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Applying Public Participation Geographic Information Systems for Coastal Wading Bird Conservation

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ABSTRACT

Coastal estuaries in the northern Gulf of Mexico are important habitat for wading birds, but are threatened by land use and ecological changes. Conservation has been demonstrated to be more effective when stakeholders are included in the decision-making process. Public Participation Geographic Information Systems (PPGIS) facilitates the inclusion of stakeholder preferences in the planning process by allowing a direct spatial comparison with other ecological data. In this study, we used a PPGIS survey of residents of two counties on Alabama's Gulf Coast to identify wading bird conservation hotspots as identified by local residents. Additionally, we assessed the ability of general public respondents to accurately identify wading bird habitat, determined whether participants associated wading bird habitat with particular land cover types, and examined whether respondents identified areas with high wading bird species richness. We found that respondents could accurately identify suitable wading bird habitat on a map of the study area, but underrepresented riparian forest, which is an important habitat for many wading bird species. Additionally, participants tended to prioritize areas that support higher wading bird species richness. Thus, this study demonstrated how PPGIS can function as an important tool for incorporating both stakeholder management preferences and identifying knowledge gaps.

KEYWORDS
Conservation; public participation; wading birds; wildlife; spatial

Introduction

Coastal areas are especially challenging to manage for wildlife because of the increasing development pressures on these lands worldwide (Lotze et al. 2006; Sullivan 1994). Along the northern Gulf of Mexico and other coastal areas, wading birds represent a diverse group of species normally associated with wetlands and open water. Perhaps the most commonly identified wading birds are those in the order Ciconiiformes, which include the herons, egrets, bitterns, wood stork, ibis, and spoonbills. Other wading birds include those in the order Gruiformes (i.e., limpkins, cranes, rails, coots and moorhens) and Phoenicopteriformes (i.e., flamingos). These species combined are common to coastal areas but challenging to manage as a group because of the diversity of habitats

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they require (Natural Resources Conservation Service 2005). Recognized for their long-legged form, these birds commonly wade through marshes, swamps and shallow waters as part of their foraging habitat. Many of the birds also seek trees and shrubs for roosting and nesting, often forming extensive rookeries with other wading birds (Batzer, Cooper, and Wissinger 2006). Salinity, vegetation structure, water depth, habitat fragmentation and seasonal cover are all features that some wading birds depend on and may determine suitability of aquatic habitats (Bent 1963; Natural Resources Conservation Service 2005).

Estuaries and coastal areas provide extensive habitats for wading birds; however, many areas have experienced significant changes that have reduced their extent or value as habitats. Mobile Bay is the sixth largest estuary in the continental United States and represents a significant ecological and economic resource for the northern Gulf of Mexico. Although the area boasts high biological diversity and productivity, it also has been altered extensively by several historical and ongoing activities including urbanization, silviculture, navigational dredging, and industry (Mobile Bay NEP 2008). These activities have contributed to the permanent loss or reduced quality of wetland habitats necessary for many of the region's wading bird populations. For example, it was estimated that over 4,000 ha of emergent wetlands were lost from Mobile Bay between the 1940s and 1970s (Duke and Kruczynski 1992). The documented loss and degradation of habitats in this region has led to extensive conservation efforts including habitat restoration and acquisition/preservation of properties with critical habitat (Mobile Bay NEP 2006). For example, the Alabama Forever Wild program is statewide land trust authorized by the state and retained after following a statewide referendum vote on whether to keep the program financially viable. Approximately 20% of the property acquisitions have been in the two coastal counties of Alabama surrounding Mobile Bay (https://www.alabamaforeverwild.com/forever-wild-tract-list). There is tremendous activity and public interest in bird watching in the region. Coastal Alabama is an important migratory passage for many neo-tropical birds flying to/from Central and South America each year (Barrow et al. 2005). Further, the State of Alabama has designated 11 coastal birding trails in the Mobile Bay region alone (https://alabamabirdingtrails.com/trails/coastal/mobile-bay-causeway-and-blakely-island-loop/).

For this study, we sought to examine public knowledge about critical habitats and potential conservation targets needed for wading birds in the Mobile Bay region of Alabama. It is increasingly understood that conservation planners must consider how ecological based conservation goals compare with stakeholder interests and preferences (Berkes 2009; Bryan et al. 2010; Knight, Cowling, and Campbell 2006; Knight et al. 2008). In recent decades, stakeholders in the United States have increasingly demonstrated discontent with expert-led, top-down management practices, and have advocated for increased participation in the natural resource decision-making process (Morse 2012; Smith and McDonough 2001). A growing body of research has demonstrated that integrating stakeholder participation in the planning process can decrease tensions between stakeholders and managers while increasing public support, awareness, trust, empowerment, and implementation efficiency (Donovan et al. 2009; Schusler, Decker, and Pfeffer 2003; Treves et al. 2006). Previous studies have also shown that local people can identify areas of conservation priority that reasonably approximate those developed by conservation planners using quantitative scientific assessments (Ban et al. 2013).

To evaluate public knowledge on wading bird habitats, Public Participation Geographic Information Systems (PPGIS) was used. PPGIS was conceived as a method to spatially capture participants' opinions and preferences about places on a landscape by allowing them to identify these preferences directly onto a map, thus inverting the often expert driven approach to using Geographic Information Systems (GIS) for resource management and conservation planning (Brown 2005; Sieber 2006). This tool allows managers to identify places on the landscape where people think wildlife should be conserved, not just where conservation-minded people live (Cox et al. 2014). This is important since people often have multiple, place-dependent attitudes about conservation (Brown, Weber, and de Bie 2015; Riley et al. 2002). PPGIS has been used to collect data on a wide range of topics, including landscape values (Brown 2005; Nielsen-Pincus 2011), development preferences (Brown and Raymond 2007), local values for coastal ecosystems (Brown et al. 2017), conservation planning (Brown, Weber, and de Bie 2015), and ecosystem services (Cox et al. 2015; Raymond et al. 2009).

