

SEA LEVEL RISE AND MIGRATION

**Understanding future climate-driven
population movements to the Atlanta region**

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As climate change leads to higher sea levels and stronger storms, many coastal cities will be increasingly at risk of a major local disaster destroying homes and vital urban infrastructure. Hurricane Katrina demonstrated how such a disaster can result in displacement of many citizens and how their social connections or existing disaster management procedures push them towards other cities, where they may settle permanently. Atlanta, as a major population center and transportation nexus for the south, should expect to receive high numbers of people forced to flee other southern cities in similar scenarios.

This paper describes Atlanta's migration shed: which coastal areas typically send people to Atlanta, which are at highest risk of future climate change impacts, and how many people could leave these areas for Atlanta. The analysis includes examinations of disaster and non-disaster migrations and sea level rise and storm vulnerability geographies in southern coastal counties. The final section consists of recommendations for a reevaluation of disaster preparedness considerations from a larger regional perspective.

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INTRODUCTION

Climate change and its relationship to major current events such as the drought in the western US, the opening of arctic shipping lanes, and the rapid melting of significant glaciers around the world are hotly debated in the media at present. Images of these far-away places are ubiquitous when climate change is referenced. Much less common are pictures of our own southeastern coastlines where, in many places, major infrastructure and dense development sit only a few feet above the water.

As sea levels rise and tropical storms strengthen, risk of serious or even catastrophic damage from coastal flooding or storm surge will increase. Determined people and governments will deal with the risks as they can, perhaps by moving to higher ground if they can afford it or by building seawalls to protect important areas. Others, however, will decide it's not worth rebuilding after yet another round of flooding and will move to a less risky city. Some may decide to look for more reliable work elsewhere after being laid off from a beachfront hotel forced to close for repairs. Still more will have to seek new homes in other towns after the rental housing they had lived in is destroyed in a hurricane and never rebuilt.

All these things happen now, of course, but climate change will escalate and accelerate these processes. Atlanta, as one of the Southeast's only large cities, and with its economic, physical, and cultural connections to the region, is likely to be the destination of choice for many migrants. This project seeks to explore three main questions: which coastal areas typically send people to Atlanta, which are at highest risk of future climate change impacts, and how many people could leave these areas for Atlanta. I propose hurricane-driven migrations as

a model for future climate migrations in the southeast. Based on analysis of past migration patterns, a migration shed for Atlanta will be projected and sea level rise data will be used to project levels of displacement of coastal populations.

The goal of this project is to demonstrate the importance of local climate-change-driven migrations to Atlanta planners and decision-makers. A better understanding of this phenomenon will be useful to those projecting Atlanta's future population, economic and community development planners, and emergency management or disaster response officials. This project attempts to predict a hypothetical number of migrants in the year 2050 in order to illustrate the seriousness of the issue. Every effort has been made to produce conservative estimates. Only the Southeast is considered; a broader geographic approach is outside the scope of this project.

This report begins with a summary of the research surrounding the vulnerability of Southeastern coastal areas, the relationship between climate change and migration, and how other cities have handled influxes of environmental migrants. A discussion of the methods used in the disaster migration modeling and the results of the model follow. Finally, I make some general policy recommendations for the reevaluation of disaster preparedness considerations from a larger regional perspective and some preliminary steps Atlanta could take to prepare for displaced persons.

LITERATURE REVIEW

Climate Change and Coastal Vulnerability

Though coastal counties make up less than 10% of the US's total area, in 2010, an estimated 39% of the US population lived in coastal counties (National Oceanic and Atmospheric Administration, 2013). Along with population, commercial uses and earnings are clustered at the coasts. Engineering and construction developments over time have allowed people to move into more difficult or dangerous places and, to a certain extent, have enabled some lack of concern for environmental limitations. Water can be pumped from distant reservoirs; lost sand from eroding beaches can be replaced; air conditioning can keep buildings cool. Environmental management methods such as these lead to population growth as they make the areas where they are used more comfortable, but "the collapse of human control in the face of disaster can produce sudden and dramatic, though potentially only short-term, population loss" (Gutmann, M. P. & Field, V., 2010). It is this population loss that this report seeks to understand further. In the context of long term climate change, however, it is uncertain whether the displacement can be short term.

Vulnerability refers to a person or group's ability to deal with a negative circumstance. In terms of an environmental disaster, like a hurricane, as an acute example, or climate change, more, broadly, a vulnerable group is less able to protect themselves from, deal with the impacts from, and recover from a disaster (Donner & Rodríguez, 2008). Vulnerability can be seen as both physical and social. Physically vulnerable places are those more prone to serious impacts; visible examples include barrier islands or concentrated development along river banks. These places need some level of environmental management to make them habitable. Social vul-

nerability is often conceived of through low socioeconomic status, non-white race, low education level, or other factors which make it harder to maintain control over the circumstances to which one is exposed. There can also be a physical element to social vulnerability, however, in the characteristics of the built environment where people live. The quality and reliability of the environmental management systems supporting life are often influenced by social factors in the community, such as wealth, growth, and level of investment (Cutter, Boruff, & Shirley, 2003). Where highly socially vulnerable people are concentrated, the risks they face from physical vulnerabilities are increased.

Along the Atlantic coastline close to Atlanta, physical factors like sea level rise and slope contribute the most to vulnerability, while social factors play a larger role along the Gulf Coast (Boruff, Emrich, & Cutter, 2005; Donner & Rodríguez, 2008; National Oceanic and Atmospheric Administration, 2013). As climate change brings higher sea levels, vulnerability will increase along the Atlantic Coast: even those with very low social vulnerability will be at increased risk. Interventions to deal with physical risk factors could reduce overall vulnerability in this area (Boruff et al., 2005). On the Gulf, physical interventions are less likely to have an overall negative impact on vulnerability.

Globally, sea level is expected to rise by between one to four feet by 2100 (Walsh, J. D., et al., 2014). It will take some time before the seawater begins to seriously encroach onto land, however. The real risk is related to storm surge, a phenomenon where rotation, wind, and pressure changes inside a strong storm, tropical storm, or hurricane increase water levels just around the storm (Masters, n.d.). The force of this water, mostly through wave action, is very destructive. Storm surge



Miami, Florida

is worst around the eye of a hurricane and can mean an increase of 25 feet or more above mean high water levels in a particularly strong storm like Hurricane Katrina (Masters, n.d.). The southeastern US has been in a period of high hurricane frequency and intensity since the 1980s. By the end of this century a slight decrease in the number of storms is projected, but hurricane strength is expected to increase further (Walsh, J. D., et al., 2014). That could mean much more destructive storms, with higher storm surge levels threatening low-lying areas.

Coastal cities are at greatest risk of severe damage related to climate change because of concentrated development. Until fairly recently, land use planning was not connected with ideas of local resiliency. Potential storm surge levels were not considered when many major interstates and bridges were designed, nor was inundation likelihood projected for sewage stations and water treatment plants. Sarasota, Florida has over 400 sewage lift stations at risk of damage inside the category 2 storm surge area, for ex-

ample (Frazier, Wood, & Yarnal, 2010). Projections show that a category 3 storm could flood the major north-south interstate and damage or make impassable some bridges, complicating rescue, relief, and recovery operations which require those transportation links (Frazier et al., 2010).

As was seen during Katrina's aftermath in New Orleans, the poor often live in areas of higher flooding risk (Colten, 2006). This means they tend to have increased physical vulnerability, despite having less capability to deal with a disaster and its impacts. Further exacerbating social vulnerability are gaps in disaster response planning, which often does not serve the poor, especially immigrants, very well (Donner & Rodríguez, 2008).

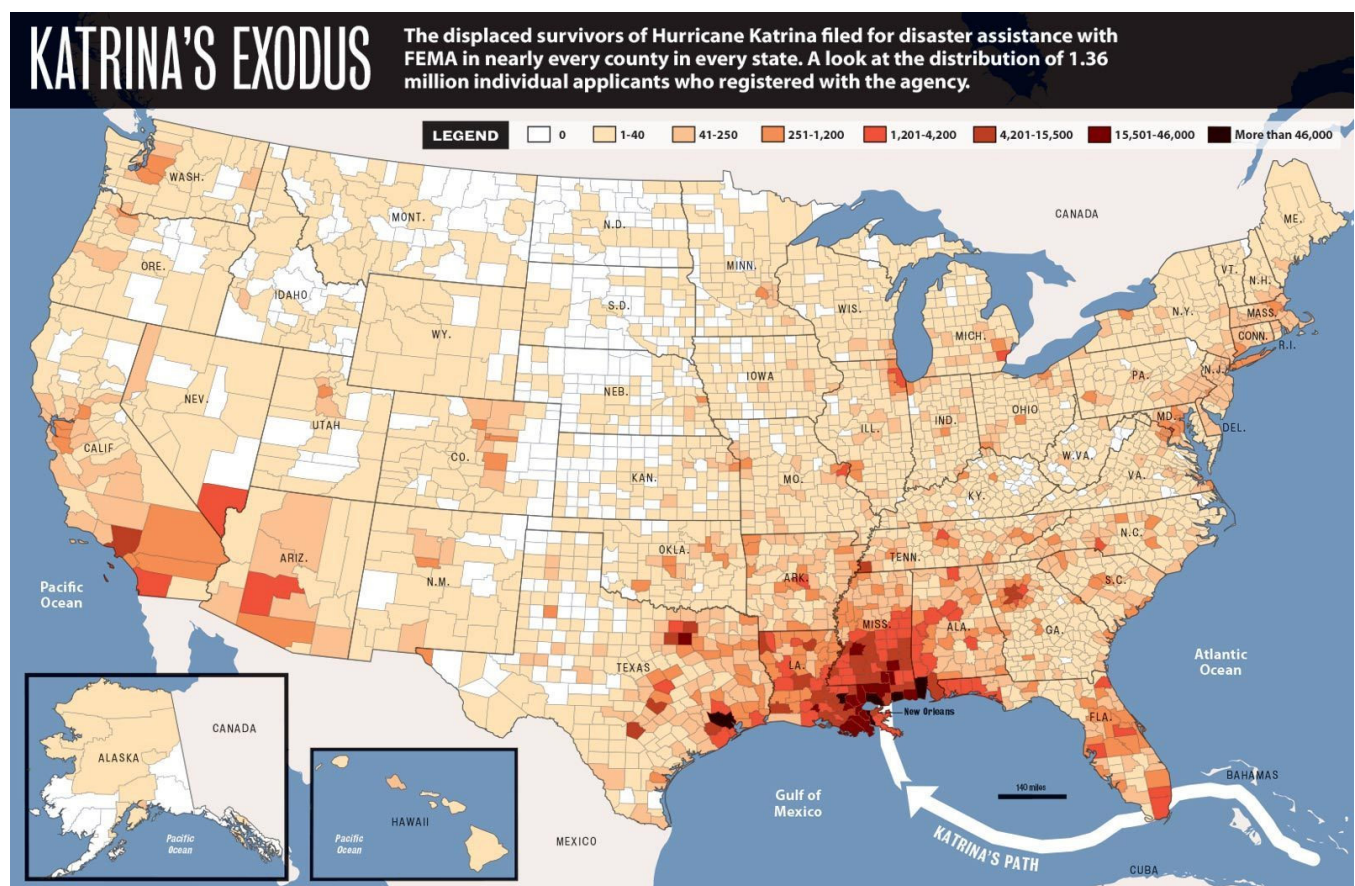
The combination of high levels of social vulnerability and the increasing physical vulnerability as a result of sea level rise present a worrying outlook for the future of much of the coastal south. To reduce overall vulnerability, substantial steps would have to be

taken to protect the infrastructure that people rely on to support their everyday needs – safe housing to water treatment to reliable electricity. If these essential services are compromised by repeated flooding or damaged in a major storm, continued residence in any area becomes more difficult. Without these essential services many people will be forced to leave, as hurricanes such as Katrina and Andrew have shown. Atlanta, less vulnerable due to its inland location and unique in its size and interconnectedness with other southern cities, may be a refuge for many.

