

3-31-2023

## Louisiana Resident Perceptions on Invasive Aquatic Plant Species and Their Management

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# **LOUISIANA RESIDENT PERCEPTIONS ON INVASIVE AQUATIC PLANT SPECIES AND THEIR MANAGEMENT**

A Thesis

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in partial fulfillment of the  
requirements for the degree of  
Master of Science

in

The School of Plant, Environmental & Soil Sciences

by  
Anna Eileen Ribbeck  
B.S., Louisiana State University, 2016  
May 2023

To my hunting mentors who helped springboard my lifelong journey into the great outdoors, where along the way, I encountered invasive species and now hope to bring awareness to the issues faced. And to the person who gave me the chance to pursue my dreams when I didn't think it was possible, I hope she follows her dreams as well.

## ACKNOWLEDGMENTS

I thank Dr. Christopher Mudge for serving as the co-chair on my committee, providing his expertise on invasive aquatic plants in Louisiana and for encouraging me to pursue a thesis topic that combined my communications career and my passion for plants. Thanks to my two favorite women, Dr. Kiki Fontenot and Dr. Heather Kirk-Ballard for not only serving on my committee but providing me so many words of encouragement and advice along the way.

Thank you to Dr. Burnett for teaching me about the thesis writing process, serving on my committee and the expert review board. He helped me face my fears, pursue my dreams and I'm so proud of the work I did to make this thesis a reality. I would also like to thank Dr. Burnett for being my biggest fan in academia and on Swamp People!

Thank you to the wonderful folks at the Louisiana Department of Wildlife and Fisheries. Thank you to Mr. Daniel Hill for serving on the expert review board for my survey. Thank you to Dr. Jack Isaacs and former employee Mr. Alexander Perret for taking the time to review my survey and grant approval from LDWF. Many, many thanks to Ms. Secunda Byrd for taking my many phone calls and making the survey postcard mailing a seamless process via LDWF.

Thank you to Ms. Kate Wilson, Commission Administrator for the Montana Department of Natural Resources and Conservation, for serving on the expert review board for my survey and providing words of encouragement.

To my boyfriend I met when I first started graduate school, Ry Smith, I want to say thank you. He agreed to come along for the stressful ride of graduate school, and he encouraged me the entire way through, sometimes with chocolate. Thank you for the support, the alligator hunting dates and treating me with kindness and respect. Ry Smith is my rock.

When I meet great people, I don't let them go. Thank you to my high school agriculture teacher, Mrs. Terry Toney. She launched my lifelong journey into the great outdoors and the agriculture industry. She was always there when I called in a thesis panic. She offered great advice, and I could never say thank you enough for everything she has done for me over the years. I hope I make her proud.

Finally, thanks to my mom for answering my phone calls when I was in tears. Graduate school is not my favorite thing, and she always encouraged me to keep going. I did it mom. I wrote a thesis, and I achieved my goal. Now it's on to more adventures, maybe invasive snake hunting.

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## **ABSTRACT**

Determining the public perception of invasive species in Louisiana is an important tool to help shape and develop future management decisions, educational material and ultimately public policy. Therefore, the primary purpose of this study was to determine the perceptions of adult Louisiana residents regarding invasive aquatic plant species and their management. An online survey was used to collect data on registered Louisiana residential boaters' perceptions towards invasive aquatic plants and their management. A postcard with a quick response code leading to the survey was mailed to 6,000 randomly selected Louisiana registered residential boaters. Of the 230 Louisiana registered boaters that participated in the study, the largest group of respondents was aged 60+. Most boaters did not belong to any environmental or conservation organizations, while most boaters participated in fishing or hunting. *Salvinia* (giant and common) was the plant identified most frequently by boaters.

The "Louisiana Department of Wildlife and Fisheries Website" was ranked as the most effective information source on invasive aquatic plant species by the largest number of respondents. Older boaters in Louisiana (60+) tended to have higher perceptions regarding the need for management of invasive aquatic plants. Registered boaters who were members of one or more environmental or conservation organizations had higher need for management perception scores as compared to boaters who were not a member. Invasive aquatic plants were reported as problematic for the majority of boaters while boating in Louisiana's waterways. Boaters considered the problem with invasive aquatic plants in Louisiana "Very Serious."

The researcher recommends a follow-up study in Louisiana be designed to study the behaviors of boaters related to invasive aquatic plants and attempt to measure boaters' intentions to prevent the future spread of these invaders in Louisiana.



# CHAPTER 1. INTRODUCTION

## 1.1. Invasive Species Around the World

Invasive species have been formally documented since the 1500s (Seebens et al., 2017). These species are brought into areas outside of their native range and compete with native plants, animals or other organisms for resources such as food, water and habitat, but may also prey on native species (Woinarski et al., 2015). Invasive species spread is the second greatest threat to biodiversity, preceded by habitat loss (Wilcove et. al, 1998). These invaders also threaten ecosystem processes (Anifowose & Fagorite, 2020) and cause worldwide economic losses of agricultural, forestry and fishery resources (Mack et al., 2000).

The term “invasive species” has been defined in numerous ways due to the ambiguity surrounding the term’s use and perceived meaning (Definitions Subcommittee of the Invasive Species Advisory Committee, 2006). Pereyra (2016) found that the term is used by many authors, but it is rarely defined, which could alter understanding among peers and lead to complications in research. The vagueness surrounding the term can also inhibit management efforts, including policy development (Definitions Subcommittee of the Invasive Species Advisory Committee, 2006) and negatively impact stakeholder education and communication on threats of invasive species (Iannone et al., 2020). For example, one study uses the invasive species definition “with regard to a particular ecosystem, a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health” (Executive Order No. 13,751, 2016, p. 88610). When discussing invasive species, “native” is another term needing clarification (Iannone et al., 2020) and uses the definition “a species that occurs naturally in a specified geographic region” (Iannone et al., 2020, p. 2).

The rates of introduced species continue to increase worldwide (Seebens et al., 2017), with help from human actions such as increasing global trade and commerce (Havel et al., 2015). Humans have transported thousands of species globally (Havel et al., 2015) with introductions being intentional or accidental (Kravitz et al., 2005). Seebens et al. (2017) found that on a global scale, there is no sign of saturation to the increase in alien species. However, not all introduced non-native species (i.e., alien species) pose threats or are considered invasive species (Iannone et al., 2020). Many of these introduced, non-native species are considered beneficial (Iannone et al., 2020). The introduced species that are considered invasive are a major concern globally.

## **1.2. Invasive Species Impacts in North America**

Invasive species caused an estimated \$1.26 trillion in economic costs to North America between 1960 and 2017 (Crystal-Ornelas, 2021). Pimental et al. (2005) noted 50,000 invasive species introductions have been estimated in the United States (U.S.). A species entering an ecosystem where it is not native nor possessing natural enemies can have serious consequences.

For example, the feral pig (*Sus scrofa* L.) causes an estimated \$1.5 billion in annual damages in the U.S. (Animal and Plant Health Inspection Service, 2020) and the United States Department of Agriculture (USDA) annually spends \$30.5 million to control the unwanted swine (Daniels, 2018). Feral pigs are the exact definition of an invasive species since they transmit disease to humans and animals, cause environmental damage because they root, trample and wallow causing substantial harm, compete with native wildlife for resources and cause economic damage to the agricultural industry, homeowner properties, etc. (Animal and Plant Health Inspection Service, 2020).

Previous research has examined the impact invasive species have on biodiversity in the U.S., with 42% of the 958 species listed as threatened or endangered in the U.S. are at risk, partly

or majorly, because of invasive species (Stein & Flack, 1996). The U.S. Forest Service (2021) states “nearly half of all species federally listed as threatened or endangered are thought to be at risk primarily due to the effects of invasive species.” Management of invasive species is pertinent to preserving biodiversity, U.S. ecosystems and reducing economic damages.

Numerous other invasive species have caused havoc to various U.S. ecosystems, including zebra mussels (*Dreissena polymorpha* Pallas) (Stein & Flack, 1996), hydrilla (*Hydrilla verticillata* (L.f.) Royle) (Theel et al., 2012), Burmese pythons (*Python bivittatus* Kuhl) (Little, 2020), and kudzu (*Pueraria montana* (Lour.) Merr.) (Harron et al., 2020). The federal government spends billions of dollars annually to limit the spread of invasive species (Crafton & Angadjivand, 2018). Additional research is needed on the economic impacts of invasives, particularly aquatic invasive species (AIS) (Lovell et al., 2006). This research is essential to help plan and prioritize invasive species management (Harron et al., 2020).

### **1.3. Aquatic Invasive Species**

AIS are plants, animals and other organisms that inhabit an aquatic ecosystem outside of their native range and cause harm or have the potential to cause harm to the economy, the environment, plant, animal or human health (U.S. Fish and Wildlife Service, 2021). Crystal-Ornelas (2021) estimated >\$14 billion in damages caused by aquatic invaders in North America from 1960 to 2017. Even as invasive species continue to increase and present a threat to the U.S., the cost of prevention and management are not well known or documented, especially for AIS (Lovell et al., 2006).

Dudgeon et al. (2006) stated “Freshwater ecosystems may well be the most endangered ecosystems in the world” (p. 164). Ricciardi and Rasmussen (1999) found that biodiversity in freshwater is declining at a far greater rate than in terrestrial ecosystems, and that AIS are

considered one of the five major threats to global freshwater biodiversity (Dudgeon et al., 2006).

For example, an invader that has become a serious threat to Louisiana's freshwater ecosystem and the crawfish and rice industry is the channeled apple snail (*Pomacea maculata* G. Perry) [Louisiana Department of Wildlife and Fisheries, 2015; Wilson & Shirley, 2020]. These snails reproduce quickly and spread rapidly. While they consume large quantities of submersed vegetation (Wilson & Shirley, 2020), the snails are opportunistic and will also feed on decaying organisms (Bernatis, 2014), eggs of amphibians (Wilson & Shirley, 2020) and a wide variety of other aquatic plants, including emergent and floating vegetation (Burks et al., 2017). Possessing these traits allows the mollusks to cause habitat degradation and outcompete native aquatic animals for resources (Louisiana Department of Wildlife and Fisheries, 2015).

Invasive species are destructive in both fresh and saltwater environments. An invasive species that is threatening to destroy Louisiana's coastal wetlands is the nutria, (*Myocastor coypus* J.I. Molina). According to the Louisiana Department of Wildlife and Fisheries (2019), nutria were accidentally or intentionally released into Louisiana's coastal wetlands in the 1930s and have contributed to the state's coastal erosion due to their voracious appetite for native wetlands plants. There are an estimated 20 million nutria living in Louisiana's coastal marshes, causing vegetative damage to thousands of acres. (U.S. Fish & Wildlife Service, 2012).

With Louisiana's extensive coastal wetlands, 2.5 million acres (Demas & Demcheck, 1996) and over 125,00 miles of rivers, bayous and streams (RTI International, n.d.), it is considered the "Sportsman's Paradise", but the state also suffers immensely from AIS (Kravitz et al., 2005). In addition to the state's abundant water resources, AIS thrive thanks to Louisiana's subtropical climate, long growing season (i.e., mild winters) and abundant annual rainfall (Louisiana Department of Wildlife and Fisheries, 2015). Thirty-three percent of the 12 most

destructive invasive species in the U.S. occur in Louisiana (Stein & Flack, 1996), which includes the invasive submersed aquatic plant hydrilla.

In 2002, the Aquatic Invasive Species Council and Advisory Task Force was created to foster collaborations between organizations focused on controlling AIS in Louisiana. In 2005, these organizations helped create the State Management Plan for Invasive Species in Louisiana to discuss the impacts of AIS in the state and present management actions to help reduce negative impacts (Kravitz et al., 2005). The Aquatic Invasive Species Council and Task Forces deemed invasive species a major threat to Louisiana's biodiversity and economy (Kravitz et al., 2005).

In 2015, Louisiana Department of Wildlife and Fisheries (LDWF) created a Wildlife Action Plan that included a list of invasive species in Louisiana, divided into four tiers, which have or are likely to have impacts on Species of Greatest Conservation Need (SGCN) and their habitats. Tier I invasive species were categorized as "currently having severe or widespread negative impacts on wildlife or natural communities in Louisiana." Out of the 43 invasive species listed in Tier I, 17 are AIS (Louisiana Department of Wildlife and Fisheries, 2015). To manage existing invasive aquatic plants, LDWF utilizes an integrated pest management approach, including chemical, mechanical and biological controls (Louisiana Department of Wildlife and Fisheries, 2021). To develop AIS prevention and management plans, it is important to understand the pathways through which AIS are introduced.

