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# Lowcountry Landowners' Wetlands Knowledge and Perceptions and the Impacts of Land Management Actions on Isolated Wetlands

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**Abstract.** The South Carolina Lowcountry has an abundance of geographically isolated wetlands (GIWs), which provide important water cycling functions and biogeochemical processing services, and which are habitat for rare and threatened plants and animals. Isolated wetlands are not well protected in a regulatory or legal sense in the United States, including South Carolina, leaving them vulnerable to land use change pressures from rapid growth and in-migration. This project investigated how private landowners in rural areas near Charleston, South Carolina, perceive wetlands and their general knowledge about wetlands using semistructured interviews and site visits. Landowners' observed and self-reported management and use activities were documented and analyzed for impacts to isolated wetland hydrology and amphibian habitat quality. Most landowners had positive perceptions of wetlands, were somewhat knowledgeable about wetland functions, and were conducting land use activities that could possibly affect the hydrology and negatively impact the habitat quality of the isolated wetlands on their property. Many landowners exhibited a disconnect between the perceived impacts of their management and use activities and the impacts observed in this study. While these private landowners do not seem to be threatening the hydrology of GIWs in this area, the impacts to habitat quality are still concerning. Landowner education programming is recommended, which would link common management activities to impacts on isolated wetlands. Furthermore, policy and land use zoning changes would encourage the protection of isolated wetlands in this region.

## INTRODUCTION

This study involved gathering information from landowners in coastal South Carolina about their perceptions on wetlands, their prior knowledge, and what management and land use activities are being conducted that might impact hydrology and the wildlife habitat quality of geographically isolated wetlands (GIWs). Our goal was to provide foundational information that can be used to develop training and educational programs to support voluntary conservation of GIWs by private landowners in South Carolina. Geographically isolated wetlands have no perennial surface water connection to other wetlands or surface waters, yet they provide critical habitat and other ecosystem goods and services (Rains et al. 2015). Regulatory or legal protection is, however, variable (McKown 2016). In the United States, wetlands are regulated under Section 404 of the Clean Water Act (CWA), which regulates the placement of fill or dredged material into waters of the United States. GIW determination is made by the US Army Corps of Engineers (USACE) as part of their regulatory process. The state's Pollution Control Act (PCA) protects most wetlands from sewage and other pollution by including them as waters of the state. Isolated wetlands are excluded from this regulation. Voluntary conservation has been identified as one method to protect these resources, but there is no existing comprehensive education program for landowners. Outreach and boundary-spanning organizations such as the ACE Basin and North Inlet-Winyah Bay National Estuarine Research Reserves, Clemson Cooperative Extension, and South Carolina Sea Grant Consortium, as well as land trusts and other private conservation organizations, will benefit from understanding the results, as they provide a solid starting point for further refining of educational needs and development of outreach and educational materials.

## BACKGROUND

GIWs are traditionally defined as wetlands surrounded by uplands that lack surface water inputs and outputs (Tiner et al. 2002). Other research suggests that these wetlands are not as isolated from other water sources as previously thought; however, the term remains (Leibowitz 2003). Isolated wetlands are common throughout the southeast coastal plain and can range in size from less than one hectare to several square kilometers. Several distinct types are found in South Carolina, including Carolina Bays, and all have hydrology dominated by precipitation inputs and loss through evapotranspiration. The terms isolated wetland, depressional wetland, and seasonally ponded wetland are used throughout the literature to refer to the same general wetland type. Plant community types vary with hydroperiod, soil type, past land use, and fire regime (Busbee et al. 2003; Kirkman, Smith, et al. 2012).

Wetland density in South Carolina's Coastal Plain is considered very high, with GIWs as the most abundant of all lentic, or still-water, wetlands (Russell et al. 2002). There are an estimated 103,991 GIWs covering 161,067 ha, which makes up 10.7% of the total freshwater wetland habitat in the state (Lane and D'Amico 2016). Lane and D'Amico express the difficulty of locating GIWs with geographical information system (GIS) techniques, due to small size, lack of connections to surface water, and overhead vegetation. An in-depth assessment was also conducted by a private firm, locating isolated wetlands in eight coastal counties along the South Carolina–North Carolina border (RTI International et al. 2011).

Despite their often-small size, GIWs are crucial for maintaining regional biodiversity (Semlitsch and Bodie 1998; Russell et al. 2002). Many species of amphibians, reptiles, invertebrates, and rare plants rely on isolated wetlands for habitat (Kirkman, Smith, et al. 2012). The flatwoods salamander (*Ambystoma cingulatum*) [vulnerable], gopher tortoise (*Gopherus polyphemus*) [vulnerable], and Canby's dropwort (*Tiedemannia canbyi syn. Oxypolis canbyi*) [imperiled] are a few species that have been impacted by isolated wetland loss in the southeastern United States. Cohen et al. (2016) write that geographical isolation should not imply biological isolation, and that the weaker connectivity between GIWs and other waters is what enhances and enables many of the important biological functions that isolated wetlands provide. Marton et al. (2015) argue that GIWs are integral to downstream water quality because of their role in biogeochemical processing, particularly nutrient and pollutant retention. Isolated wetlands lack federal legal protection because they are not easily recognized as connected to surface water, and many are small (Semlitsch and Bodie 1998). Difficulties locating and delineating boundaries, mainly due to variable hydroperiods, also make protection difficult (Lane and D'Amico 2016).

The hydrology of GIWs is highly influenced by surrounding land use, but the interactions between anthropogenic activity and natural hydrologic process are not well understood or easily recognized (Kirkman, Golladay, et al. 1999). Land use change and human activities, specifically urbanization, ditching, and draining, are drivers for wetland degradation and loss (Brinson and Malvárez 2002). An estimated 24,400 acres of coastal southeastern US wetlands are lost every year on nonfederal lands (Stedman and Dahl 2008). There do not seem to be any current predictions for wetland loss in the southeastern US, but past growth and future predictions for the Charleston area could indicate potential for more loss of wetlands.

