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Representing the Intertwined Visual And Heritage Implications of Sea-level Rise

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ABSTRACT

Visualizing the impacts of urban development, energy infrastructure and forest harvest practices has become a key element in the discussion and approval or rejection of development plans. Great efforts are expended to achieve accuracy and repeatability in representation to ensure that decision-making is well-informed. Professional ethics on the part of those creating the visualizations generally require fact-based representations that minimize appeal to the emotions. "Sense of place", an aesthetic or culturally-driven response, is implicitly active in determining the appropriateness, or not, of a landscape intervention but has not lent itself to systematic scientific study. Perceived sense of place may, however, be disproportionately active in determining people's reactions to the incremental impacts of climate change. There is substantial evidence that, despite science-based projections of future flood and damage-prone areas, people will choose to stay in place—for many reasons but importantly because of attachment to place, an emotional response. Addressing the effects of climate change might then require directly representing altered sense of place in order to motivate people to act wisely in the face of unavoidable and unwanted change. We have developed a prototype immersive visualization and verbal elicitation tool to deliberately engage citizens and elicit their responses to projective representations of the future with supporting cultural narratives, for a threatened community with deep cultural roots, and have developed some guidance and prototypes for achieving appropriate citizen engagement. We report here on a pilot study to investigate the linked impacts of landscape visual change and change narratives on place attachment and on anticipated actions in the face of climate-related changes.

INTRODUCTION

Coastal Georgia is a region remarkable for its combination of visually distinctive salt-marsh scenery, history and culture, and social differentiation and vulnerability, and it is faced by the potential to be dramatically affected by a changing climate (KC, Shepherd and Gaither 2015). Previous work by two of the authors (Orland and Welch-Devine, 2016) demonstrated the strength of attachment residents have for their coastal setting and their reluctance to consider migration to other, less-threatened, locations, despite their vulnerability and even in the aftermath of the damage caused by Hurricanes Matthew and Irma (Rickless et al. 2019).

Residents elsewhere and government officials wonder why coastal residents do not simply move away as their homes are increasingly threatened by severe storms and sea level rise. The mission of the Federal Emergency Management Agency (FEMA 2005) "Helping people before, during, and after

disasters" is reflected in the agency's Resilience program (https://www.fema.gov/resilience) that seeks to prepare communities through preparedness, mitigation, and insurance programs. In each of these areas FEMA's solutions are comprehensive, but in the first two areas they assume a readiness to adopt changes, and in the third, insurance, they focus on the restoration of financial losses. Nevertheless, FEMA is acutely aware of the importance of sense of place for residents of threatened communities. Press Release NR 39, January 18, 2017, in the aftermath of Hurricane Matthew, addressed the care being taken to restore historic cemeteries in Savannah, Georgia to ensure that "rebuilding activities align with the "sense of place" that communities work hard to maintain". FEMA's guide for communities, "*Integrating historic property and cultural resource considerations into hazard mitigation planning"* (FEMA 2005) provides extensive rationale and guidance for recognizing assets and devising plans for preservation and protection. In all of these there is an implicit acceptance that the existing is good and worth protecting and for recognized historic properties, the National Historic Preservation Act (1966) and the associated Register assure a high level of protection. FEMA's guidelines also address the necessity to motivate communities to act—page 1-9 of the guide shows a dramatic 1906 picture of the San Francisco earthquake as an example of motivational graphics that might be used in public outreach (FEMA 2005). Risk and loss assessments do not address the potential impacts of necessary and unavoidable mitigation measures in diminishing the cultural and historic values that constitute the current sense of place.

