TSA
TECHNOLOGY STUDENT ASSOCIATION

GEOSPATIAL TECHNOLOGY

2023-2024

Ewing, NJ
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INTRODUCTION

This year's Geospatial Technology theme is centered around researching a local, regional, state, or national Ecosystem Issue. As aspiring meteorologists, we were struck by the idea of investigating something truly transformative. With our community still grappling with the aftermath of intense river flooding caused by excessive rainfall last year, we recognized the urgency of addressing this issue. It became clear that our focus needed to be on finding solutions. Each year in the United States, 36 million trees are cut down due to urban expansion, many of them being from our wetlands. While this has obvious effects such as deforestation, there is another consequence that often goes overlooked. This practice also leads to a decrease in groundwater infiltration, which in turn contributes to more frequent and severe floods. Wetlands play a crucial role in mitigating flooding by acting as natural sponges, absorbing excess water during heavy rainfall and storms. Their capacity to retain and slowly release water helps to regulate the flow of rivers and streams, reducing the risk of flash floods downstream. Additionally, wetlands serve as vital buffers against coastal flooding by absorbing wave energy and reducing erosion along shorelines, thereby safeguarding adjacent communities and infrastructure from the destructive impacts of storm surges.

Recently in New Jersey, a significant portion of our wetland territory has been paved over to make way for sprawling shopping complexes and urban areas. Already, the repercussions of this extensive deforestation initiative have become palpable within the community. With the occurrence of increasingly frequent and intense rainfall events, our states primary defense against flooding has been obliterated, resulting in a surge of inundation incidents.

With wetland habitats continuing to shrink in New Jersey, it has become increasingly imperative to take action. Through our research on this project, we aim to highlight the precise effects of wetland destruction on flooding, with the goal of preventing the situation from deteriorating further.

DATA

To begin, it is important to identify the concerning increase in the severity of recent hurricanes at a national level, as this demonstrates the danger posed by rising sea levels and rising incidences of flooding.

Current Day:

Atlantic Hurricane Season 2022:
Dates: June 1, 2022 - November 30, 2022
Named Tropical Storms: 19
Number of Hurricanes: 9 (Including Two Major Hurricanes)
Total Fatalities: 303
Total Damage: $121.03 Billion (2022 USD)
Records: Third Costliest Tropical Cyclone Season On Record

Atlantic Hurricane Season 2021:
Dates: May 22, 2021 - November 7, 2021
Named Tropical Storms: 21
Number of Hurricanes: 4 (Including Four Major Hurricanes)
Total Fatalities: 194
Total Damage: $80.727 Billion (2021 USD)
Records: Third Most Active Atlantic Hurricane Season On Record

Atlantic Hurricane Season 2020:
Dates: May 16, 2020 - November 18, 2020
Named Tropical Storms: 31
Number of Hurricanes: 14 (Including Seven Major Hurricanes)
Total Fatalities: >417
Total Damage: $51.114 (2020 USD)
Records: Highest Number of Recorded Storms In History

Historically:

Atlantic Hurricane Season 2004:
Dates: July 31, 2004 - December 3, 2004
Named Tropical Storms: 16
Number of Hurricanes: 9 (Including Six Major Hurricanes)
Total Fatalities: 3261
Total Damage: $61.148 Billion (2004 USD)
Records: Most Major Hurricanes Since 1996 (Record was broken in the years after)

Atlantic Hurricane Season 2003:
Dates: April 20, 2003 - December 11, 2003
Named Tropical Storms: 21
Number of Hurricanes: 7 (Including Three Major Hurricanes)
Total Fatalities: 93
Total Damage: $4.42 Billion (2003 USD)
Records: N/A

Atlantic Hurricane Season 2002:
Dates: July 14, 2002 - October 16, 2002
Named Tropical Storms: 12
Number of Hurricanes: 4 (Including Two Major Hurricanes)
Total Fatalities: 50
Total Damage: $2.47 Billion (2002 USD)
Records: N/A

Next, it is important to identify how wetlands correlate to a decrease in flooding. Compiled historical data can be used to explain this relationship at a national level.

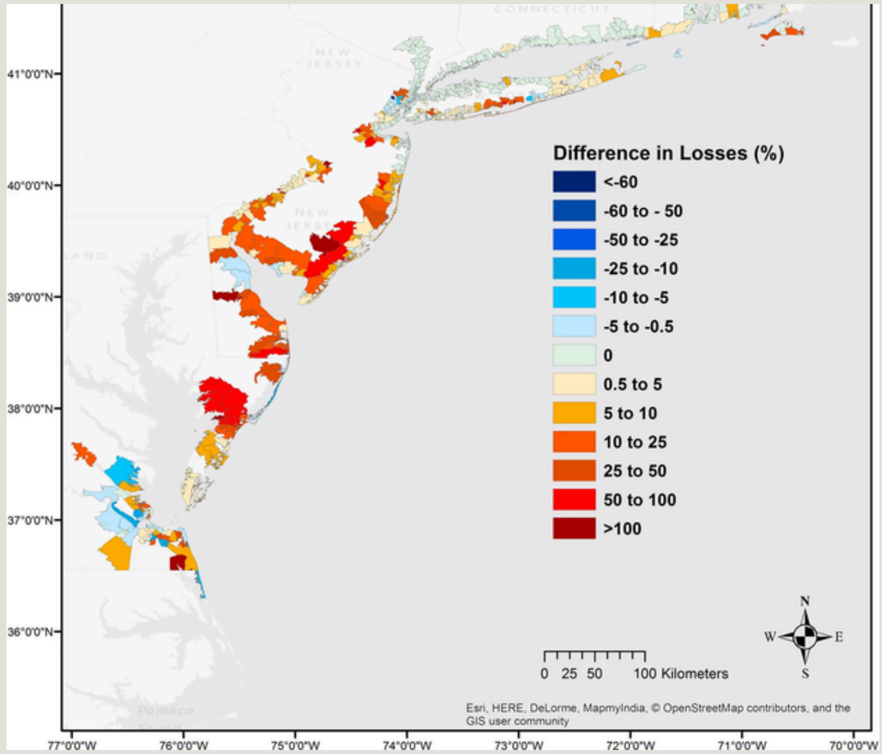
In order to uncover this relationship, we begin by analyzing the effects wetlands had on one of the costliest hurricanes in American history, Hurricane Sandy. In total, Sandy resulted in $50 billion worth of damage for Eastern United States.

Table 1: State-wide losses during Hurricane Sandy for two scenarios, "Wetlands Present" and "Wetlands Lost". The last column shows the state-wise difference in flood losses between the two scenarios as a percentage of the total damages for the scenario "Wetlands Present".