The Charleston area is growing rapidly, with one estimate of tripling the urban area by 2030, which would impact up to 35% of wetlands (Allen and Lu 2003). The United States Census Bureau reports Charleston County's 2020 population as 408,235, which outstrips a South Carolina Revenue and Fiscal Affairs Office report that projected that the county would grow from 350,209 in 2010 to 396,700 in 2030. For the same period, Dorchester County's population grew from 136,555 in 2010 to 161,540 in 2020. People move to South Carolina for jobs, school, and retirement, and there is little reason to think either county would prove an exception to those draws. Both counties also show an increase in the population of adults ages 50 to 79 since around 1975, supporting the idea that people, both lifelong residents and in-migrants, retire in Charleston and Dorchester Counties (US Census Bureau 2017).

## STUDY AREA

The study area outlined in yellow in Figure 1 includes the southwestern portion of Charleston County and the southern portion of Dorchester County. Both counties are in the lower coastal plain in South Carolina, although only Charleston County contains coastline. This area is very flat, and precipitation inputs and low runoff amounts combine to create isolated wetlands in low-lying areas (Aucott 1996). The lower coastal plain has high to very high wetland density (Stedman and Dahl 2004), as shown in Figure 1. The isolated, depressional wetland density is 2.23 to 7.15 hectares of wetlands per square kilometer (Lane and D'Amico 2016). Land use is dominated by commercial pine production and agricultural and residential areas. Lands across the Gulf and Atlantic Coastal Plain, including the study area, have experienced substantial wetlands loss, in large part due to drainage infrastructure (e.g., ditches installed to lower the water table) since the 1700s (Fretwell et al. 1996). The wetlands discussed with landowners for this study are existing geographically isolated wetlands that have survived

a long history of land use engineering in the region. Only one of the locations described for this study had silvicultural (row pine production) activities, but we recognize that millions of hectares across the Southeast and South U.S. are managed in this way, on lands that formerly had numerous wetlands prior to the 1700s. Like the rest of the southeastern coastal plain, natural and human-induced fire has influenced the ecology of the study area, and thus the ecology of isolated wetlands, for millions of years. Urbanization and active fire suppression could have recently changed the relationship between fire and isolated wetland ecology in the study area (Noss 2018). The study area has experienced population and land use change in recent decades due to easy driving distance to Charleston and proximity to publicly accessible scenic areas such as the ACE Basin (Hurley and Halfacre 2011).

## MATERIALS AND METHOD

One member of the study team (Locatis Prochaska) collected data on landowner perceptions, knowledge level, and land management activities through 16 semistructured interviews and site visits. Time and resource constraints prevented interviewing more participants to reach the original goal of 20, although this sample size yielded "saturation" in the data—that is, in qualitative research, if you keep hearing similar responses, you have reached a "saturation" in the range of possible responses to the research questions. During the fall of 2018, landowners were recruited through an area nonprofit's email list and by posting in local community Facebook groups, such as Hollywood/Ravenel United, with two participants referred by contacts. Properties could be any size, could not be used for primary income, and featured at least one freshwater wetland that was completely or partially located on the property and that could possibly be isolated based on aerial imagery (2017 Aerial Imagery, Charleston County GIS Parcel Viewer) or the NFWS wetlands mapper and data on putative isolated wetlands from Lane and D'Amico (2016), or identified by the landowner as isolated.

Semistructured, recorded interviews were conducted at the properties of interest, usually in the landowners' homes. Interviews focused on the participants' knowledge and perceptions of wetlands, as well as their land management activities, through questions such as: "What have you done on your property since acquiring it?"; "Will you give me a definition of a wetland?"; and "What do you think wetlands do in the SC Lowcountry?" An aerial map of the participant's property was provided during each interview for the participant to mark with wetlands, and these marked-up maps were included as data, as they often provided context for phenomena or actions described by the landowner.

Following the interviews, site visits were conducted on the properties of interviewed landowners to determine how landowners manage and use their land. Site visits can result in more information than interviewing alone because a tour of the property typically reminds landowners of actions they have implemented on the property, and the researcher is able to observe and photograph the landscape, which yields more rigorous data (Doody et al. 2014; Cooke and Lane 2015; Strang 2010). Site visits resulted in two categories of data: data provided by the participant (conversation) and data collected by the researcher (mapped information, photographs, and observations). During the site visit, the researcher was able to visibly observe wetland vegetation, signs of wetland hydrology, and hydric soils to confirm the presence of wetlands. Exact wetland boundaries were not delineated due to concerns about landowner comfort with this research taking place on their land.

Using interview responses as a guide, the site visit focused on areas of the property that had changed since purchase, areas being managed, wetlands, and any other areas the landowner deemed significant or wanted to show. The route of the site visit was recorded using GAIA Earth, a GPS tracking application, to provide location information for areas of interest, which were photographed and geo tagged. Conversations during the site visit were also recorded. Locations of some isolated wetlands identified by Lane and D'Amico (2016) were also verified.

Questions such as, "Will you take me to where you have made changes to the property?" and "Will you take me to where you have wetlands or noticed that there is standing water sometimes?" were used as a starting point for the site visit; however, the landowner generally had a plan for what they wanted to talk about. Thus, these site visit interviews were driven by the respondents.

Interviews and site visit conversations were recorded with an audio recorder, transcribed, and coded using a combination of open and selective coding, with the units of analysis ranging from single words to paragraphs, depending on the code. Interview and site visit transcripts were analyzed holistically, as a participant often spoke about land management or wetland values at any time during the interview or site visit. Some thematic codes were predetermined before data were collected, according to the literature, and others emerged in the course of analyzing the data.