BACKGROUND

Coastal residents stay in place in part as a result of limited opportunities to move elsewhere, but also in response to their attachment to place -- home, family, the familiar, the known. People are not tied to place solely by rational calculations of risks and opportunities but by deep cultural bonds and roots, by histories and cultural narratives largely invisible and unavailable to "outsiders" and by dreams and imaginations about the futures they will enjoy in their favored places. Designers and planners often attribute this attachment to people's sense of "place". In his seminal book "Place and Placelessness", Edward Relph described how individuals construct holistic impressions of the places they inhabit and value from the phenomena they associate with the place – its look, its stories, its histories and its promises for the future. In the 2008 edition of the book, Relph points to the potential values of his conception of "place" as a foundation for addressing the implications of local and global changes (Relph 1976, 2nd edition 2008). Henderson and Seekamp (2018) found that residents with known connections to the historic buildings located within cultural landscapes on the barrier islands of Cape Lookout National Seashore held significant attachments to place as well as to the structures that constitute place. The tools that society has adopted to prompt adaptive action, science-based projections and economically-framed incentives, are helpful but fail to address key elements of why people stay in place and why they may be reluctant to take other protective measures. Our prior work, along with that of other scholars (e.g. Alexander, Ryan, and Measham 2012, Bukvic and Owen 2017; Fussell, Sastry, and VanLandingham 2010) has shown that complex combinations of economic, social, and cultural factors reinforce inertia and inaction. Residents responded to the question "*Why have you chosen to live in coastal Georgia?*" as shown in Table 1 (Orland and Welch-Devine 2016), displaying strong connection to the area's beauty and amenity values.

	Slightly/Not at all Important	Important/ Very important
I enjoy the area's natural beauty [Q]	16.4%	78.8%
I like the pace of life [Q]	19.1%	74.5%
It's an affordable place to live [Q]	21.2%	71.0%
It's a good place to retire to [Q]	21.4%	66.3%
I feel a strong connection to the coast [Q]	26.5%	65.8%
I enjoy the recreational opportunities [Q]	26.4%	65.0%
I have family and friends in the area [F]	18.8%	63.8%
I grew up in the area [F]	21.8%	39.3%
It's a good place to raise kids [P]	21.1%	59.3%
I moved for job-related reasons [P]	22.2%	45.7%
It's a good financial investment [P]	36.5%	42.0%

Table 1. Reasons for living in coastal Georgia. [Q] = Quality of Life, [F] = Family ties, [P] = Pragmatic. The superscript letter indicates the factor grouping from Principal Components Analysis.

Federal and local governments do have a compelling interest in responding to sea level rise, because the economic and social consequences of not responding are becoming too great. A 2018 Special Issue of the journal of the National Alliance of Preservation Commissions (NAPC, 2018), *Rising Water, Rising Challenges — Elevating Historic Buildings Out of Harm's Way*, highlighted community responses in Annapolis, Maryland; Charleston, South Carolina; and Cedar Rapids, Iowa and underscored the extreme measures being considered as adaptations. Al (2018), in *Adapting Cities to Sea Level Rise: Green and Gray Strategies*, explored a yet-wider range of options including sea walls, levees, elevation-raising, and moving high value structures to new locations. While all of these have value in protecting architecture, all result in significant changes to their broader cultural settings.

Two significant problems arise. First, residents have a right to understand the full range of implications of their adaptation or avoidance responses, including their visual appearance. While the studies referenced above frequently show what structures will look like when raised on pillars or changed ground level (FEMA 2005, NAPC 2018), we have been unable to find examples of studies that show the alternative impacts of levees, raised roadways, altered shorelines, relocated docks and migrated wetlands that might be implemented as different responses to rising sea-levels in typical coastal locations. Furthermore, and complicating the issue further, accommodating the timeframes over which sea level rise will impact communities, and the uncertainty of shoreline re-shaping, means that the future cultural landscape is not a single fixed possibility but an evolution through several stages, each with quite different appearances. Instead of being able to show residents a single solution, in order to properly inform about the possibilities, it may be necessary to show several alternate futures.

Visual imagery is the most common way to convey this information in a convincing manner and will be central to the efforts of any planning agency to communicate design and planning intentions. The FEMA guide includes photographs of homes raised on plinths and piers to protect against flooding, most notably in Belhaven, North Carolina, where 379 properties were elevated (FEMA 2005, page 3-16). Archival photographs were taken before the projects were undertaken, emphasizing the importance of the historic visual record of place. In addition, however, to seeing a place, sense of place is also a function of what is known about a place, information available from a variety of cultural and historical sources, some formally recognized in archived records, others existing in the memories of community members and unevenly committed to any archival records. To access these broader ranges of values, a larger project*, Experiencing Past and Future Coastal Georgia,* supported through the Wilson Center for

the Humanities at the University of Georgia by the Andrew W. Mellon Foundation, focuses on residents' understandings and expectations of climate change with respect to their daily lives in coastal Georgia.