Disaster-Driven Displacement in the US: Examples from Hurricane Katrina

The most obvious example of disaster driven displacement in recent US history is Hurricane Katrina. Many people evacuated before the storm and many more as the floodwaters began rising. Thousands of residents were trapped in the city by the floods, only able to leave after days spent in the overcrowded Superdome or Convention Center or sleeping under highway overpasses. Much of the city was destroyed and, across New Orleans and the Gulf Coast, millions were left without homes.

Another destructive storm that resulted in the displacement of a large number of people was Hurricane Andrew, which made landfall just south of Miami in 1992. The cost of the damage was estimated to be more than \$22 billion (Smith & McCarty, 1996).



New Orleans residents and others from hard-hit coastal areas spread out across the country after Katrina. In contrast, the majority of Hurricane Andrew's damage was isolated to a couple of south Florida counties and most people stayed close by, often in neighboring counties (Smith & McCarty, 1996).

Many displaced, especially the poor, do not get to choose their destination, however. People without personal vehicles or who cannot afford to drive a great distance, must be offered assistance with evacuation transportation (Fothergill & Peek, 2004). Those relying on public evacuation transportation are often unable to choose their destinations. Stories about Katrina evacuees who boarded planes and busses with no idea of their destination are common.

Similarly, these public transportation-reliant evacuees are unable to leave the destination without further transit assistance, whether to return to their home city to another, until transportation is offered again or they can provide for their own travel. It is common, though, that, in the transition from evacuee to displaced person, more travel happens. After Andrew, displaced families reported moving an average of two times before settling back into repaired or new homes. After Katrina, African American women moved more than any other group before being able to settle back into their neighborhoods (Li, Airriess, Chen, Leong, & Keith, 2010).

Where Andrew did less damage, people were able to return to their homes after a couple of weeks. In areas of heavy damage, however, most were gone for over 6 months and 12.7% for over a year (Smith & McCarty, 1996). It was found that the people still gone at the 2 year point or later were not likely to return. Also, the farther away people moved initially, the less likely they were to return (Smith & McCarty, 1996). The outlook

on the future of the community is also very important for the decision to return home or now. After Katrina, in a neighborhood inhabited by African Americans and a sizable Vietnamese community, the Vietnamese were quicker to return and more positive about the future of the neighborhood (Li et al., 2010).

In the case of Hurricane Katrina, many people could not return quickly. Thousands ended up far from home, in South Carolina or Colorado for example, and, knowing that the city could not be rebuilt very quickly, resigned themselves to staying in their new cities for some time. They rented apartments, looked for jobs, and enrolled their kids in local schools. While some did this with hope for a new start and others with longing for their old lives, most understood there was little alternative (Weber & Peek, 2012). But many of the receiving cities were not prepared to take on these displaced persons and much of the assistance structure was insufficient.

Housing issues were seen across the board. Different assistance programs had different benefits, requirements, and timelines. This led to confusion for the displaced and local landlords centered around where the money would come from and prejudices about HUD funding (Lein, L., et al., 2012; Pardee, Jessica, 2012). Also, as the displaced streamed in, demand for housing in migration cities drove up rental prices but HUD voucher values were not adjusted accordingly. Many of the displaced struggled to find housing options they could afford (Pardee, Jessica, 2012). Differences state-to-state made other social assistance programs, such as Medicare and food stamps, difficult to navigate for the displaced. Missing IDs and other personal records slowed enrollment (Lein, L., et al., 2012).

Many former New Orleans residents were also surprised by the lower assistance levels

offered in other states and found it hard to make ends meet in the way they had been accustomed to at home (Lein, L., et al., 2012; Weber, Lynn, 2012). Transportation issues were very common for the displaced who had very low car ownership levels but who were moved, in many cases, to much more sprawling cities than New Orleans with much more limited public transportation. Among other things, this made looking for and keeping work difficult for many (Weber, Lynn, 2012).

These problems were partially due to the lack of recognition of displacement in US law. Complaints against the US disaster relief law, commonly known as the Stafford Act, have been raised since Hurricane Katrina. This law does not recognize disaster recovery as a federal responsibility and does not require the federal government to provide any standard of assistance. Critics argue that this Act leaves US citizens deprived of their rights to assistance and recovery as laid out by the UN and other human rights organizations (Advocates for Environmental Human Rights, et al., 2010). There is no current US legal structure that defines internal displacement or which sets out actions to respond to displacement (Stephens & Reide, 2006).

Ultimately, many of the displaced felt stigmatized and discriminated against, partially because of racism and partially because of ideas of refugees as backwards, unintelligent, or criminal (Peek, Lori, 2012). Resentment was high in many receiving cities as well, where the welcome wore thin rather quickly as the displaced were no longer seen as people in need of assistance but, instead, as outsiders taking up local resources (Weber & Peek, 2012). The displaced, on the other hand, felt isolated from their culture, friends, and way of life (Weber, Lynn, 2012).

Planners and other decision makers in the Katrina destination cities did not anticipate

the influx of the displaced that awaited them after Katrina. National assistance programs offered some limited solutions for people, but the situation on the ground in different states and cities caused unexpected problems. In addition, federal and local assistance systems became increasingly ill-suited to the needs of the displaced as the months after the storm stretched into years. Frustration grew on both sides: among the displaced, who hadn't wanted to leave New Orleans and felt trapped in new places, and among the receiving communities, which had little desire to support the needs of outsiders who didn't want to be there.

People forced to leave their homes have different needs than those who move to a city for a new job, for example. Even if they choose their destination, they may be unprepared to build a new life there from scratch. Cities like Atlanta, in insulated inland positions but not far from the coast, understand they will occasionally shelter coastal citizens because of hurricanes. Climate change threatens to make these brief displacements permanent.

Connecting Climate Change to Displacement

The increase in climate change related natural disasters that require people to flee their homes means there are likely to be more displaced persons in the future. Many of these people will come from low-lying coastal regions, as encroaching sea water increases flooding risks and storm damage and seeps into soil and groundwater. Some climate change adaptation and mitigation measures will also lead to displacement, for instance where the choice is made to retreat from a coastal plain rather than defend it with sea walls and pumps. Much of the existing literature considers climate displacement globally, in general terms about mass migrations from threatened areas.

The places and peoples under consideration are, for the most part, in developing countries and it is the necessity of planning for these high risk, low resource populations that is discussed.

At the international level, an important facet of the discussion of this issue is how to classify those people forced to move. Under the framework by which the UN currently recognizes refugees, in order for an individual to be considered a refugee, they must have a fear of persecution on the grounds of their "race, religion, nationality, or membership of a particular social group or political opinion" and have migrated to another country to escape it (1951 Convention Relating to the Status of Refugees and 1967 Protocol, in de Sherbinin et al., 2011). This definition is clearly shaped around political refugees, those fleeing a war, political upheaval, religious conflicts, etc.

Though many have pushed for the inclusion of environmental issues, such as drought, as drivers of displacement, this has not yet happened. Critics of the idea feel that an environmental issue is not usually the sole or even main reason for flight and that, if it were, people would only need leave temporarily and would return home soon enough (de Sherbinin et al., 2011). The general belief is that political upheaval and state mismanagement are the ultimate causes of refugee movements, regardless of underlying environmental issues. Thus, those forced to leave their homes due to the environmental impacts of climate change are considered displaced persons (Albuja & Adarve, 2011; de Sherbinin et al., 2011).

The internally displaced, i.e. those who remain within the boundaries of their home country, are considered at the international level. Human rights groups and formal commissions have recognized the risk that disasters pose and have found that countries should

protect their citizens from disasters and displacement (Albuja & Adarve, 2011). The UN Guiding Principles on Internal Displacement lay out the rights of the internally displaced, including that displacement should not be "arbitrary," that they should be protected from conflict and discrimination, that they should be free to move about the country or seek asylum elsewhere, that they should be provided with food, housing, healthcare, and other essentials, and that they should be "protected against forcible return to or resettlement in any place where their life, safety, liberty, and/or health would be at risk" (United Nations, 2004). Natural disasters, though not climate change specifically, are recognized as a cause of displacement.

The extent to which the legal frameworks, at any level, recognize "slow-onset disasters induced by climate change, such as droughts or depletion of resources" as drivers of displacement and, therefore, the people fleeing as officially displaced is unclear (Thomas, 2014). As the environmental problems unfold slowly, migration from the area may be seen as a voluntary, economic decision rather than forced movement (Thomas, 2014). In these scenarios, it is likely that people would lack legal protections (Albuja & Adarve, 2011). Also, the nature of slow but irrevocable change complicates the idea of displacement as temporary. The UN Guiding Principles state that the displacement should "last no longer than required by the circumstances" (United Nations, 2004). When circumstances prohibit the return of displaced people, it is unclear how they should be considered.

Some scholars differentiate displacement due to development and displacement due to disaster, though much of the difference seems to relate to the extent to which the displacement was anticipated and whether a return to the status quo is the goal, or even an option, of response efforts (Berringer,

2011; Wilmsen & Webber, 2015). Increasingly, however, scholars are recognizing that climate change blurs the lines between these advance planning and emergency response approaches and are advocating for a model that combines the two (Berringer, 2011). Research tends to discuss migration and resettlement outcomes separately, favoring migration as it offers substantially more agency, such as choice in timing and destination, than forced resettlement (de Sherbinin et al., 2011; Farquhar, 2014; Wilmsen & Webber, 2015).

The result of several international meetings on the subject has so far been that forced resettlement because of development can offer guidelines and lessons to those planning for climate resettlement, but there is general agreement that it is a last resort, meant for those “unable to adapt in situ or migrate” (Wilmsen & Webber, 2015). It should not be overlooked that “pre-emptive” migration also suits receiving countries well, as it allows them a greater element of control over the influx of people (Farquhar, 2014).

Displacement is more likely to be seen from more heavily damaged places, especially where there is damage to residences, and the people from these places are likely to be displaced for longer periods of time (L. Perch-Nielsen, B. Böttig, & Imboden, 2008; Smith & McCarty, 1996). People in these situations are already less likely to return, and that chance shrinks even further if work options are impacted or if migration was already happening (L. Perch-Nielsen et al., 2008). It is at this point that the lines between displacement and migration become blurred.

With no formal designation at the international level or within the US, there is no standard for the support of and provision for the long-term displaced. Lack of clear process

and requirements will not prevent them from seeking refuge, however. Similarly, what impact climate-change-driven in-migration could have on local planning, which has focused for the most part on economic drivers, is unknown. Ultimately, without further progress on this front, future receiving cities, like Atlanta, will set the example of best (and worst) practice integration of the displaced and climate migrants.

Facing Climate Change at our Doorstep

In an overview of existing attempts made at climate migration modeling, McLeman (2013) was unable to find any work previous to the early 2000s. Since that time, researchers have experimented with various methods of modelling climate-driven migration, focusing overwhelmingly on out-migration. This starts with an identified environmental driver, such as crop changes, or, in the case of multi-hazard analyses, another life event that could spur migration (McLeman, 2013). Most have struggled to expand the scale of models beyond the regional level, as access to or specificity of data on migrant populations at national or international levels is often lacking (McLeman, 2013). Uncertainty remains about the exact numbers of migrants and the extent to which projections rooted in very specific situations can be made more broadly applicable (Findlay, 2011).