State (State Code)	Damages: Wetlands Present ($)	Damages: Wetlands Lost ($)	Absolute Difference ($)	% Difference (total damages)
Connecticut (CT)	2,180,600,000	2,181,000,000	400,000	0.02
Delaware (DE)	228,100,000	251,900,000	23,800,000	10.43
Massachusetts (MA)	1,452,300,000	1,458,600,000	6,300,000	0.43
Maryland (MD)	15,500,000	20,000,000	4,500,000	29.03
Maine (ME)	17,600,000	17,603,000	3,000	0.02
North Carolina (NC)	9,400,000	8,800,000	−615,000	−6.47
New Hampshire (NH)	29,600,000	30,500,000	900,000	3.04
New Jersey (NJ)	14,014,600,000	14,443,300,000	428,700,000	3.06
New York (NY)	32,314,600,000	32,452,800,000	138,200,000	0.43
Pennsylvania (PA)	174,400,000	188,100,000	13,600,000	7.86
Rhode Island (RI)	72,100,000	72,400,000	300,000	0.42
Virginia (VA)	195,400,000	205,300,000	9,900,000	5.07

Figure 1: The figure to the right illustrates the regional impacts of wetlands on property damage during Hurricane Sandy. It displays the spatial variation in property damages caused by the hurricane, indicating the potential increase in damage if all existing wetlands were lost, relative to the losses incurred under the scenario where wetlands are present.

The map is produced with the results of the Regional Study using ArcGIS v10.4.1 software.



At the state level, apart from North Carolina, there was a robust correlation between wetland extents and avoided damages (see Fig. SI 1, R2 = 0.8, p < 0.001): greater wetland coverage corresponded to a more significant reduction in damage. Among the top four states in terms of wetland coverage—Maryland, Delaware, New Jersey, and Virginia—wetlands are estimated to have mitigated flood damages by 20–30%.

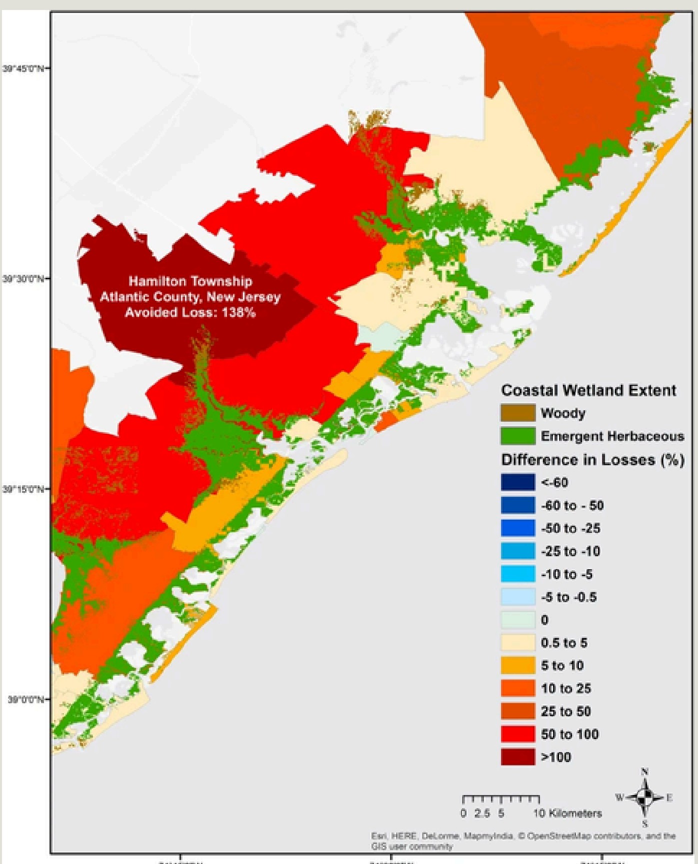
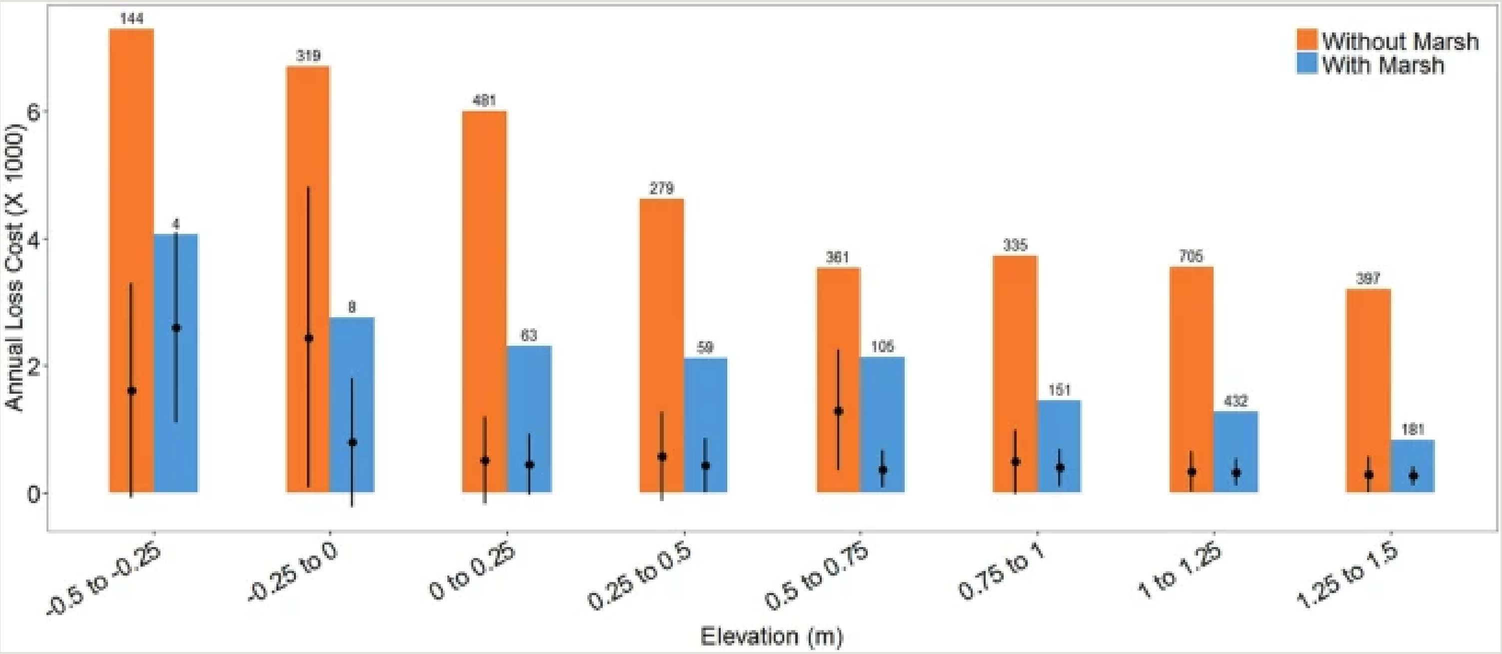


Figure 2: Hamilton Township (shown in dark red) would have experienced a 139% rise in property damages if the wetlands (depicted in green) between the township and the coastline had been depleted. Negative values indicate increased damage attributable to wetlands (i.e., risk reduction is <0), while positive values indicate decreased damage due to wetlands (i.e., risk reduction is >0).