#### **1.4. Pathways for Introduction and Spread**

Invasive species may enter a new region by three modes: importation of a commodity, arrival of transport vector and/or natural spread from a neighboring region where the species itself is non-native (Hulme, 2009). Introductions of many invasive species are caused by humans,

through either intentional or unintentional introductions (Seebens et al., 2017), including the shipping industry (Kravitz et al., 2005), the aquaculture industry (U.S. Congress, Office of Technology Assessment, 1993), the aquarium industry (Padilla and Williams, 2004), gardening and boating (Kubeck, 2008).

Within the last 60 years, the increased global trade in commodities has led to an acceleration in the number of introduced biological invaders (Hulme, 2009). It comes as no surprise that the shipping industry in Louisiana is the state's premiere pathway for unintentional species introductions (Kravitz et al., 2005). Based on cargo tons, Louisiana hosts the busiest port system in the nation, and one of the most problematic ways an invasive species is transported through the shipping pathway is ballast water, which is used as a weight on the cargo hold of a ship to prevent overturn (Kravitz et al., 2005; Hulme, 2009).

The aquaculture industry is another pathway for AIS introductions (U.S. Congress, Office of Technology Assessment, 1993). The aquaculture industry in Louisiana has the most acreage compared to any other state (Kravitz et al., 2005) and in 2018, the total economic impact of commercial aquaculture in Louisiana was \$673.2 million (Guidry & Gould, 2019). Commercial aquaculture in Louisiana involves the farming of products such as red swamp crawfish (*Procambarus clarkii* Girard), white river crawfish (*Procambarus zonangulus* Hobbs and Hobbs), alligators (*Alligator mississippiensis* Daudin), oysters (*Crassostrea virginica* Gmelin), crabs (*Callinectes sapidus* Rathbun & *Menippe adina* Williams and Felder), baby turtles and ornamental fish (Guidry & Gould, 2019). Some species like tilapia (multiple fish species in the family Cichlidae), are farmed for human-consumption, while others such as the sterile agent grass carp (*Ctenopharyngodon idella* Cuvier and Valenciennes) is used for biological control of

aquatic plants (Weeks & Hill, 2021), respectively, can become invasive if they escape cultivation (Kravitz et al., 2005).

The aquarium industry is recognized as a well-known pathway for invasive aquatic plant introductions (Padilla and Williams, 2004). In 2004, the aquarium industry was growing 14% annually worldwide (Padilla & Williams, 2004). This is a highly unregulated industry (Padilla & Williams, 2004), where aquarium and pet stores sell both plant and animal species, with the majority being non-native (Kravitz et al., 2005). The dioecious biotype of hydrilla was introduced to Florida in the 1950s as an aquarium plant, where it quickly escaped cultivation and has spread throughout the southeastern U.S. and California (Gettys & Enloe, 2019). Releases of invasive aquatic plants and animals occur mainly due to “aquarium dumping”, or when an aquarium or pet owner does not wish to care for their pet and these organisms are humanely released into a waterbody and ultimately become issues for others to manage (Kravitz et al., 2005). An aquarium dumping was thought to be the source of introduction for the floating fern, giant salvinia (*Salvinia molesta* D.S. Mitchell) and hydrilla in Louisiana (Kravitz et al., 2005).

Water gardening has also gained popularity and become a contributing pathway for invasive aquatic plant introductions in the U.S. (Kay & Hoyle, 2001), including Louisiana (Kravitz et al., 2005). Many nurseries lack knowledge on the aquatic plants they sell, and invasive plant species are often misidentified or sometimes intentionally misrepresented as non-invasive species (Kay & Hoyle, 2001). Accelerating the spread is the selling of these invaders via global e-commerce (Kay & Hoyle, 2001; Kravitz et al., 2005), and there is a need for online plant trade regulation. Humair et al. (2015) found many invasive plants were offered online daily to ship to most countries in the world and Kay and Hoyle (2001) found that most plants sold on

websites were included on the Federal Noxious Weed List or as a noxious weed in one or more states.

Hulme et al. (2008) suggested that intentional releases, like in the aquarium and horticulture industry, should be the easiest to regulate, but developing legislation for these sectors has proved difficult. There is a Federal Noxious Weed List, but each state maintains their own noxious weed list, that may include or exclude plants from the Federal Noxious Weed List (Kay & Hoyle, 2001). To add to the confusion, noxious weed lists may differ among state agencies (Kay & Hoyle, 2001). In Louisiana, the law states that noxious plants cannot be transported across state lines into Louisiana (Kravitz et al., 2005). The loophole in the law is that once a plant is within the state, it is not illegal to sell or transport across Louisiana (Kravitz et al., 2005). This has led to the selling of the invasive aquatic plants: water lettuce (*Pistia stratiotes* L. Royle), water hyacinth (*Eichhornia crassipes* (Mart.) Solms), giant salvinia and others at Louisiana nurseries and water garden stores (Kravitz et al., 2005).

Four recreational activities—boating, fishing, hunting and gardening—have the potential to introduce and spread invasive species across the Bayou State (Kubeck, 2008). Gardening is consistently listed as a top hobby in the U.S. (Reichard & White, 2001). With uninformed gardeners and aquarium hobbyists becoming vectors for AIS, these groups often unintentionally spread these invaders by sharing among friends and gardening clubs (Kay & Hoyle, 2001) and disposing of the plants into natural waterways (Illinois-Indiana Sea Grant, 2007). The U.S. Congress, Office of Technology Assessment (1993) suggests public education and awareness program development should target the introductions of ornamental plants, including invasive aquatic plants.



Recreational boating is considered an important vector in the spread of AIS (Kelly et al., 2013), and is considered a primary means by which AIS such as hydrilla, common salvinia (*Salvinia minima* Baker) and giant salvinia are spread through Louisiana's waterways (Kravitz et al., 2005; Louisiana Department of Wildlife and Fisheries, 2015). Boaters can unintentionally transport AIS from one body of water to another if they do not thoroughly wash and rinse their boat and boat trailer (Kravitz et al., 2005). These small invaders can become wedged/trapped between the boat and trailer padding and survive for several days (C. Mudge, personal communication, January 17, 2023). Kelly et al. (2013) suggests increasing public awareness of proper boater hygiene practices to limit these issues. Other pathways for AIS introductions that concern Louisiana include transportation corridors, river diversions, deliberate sportfish stocking, baitfish introductions and the agricultural industry (Kravitz et al., 2005).

### **1.5. Aquatic Invasive Plant Species in Louisiana**

Invasive plants disrupt entire ecosystems by replacing native plants and animals, which causes one of the greatest ecological threats (Mack et al., 2000). According to U.S. Congress (Office of Technology Assessment, 1993), \$100 million is invested annually in alien species aquatic weed control. Invasive aquatic plants clog waterways, limit recreational use, hinder waterborne navigation (Mudge & Ribbeck, 2021), reduce water quality, hinder native flora, damage fisheries and waterfowl habitat and negatively impact the overall ecology of Louisiana's waterways and economy (Sanders et al., 2010). Invasive aquatic plants include "plants and algae that grow partially or entirely submerged in water" (Anderson 2011; Smith 2011) and are non-native organisms "whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health" (Executive Order No. 13,751, 2016, p. 88610).

Invasive aquatic plants have certain attributes that allow them to thrive in the ecosystems they invade including the ability to adapt to a wide range of environmental conditions, reproducing early and often, growing rapidly and thwarting management control efforts (Anifowose & Fagorite, 2020; Illinois-Indiana Sea Grant, 2007). Over 30 invasive aquatic plants have been documented in Louisiana based on data collected by Anifowose and Fagorite (2020) from the United States Geological Survey Non-indigenous aquatic species database and United States Department of Agriculture Early Detection and Distribution Mapping system. Some of these species have been eradicated, but most are continuing to spread across the state (Anifowose & Fagorite, 2020). The Wildlife Action Plan (Louisiana Department of Wildlife and Fisheries, 2015) lists seven aquatic invasive plant species in Tier I of the Louisiana Invasive Species List, which include hydrilla, water hyacinth, common salvinia and giant salvinia.

Not only is hydrilla considered a Tier 1 invasive species in Louisiana (Louisiana Department of Wildlife and Fisheries, 2015), it is also listed as one of the dozen most destructive invasive species in the U.S. (Stein & Flack, 1996). Introduced to Louisiana in the 1970s, this submersed invasive aquatic plant can form dense mats, block light to the lower water column, displace native plants and degrade water quality (Louisiana Department of Wildlife and Fisheries, 2015; Mudge & Ribbeck, 2021). Hydrilla also limits aquatic recreation and at times has caused waterbodies to be unusable for recreation, including Henderson Lake in the Atchafalaya Basin (Anifowose & Fagorite, 2020). This invader is easily transferred between waterbodies via boats and trailers and is essentially distributed statewide (Louisiana Department of Wildlife and Fisheries, 2015).

Water hyacinth was distributed as a gift at the 1884 World's Industrial and Cotton Centennial Exposition in New Orleans (Sanders et al., 2010). It remains the first documented

AIS in Louisiana and has the most documented observations to date (Anifowose & Fagorite, 2020; Sanders et al., 2010). Because of its beautiful, lavender flowers, it became a popular plant with gardeners, and it has since escaped cultivation (Louisiana Department of Wildlife and Fisheries, 2015). Water hyacinth spreads rapidly by producing daughter plants (i.e., clones of parent plant) and creates dense mats of plants that clog waterways, hinders boat traffic, reduces biodiversity by crowding out native plants and lowers water quality which harms aquatic wildlife (Louisiana Department of Wildlife and Fisheries, 2015; Mudge & Ribbeck, 2021). This invasive aquatic plant is listed as one of the world's worst invasive alien species, and has spread to more than 50 countries on five continents (Padilla and Williams, 2004; Lowe et al., 2000/2004). As of 2015, water hyacinth was considered the most widely distributed invasive aquatic plant in Louisiana (Anifowose & Fagorite, 2020) (see Fig. 1.1) (Louisiana Department of Wildlife and Fisheries, 2015), and it is estimated that \$111 million has been spent on its management and research from 1975-2014 (Wainger et al., 2017).

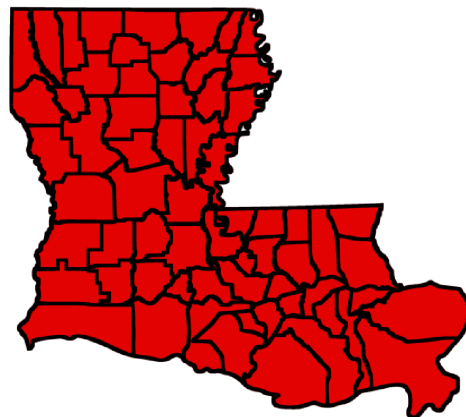


Figure 1.1. Distribution of water hyacinth from field observations by LDWF fisheries staff (Louisiana Department of Wildlife and Fisheries, 2015).

Giant salvinia is a free-floating invasive aquatic fern that was first documented in the Toledo Bend Reservoir in the late 1990s (Anifowose & Fagorite, 2020) and has aggressively spread throughout most of the state's inland and coastal waterways (Mudge & Ribbeck, 2021).

After the Louisiana Department of Agriculture and Forestry discovered the plant was being sold for water gardens, sales were banned, but the infestation had already begun (Sanders et al., 2010). This fern forms a thick mat (Thomas & Room, 1986), displaces native vegetation (McFarland et al., 2004), degrades water quality and hinders recreational use (Thomas & Room, 1986). This invader spreads easily via vegetative growth and is unintentionally transported by boats and trailers (Louisiana Department of Wildlife and Fisheries, 2015). Giant salvinia damage in Louisiana has an annual economic impact of \$6.9 million in the state (LSU Division of Strategic Communications, 2015). In 2019, giant salvinia had established in nearly every parish in Louisiana (Moshman & Diaz, 2019).