To understand how landowners perceived wetlands, statements that regarded wetland perception were categorized into positive, negative, and neutral categories. Answers to interview questions about knowledge level, as well as questions about where wetlands existed on their properties, were often expressed with words that are typically related to perceptions and feelings.

Wetland knowledge level was determined via a rubric (see Table 1). The categories in this rubric were developed based on basic wetland information that is readily accessible online, made available by agencies such as the

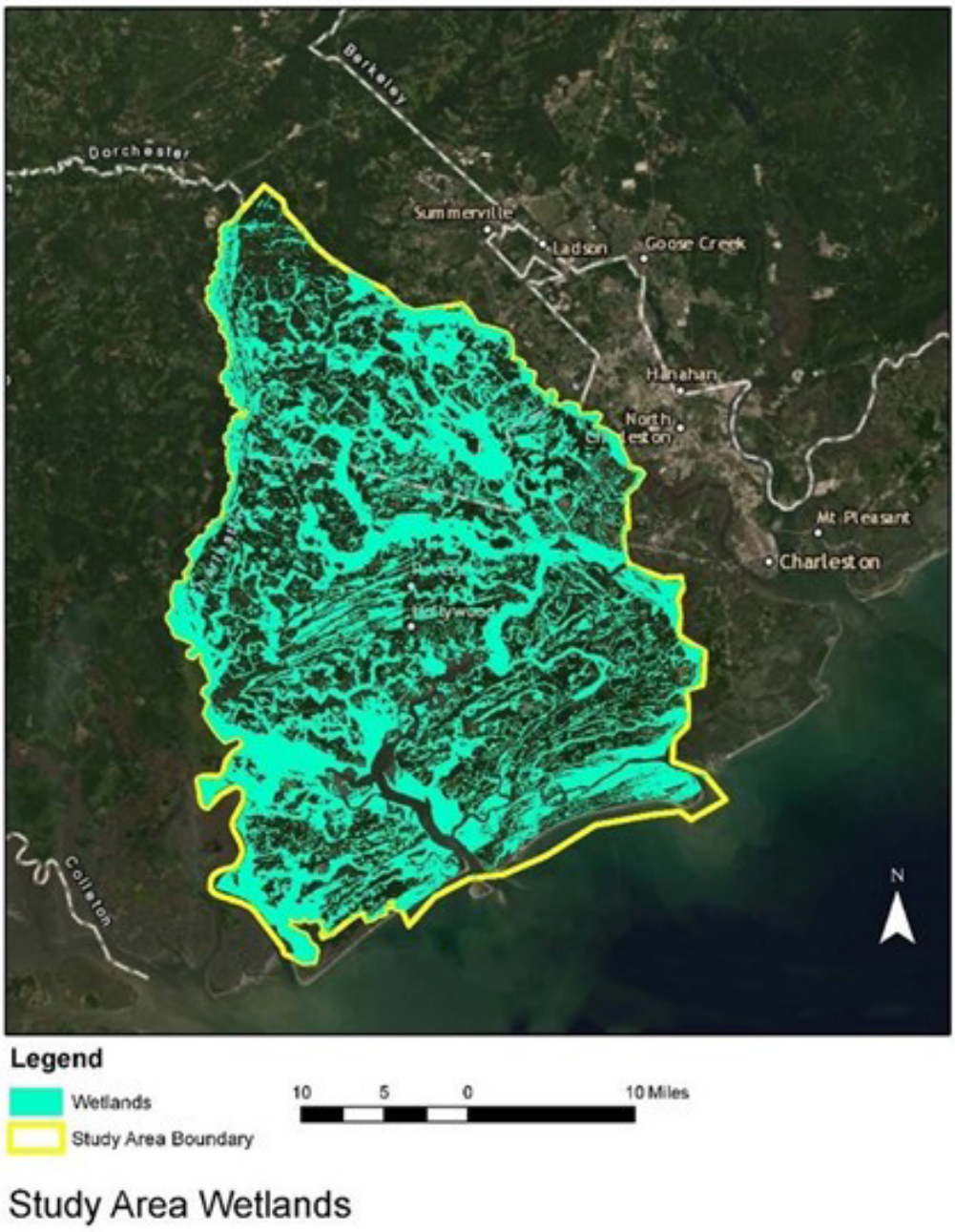


**Figure 1.** Location map of the study area at which landowners were surveyed; shaded areas identify locations defined as wetland.