The map is produced with the results of the Regional Study using ArcMAP v10.4.1 software.

Figure 3: Annual flood-related loss costs for properties with and without marshes, a type of wetland, are presented according to elevation class. Loss costs are displayed for properties with marshes and those without, ranging from −0.5 to +1.5 meters above the NAVD88 sea-level datum. Colored bars indicate the range of loss costs within each class. Black dots signify the mean loss costs, while black bars represent one standard deviation from the mean. The numbers on top of each bar indicate the number of properties assessed.



This information regarding the impact of wetlands on flooding during Hurricane Sandy can be extrapolated to other flooding events characterized by similar rainfall rates and totals. Despite potential objections to this comparison, previous studies have demonstrated that rainfall rates do not significantly affect the porosity of wetlands.

To substantiate the impact of deforestation on wetland destruction, it is essential to analyze the historical wetland concentration in New Jersey and contrast it with the present-day situation. This will help us examine the differences.

Figure 4: Wetland Concentration In NJ in 1986

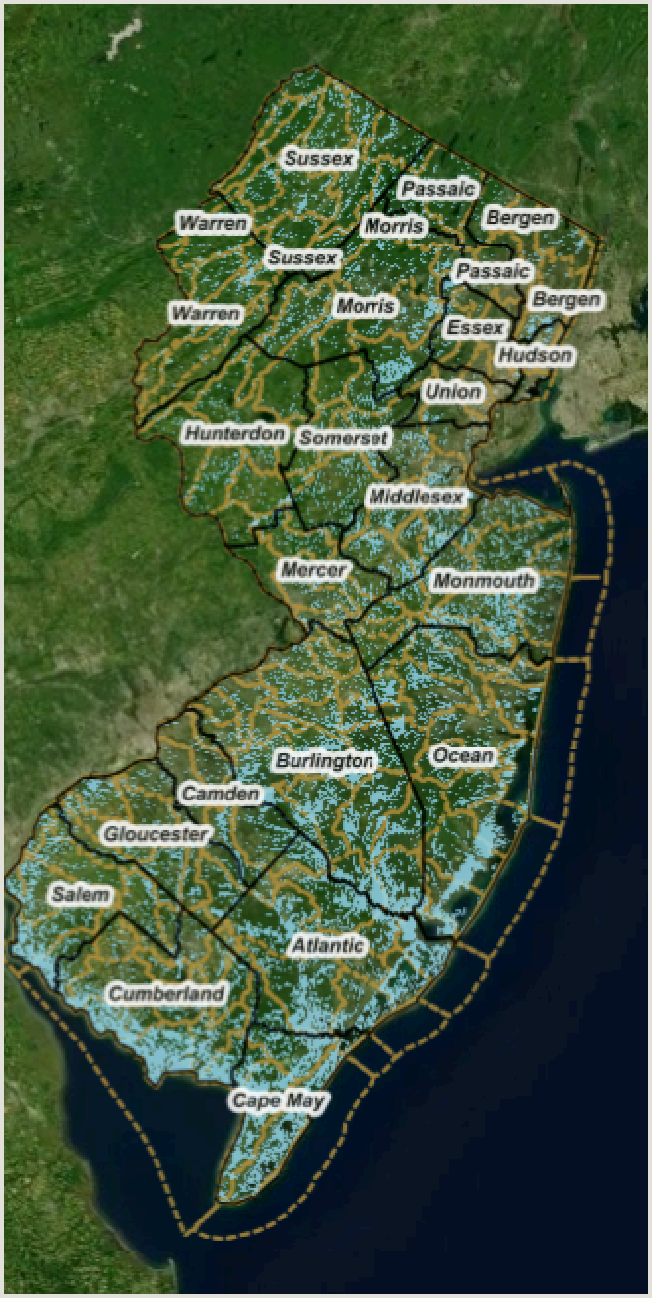


Figure 5: Wetland Concentration In NJ in 2020

While it may not be completely evident from the graphs, New Jersey has seen around a 11.9% decrease in wetlands between 1986 and 2020.

To concentrate our focus on wetlands, we take the example of one of the largest swathes of wetlands in the state: the Meadowlands in and around Bergen County, NJ.

Figure 6: Current area covered by the NJ Meadowlands Commission

Figure 7: Storm Surge extent caused by Hurricane Sandy

The Meadowlands have been rapidly industrializing over the past few years, and this has caused flooding to worsen, with storm surges from Hurricane Sandy reaching as far as 10 miles inland.

The usage of large areas of the Meadowlands as waste disposal, compounded with the rapid urbanization of the area, has led to a decrease in wetland acreage.

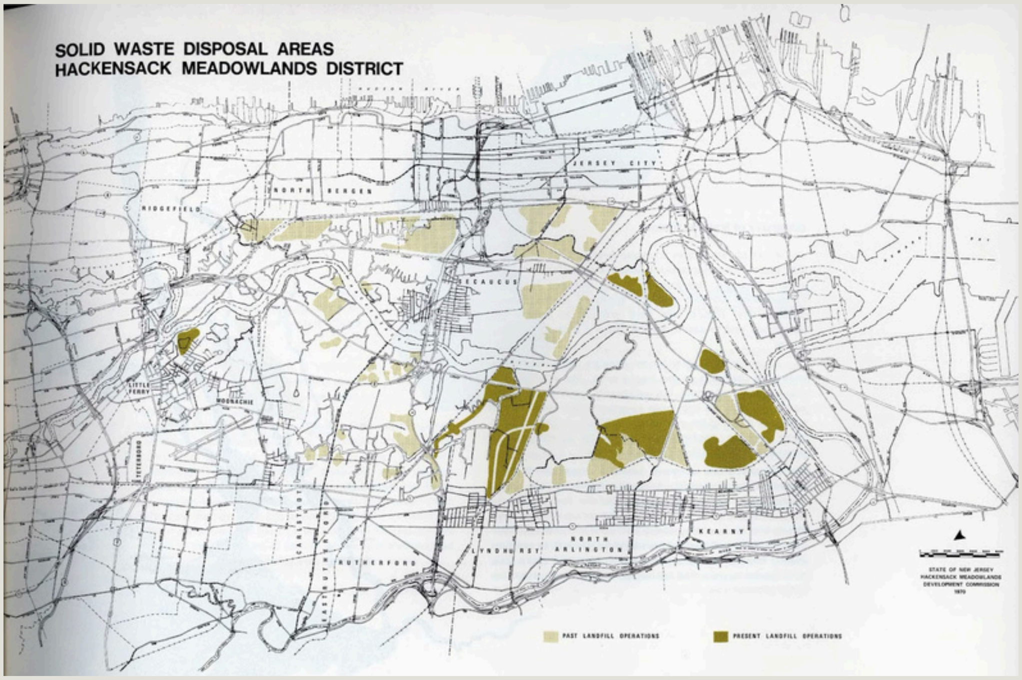


Figure 8: Waste disposal areas created in the Hackensack Meadowlands District, representative of a greater trend of wetland drainage in the Greater Meadowlands Region