Utilizing PPGIS, our specific goals for this study included: (1) assessing the capability of residents to identify valuable wading bird habitat in the region, (2) identifying whether participants strongly associated wading bird habitat with certain land cover types or areas, and (3) identifying whether those land cover types or areas provide sizeable and/or important wading bird habitat. Recognizing habitats underrepresented by citizen respondents may indicate a potential knowledge gap. Finally, we wanted to examine whether the respondents to our PPGIS study would identify the most valuable habitats in the region in terms of supporting a diversity of species or a specific threatened species, such as the reddish egret (*Egretta rufescens*). It is important to understand whether the places that participants associate as important for conservation provide habitat for multiple species or threatened species or if they primarily support only one or two generalist species of lesser conservation priority. By analyzing public perceptions, managers can gain important insights into what the public may support in terms of property acquisitions or conservation activities and what knowledge gaps exist to guide future outreach and education activities.

Study area

The study area was an 11,932 km^2 region centered around Mobile Bay, which is a large bay located along the northern Gulf of Mexico on the coast of Alabama (Figure 1). This region included nearly all of both Baldwin and Mobile County, Alabama. Baldwin and Mobile counties contain the entire coastline of Mobile Bay, the Mobile-Tensaw River Delta, other smaller bays, and all of Alabama's Gulf Coast. The region also includes Dauphin Island, located just off the coast in the Gulf of Mexico, which is renowned as a birdwatching destination due to its location as a first land mass encountered by birds migrating north across the Gulf of Mexico. The total combined 2010 population of Baldwin and Mobile counties was 599,294 (U.S. Census Bureau 2010). However, the human impact on this landscape is unevenly distributed. This study site was chosen due to its prominent bays, diversity of ecosystems, inclusion of many prime recreation destinations, and vulnerability to human threats. In addition, the Mobile Bay region provides habitat for an array of threatened and endangered species, including species of wading birds such as the reddish egret (*Egretta rufescens*) (Alabama Natural Heritage Program 2011).

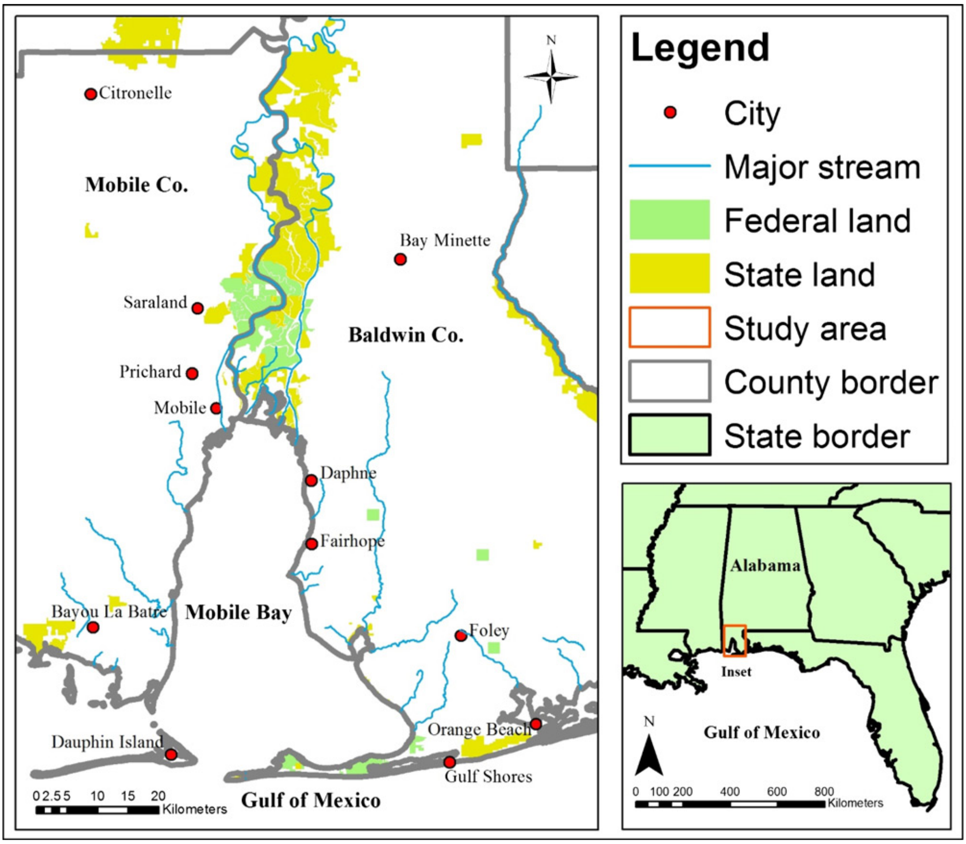

Figure 1. Study area: Mobile Bay, AL.

Methods

Survey methods

In the summer of 2012, we developed a map-based survey and sent it to 988 residents of Baldwin and Mobile counties. To accurately represent the opinions of stakeholders, the number of surveys sent to residents was proportional to each county's percentage of the total population. Thus, 69% of the surveys were sent to residents of Mobile County and 31% were sent to residents of Baldwin County. Residents were randomly selected from within each county. The survey methodology followed a modified version of the Dillman four contact method, employing a pre-notice letter informing the recipient of his/her selection to participate in the study, a survey packet that included a questionnaire and PPGIS mapping activity, a reminder postcard, and a final reminder letter (Dillman, Smyth, and Christian 2008). The survey was part of a larger project to identify the location of important places for stakeholder cultural and watershed values, location of conservation preferences for wildlife, and development preferences among others (Cox 2013). The survey was pre-tested with students at Auburn University.