**Table 1.** Wetland Knowledge Rubric

| | Low Knowledge | Medium Knowledge | High Knowledge |
|---|---|---|---|
| **Wetlands Definition:** "Wetland definitions, then, often include three main components: 1. Wetlands are distinguished by the presence of water, either at the surface or within the root zone. 2. Wetlands often have unique soil conditions that differ from adjacent uplands. 3. Wetlands support biota such as vegetation adapted to the wet conditions (hydrophytes) and, conversely, are characterized by an absence of flooding-intolerant biota." (Mitsch and Gosselink 2015) | Says I don't know, doesn't answer question, or gives wrong answer | Definition focuses on appearance of one or two factors | Definition mentions all three factors: hydrology, soils, and hydrophytic vegetation. |
| **Wetland Types**<br>• Distinguishes between wetland types. (For purposes of understanding how these are different but all are still wetlands. Landowner does not need to know highly technical definitions or terms to have high knowledge.)<br>• Marsh, swamp, bog, and fen are the four main types listed by the EPA. There are other, more specific names within these categories.<br>• The Cowardin System (1979) classifies by landscape position, vegetation cover, and hydrologic regime. Landowners may mention ideas like salt or freshwater, tidal or nontidal, types of vegetation, and how much water is usually in the wetland (hydroperiod) | Says I don't know, doesn't answer question, or gives wrong answer | Can name at least two different types of wetlands, but not sure what makes them different | Can name different types and names some or most of the reasons they might be different |
| **Wetland Functions: Functions exist in the absence of society (Brinson 1993)**<br>*EPA Fact Sheet Functions*<br>• Water storage (groundwater recharge/discharge, flood prevention, retention/detention)<br>• Nutrient Cycling (filtering nutrients, nutrient source)<br>• Biological Productivity—Wildlife Habitat<br>• Biological Productivity—Vegetation biodiversity and production | Says I don't know, doesn't answer question, or gives wrong answer | Names one or two functions | Names three or more functions |
| **Does landowner recognize all freshwater wetlands on property?** Evidence for this is found on the property map, as well as in interview data. | No | Yes, but not the full size | Yes, including the full size |
| **Familiarity with isolated wetlands:** Isolated wetlands are a common type in the study area, with most landowners having at least one on or adjacent to their properties. | Has never heard the term isolated wetlands and does not know what they are | Has heard the term isolated wetlands or knows what one is, but not both | Has heard the term isolated wetlands and knows what one is |
| **Overall Knowledge Score:** Determined by whether the majority of answers were low, medium or high. | | | |

US Environmental Protection Agency (EPA) and National Oceanic and Atmospheric Administration (NOAA), as well as by organizations such as the Wetlands Initiative. Landowners were specifically asked to define wetlands, if they could name and differentiate between different types of wetlands, what they thought was the function of wetlands, and if they had heard of isolated wetlands.

The category of "Does landowner recognize all freshwater wetlands on property?" was included to determine if the landowner knew of both the existence and the full size of wetlands on their property and was answered by comparing the respondents' notes they made on their maps with a map of wetlands showing US Fish and Wildlife Service (USFWS) wetland inventory data as well as putative isolated wetlands from Lane and D'Amico (2016). To determine the potential impact of property management actions on isolated wetlands, observational and photographic data, as well as locations of actions, were collected during the site visit. Combined with actions listed during the interview, this was used to develop a list of management and use actions that occurred on each property since purchase, as well as intended future changes.

Each action was first analyzed to determine if it was likely to have an impact on the hydrology of the wetland, using data collected during the study as well as literature about specific activities. The water budget equation was central to this analysis. An isolated wetland's water budget, or change in volume over change in time, depends on net precipitation (Pn), surface inflows (including overland flow or runoff), and, to a lesser extent, outflows, groundwater inflows (Gi) and outflows (Go), and evapotranspiration (ET) (Mitsch and Gosselink 2015). Basin morphology and topographic position also strongly influence hydrology. Hydrologic connectivity to groundwater also varies, and several studies have shown that isolated wetlands' groundwater connectivity is much more complex and influential than previously thought (Pyzoha et al. 2007; Kirkman, Smith, et al. 2012).

Precipitation is not directly modifiable by landowners; however, other factors of the water balance can be intentionally or unintentionally modified. Modifying these inputs and outputs changes the frequency and duration of ponding in the wetland. Changes to the hydrologic regime of the isolated wetland that resulted in a significantly different regime (i.e., is always ponded, never ponded) were deemed negative, as the wetland no longer functions as an isolated wetland. Activities that could impact hydrology according to the literature but were not observed to change the isolated wetland's hydrologic function were considered as having possible impacts. Activities that observably restored an isolated wetland's hydrologic regime would be considered positive, whereas activities that did not impact the hydrology, either by nature of the activity or by some other factor such as position in the landscape, were considered to have no impact.

Activities were also analyzed for impacts to wildlife habitat quality, specifically for amphibians and reptiles. Isolated wetlands are important breeding habitats for several species of amphibians, as fluctuating hydroperiods limit predators such as fish (Semlitsch and Bodie 1998). As they get older, juvenile frogs and toads venture into upland habitats, and surviving adults return to isolated wetlands to breed (Pittman et al. 2014). The wetland needs to be surrounded by useful upland habitats, in this case forested areas, that connect to other isolated wetlands and habitats suitable for amphibians in various life-cycle stages (Kirkman, Smith, et al. 2012; Zamberletti et al. 2018). Land use changes around the wetland, such as forest conversion to residential or agricultural use and road-building, can fragment and disconnect an isolated wetland from the larger network of habitats. If it is too difficult for adult amphibians to reach the wetland to breed, an otherwise suitable isolated wetland is no longer useful to these species (Sawatzky et al. 2018). Some species of semiaquatic turtles and juvenile alligators also use isolated wetlands and require navigable corridors between wetlands.

In this context, the location of a land management or use activity is particularly significant for whether it impacts an isolated wetland's habitat quality. Activities taking place in or directly adjacent to the wetland are prime candidates for negative impacts; however, even activities that are farther away can have negative impacts if the activity eliminates connections between wetlands and other amphibian habitats (Sawatzky et al. 2018). There are various estimates as to how wide the area of upland habitat (buffer) should be to keep the wetland suitable for amphibian and reptile habitats—for example, 164.3 meters for breeding salamanders (Semlitsch 2001) and 275 meters for freshwater turtles (Burke and Gibbons 1995)—which is why this study focused on whether landowners were severing connections between isolated wetlands to determine impacts. Activities that eliminated or reduced suitable upland habitat (forested areas) adjacent to isolated wetlands, as well as eliminated connections between upland habitats and other wetlands, were deemed negative. Activities that restored either of these were deemed positive. Activities that neither reduced, eliminated, nor restored were deemed to have no impact on the isolated wetland.

