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RESEARCH ARTICLE

Waterfront property owners' shoreline preferences amid salt marsh to mangrove transitions

Jahson B. Alemu I[1,2] | A. Randall Hughes[1] | Michael J. Osland[3] | Savannah H. Swinea[1,2,4] | Kalaina A. Thorne[1] | Rémi Bardou[1] | Christine C. Shepard[5] | Steven B. Scyphers[2,4,6]

[1]Marine Science Center, Northeastern University, Nahant, Massachusetts, USA; [2]Stokes School of Marine and Environmental Sciences, University of South Alabama, Mobile, Alabama, USA; [3]U.S. Geological Survey, Lafayette, Louisiana, USA; [4]Dauphin Island Sea Lab, Dauphin Island, Alabama, USA; [5]The Nature Conservancy, Gulf of Mexico Program, Key West, Florida, USA and [6]Department of Sociology, Anthropology, and Social Work, University of South Alabama, Mobile, Alabama, USA

Correspondence
Jahson B. Alemu I
Email: jalemu@southalabama.edu

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Abstract

1. We examined the influence of mangrove encroachment into salt marsh areas along the northern Gulf of Mexico (USA) on waterfront property owners' perceptions of coastal health and preferences for shoreline management.
2. Using mail-in and online surveys, we targeted over 3000 waterfront property owners across four jurisdictions experiencing or anticipating mangrove encroachment.
3. Our findings revealed a nuanced perception of coastal health, with many respondents recognizing the potentially environmental impacts of mangrove encroachment but favouring low-cost management strategies, such as maintaining current shoreline or passive monitoring. This reluctance to engage in active management highlights a perception-behaviour gap, likely influenced by the gradual nature of mangrove transitions, which diminishes urgency for active intervention.
4. Socio-demographic factors such as age, gender, income, residency and reliance on coastal resources significantly shaped preferences for shoreline management and regional responses. These preferences varied across jurisdictions, reflecting the importance of incorporating localized community values into management decisions.
5. Our findings highlight the need for a balanced approach to shoreline management that integrates ecological insights with the socio-cultural priorities of local communities. By aligning adaptation strategies with regional perceptions and values, it is possible to protect individual properties while enhancing the long-term resilience of coastal ecosystems under climate change pressures.

KEYWORDS
coastal management, ecosystem services, habitat shifts, perception-behaviour gap, social-ecological systems, stakeholder engagement

1 | INTRODUCTION

Climate change is increasingly transforming ecosystems worldwide by altering species distributions and community compositions across various habitats (Chen et al., 2011; Huntley, 1991; Pecl et al., 2017). In areas where people and nature are in close contact, ecosystem transformations can significantly alter the ecological and societal benefits that people derive from the ecosystem (Abrahms et al., 2023). For example, ecosystem transitions near residential areas may influence how residents perceive and interact with nature, creating ecological and societal trade-offs that vary across stakeholders and scales (Standish et al., 2013). In this study, we examine coastal property owners' perceptions of a temperate-to-tropical ecosystem transformation that is occurring in coastal wetlands in North America.

In the northern Gulf of Mexico (USA), a temperate-to-tropical ecosystem transformation is underway. The black mangrove (*Avicennia germinans*), a tropical woody plant, is expanding its geographic range and abundance northward into regions traditionally dominated by salt marshes (cold-tolerant herbaceous grasses; Saintilan et al., 2014). This transition, driven by warmer winters and fewer severe freeze events (Cavanaugh et al., 2013; Osland et al., 2013, 2020), is expected to intensify with climate change, which could lead to black mangroves (hereafter referred to as mangroves) replacing salt marshes as the dominant coastal wetland vegetation throughout the northern Gulf of Mexico (Bardou et al., 2024; Osland et al., 2013). As foundational species, mangroves and salt marshes play crucial roles in habitat creation and ecological processes, making this transition consequential for wildlife (Goeke et al., 2023; Macy et al., 2021), fisheries and human economies (Kelleway et al., 2017; Walker et al., 2019). Impacts may even extent to cultural values such as aesthetics, recreation and property values (Lundquist et al., 2014; McKinley et al., 2020). In Texas, for example, coastal wetlands support commercial and recreational fisheries (e.g. red drum, *Sciaenops ocellatus*, and brown shrimp, *Farfantepenaeus aztecus*), improve water quality, reduce storm damage and coastal erosion, provide habitat for endangered species (e.g. whooping crane, *Grus americana*) and support tourism (Engle, 2011). The expansion of mangrove forests into traditionally salt marsh-dominated areas could negatively impact all these ecosystem services (Osland et al., 2022) and require changes in the way coastal resources are managed.

Waterfront property owners are central to the management of these transitioning landscapes. Situated at the frontline of climate change impacts, including sea-level rise, storm surges (Gedan et al., 2020) and escalating coastal erosion (Himmelstoss et al., 2017), their decisions regarding shoreline maintenance, whether through natural maintenance, living shorelines or hardened structures have far-reaching ecological and economic consequences (Gittman et al., 2016; Scyphers et al., 2019). Furthermore, they must now navigate the added challenge of adapting to mangrove encroachment into traditionally salt marsh-dominated areas. In navigating this transition, waterfront property owners must weigh environmental concerns against a complex array of factors, including aesthetics, property values and shoreline accessibility (Guthrie et al., 2023; Scyphers et al., 2015, 2019; Siders & Keenan, 2020). For example, while mangroves provide greater protection against storm surges than salt marshes (Temmerman et al., 2023), they may obstruct waterfront views and restrict shoreline access, leading some waterfront property owners to view mangrove expansion unfavourably (Osland et al., 2022). Understanding these perceptions and the factors influencing local decisions to promote or restrict mangrove expansion is therefore critical for developing management strategies that align ecological benefits with societal priorities. This is especially relevant in the northern Gulf of Mexico, where private ownership dominates the coastline and living shorelines are being promoted as a sustainable approach to buffer against coastal hazards and enhance coastal resilience (DeLorme et al., 2022; Reguero et al., 2018). However, the adoption of living shorelines in this region requires alignment between waterfront property owners' values and needs (Scyphers et al., 2019). Therefore, as climate hazards intensify, balancing individual residential preferences with broader resilience goals will necessitate a landscape-scale approach that addresses both environmental and societal needs (Paterson et al., 2014).

Amid climate-driven ecosystem transitions, this study investigates the perceptions and decisions of waterfront property owners in response to mangrove encroachment into salt marsh areas. Specifically, we explore the factors influencing these perceptions, their implications for residential shoreline management and their relationship with broader landscape-scale resilience. By linking residential and landscape-scale preferences, we address a critical knowledge gap regarding the role of waterfront property owners in managing ecosystem transitions and shaping resilience of the northern Gulf of Mexico.