Figure 9: Present day image of the Meadowlands Sports Complex, a sprawling example of urbanization

Figure 10: Historical image of the Meadowlands Sports Complex in the 1950s

The Meadowlands has seen a stark decrease in wetland acreage, and a large population is now at risk of increased flooding

1900 Wetland Acreage: 38,000 acres
Pre-World War II Wetland Acreage: 21,000 acres
Current Wetland Acreage: 7,000 acres
Landfills in 1970: 51
Current Population: 985,011 people

Table 2: Data for a variety of different observations areas under the MSSRI from 2005, indicating the water levels for storm surges, rainfall, etc.

All Elevations NAVD88	Berry's Creek Carlstadt	Hackensack River Little Ferry/ Ridgefield	Hackensack River Route 3/ Secaucus	Hackensack River Amtrak/ Kearny
25-Year Rainfall Total[1]	6.3 inches	6.3 inches	6.2 inches	6.2 inches
25-Year Rainfall Intensity[2]	5.6 inches	5.6 inches	5.6 inches	5.6 inches
Mean High Water (MHW)[3]	2.4 feet	2.1 feet	2.1 feet	2.0 feet
Mean High Water Spring (MHWS)[3]	3.0 feet	2.7 feet	2.6 feet	2.4 feet
Mean Low Water (MLW)[3]	-3.2 feet	-3.3 feet	-3.1 feet	-3.5 feet
25-Year Flood Surge Elevation[4]	5.7 feet	6.1 feet	6.1 feet	6.5 feet
Category 1 Hurricane[5]	4.1 feet	6.0 feet	5.6 feet	7.1 feet
Category 2 Hurricane[5]	6.1 feet	7.3 feet	6.6 feet	8.4 feet
Category 3 Hurricane[5]	8.0 feet	9.0 feet	8.6 feet	11.5 feet

Given this information, we decided to create a visual representation of the areas in the current Meadowlands that will be underwater due to rising sea levels by 2100

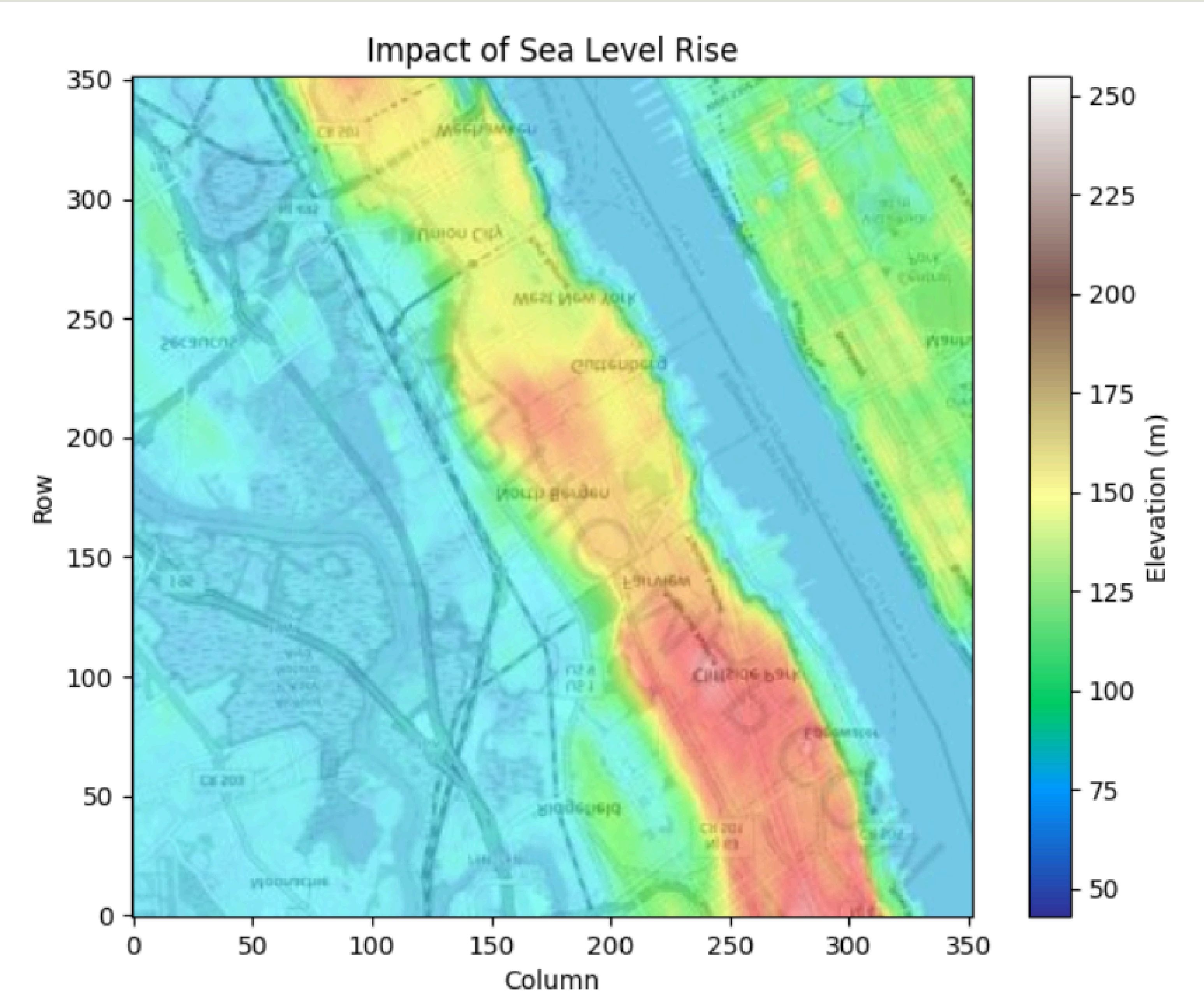


Figure 11: This representation was created using the predicted sea level increase in the NYC metropolitan area in conjunction with a 2D array of Meadowlands elevations.