There are many successful models and use-cases of emerging visualization technology being used to communicate cultural and historical narratives. Important prior virtual reality (VR) examples include the Cathedral of Notre Dame (https://samsungvr.com/view/LsSvbbii1Mx), the city of Petra (https://www.cyark.org/projects/petra), and ancient Rome (https://www.romereborn.org/). VR immerses users into a surrogate of a real place, without the necessity to be in that location. However, our principal interest lies in achieving on-site interaction as a key to allowing residents to connect with history as it happened *in-situ*, and to stimulate both recollections of their past and expectations of their future as impacted by change, also while *in-vivo* (in the course of everyday life) where the direct consequences of change can be assessed in more authentic context. Augmented reality (AR) lends itself better to the *in-situ*, *in vivo* experience that we believe carries the authenticity, accessibility and immediacy that we seek. The expression "augmented reality" covers a wide range of approaches. Closest to the familiar immersed VR experience is the ability via headsets, such as the transparent visor Microsoft Hololens, to float still or moving images over the view of a scene, maintaining their correct geospatial location relative to that scene. A second approach, and the one we favor for its accessibility to a broader public, implements target-based AR via mobile smartphones or tablets. Examples already in use include an AR application for Deok Sugung Palace in Seoul, South Korea in which users 'augment' the existing scene with formerly-present structures, historical site information, and virtual characters from past time periods onto various sites of the palace grounds (Chung et al. 2018). This digital interaction and experience enhances museum visitors' understanding and experience with the past beyond viewing the artifacts alone, "the wearer's interactivity with artifacts and information contributes to an alluring virtual space and one that goes well beyond what is visible in a regular museum environment". A similar 'reactivation of cultural heritage' was made possible in the Cisneros marketplace in Medellin, Colombia with a mobile augmented reality application that augments on-site experience with 'pop-up' maps, historic images, audio, physical 3D models, weblinks, etc. (Hincapie et al. 2016).

Our goal is to develop an integrated suite of tools accessible via the smartphones owned by 81% of Americans (pewresearch.org). Mobile applications will *augment* (display) digital content through a mobile device camera onto the landscape being viewed. Users will engage with digital content cued to their appropriate geographical locations and displayed as a visual overlay of their surroundings including images, videos, 3D models, floating links to websites, audio recordings, and interactive widgets. What sets our project apart, though, is its focus not on delivery of already curated material, but on collecting, moderating and locating others' contributions. We plan to collect first-hand versions of place history from residents and visitors, understanding how people envision their personal stories evolving as their homes are threatened by the impacts of sea-level rise and increasing storm damage and as the crowd-sourced impressions of their neighbors provide new insights into the implications and communication of future and unimagined change. However, at present, immersive technologies are viewed as novelties or games and there has not yet been sufficient focus on making and evaluating tools that have the everyday familiarity, utility and engagement to ensure long-term adoption and use.

The wide range of past examples does not coalesce into a tool set or road map of best practices or guidelines to achieve a successful project. Al-Khodmany (1999) examined the performance of different visualization media in public participation using interactive digital media, Petrie, Othman and Power (2017) examined the usability and quality of experience using smartphone-based multimedia guides, and Roued-Cunliffe and Japzon (2017) evaluated a variety of mechanisms for crowd-sourcing participatory heritage and their implications for different delivery platforms. In sum, however, while

there are numerous cogent ideas about how to design community-based cultural heritage resources, and examples that employ some but not all of these ideas (Giaccardi and Palen 2008, Poplin 2012), there is little published guidance about their effectiveness.

The goal of this project is to start developing a technology standard that better fits the participatory model of humanities research blending science, history and personal experience. This paper describes novel and potentially useful approaches to representing the range of visible and invisible information needed to make an assessment of place—and then judge how sense of place might change when some change is unavoidable, but its exact nature is not knowable. The setting is the small community of Darien, Georgia, in McIntosh County, approximately midway between Savannah, Georgia and Jacksonville, Florida. The Georgia coast for much of this stretch has extensive salt marsh wetlands backed by low-lying coniferous forest. The tidal range in the area is 6-9 feet (1.8-2.7m). Sea-level rise is already impacting the region—Tybee Island, east of Savannah, was one of the first communities in the United State to enact a plan for responding to sea level rise (Evans et al. 2016).