The purpose of this portion of the survey was to identify which terrestrial and aquatic places stakeholders in the Mobile Bay region think are important and should be conserved and/or managed as habitat for the benefit of wading birds. The survey packet included a questionnaire and a PPGIS mapping activity that asked participants to identify places in the Mobile Bay region that should be maintained as habitat for the conservation of wading birds. In this exercise, participants were asked to place 0.64-cm stickers that were coded to correspond to each item onto a 60×90 cm full color map of the Mobile Bay region to identify the locations of those important habitats following established methodology (Brown 2005). The exact wording describing the sticker for this analysis was, "I would like to see these places maintained for the conservation of wading birds (cranes, herons, egrets, etc.)." The map consisted of a true color aerial photograph of the region at a scale of 1:150,000. Cities, roads, and protected land boundaries were labeled as references. The results of the PPGIS mapping exercise were entered into a GIS database through the process of "heads-up" digitizing, in which points were manually entered onto a GIS map displayed on the computer screen to match the stickers on the physical map as closely as possible (Brown et al. 2004). The size ratio of the physical map to its digital counterpart was set at 1:1 for the digitizing process to minimize error.

Data analysis

Respondent identification of wading bird habitat

In order to determine where participant-identified important places for wading bird conservation clustered, a kernel density analysis of the respondent-identified points was conducted using a grid cell size of 500 m and a search radius of 3,000 m (Brown 2012). To calculate kernel density values, a GIS tool was used to "fit a smoothly curved surface (grid) over each point producing a circular area (kernel) of a certain bandwidth (or search radius)" (Brown and Weber 2013, 462). Higher kernel density scores represented greater stakeholder consensus favoring wading bird conservation at those areas. We used a 0.67 kernel density percentile threshold, meaning that the upper third of the raw kernel density values were selected, to identify kernel density hotspots (Brown 2012). Hotspots are areas of significant kernel density, meaning that there is considerable stakeholder support for wading bird conservation at these locations.

We then acquired maps of suitable wading bird habitat developed by the Alabama Gap Analysis Program (AL-GAP) (Silvano et al. 2007). A total of 11 wading bird species representing the order Ciconiiformes were selected for this study (Table 1). These species were selected because it was expected that the public would be most familiar with them and identify them as wading birds. Habitat maps for each Alabama wading bird species were created by incorporating their known range and a habitat association model that factored in habitat requirements, such as land cover, habitat patch size, hydrology, and elevation. Maps were developed for each individual species and were then combined to identify the total extent of habitat suitable for any wading bird species within the study area. The kernel density hotspots were then overlaid with the suitable habitat to identify areas of overlap. The spatial accuracy of the hotspot areas was determined by calculating the percentage of the participant identified hotspots that were included as GAP defined suitable habitat (Cox et al. 2014). The portions of the hotspots that overlapped with suitable habitat were termed "conservation targets" because of the potential for public support to acquire/maintain these areas. We also analyzed the spatial accuracy of participants to identify wading bird habitat by determining the percent of the points that fell within the GAP defined suitable habitat.

Table 1. Common Alabama wading birds in the order Ciconiiformes and their habitat preferences (per Bent 1963; Natural Resources Conservation Service 2005).

Common name	Species	Habitat preference: Emergent marsh	Open water	Herbaceous uplands	Trees shrubs	Nesting habit
Great blue heron	*Ardea herodius*	F	F		N	C
Great egret	*Ardea alba*	F	F		N	C, S
Snowy egret	*Egretta thula*	F	F		N	C
Little blue heron	*Egretta caerulea*	F		F	N	C
Cattle egret	*Bubulcus ibis*			F	N	C
Green heron	*Butorides virescens*	F, N	F		N	S, C
Black-crowned night heron	*Nycticorax nycticorax*	F, N	F		N	C
Yellow-crowned night heron	*Nyctanassa violacea*	F	F		N	C
White ibis	*Eudocimus albus*	F, N	F		N	C
Reddish egret	*Egretta rufescens*	F	F		N	C
Tricolored heron	*Egretta tricolor*	F	F		N	C

F = feeding; N = nesting; C = colonial; S = solitary.

Respondent identification of land cover as wading bird habitat

Next, we analyzed land cover data for the study area derived from the Alabama GAP from Enhanced Thematic Mapper Plus (ETM+) satellite imagery (Kleiner et al. 2007). The land cover data featured subpixel accuracy and a maximum positional error of 30 m. The GAP data divided the land cover of Baldwin and Mobile counties into 71 specific land cover classes, but we combined these into eight broader categories: water, developed, beach, barren, riparian forest, other forest, agriculture, and wetlands. We then calculated the percentage of the study area that fell in each land cover class.

Subsequently, we overlaid the PPGIS points used by participants to identify their perceived wading bird conservation preferences with the reclassified land cover map to determine the number of points placed on each land cover type. We performed a chi-square proportional analysis to determine whether the number of points placed by participants on each land cover type was significantly different than points placed randomly on the map. To accomplish this, we identified the number of wading bird points that would be expected for each land cover type based on the percentage of the study area that the land cover type occupied. Then, we performed a chi-square analysis for each land cover type to determine whether the actual distribution of points was significantly different from the expected distribution. These data allow for an assessment of the participants' association of land cover with wading bird habitat. Participant knowledge gaps were discerned by identifying land cover that provides important habitat but was underrepresented by participants, or by identifying land cover that does not provide suitable habitat but was overrepresented by participants.

Next, we overlaid the PPGIS hotspots with the land cover data to determine the percentage of hotspots that were included in each land cover type. For each land cover type, we compared the area within the hotspots to the total area within the study area to determine the percent of the land cover that was included in the hotspot for each land cover type. This allowed us to determine whether certain land cover classes were under- or over-represented within the hotspots. We performed the same analyses with land cover data and wading bird conservation targets to determine the land cover composition of the conservation targets by percent and the percent of the total area of each land cover class that was included in the conservation targets.