Following this, it was important to determine exactly how much of a threat rising sea leveles posed to our states and others surrounding it

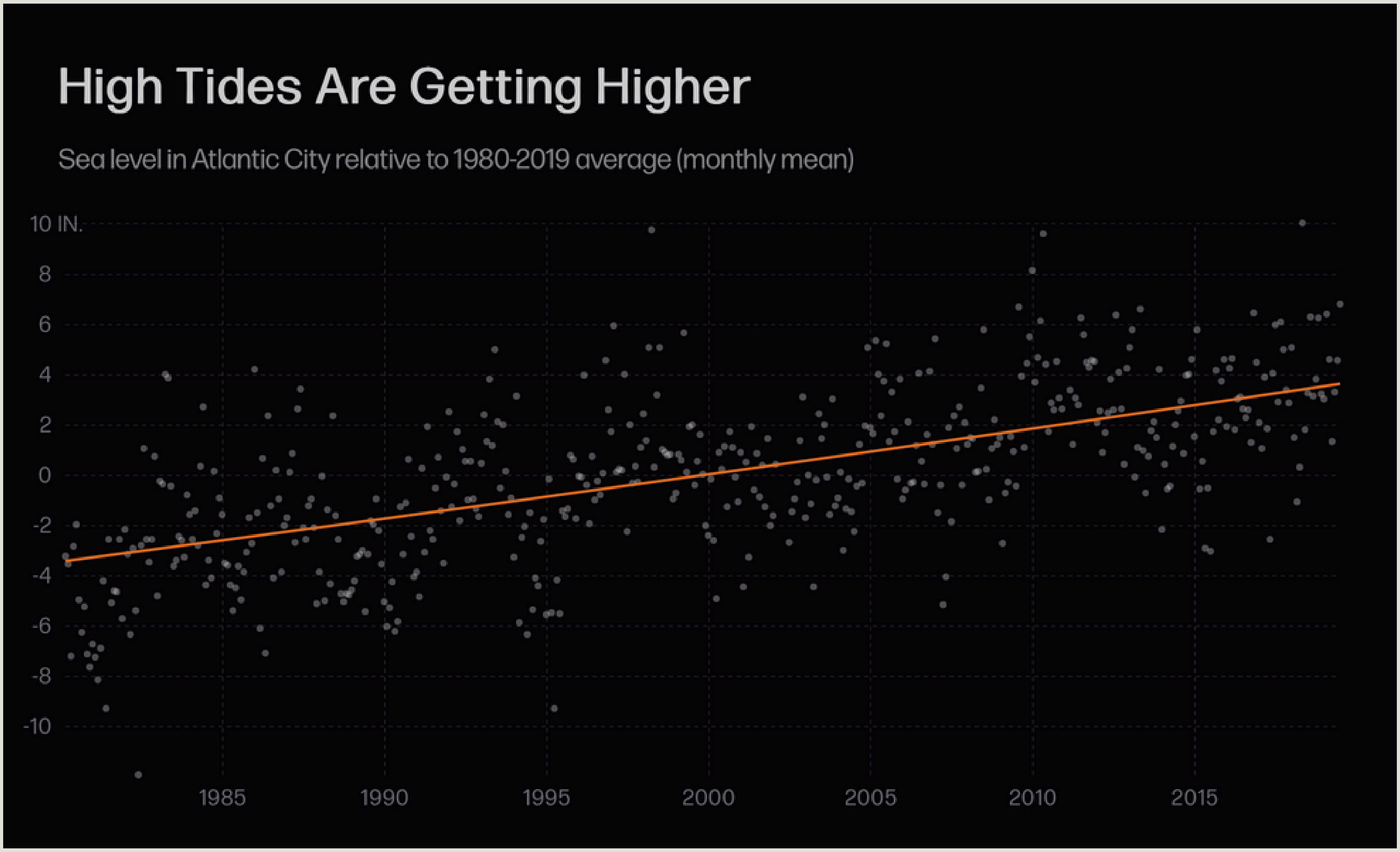


Figure 12: Graphical representation of the relatively steep increase in rising sea level in the Atlantic City area

		2030	2050	2070			2100			2150		
				Emissions								
	Chance SLR Exceeds			Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End	> 95% chance	0.3	0.7	0.9	1	1.1	1.0	1.3	1.5	1.3	2.1	2.9
Likely Range	> 83% chance	0.5	0.9	1.3	1.4	1.5	1.7	2.0	2.3	2.4	3.1	3.8
	~50 % chance	0.8	1.4	1.9	2.2	2.4	2.8	3.3	3.9	4.2	5.2	6.2
	<17% chance	1.1	2.1	2.7	3.1	3.5	3.9	5.1	6.3	6.3	8.3	10.3
High End	< 5% chance	1.3	2.6	3.2	3.8	4.4	5.0	6.9	8.8	8.0	13.8	19.6

**2010 (2001-2019 average) Observed = 0.2 ft*

Table 3: New Jersey sea level rise above the year 2000 (1991-2009 average) baseline (ft), represents the likely chance of sea level rise