METHOD

The augmented reality application we are developing displays digital content onto photos of cultural and historically significant sites in Darien, a small town in McIntosh County, Georgia. We chose eight images representative of meaningful settings in and around the historic community and then identified a range of plausible sea-level rise impacts at each location (Table 2).

Butler Plantation	*a. Inundated marsh and kayaker, raised pedestrian walkway and house,* *b. Pop-up NOAA static flood map, interactive flood map.*
Tabby Ruins	*a. Flooded roadway, underwater utilities.* *b. Pop-up NOAA static flood map, interactive flood map.*
Sapelo Visitors Center	*a. More inundated marsh.* *b. Hurricane image, pop-up NOAA static flood map, interactive flood map.*
Smallest Church	*a. Altered vegetation,* *b. Pop-up NOAA static flood map, interactive flood map.*
St. Simons Lighthouse	*a. Receding coastline* *b. Pop-up NOAA static flood map, interactive flood map.*
Shoreline	*a. Floating homes on the marsh, historic shoreline.* *b. Pop-up NOAA static flood map, interactive flood map.*
Darien Harbor	*a. Marsh restoration, sea-wall, blessing of the fleet shrimp boat.* *b. Pop-up NOAA static flood map, interactive flood map.*
Fort King George	*a. Colonial sniper over marsh, inundated marsh.* *b. Pop-up NOAA static flood map, interactive flood map.*

Table 2. Darien, Georgia, locations, some plausible impacts of raised sea level and ancillary information.

Our focus for this paper was to begin to investigate how people engage with different modalities of augmentation. The core aspect of AR is the geometrically and spatially accurate registration of new or altered visual information over a live view of the surrounding world. Once that is achieved, however, a wide variety of other visual material can be delivered within the visual field in the same manner as a "heads-up" display. Federal agencies including the United States Geological Survey (USGS) and National Oceanic and Atmospheric Administration (NOAA) provide static and interactive representations of the projected extent of sea-level rise that are generally regarded as authoritative sources. With few exceptions these provide the basis of visualizations that are used to convey the impacts of sea-level rise (e.g., Figure 1).

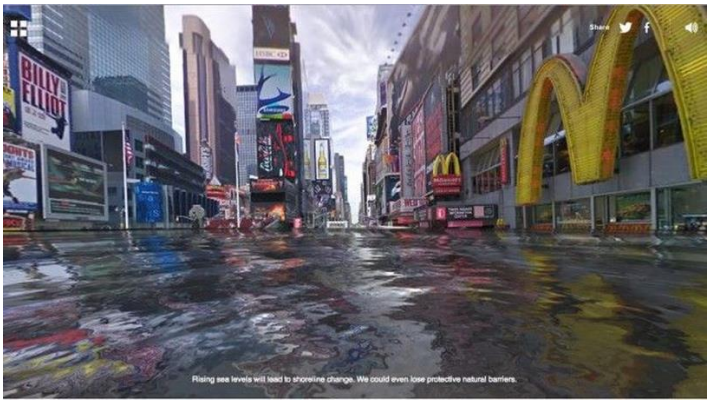

Figure 1. Sea level rise projections. ***Image: worldunderwater.org***

However, these resources show projections overlaid on current conditions. The most certain aspect of the future is that those conditions will not remain static, that actions will be taken to armor, protect or avoid risks as they become urgent enough to motivate residents and government. These remedies—sea walls, raising structures, relocation, allowing inundation—will fundamentally change the visual environment. At any given location it may be impossible to judge which of these remedies will be enacted—yet decisions will be made. Our response is to create augmented reality registered overlay visualizations of plausible remedies (Table 2 (a), Figure 2) and present those together with NOAA information displayed as "pop-up" overlay data and ancillary information (Table 2 (b), Figure 3).

Figure 2. Butler plantation.

Figure 3. Alternate views.