Respondent identification of critical wading bird habitat

We combined the raster range maps for each of the 11 wading bird species for which GAP habitat existed (Silvano et al. 2007). This allowed us to view the total extent of wading bird habitat in the study area and determine the number of species that could inhabit each location. We calculated the percent of the study area that provided habitat for each number of species, ranging from 0 to 10, since no locations provided habitat for all 11 species. We then clipped this layer to the range of the PPGIS hotspots and determined the percent of the hotspots that provided habitat for each number of species. The results were compared with the hotspots in the study area to determine if participants overrepresented certain species richness values. Among the species considered in our study, the Alabama Department of Conservation and Natural Resources (ALDCNR) has designated the reddish egret as a species of high conservation concern (ALDCNR 2014). Therefore, we conducted an individual assessment of the percent of reddish egret range that fell within the hotspots to determine whether hotspots were including habitat suitable for the most threatened wading bird species in the area.

Results

Survey response

Of the 988 survey packets that were mailed, 7.6% (n = 75) were returned as undeliverable by the U.S. Postal Service. A total of 274 responses were received (30.0%), with 88.3% (n = 242) of those participating in the PPGIS mapping exercise. The 242 respondents who chose to participate in the mapping exercise used 715 stickers to identify places that they believe should be maintained for the conservation of wading birds. This represents a mean of 2.95 out of 5 possible stickers used per respondent, which is 59.1% of the possible stickers available to respondents. Based on respondent demographic data provided, the responses overrepresented males, Caucasians, people with higher incomes, people over the age of 65, and people with higher levels of education when compared with the 2010 census results for Baldwin and Mobile counties (U.S. Census Bureau 2010). Based on this result, caution should be taken when generalizing these results to the general public.

A kernel density analysis of these points resulted in wading bird conservation hotspots that covered 275 km^2 and were primarily located near the coast (Figure 2). These locations indicated that there was strong public consensus in support of wading bird conservation at several large, distinct locations throughout the study area.

Accuracy assessment

Respondent identification of wading bird habitat

Hotspots were overlaid with a map of suitable wading bird habitat developed by the Alabama GAP (Figure 3). This analysis showed that 79% (216 km^2) of the publicly identified wading bird conservation hotspot area fell on GAP defined suitable habitat. This indicated that participants had an understanding of the habitat requirements of wading bird species. These areas of overlap (i.e., conservation targets) highlighted potential

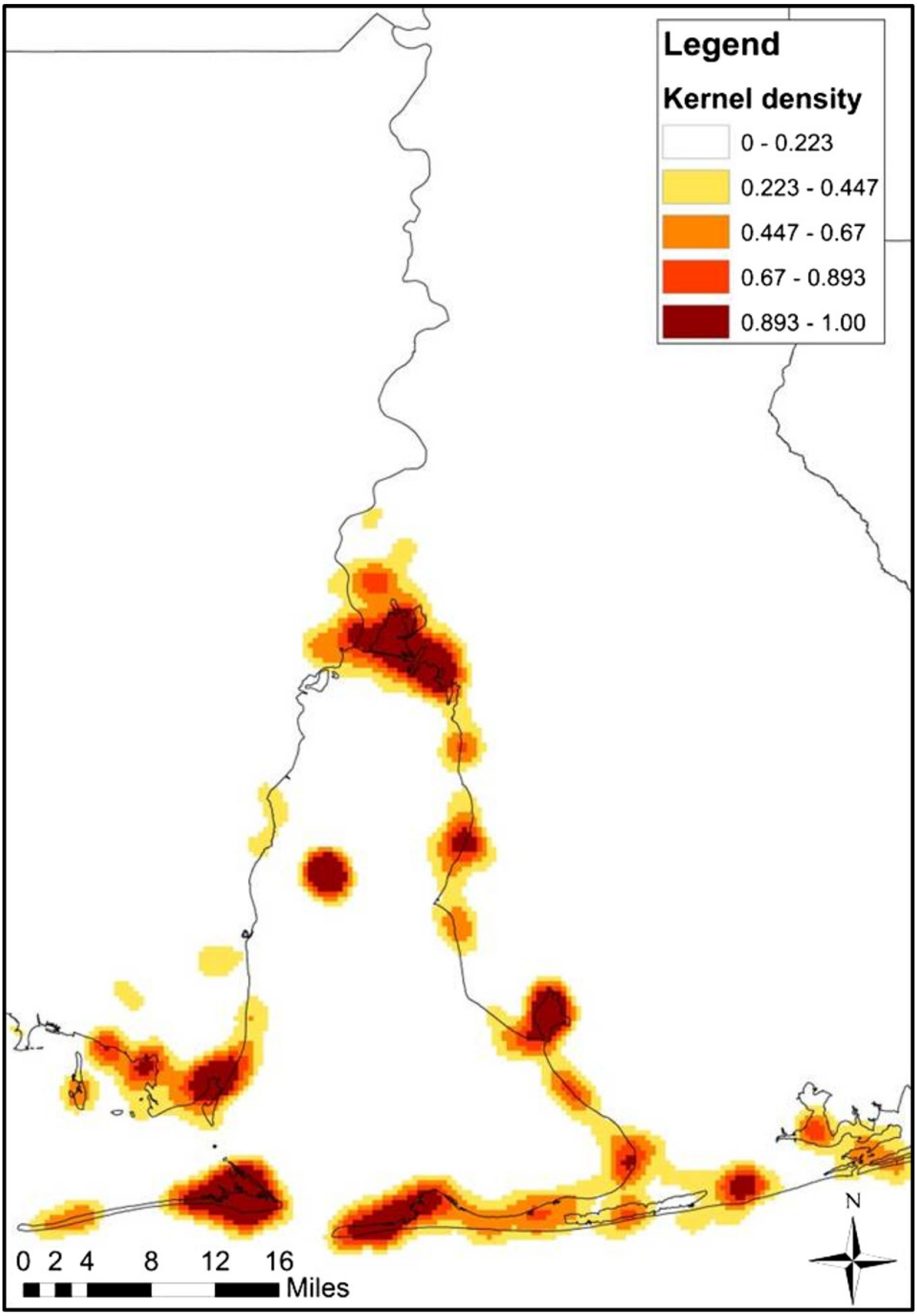

Figure 2. Kernel densities for wading bird conservation.