2 | METHODOLOGY

2.1 | Study setting

Our study focuses on four jurisdictions along the northern Gulf of Mexico (USA), where mangrove encroachment into salt marsh areas is already occurring or anticipated: Galveston and Corpus Christi in Texas (northwestern Gulf of Mexico), and Cedar Key/Homosassa and Panama City Beach in Florida (northeastern Gulf of Mexico; see Figure 1). Cedar Key/Homosassa (hereafter referred to as Cedar Key) and Corpus Christi are within the current range of established mangroves, while Panama City Beach and Galveston lie at the forefront of the ecosystem transition (Bardou et al., 2024). Mangrove populations are denser and taller in Cedar Key and Corpus Christi (Yando et al., 2016). Corpus Christi is unique due to its high salinity levels, caused by low rainfall and limited freshwater inputs into estuaries (Osland et al., 2014). These more arid conditions present physiological challenges to mangrove growth, resulting in marsh communities dominated by succulent plants rather than the graminoid plants typical of salt marshes in the more humid study sites (Gabler et al., 2017; Osland et al., 2017). This unique combination of arid conditions and mangrove encroachment creates distinct

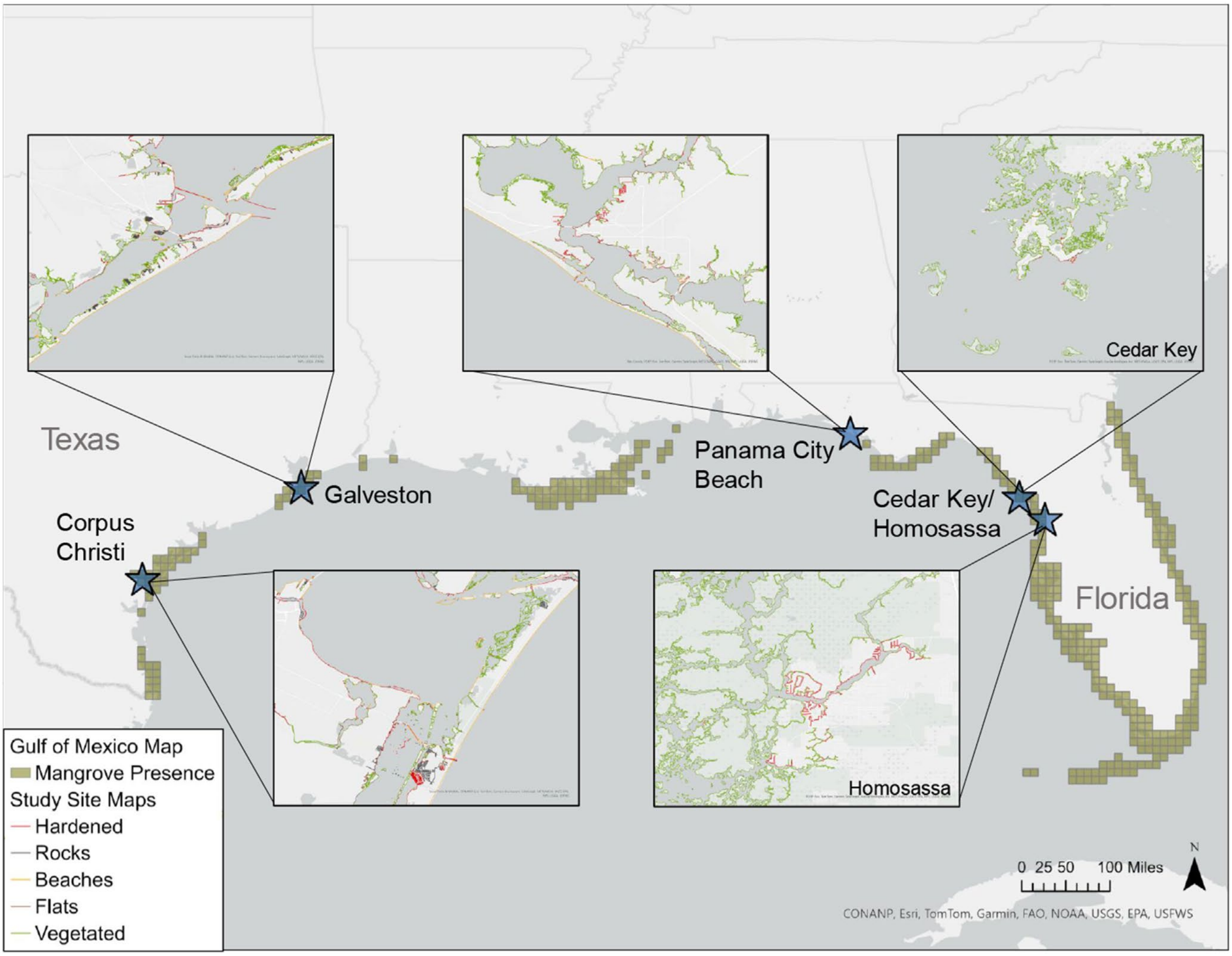

FIGURE 1 Map of the northern Gulf of Mexico (USA) highlighting the study sites (blue stars). Cedar Key and Homosassa were combined to achieve a sample size similar to the other study areas. Shoreline data from NOAA (2017), and mangrove presence data from Bardou et al. (2024). The insets show the shoreline types at all sites: Hardened (in red) = seawalls or other vertical structures, rocks (in grey) = rocky and steep shorelines, beaches (in yellow) = sand/gravel, flats (in purple) = mud/sand and vegetated (in green) = grass/salt marsh/mangrove/scrub.

ecological pressures, which, in turn, shape local adaptation strategies and the ways in which property owners engage with their changing environments.

Communities along the northern Gulf of Mexico, particularly in Florida and Texas, are characterized by the complex interactions of environmental vulnerability, economic interests, social values and varying governance structures (Paterson et al., 2014). The Gulf of Mexico coast of Florida and Texas are highly urbanized, low-lying coastal regions with large portions of coastline armoured in seawall or wetland habitat (Gittman et al., 2015). In Florida, mangroves can be trimmed to a height of 1.8 m to reduce obstruction of views under certain conditions, as regulated by the Florida Department of Environmental Protection and specified by the 1966 Mangrove Trimming and Preservation Act (amended in 1996). No such regulatory guidance exists for Texas. The sites were selected to provide a general representation of mangrove presence and regulations along the northern Gulf of Mexico.

2.2 | Survey design and administration

This research was approved by the Northeastern University Institutional Review Board Protocol 12-05-17. All respondents consented to participate in this study with measures put in place to maintain respondent anonymity and data confidentiality.

We employed a Knowledge, Attitude and Practices (KAP) framework (Bandura, 1976; Roger, 1995) to assess waterfront property owners' perceptions and preferences regarding mangrove encroachment into salt marshes along the northern Gulf of Mexico. Survey data were collected from a stratified sample selected from public county property records between fall 2021 and fall 2022. This address-based approach was previously used for a similar survey in coastal Alabama (Scyphers et al., 2015). The initial sample included 3200 residential waterfront addresses (800 addresses from each of the four study areas). Properties that had been listed for sale in the preceding year were filtered out to focus on long-term property owners more likely to be involved in local

TABLE 1 Key questions used in this study (question themes are shown in bold italic).

Key questions	Question aim	Scale
Knowledge		
• How familiar are you with marshes?	Filter	Likert 1 "*I don't know what marshes are*" to 5 "*Extremely familiar*"
• How familiar are you with mangroves?	Filter	Likert 1 "*I don't know what mangroves are*" to 5 "*Extremely familiar*"
Attitude		
• Which statement aligns most closely to your feelings about the expansion or removal of mangroves in the northern Gulf of Mexico?	Landscape preference	Nominal 1 "*promote*" to 4 "*left alone*"
• Which statement aligns most closely to your feelings about the expansion or removal of mangroves along your shoreline?	Residential preference	Nominal 1 "*plant*" to 4 "*let nature take its course*"
Perceptions		
• If mangroves did replace salt marshes, how would that impact the health of the coast?	Outlook	Likert 1 "*Very harmful*" to "*Very beneficial*"
• How would you describe the relative differences in marshes and mangroves for each of [15 ecosystem services]?	Outlook	Likert 1 "*Mangroves are Much Better*" to 5 "*Marshes are Much Better*"
• Please explain why you think mangroves replacing salt marshes would benefit or harm the health of the coast.	Outlook	Open-ended

management decisions. Surveys were administered using Dillman's Tailored Design Method for mixed-mode surveys (Dillman et al., 2014). This method involved a maximum of three contacts per sample member. In the first contact, a cover letter explaining the project featuring a web address and QR barcode, and unique password to access the online survey hosted on Qualtrics Research Suite (Qualtrics, Provo, UT) was sent to the physical address. In the second contact, a follow-up reminder was sent to the physical address, which included a fully printed survey and return envelope. Second contact was not made to addresses from which responses were already received or that resulted in 'returned mail' from the first contact. In the third contact, a cover letter with QR barcode, unique password to access survey and a small cash inducement were sent to the physical addresses from which responses were not previously received. We also offered raffle-based prizes to incentivize survey participation.