Instead of beginning with the migrants, this project will look at the issue from the perspective of the destination. Though the number of migrants and the context of future migrations are uncertain, what is not is the fact that they will come. As Allan Findlay writes: “A pre-occupation with forecasting a single number of environmental movers has diverted attention from thinking...about how to plan for the impacts at different migration destinations in relation to the multiple and

complex ways in which environmental migration is, and will be, produced” (Findlay, 2011). Additionally, migration discussions that begin with the drivers lend themselves best to solutions that begin with drivers as well, which, though important, are more significant in terms of sending community rather than receiving community adaptation.

The destination first approach allows a potential receiving city to embrace uncertainty to some extent and incorporate higher or lower migrant numbers into future scenario planning processes. In one example, Abel and his collaborators attempted to predict future environmentally-driven migration to the UK with a Bayesian statistical analysis based on a Delphi study of migration and demography experts. The migrants in question were international newcomers to the UK and experts were asked first to predict future totals, then to discuss and defend their predictions to the full panel, with the option to change their final prediction (Abel, Bijak, Findlay, McCollum, & Wiśniowski, 2013). Predictions were also assigned a level of uncertainty, allowing a kind of fan of possible values to be forecasted – though this is not to be confused with the statistical reliability of a confidence interval (Abel et al., 2013).

Results, following the median output, show an overall decline in in-migration to the UK and an initial increase in environmental migration followed up by a slight decline by 2060 (Abel et al., 2013). Allowing for the provided uncertainty levels, the estimates vary widely: from 600 to 177,700 environmental migrants in 2030 and from 600 to 312,700 migrants in 2060 (Abel et al., 2013). This variation can be explained in large part by differing expert opinions on the origin countries of potential migrants and the comparative attractiveness of the UK as a destination.

Though it is not the central focus of the paper, the authors suggest policy makers should strive to better understand what features may make the UK a more or less attractive destination in the future which can offer “an early warning” of migrant flows or inspire development investments in more attractive places (Abel et al., 2013). This furthers the idea that cities should see themselves as part of a larger migration system where they are one of many migration destination options. As circumstances change who may be most likely to choose a particular city as a destination, thorough understanding of migrant characteristics and needs will increase preparedness. Attractiveness to migrants can also be a goal, especially as they can potentially fill labor gaps or spur growth (Harper, 2012).

As this report focuses on Atlanta and the southeastern US, it is migration in the context of the developed world that is the closest parallel. The European Union’s Demographic and Migratory Flows Affecting European Regions and Cities project (DEMIFER) commissioned a report on climate change and migration which concludes that climate-driven internal migration is unlikely in Europe as adequate adaptive infrastructure development is assumed (European Spatial Planning Observation Network, 2010). Obviously, further information about migrants was not provided.

In the US, even in the National Climate Assessment, discussion of migration mostly concerns plant and animal species and relocation of humans is mentioned only in relationship to low-lying Pacific islands (US Global Change Research Program, 2014). Academic research in the field consists mainly of identifications of vulnerable groups and high risk areas, as discussed in the previous section on vulnerability. Cutter’s social vulnerability index has, for example, been combined with sea level rise, land use, and

land value data to perform a cost benefit analysis that maps coastal areas most and least likely to be protected with sea walls or other physical interventions (Martinich, Neumann, Ludwig, & Jantarasami, 2013). Though the risk factors that lead to the conclusion that some areas are more likely to be abandoned are clearly defined, no further analysis of where the residents will go is provided.

Resettlement due to climate change or adaptation or mitigation projects is also a popular subject (de Sherbinin et al., 2011; Ferris, 2015; Johnson, 2012; Wilmsen & Webber, 2015). The debate surrounding climate resettlement is an interesting one, but, at least in terms of the development forced resettlement model, speaks, again, more to large-scale, international issues where the UN and other large organizations can intervene and act to move people.

Organized relocation has only been discussed in the US in relationship to some indigenous groups living on threatened islands or river deltas (Kan, 2015; Maldonado, Shearer, Bronen, Peterson, & Lazrus, 2013; Thomas, 2014). Action on resettlement for these groups has been hindered by the mismatch of the current government disaster-response framework and the need for preemptive movement. There is no specific funding set aside to relocate people and no designated responsible agency (Maldonado et al., 2013).

It would require substantial political upheaval in the US for an outside organization, like the UN, or even the Federal government to step in and forcibly move a large number of people to a new location. Though some possible examples do exist from our past, any climate-change-related actions at such a scale seem unlikely under the current political context. As it is impossible to forecast such broad shifts, this project focuses

mainly on migrant movements rather than resettlement.

Drawing on the larger migration literature, Findlay suggests that the central features of environmental migration are movements over short distances and reliance on social networks (Findlay, 2011). Urban destinations are particularly attractive because of the prevalence of these networks and improved economic chances, though long-distance or international migration is still limited to those who have more personal resources. The poor may want to travel farther but tend to stay in the first available location with the opportunity to find secure work and living space (Findlay, 2011). A study of US household movements shows some evidence that extreme weather, even when not at a disaster level, may drive migrants to urban destinations (Cameron, Saif, & Duquette, 2011). It is not surprising that urban areas, with more diversified work and living options and dense social networks, would be preferred destinations.

Of particular interest for this project is the line that separates displaced persons and migrants. It seems to lie in the timing of the situation: as long as return home seems possible or is desired, people are only temporarily displaced but, once they desire to leave the threatened area or not to return to it, they become migrants. As is seen in the examples from New Orleans' displaced, it is not always this simple. While return home may be technically possible, it may not be realistic due to lack of transportation, jobs, or fundamental changes at home like the drastic spike in rental costs in New Orleans after Katrina (Weber & Peek, 2012).

And this exception rather proves the rule, as it stands now, that displacement is seen as a problem for 'others.' In the same way that many in receiving cities had a hard time empathizing with those displaced because

of Katrina, the United States has not yet come to terms with the fact that disasters due to climate change will not happen only in some isolated far-away place. In this we are not alone, as the omission of climate change drivers from refugee frameworks shows the refusal to accept the scale of the coming problems or, with a slightly more sinister view, the refusal to accept the displaced. Migrants can be turned away, refugees cannot (de Sherbinin et al., 2011).

Currently, research on climate-driven migration and displacement in the US is just getting started. Much of this work focuses on the sending communities: what are the risks and who are the most vulnerable. Migrant destination choice research shows that people are likely to choose urban destinations close to home where they have some social connections. These two threads have not been combined to forecast where potential climate migrants may end up in the future, at least in the US. While this project is not able to explore that question on a broad scale, the goal is to contribute predictions for one city. This report will take a destination-centered approach for Atlanta, Georgia with the aim of creating a climate migration shed for the city, identifying areas of strong social and physical connection and the populations that may be most likely to leave them for Atlanta.

METHODS

Three related research questions drive this project: which coastal areas typically send people to Atlanta, which are at highest risk of future climate change impacts, and how many people could leave these areas for Atlanta. An examination of the existing migration relationships between Atlanta and its southeastern coastal neighbors and some simple population growth estimates were used to help answer the first and last questions. GIS analysis of sea level rise scenarios and the geography of coastal areas was used to tackle the second question. This section describes these methods and their application for this project; results are discussed later.

As a benchmark, 2050 was selected as the goal year for this analysis. Current projections estimate up to four feet of sea level rise by 2100 (Walsh, J. D., et al., 2014), though the rate of progress of the rise is unclear. The year 2050 presents a time point in which sea level rise and its effects are likely to be widespread, but not catastrophic. At less than 35 years away, this time point is not so distant as to be unimaginable and people's daily lives and needs are likely to be relatively similar to the present.

Migration Relationships

In order to better understand the coastal migration shed for the Atlanta region, the first step was to understand what migration to and from Atlanta and nearby coastal counties has looked like in recent years. Referred to here as the migration relationship, this speaks to the relative level of connection, in terms of out-moving residents, between a coastal county and the Atlanta area and the associated contribution to Atlanta's in-moving migration totals. Most useful to

the analysis is the outmigration share: the ratio of those leaving a county for the Atlanta region to the total of all out-movers from that county. A high outmigration share indicates a strong sending relationship between a county and the Atlanta region.

Internal Revenue Service Statistics of Income (IRS SOI) data were used to calculate these values. These data record the number of income tax return filers each year at the state and county level, how many have moved since their previous years' filing, and where they moved to. These data provide a high level of accuracy in tracking migration movements because it is collected every year and for all tax filers, and they are generally recognized as a high quality source for internal migration information (Curtis, Fussell, & DeWaard, 2015). For a finer level of detail and increased accuracy, the county migration totals were used in this analysis.

Migration numbers taken from the SOI data tend to be conservative for several reasons. First, many older citizens and many of the very poor, who are not required to file taxes, do not do so, and, therefore, are not accounted for. Also, totals lower than ten are suppressed to protect movers' identities. Therefore, for each county, only those counties which sent or received at least 10 filers are listed. That means, in this analysis, counties sending or receiving fewer than 10 individuals from any of the Atlanta region's counties received a zero value.

Thus, especially among counties with very low migration flows, the calculated migration share may be lower than the true value. It is also important to note that the SOI data collection methodology was changed after 2010 to improve accuracy. From the 2011-2012 year and on, the data include improved return matching methods and a full year

of returns. Previous to this, only returns received before September were included in migration totals (Pierce, 2015).

From the most recent year of data available (2012-2013) and the previous ten years, county-to-county migration flow data were examined for coastal counties in Alabama, Florida, Georgia, Louisiana (only the New Orleans area), Mississippi, and South Carolina. Counties were considered coastal if they border the ocean or a large bay or sound; that is coastal counties are those one deep from the coastline, determined visually. Due to their distance from Atlanta and, in the case of New Orleans, the confounding factor of levee construction on the SLR impacts, Mississippi and Louisiana were later excluded.

For each county, total numbers of people moving were collected from IRS SOI files for the 10 years between 2013 and 2003. This included the total number of out-migrants from each county, of in-migrants to the Atlanta region, and of out-migrants from each county to each Atlanta regional county.

For the purposes of this project, the Atlanta region was defined according to the MSA boundaries used by the US Census Bureau for the 2000 decennial census.

This allowed an outmigration share to be calculated for each county. Applying only the outmigration share to estimate migration relationship favors counties with a strong sending relationship with Atlanta, those which tend to have higher numbers of people moving to the Atlanta region. However, there are zero values for some counties that did not send at least ten people to Atlanta in any single year. Though it is possible that these counties did send some people to the Atlanta region, they cannot be counted with this method.

Therefore, the outmigration share as calculated here underestimates the coastal county to Atlanta sending relationship. Still, the value calculated is a strong predictor of the business as usual migration connection and provides a simple measure of where new incomers to the region, especially from higher population counties, tend to move from.

Population Projections

In order to calculate a number of potentially displaced people in 2050, population estimates for each county in 2050 were needed. Most state governments or other planning organizations have not yet forecasted future populations that far into the future, though, so a simple linear method was used to create 2050 population projections. The population estimates for each of the 50 counties in 2010 and 1970 were collected from the Census Bureau and a growth factor was calculated by dividing the 2010 population by the 1970 population. This is essentially the rate of growth for each county across the forty years before 2010. Across all fifty counties, this growth factor ranged from 21.5% for Flagler County, Florida, to 1.3% for Mobile County, Alabama. To project populations in 2050, the 2010 population was then multiplied by the forty year growth factor.