priority areas for wading bird conservation since they represented places where public support for conservation and expert identified habitat overlapped. The conservation targets highlighted 4.9% of the total GAP defined suitable habitat in the study area. Similarly, of the 715 points used by participants to identify places for wading bird conservation, 534 (74.7%) fell within the GAP defined habitat.

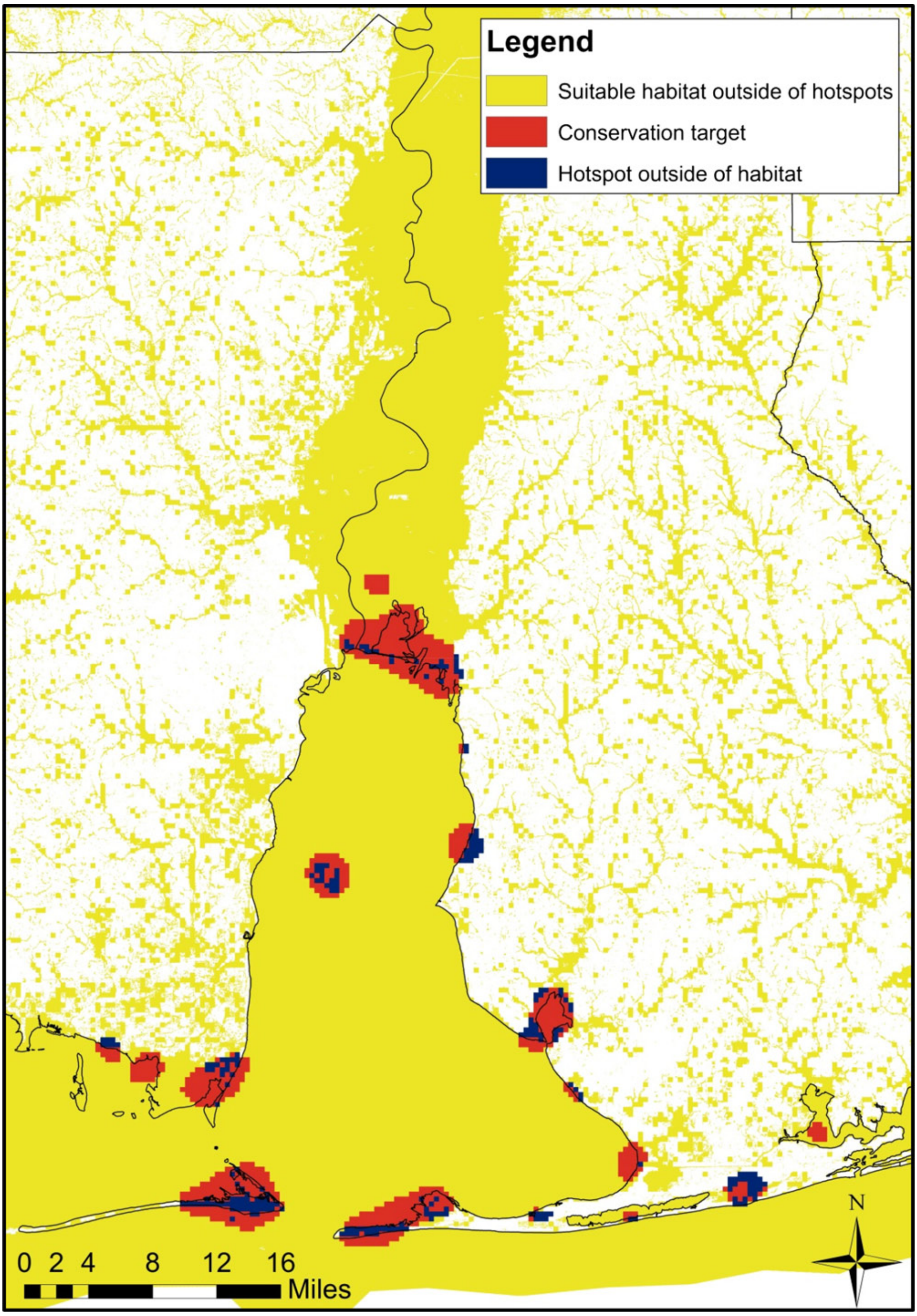

Figure 3. Conservation targets identified from hotspots and GAP data.

Respondent identification of land cover type as wading bird habitat

The conservation targets were overlaid with land cover data to identify whether there was a difference in the distribution of land cover types within the conservation targets from that in the hotspots. This also highlighted the type of land cover participants most often identified incorrectly as wading bird habitat (Figure 4). Table 2 shows that respondents tended to err on the side of identifying terrestrial areas (such as other forest types and developed lands) that are not suitable for wading birds. The distribution of land cover within the conservation targets as compared with the land cover of the total GAP habitat shows that participants underrepresented riparian forest (4.8 vs. 27.3%) in their identification of wading bird habitat. This result showed that participants either viewed riparian forest as less important for wading bird habitat than other land cover types, did not support conservation of this land cover, or were less aware of its importance as habitat for wading birds.