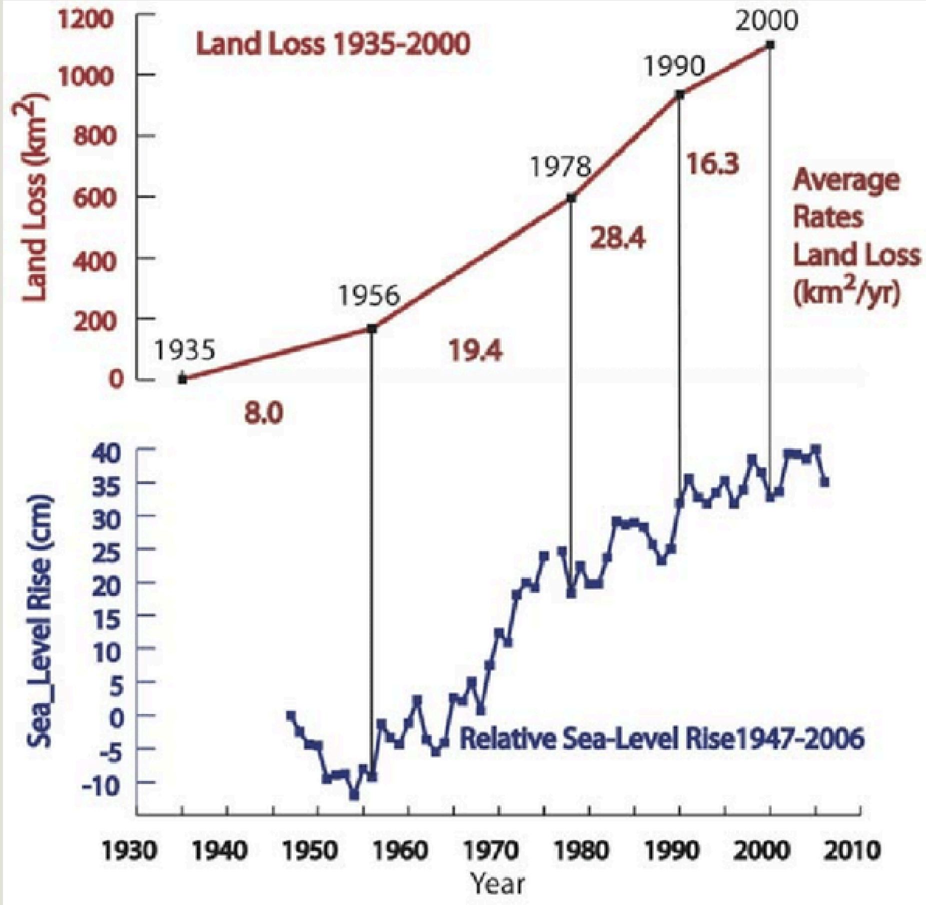


Figure 13: Graphical representation of the relation between land loss and the average rise in sea levels.

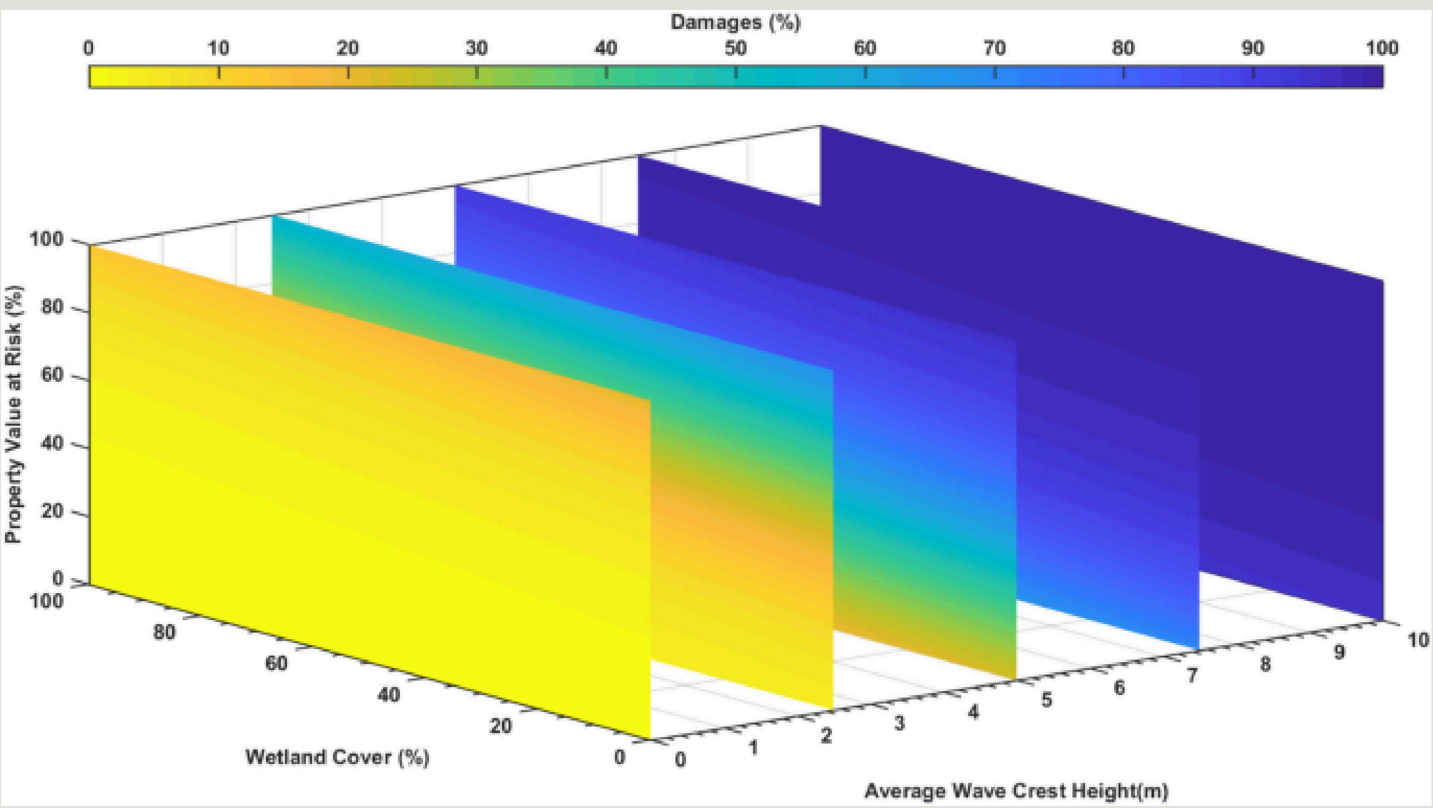


Figure 14: RGB representation of the relation between Wetland Cover, Property Risk Value, and Damages.

We then continued to examine rising sea levels as well as the overall climate change in the state

Figure 15: Current and future flood risk areas in the Manhattan Borough of NYC, with 1 inch of sea level increase expected to cause $250,000 in damage.