The survey consisted of open- and close-ended questions, soliciting information on respondents' socio-demographic characteristics, shoreline uses and characteristics, perceptions of coastal health and ecosystem values in the context of mangrove encroachment into salt marshes, fishing behaviour and adaptation preferences if mangroves did replace salt marshes. See Text S1 for the full survey instrument. In this study, we focused only on those questions related to understanding the socio-demographic characteristics, perceptions of coastal health amid mangrove encroachment (hereafter referred to as mangrove encroachment outlook), perceptions of the ability of marshes versus mangroves to deliver ecosystem services and mangrove encroachment adaptation preferences (i.e. response to mangrove encroachment; Table 1).

Survey respondents who were not property owners or were unfamiliar with or unknowledgeable about mangrove or salt marsh functions or services were excluded from the sample. Socio-demographic data included age, gender, income, education level, residency and dependency on coastal resources. The mangrove encroachment outlook and ecosystem services questions were measured along a question specific 5-point Likert scale (Table 1). An associated open-ended question was also presented to give opportunity to add additional information if desired. The final survey questions included agreement statements meant to capture management preferences on residential shorelines and the broader landscape amid mangrove encroachment. The questions analysed in this study are presented in Table 2.

As the structural characteristics of mangroves vary along the northern Gulf of Mexico, an experimental treatment was also applied to the survey instrument to assess the influence of mangrove structural traits ("full grown mangrove trees" [>2 m tall] versus "mangrove shrubs" [<1.5 m tall]) on perceptions and preferences. The control group received no assignment. Treatments were randomly assigned.

2.3 | Analysis

All statistical analyses were performed using R v.4.2.3 (R Core Team, 2023). The treatment effect was tested using the chi-square (χ^2) goodness of fit test; however, no statistically significant effect was detected ($\chi^2 = 5.41$, $p > 0.05$), so this factor was not considered in subsequent analyses.

Regression analyses were performed to estimate the significance of predictors and their effects on the three primary outcomes: (i) mangrove encroachment outlook (ordinal), (ii) residential adaptation preferences for mangrove encroachment (multinomial) and

TABLE 2 Agreement statements (statement themes are shown in bold italic).

Variable	Description
Residential shorelines	
Promote	I would be open to planting mangroves along my shoreline in support of this expansion
Maintain	If mangroves showed up on my property I would maintain/trim them in accordance with my continued ability to use the existing resources along my shoreline
Remove	I would remove mangroves along my shoreline should they become present there
Neutral	I would let nature take its course
Landscape	
Promote	Mangrove range expansion in the northern Gulf of Mexico should be promoted by planting in my local area
Monitor	Mangrove range expansion in the northern Gulf of Mexico should be monitored, and maintenance of mangroves should be appropriate to maintain my ability to use the resources in my local area
Hinder	Mangrove range expansion in the northern Gulf of Mexico should be hindered by removal and control efforts in my local area
Neutral	Mangrove range expansion in the northern Gulf of Mexico should be left alone to let nature take its course

(iii) landscape adaptation preferences for mangrove encroachment (multinomial), as explained by the contributions of socio-economic characteristics and belief variables. To assess whether there was an association between residential and landscape preferences, χ^2 tests of independence were performed followed by Cramér's *V* test to quantify the strength of the association (effect sizes: 0.1 = small, 0.1 to 0.49 = medium, ≤0.5 = large). The explanatory variables used in the models were age (continuous), gender (nominal), income (nominal), education level (nominal), study site (nominal), residency (continuous), job dependency (nominal) and ecosystem service perceptions (ordinal). By including ecosystem service perceptions as an independent variable, we aimed to capture how environmental values shape coastal management decisions.

Multicollinearity, survey bias and data incompleteness are three common issues with regressions using data derived from social surveys (Ogundimu & Collins, 2019). Regarding the first issue, to avoid model overfitting (Graham, 2003), the variance inflation factor (VIF) multicollinearity test was computed (Dormann et al., 2013). The estimates shown in Table S1 revealed that VIF did not exceed the threshold of 10, with the average being 1.29. Regarding the second issue, we implemented follow-up efforts aimed at engaging non-respondents. These efforts included sending reminder postcards, offering the survey online and in paper format to accommodate different preferences (Dillman et al., 2014), and incentivizing participation through cash inducements and a raffle. For the third issue, missing data (<10%) were imputed using the multiple random forest regression imputation method (Rubin, 2004; Van Buuren & Groothuis-Oudshoorn, 2011). Values more than two standard deviations from the mean were deemed to be erroneous and were consequently removed before the main analysis.

The non-parametric Kruskal–Wallis test followed by Dunn's multiple comparison test was used to compare average Likert scores for ecosystem services among locations. The ecosystem services are described in Table S2.

Thematic analysis was used to assess the open-ended question. The original texts were prepared for analysis by compiling them into one continuous text and the text was filtered for congruency (Braun & Clarke, 2006). The online word cloud generator (https://www.wordclouds.com) was used to generate the wordlist (Text S2).

3 | RESULTS

3.1 | Sample profile

A total of 530 surveys were received, resulting in a response rate of 20.9%, with similar numbers across the four sites (Corpus Christi [113], Galveston [148], Panama City Beach [143] and Cedar Key [126]). Fifty-five surveys were excluded for not meeting the minimum sample criteria. Table 3 summarizes the socio-demographic characteristics of the final sample, disaggregated by location. Across sites, there were no statistically significant differences ($p > 0.05$) in age, education, gender, or ethnicity characteristics. Most respondents were 60 years or older (72%), at least college educated (78%), male (61%) and white (87%). Half of the respondents (50%) resided at their property for 10 years or less, with more Cedar Key respondents making up this group compared to other locations ($\chi^2 = 32.95$, $p < 0.01$). Most (57%) respondents reported annual household income of USD $150,000 or higher, with Galveston respondents contributing a

TABLE 3 Sample socio-demographic characteristics.

Variable	Category	Corpus Christi	Galveston	Panama City Beach	Cedar Key	Sample percent
Age (years)	20–50	14	14	13	4	10%
	51–60	16	25	19	17	18%
	>60	62	79	82	89	72%
Gender (count)	Man	48	72	75	69	61%
	Woman	42	37	42	38	36%
	Undisclosed	1	9	1	2	3%
Race/ethnicity (count)	Asian	2	1	1	1	1%
	Black or African American	1	1			0%
	Hispanic or Latino	8	1	3		3%
	White	72	102	102	105	87%
	American Indian or Alaska Native	1		1		0%
	Undisclosed	8	13	10	4	8%
Highest education (count)	Up to high school	4	1	4	4	3%
	Some other degree	17	11	21	30	18%
	College or higher	70	105	93	74	78%
	Undisclosed	1	3		1	1%
Residency (years)	≤10	35	61	49	70	50%
	10–20	26	28	16	19	20%
	21–30	18	16	31	14	18%
	>30	13	11	22	7	12%
Household income in 2021 (USD)	>50k	11	3	7	7	6%
	50,001 to 100k	16	8	21	28	17%
	100,001 to 150k	22	18	21	20	19%
	150,001 to 250k	12	12	13	25	14%
	>250k	13	44	28	11	22%
	Prefer not to answer	18	33	26	16	21%
Environmental behaviour (count)	Donated to an environmental group	86	111	101	104	77%
	Pro-environmental purchasing	82	91	101	97	72%
	Attended environmental meeting	60	72	76	78	56%
	Reported environmental problem	54	47	73	50	43%
	Pro-environmental voting	87	90	95	95	71%
	Any pro-environmental behaviour change	95	116	119	111	85%
	Dependency on coastal resources (count)	26	23	37	18	24%

significant portion of this category ($\chi^2 = 52.62$, $p < 0.01$). Most (43% to 77%) respondents reported changing their behaviour in some way due to concern for the environment, and one-in-four respondents were dependent on coastal resources for income.