Common salvinia is a floating aquatic invasive fern that is closely related to giant salvinia, but less aggressive (Mudge & Ribbeck, 2021). It was first reported in Louisiana near Bayou Teche in 1980 (Anifowose & Fagorite, 2020) and forms a single layer on the water's surface (Mudge & Ribbeck, 2021) that crowds out native plants and negatively impacts wildlife (Louisiana Department of Wildlife and Fisheries, 2015). It has been found essentially statewide and is often spread via boats and trailers (Louisiana Department of Wildlife and Fisheries, 2015).

## **1.6. Management of Invasive Species**

Managing unwanted vegetation is a complex issue since it is highly multidisciplinary (Kravitz et al., 2005) and there are many obstacles that hinder efforts to manage these invaders. A few of these factors include the ambiguity and perceived meaning surrounding the term “invasive species” (Definitions Subcommittee of the Invasive Species Advisory Committee, 2006), development and implementation of regulatory policies to control invasive species introductions (Kravitz et al., 2005), deciding the best control method based on efficiency and cost-effectiveness (Buhle et al., 2005), and the public perception of invasive species and the role

the public plays in invasive species management (Oxley et al., 2016; Wilson, 2012; Norgaard, 2007).

Bremner and Park (2007) focus on the importance of public support and how it can play a key role in the success or failure of control or eradication projects for an invasive species. It is important to consider the public's perception before implementing these plans. For example, in February 2017, the growing feral hog problem in Texas led to the Texas Agriculture Commissioner, Sid Miller, approving a warfarin laced-bait food (Kaput® Feral Hog Bait) as a management action in the fight against feral hogs (Frey, 2017). In April 2017, the bait manufacturer withdrew its Texas registration after facing strong backlash from the community including hunters, meat processors and environmentalists (Murphy, 2017) because of concerns relating to ingestion of the bait by non-target species, including humans (Frey, 2017).

Norgaard (2007) notes that herbicides are one of the main management actions that sparks social controversy regarding invasive species. In 1997, the invasive species spotted knapweed (*Centaurea stoebe* L. subsp. *micranthos* (Gugler) Hayek) was found in a rural region of northern California and the U.S. Forest Service proposed use of an herbicide treatment sparked an ongoing controversy with 90% of community members in the region opposing the plan (Norgaard, 2007). The project has been placed on hold “due to lack of funding” with U.S. Forest Service members alluding to the controversy as a factor (Norgaard, 2007). These examples demonstrate how public support or opposition are contributing factors in invasive species management.

Currently, LDWF implements an integrated pest management (IPM) program for invasive aquatic plants including biological, chemical and mechanical control (Anifowose & Fagorite, 2020). For example, giant salvinia is managed with an IPM approach of biological

control (salvinia weevil,) (*Cyrtobagous salviniae* Calder & Sands), chemical control (foliar/subsurface herbicide applications) and mechanical control (lake drawdowns) (Kravitz et al., 2005; Sartain, 2018). Even with continued management efforts from LDWF and the State Management Plan for Aquatic Invasive Species in Louisiana, the spread of invasive aquatic plants continues in Louisiana (Anifowose & Fagorite, 2020).

### **1.7. Public Perception of Invasive Species and the Need for Education**

Invasive species issues are multidisciplinary, which can impede progress when management plans and policies are being developed (Kravitz et al., 2005). Sometimes, substantial conflicts of interest arise when management plans are constructed (Novoa et al., 2017). Public awareness, knowledge and support are important social dimensions to consider when creating plans for prevention, management and control of invasive species (Bremner & Park, 2007; Oxley et al., 2016; Novoa et al., 2017; Eiswerth et al., 2011).

Awareness and education are key components to increase public support for invasive species control and management projects. Bremner and Park (2007) found that participants who supported management and eradication programs had prior knowledge of these programs. Novoa et al. (2017) found that when the public was informed about the invasive status of a species and its prior negative impacts, there was an increased public support for management actions. Not only does public education and awareness help increase support for management efforts, but it can also help prevent species introductions and control existing invasive species (Wilson, 2012). Louisiana Department of Wildlife and Fisheries (2015) discusses the importance of educating the public on invasive species to help prevent further introductions into Louisiana. The lack of education about invaders has been recognized by the State Management Plan for Aquatic Invasive Species in Louisiana (Kravitz et al., 2005), but also notes the lack of funding for

educational outreach. The plan discusses the development of a “Citizens Guide to Invasive Species in Louisiana” and the development of a statewide invasive species educational and informational website, but funding is lacking.

Determining the public perception of invasive species in Louisiana is an important tool to help shape and develop future management decisions, educational material and ultimately public policy. Invasive aquatic plants continue to threaten Louisiana’s inland freshwater system of rivers, streams, lakes, swamps and ponds (Anifowose & Fagorite, 2020). Therefore, to help with prevention and management of these species, public awareness and attitudes are important to take into consideration. Since 2010, several research studies have been conducted on social perceptions of invasive species, but this area of research is still at the early stages (Kapitza et al., 2019). Kravitz et al. (2005) recommended the State Management Plan for Aquatic Invasive Species in Louisiana be evaluated partially through quantitative social measures, including knowledge of invasive species and management actions taken by the public. Although research studies have assessed public perception in other states (Oxley et al., 2016; Williams et al., 2021; Wilson, 2012), Louisiana residents have not been surveyed on their perceptions of invasive aquatic plants impacting the state.

Therefore, the primary purpose of this study was to determine the perceptions of adult Louisiana residents regarding invasive aquatic plant species and their management.

The following objectives were established to aid in accomplishing the purpose of the study:

- To describe adult (18+) Louisiana residents who were registered boaters on the following characteristics:
  1. Parish of residence;

2. Age;
3. Employment status;
4. Membership in environmental or conservation organizations;
5. Highest level of education completed;
6. Participation in:
  - a. Gardening;
  - b. Fishing;
  - c. Boating;
  - d. Hunting.

- To determine the perceptions of adult Louisiana residents who were registered boaters regarding the awareness and impacts of invasive aquatic plant species in Louisiana.

- To determine the perceptions of adult Louisiana residents who were registered boaters regarding the need for management of invasive aquatic plant species in Louisiana.

- To determine the currently used and perceived effectiveness of selected sources of information regarding invasive aquatic plant species among Louisiana adults who were registered boaters.

- To determine if a relationship exists between the perceptions of adult Louisiana residents who were registered boaters regarding the need for management of invasive aquatic plant species in Louisiana and each of the following socio-demographic characteristics:

1. Age;
2. Membership in environmental or conservation organizations;
3. Highest level of education completed;
4. Participation in:



- a. Gardening;
- b. Fishing;
- c. Hunting.

## CHAPTER 2. METHODOLOGY

### 2.1. Population and Sample

The target population for this study was defined as adult residents of the state of Louisiana. Adult residents of Louisiana were defined as “all adult individuals of the age eighteen or older, living or residing within the legal boundaries of the state” Richard (2009). The defined target population of the state was estimated at 3,560,976, excluding anyone under the age of 18 (U.S. Census Bureau, 2019). A person must be a permanent resident and be a taxpayer to the state of Louisiana to be considered a legal resident of Louisiana (Richard, 2009).

Voting and taxpayer lists are not always accessible, nor are email addresses available as they are protected by law. For these reasons and along with cost limitations, a non-probability sampling method was used for this research study. Since recreational boating is considered an important vector in the spread of aquatic invasive species (AIS) (Kelly et al., 2013), and is considered a primary means by which AIS spread through Louisiana’s waterways (Kravitz et al., 2005), a survey was distributed to a random sample of Louisiana residential boaters registered with the Louisiana Department of Wildlife and Fisheries (LDWF), a subset of the target population. Based on Cochran’s (1977) formula, the required minimum sample size for this study was 172.

$$\begin{aligned}n &= \frac{(t^2)(s^2)}{d^2} \\&= \frac{(1.96)^2(.67)^2}{(.1)^2} \\&= \frac{3.84(.449)}{.01} \\n &= 172\end{aligned}$$

## **2.2. Instrumentation**

An online survey was established using Qualtrics to collect data on registered Louisiana residential boaters' perceptions towards invasive aquatic plants and their management (see Appendix B). The survey instrument was adapted from three existing survey instruments (Wilson, 2012; Bremner & Park, 2007; Oxley et al., 2016). It was modified to accomplish the goals and objectives of this research. To ensure content validity, an expert review board examined the survey for modifications. The review board consisted of the following individuals: Ms. Kate Wilson, Commission Administrator for the Montana Department of Natural Resources & Conservation, Dr. Michael Burnett, Department Head of the Agricultural and Extension Education and Evaluation Department and Mr. Daniel Hill, Louisiana Department of Wildlife and Fisheries Biologist Manager, Aquatic Plant Control – South.

The survey instrument was separated into four sections. The first section investigated registered boaters' perceptions regarding the awareness and impacts of invasive aquatic plants. The second section investigated their perceptions towards the need for management of invasive aquatic plants. The third section assessed where the respondents currently accrued information on invasive aquatic plants and their perceived effectiveness of the information. The final section described the registered boaters on selected sociodemographic characteristics.

## **2.3. Data Collection**

Permission for conducting this study and accessing the data was approved by the Institutional Review Board (IRB). Approval was granted as the online survey presented minimal risks for respondents (see Appendix A). In addition to the expert review panel, additional oversight was provided by Mr. Alexander Perret, former LDWF Operations Manager (Inland

Fisheries), and Dr. Jack Isaacs, LDWF Economist who reviewed the survey and granted approval for LDWF's collaboration in distributing the survey.

The online survey was distributed on August 2022. Invasive aquatic plants are actively growing and invading Louisiana waterways during the summer months. This time frame was chosen as registered boaters were more likely to be aware of invasive aquatic plants when they were actively causing problems.

The online survey was administered to a random sample of 6,000 registered Louisiana residential boaters (311,442 total in state) (S. Byrd, personal communication, March 21, 2022). The LDWF sent physical mailing addresses for the 6,000 randomly selected boaters to the Office of Technology Services (OTS) Production Support Services Enterprise Print Center, a sector of the OTS agency that provides printing operations for various state agencies in Louisiana. The OTS Production Support Services Enterprise Print Center addressed and mailed 6,000 postcards with a quick response (QR) code to direct boaters to the online survey (see Appendix C). Selected boaters were given approximately one month to complete the survey from the mailing date. No incentives were given for survey participation. Data was collected using the online survey form via Qualtrics and analyzed using the IBM Statistical Package for the Social Sciences (SPSS). When the survey closed in Qualtrics, a total of 230 usable responses had been received. This number exceeds the minimum acceptable response of 150.

## **2.4. Data Analysis**

Throughout the study, the alpha level of 0.05 was utilized in all of the statistical tests.

The first objective of the study was:

To describe adult (18+) Louisiana residents who were registered boaters on the following characteristics:

1. Parish of residence;
2. Age;
3. Employment status;
4. Membership in environmental or conservation organizations;
5. Highest level of education completed;
6. Participation in:
  - a. Gardening;
  - b. Fishing;
  - c. Boating;
  - d. Hunting.

Objective one was accomplished utilizing descriptive statistical techniques. Variables that were measured on a categorical scale of measurement were summarized using frequencies and percentages in categories.

The second objective of the study was:

- To determine the perceptions of adult Louisiana residents who were registered boaters regarding the awareness and impacts of invasive aquatic plant species in Louisiana.

For the second objective, the mean and standard deviation was reported for each of the items used to measure their familiarity with invasive aquatic plant species. The scale used to measure this familiarity was a five-point anchored scale with values ranging from 1 = No familiarity to 5 = Extreme familiarity. The mean and standard deviation was reported for each of the items used to measure their perceptions of the seriousness of the invasive aquatic plant problem. The scale used to measure this seriousness was a five-point anchored scale with values ranging from 1 = Not at all serious to 5 = Extremely serious. The mean and standard deviation

was reported for each of the items used to measure the amount of information they had heard or read about each of the selected invasive aquatic plants included in the study. The scale used to measure this construct was a four-point anchored scale with values ranging from 1 = No information to 4 = A large amount of information.

The third objective was:

- To determine the perceptions of adult Louisiana residents who were registered boaters regarding the need for management of invasive aquatic plant species in Louisiana.

The mean and standard deviation was reported for each of the items used to measure the participants' perceptions regarding the need for management of invasive aquatic plants for objective three. The scale used to measure these perceptions was a five-point Likert-type scale with values ranging from 1 = Strongly disagree to 5 = Strongly agree. The scale values were then further summarized by computing the mean scores for overall scale. The mean and standard deviation was also reported for each of the items used to measure the participants' perceptions regarding their opinions towards invasive aquatic plant control methods. The scale used to measure these perceptions was a five-point Likert-type scale with values ranging from 1 = Strongly opposed to 5 = Strongly favor. The scale values were then further summarized by computing the mean scores for the overall scale.