This process assumes that the growth rate over the 40 years between 2010 and 1970 will remain the same from 2010 to 2050. For many counties, especially in Florida, which have seen extremely high growth rates over the past 40 years, this assumption is likely to be incorrect. It is probable that, as climate change and sea level rise move out of the politically debated sphere they currently inhabit in our national public discourse and into the real, lived experience of coastal citizens, fewer people may choose to move to coastal counties and some current residents may even choose to move out before impacts become widespread.

Still, considering the lack of urgency with which these issues are discussed by policy-makers and the absence, in most cases, of barriers or disincentives to coastal development, it is also quite possible that growth rates will remain high well into the future. In any case, projecting how these growth rates may change in the future for each county

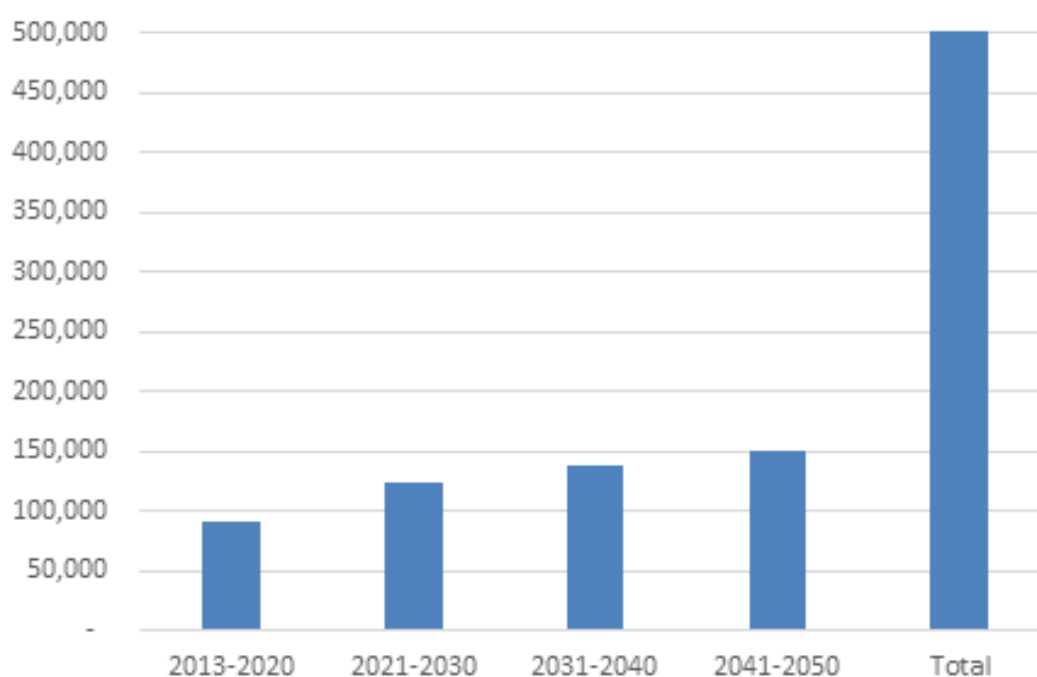
was outside the scope of this project. In the interest of preparation, the estimates based on past growth were used with the idea that planning for a greater number of displaced persons will improve readiness.

As census tract level data on populations was used for the GIS analysis, the population of individual tracts was projected for 2050 wherever possible by multiplying the given 2010 tract population by the linear growth factor for its county. For Florida's five southernmost counties, for which tract level SLR analysis was not possible, the growth factor was applied to the overall county population.

In order to compare the sea level rise migrant group to the expected in-migration from the coastal counties, Atlanta's 2049-2050 total in-migration needed to be estimated. Using a line of best fit to the ten years of IRS SOI migration data already collected, in-migration in Atlanta was estimated at approximately 319,748 people. This indicates a growth rate of about 1.52% from the current situation, using the mean of the in-migration totals available. The estimated total in-migration was multiplied by each county's Atlanta migration share to estimate a number of migrants who may be anticipated and for whom, through standard planning and development practices, the region may already be prepared.

Figure 1 shows the expected incoming migrants by decade from the fifty county study area and the total of all expected in-migrants from this area by 2050. From 2013 to 2050, approximately 500,000 of the Atlanta region's incoming migrants are expected to come from these counties, assuming their respective shares of Atlanta's in-migration remain the same in the future. This represents about 4.7% of the total of all incoming migrants to the Atlanta region.

Figure 1: Expected In-Migrants from the Fifty Coastal Counties



GIS Analysis

This project concerns itself not only with those displaced due to actual inundation but also those who are pushed to move due to nuisance issues related to SLR, such as frequent flooding. While it is unlikely that someone living six feet above current sea level would be inundated by 2050, they would certainly be at much higher risk of damage from flooding or storm surge and much of the infrastructure they rely on, like roads, would also be threatened.

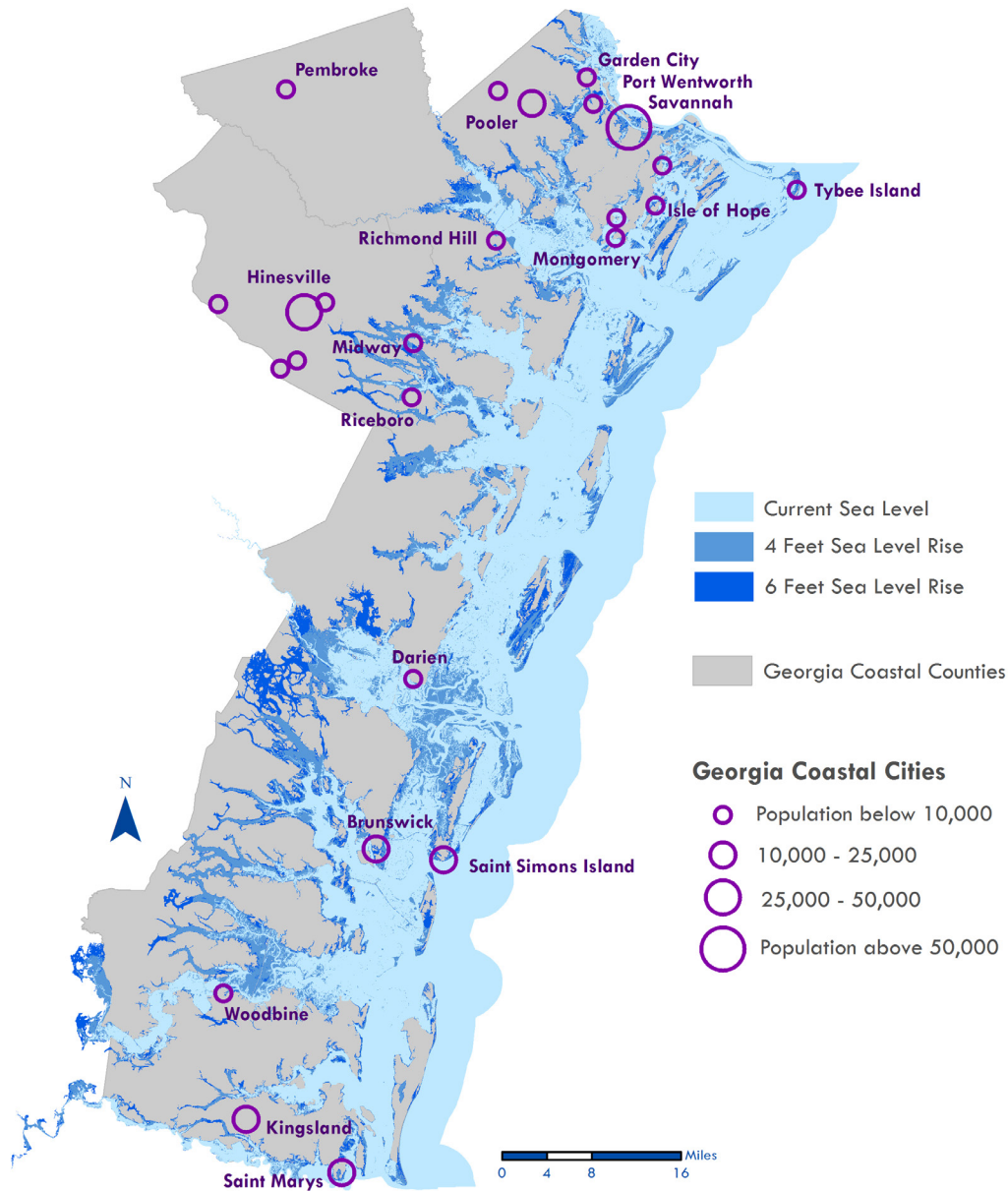
To compare areas where risk of these SLR-related impacts will increase, the National Oceanic and Atmospheric Association's (NOAA) sea level rise GIS data were downloaded from the Digital Coast open data website and clipped to the Alabama, Florida, Georgia, and South Carolina coastal counties. NOAA's mean higher high water inundation files (polygon) were used to calculate areas of inundation at 0ft SLE (present day), 4ft SLR (the 2100 estimate), and 6ft SLR. The

use of both inundation scenarios provides a high and low risk of migration estimate, assuming that those closer to sea level are more likely to migrate even before their land is inundated because of increased overall flooding risk (Sweet & Park, 2014).

At the scale of the full study area, the details of these SLR scenarios are difficult to make out. Figure 2 shows a view of the Georgia coast with the different inundation areas and the locations and population sizes of coastal towns and cities.

NOAA's SLR polygons were overlaid with 2010 census tract boundaries, obtained from the US Census Bureau. Tracts under consideration were limited to those in the coastal counties for which migration data was calculated. Especially in cases of river deltas, SLR will encroach farther inland than this first line of coastal counties, but land loss was not calculated farther inland as migration data was not collected for these areas.

Figure 2: Sea Level Rise along the Georgia Coast



ArcGIS's identity and dissolve tools were used to calculate and compare the percent of each tract covered by water in all three SLR scenarios. The identity tool combines the census tract boundaries and the boundaries of the inundation area and allows only those portions of tracts within the inundation area to be cut from the full census tracts file. The area of these tracts and parts of tracts was calculated and then the dissolve tool was used to sum the total inundated area for each tract. The area of each tract and the

part of the tract intersected by zero feet, four feet, and six feet of SLR was determined using the calculate geometry function.