Regarding waterfront property owner outlook on coastal health in response to mangrove encroachment, approximately one in three (34%) respondents viewed the encroachment as very or somewhat harmful (Figure 2a), citing concerns around effects on local biodiversity, shoreline stability and broader ecosystem functions (Figure 2b). In contrast, optimism about the benefits of mangrove encroachment on coastal health was less prominent, with 19% of respondents indicating that the transition would be very or somewhat beneficial (Figure 2a), citing potential improvements in erosion control and wildlife habitat (Figure 2b). Differences in these outlooks were also

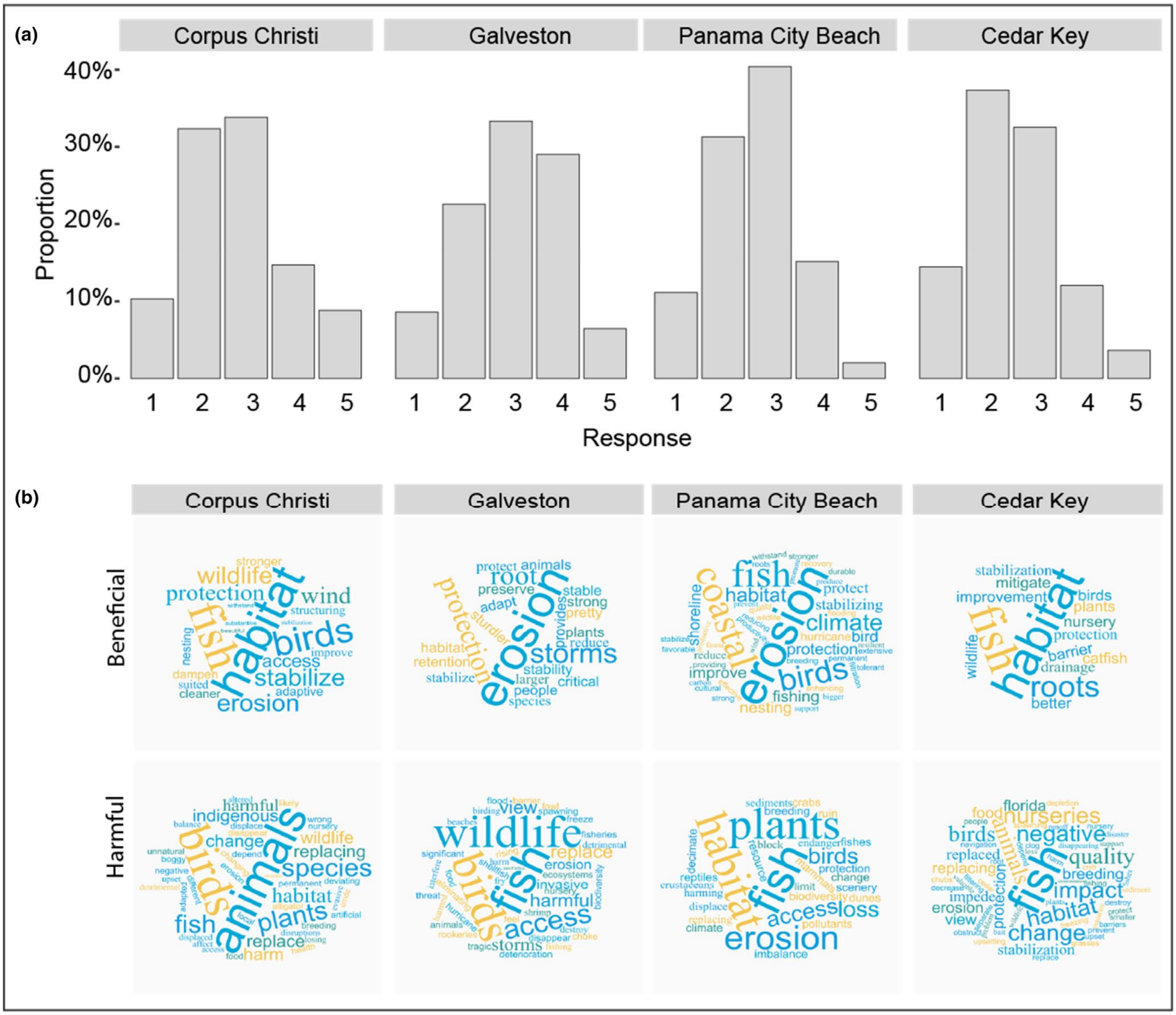

FIGURE 2 Waterfront property owners' (a) mangrove encroachment outlook and (b) word cloud of terms used to describe the outlook across study sites. Responses in (a) are coded as 1 = Very harmful, 2 = Somewhat harmful, 3 = Neutral, 4 = Somewhat beneficial, 5 = Very beneficial. The size of each word in (b) reflects the number of times a word was cited by the respondents to describe the benefits and harms of the ecosystem transition.

apparent ($\chi^2 = 23.14$, $p = 0.03$) across the region, with Galveston respondents being more optimistic about the benefits of mangrove encroachment, while those from Cedar Key exhibited higher levels of concern about potential harm (Figure 2a).

3.2 | Determinants of mangrove encroachment outlook

Results of the ordinal regression (Figure 3) indicated that gender, location and dependency on coastal resources significantly influenced how respondents viewed mangrove encroachment into salt marshes. Generally, women were more likely to perceive the transition as beneficial ($t = 1.82$, $p < 0.05$), and respondents from Panama City Beach ($t = -2.91$, $p < 0.01$) and those highly dependent on coastal resources ($t = -2.26$, $p < 0.05$) were more likely to view the transition as negative.

3.3 | Ecosystem service preferences

Respondents also expressed varying views regarding the ability of mangroves versus salt marshes to deliver ecosystem services. Most notably, respondents highly favoured mangroves for pollination, fisheries and coastal protection services, but salt marshes for freeze recovery and flood stabilization services (Figure 4). Overall, mangroves were more frequently viewed as better able to deliver a wider array of ecosystem services compared to salt marshes