It is important to note that impacts can vary over time, and a certain activity on a given property may not have the same consequences as conducting the same activity on another property. Factors such as reference state of the wetland, geomorphology, season, climate, and surrounding land use influence how an activity may impact a wetland. Therefore, it was difficult to assign a rating of how negative or positive an activity may have been to the wetland's health. This study intended to develop a list of common land management and use activities and likely impacts on isolated wetlands based on available literature and the data gathered in the field.

Landowner knowledge level and perceptions were also compared to their impacts on the hydrology and wildlife habitat quality of their wetlands. Each landowner thus had a "knowledge, perceptions, impacts" pattern, a first step for determining if there are relationships between knowledge level and perceptions and impacts on isolated wetlands.

To determine if landowners accurately perceived the impacts their actions might have on isolated wetlands, participants were asked what kind of impact they thought they had on the area in general and on wetlands specifically. Perceived impacts were categorized as no impact, negative, or positive and were compared to observed hydrologic impacts and wildlife habitat quality impacts.

## RESULTS

Overall, the landowners interviewed had positive perceptions of wetlands and were fairly knowledgeable. Even though many were not recognizing the full extent of wetlands on their properties, they were not making drastic changes to wetland hydrology. However, the literature supports the idea that common landowner activities, like mowing, clearing, and building structures, have some impact on wetland hydrology. Most landowners were likely having a negative impact on the habitat quality of the wetland with respect to amphibians. While landowner knowledge and perceptions of wetlands did not seem to be driving their impacts, property size and landowner goals emerged as likely factors to determine impacts on isolated wetlands. Landowners mostly thought they had no impacts on wetlands on their properties, but the evidence supports the idea that they were altering hydrologic processes and habitat quality.

The 16 participating landowners had a median age of 60, all owned property within Charleston County, all were white, and all but two self-identified as "environmentalists." In all, 10 were migrants to the study area, with the beauty of the area being a strong attractor for moving there, and 6 were long-term residents, identifying as being originally from or growing up in the area. About half were male and half were female, and they identified with a variety of political beliefs. The majority of landowners stated that they enjoy living near the water. Education level and professional background were mixed as well, with no wetland professionals interviewed. Property size ranged from 4.7 to 403 acres, with an average of 64 acres and a median of 8.9 acres. Length of ownership ranged from 2 to 45 years, with an average ownership of 15 years. All properties had evidence of land use activities from prior owners, several properties had more than one wetland, and some properties featured multiple types of wetlands.

## WETLAND PERCEPTIONS

Most landowners had positive perceptions of wetlands, particularly regarding wetlands' abilities to prevent flooding and provide wildlife habitat. They used words like "valuable," "vital," "important," "special," and "beautiful" when describing wetlands, both in general and on their properties. Positive statements were often related to the wetland functions of flood protection and wildlife habitat. A landowner in a quickly developing area that was experiencing increased flooding issues said, "I think they're vital. They're like a reserve tank. They give moisture a place to go until nature can absorb it, and it's a harmless place for it to go where it won't hurt anything." While negative perceptions were scarce, a few landowners mentioned that the proximity of the wetland to their home or management activities might have negative impacts on desired property uses and activities. One owner, a landscape designer by profession, admitted that she knew that her property's location, adjacent to a salt marsh, might have negative impacts on her permaculture plans when purchasing the property. This owner had direct plans to modify the hydrology of her isolated wetland to suit her land use goals. Table 2 shows the overall number of landowners who had positive, negative, and positive and negative perceptions of wetlands.

There was an overall sentiment that wetlands should be protected via regulations, but wetland size, water source, who the landowner is, and what they are trying to do might make a difference in what regulations are deemed appropriate. "Development" was named as a clear enemy of wetlands, with negative consequences due to subsequent flooding.

**Table 2.** Perception of Wetlands and Knowledge Level by Number of Landowners

| | Positive | Negative | Positive and Negative |
|---|---|---|---|
| **Perception of Wetlands** | 14 | 0 | 2 |
| | **Low** | **Medium** | **High** |
| **Knowledge Level** | 0 | 13 | 3 |

**Table 3.** Example Quotes of Wetland Knowledge Results

| | Low | Medium | High |
|---|---|---|---|
| **Definition** | "I would say that that's a place that retains moisture more than 60% of the time." —Landowner I | "A wetland is usually wet, but it can be dry. It is characterized usually by a subspecies, uh sets of species of plants that aren't necessarily found anywhere else. Um, they certainly flooded when there're hurricanes." —Landowner A | No landowner scored in this category |
| **Type** | "I would almost say they're almost all the same because once you start displacing this water and you start trying to build on it or develop on it, I think you're asking for trouble." —Landowner K | "F1: No, I'm just choosing different terms. I don't distinguish between the two. Do you? F2: Well to me swamp sounds F1: It's like where we grew up in New Jersey, because we always called the meadow lands, you ever hear of the meadow lands up in New Jersey? Interviewer: Yeah. F1: Of course we lived on the edge of the meadowlands, but we always called it the swamps, so maybe I just grew up thinking of the two terms in a similar way. F2: Yeah, swamp kind of denotes wetter than marsh? Interviewer: Okay. F2: But, that may not be true, but it's kinda what I always thought." —Landowner F | "I suppose a marsh is a wetland, I hadn't really thought of that but it's a saltwater wetland I guess. Bogs, swamps, that's about the extent of my vocabulary. . . . I think the habitat of a bog is more mossy than we think of as a swamp." —Landowner L |
| **Functions** | No landowner scored in this category | "Habitat. Habitat for birds and critters and . . . all of that." —Landowner B | "Well they filter the water for sure. And uh, they provide nesting habitat and places for animals to eat. Raccoons need them for their food. Um, alligators. . . . It serves as a natural drainage area where excess water goes." —Landowner O |
| **Recognizing Wetlands** | "I wouldn't call that field where we're talking about [a wetland]." —Landowner M | Evidence was found in mapping | Evidence was found in mapping |
| **Isolated Wetland Familiarity** | "No. No, no no I haven't." —Landowner H | "Yeah, and that's sort of what I'm talking about, and I don't really understand it. You know, people say well ducks use them. Well that's fine, if ducks really use them, but I don't know." —Landowner N | "An isolated wetland? Um, I would imagine an isolated wetland is one that is completely surrounded by a dry area and does not have a creek or a um, source of water that's flowing in like a stream, that flows into the property. It's probably, I imagine that's it's mainly just a low spot where rainwater um will flow towards that that direction. That's, I'm assuming, just based on the description." —Landowner P |