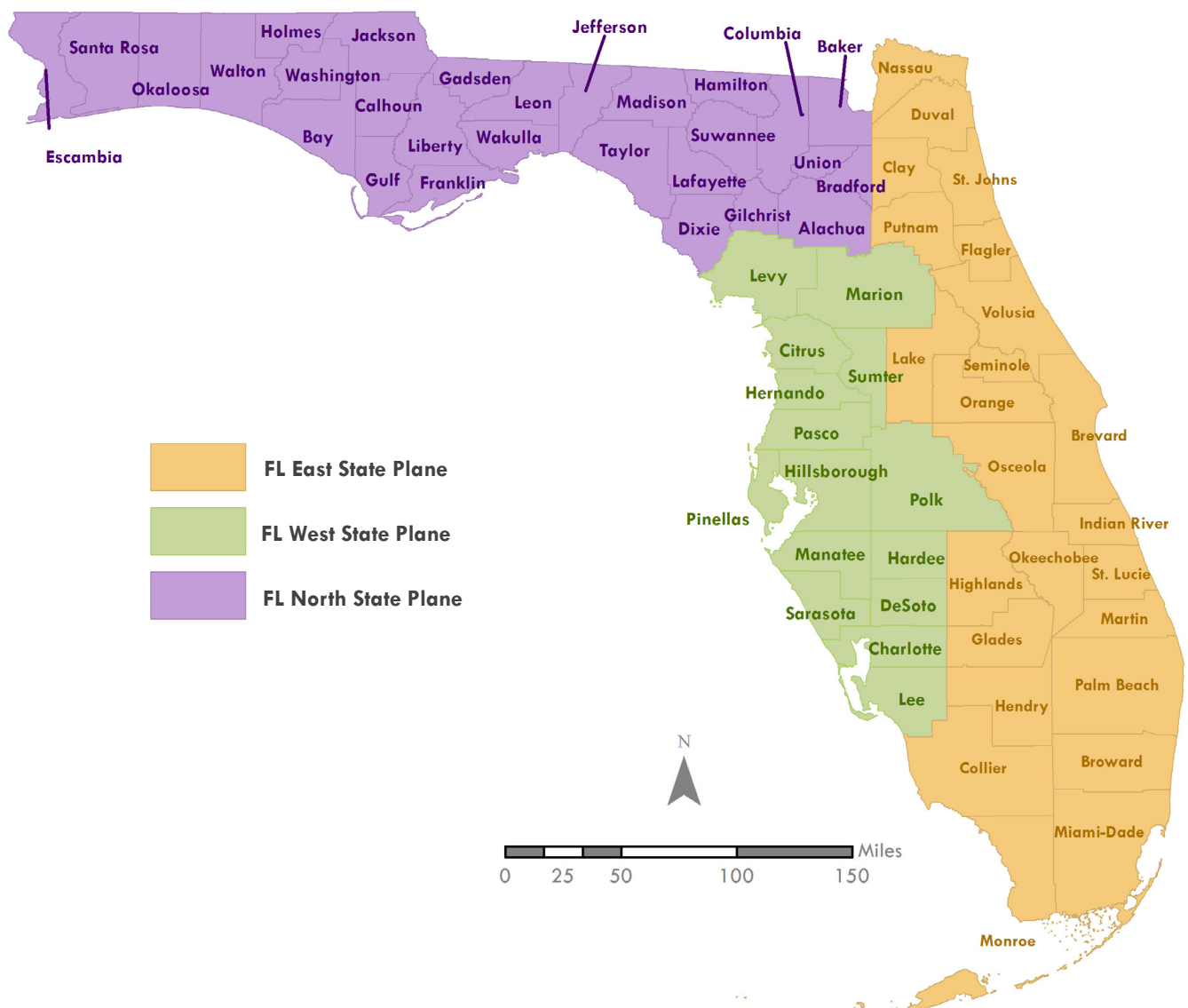
For each state, the Census and NOAA shapefiles were projected into the appropriate state plane to ensure accurate area measurements. Map projections convert geographic coordinates into linear measurements, allowing for area and other calculations. Different projections are more or less appropriate for different areas, and

state plane projections are designed to be accurate for measurements within each US state. Large states often have multiple state planes. For this analysis, only Florida was affected by this. References in this document to east, west, and north Florida refer to the counties within those state planes, as shown in Figure 3.

Consideration of the inundation area at 0ft was necessary because census tracts are drawn to be contiguous and, therefore, include areas of water. Though certainly some other parts of each tract would not be inhabited, to simplify analysis, the assump-

tion was made that population is spread evenly across all dry areas. Therefore, the percentage of land lost was assumed to be equal to the percentage of population lost. This percentage was obtained by dividing the original tract area by the area covered by each SLR polygon and then subtracting the zero feet SLR water percentage from the four and six feet water percentages. Then, the potential number of total migrants from each area, i.e. those who would be likely to move due to the impacts of SLR, was calculated by multiplying the projected 2050 population of each tract by percentage of land lost at each SLR level.

Figure 3: Florida State Plane Systems



These formulas demonstrates how the potential migrant totals were calculated:

$$\text{Potentially Displaced}_{(4\text{ft SLR})} = 2050 \text{ Population} \times \left(\frac{\% \text{ water}_{(4\text{ft SLR})}}{\% \text{ water}_{(0\text{ft SLR})}} \right)$$

$$\text{Potential Atlanta Migrants}_{(4\text{ft SLR})} = \text{Potentially Displaced}_{(4\text{ft SLR})} \times \text{County's Atlanta Out-migration Share}$$

It should be noted that data was missing for Florida's five southernmost counties (Broward, Collier, Miami-Dade, Monroe, and Palm Beach) and a small area just off of the western coast of Citrus and Hernando Counties. The tract-level SLR analysis thus could not be completed for the five missing counties. Instead, for these southern Florida counties, land loss percentages for each SLR scenario were obtained from the Climate Central Surging Seas project, which made use of the same NOAA SLR data used in this analysis. The Surging Seas data also provided the number of people estimated to be living within 4 feet and 6 feet of sea level, as calculated from 2010 census blocks.

This data allowed the same population growth and migration share calculations to

be completed for these five counties as for all others in the study area. The small missing piece of sea level rise data off of Citrus and Hernando Counties was assumed to have less impact on accuracy because much of it lies over an area that is currently covered by water. The land loss estimate for this county is likely to be somewhat smaller than the real value.

Ultimately, there were ten values each for the outmigration share and Atlanta in-migration share for each county for each year from 2003 – 2013. All of the values were averaged across the 10 year period to reduce year-to-year fluctuations. The average outmigration share was multiplied by the total migration population to calculate the number of migrants likely to head for Atlanta.

The analysis assumes that these recent migration relationships will remain consistent through to 2050. This will lead to rather conservative results for two main reasons: the IRS SOI data do not cover all movers, only those filing taxes, so they underestimate the actual migration relationships; and coastal counties have recently been growing more quickly than inland counties (National Oceanic and Atmospheric Administration, 2013), which is unlikely to hold true once SLR impacts become more severe. Only the population projections differ from this conservative focus because it was outside the scope of this project to do more precise projections for each of the fifty counties under consideration.

The estimation of migration relationship was based on ten years of recent migration data due to, on the one hand, the desire to use more current population trends because of the distance projection date, and, on the other, the limitations of the project. A longer history of migration analysis would naturally be helpful in any expansion of this analysis as it may illustrate important, long-lasting relationships between Atlanta and some coastal cities.

The methods used for this project are intended to provide a first, hypothetical look at future SLR-driven migrations from the point of view of a destination city. As such, they are very preliminary. Further research in the field of migration and migration projections and broader data collection would certainly improve results. Still, the methods used here are worthwhile for their simplicity and ease of implementation to produce an initial estimate of in-movers and to shed light on the possible severity of the phenomenon of SLR-driven migration in the United States.

RESULTS

Using the methods explained above, migration relationships, 2050 populations and migration totals, and sea level rise impact were calculated for each of the fifty southeastern coastal counties. This section describes the values found and their interactions, seeking to answer some of this project's central questions. Migration relationship data is used to determine which cities may be most likely to send sea level rise driven migrants to the Atlanta area. Relative impact of sea level rise in each county is used to determine what level of damage each county could experience and the associated number of people who would be displaced. This information is combined to estimate a potential total number of Atlanta area in-migrants due to sea level rise.

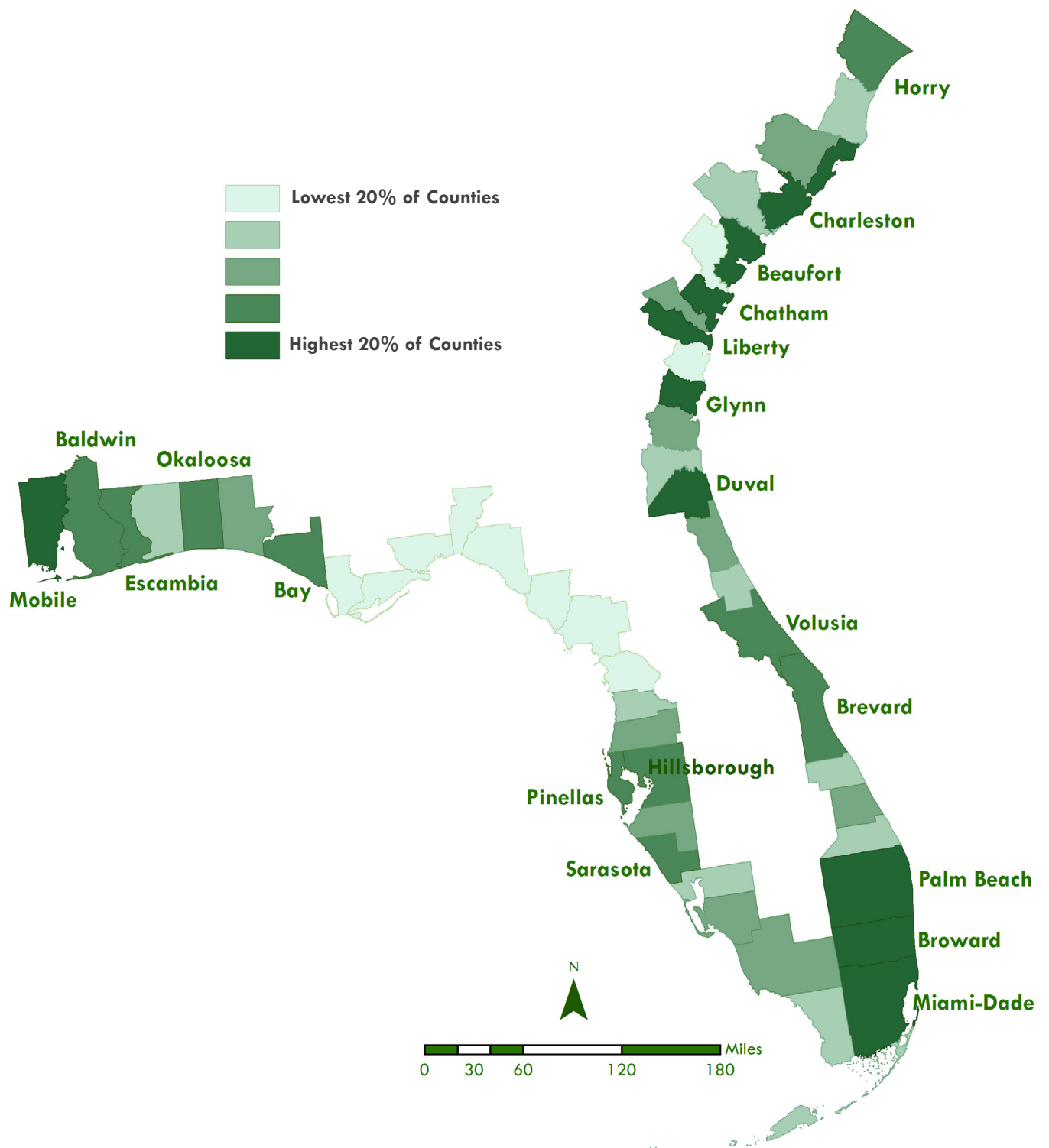
Atlanta's Migration Relationships

Analysis of Atlanta's relationship with surrounding coastal counties shows higher levels of migration connection, first, to those counties closest to Atlanta and, second, to more urbanized counties. As Table 1 indicates, Georgia coastal county connections tend to be higher than for any other coastal counties and, unsurprisingly, highest for Chatham and Glynn, the two counties with the highest populations on Georgia's coast. This trend is also true for South Carolina and Alabama (though Alabama does have only two coastal counties). Despite the increased distance from Atlanta, the population centers of Miami, Palm Beach, and Tampa also send relatively high percentages of their migrants to Atlanta.