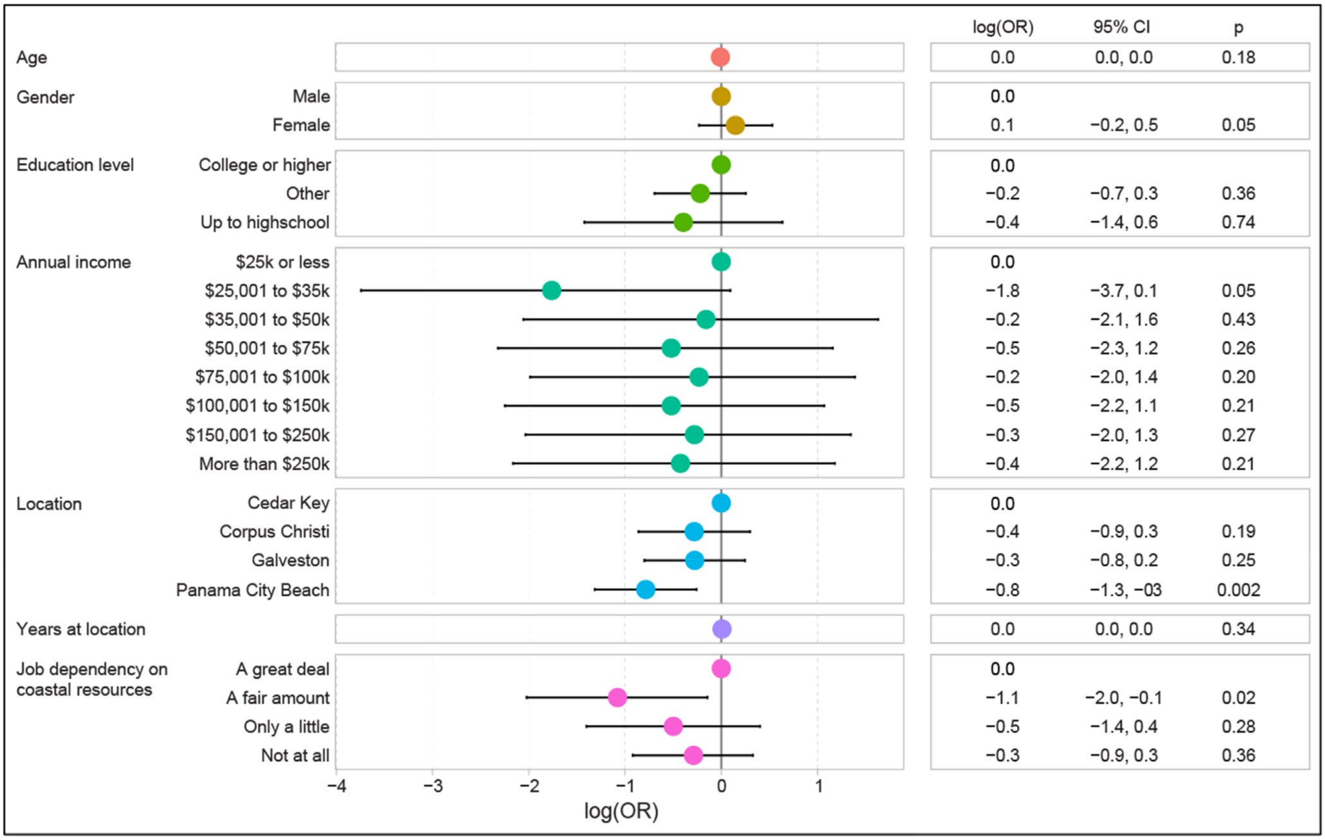

FIGURE 3 Ordinal regression showing the socio-demographic factors that influence the mangrove encroachment outlook among waterfront property owners in the northern Gulf of Mexico (USA). Dots represent model coefficient estimates in log odds-ratios [log(OR)] and whiskers represent confidence intervals. Parameters that do not overlap with the zero line are significantly different from the reference variable for that characteristic. Positive estimates indicate increasing probability of perceiving benefits of the ecosystem transition, and negative estimates indicate increasing probability of perceiving harmful impacts.

(Figure 4), but the degree of preference varied among services and regions (Figure 5). For example, while the broader landscape-scale trend favoured mangroves for water purification (Figures 4 and 5), at the local scale some differences emerged such as Galveston respondents (average Likert score 3.01) favouring salt marshes for this service ($\chi^2 = 12.99$, $p = 0.01$; Table 4). Another example relates to the soil formation service, where the broader trend reflects a more balanced perception, with 24% of respondents seeing no difference in service delivery between the two ecosystems (Figure 4). However, Galveston (mean Likert score 3.41) and Panama City Beach (mean Likert score 3.00) respondents favoured salt marshes for this service ($p < 0.05$; Table 4), while Cedar Key respondents (mean Likert score 2.59) tended to favour mangroves (Table 4). This regional variation in the context of differiential preferences for ecosystem services between ecosystems was again notable, with respondents from Galveston favouring salt marshes for soil stabilization (mean Likert score 3.76) and bird habitat (mean Likert score 3.26) more so than those from other locations (Figure 5).

The influence of ecosystem service perceptions on mangrove encroachment outlook was also examined using ordinal regression. Respondents were more likely to view the ecosystem transition as harmful if they also favoured salt marshes for aesthetics ($t = -2.77$, $p = 0.01$), fisheries support ($t = -2.52$, $p = 0.01$) and bird nesting habitat ($t = -2.65$, $p = 0.01$) services compared to mangroves (Figure 6).

3.4 | Determinants of residential and landscape adaptation preferences to mangrove encroachment

Most respondents agreed that maintaining the current shoreline condition would be preferred if mangroves did replace salt marshes. This preference was expressed by 36% of respondents for residential shorelines (Figure 7a) and 35% for the landscape-scale (Figure 7b). A comparable proportion, 38% for residential shorelines and 32% for the landscape-scale, favoured allowing mangroves to expand naturally, without intervention. In contrast, opinions on active management of mangrove encroachment varied. Specifically, 18% of respondents favoured planting or supporting mangrove growth on residential shorelines, compared to 30% at the landscape-scale. Only 8% of respondents supported actively hindering or removing mangrove encroachment on residential shorelines, with an even smaller proportion, 3%, in favour of such action at the landscape-scale.

Overall, differences in shoreline management preferences were significant at both the residential ($\chi^2 = 39.76$, $p < 0.001$)

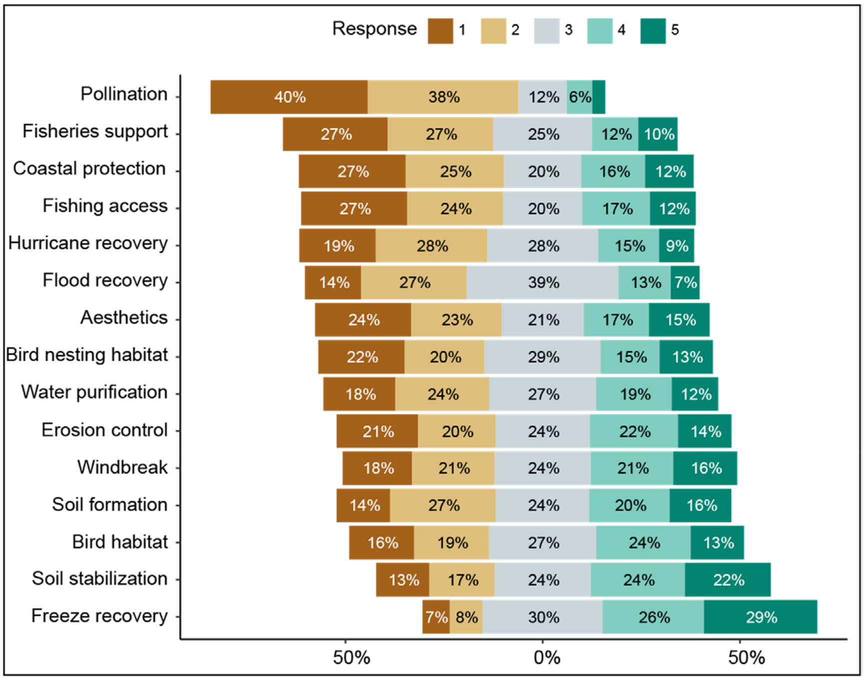

FIGURE 4 Waterfront property owners' perceptions of the ability of marshes versus mangroves to deliver ecosystem services. Responses are coded as 1 = Mangroves are much better than marshes, 2 = Mangroves are slightly better than marshes, 3 = no difference, 4 = Marshes are slightly better than mangroves and 5 = Marshes are much better than mangroves. Ecosystem service descriptions are shown in Table S2.