The PPGIS points were also overlaid on land cover data to determine the number of points that were located on each land cover type (Table 3). The proportional chi-square analysis showed that water, beach, and wetlands land cover types were significantly overrepresented by the PPGIS points, while barren, riparian forest, other forest, and agriculture land cover types were significantly underrepresented (Table 4). The result for developed land cover was not significant. These results were mostly consistent with the land cover types that are overrepresented by the GAP habitat, demonstrating that the participant point distribution overrepresented the types of land cover that are more likely to provide wading bird habitat and underrepresented those that are less likely. However, participants also underrepresented riparian forest, as well, which makes up a large percentage of the GAP habitat.

Respondent identification of critical wading bird habitat

The species richness analysis showed that 36.4% of the study area did not provide habitat for wading birds, while an additional 47.6% provided habitat for one to five species (Table 5). Thus, only 15.9% of the study area provided habitat for six to ten species of wading bird. Based on the overlaid PPGIS hotspots and species richness map (Figure 5), only 2.6% of the hotspots did not overlap with wading bird habitat while 55.9% provided habitat for one to five species. However, 41.5% of the hotspot overlapped with habitat mapped for six to ten species. Thus, participants appeared to be successfully identifying places that provide habitat for a diverse array of wading bird species based on their selection of conservation preferences. Further, 32% of the reddish egret range within the study area was included in the respondent hotspots.

Discussion and conclusions

We found that the participants identified suitable wading bird habitat with high levels of spatial accuracy since 79% of the hotspot area fell on suitable habitat and was included in the conservation target. This result indicates that respondents had an understanding of the types of places that provide suitable habitat for wading birds and can provide informed opinions on places where they might support increased conservation

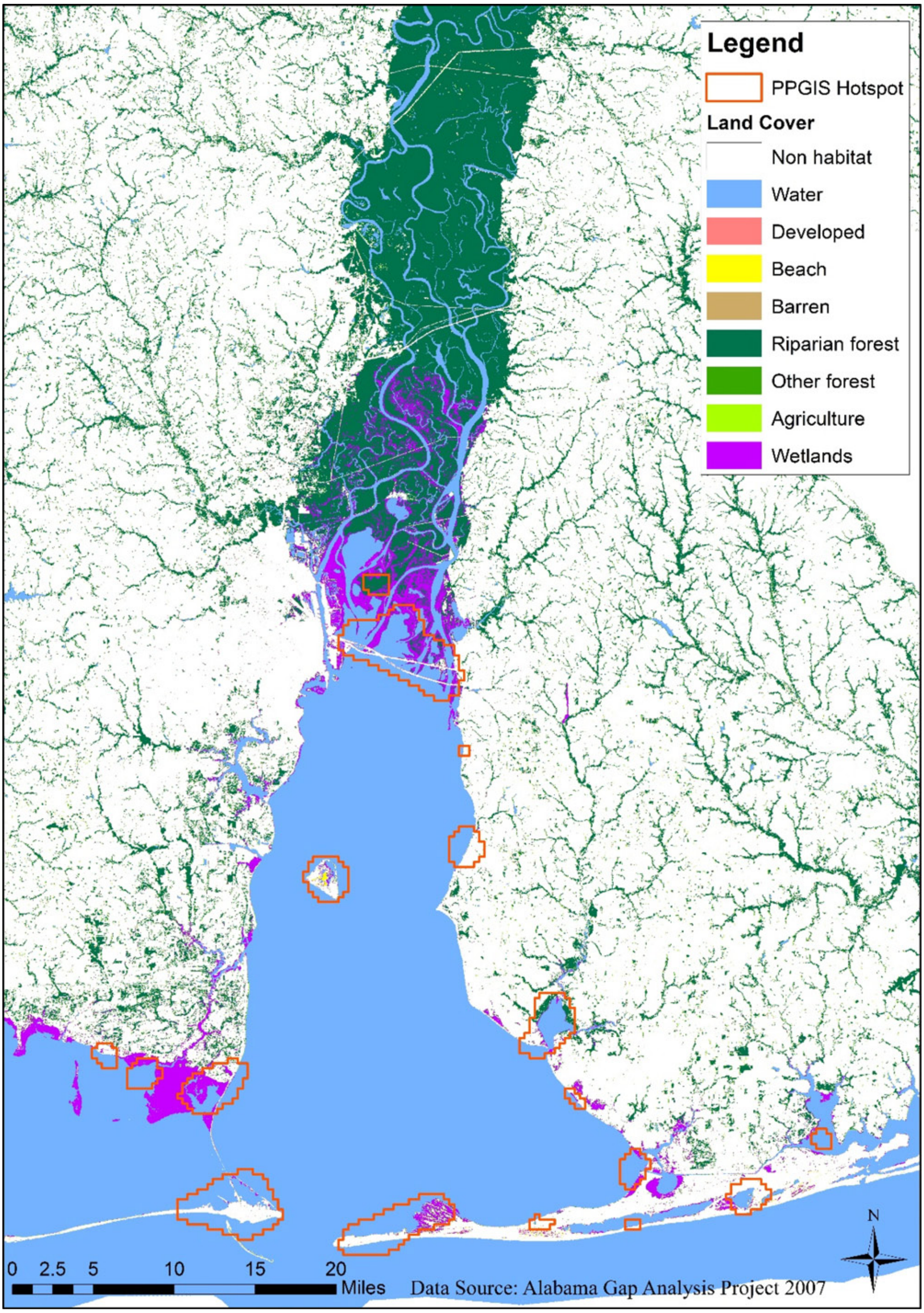

Figure 4. Land cover of wading bird habitat.

efforts. Since there is likely a higher degree of public support for conservation in these conservation targets and they provide the necessary habitat, it might be effective for managers to consider conservation efforts in these hotspots. These conservation targets may represent low hanging fruits for conservation or management since they would

Table 2. Land cover of wading bird hotspots and conservation targets.

