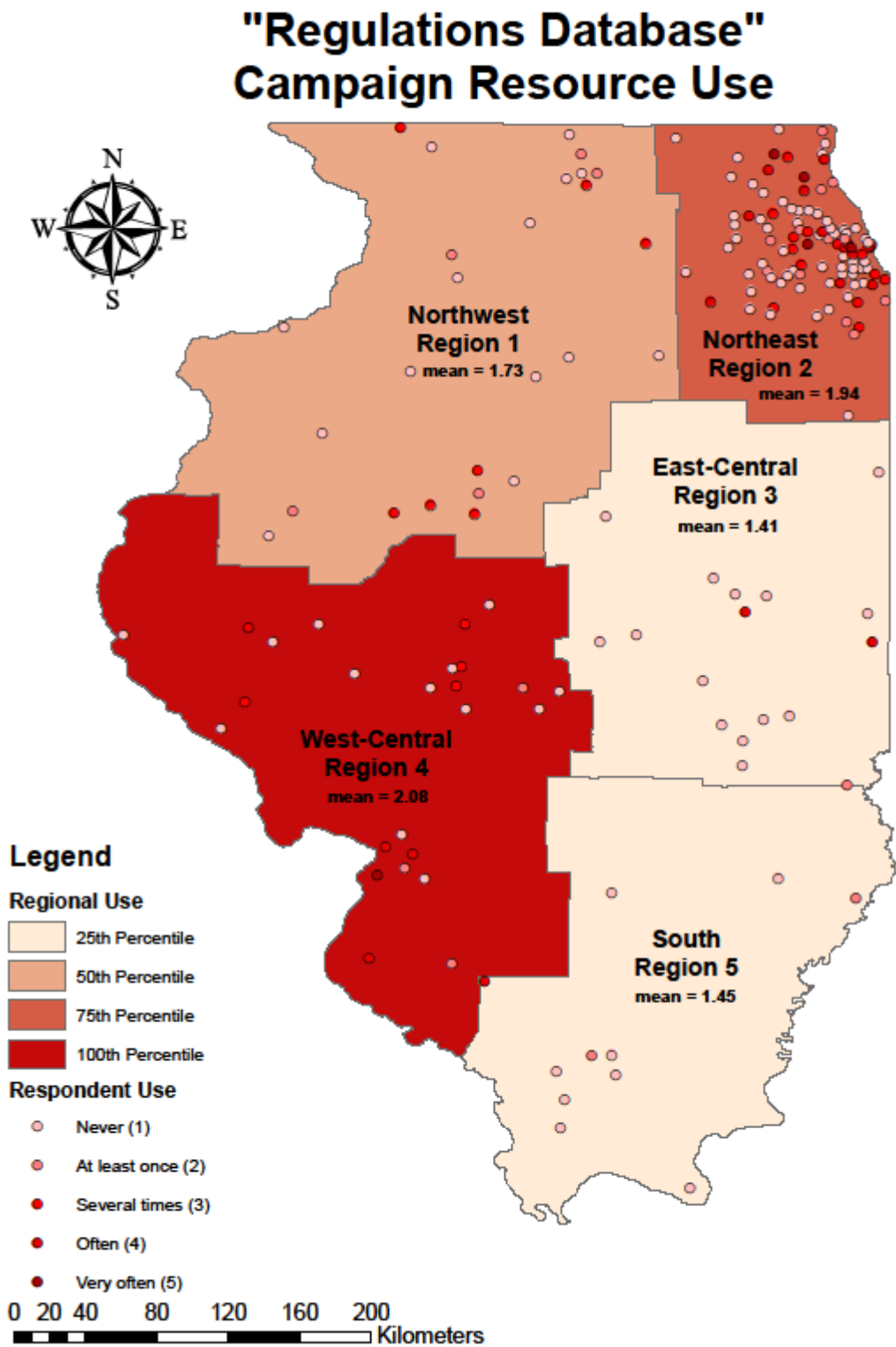
**Figure 24.** *Hobbyist use of pet disposal guidelines provided by invasive species outreach campaigns in Illinois.*