### WETLAND KNOWLEDGE

Most participating landowners received a "medium" score on their wetland knowledge rubric, meaning that they knew many but not all of the wetland facts that are readily available to public audiences. Knowledge level by number of landowners is shown in Table 2. Representative quotes and their scores are included in Table 3. Most landowners defined wetland according to hydrologic and vegetation characteristics. The remaining landowners mentioned hydrology as the defining characteristic of a wetland, and no landowners mentioned soils in their wetland definition. Most landowners were able to name different types of wetlands, as well as one or more of the distinguishing features of different types. Marsh and swamp were frequently named wetland types, and whether the water was fresh or salt was a prominent distinguishing characteristic. All landowners scored medium or high in the wetlands function category. All landowners were able to name at least one wetland function, and wildlife habitat was the most frequently named function.

While many landowners had medium or high knowledge level scores, it was clear from the created wetland maps, and from statements some landowners made during the interview, that most landowners were not recognizing the full size of their wetlands, which is a component of knowledge that most likely has implications for management impacts. In landowners' minds, as evidenced by how they drew on property maps, wetlands appear to stop at property boundaries and are unable to cross driveways. This may be related to landowners associating seeing surface water with the area being considered a wetland.

### PROPERTY MANAGEMENT ACTIVITIES AND IMPACTS

Most landowners interviewed were not observably changing the hydrology of their isolated wetlands, but many were conducting activities that could possibly alter the hydrology. Most landowners had negative impacts on wetlands' ability to provide suitable habitat for amphibians. No landowners had positive impacts on hydrology or wildlife habitat. As shown in Table 4, landowners conducted 30 different activities on their properties.

The creation of roads, paths, and trails, as well as vegetation removal, happened on every property. Building structures like houses and sheds, creating or maintaining drainage features, keeping livestock and having pets, and planting vegetation took place on more than three quarters of the properties. Every other activity took place on half the properties or less. It should be noted that wells and septic systems were mentioned less than half the time, but any property with a residential structure in the study area would most likely have both. Most activities were not conducted within wetlands, but driveways through wetlands were the exception, happening on several properties. All activities took place within 750 meters of an isolated wetland, with many taking place directly adjacent to the edge of the wetland. It might be obvious that smaller properties often had activities closer to wetlands, but even on larger properties activities could still be close to a wetland, despite more acreage, often because these properties had multiple wetlands. A summary of impacts by the number of landowners is presented in Table 5.

Most landowners interviewed were not observably changing the hydrology of their isolated wetlands. No one

**Table 4.** Management and Use Activities

| Activity | Percentage of Properties Where Activity Occurred | Hydrologic Impacts from Literature | Wildlife Habitat Quality (Amphibians) from Literature |
|---|---|---|---|
| Roads, Paths, and Trails | 100.0% (n=16) | Surface water changes | Disturbance, reduces habitat and connectivity |
| Vegetation Removal | 100.0% (n=16) | Possible ET changes, surface water | Disturbance, reduces habitat and connectivity |
| Structures | 93.8% (n=15) | Surface water changes | Disturbance, reduces habitat and connectivity |
| Drainage | 87.5% (n=14) | Surface water, groundwater, and ET changes | Changing hydrology impacts wildlife |
| Livestock and Pets | 81.3% (n=13) | Surface water changes if compacted trails are created | Disturbance, removal of resources |
| Vegetation Planting | 81.3% (n=13) | ET changes, surface water | Possibly restores habitat and connectivity |
| Hands-Off Management | 50.0% (n=8) | Depends on prior conditions | Depends on prior conditions |