	Water	Developed	Beach	Barren	Riparian Forest	Other Forest	Agriculture	Wetlands
Percent of study area	24.50%	8.18%	0.29%	6.33%	9.81%	34.84%	13.99%	2.08%
Percent of GAP habitat	60.25%	0.55%	0.09%	0.75%	27.27%	6.05%	0.71%	4.32%
Percent of hotspot	60.99%	7.55%	3.21%	0.55%	4.07%	7.65%	0.97%	15.01%
Percent of conservation target	76.37%	0.69%	0.73%	0.11%	4.76%	1.15%	0.08%	16.91%
Percent of hotspot error	4.35%	32.81%	12.36%	2.18%	1.57%	31.55%	4.22%	10.96%
Percent of GAP habitat in conservation target	6.22%	6.15%	38.15%	0.72%	0.86%	0.93%	0.56%	18.28%
Percent of study area in GAP habitat	23.22%	0.21%	0.04%	0.29%	10.51%	2.33%	0.27%	1.67%
Percent of study area land cover in GAP habitat	94.89%	2.61%	12.37%	4.54%	78.66%	7.45%	0.85%	80.28%

Table 3. PPGIS points by land cover type.

Land cover	Number of PPGIS points	Percent of total PPGIS points	Number of accurate PPGIS points	Number of inaccurate PPGIS points
Water	405	56.64%	399	6
Developed	68	9.51%	3	65
Beach	37	5.17%	9	28
Barren	6	0.84%	1	5
Riparian Forest	48	6.57%	48	0
Other Forest	43	6.15%	2	41
Agriculture	4	0.56%	1	3
Wetlands	104	14.55%	81	23
Total	715	–	544	171

Table 4. Chi-square analysis of PPGIS points by land cover type.

Land cover	Observed points	Expected points	X^2	*df*	*p*
Water	405	175	152.11	1	<.0001
Developed	68	59	0.55	1	.4583
Beach	37	2	30.47	1	<.0001
Barren	6	45	29.36	1	<.0001
Riparian forest	48	70	4.07	1	.0437
Other forest	43	249	180.85	1	<.0001
Agriculture	4	100	93.59	1	<.0001
Wetlands	104	15	70.98	1	<.0001
Total	715	715	–	–	–

have public support and provide the necessary habitat. Many of these areas are public lands that are already protected.

While respondents were largely successful at identifying wading bird habitats, there were important components that were under-represented. Both the chi-square analysis of the PPGIS points and the assessment of the land cover of the conservation targets showed that participants significantly underrepresented riparian forest in their identification of places for wading bird conservation. There are several possibilities why this result may have occurred including the fact that participants do not support conservation of riparian forests because they might value them for other uses or do not think riparian forests are as important for wading bird. It is also possible that respondents considered these areas as already protected at either the federal or state level, and therefore identified other areas for conservation. However, it is likely that many participants

Table 5. Wading bird species richness.

Number of species	0	1	2	3	4	5	6	7	8	9	10
Percent of study Area	36.43%	17.07%	6.78%	0.29%	2.01%	21.48%	12.66%	0.54%	0.82%	1.85%	0.07%
Percent of hotspot	2.59%	12.00%	5.74%	0.20%	1.00%	36.99%	19.28%	3.87%	0.65%	16.67%	1.02%