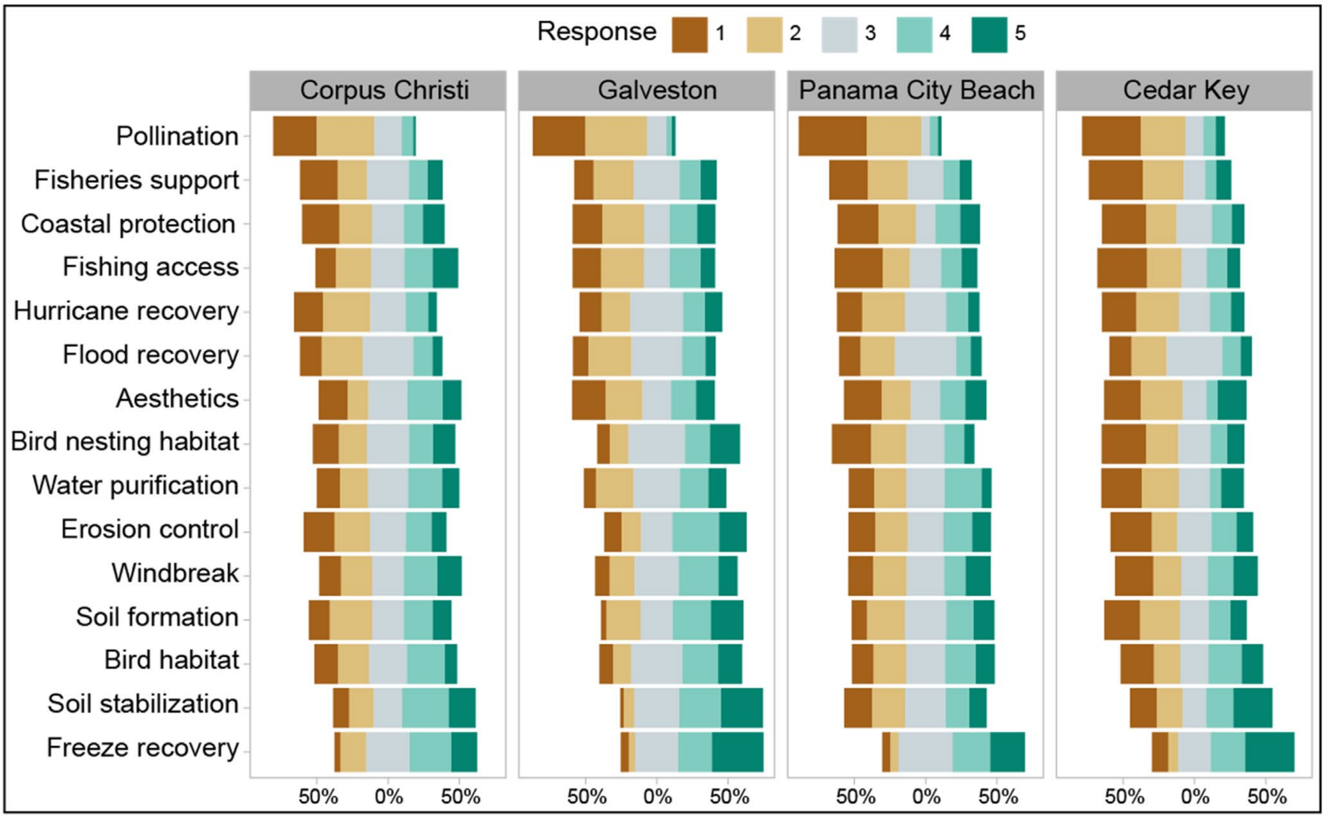

FIGURE 5 Differences in waterfront property owner perceptions of the ability of marshes versus mangroves to deliver ecosystem services across study sites. Responses are coded as 1 = Mangroves are much better than marshes, 2 = Mangroves are slightly better than marshes, 3 = no difference, 4 = Marshes are slightly better than mangroves, 5 = Marshes are much better than mangroves. Ecosystem service descriptions are shown in Table S2.

TABLE 4 Mean differences in waterfront property owners' perceptions of the ability of marshes versus mangroves to deliver ecosystem services across the study sites by average Likert score (±SD).

Ecosystem service	Corpus Christi	Galveston	Panama City Beach	Cedar Key	Test statistic and *p*-value
Pollination	2.10 (0.99)	1.91 (0.94)	1.77 (0.97)	2.08 (1.21)	$\chi^2=6.02$; $p=0.19$
Fisheries support	2.60 (1.29)	2.81 (1.18)	2.46 (1.24)	2.24 (1.32)	$\chi^2=5.17$; $p=0.27$
Coastal protection	2.68 (1.40)	2.74 (1.33)	2.61 (1.42)	2.48 (1.30)	$\chi^2=4.92$; $p=0.30$
Fishing access	3.02 (1.33)	2.72 (1.29)	2.49 (1.37)	2.38 (1.33)	$\chi^2=0.56$; $p=0.97$
Hurricane recovery	2.54 (1.16)	2.88 (1.21)	2.66 (1.17)	2.55 (1.26)	$\chi^2=2.89$; $p=0.58$
Flood recovery	2.68 (1.11)	2.78 (1.07)	2.71 (1.09)	2.73 (1.12)	$\chi^2=0.35$; $p=0.99$
Aesthetics	2.96 (1.32)	2.71 (1.35)	2.74 (1.41)	2.67 (1.46)	$\chi^2=2.90$; $p=0.57$
Bird nesting habitat	2.92 (1.32)	3.29 (1.20)	2.48 (1.23)	2.51 (1.36)	$\chi^2=1.76$; $p=0.78$
Water purification	**2.96 (1.26)**	**3.01 (1.15)**	**2.81 (1.20)**	**2.57 (1.40)**	$\boldsymbol{\chi^2=12.99, p=0.01}$
Erosion control	2.70 (1.28)	3.33 (1.28)	2.86 (1.31)	2.65 (1.37)	$\chi^2=3.78$; $p=0.44$
Windbreak	3.05 (1.33)	3.16 (1.18)	2.91 (1.34)	2.79 (1.45)	$\chi^2=3.06$; $p=0.46$
Soil formation	**2.87 (1.27)**	**3.41 (1.19)**	**3.00 (1.22)**	**2.59 (1.33)**	$\boldsymbol{\chi^2=10.44, p=0.03}$
Bird habitat	2.88 (1.22)	3.26 (1.17)	2.95 (1.26)	2.88 (1.40)	$\chi^2=3.55$; $p=0.47$
Soil stabilization	3.30 (1.28)	3.76 (1.04)	2.78 (1.28)	3.18 (1.49)	$\chi^2=7.13$; $p=0.13$
Freeze recovery	3.39 (1.11)	3.80 (1.15)	3.57 (1.10)	3.63 (1.33)	$\chi^2=6.13$; $p=0.19$

Note: The *p*-value denoting the statistical significance of these differences was derived using the Kruskal–Wallis test. Likert scores are coded as 1 = Mangroves are much better than marshes, 2 = Mangroves are slightly better than marshes, 3 = no difference, 4 = Marshes are slightly better than mangroves, and 5 = Marshes are much better than mangroves. Significant differences are heighted in bold. Ecosystem service descriptions are shown in Table S2.

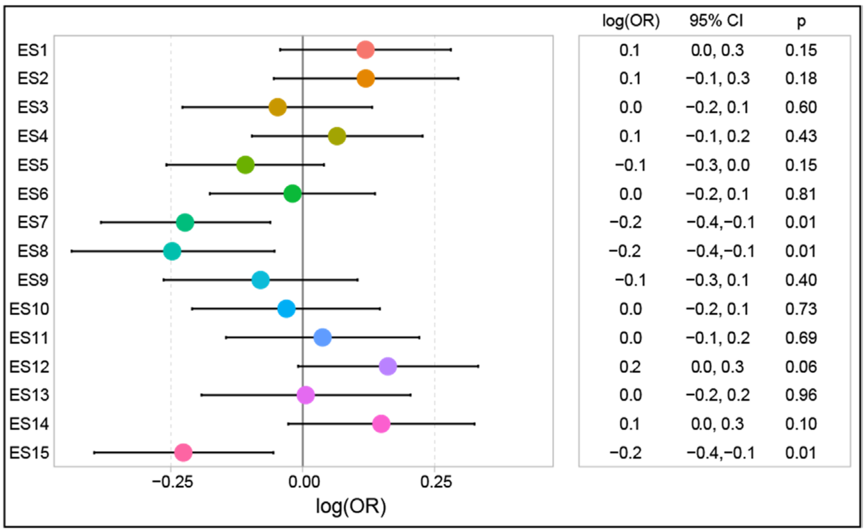

FIGURE 6 Ordinal regression showing the influence of ecosystem service perceptions on mangrove encroachment outlook by waterfront property owners. Dots represent model coefficient estimates in log odds-ratios [log(OR)] and whiskers represent confidence intervals. Parameters that do not overlap with the zero line are significantly different from the reference variable for that characteristic. Positive estimates indicate increasing probability of perceiving benefits of the ecosystem transition, and negative estimates indicate increasing probability of perceiving harmful impacts. ES1 = Coastal protection, ES2 = Bird habitat, ES3 = Erosion control, ES4 = Soil formation, ES5 = Fishing access, ES6 = Windbreak, ES7 = Aesthetics, ES8 = Fisheries support, ES9 = Hurricane recovery, ES10 = Water purification, ES11 = Flood recovery, ES12 = Soil stabilization, ES13 = Pollination, ES14 = Freeze recovery, ES15 = Bird nesting habitat. Ecosystem service descriptions are shown in Table S2.