Table 1: Top Ten Sending Counties (Out-Migration Share)

| COUNTY | STATE | OUT-MIGRATION SHARE |
|------------|-------|---------------------|
| Chatham | GA | 10.2% |
| Glynn | GA | 7.3% |
| Mobile | AL | 3.6% |
| Broward | FL | 3.5% |
| Miami-Dade | FL | 3.2% |
| Liberty | GA | 3.2% |
| Duval | FL | 3.1% |
| Palm Beach | FL | 2.7% |
| Beaufort | SC | 2.7% |
| Charleston | SC | 2.5% |

Figure 4: Atlanta Out-Migration Shares



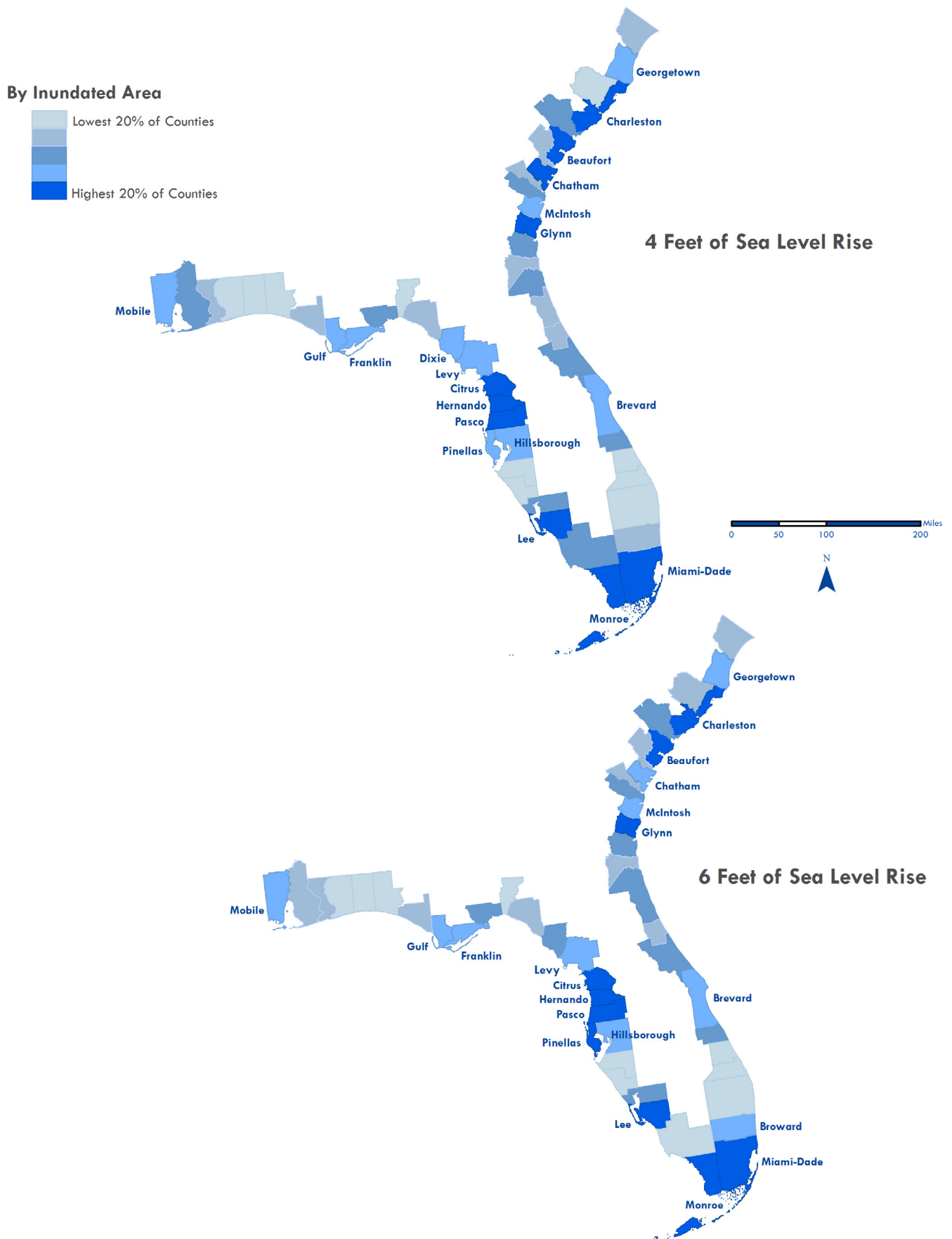
Because of their location along the coast, all of these counties will be impacted by sea level rise. Through the GIS analysis of NOAA's SLR boundaries, the amount of land lost from coastal census tracts was estimated for 4 feet and 6 feet of sea level rise. Table 2 shows the counties which are expected to lose the most land due to sea level rise. Especially in southern Florida, many counties will see inundation in up

to one fifth or one quarter of their land by 2100, with some areas like the Keys, nearly disappearing completely. Even more land will be within only a couple feet of sea level, bringing much higher risk of flooding and storm surge to areas considered fairly safe today.

Table 2: Top Ten Counties by Percentage of Land Lost to Sea Level Rise

| 4 FEET OF SEA LEVEL RISE | | | 6 FEET OF SEA LEVEL RISE | | |
|--------------------------|-------|-------------------|--------------------------|-------|-------------------|
| COUNTY | STATE | PERCENT LAND LOST | COUNTY | STATE | PERCENT LAND LOST |
| Monroe | FL | 82% | Monroe | FL | 97% |
| Hernando | FL | 47.5% | Miami-Dade | FL | 77% |
| Miami-Dade | FL | 36% | Hernando | FL | 61.1% |
| Citrus | FL | 34% | Pasco | FL | 43.4% |
| Pasco | FL | 32.2% | Citrus | FL | 41.8% |
| Beaufort | SC | 25.3% | Beaufort | SC | 37.3% |
| Charleston | SC | 21.6% | Glynn | GA | 33.9% |
| Chatham | GA | 21.5% | Charleston | SC | 32.4% |
| Glynn | GA | 20% | Pinellas | FL | 31.6% |
| Lee | SC | 20% | Lee | FL | 30.4% |

Figure 5: Coastal County Land Loss Due to Sea Level Rise



Potential In-Migrants

Using the migration patterns and sea level rise data described above, this project first attempts to estimate the number of people at high risk of displacement in 2050 and, subsequently, a potential number of sea level rise driven migrants who could come to the Atlanta region if those coastal residents choose or are forced to move. The projections made here rely on several assumptions made due to limited data. First, population growth over the 40 years between 2010 and 2050 is assumed to be equal to the growth from 1970 to 2010 and was calculated using a linear growth model. The large study area prevented individual population growth projections for each county. Second, it was assumed that population is spread evenly across each census tract. In this case as well, the large study area prevented finer detail in the analysis.

The number of potentially displaced is the total number of people, according to the growth projections made earlier, who will be

living in the areas within four and six feet of sea level in 2050. Naturally, if sea level rise has already claimed some land by that time, people may no longer live in those places. This total is not meant to represent realistic populations in coastal tracts. It is an artificial construct of the total number of people who, if growth and settlement patterns were to remain the same, would likely need to find new places to reside by or before 2050.

While the actual sea level in 2050 remains unknown, approximately four feet of rise is expected by 2100 (Walsh, J. D., et al., 2014). The four and six feet sea level rise scenarios were selected to best approximate a range of increased risk of damage not only from inundation, but also occasional flooding that will exist by 2050. Because the year-to-year change in sea level remains uncertain, it was not possible to track this displacement across the next 35 years. Therefore, the methods used here essentially compress sea level rise and coastal growth into a single year, 2050.

Table 3: Coastal Populations and Potential Displacement

| STATE | | 2010 POP | 2050 POP | Potentially Displaced 4ft | Potentially Displaced 6ft |
|----------------|-------|-------------------|-------------------|------------------------------|------------------------------|
| Alabama | | 595,257 | 1,096,967 | 64,777 | 79,039 |
| Florida | | 14,634,153 | 55,170,979 | 3,627,508 | 9,188,651 |
| | East | 8,782,661 | 33,538,134 | 2,420,576 | 6,960,869 |
| | West | 4,446,293 | 21,632,845 | 1,072,502 | 2,036,387 |
| | North | 1,405,199 | 4,408,757 | 134,430 | 191,395 |
| Georgia | | 503,286 | 1,121,790 | 82,416 | 122,622 |
| South Carolina | | 1,083,403 | 2,824,056 | 222,249 | 343,326 |
| Total | | 16,816,099 | 60,213,792 | 3,996,950 | 9,733,638 |

Shown in Table 3, this results in a cumulative total of approximately 4 to 9.7 million people at very high risk of displacement. This displacement area lies so close to the water that a major, Katrina-style storm will not be necessary to force people out. Instead, the slow advance of the water line, along with increased flooding, salt water intrusion, and other sea level rise side effects will damage homes, buildings, and infrastructure. The potentially displaced total given here is an estimate of the people who will be most exposed to these negative sea level rise impacts.

As these calculations were made using state plane geographic projections, Florida was divided into three parts. The Florida east state plane extends from Duval County, the seat of Jacksonville, FL, to Monroe County, which holds the Keys and the Everglades. The Florida west state plane includes the area between Lee and Levy Counties along the Gulf coast. The Florida north state plane extends from Dixie County to the Alabama boarder.

Though these areas are not formal political boundaries in Florida, they demonstrate the relative importance of different areas of Florida in this sea level and migration context. Both the East and West geographic areas of Florida contribute, each, to the population of potentially displaced more than Alabama, Georgia, and South Carolina combined.

The appropriate county Atlanta outmigration share was applied to the total number of potentially displaced in each census tract to find the total number of in-migrants to the Atlanta region. This results in a total of 84,278 to 229,863 migrants from the fifty southeastern coastal counties in the study area.

This does not include migrants who are likely to come to Atlanta from other areas inside these counties. In the past ten years these fifty counties have contributed approximately 103,400 residents to Atlanta. Netting out total in-migration to the Atlanta region from 2003-2013 to estimate future in-migration leads to a projected cumulative

Table 4: Potential Migrants to Atlanta, 2050

| STATE | | Potentially Displaced 4ft | Potentially Displaced 6ft |
|-----------------------|--------------|------------------------------|------------------------------|
| Alabama | | 1,454 | 1,798 |
| Florida | | 73,545 | 213,910 |
| | <i>East</i> | <i>59,009</i> | <i>185,789</i> |
| | <i>West</i> | <i>13,146</i> | <i>26,041</i> |
| | <i>North</i> | <i>1390</i> | <i>2080</i> |
| Georgia | | 5,096 | 7,537 |
| South Carolina | | 4,183 | 6,618 |
| Total | | 84,278 | 229,863 |

total of 500,000 in-migrants from these fifty counties between 2013 and 2050. The IRS data used for migration analysis in this paper does not allow for tracking migration at sub-county levels. As some of the people in the displacement area would likely have chosen to move to Atlanta, regardless, the potential sea level rise migrants cannot simply be added to the total of all migrants from these counties.

However, as residents of these counties who live outside of the displacement area should also be considered equally as likely to be a part of this 500,000 'business as usual' migrant total, neither can the sea level rise migrants be assumed to fall completely within this projected migration total. The true share of this migration that the sea level rise migrants will make up is not possible to find using the methods in this project. It is possible to say, though, that the total of all migrants from southeastern counties by 2050, whether choice or sea level rise driven, will fall above 500,000 and below 730,000 and that the majority of those will come from Florida's east coast.

Risk of Increased Outmigration

Though many factors can influence the total number of migrants from any one area, the data collected for this analysis can also be used to help narrow down which coastal counties may be those most likely to send migrants to Atlanta due to sea level rise. Assuming that any county with a strong Atlanta out-migration share will retain that relationship and that those counties with higher land loss will be those likely to see higher levels of displacement, a simple model was constructed.