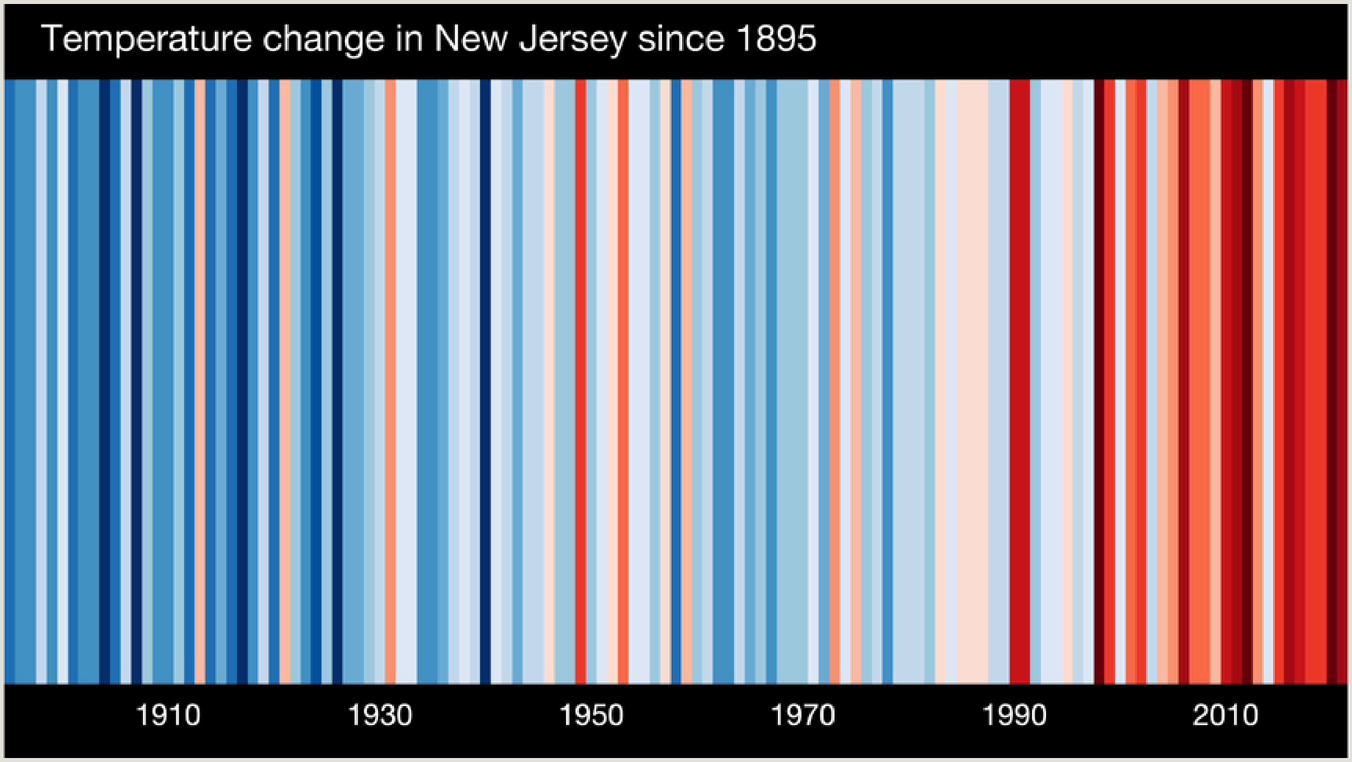


Figure 16: Representation of the change in temperature for New Jersey over the past 100 years in terms of "warming bands".

We found a worrying trend in the areas that have historically been dominated by wetlands and are slowly seeing their destruction

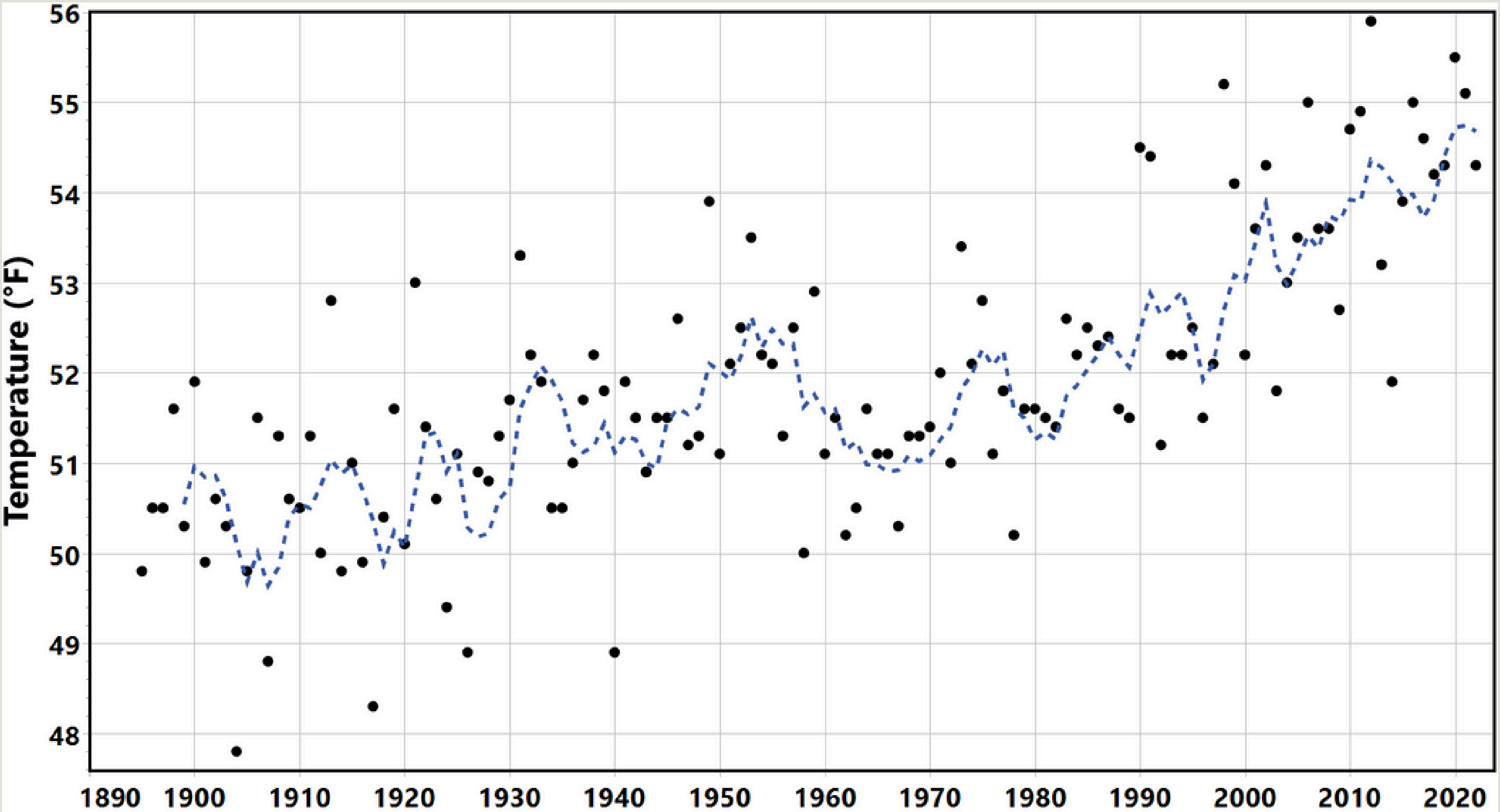


Figure 17: New Jersey's 12-Month Average Air Temperature from 1895 to 2022

	°C	°F				
	Annual	*Annual*	*Winter*	*Spring*	*Summer*	*Fall*
Statewide	2.1	3.8	5.2	3.3	3.5	3.3
North	2.2	4.0	5.5	3.4	3.4	3.4
South	2.1	3.8	5.0	3.2	3.5	3.1
Coast	2.4	4.3	5.4	3.8	4.1	3.8