Respondents for this study were final-semester undergraduate landscape architecture students (N=12). We used this sample based on their having professional-level exposure to two sets of issues—the potential impacts of climate-driven coastal change, and the preparation of visual communication materials encompassing technical and aesthetic concerns. Using wall-poster targets we asked respondents first to rate static images of coastal Georgia on a 1 (low) through 10 (high) scale for their perceived cultural heritage value. The cultural/historic content of the image was conveyed via the brief location titles in Table 2. We next asked the respondents to revisit each of the scenes and make the same evaluation but this time first using our AR app to navigate and view as many of the supplied AR resources as they wished (Figures 2 and 3). Finally, we asked each respondent a series of questions about how the AR materials affected their choices, and why as well as how they used the app.

RESULTS

While our focus is not on respondent's ratings of the scenes (Figure 4), our interest did lie in the differences between initial evaluations and then second ones after adding the augmented reality elements (Figure 5). With the exception of the St. Simon's Lighthouse scene, all ratings exhibited reduced values when accompanied by the augmented reality information (Figure 5).

Figure 4. Eight McIntosh County locations chosen for their historical/cultural significance.

One pair of ratings, those for Darien Shoreline, showed a significant difference at the p=0.03 (N=12) level using a matched-pair t-test, mean response value for current scene, x=7.42, for AR scene, x=5.42.

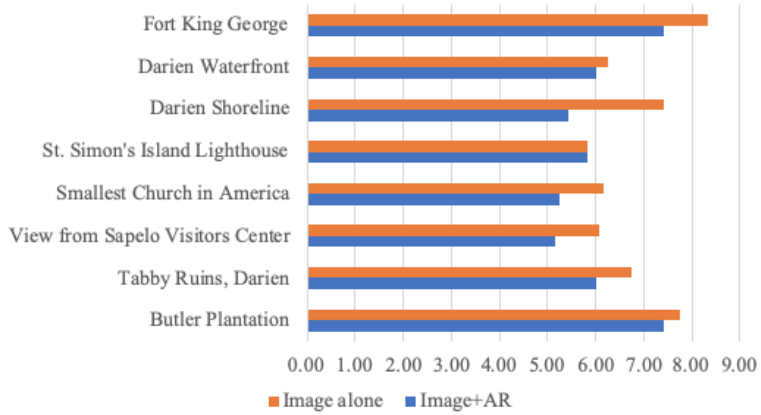

Figure 5. Comparison of perceived cultural heritage value "before" and "with AR" mean ratings

For each augmented image we asked two multiple-choice questions—"What augmented content most influenced your new rating?" and "What method would be most appropriate to protect the site?" The initial question was tailored to the specific augmentations presented for that site (Table 2); for the second question the same responses were available throughout (sea walls, raising structures, relocation, extend natural buffer, do nothing). For four of the scenes 11 out of 12 respondents found the overlay AR imagery most influential in their ratings. For two more that number was 10 out of twelve, for a further one, all 12. For one scene, that of Fort King George, a restricted view through the restored wooden palisade, three respondents found the pop-up NOAA data most influential. A wide range of appropriate remedies was identified (Figure 6). In general, the patterns of responses corresponded with

expectations—small structures could be raised or relocated, bigger ones or sites could not but could be protected by sea walls. The frequency of extending natural buffers may be an artifact of our respondent population but if so, showed an optimistic expectation of the utility of natural buffers against rising ocean levels. Some respondents appear to indicate philosophical positions such as "rely on natural buffers" or "do nothing".

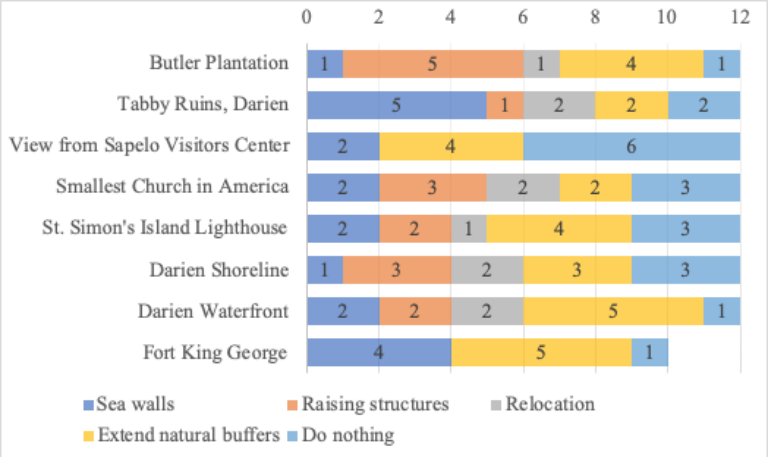

Figure 6. Frequency of choice of remedies judged appropriate to address sea level rise