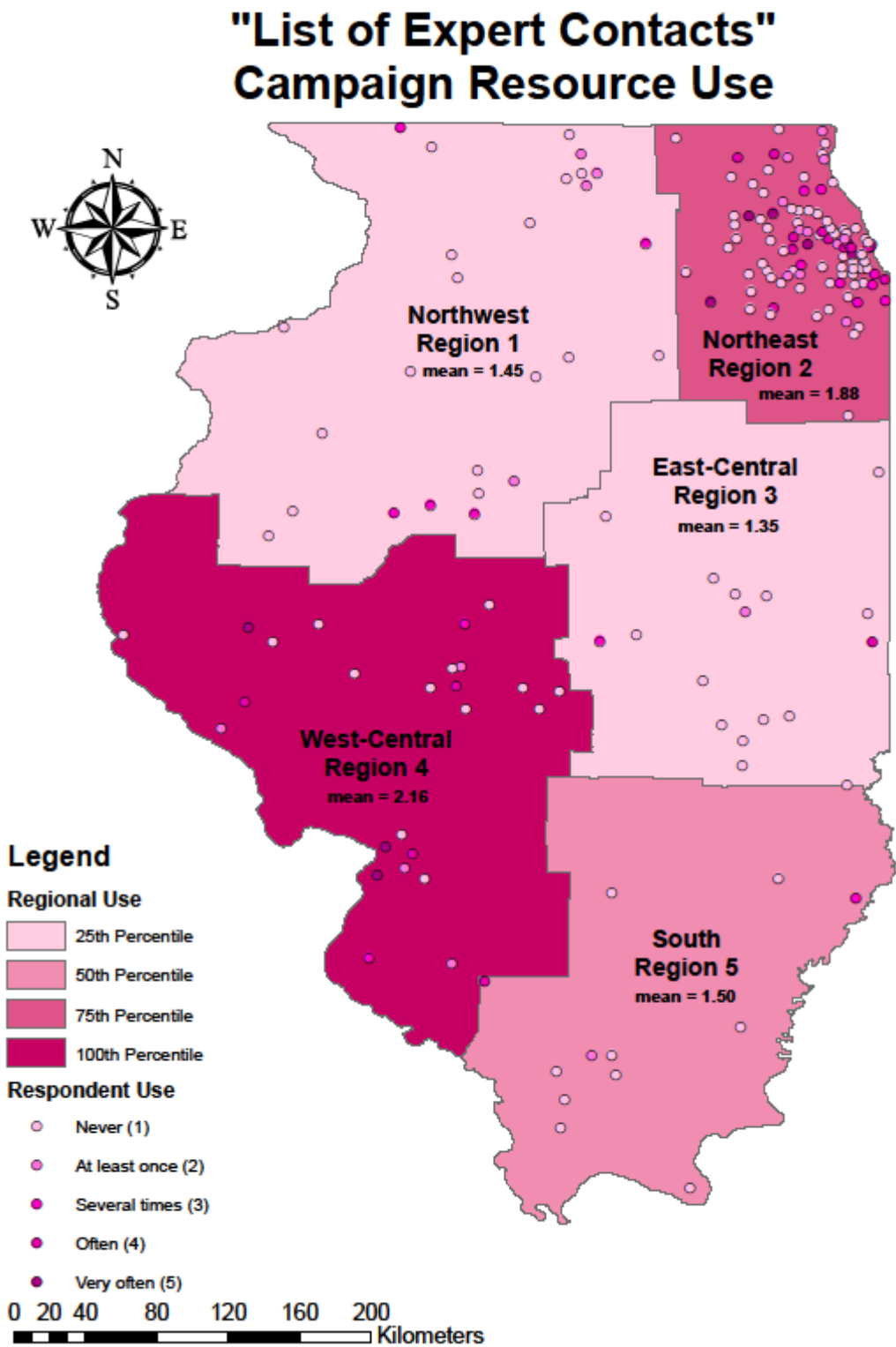
**Figure 25.** *Hobbyist use of websites developed by invasive species outreach campaigns in Illinois.*



**Figure 26.** *Hobbyist use of regulation databases provided by invasive species outreach campaigns in Illinois.*



**Figure 27.** *Hobbyist use of lists of expert contacts provided by invasive species outreach campaigns in Illinois.*



**Figure 28.** *Hobbyist use of lists of invasive and non-invasive species provided by invasive species outreach campaigns in Illinois.*

## "List of Invasive and Non-Invasive Species" Campaign Resource Use