The fourth objective was:

- To determine the currently used and perceived effectiveness of selected sources of information regarding invasive aquatic plant species among Louisiana adults who were registered boaters.

The fourth objective was accomplished by ranking the sources of information based on both the number of times they were reported as used and the ranking of the effectiveness of each source.

The fifth objective of the study was:

- To determine if a relationship exists between the perceptions of adult Louisiana residents who were registered boaters regarding the need for management of invasive aquatic plant species in Louisiana and each of the following socio-demographic characteristics:

1. Age;
2. Membership in environmental or conservation organizations;
3. Highest level of education completed;
4. Participation in:
  - a. Gardening;
  - b. Fishing;
  - c. Hunting.

To accomplish the fifth objective, both relational and comparative statistical procedures were used. For those independent variables that were measured on an ordinal scale of measurement, the Spearman Rank Order correlation coefficient was used. For the independent variables that were measured on a categorical scale (nominal or ordinal), the perception scale scores were compared by categories of the independent variable. Since all of the other independent variables were measured as binary variables, the test that was used was the t-test.

## CHAPTER 3. RESULTS

### 3.1. Objective One: Description of Registered Boaters in Louisiana on Selected Demographic Characteristics

The first objective of this study was to describe adult (18+) Louisiana residents who were registered boaters on the following characteristics: parish of residence, age, employment status, membership in environmental or conservation organizations, highest level of education completed and participation in gardening, fishing, boating and hunting. Two hundred-thirty adult Louisiana residents who were registered boaters participated in the survey. The results for each of these variables are described here.

#### Parish of Residence

The first variable on which adult Louisiana residents who were registered boaters were described was their parish of residence. A total of 47 parishes were selected by the 230 registered boaters who responded. The parish of residence reported most frequently was East Baton Rouge (n = 16, 7.0%), followed by Caddo (n = 13, 5.7%), Lafayette (n = 13, 5.7%) and Rapides (n = 13, 5.7%) (see Table 3.1).

Table 3.1. Parishes with the Greatest Respondents of Adult Louisiana Residents Who Were Registered Boaters

Parish	Frequency	Percent
East Baton Rouge	16	7.0
Caddo	13	5.7
Lafayette	13	5.7
Rapides	13	5.7
Terrebonne	12	5.2
Ascension	11	4.8
Calcasieu	11	4.8
Total	89	38.9

*Note.* A complete list of all parishes selected by registered boaters is reported in Appendix D.



## Age

The next variable on which the respondents were described was their age. Survey respondents were asked to select the most appropriate age category from the following choices: 18-29, 30-39, 40-49, 50-59 and 60+. Of the 206 respondents who identified their age, the largest group of respondents was 60+ (n = 120, 58.3%). The second largest group of respondents identified their age as 50-59 (n = 45, 21.8%). Respondents ages 18-29 was the least frequently selected response category (n = 5, 2.4%) (see Table 3.2).

Table 3.2. Age of Adult Louisiana Residents Who Were Registered Boaters

Age	Frequency	Percent
18-29	5	2.4
30-39	15	7.3
40-49	21	10.2
50-59	45	21.8
60+	120	58.3
Total	206 <sup>a</sup>	100.0

<sup>a</sup>24 of the participants did not report their age.

## Employment Status

Another variable on which the boaters were described was their employment status. Of the 203 respondents who reported their employment status, the largest percentage of respondents were employed full-time (n = 100, 49.3%). Respondents identifying their employment status as retired (n = 97, 47.8%) made up the second greatest-responding group (see Table 3.3).

Table 3.3. Employment Status of Adult Louisiana Residents Who Were Registered Boaters

Employment Status	Frequency	Percent
Employed Full-time	100	49.3
Retired	97	47.8
Employed Part-time	3	1.5
Unemployed	3	1.5
Student	0	0.0
Total	203 <sup>a</sup>	100.0

<sup>a</sup>27 of the participants did not report their employment status.

## Membership in Environmental or Conservation Organizations

Membership in environmental or conservation organizations was another variable that was used to describe adult Louisiana residents who were registered boaters. Of the 204 respondents, 158 boaters (77.5%) identified that they were not members of any environmental or conservation organizations, while 46 boaters (22.5%) identified that they were members of one or more environmental or conservation organizations. No response to this item was provided by 26 of the participants.

## Highest Level of Education Completed

The next variable on which the respondents were described was their highest level of education completed. Of the 203 respondents who reported their highest level of education completed, the largest group of boaters identified as having a high school diploma (n = 84, 41.4%). The second largest group of respondents identified having a bachelor's degree (n = 54, 26.6%) (see Table 3.4).

Table 3.4. Highest Level of Education Completed by Adult Louisiana Residents Who Were Registered Boaters

Level of Education	Frequency	Percent
Less Than High School	6	3.0
High School Diploma	84	41.4
Associate degree	28	13.8
Bachelor's Degree	54	26.6
Master's Degree	21	10.3
Doctorate	10	4.9
Total	203 <sup>a</sup>	100.0

<sup>a</sup>27 of the participants did not report their highest level of education completed.

## Participation in Gardening, Fishing and Hunting

Participation in outdoor activities – gardening, fishing and hunting – was another variable used to describe adult Louisiana residents who were registered boaters. Respondents

were asked to select the outdoor activities that applied to them. Multiple answers were accepted. The majority of respondents (n = 195, 96.5%) included fishing as an outdoor activity in which they participated. Additionally, of the 202 boaters that responded, 146 (72.3%) included hunting as an outdoor activity in which they participated (see Table 3.5).

Table 3.5. Participation in Outdoor Activities by Adult Louisiana Residents Who Were Registered Boaters

Outdoor Activity	Frequency <sup>a</sup>	Percent <sup>b</sup>
Fishing	195	96.5
Hunting	146	72.3
Gardening	132	65.3
Hunting, Fishing & Gardening	96	47.5
Hunting & Fishing	47	23.3
Fishing & Gardening	31	15.3
Hunting & Gardening	1	0.5

<sup>a</sup>A total of 202 participants responded to this item. 28 did not report their participation in gardening, fishing and hunting.

<sup>b</sup>Percentages do not total to 100 since respondents were asked to mark all that apply.

### Participation in Boating

Another variable on which the boaters were described was the number of boating trips taken on Louisiana's waterways, including rivers, streams, marshes, lakes, ponds and swamps, during the past year. Approximately half of the respondents (n = 109, 50.7%) reported they had taken 20 or more boating trips on Louisiana's waterways. Of the 215 boaters who responded to this item, 59 boaters (27.4%) reported that they had taken 9 or fewer boating trips on Louisiana's waterways in the past year (see Table 3.6).

Table 3.6. Number of Boating Trips in Louisiana Taken by Adult Louisiana Residents Who Were Registered Boaters

Boating Trips	Frequency	Percent
0-9	59	27.4
10-19	47	21.9
20+	109	50.7

(table cont'd.)

Boating Trips	Frequency	Percent
Total	215 <sup>a</sup>	100.0

<sup>a</sup>15 of the participants did not report the number of boating trips taken in Louisiana.

### **3.2. Objective Two: Louisiana Registered Boaters Perceptions Regarding Awareness and Impacts of Invasive Aquatic Plant Species**

Participants were asked how familiar they were with invasive aquatic plant issues in Louisiana. The mean familiarity score derived from the 226 responses received was 3.46 (SD = 1.088) with values ranging from 1 to 5. To further interpret this data, the researcher established an interpretive scale with the values as follows:  $\leq 1.50$  = “Not Familiar at All,” 1.51 to 2.49 = “Slightly Familiar,” 2.50 to 3.49 = “Moderately Familiar,” 3.50 to 4.49 = “Very Familiar” and 4.50 or higher = “Extremely Familiar.” Using this interpretative scale, the mean response falls into the “Moderately Familiar” category. Four boaters chose not to respond to this item.

As a follow-up to the previous item, adult Louisiana residents who were registered boaters were asked to provide an example of an invasive aquatic plant in Louisiana if they knew of one. A total of 159 boaters correctly provided an example of one or more invasive aquatic plants. The most frequently identified plant was salvinia, collectively known as giant and/or common salvinia ( $n = 82$ , 48.2%). The next most frequently identified plant was water hyacinth ( $n = 63$ , 37.1%) (see Table 3.7).

The registered boaters were asked their opinion on how serious of a problem invasive aquatic plant species are in Louisiana. The mean seriousness score derived from the 219 responses received was 4.23 (SD = 0.831) with values ranging from 1 to 5.

To further interpret this data, the researcher established an interpretive scale with the values as follows:  $\leq 1.50$  = “Not at All Serious,” 1.51 to 2.49 = “Slightly Serious,” 2.50 to 3.49 = “Moderately Serious,” 3.50 to 4.49 = “Very Serious” and 4.50 or higher = “Extremely Serious.”

Table 3.7. Invasive Aquatic Plants Identified by Adult Louisiana Residents Who Were Registered Boaters

Invasive Aquatic Plant	Frequency <sup>a</sup>	Percent
Salvinia (Giant & Common)	82	48.2
Water Hyacinth	63	37.1
Hydrilla	17	9.9
Duckweed	3	1.8
Alligator Weed	3	1.8
Crested Floating Heart	1	0.6
Water Lettuce	1	0.6
Total	170	100.0

<sup>a</sup>159 registered boaters reported one or more invasive aquatic plant species. A Total of 170 invasive aquatic plant species were reported.

Using this interpretive scale, the mean response falls into the “Very Serious” category. Eleven boaters chose not to respond to this item.

Another aspect of the boaters’ awareness of invasive aquatic plant species was the amount of information the respondents had heard or read about selected invasive aquatic plant species. Boaters were asked to rate the amount of information they were exposed to on a four-point anchored scale with the following values: 1 = None, 2 = Small Amount, 3 = Moderate Amount, and 4 = A Large Amount. The following interpretive scale was established by the researcher to aid in the interpretation of the findings: 1.50 or less = “None,” 1.51 to 2.49 = “Small Amount,” 2.50 to 3.49 = “Moderate Amount” and 3.50 or higher = “A Large Amount.” The invasive aquatic plant species about which the respondents reported they knew the greatest amount of information was “Water Hyacinth” with a mean of 2.65 (SD = 1.014). Using the researcher designed interpretive scale, this item was classified as “Moderate Amount.” “Giant Salvinia” was also in the “Moderate Amount” of information category for the boaters (mean = 2.63, SD = 1.047). Overall, two plants were listed in the “Moderate Amount” category, four items in the “Small Amount” category, and one item was in the “None” category (see Table 3.8).

Table 3.8. Amount of Plant Information Heard or Read About by Adult Louisiana Residents Who Were Registered Boaters

Invasive Aquatic Plant	Frequency	Mean <sup>a</sup>	Standard Deviation	Category <sup>b</sup>
Water Hyacinth	211	2.65	1.014	Moderate Amount
Giant Salvinia	205	2.63	1.047	Moderate Amount
Common Salvinia	206	2.49	1.030	Small Amount
Hydrilla	208	2.43	0.924	Small Amount
Water Lettuce	208	1.79	0.863	Small Amount
Crested Floating Heart	209	1.51	0.791	Small Amount
Cuban Bulrush	209	1.43	0.744	None

*Note.* Range of responses was 1 to 4 for all listed invasive aquatic plants.

<sup>a</sup>Response scale included the following possible values: 4 = Large Amount, 3 = Moderate Amount, 2 = Small Amount, 1 = None

<sup>b</sup>Interpretive scale included the values: 1.50 or less = None, 1.51 to 2.49 = Small Amount, 2.50 to 3.49 = Moderate Amount, 3.50 or higher = Large Amount.

To investigate the perception of Louisiana registered boaters regarding impacts of invasive aquatic plants, the participants were asked if invasive aquatic plants caused problems for them while boating in Louisiana's waterways. One-hundred seventy boaters (73.9%) reported invasive aquatic plants caused them problems, while 44 boaters (19.1%) indicated that the plants had not caused issues for them while boating. Sixteen boaters chose not to respond to this item.