**Table 4.** (*continued*)

| Activity | Percentage of Properties Where Activity Occurred | Hydrologic Impacts from Literature | Wildlife Habitat Quality (Amphibians) from Literature |
|---|---|---|---|
| Well | 50.0% (n=8) | Groundwater changes, drawdown | Changing hydrology impacts wildlife |
| Pond | 43.8% (n=7) | Groundwater changes, changes hydrologic regime if excavating wetland | Changing hydrology impacts wildlife, disturbance |
| Chemicals, Fertilizers, and Pesticides | 37.5% (n=6) | No impact | Some are harmful to some wildlife, especially if improperly applied |
| Hunting | 31.3% (n=5) | No impact | Possible disturbance |
| Beekeeping | 25.0% (n=4) | No impact | Freshwater wetlands benefit bees |
| Buffer | 25.0% (n=4) | Beneficial to slowing down runoff, depends on prior conditions | Possibly restores habitat and connectivity |
| Dike | 25.0% (n=4) | Changes surface water | Reduces connectivity |
| Filling (non-wetland area) | 25.0% (n=4) | Possible surface water changes | No impact unless reducing upland habitat |
| Surveying | 25.0% (n=4) | No impact | No impact |
| Burning | 18.8% (n=3) | | Temporary reduction in habitat connectivity, depends on prior conditions |
| Composting | 18.8% (n=3) | If in wetland, possible sedimentation issues | No impact |
| Reverse Osmosis System | 18.8% (n=3) | Additional surface water | Possible issues with salt |
| Septic System/Leach Field | 18.8% (n=3) | | |
| Erosion Control | 12.5% (n=2) | Could reduce sediment entering wetland, possible impacts | Disturbance if close to wetland |
| Fishing | 12.5% (n=2) | No impacts | Negative impacts for amphibians if fish are stocked in wetland or former wetland |
| Garbage Removal | 12.5% (n=2) | Depends on what the garbage was and how it was removed | Possibly restorative |
| Soil Enrichment | 12.5% (n=2) | No direct impacts | No direct impacts |
| Walking | 12.5% (n=2) | No impact (unless paths/trails created) | Possible disturbance |
| Camping | 6.3% (n=1) | No impacts (unless permanent, compacted soil areas are created) | Possible disturbance if close to wetland |
| Cemetery | 6.3% (n=1) | Historical use, no current impacts | Historical use, no current impacts |
| Events (no permanent structures) | 6.3% (n=1) | No Impact | Possible disturbance |
| Plant Nursery | 6.3% (n=1) | Similar to vegetation planting | Similar to vegetation planting, possible disturbance, loss of suitable upland habitat |
| Power Easement | 6.3% (n=1) | See Roads, Paths, and Trails | See Roads, Paths, and Trails |

**Table 5.** Wetland Impacts by Number of Landowners

| | No Impact | Possible Impact | Negative Impact | Positive Impact |
|---|---|---|---|---|
| **Hydrologic Impact** | 1 | 14 | 1 | 0 |
| **Wildlife Habitat Quality Impact** | 3 | n/a | 13 | 0 |

was deliberately attempting to drain and fill their isolated wetlands—two major hydrology altering activities that require permitting in jurisdictional wetlands. However, most landowners were conducting activities that have been shown by literature to impact wetland hydrology, just not to the extent of noticeably changing the wetland to upland or open water. Activities included possibly modifying surface flow through construction of roads, paths, and trails; removing vegetation; building structures; and directly modifying drainage through activities such as creating or maintain ditches.

The majority of landowners had negative impacts on wetlands' ability to provide suitable habitat for wildlife, specifically amphibians. A minority of landowners had no impact, and no landowners had a positive impact. Vegetation removal (mowing and clearing) in or adjacent to wetlands was the largest cause of negative impacts to wildlife. Landowners were removing forested areas that are suitable upland habitat and that provided connective corridors between freshwater wetlands. Landowners were also actively maintaining nonforested areas through mowing or clearing brush that continued a previous pattern of fragmentation. The type of activity, the hydroperiod stage, and the current activities of the reptiles and amphibians influences how much wildlife will be disturbed. Roads, paths, and trails, as well as vegetation removal in wetlands, were the primary activities that would cause negative impacts to amphibians and reptiles. Property size, wetland density, and the landowner's goals for the property, which influence management and use activities, seem to influence whether an activity had hydrologic and wildlife habitat impacts to wetlands.

## RELATIONSHIP BETWEEN KNOWLEDGE, PERCEPTIONS, AND IMPACTS

The majority of landowners had possible hydrological impacts, medium knowledge levels, and positive perceptions of wetlands. About half of the landowners had negative habitat quality impacts, medium knowledge levels, and positive perceptions. Landowners who did not fit these patterns exhibited various other impacts, knowledge levels, and perceptions patterns, all shown in Tables 6 and 7. This study anticipated that higher levels of knowledge and positive perceptions would coincide with positive or neutral impacts on wetlands, but the evidence does not support this.

## PERCEPTION OF IMPACTS

Most landowners did not accurately perceive their impacts on isolated wetlands. They perceived themselves as having no impacts on their wetlands or the area in general, though they had possible hydrologic or negative wildlife impacts on wetlands. Out of the interviewed landowners who perceived that their land management practices had no impacts to their wetlands, only one implemented activities that actually resulted in no impact to their wetlands. Several of the landowners who inaccurately perceived their impacts did appear to understand that land use and management activities could possibly alter hydrologic cycling, but they still did not think their activities had an impact on isolated wetlands on their properties.

An illustrative example of this was Landowner C, who owns a property that has been extensively hydrologically modified, both by himself and by previous owners. The landowner stated, "And I'm thinking . . . if I tried to bring in dirt. I don't, I think it would just drain somewhere else and make another place. Water's got to go somewhere and when it can't soak in anymore; it's got to go to some kind of low land and be drained off." This shows that he knows filling would alter the hydrology in terms of where water collects in a given time frame, but he thinks the specific locations of where water collects do not matter overall. This landowner additionally stated, "I don't think it would impact a whole lot if [the wetlands] were not there. I don't think it would be any different." This statement shows that Landowner C does not really think it would matter if he were to alter the hydrology of the wetland.

Despite inaccurately perceiving that they, individually, do not impact isolated wetlands through land management activities, landowners pointed to two groups they thought were having impacts: "neighbors" and "developers." Neighbors were mentioned by half the landowners as perpetrators of activities that the interviewee thought might a harm a wetland. A little over a third of landowners pointed to developers as "destroyers of wetlands," supplying anecdotes about development activities in the study area.