and landscape ($\chi^2 = 118.53$, $p < 0.001$) scales (Tables S3–S5). Interestingly, respondents from Galveston and Panama City Beach were the most in favour of removing mangroves from residential shorelines (Figure 7a), while Cedar Key respondents were the most in favour of hindering mangrove encroachment at the landscape-scale (Figure 7b). The variations in preferences among sites were mainly driven by Cedar Key respondents preferring for the promotion of mangrove encroachment

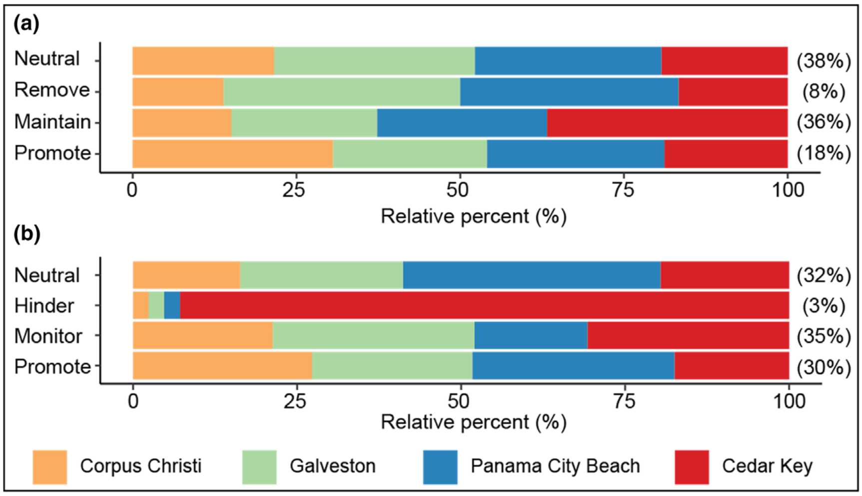

FIGURE 7 Distribution of waterfront property owners' adaptation preferences for mangrove encroachment on (a) residential shorelines and for (b) the broader landscape. Colours in (a) and (b) indicate survey location: Corpus Christi (orange); Galveston (green); Panama City Beach (blue); and Cedar Key (red).

through planting (Figure 7a), while landscape-scale difference were influenced by Cedar Key respondents supporting monitoring efforts and Panama City Beach respondents favouring the natural expansion of mangroves without interference (Figure 7b).

Chi-squared test of independence revealed that overall residential and landscape-scale preferences were significantly associated with each other ($\chi^2 = 231.05$, $p < 0.001$; Cramer's $V = 0.42$), even at the site-scale ($p < 0.001$, $0.33 \leq V \leq 0.54$; Table S6). Given the significant association between both preferences, only the residential preferences were fitted as the dependent variable in the subsequent multinomial regression model.

The multinomial model showed that age ($p < 0.001$), income ($p < 0.05$), location ($p < 0.001$), residency ($p < 0.001$) and environmental values related to soil formation ($p < 0.05$), windbreak ($p < 0.05$), and freeze recovery ($p < 0.05$) services had a statistically significant influence on shoreline adaptation preferences (Table 5; Table S7). Specifically, older respondents were significantly less likely to favour strategies that promoted mangrove encroachment ($p < 0.01$), maintain the current shoreline ($p < 0.01$), or lead to mangrove removal ($p < 0.05$) relative to monitoring mangroves without interference (the reference category; Table S7). Furthermore, Corpus Christi, Galveston and Panama City Beach respondents were significantly less likely to favour strategies that maintained the current shoreline ($p < 0.05$), while Panama City Beach respondents were significantly less likely to favour strategies that remove mangroves ($p < 0.05$). Respondents with the highest residency times were more likely to favour strategies that maintained the current shoreline ($p < 0.05$). It was also more likely for respondents that viewed mangroves positively for soil formation ($p < 0.05$) and windbreak ($p < 0.05$) services to favour strategies that promoted mangrove encroachment, but more likely for respondents that viewed salt marshes positively for freeze recovery ($p < 0.05$) services to favour strategies that removed mangroves. Other factors such as gender, education and soil stabilization preference had a marginal ($p < 0.1$) influence on shoreline adaptation preferences that were not explored here.

4 | DISCUSSION

Our study highlights a significant perception-behaviour gap among waterfront property owners in the northern Gulf of Mexico (USA) in response to mangrove encroachment into traditionally salt marsh areas. Despite recognizing the potentially negative ecological impacts of this shift on coastal health, many waterfront property owners favoured passive management strategies such as maintaining the current shoreline or monitoring, reflecting a disconnect between environmental perception and proactive adaptation behaviour. This tendency to favour passive management approaches aligns with findings from other coastal regions (see Friesinger & Bernatchez, 2010; Gittman & Scyphers, 2017; O'Donnell et al., 2022), suggesting that the hesitancy toward active management may stem from the gradual nature of these habitat transitions (Adger et al., 2013). The gradual transition from salt marsh to mangrove may reduce the urgency for action, leading to weaker motivation for proactive measures like planting or removing mangroves (Moser, 2014).

The distinctive traits of mangroves compared to salt marshes may further shape these perceptions. Mangroves, for example, provide superior storm protection and carbon storage (Temmerman et al., 2023), whereas salt marshes are more cold-tolerant and support specific local species (Osland et al., 2022), differences also reflected in our respondents' views. These functional differences create trade-offs, as neither ecosystem type optimally provides all desired services. These trade-offs arise from each vegetation type's functional traits, combined with the varying priorities, preferences and perspectives of those who benefit from these services (Kelleway et al., 2017). For example, while mangroves are less resilient than salt marshes to freeze events, they uniquely contribute to pollination by providing flowers for honey production and are highly valued for this service (Loveless & Smee, 2019; Nathan, 2020). This variation in traits highlights the need for shoreline adaptation strategies to balance ecological benefits with community needs and values, recognizing that neither mangroves nor salt marshes can optimally provide every desired service.

TABLE 5 Multinomial regression likelihood ratio and model fitting criteria.

Effect	−2 log-likelihood of reduced model	χ^2	df	Sig
Intercept	−360.77	369.86	234	<0.001
Age	**−372.97**	**24.42**	**3**	**<0.001**
Gender	−375.29	4.64	3	0.20
Education level	−376.53	2.48	6	0.87
Annual income	**−393.33**	**33.59**	**21**	**0.04**
Study site	**−413.15**	**39.65**	**9**	**<0.001**
Residency	**−423.83**	**21.36**	**3**	**<0.001**
Job dependency on coastal resources	−428.80	9.93	9	0.36
Coastal protection	−434.72	11.84	12	0.46
Bird habitat	−442.03	14.62	12	0.26
Erosion control	−451.70	19.35	12	0.08
Soil formation	**−462.55**	**21.70**	**12**	**0.04**
Fishing access	−470.02	14.94	12	0.24
Windbreak	**−480.51**	**20.97**	**12**	**0.05**
Aesthetics	−489.91	18.81	12	0.09
Fisheries support	−494.37	8.92	12	0.71
Hurricane recovery	−503.46	17.53	12	0.13
Water purification	−510.46	14.64	12	0.26
Flood recovery	−518.35	15.77	12	0.20
Soil stabilization	−521.34	5.99	12	0.92
Pollination	−526.95	11.22	12	0.51
Freeze recovery	**−538.34**	**22.77**	**12**	**0.03**
Bird nesting habitat	−545.70	14.42	12	0.26

Note: See Table S7 for parameter odd-ratio coefficients. Significant predictors are in bold.