### **3.3. Objective Three: Louisiana Registered Boaters Perceptions Regarding the Management of Invasive Aquatic Plant Species**

To investigate the perceptions of registered boaters regarding the management of invasive aquatic plants, respondents were asked their opinions on a series of management related questions. They were asked to report their opinion for each statement on a Likert-type scale with the following values: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree and 5 = Strongly Agree. The following interpretive scale was established to aid in the interpretation of the findings: 1.50 or less = "Strongly Disagree," 1.51 to 2.49 = "Disagree," 2.50

to 3.49 = “Neither Agree nor Disagree,” 3.50 to 4.49 = “Agree” and 4.50 or higher = “Strongly Agree.”

The item with the highest level of agreement was “Invasive aquatic plant species should be controlled when they cause harm to Louisiana’s native plants and animals” with a mean of 4.88 (SD = 0.391) (see Table 3.9). All four of the items included in this scale received responses that were classified in the “Strongly Agree” category using the interpretive scale established by the researcher. To further examine the data from this series of items, an overall perceptions of registered boaters regarding the management of invasive aquatic plants score was established as the mean of the four items in the scale. The value of this overall perception score was 4.81 (SD = 0.433) with individual scores ranging from 2.0 to 5.0.

Table 3.9. Respondents Reported Opinions on Invasive Aquatic Plant Management Statements

Item	Mean <sup>a</sup>	SD	Category <sup>b</sup>
Invasive aquatic plant species should be controlled when they cause harm to Louisiana’s native plants and animals.	4.88 <sup>c</sup>	0.391	Strongly Agree
Invasive aquatic plant species should be controlled when they cause economic damage to Louisiana.	4.87 <sup>d</sup>	0.439	Strongly Agree
Controlling some invasive aquatic plant species is necessary to help conserve Louisiana’s environment.	4.81 <sup>c</sup>	0.509	Strongly Agree
Protecting Louisiana waterways from invasive aquatic plants should be a Louisiana state government funding priority.	4.68 <sup>d</sup>	0.656	Strongly Agree

<sup>a</sup>Response scale of 1 to 5 included the following possible values: 5= Strongly Agree, 4= Agree, 3 = Neither Agree nor Disagree, 2 = Disagree, 1 = Strongly Disagree

<sup>b</sup>Researcher-designed interpretive scale included the values: 1.50 or less = Strongly Disagree, 1.51 to 2.49 = Disagree, 2.50 to 3.49 = Neither Agree nor Disagree, 3.50 to 4.49 = Agree, 4.50 or higher = Strongly Agree.

<sup>c</sup>n = 211

<sup>d</sup>n = 210

To further investigate the perceptions of registered boaters regarding the management of invasive aquatic plants, participants were asked their opinions on invasive aquatic plant control methods. Boaters were asked to report their opinion for each control method on a Likert-type

scale with the following values: 1 = Strongly Oppose, 2 = Somewhat Oppose, 3 = Neither Favor nor Oppose, 4 = Somewhat Favor, 5 = Strongly Favor. The following interpretive scale was established by the researcher to aid in the interpretation of the findings: 1.50 or less = “Strongly Oppose,” 1.51 to 2.49 = “Somewhat Oppose,” 2.50 to 3.49 = “Neither Favor nor Oppose,” 3.50 to 4.49 = “Somewhat Favor” and 4.50 or higher = “Strongly Favor.”

The control method that boaters favored the most was mechanical harvesting with a mean of 4.44 (SD = 0.760). The control method that boaters favored the least was drawdowns with a mean of 3.47 (SD = 1.215). Overall, one of the items was in the “Neither Favor nor Oppose” category and three of the items were in the “Somewhat Favor” category (see Table 3.10).

As a follow-up to the previous item, respondents were asked if the chosen method of control (aquatic herbicide, mechanical, biological or drawdown) would have an influence on their decision to support projects that would help control invasive aquatic plants in Louisiana waterways.

Table 3.10. Opinions on Invasive Aquatic Plant Control Methods From Adult Louisiana Residents Who Were Registered Boaters

Control Method	Mean <sup>a</sup>	SD	Category <sup>b</sup>
Mechanical harvesting methods (use of machines)	4.44 <sup>c</sup>	0.760	Somewhat Favor
Biological control methods (use of insects, fish, diseases and other bio agents)	3.93 <sup>c</sup>	1.056	Somewhat Favor
Aquatic herbicide control methods (use of chemicals)	3.88 <sup>d</sup>	1.173	Somewhat Favor
Drawdowns (process to lower water levels for a period of time)	3.47 <sup>d</sup>	1.215	Neither Favor nor Oppose

<sup>a</sup>Response scale of 1 to 5 included the following possible values: 5= Strongly favor, 4= Somewhat Favor, 3 = Neither Favor nor Oppose, 2 = Somewhat Oppose, 1 = Strongly Oppose

<sup>b</sup>Researcher-designed interpretive scale included the values: 1.50 or less = Strongly Oppose, 1.51 to 2.49 = Somewhat Oppose, 2.50 to 3.49 = Neither Favor nor Oppose, 3.50 to 4.49 = Somewhat Favor, 4.50 or higher = Strongly Favor.

<sup>c</sup>n = 207

<sup>d</sup>n = 208



There were 108 boaters (51.7%) who reported that the chosen method of control would impact their decision to support these projects. The number of boaters who reported that the chosen method of control would not impact their decision to support these projects was slightly less (n= 101, 48.3%). Twenty-two boaters chose not to respond to this item.

### **3.4. Objective Four: Louisiana Registered Boaters Perceptions Regarding Use and Effectiveness of Selected Information Sources**

The fourth objective was to determine the currently used and perceived effectiveness of selected sources of information regarding invasive aquatic plant species among adult (18+) Louisiana residents who were registered boaters. The results for each of these variables are as follows:

To investigate currently used sources of information regarding invasive aquatic plants, the researcher compiled a list of information sources and respondents were asked if they had heard or read about invasive aquatic plants from each of the sources using a yes or no response. The information sources were ranked by the number of times each was reported to have been used as an information source by the registered boaters. Respondents reported that they had heard or read about invasive aquatic plants from “Friends and Family” the most frequently (n = 105, 45.7%) followed by the “Louisiana Department of Wildlife and Fisheries Website” (n = 92, 40%) (see Table 3.11).

To investigate the perceived effectiveness of selected sources of information regarding invasive aquatic plants among registered boaters, respondents were asked to select and rank the three sources of information from the previous item that they considered most effective at providing information on invasive aquatic plant education and prevention.

The researcher designed the following analysis procedure: each information source that was ranked first was assigned a value of 15. Fifteen information sources were included in the list

of information sources. Any information source that was not ranked first was assigned a value of zero to complete the summary of this section of the rankings.

Table 3.11. Invasive Aquatic Plant Information Sources Ranked by Most Mentions by Adult Louisiana Residents Who Were Registered Boaters

Information Source	n <sup>a</sup>	%
Friends & Family	105	45.7
The Louisiana Department of Wildlife and Fisheries Website	92	40
Magazines/Journals	81	35.2
Television	62	27.0
Posted Signs at Boat Ramps	61	26.5
Other Social Media	56	24.3
Other Websites	50	21.7
Newspapers	48	20.9
The Louisiana Department of Wildlife and Fisheries Social Media	43	18.7
LSU AgCenter Website	32	13.9
Other	24	10.4
LSU AgCenter Social Media	21	9.1
Events/Conferences	19	8.3
Radio	14	6.1
YouTube	1	0.4

*Note.* n = 230

<sup>a</sup>Based on Yes or No response to each information source.

The information source that was ranked first by the largest number of respondents was the “Louisiana Department of Wildlife and Fisheries Website” (n = 70, 30.4%). The information source that was ranked first by the second largest number of respondents was the “Louisiana Department of Wildlife and Fisheries Social Media” (n = 26, 11.3%) (see Table 3.12).

Information regarding information sources ranked second by the respondents were also summarized. Each information source that was ranked second was assigned a value of 14. Any information source that was not ranked second was assigned a value of zero to complete the summary of this section of the rankings. The information source that was ranked second by the largest number of respondents was the “Louisiana State University Agricultural Center Website” (n = 28, 12.2%). The information source that was ranked second by the second largest number of

respondents was the “Louisiana Department of Wildlife and Fisheries Website” (n = 27, 11.7%) (see Table 3.12).

Finally, information sources that were ranked third by the respondents were also summarized. Each information source that was ranked third was assigned a value of 13. Any information source that was not ranked third was assigned a value of zero to complete the summary of this section of the rankings. The information source that was ranked third by the largest number of respondents was “Posted Signs at Boat Ramps” (n = 22, 9.6%). The information source that was ranked third by the second largest number of respondents was Television (n = 21, 9.1%) (see Table 3.12).

Table 3.12. Ranked Effectiveness of Invasive Aquatic Plant Information Sources by Adult Louisiana Residents Who Were Registered Boaters

Information Source	1st		Ranking 2nd		3rd	
	n	%	n	%	n	%
The Louisiana Department of Wildlife and Fisheries Website	70	30.4	27	11.7	12	5.2
The Louisiana Department of Wildlife and Fisheries Social Media	26	11.3	25	10.9	10	4.3
Television	18	7.8	12	5.2	21	9.1
Posted Signs at Boat Ramps	18	7.8	8	3.5	22	9.6
LSU AgCenter Website	16	7	28	12.2	17	7.4
Other Websites	7	3	5	2.2	11	4.8
Magazines/Journals	6	2.6	13	5.7	15	6.5
YouTube	6	2.6	6	2.6	9	3.9
Other Social Media	3	1.3	15	6.5	14	6.1
LSU AgCenter Social Media	3	1.3	11	4.8	11	4.8
Other	3	1.3	0	0	6	2.6
Newspapers	2	0.9	12	5.2	6	2.6
Radio	2	0.9	4	1.7	6	2.6
Events/Conferences	0	0	5	2.2	7	3.0
Friends & Family	0	0	0	0	0	0

*Note.* Total number of respondents = 230

Overall effectiveness of the listed information sources was analyzed. An effective rating score was computed as follows: the number of first place rankings multiplied by a factor of 15 plus the number of second place rankings multiplied by a factor of 14 plus the number of third place rankings multiplied by a factor of 13. This number was the effectiveness rating score for each of the information sources. The information source that had the highest effectiveness rating score was the “Louisiana Department of Wildlife and Fisheries Website” with a score of 1,584 followed by the “Louisiana Department of Wildlife and Fisheries Social Media” with a score of 870 (see Table 3.13).

Table 3.13. Overall Ratings Regarding Effectiveness of Invasive Aquatic Plant Information Sources by Adult Louisiana Residents Who Were Registered Boaters

Information Source	Sum
The Louisiana Department of Wildlife and Fisheries Website	1584
The Louisiana Department of Wildlife and Fisheries Social Media	870
LSU AgCenter Website	853
Television	711
Posted Signs at Boat Ramps	668
Magazines/Journals	467
Other Social Media	437
LSU AgCenter Social Media	342
Other Websites	318
YouTube	291
Newspapers	276
Radio	164
Events/Conferences	161
Other	123
Friends & Family	0

*Note.* Total number of respondents = 230

### **3.5. Objective Five: Relationships Between Perceived Need for Management of Invasive Aquatic Plant Species and Selected Socio-Demographic Characteristics**

The fifth objective was to determine if a relationship exists between the perceptions of adult Louisiana residents who are registered boaters regarding the need for management of invasive aquatic plant species in Louisiana and each of the following socio-demographic

characteristics: age, membership in environmental or conservation organizations, highest level of education completed, participation in gardening, fishing and hunting. There were 230 registered boaters who met the criteria of this objective. The results for each of these variables are as follows:

To examine the relationship between the age of the respondent and perceptions regarding the need for management of invasive aquatic plants, the researcher computed a correlation between the two measures. Since the variable age was measured as ordinal data, the most appropriate correlation coefficient to accomplish this purpose was the Spearman Rank Order Correlation coefficient. This measurement was  $r = .19$ ,  $p = 0.007$ . Therefore, older boaters in Louisiana tended to have higher perceptions regarding the need for management of invasive aquatic plants compared to younger age groups.