Counties were compared with a ranking system in which each factor, i.e. percentages

of land lost and the outmigration flow share, was placed on ten point scales by deciles. The lowest 10% of outmigration counties, therefore, were assigned a value of 1 and the highest 10% a value of ten. As the analysis considers the extent of loss of coastal land, using acreage to rank SLR impact would push counties with larger amounts of coastal land to the top. In a large county, the acreage lost could be high, compared to a smaller county, while the overall percentage of land lost could remain small. Ranking counties by percent of land lost allowed them to be more accurately compared to one another.

Using ArcGIS's raster calculator, the three scales were then combined with outmigration share and land loss weighted equally – 50% of the final value was outmigration share and 25% was assigned to each four feet and six feet SLR land loss – so the highest possible end value for each county was ten and the lowest was one. Results are shown in Table 5 and Figure 6.

The highest possible risk score is ten. Unsurprisingly, Miami-Dade County scored highest. With up to 77% of the county's land either inundated or at high risk of flooding or storm surge damage, it is very likely that many Miami-Dade residents will move away in the future. Considering the strong existing Atlanta migration relationship, it is also likely that many of these migrants would choose Atlanta as their destination.

Though migrants are likely to come from all of the counties in the study area, those ranked highly here can be considered the counties to watch in terms of relative risk of displacement and impact on Atlanta in-migrant totals. This is a fairly rough approximation, however. The model would certainly be improved through the use of more variables, such as density of important coastal infrastructure and services (such as highways and hospitals) within the displacement area.

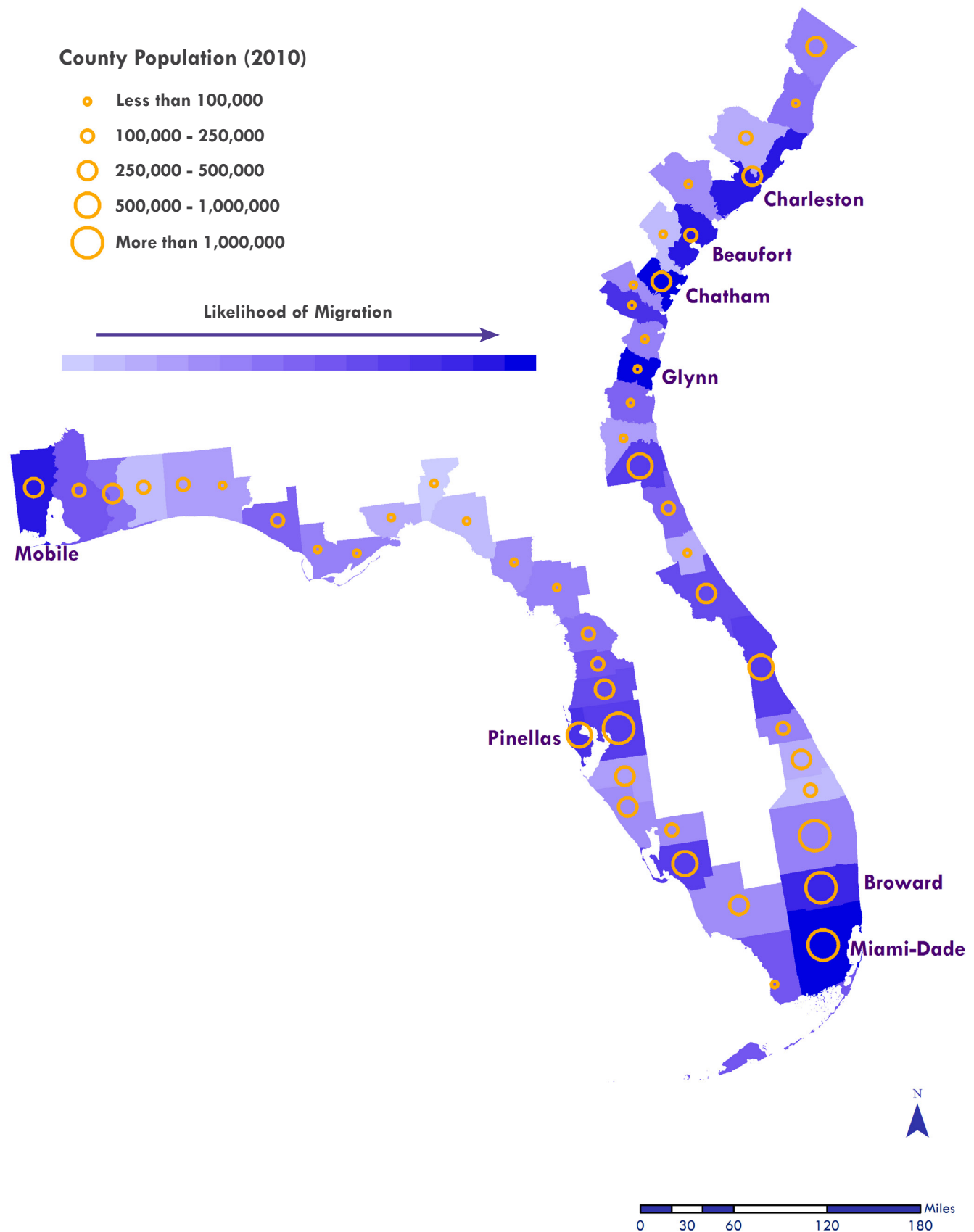
For the most part, the coastal urban areas closest to Atlanta are those with the highest levels of future SLR migration. Even in southern Florida, however, areas of very high population are ranked highly. As total population was not taken into account in these calculations, this is an interesting result. It underlines the fact that urban areas tend to

have stronger migration relationships with other urban areas (Findlay, 2011). Also important, it implies that migration movements to the Atlanta area due to sea level rise may involve high numbers of people if migrants are more likely to come from populous areas.

Table 5: Coastal Counties Most Likely to Send SLR Migrants to Atlanta

| SCORE | COUNTY | STATE | Out-migration Share | Percent Land Lost | |
|-------|------------|-------|---------------------|-------------------|----------|
| | | | | 4 Ft SLR | 6 Ft SLR |
| 9.5 | Miami-Dade | FL | 3.2% | 36% | 77% |
| 9.25 | Chatham | GA | 10.2% | 21.5% | 30% |
| | Glynn | GA | 7.3% | 20% | 33.9% |
| 8.5 | Mobile | AL | 3.6% | 17.2% | 21.8% |
| | Beaufort | SC | 2.7% | 25.3% | 37.3% |
| | Charleston | SC | 2.5% | 21.6% | 32.4% |
| 8 | Broward | FL | 3.5% | 7% | 28% |
| 7.5 | Pinellas | FL | 1.8% | 17.2% | 31.6% |

Figure 6: County Likelihood of Sending Future Migrants



DISCUSSION

Atlanta is a growing region: projecting the Atlanta Regional Commission's future population forecasts forward another ten years to 2050 results in an Atlanta regional population of about 9 million people. Therefore, at first glance, an estimate of 84,000 – 230,000 sea level rise migrants does not seem overwhelming compared with the likely number of overall Atlanta in-migrants or even the total number of migrants from this limited area, especially when considered over a period of 35 years. And, it is also important to note that in-migration in Atlanta is often balanced by outmigration, so this sea level migration total does not imply an absolute increase in population. Thus, it could be argued that the Atlanta region could absorb the coming sea level rise migrants with few problems.

There are several good reasons to reject that argument, however. First of all, these migrants are unlikely to distribute themselves equally across the region. While data were collected for migrants to all twenty of the counties in the Atlanta region (as defined by the 2000 Census), the majority of counties in this area did not receive the minimum ten migrants required to be listed in the IRS SOI files.

Five Atlanta area counties, did, however, receive migrants from nearly all coastal counties in each year of the analysis: Clayton, Cobb, DeKalb, Fulton, and Gwinnett. Across the ten years of migration data, these five counties received an average of about 81.8% of the region's total incoming migrants from the fifty coastal counties examined here. If that relationship remains the same into 2050, these counties can expect to receive the great majority of sea level rise migrants to the region: 68,940 – 188,028 new residents.

This indicates that, as part of the influx of former coastal residents, the Atlanta area could see a stronger trend of centralization of population due to sea level rise driven in-migration. Much higher demand for housing, jobs, places in schools, and other services would be seen within these counties as a result of this migration: there would be a comparatively higher impact in the center of the region than in the peripheral counties.

Second, the estimates given here consider only direct complications from sea level rise, such as coastal flooding, which happen in the immediate area, within a few feet, of the mean high water level. Studies show, though, that climate change will also lead to stronger hurricanes and tropical storms, so much greater areas, and therefore populations, would be at risk of displacement as a result of these storms (Walsh, J. D., et al., 2014). If more people are displaced, more people will come to Atlanta, just as was seen after Hurricane Katrina.

Based on the same IRS data used for this analysis, in the year after Katrina struck, the number of out-migrants from Orleans, Plaquemines, and St. Bernard Parishes to any other parish or US county was nearly six times higher than the year before. The number of migrants choosing to come to the Atlanta region was 15 times higher. It is impossible to predict if or where a strong storm could strike, but it would undoubtedly have a major impact on the Atlanta region if it were to land somewhere among the fifty coastal counties considered here.

Also, the method of calculation of the potentially displaced assumed that the percentage of land lost in each inundation scenario would match the percentage of population lost from a census tract. Some tracts will lose very high percentages of land, however,

especially with six feet of sea level rise. There is likely to be a point at which so much of the important infrastructure, like schools, power substations, etc., inside a tract is lost or threatened with repeated damage that most or all of the people living in that tract will decide to move elsewhere, even if they themselves remain on higher and relatively safe ground.

Finally, the number of sea level rise migrants predicted here relies on historical migration data. Migration patterns may change drastically in the future, though. Currently, the share of people leaving one coastal county for another destination in the same state is very high. Across the ten years of migration data collected, for example, about 60% of the out-migrants from Miami-Dade County stayed within the state of Florida. By 2050 this may simply no longer be possible. With 3.6 to 9.2 million Florida residents at risk of displacement and considering the large areas of inundation and high flood risk across the state, available space for resettlement in state may be difficult to find. The share of migration to Atlanta could increase as a result.

A further concern is the structure of the migration to Atlanta. As coastal residents are inconvenienced by nuisance flooding and infrastructure damage, they will begin to retreat, and some will choose Atlanta as their destination. Once more serious flooding and damage from storms make it clear that residents, their property, their jobs, or their businesses are no longer safe or reliable on the coast, they will be forced to move and many will end up in Atlanta. So, while the migration is likely to begin slowly, severe SLR impacts, like increased storm surge damage in a large city, could cause it to accelerate unexpectedly. Some migrants are likely to resemble traditional choice migrants, taking time to plan and prepare for a move, while others may be more like refugees with little

time and few resources to shape a new life in a new city.

Therefore, Atlanta should be concerned about the accumulation of SLR migrants over time during the middle part of the century, accompanied by spikes in the SLR migrant numbers with major coastal storms. Historical migration relationships indicate that the closest urban coastal counties in the Southeast and the Miami area are both most likely to send migrants to Atlanta for any reason. When risk of SLR impact is included, this relationship remains true: coastal cities in Georgia, South Carolina, Alabama, and the Miami area are all most likely to send sea level rise driven migrants to the Atlanta area.