Regional variations in ecosystem perceptions were also evident. Respondents in the northern sites (Panama City Beach and Galveston) emphasized the freeze resilience of salt marshes in these areas (Kang et al., 2024; Martinez et al., 2024; Snyder et al., 2022), while Florida respondents valued mangroves for supporting fisheries (Swinea et al., 2025). These differences likely reflect local ecological contexts, such as the importance of salt marshes for local avian species that rely on these habitats, with concerns among Texas respondents about the potential negative impact of mangrove encroachment on habitats critical to the endangered whooping crane (*Grus americana*; Kelleway et al., 2017; Osland et al., 2022). As climate change and sea-level rise accelerate, these perceptions may shift in the coming decades. For example, residents in areas like Cedar Key, which have experienced recent hurricanes (Ida in 2023, Helene in 2024, and Milton in 2024), may be prompted to re-evaluate the storm protection benefits of mangroves. However, because mangrove encroachment and storm impacts vary across the region, residents' views on storm protection benefits from mangroves are likely to evolve differently across the region.

The management of these ecosystems presents a unique challenge for conservation scientists and coastal managers, as the decisions of waterfront property owners directly influence both residential coastlines and the broader landscape (Peterson et al., 2019; Scyphers et al., 2015). While mangroves and salt marshes provide critical ecosystem services such as erosion control, storm protection and biodiversity support (Friess et al., 2020), our findings suggest that waterfront property owners prioritize immediate, private benefits over broader conservation goals, such as soil formation to counter rising sea levels and windbreaks to shield against storms. This preference complicates efforts to align individual shoreline management practices with regional resilience goals. Unlike sectors such as forestry or agriculture, which are often economically motivated, shoreline management decisions are closely tied to perceptions of risk, property rights and aesthetic preferences (Bubeck et al., 2012; Guthrie et al., 2023; Walsh et al., 2019). Targeted outreach efforts could be used to bridge the perception-action gap and cultivate proactive responses, for example regarding the protective benefits of mangrove for residential shorelines (Jones & Pippin, 2022). Citing examples from comparable coastal communities can also help dispel hesitations and encourage a more proactive engagement with shoreline management in response to mangrove encroachment. Additionally, implementing policies and programs that support ecosystem adaptation by leveraging neighbourhood influence and social norms could help align local actions with broader resilience goals. For example, initiatives such as selective planting, which is both low-cost and ecologically beneficial, could be promoted alongside clear, accessible information on the risks of non-intervention such as increased vulnerability to storms, erosion and habitat loss (Gittman et al., 2016, 2021). By creating a sense of shared responsibility and highlighting the need for timely, collective action, these programs can mobilize communities to adopt practices that strengthen resilience at both residential and landscape scales, fostering a coastline that is more prepared for climate impacts.

Socio-demographic factors also play a role in shaping adaptation preferences. Older, wealthier respondents and those from Corpus Christi, Galveston and Panama City Beach preferred preserving salt marshes or maintaining the *status quo*, whereas respondents in Cedar Key were supportive of promoting mangroves. This difference highlights the need for inclusive policies that respect localized values and perceptions, while addressing boarder ecological and social equity considerations (Cutter & Derakhshan, 2021; O'Brien et al., 2007; Swinea et al., 2025). While location-specific recommendations, such as mangrove trimming in Cedar Key or low-cost interventions such as monitoring in Galveston, can address immediate local concerns, a scalable, regional framework that integrates these localized approaches could support adaptive and sustainable coastal management across the region.

The challenges and opportunities identified in our study are globally relevant to other coastal regions undergoing similar ecosystem transitions such as those between mangroves and salt marshes. For instance, in China, where mangrove encroachment into subtropical regions has raised concerns about its impact on salt marsh biodiversity, management frameworks must balance species preservation with the need for climate resilience (Gu et al., 2018). Similarly, in Australia, local communities might value mangrove encroachment differently based on their benefits for storm protection, fisheries or carbon storage, highlighting the importance of tailoring conservation efforts to these regional priorities (Saintilan et al., 2019). Furthermore, in Brazil, where both mangroves and salt marshes are critical to local fisheries and aquaculture, successful shoreline management hinges on prioritizing community engagement to ensure that habitat protection aligns with livelihoods (de Lacerda et al., 2021). By adapting these lessons, coastal management efforts worldwide can better integrate local values and ecological priorities, creating pathways for collaboration and proactive decision making.

Finally, our study contributes to the growing discourse on climate adaptation by highlighting how local perceptions of ecosystem transitions, such as mangrove encroachment into salt marsh areas, can either hinder or facilitate adaptive responses. Our findings highlight the value of designing climate adaptation strategies that integrate scientific knowledge with community values to create solutions that are ecologically sound and socially acceptable. Recognizing the diverse socio-demographic factors influencing these perceptions can be helpful, as it points to the value of inclusive, community-centred decision making, helping to craft adaptive management practices that are equitable and responsive to local needs in the face of accelerating climate change and habitat transformations. We therefore conclude that a comprehensive approach to residential shoreline management that considers both local community values and ecological insights can help support resilience across the broader coastal landscape. By integrating regional perceptions and preferences into management strategies, coastal managers can foster adaptive solutions that not only protect individual properties but also enhance the long-term health and resilience of coastal ecosystems under the pressures of climate change.

AUTHOR CONTRIBUTIONS

Jahson B. Alemu I, Savannah H. Swinea and Kalaina A. Thorne: data curation, statistical analysis, visualization; A. Randall Hughes, Steven B. Scyphers and Christine C. Shepard: study conceptualization, funding acquisition, project administration, study oversight; Steven B. Scyphers, Savannah H. Swinea and A. Randall Hughes: survey design, validation. Jahson B. Alemu I and Michael J. Osland: data interpretation; Michael J. Osland: ecological context; Jahson B. Alemu I: wrote the original draft. All authors contributed critically to the drafts, reviews and gave their final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data available from the Gulf of Mexico Research Initiative Information & Data Cooperative (GRIIDC): https://doi.org/10.7266/tyrynxga.

ORCID

Jahson B. Alemu I https://orcid.org/0000-0002-6936-2857
A. Randall Hughes https://orcid.org/0000-0001-5072-7310
Michael J. Osland https://orcid.org/0000-0001-9902-8692
Savannah H. Swinea https://orcid.org/0000-0003-3995-9043
Rémi Bardou https://orcid.org/0000-0002-7439-0967
Christine C. Shepard https://orcid.org/0000-0003-3400-4387
Steven B. Scyphers https://orcid.org/0000-0002-1845-6909

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Text S1. Survey instrument.

Text S2. Word Cloud.

Table S1. Results of the variance inflator factor test.

Table S2. Description of the target ecosystem service investigated and the dimensions of human wellbeing they serve. Ecosystem service typology is in bold italic, and the human wellbeing dimensions are based on MEA (2005).

Table S3. Proportions test comparing waterfront property owner shoreline management preferences between private shorelines and in the wider region.

Table S4. Proportions test comparing waterfront property owner shoreline management preferences on private shorelines.

Table S5. Proportions test comparing waterfront property owner shoreline management preferences in the wider region.

Table S6. Chi-squared test of independence and Cramér's V test to quantify the strength of the association (effect sizes: 0.1 = small, 0.1 to 0.49 = medium, ≤0.5 = large).

Table S7. Multinomial logistic regression analysis to predict preference of shoreline management preference (OR = odds ratio, CI = confidence interval).

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