Other socio-demographic variables examined for relationships with management scores were all measured as binary variables. Consequently, the most effective methods for analyzing the data to determine if these variables were related to the management scores was using the independent samples t-tests. When these tests were computed, the variable “Whether or not the registered boater was a member of a conservation or environmental organization” was found to have the greatest difference in the need for management perception scores. Individuals who indicated that they were members of a conservation or environmental organization had a mean need for management perception score of 4.94 (SD = .232) while those who reported that they were not a member of a conservation or environmental organization had a mean need for management perception score of 4.77 (SD = .477). This difference was found to be statistically significant ( $t_{202} = 3.244$ ,  $p = 0.001$ ). Therefore, registered boaters who were members of one or more conservation or environmental organizations had higher need for management perception

scores. Among the other sociodemographic characteristics examined for associations with management perceptions, no significant relationships were found (see Table 3.14).

Table 3.14. Comparison of the Need for Management Perception Scores by Selected Socio-Demographic Characteristics of Registered Boaters in Louisiana

Socio-Demographic Characteristic		n	Mean	SD	t	df	p
Membership in Environmental or Conservation Organizations	Yes	46	4.93	0.232	3.244	155.84	0.001
	No	158	4.77	0.477			
Participation in Hunting	Yes	146	4.83	0.358	1.236	70.31	0.220
	No	56	4.73	0.604			
Participation in Gardening	Yes	132	4.79	0.489	0.649	200	0.517
	No	70	4.83	0.332			

*Note.* Participation in fishing was not used as a variable of comparison since only seven registered boaters indicated that they do not participate in fishing.

## **CHAPTER 4. SUMMARY AND CONCLUSIONS**

### **4.1. Purpose and Objectives**

The primary purpose of this study was to determine the perceptions of adult Louisiana residents regarding invasive aquatic plant species and their management. To guide this research study, the following objectives were developed. The first objective was to describe adult (18+) Louisiana residents who were registered boaters on the following characteristics: parish of residence, age, employment status, membership in environmental or conservation organizations, highest level of education completed, participation in gardening, fishing, boating and hunting. The next objective was to determine the perceptions of adult Louisiana residents who were registered boaters regarding the awareness and impacts of invasive aquatic plant species in Louisiana. The third objective was to determine the perceptions of adult Louisiana residents who were registered boaters regarding the need for management of invasive aquatic plant species in Louisiana. The fourth objective was to determine the currently used and perceived effectiveness of selected sources of information regarding invasive aquatic plant species among Louisiana adults who were registered boaters. The final objective was to determine if a relationship exists between the perceptions of adult Louisiana residents who were registered boaters regarding the need for management of invasive aquatic plant species in Louisiana and each of the following socio-demographic characteristics: age, membership in environmental or conservation organizations, highest level of education completed, participation in gardening, fishing and hunting.

### **4.2. Procedures and Methodology**

An online survey using Qualtrics was established to collect data for this study on registered Louisiana residential boaters' perceptions towards invasive aquatic plants and their

management (see Appendix B). The target population was adult residents (18+) of the state of Louisiana. Due to limited access to email addresses and cost limitations, a non-probability purposive sampling method was used, and Louisiana residential boaters registered with LDWF were the focused subset of the target population.

The IRB granted permission to conduct this study and access the data. LDWF employees reviewed the survey and granted approval for their collaboration in the study. The survey was distributed to a random sample (6,000) of Louisiana residential boaters registered with the LDWF. Postcards with a QR code to the online survey were addressed and mailed via OTS Production Support Services Enterprise Print Center. Selected boaters had one month to complete the survey and data was collected using Qualtrics and analyzed by the SPSS. When the survey closed, 230 Louisiana residential boaters had participated in the study.

#### **4.3. Findings**

Two hundred and thirty adult Louisiana residents who were registered boaters participated in this study. The largest group of respondents was 60+ (n = 120, 58.3%) and the smallest group was 18-29 (n = 5, 2.4%). The largest group of respondents was employed full-time (n = 100, 49.3%) and the second largest group was retired (n=97, 47.8%). Most boaters did not belong to any environmental or conservation organizations (n =158, 77.5%), while the majority of boaters participated in fishing (n = 195, 96.5%) or hunting (n = 146, 72.3%). Approximately half of the boaters (n = 109, 50.7%) reported they had taken 20 more boating trips on Louisiana's waterways in the past year.

The boaters' mean response when asked familiarity with invasive aquatic plant issues in Louisiana was categorized as "Moderately Familiar" (3.46, SD = 1.088, n = 226). *Salvinia* (giant and common) was the plant identified most frequently by boaters (n = 82, 48.2%) and water



hyacinth was identified the next most frequently ( $n = 63$ , 37.1%). According to the mean response, boaters considered the problem with invasive aquatic plant species in Louisiana “Very Serious” (4.23,  $SD = 0.831$ ,  $n = 219$ ). Invasive aquatic plants had caused problems for most boaters while boating in Louisiana’s waterways ( $n = 170$ , 73.9%).

According to the mean response, boaters “Strongly Agree” that invasive aquatic plants should be controlled when they cause harm to Louisiana’s native plants and animals (4.88,  $SD = 0.391$ ,  $n = 211$ ). The boaters mean response was also “Strongly Agree” that invasive aquatic plants should be controlled when they cause economic damage to Louisiana (4.87,  $SD = 0.439$ ,  $n = 210$ ). Boaters “Strongly Agree” that controlling some invasive aquatic plants is necessary to help conserve Louisiana’s environment (4.81,  $SD = 0.509$ ,  $n = 211$ ). Boaters also “Strongly Agree” that protecting Louisiana’s waterways from invasive aquatic plants should be a Louisiana state government funding priority (4.68,  $SD = 0.656$ ,  $n = 210$ ).

The control method favored the most by boaters was mechanical harvesting with a mean of 4.44 ( $SD = 0.760$ ,  $n = 207$ ). The control method favored the least by boaters was drawdowns with a mean of 3.47 ( $SD = 1.215$ ,  $n = 208$ ). The chosen method of invasive aquatic plant control would impact the majority of boaters decisions to support projects that would control invasive aquatic plants in Louisiana’s waterways ( $n = 108$ , 51.7%).

Respondents reported that they had heard or read about invasive aquatic plants from “Friends and Family” the most frequently ( $n = 105$ , 45.7%). Boaters had heard or read about these invaders the second most frequently from the “Louisiana Department of Wildlife and Fisheries Website” ( $n = 92$ , 40%). The “Louisiana Department of Wildlife and Fisheries Website” was ranked as the most effective information source on invasive aquatic plant species by the largest number of respondents ( $n = 70$ , 30.4%). The information sources ranked first by

the second largest number of respondents was the “Louisiana Department of Wildlife and Fisheries Social Media” ( $n = 26$ , 11.3%). The information source that had the highest overall effectiveness rating score was the “Louisiana Department of Wildlife and Fisheries Website” with a score of 1,584 and the information source that had the lowest effectiveness rating score was “Friends and Family” with a score of 0.

Older boaters in Louisiana tended to have higher perceptions regarding the need for management of invasive aquatic plants ( $r = 0.19$ ,  $p = 0.007$ ). Participation in hunting or gardening had no significant correlation with management perceptions. Registered boaters who were members of one or more environmental or conservation organizations had higher need for management perception scores (4.94,  $SD = 0.232$ ) as compared to boaters who were not a member (4.77,  $SD = 0.477$ ). This difference was found to be statistically significant ( $t_{202} = 3.244$ ,  $p = 0.001$ ).

#### **4.4. Conclusions and Recommendations**

##### **Conclusion 1- Age of Boaters**

Registered boaters who participated in the study tended to be older. This conclusion is based on the following findings of the study. The largest group of respondents was 60+ ( $n = 120$ , 58.3%). The second largest group of respondents was 50-59 ( $n = 45$ , 21.8%).

Response to the survey required scanning a QR code with a phone and taking the survey online. Among older people, internet usage is lower when compared to other age groups (Morris & Brading, 2007) and there tends to be a lack of expertise with computer and web skills (Morris et al., 2007). However, since the survey was initially mailed, and the Louisiana Department of Wildlife and Fisheries was the source of the mailing, older boaters may have chosen to take the survey due to the credible source and physical mailing of the postcard, as older people tend to

like getting mail. Older people tend to face discomfort with technology. Participation in app-based surveys and research using new techniques like smartphones begins to decline around age 50 (Mulder & de Bruijne, 2019). However, older boaters may have responded to the survey, even with this resistance to technology, because they may have viewed invasive aquatic plants as a very important subject.

Since the results indicated that 80.1% of the respondents were older, this may indicate a biased response group. Therefore, the researcher recommends a follow-up study be conducted to capture more responses from a wider demographic. To reduce nonresponse bias, multiple survey formats are needed such as mail, telephone and internet surveys (Dolnicar et al., 2009; Hunter et al., 2013). The researcher recommends a mixed mode survey design for the follow-up study.

There may have been a degree of nonresponse bias in the respondents since younger people were less likely to respond. This older demographic was also found in Wilson (2012) where the survey respondents average was age 59 and Bremner & Park (2007) where the respondents were significantly older as well. Younger boaters may not have responded due to the survey being mailed out. A study using mixed mode survey design found that online respondents were younger as compared to those who returned paper surveys (Dolnicar et al., 2009) and Gigliotti and Dietsch (2014) found that different age groups were represented by internet and mail survey samples. Many of the boaters who responded were retired ( $n = 97$ , 47.8%) and it is likely that respondents who were working full-time ( $n = 100$ , 49.3%) were nearing retirement as most of the respondents were older. Most likely, the respondents may have been older due to the physical mailing of the postcard.

## **Conclusion 2 – Membership in Environmental/Conservation Organizations**

Most boaters who participated in the study did not belong to any environmental or conservation organizations. This conclusion is based on the following findings of the study. One hundred and fifty-eight boaters (77.5%) identified that they were not members of any environmental or conservation organizations, while 46 boaters (22.5%) identified they were members of one or more environmental or conservation organizations.

The researcher found this conclusion surprising as most respondents participated in fishing (n = 195, 96.5%), while 72.3% (n = 146) participated in hunting. This finding is similar to Wilson's (2012) finding that the majority of respondents boated and fished. Both anglers and hunters are conservationists. Fees from fishing licenses fund conservation and restoration (U.S. Fish & Wildlife Service, n.d.) and funds from taxes on items such as firearms, ammunitions and sport fishing equipment go towards conservation of wildlife and sport fish because of The Pittman Robertson Act (The Wildlife Restoration Act) (U.S. Fish & Wildlife Service, n.d.) and the Sport Fish Restoration Act (U.S. Fish & Wildlife Service, n.d.). The study found that registered boaters who were members of one or more environmental or conservation organizations tended to have higher perceptions regarding the need for management of invasive aquatic plants. This aligned with the findings from Bremner & Park (2007) and Oxley et al. (2016) who noted that members of conservation or environmental organizations, generally, showed higher levels of support for controlling invasive species.

Since the majority of boaters in this study were also anglers or hunters, the researcher recommends the LDWF add an option for boaters to join a conservation organization on the boater registration form. Furthermore, the researcher recommends that the LDWF explore the possibilities of including membership in a reputable conservation organization as part of the fee

for boater registration. The LDWF could negotiate with a conservation organization to give boaters a 3-year membership to their organization at a lower cost. Since the study showed a correlation between boaters who were members of conservation or environmental organizations and higher need for management perception scores, having boaters join an organization when registering could be beneficial to both the boaters and LDWF.

### **Conclusion 3 – Awareness of Invasive Aquatic Plant Species**

The invasive aquatic plant identified most frequently by survey respondents was salvinia (giant and common) followed by water hyacinth. This conclusion is based on the following findings of the study. A total of 159 boaters identified one or more invasive aquatic plants. Salvinia, giant and common, were identified by boaters the most frequently ( $n = 82$ , 48.2%). Water hyacinth was identified the second most frequently by boaters ( $n = 63$ , 37.1%).

The registered boaters who participated in this study were aware of some of the most widely distributed invasive aquatic plants in Louisiana. These findings are similar to Wilson's (2012) findings that boaters and anglers' awareness was greatest for hydrilla and water hyacinth, AIS that are widely distributed throughout Florida. Giant and common salvinia have established in nearly every parish in Louisiana (Moshman & Diaz, 2019; Louisiana Department of Wildlife and Fisheries, 2015) and water hyacinth was the first documented AIS in Louisiana and has the most documented observations to date (Anifowose & Fagorite, 2020; Sanders et al., 2010). The plants identified most likely caused the registered boaters the most problems while boating on Louisiana's waterways. To help educate boaters further, the researcher recommends the LDWF and the LSU AgCenter develop a statewide invasive species educational and informational website suggested in the State Management Plan for Aquatic Invasive Species in Louisiana (Kravitz et al., 2005). This would help create more content for boaters on the two most visited

websites. Since recreational boating is considered a primary means by which AIS spread through Louisiana's waterways (Kravitz et al., 2005, Kelly et al. 2013) suggests an increase of public boater hygiene practices to limit these issues, the researcher recommends the two organizations add short tutorial videos on how to properly clean their boats when moving from one waterway to the next.