Following questions about the AR imagery we asked supplemental questions about respondents' beliefs in climate-driven sea-level rise and then an array of questions about the roles and usefulness of AR visualization in different decision-making settings. Of twelve respondents, nine felt that significant sea-level rise was *highly likely*, three responded *somewhat likely*. All twelve reported the AR overlay imagery to be the most useful in informing their responses. Their open-ended responses as to why they had these responses spoke to the ease of understanding "realistic" images and greater awareness of the scope of impacts expected. In contrast, ten of the twelve felt the pop-up elements to be least helpful, their open-ended explanations included the challenges of relating maps and charts to ground-level impacts, and the uncertain reliability of some visualizations, e.g., animations of canoers in flooded shorelines. Nevertheless, for ten out of twelve respondents the visualizations in general caused them to think differently about sea-level rise, for one the information was too location-specific. There was one non-respondent.

A final group of questions asked respondents to speculate about how AR might facilitate decision-making in the face of sea-level rise. Ten out of twelve respondents felt that the visualizations would be *most helpful* in decision-making, two felt them *somewhat helpful*. A question asked respondents to sort categories of decision-makers to indicate which ones would most benefit from AR—Local businesses, Regional planners, General public, City officials, FEMA. Treating the rank order as a simple numeric, top-ranked =1, lowest = 5, respondents felt that the General public would benefit most (x=2.58), then Regional planners (2.67), City officials and Local businesses equally (3.08), and least useful for FEMA (3.58). In response to an open-ended question about the value of including AR visualizations within the range of visualization services offered to clients, nine out of twelve respondents felt that this method of delivery would be useful in motivating change, two felt VR important but not necessarily an integral part of professional services. One respondent did not feel that AR was helpful. We finally asked for feedback on the AR presentation since the method is novel to most practitioners and students. Eight out of twelve provided constructive criticism about legibility and related user interface issues, four were non-respondents, there was no negative feedback.

DISCUSSION AND CONCLUSION

While our methods are evolving and our respondent pool was small and already invested in a profession deeply committed to visualization, there were provocative outcomes of our approach. Even to this group, supposedly immediately familiar with issues surrounding ecological change, several reported on the ability of the AR visualizations to "shock" them into realizing the potential impacts of change. Some of this relates to our previous observation that people habitually think of change in terms of current conditions. Unless alerted to it, the necessity for sea walls, raised or relocated homes, or abandonment may not be part of people's thinking, whether experts or lay public. Our authoritative resources, maps and interactive tools from federal and state agencies fail to connect creeping blue lines to the reality of ground-level changes. Ten out of twelve of our "expert-in-the-making" respondents reported that the visualizations shared with them in this one small interaction had caused them to think differently about sea-level change. Another potentially important observation was the significant heterogeneity of respondent responses. Despite one or two having evidently strong philosophies regarding reliance on nature or letting nature take its course, there was no discernible pattern in how, say, historically significant vs. visually significant resources were expected to be managed – there was substantial difference of opinion on what approach should be taken to each location. Finally, while our respondents hopefully have long lifetimes ahead of them, many coastal residents are older, a substantial number retired. For some, the changes anticipated will occur beyond their lifetimes. Decision-making in the face of change will continue to be highly challenging when there is such divergence in appreciation of the issues that coastal communities face. While there are powerful tools available that could help to energize change, there is so little information about how best to assemble useful and understandable information that the visualization professional barely knows where to start. It is critical that we develop a research agenda to address these topics so that we can invest resources in tools with direct relevance to problem-solving and not let technical innovation decide which directions we pursue.

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