**Table 6.** Relationship of Hydrologic Impact, Knowledge Level, and Landowner Perceptions

| Hydrologic Impact | Knowledge Level Score | Landowner Perceptions | Number of Landowners |
|---|---|---|---|
| Possible | Medium | Positive | 11 |
| Possible | High | Positive | 1 |
| Possible | Medium | Positive and Negative | 2 |
| Negative | High | Positive | 1 |
| No Impact | High | Positive | 1 |

**Table 7.** Relationship of Wildlife Habitat Quality Impact, Knowledge Level, and Landowner Perceptions

| Habitat Quality Impact | Knowledge Level Score | Landowner Perceptions | Number of Landowners |
|---|---|---|---|
| Negative | Medium | Positive | 9 |
| Negative | High | Positive | 2 |
| Negative | Medium | Positive and Negative | 2 |
| No Impact | Medium | Positive | 2 |
| No Impact | High | Positive | 1 |

## DISCUSSION

The results of this study bring a somewhat positive, though tempered addition to the literature. While this study is enlightening about the perceptions, knowledge, and impacts of white "environmentalist" landowners who wanted to participate in a research study, the authors of this study recognize that there are several other landowner groups in the study area that may have different perceptions, knowledge, and impacts. Researchers who are people of color, or working with groups that have strong ties to landowners of color, could possibly have better traction engaging nonwhite landowners in similar research. Wetlands in this area are certainly vulnerable but the landowners interviewed were not deliberately eliminating isolated wetlands through draining and filling; they were rather indirectly, nondeliberately impacting wetlands through other activities, most notably vegetation removal, which has been shown to change hydrology in the southeastern US Coastal Plain (McLaughlin et al. 2013). Perceptions and even hopes of being beneficial to wetlands mean that this may be a prime group to enlist more effectively to halt the destruction of isolated wetlands in the area, or even to ensure that existing isolated wetlands remain unstressed by development. The main problem appears to be that these landowners simply do not know how their activities are impacting wetlands, stemming from not really knowing the true extent of wetlands on their properties—or not trusting scientists (or, in particular, "government scientists") in delineating and defining these wetlands.

Not recognizing the scientifically defined boundaries of their wetlands seems a likely reason why participating landowners thought they had less impact on isolated wetlands than they actually did. There was a general sentiment that landowners thought they should not "mess with" wetlands, but if a landowner is simply not recognizing wetlands, then there is no reason for the landowner to choose to conduct management and use activities in another place on the property to avoid "messing with" the wetland. This issue appears to stem from the biggest gaps in wetland knowledge: none of the landowners interviewed included anything about soil in their definitions of wetland, much less hydric soil specifically, and several failed to recognize that wetlands do not require surface water at all times.

Landowners also did not seem to be aware of how much connected habitat around a wetland is necessary for the survival of certain wetland wildlife. This is not surprising, as the answer to how much connected habitat is needed varies along a wide array of conditions (Sawatzky et al. 2018). Landowners also did not bring up the idea that certain activities may disturb wetland wildlife, even if it does not disturb the wetland itself. What is interesting is that wildlife habitat was the most-mentioned wetland function and a significant reason that landowners felt positively about wetlands. Enhancing wildlife habitat could possibly be a key to getting landowners involved in wetland protection; however, in this study, landowners mentioned wildlife that are not dependent on isolated wetlands, such as white-tailed deer or birds in general, as being important to them.

Although landowners often did not have a full grasp of or belief in the scientific definition of wetland, the idea that you should not "mess with" a wetland because of regulations was present in several interviews. While helpful to wetlands, this requires that the landowner first recognize an area as a wetland and then have a rather broad definition of "mess with" in order to have no impacts. Wetland regulations in the area prevent draining and filling jurisdictional wetlands, but there is little clarity for how nonjurisdictional wetlands are treated, and the existing regulations also seem to have a rather a narrow scope of "mess with." Landowners can in fact obtain permits to "mess with" certain wetlands in certain cases, and there are also activities that do not require permits, as well as wetlands that do not require permits for any activity. This simplified view of the legality of performing activities that impact wetlands, which seems promising at first, is still not very helpful for protecting isolated wetlands.

There is much that can be done to improve the education and policy approach for improving isolated wetland outcomes in the Lowcountry. If the activity is not taking place in a wetland, how much is the activity really impacting the wetland? The scientific answer to this is the field of ecohydrology, which essentially answers this question with "it depends, and it's complicated." It is little wonder that non-ecohydrologist landowners do not understand the connection between their activities and impacts on wetlands. Targeted and area-specific policies and education programs would likely assist landowners in having fewer negative impacts on isolated wetlands

## RECOMMENDATIONS AND CONCLUSIONS

Further research by social scientists to help shape landowner education efforts is still needed. Focusing on increasing understanding of how common activities impact isolated wetlands and providing information and guidance on best practices for conducting common activities could bring desired results of voluntary conservation of critical habitats and ecological services provided by isolated wetlands. This study identified several common activities through which landowners are most likely influencing isolated wetland hydrology and habitat quality: creation of roads, paths, and trails; removal of vegetation; building structures; and activities that modify drainage patterns. Education efforts should focus on assisting landowners with identification of wetlands and supporting their understanding of how these activities influence hydrology and habitat quality of isolated wetlands and provide a framework of best practices to eliminate or reduce negative impacts on isolated wetlands while still supporting the landowners' goals for their properties.

Moving beyond landowners, there is anecdotal evidence that real estate agents are reaching out to environmental scientists, managers, and educators for more information about stressors like flooding; this may be driven by the knowledge of homebuyers asking questions during the decision-making process. Educating real estate agents on identifying isolated wetlands and their benefits could result in matching potential buyers to land based on desired uses in a way that would protect wetlands. Local ordinances seem to be an effective solution to some issues, especially those related to building and construction, such as improving the design of driveways across isolated wetlands to reduce impacts on hydrology. Furthermore, policymakers should consider the findings in this and related studies as informative guidance on the perceptions of residents in their analysis of effective regulatory policy that will provide environmental protections as well as protections to property value in a region experiencing accelerating population growth. The research results from this study clearly show a stark lack of awareness of the very landscapes that have supported multigenerational residents and that also attract migrants to the region.

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