The researcher also recommends the statewide invasive species website be housed on the LDWF and LSU AgCenter websites since both websites were given a high effectiveness rating score regarding the effectiveness of invasive aquatic plant information sources by registered boaters, first and third respectively (see Table 3.13). The websites should be promoted via LDWF's social media since the study found that their social media was considered the most effective information source on invasive aquatic plant information and prevention by the second largest number of boaters (n = 26, 11.3%).

#### **Conclusion 4 – Boating Activity Among Registered Boaters in Louisiana**

Respondents tended to be active boaters. This conclusion is based on the following findings of the study. Approximately, half of the respondents (n = 109, 50.7%) reported they had taken 20 or more boating trips on Louisiana's waterways and 21.9% had taken 10 to 19 boating trips (n = 47). This is similar to Wilson (2012) finding that only a small percentage (11%, n = 1395) of respondents did not boat in the past year of the study.

Since respondents tended to be active boaters, they may have been more familiar with invasive aquatic plants and the issues they cause, which may have been why respondents were very supportive of controlling invasive aquatic plants in Louisiana. The registered boaters were asked four management-related questions and each of the items mean response was classified as "Strongly Agree." An overall perception score regarding the management of invasive aquatic

plants was established as the mean of the four items in the scale (4.81, SD = 0.433). This score was classified as “Strongly Agree”, thus showing the respondents strongly supported the management of invasive aquatic plants in their home state.

Since active boaters seemed more aware and supportive of controlling invasive aquatic plants, the researcher recommends that LDWF include more information on prevention of these invasives with boater registration materials. In Wilson (2012) study, findings showed that only 27% of respondents received AIS information in boat registration materials and that including more AIS information with these materials could be an impactful and cost-effective solution.

### **Conclusion 5 – Problems Caused by Invasive Aquatic Plant Species**

Invasive aquatic plants had caused problems for the majority of boaters while boating in Louisiana’s waterways. This conclusion is based on the following findings of the study. There were 170 boaters (73.9%) who reported that invasive aquatic plants caused them problems, while only 44 boaters (19.1%) indicated that the plants had not caused issues for them while boating. Sixteen boaters chose not to respond. As indicated by the findings, invasive aquatic plants are a growing problem for boaters, but not just in Louisiana. A study conducted in Florida found that 40% of boaters (n = 443) had experienced AIS - related problems (Wilson, 2012). Recreational boating is considered an important vector in the spread of AIS (Kelly et al., 2013) and these studies indicate an increase in AIS-related problems that boaters are experiencing. The researcher recommends a follow-up study in Louisiana be designed to study the behaviors of boaters related to invasive aquatic plants and attempt to measure boaters’ intentions to prevent the future spread of these invaders in Louisiana. This information would be useful to LDWF, to effectively create an educational campaign targeted at registered boaters in Louisiana to help prevent the spread of invasive aquatic plants.

## **Conclusion 6 – Preferred Invasive Aquatic Plant Control Methods**

The control method for invasive aquatic plants that boaters favored the most was mechanical harvesting. Boaters somewhat favored aquatic herbicide control methods and biological control methods. The control method favored the least was drawdowns. This conclusion is based on the following findings of the study. Mechanical harvesting was favored the most by boaters with a mean of 4.44 (SD = 0.760). Even though it was favored the most, this control method was categorized in the “Somewhat Favor” category (3.50 to 4.49). Biological control methods were somewhat favored by boaters with a mean of 3.93 (SD = 1.056). Aquatic herbicide control methods were somewhat favored with a mean of 3.88 (SD = 1.173). The control method that boaters favored the least was drawdowns with a mean of 3.47 (SD = 1.215). Drawdowns were categorized in the “Neither Favor nor Oppose” category (2.50 to 3.49).

Mechanical harvesting was favored the most by boaters to control invasive aquatic plants, while herbicides and drawdowns were favored the least. This is similar to the findings in Oxley et al. (2016) where cutting down and digging up invasive plant species were favored over the use of herbicides and dredging in the San Marcos River, Texas. Bremner & Park (2007) also found that poisoning and herbicides were the least favored control methods for invasive species. In Wilson (2012), boaters reported their most favored control methods for AIS as mechanical and physical, but they also reported they had the most knowledge about mechanical and physical control methods.

These studies show that mechanical harvesting is favored the most, possibly because it appears the most environmentally friendly. Even though the findings demonstrated favorability, mechanical harvesting can be very costly due to the transport and disposal of the biomass removed (Sperry et al., n.d.). This control method is non-selective and can result in by catch and



disruptions of native plants (Sperry et al., n.d.). On average, a single harvester can only harvest 0.25 to 1.5 acres per hour depending on the invasive plant species (Sperry et al., n.d.). Due to cost and efficiency, mechanical harvesting may not always be the best option for Louisiana's waterways and may only be used as a complementary source in smaller areas as compared to other control options where access is restricted. A single control option for an invasive aquatic plant is very limiting (Sperry et al., n.d.), and support for certain management projects could become a problem when boaters highly favor one control method over another. The researcher recommends a follow-up study be conducted to investigate the current knowledge level of boaters' regarding each control method used in Louisiana and their support towards specific management projects that utilize different control methods.

#### **Conclusion 7 – Support of Projects to Control Invasive Aquatic Plant Species**

The chosen method of invasive aquatic plant control would impact the majority of boaters decisions to support projects that would control invasive aquatic plants in Louisiana's waterways. This conclusion is based on the following findings of the study. There were 108 boaters (51.7%) who reported that the chosen method of control for invasive aquatic plants would impact their decision to support projects that would control invasive aquatic plants in Louisiana's waterways, while 48.3% of boaters (n = 101) indicated that it would not impact their decision to support these projects.

Public awareness, knowledge and support are important social dimensions to consider when creating plans for prevention, management and control of invasive species (Bremner & Park, 2007; Oxley et al., 2016; Novoa et al., 2017; Eiswerth et al., 2011). Previous research, Oxley et al., (2016), Bremner & Park (2007) and Wilson (2012) found that respondents favored certain control methods for invasive species over others. These results are similar to current

findings where boaters not only favored one control method over another, but also indicated that the chosen control method would impact their decision to support management projects for invasive aquatic plants in Louisiana's waterways. Bremner and Park (2007) found that participants who supported management and eradication programs had prior knowledge of these programs. It is important to educate boaters on management programs and the control methods used.

Not only does public education and awareness help increase support for management efforts, but it can also help prevent species introductions and control existing invasive species (Wilson, 2012). Louisiana Department of Wildlife and Fisheries (2015) discusses the importance of educating the public on invasive species to help prevent further introductions into Louisiana. To help increase support for management projects and prevent further species introductions, the researcher recommends the LDWF and LSU AgCenter create a statewide invasive species website that includes a section on control methods used for aquatic invasive species and the advantages and disadvantages of each option.

### **Conclusion 8 – Invasive Aquatic Plant Information Source Effectiveness**

The LDWF website was ranked as the most effective information source on invasive aquatic plants by the largest number of respondents. This conclusion is based on the following findings of the study. The information source that was ranked first by the largest number of respondents was the LDWF website (n = 70, 30.4%). Understanding where boaters seek information on invasive aquatic plants and which sources they perceive as most effective is important for communicating and developing educational outreach in the future. This study shows that LDWF is both an important and effective source of information for boaters to learn about invasive aquatic plants. Forty percent of boaters (n = 92) reported they had heard or read

about these invaders from the LDWF website, while the largest number of respondents ranked the LDWF website as the most effective information source. Unsurprisingly a similar study surveying boaters in Florida, found that boaters perceived the Florida Fish & Wildlife Commission (FWC), which is also a natural resource agency, as their most trusted source of information (Wilson, 2012).

Boaters are more likely to receive and process messages from a trusted source of information. Although boaters had heard or read about invasive aquatic plants from friends and family the most frequently ( $n = 45$ , 45.7%), none of the respondents selected friends and family as a source of information they considered most effective at providing information on invasive aquatic plant education and prevention. These findings suggest that the LDWF website and the LSU AgCenter website are good sources to house information on invasive species and future educational campaigns. Awareness and education are key components to increase public support for invasive species control and management projects. The State Management Plan for Aquatic Invasive Species in Louisiana (Kravitz et al., 2005), discusses the development of a statewide invasive species educational and informational website, but funding is lacking. The researcher recommends that future educational campaigns and a potential statewide invasive species website be housed on the LDWF and the LSU AgCenter websites. The researcher additionally recommends the LSU School of Plant, Environmental and Soil Sciences and the LSU School of Renewable Natural Resources cooperatively develop an undergraduate course on invasive species management to educate the next generation.

#### **4.5. Impact**

This study is an important tool to help shape and develop future management decisions, educational material and ultimately public policy. Survey responses showed there is a need for

more educational material regarding invasive aquatic plants and their management. This is one of the first studies in Louisiana to focus on boaters' perceptions of these invasive plants.

Organizations, such as LDWF, can use this study to develop educational materials in the future and consider boaters' perceptions when implementing management decisions. This study supports the case for the development of a "Citizens Guide to Invasive Species", and the creation of a statewide invasive species educational website discussed in the State Management Plan for Aquatic Invasive Species in Louisiana (Kravitz et al., 2005).

## APPENDIX A. ACTION ON EXEMPTION APPROVAL REQUEST



**TO:** Kathryn Karsh Fontenot  
LSU AG | Admin | Communications

**FROM:** Michael Keenan  
Chair, Institutional Review Board

**DATE:** 14-Apr-2022

**RE:** IRB AG-22-0002

**TITLE:** Louisiana Resident Views on Invasive Aquatic  
Plants and Their Management

**SUBMISSION TYPE:** Initial Application

**Review Type:** Exempt

**Risk Factor:** Minimal

**Review Date:** 14-Apr-2022

**Status:** Approved

**Approval Date:** 14-Apr-2022

**Approval Expiration Date:** 13-Apr-2025

**Re-review frequency:** (three years unless otherwise stated)

**Number of subjects approved:** 6000

**LSU Proposal Number:**

**By:** Michael Keenan, Chair

Continuing approval is **CONDITIONAL** on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects\*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.

6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

*\*All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents.*

Mike Keenan ○ 225-578-1708  
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Baton Rouge, LA 70803

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## APPENDIX B. SURVEY INSTRUMENT

### Aquatic Weeds

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Study Title: Louisiana Resident Views on Invasive Aquatic Plant Species and Their Management

Performance Site: Louisiana State University and Agricultural and Mechanical College

Investigators: M-F, 8:00 am- 4:30 pm Anna Ribbeck 225-578-4270 aribbeck@agcenter.lsu.edu  
Dr. Kathryn Fontenot 225-578-2417 kkfontenot@agcenter.lsu.edu Dr. Christopher Mudge 225-578-1208 cmudge@agcenter.lsu.edu Dr. Michael Burnett 225-578-6914  
mburnett@agcenter.lsu.edu Dr. Heather Kirk-Ballard 225-578-2110 hkbballard@agcenter.lsu.edu

Purpose of the Study: The primary purpose of this study is to measure Louisiana resident awareness, attitudes and opinions of invasive aquatic plant species in Louisiana and their management options.

Subject Inclusion: Louisiana residential boaters registered with the Louisiana Department of Wildlife and Fisheries.

Number of subjects: 6,000

Study Procedures: Participants will spend 10 minutes or less completing this questionnaire related to their views on invasive aquatic plant species and their management.

Benefits: This study will assist in developing appropriate control and management policies to minimize invasive aquatic plants in Louisiana's waterways.

Risks/Discomforts: Since there is no sensitive information being collected, there are no known risks related to participation in this study.

Measures taken to reduce risk: The researcher will maintain the confidentiality of the survey results.

Right to Refuse: Participation in this study is voluntary and participants may withdraw from the study at any time without penalty.