This likelihood speaks to the long-term accumulation: over time, Atlanta is likely to see increasing numbers of residents from these areas as SLR impacts develop. For shorter term influxes due to disasters, population of the origin is of more importance. Table 6 shows the counties sending the highest absolute numbers of migrants from the 2050 calculations. As this demonstrates, though they have lower overall likelihood of sending migrants, many highly populated counties in Florida would still send a significant number of people to the Atlanta area in cases of large displacements.

Choice migrants from the coast can be incorporated into existing planning processes at the local level. With adequate information on numbers and characteristics, appropriate steps can be taken to absorb these newcomers, who are likely to have planned their own resettlement in advance. Those coastal residents displaced due to disasters will pose a different challenge. They are likely to come in higher numbers and with little preparation. Their long term housing options, transportation, healthcare, and employment needs will need to be sorted out after they arrive.

Table 6: Top Ten Total Migrant-Sending Counties, 2050

4 FEET OF SEA LEVEL RISE

| COUNTY | STATE | Total Atlanta Migrants |
|------------|-------|------------------------|
| Miami-Dade | FL | 22,284 |
| Broward | FL | 20,707 |
| Lee | FL | 4,707 |
| Palm Beach | FL | 3,872 |
| Chatham | GA | 3,451 |
| Collier | FL | 3,290 |
| Volusia | FL | 2,920 |
| Pinellas | FL | 2,862 |
| St. Johns | FL | 2,389 |
| Duval | FL | 1,939 |

6 FEET OF SEA LEVEL RISE

| COUNTY | STATE | Total Atlanta Migrants |
|--------------|-------|------------------------|
| Miami-Dade | FL | 82,576 |
| Broward | FL | 68,415 |
| Palm Beach | FL | 11,291 |
| Lee | FL | 9,594 |
| Collier | FL | 6,805 |
| Pinellas | FL | 5,953 |
| Volusia | FL | 5,836 |
| Chatham | GA | 4,947 |
| St. Johns | FL | 3,660 |
| Hillsborough | FL | 3,538 |

Policy Concerns

In any attempt to understand sea level rise, it is important for planners and decision-makers to be aware of these types of migration relationships and Atlanta's role, as a nearby inland city, as refuge for many seeking to escape the impacts of sea level rise. Regional and local governing bodies in Atlanta and the state of Georgia should recognize the potential for major future population movements in the Southeast and prepare for them. Steps should be taken to streamline the process of integration into the Atlanta area for new residents, including planning for increased in-migration, considering the needs of potential future migrants, and accepting a role in coastal adaptation and disaster preparation.

Currently, most of the local and county governments in the Atlanta region lack formal climate change plans. Those that have adopted climate change plans, such as the City of Atlanta and the Atlanta Regional Commission (ARC), mention only emissions reduction and water consumption. Others, like Fulton County, have, at most, Earth Day initiatives. This focus only on reducing, incrementally, the region's contribution to the drivers of climate change is insufficient. The expansion of general climate change planning efforts is very important at the local and regional levels to ensure more cohesive action on impacts rooted locally, such as heat waves, drought, and air quality, and on those coming from external pressures, such as migration. Planning work around climate change needs to expand from mitigation to adaptation concerns.

An important first step is to include consideration of potential climate-driven migrants in future population projections for the Atlanta area. Housing prices can be expected to increase due to higher demand. The number of new residents will also stress the local education, healthcare, and transportation systems. Bearing in mind that the majority of the migrants to the region are likely to move into only five counties, impacts in these areas will be more severe. Further research is needed into how migration movements may develop in relationship to sea level rise at a smaller scale, such as within significant sending cities like Miami, and into how migrants will make choices about when and where to move. This information needs to be incorporated beyond disaster management, into future scenario plans, transportation models, and land use decisions.

Planning organizations making future population predictions, such as the ARC, need to take on a leading role in this work. The projections they make are used for comprehensive planning efforts in most counties in the region and the ARC's regional goals help shape transportation and land use decisions with far-reaching impact. Already, planning horizons reach 2040 – a time when sea level rise driven migration will have begun. All of the ARC's formal, regional-scope planning documents – not just those on the subject of climate or environmental concerns – should discuss coastal in-migration and its benefits and risks. In their role as a research and guidance organization for smaller local governments, the ARC should take on the responsibility of further investigating sea level rise driven migration and of educating local counties and municipalities about potential types of migration flows. For example, information about the size of populations at risk of displacement should be shared along with county-specific estimates of potential in-migration.

Working together with local counties and cities, the ARC should help planners determine where strong migration relationships exist. This can help shape a long-term in-migration timeline and a short-term displacement likelihood map. From there, the City of Atlanta and/or some of the large central counties expected to see much of the growth should include sea level rise driven in-migration in their plans. For longer-term gradual inflows of coastal residents, they should consider how increases in population will affect transportation investments, housing availability, and school enrollment.

Special attention should also be paid here to the displaced, who will require services some governments may not be expecting, such as temporary housing or public transit. The Atlanta Fulton County Emergency Management Agency and other local emergency management agencies should expand local disaster response plans to include disasters affecting these high migration likelihood populations. Disaster preparation should include some level of stress testing of important service and infrastructure resilience to large influxes of people. These agencies should educate local rental agencies and landlords about the needs and funding for displaced persons, which may help minimize some of the housing access problems displaced New Orleans residents experienced in other states.

By identifying the high likelihood origin locations of migrants, Georgia counties and cities can build a profile of the characteristics of likely migrant groups, such as income, age, education, car ownership, etc., which will help them anticipate migrants' needs. Partnerships between the Atlanta region and specific high sending likelihood counties would support this work. Focused relationship-building with coastal counties could have economic benefits as well. The Atlanta region could capitalize on its role as

a city of refuge through marketing to coastal businesses and industries which may see interruptions due to sea level rise. Atlanta – as the resettlement location likely to be preferred by many coastal residents – could also house satellite offices for important management and logistics concerns which need to be isolated from coastal risks.

Action on sea level rise driven migration will be required above the local level, too. State governments will need to pay more attention to these concerns. Many of the people displaced because of Hurricane Katrina found that the bureaucratic aspects of their displacement were often the largest obstacle to settling easily in new cities (Fothergill & Peek, 2004; Lein, L., et al., 2012; Pardee, Jessica, 2012; Weber, Lynn, 2012). As larger migration movements between different southeastern states become more common, these problems will only be exacerbated. The Atlanta region and the state of Georgia should seek, wherever possible, to standardize and coordinate administrative actions related to Medicaid, food stamps, and other public assistance application processes and requirements. Professional licensing standards, i.e. for teachers, nurses, contractors, cosmetologists, etc., should be made more consistent or, ideally, a Southeast regional licensing process should be pursued. This will help improve employment rates for migrants and, especially in the case of teachers, nurses, and contractors, help ensure that new populations are more easily absorbed. These changes should begin as soon as possible with the goal to have coordinated systems in place before serious climate migration begins.

State-level southeast regional partnerships should be developed to encourage cooperation and information sharing. For example, it will be important to gain access to fraud and crime databases as people who may have a criminal background or major mental

health issues move across state lines. Access to other records, like school enrollment and vaccinations, from local departments of education and health will also help streamline migrant resettlement.

Engagement by all Southeast states and regional governments will be necessary for issues such as coastal adaptation projects and disaster preparation and response. State emergency management agencies should coordinate disaster response actions, such as evacuations that may need to extend across state lines. Inland areas like Atlanta will not be completely immune to sea level rise impacts merely because they themselves will not experience the flooding; this issue connects the entire region and requires cooperation and collective action.

If Georgia and the Atlanta region want to avoid many of the negative impacts that large waves of migrants could bring, then they must support actions on the coast that will reduce the risks of sea level rise and support resiliency in coastal communities. Right now, this will involve cooperation on the part of many state departments, including environmental protection and local governments pursuing hard and soft barrier construction, such as sea walls and barrier island renourishment. Development of state climate adaptation agencies could support improved actions at a broad level. These agencies could push for adaptation-focused policies and guide the work of the various state departments. Though it remains uncertain that state-level climate adaptation agencies will be created in the southeast anytime soon, these types of organizations would be especially helpful in bringing together work on physical and human impact issues related to climate change. The most benefit, at larger scale, would come if they work together rather than in competition against one another for funding for coastal adaptation projects.

CONCLUSION

After Hurricane Katrina, the problems of large internal population displacements in the US were demonstrated on a large scale. Yet, concerns about this issue have faded into the background since. Inland cities, like Atlanta, have not yet begun to include future climate-driven migration in their future plans. Little doubt that such migration will happen should exist, however. Research shows that people living along the US coast are increasingly vulnerable to the effects of sea level rise (Cutter et al., 2003; National Oceanic and Atmospheric Administration, 2013). As flooding and other risks increase, these coastal residents will become increasingly likely to leave their homes (Colten, 2006; Sweet & Park, 2014). Still, there has been little investigation in the US of where these people may choose to move and how that may impact inland areas.

This project focused on the potential of sea level rise driven migration to the Atlanta, Georgia region and attempted to estimate a conservative number of sea level rise migrants that the area could expect to receive by 2050. Assuming that coastal settlement in the southeast continues at historical rates and that existing migration relationships between the coastal counties and the Atlanta region remain constant, sea level rise driven migrants to the Atlanta area could total between about 84,000 and 230,000 by 2050. At least 65,000 to 188,000 can be expected in the five central Atlanta counties: Clayton, Cobb, DeKalb, Fulton, and Gwinnett. Most migrants will come from the areas around Miami, the largest concentration of coastal population in the southeast and a city with a historically strong migration relationship with the Atlanta region.

While any attempt to estimate an accurate number of SLR migrants to Atlanta relies on many assumptions which may not remain

true in the future, a projected total was vital to demonstrate the seriousness of this issue. Every effort was made to ensure that the estimations were based on historical data and as conservative as possible, so, while they may easily be debated, the intention was to provide a low end projection. With about 4 to 9.1 million people at risk of displacement across the fifty counties of the southeast coast, it is very likely that the total number of SLR migrants could be higher than the estimate given here. Especially if few coastal adaptation projects are pursued and if one or more major population centers were to be hit by a large hurricane, very high numbers of migrants are likely to come to Atlanta.

Local governments in Atlanta are not yet planning for climate migration to the area, however. Clearly there is a need for increased understanding of the issue and of education about possible migrant groups, their size, and possible local impacts. The Atlanta Regional Commission should take action now to include climate migration in their population forecasts for the region, as these totals are used widely by local cities and counties for land use and transportation decision-making. Additional housing with public transportation access may be needed, especially in the five central Atlanta counties.

State and local emergency management agencies should research past hurricanes and coastal disasters to learn how large migration waves develop and apply this information to their preparedness and response planning efforts. Systems for professional licensure and applications for public assistance should be coordinated, if not standardized, at the regional level. Finally, a focus on climate adaptation, including consideration of migration, should be incorporated into planning at all levels. If

possible, this should be supported by the creation of state climate adaptation agencies to oversee the work of other, related departments.

Even further action will certainly be necessary. The threat that sea level rise poses to the Southeast coast is, at this point, inescapable. With 39% of the total US population living on the coast (National Oceanic and Atmospheric Administration, 2013), displacement is a major concern around the country, including in the coastal areas close to Atlanta. Significant numbers of people can be expected to move inland and Atlanta is a logical destination for many who have strong social and cultural connections in the region or who are seeking the closest large city for better opportunities. Action to slow climate change and to adapt to sea level rise could reduce the number of potentially displaced persons and the subsequent number of migrants, but there is little doubt that many people will still be required to move. Atlanta cannot afford to ignore their numbers or their potential impact on local services and infrastructure.

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DATA SOURCES

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Climate Central: Surging Seas Project