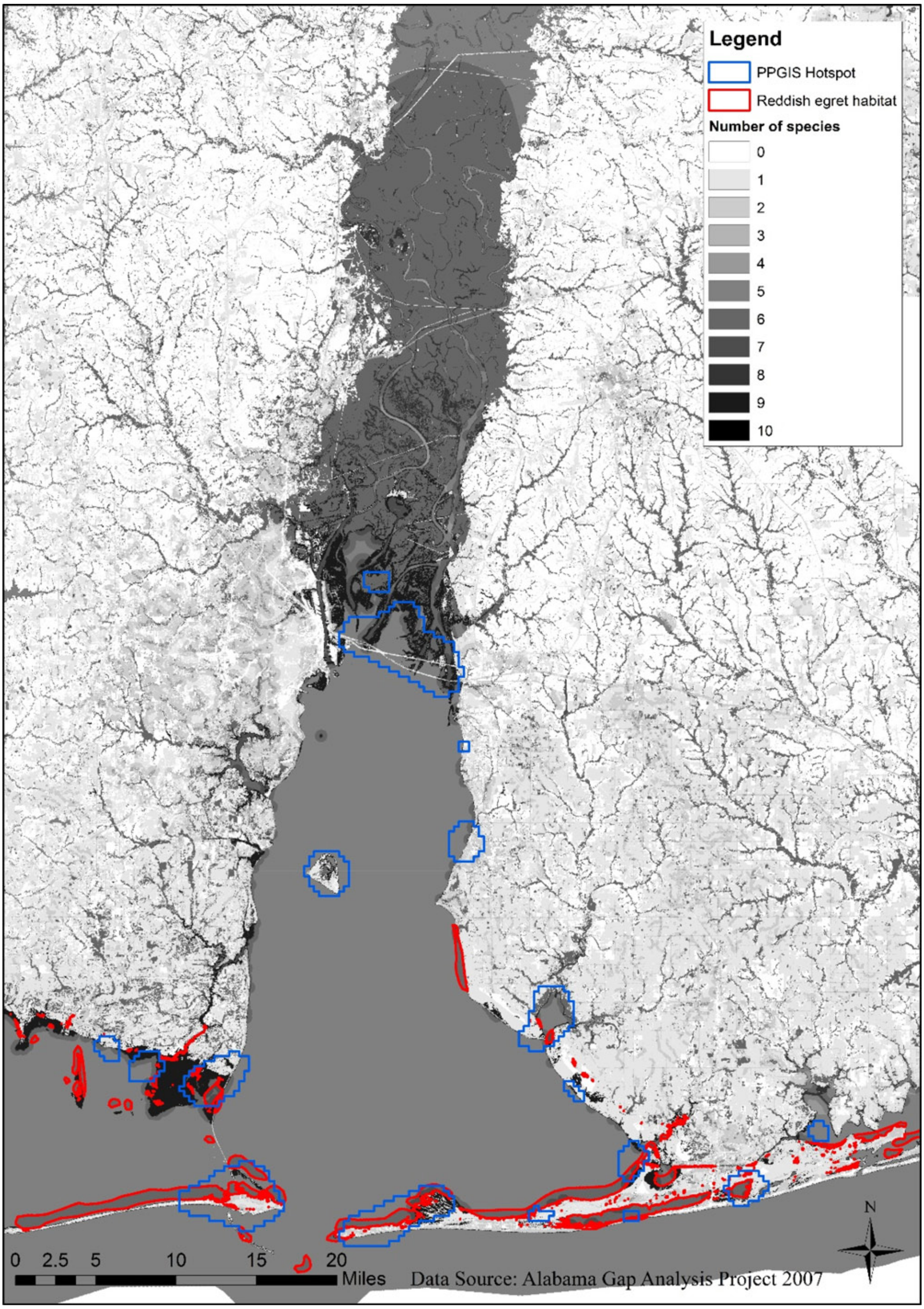

Figure 5. Wading bird species richness and PPGIS hotspots.

were unaware that riparian forests provide important habitat for several wading bird species. This would not be surprising given that salt marshes and other open water habitats are more visible to the public and wading birds are often readily observed in these habitats. Forested wetlands however are much less accessible and there is probably less certainty by the public about their value as wading bird habitat. Our results suggest that forested wetlands were less valued as habitat from the respondents even though these areas are very important for foraging, nesting and roosting (Barrow et al. 2005; Bent 1963). We suggest that local nature outreach and education programs include the role of riparian forest as wading bird habitat.

The species richness results showed that respondents not only identified wading bird habitats but selected locations that support multiple wading bird species. Thus, participants identified areas that would be valuable targets for conservation efforts (since protecting these areas would benefit numerous species). Additionally, participants included a large portion of the reddish egret range in their preferences thereby selecting habitat critical for a threatened species. The reddish egret has a more restrictive range than most wading birds normally frequenting saline environments such as coastal lagoons, beaches, and estuaries (ALDCNR 2014). While respondents generally identified habitats supporting multiple wading bird species they also omitted riparian forests which also provides relatively high species richness (normally <6 species).

The use of PPGIS provided a realistic assessment of public stakeholder perception of wading bird habitat. Nevertheless, this study presents certain limitations. A portion of the 21.6% error in identifying suitable habitat can be attributed to the fact that each sticker represented 0.71 km^2 on the ground (a 3,000-m search radius) and was applied to a 500-m grid cell size to create the kernel densities. This meant that small areas of unsuitable habitat in close proximity to suitable habitat could have been unintentionally included in the hotspots even though that might not have been the intent of the participants. Additionally, the selection of a 0.67 percentile threshold for determining kernel density hotspots affects the resulting size and shape of the hotspots. Another limitation of this study, we did not include qualitative data regarding the reasons why participants chose locations to place their conservation preferences. Thus, it was not possible to determine why participants under-represented riparian forests, what factors influenced their decisions to over-represent places with higher levels of wading bird richness, or whether they were aware that they were identifying reddish egret habitat.

Finally, there was a tendency for respondents to select areas already established for wildlife viewing and protection. Much of the Mobile-Tensaw River Delta at the upper part of Mobile Bay has been acquired by the State of Alabama and set aside as wildlife management and conservation areas (ALDCNR 2014). Likewise, wading bird hotspots along the east coast of Mobile Bay coincided with other public land holdings and conservation lands such as the Fairhope Municipal Pier and Beach (designated on the Alabama Coastal Birding Trail), the Weeks Bay National Estuarine Research Reserve, the Bon Secour Wildlife Management Area, and the Bon Secour National Wildlife Refuge. Dauphin Island is located at the southwest mouth of Mobile Bay and is home to the Dauphin Island Sea Lab, a state marine education and conservation institution. Respondents commonly selected these public areas as important habitat for wading birds. This result may be attributed to successful education programs regarding these sites, respondent knowledge of the appropriate habitat, or both. The tendency for respondents to identify existing public lands for conservation has been found in other PPGIS studies (Brown, Weber, and de Bie 2015).

PPGIS can be used to not only identify public wildlife conservation preferences but also the spatial accuracy of those preferences and important knowledge gaps. This is potentially very useful information for informing outreach education programs. Other studies to engage the public have used similar methods for such analyses, including identifying the locations of human-wildlife conflicts (Krester, Curtis, and Knuth 2009; Lowery, Morse, and Steury 2012) and examining how human opinions about black bear recovery strategies cluster based on the home addresses of the participants to determine where conservation minded people live (Morzillo et al. 2007). Cox et al. (2014) used PPGIS to identify places where significant numbers of general public survey respondents supported the conservation of threatened species. Alessa, Kliskey, and Brown (2008) and Brown et al. (2004) assessed biological and biodiversity value, respectively, using PPGIS even though their data might be somewhat vague for specific use in wildlife management and conservation planning. Similarly, Bryan et al. (2010) identified areas of high social and ecological value in providing ecosystem services and explained how this could inform landscape conservation. These applications of PPGIS and related methods can be quite beneficial for increasing public participation in the wildlife conservation planning process while also gaining greater insight into public preferences and knowledge. Adding a qualitative approach to determine why participants located their preferences where they did and the roles that interpretation centers and media reports played in these selections would be very valuable additions to exercises such as the study presented here. Nevertheless, this analysis represents an important demonstration in using PPGIS as a tool for wildlife management and outreach.

Disclosure statement

No potential conflicts of interest are reported by the authors.

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