Privacy: Results of the study may be published, but no names or identifying information will be included in the publication. Subject identity will remain confidential unless disclosure is required by law.

The study has been discussed with me and all of my questions have been answered. I may

direct additional questions regarding study specifics to the investigators. If I have questions about participants' rights or other concerns, I can contact Michael Keenan, Chairman, LSU AgCenter Institutional Review Board, mkeenam@agcenter.lsu.edu.

I am 18 years of age or older and I agree to participate in this study and completion and submission of the questionnaire constitutes my consent to participate.

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**Default Question Block**

Are you a registered boater in Louisiana?

☐ Yes (1)

☐ No (2)

*Skip To: End of Survey If Are you a registered boater in Louisiana? = No*



In what Louisiana parish is your primary residence located, if any?

- ☐ Acadia (1)
- ☐ Allen (2)
- ☐ Ascension (3)
- ☐ Assumption (4)
- ☐ Avoyelles (5)
- ☐ Beauregard (6)
- ☐ Bienville (7)
- ☐ Bossier (8)
- ☐ Caddo (9)
- ☐ Calcasieu (10)
- ☐ Caldwell (11)
- ☐ Cameron (12)
- ☐ Catahoula (13)
- ☐ Claiborne (14)
- ☐ Concordia (15)
- ☐ DeSoto (16)
- ☐ East Baton Rouge (17)
- ☐ East Carroll (18)
- ☐ East Feliciana (19)
- ☐ Evangeline (20)
- ☐ Franklin (21)

- ☐ Grant (22)
- ☐ Iberia (23)
- ☐ Iberville (24)
- ☐ Jackson (25)
- ☐ Jefferson (26)
- ☐ Jefferson Davis (27)
- ☐ LaSalle (28)
- ☐ Lafayette (29)
- ☐ Lafourche (30)
- ☐ Lincoln (31)
- ☐ Livingston (32)
- ☐ Madison (33)
- ☐ Morehouse (34)
- ☐ Natchitoches (35)
- ☐ Orleans (36)
- ☐ Ouachita (37)
- ☐ Plaquemines (38)
- ☐ Pointe Coupee (39)
- ☐ Rapides (40)
- ☐ Red River (41)
- ☐ Richland (42)

- ☐ Sabine (43)
- ☐ St. Bernard (44)
- ☐ St. Charles (45)
- ☐ St. Helena (46)
- ☐ St. James (47)
- ☐ St. John The Baptist (48)
- ☐ St. Landry (49)
- ☐ St. Martin (50)
- ☐ St. Mary (51)
- ☐ St. Tammany (52)
- ☐ Tangipahoa (53)
- ☐ Tensas (54)
- ☐ Terrebonne (55)
- ☐ Union (56)
- ☐ Vermillion (57)
- ☐ Vernon (58)
- ☐ Washington (59)
- ☐ Webster (60)
- ☐ West Baton Rouge (61)
- ☐ West Carroll (62)
- ☐ West Feliciana (63)

- ☐ Winn (64)
- ☐ None of the above (65)

*Skip To: End of Survey If In what Louisiana parish is your primary residence located, if any? = None of the above*

---

### **Awareness & Impacts of Invasive Aquatic Plant Species in Louisiana**

Q1 Many invasive aquatic plant species have been introduced into Louisiana's environment causing ecologic and economic harm. How familiar are you with invasive aquatic plant issues in Louisiana?

- ☐ Extremely familiar (1)
- ☐ Very familiar (2)
- ☐ Moderately familiar (3)
- ☐ Slightly familiar (4)
- ☐ Not familiar at all (5)

Q2 Invasive aquatic plants clog waterways, affect water quality, hurt native flora and fauna and overall, have a negative impact on the ecological stability of Louisiana's waterways. If you happen to know an example of an invasive aquatic plant in Louisiana, please give the name of that plant.

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Q3 How serious of a problem do you think invasive aquatic plant species are in Louisiana?

- ☐ Extremely serious (1)
- ☐ Very serious (2)
- ☐ Moderately serious (3)
- ☐ Slightly serious (4)
- ☐ Not at all serious (5)

Q4 Invasive aquatic plants have no natural checks and balances. Their overgrowth can cause harm to native plants and animals and affect water quality. How much information have you heard or read about on each of the invasive aquatic plant species listed below?

	A Large Amount (1)	A Moderate Amount (2)	A Small Amount (3)	None (4)
Hydrilla (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Giant Salvinia (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Common Salvinia (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water Hyacinth (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water Lettuce (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Crested Floating Heart (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cuban Bulrush (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q5 How many boating trips have you taken on Louisiana's waterways (rivers, streams, marshes, lakes, ponds and swamps) in the past year?

- ☐ 0-10 (1)
- ☐ 10-20 (2)
- ☐ 20+ (3)

Q6 Have invasive aquatic plants caused problems for you while boating in Louisiana's waterways?

- ☐ Yes (1)
  - ☐ No (2)
-

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**Management of Invasive Aquatic Plant Species in Louisiana**

Q7 Controlling some invasive aquatic plant species is necessary to help conserve Louisiana's environment.

- ☐ Strongly agree (1)
- ☐ Somewhat agree (2)
- ☐ Neither agree nor disagree (3)
- ☐ Somewhat disagree (4)
- ☐ Strongly disagree (5)

Q8 Invasive aquatic plant species should be controlled when they cause harm to Louisiana's native plants and animals.

- ☐ Strongly agree (1)
- ☐ Somewhat agree (2)
- ☐ Neither agree nor disagree (3)
- ☐ Somewhat disagree (4)
- ☐ Strongly disagree (5)

Q9 Invasive aquatic plant species should be controlled when they cause economic damage to Louisiana.

- ☐ Strongly agree (1)
  - ☐ Somewhat agree (2)
  - ☐ Neither agree nor disagree (3)
  - ☐ Somewhat disagree (4)
  - ☐ Strongly disagree (5)
- 

Q10 Protecting Louisiana waterways from invasive aquatic plants should be a Louisiana state government funding priority.

- ☐ Strongly agree (1)
  - ☐ Somewhat agree (2)
  - ☐ Neither agree nor disagree (3)
  - ☐ Somewhat disagree (4)
  - ☐ Strongly disagree (5)
-



Q11 The Louisiana Department of Wildlife and Fisheries uses an integrated pest management approach, which combines chemical, mechanical and biological controls, to manage invasive aquatic plants in Louisiana's freshwater systems. Please indicate your opinions about each of the following control methods.

	Strongly Favor (1)	Somewhat Favor (2)	Neither Favor nor Oppose (3)	Somewhat Oppose (4)	Strongly Oppose (5)
Aquatic herbicide control methods (use of chemicals) (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mechanical harvesting methods (use of machines) (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drawdowns (process to lower water levels for a period of time) (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Biological control methods (use of insects, fish, diseases and other bio agents) (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q12 The most effective control strategies are different for different invasive aquatic plants and the waterbodies they are located in. Would the chosen methods of control (aquatic herbicide, mechanical, biological, drawdown) have any influence on your decision to support projects that would control invasive aquatic plants in Louisiana waterways?

☐ Yes (1)

☐ No (2)

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**Information Accrual on Invasive Aquatic Plant Species**

Q13 Have you heard or read about invasive aquatic plants from any of the following sources?  
(select all that apply)

- ☐ The Louisiana Department of Wildlife and Fisheries website (1)
- ☐ LSU AgCenter website (2)
- ☐ Other websites (3)
- ☐ The Louisiana Department of Wildlife and Fisheries social media (4)
- ☐ LSU AgCenter social media (5)
- ☐ Other social media (6)
- ☐ Newspapers (7)
- ☐ Magazines/Journals (8)
- ☐ Posted signs at ramps and boat docks (9)
- ☐ Television (10)
- ☐ Radio (11)
- ☐ Events/Conferences (12)
- ☐ Friends/Family (13)
- ☐ Other (14) \_\_\_\_\_
- ☐ I have not heard or read about invasive aquatic plants. (15)

*Skip To: End of Block If Have you heard or read about invasive aquatic plants from any of the following sources? (select a... = I have not heard or read about invasive aquatic plants.*

Q14 Of all the sources of information in Question 16, which three would you consider to be the MOST EFFECTIVE at providing information on invasive aquatic plant education and prevention for you? Please rank them.

	The Louisiana Department of Wildlife and Fisheries website (1)	LSU AgCenter website (2)	Other Websites (3)	The Louisiana Department of Wildlife and Fisheries social media (4)	LSU AgCenter social media (5)	YouTube (6)	Other Social Media (7)	Newspapers (8)
1 (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2 (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3 (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

---

**Start of Block: Block 5**

Q15 What is your age?

- ☐ 18-29 (1)
- ☐ 30-39 (2)
- ☐ 40-49 (3)
- ☐ 50-59 (4)
- ☐ 60+ (5)

Q16 What is the highest level of education you have completed?

- ☐ Less than high school (1)
- ☐ High school graduate (2)
- ☐ Associate degree (3)
- ☐ Bachelor's degree (4)
- ☐ Master's degree (5)
- ☐ Doctorate (6)

Q17 What is your employment status?

- ☐ Employed full-time (40 or more hours/week) (1)
- ☐ Employed part-time (up to 39 hours/week) (2)
- ☐ Unemployed (3)
- ☐ Student (4)
- ☐ Retired (5)

Q18 Are you a member of any environmental or conservation organizations?

- ☐ Yes (1)
- ☐ No (2)

Q19 Which of the following outdoor activities do you participate in? (select all that apply)

☐

Hunting (1)

☐

Fishing (2)

☐

Gardening (3)

## APPENDIX C. SURVEY CORRESPONDENCE- POSTCARD



### **Invasive Aquatic Plant Survey**

A study is being conducted by the LSU AgCenter and the Louisiana Department of Wildlife and Fisheries to measure opinions of boaters in Louisiana regarding invasive aquatic plants. We need your input to help with this issue.

Thank you for your help!  
Please scan the QR code below to take the short survey.



## APPENDIX D. PARISH OF RESIDENCE

Parish	Frequency	Percent
Acadia	7	3.0
Ascension	11	4.8
Avoyelles	9	3.9
Beauregard	1	0.4
Bienville	2	0.9
Bossier	6	2.6
Caddo	13	5.7
Calcasieu	11	4.8
Caldwell	2	0.9
Claiborne	3	1.3
Concordia	2	0.9
DeSoto	1	0.4
East Baton Rouge	16	7.0
East Feliciana	2	0.9
Evangeline	1	0.4
Grant	3	1.3
Iberia	5	2.2
Iberville	1	0.4
Jefferson	5	2.2
Lafayette	13	5.7
Lafourche	9	3.9
Lincoln	1	0.4
Livingston	9	3.9
Natchitoches	4	1.7
Orleans	2	0.9
Ouachita	6	2.6
Plaquemines	2	0.9
Pointe Coupee	1	0.4
Rapides	13	5.7
Red River	2	0.9
Richland	1	0.4
Sabine	1	0.4
St. Bernard	2	0.9
St. Charles	1	0.4
St. John The Baptist	2	0.9
St. Landry	6	2.6
St. Martin	5	2.2
St. Mary	6	2.6
St. Tammany	8	3.5
Tangipahoa	4	1.7
Terrebonne	12	5.2



Union	1	0.4
Vermillion	3	1.3
Vernon	4	1.7
Webster	7	3.0
West Baton Rouge	2	0.9
Winn	1	0.4
Total	230	100.0

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## VITA

Anna Eileen Ribbeck, born in Covington, Louisiana, worked as the marketing director at a large wholesale/retail nursery in Louisiana after receiving her bachelor's degree in horticulture from Louisiana State University. In 2020, she was hired as the first-ever social media strategist for the Louisiana State University Agricultural Center. As an avid outdoorsman and cast member of Swamp People Season 14, she has experienced first-hand the problems caused by aquatic invasive plants in Louisiana's waterways. Her passion for the outdoors and agricultural communications led her to pursue a master's degree in the Department of Plant, Environmental and Soil Sciences at Louisiana State University. She plans to continue to work as the social media strategist for the LSU AgCenter and be an advocate for Louisiana's natural environment. She also plans to receive her master's degree in Plant, Environmental, and Soil Sciences in May 2023. This degree with an additional emphasis in Agricultural and Extension Education will enhance both her ability to contribute to the field of aquatic sports and her expertise as a social media strategist.