Figure 18: Annual and Seasonal Increases in Air Temperatures Over the Period 1895 to 2022, dividing the state into three distinct areas

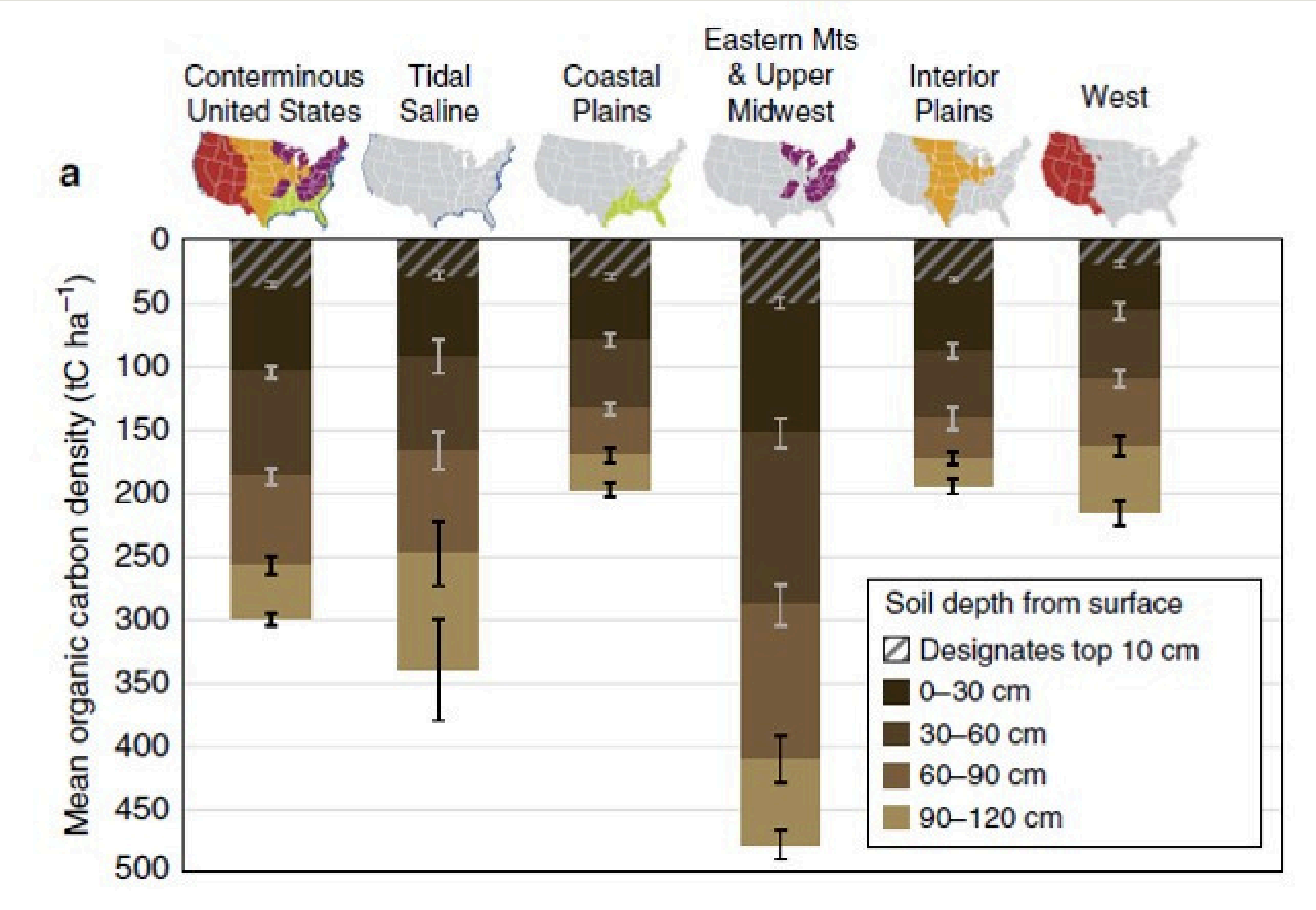


Figure 19: Depth of soil from surface at different areas in the United States

ANALYSIS OF DATA

From the data included above, it is made abundantly clear that wetlands are vital to the overall protection of wide areas of population across the state, as there is a provable direct correlation between wetland concentration and overall damage from storm surges. To prove this correlation, it is essential that prominent definitions and facts, no matter how mundane, are properly stated. One such definition is the type of ecosystem that is encompassed by the phrase wetland, that being an area that is saturated by water for a significant length of time. Wetlands can either be permanent (water-logged for the entire year) or seasonal (dependent on rain in different seasons). Furthermore, it is also important to define how exactly a wetland contributes to the reduction of flooding damages. A wetland functions in a similar fashion to a sponge: it traps excess water from rainfall or flooding and slowly releases it over time, allowing the effects of this rapid increase in water to be mitigated.

We can see from the historical information about hurricanes (page 4), that hurricanes and tropical storms are only increasing in the amount of damage that they inflict as time goes on. In the 2002 Hurricane Season, the 12 tropical storms (including 4 hurricanes) accounted for $2.47 billion in damages, which rose to $61.48 billion in 2004 (caused by 16 tropical storms, which included 9 hurricanes, 4 of which were major). This is obviously far too short of a time period to draw meaningful, accurate conclusions from, so it would be prudent to compare these statistics to far more recent hurricane seasons. In 2021, there were 21 total tropical storms of which four were hurricanes. All four of these were major storms and in total accounted for $80.727 billion worth of damage. This year was also the third most active hurricane season ever recorded. However, even this pales in comparison to the 2022 season, which saw 19 tropical storms, inclusive of 9 hurricanes, of which two could be classified as major, and $121.03 Billion worth of damage. From this data, it is clear that hurricanes have been increasing in frequency and strength, causing more damage as we move forward in time. This can be correlated with rising sea levels and global temperatures, both of which increase the risk of flooding.

Hurricane Sandy Analysis + Statewide Problem

From this information, we decided to then determine the overall value that wetlands provided in flood prevention. We utilized the example of Hurricane Sandy, one of the costliest hurricanes in recent memory and a storm that we still are feeling the effects of to this day. According to the data collected in Table 1 (Page 5), wetlands contributed a significant damage reduction as a result of their sponge-like properties. Using a model that predicted property damage as a result of the removal of wetlands, the paper found that in New Jersey specifically, wetlands contributed to a reduction of $428,700,000, or about 3.06% of total damages.

We followed this with an examination of a visual representation from ArcGIS showing the regional impacts of damages (Figure 1). The information displayed included color-coded data for whether wetlands contributed to flooding or decreased it in a specific region. From the data, it can immediately be seen that there is a distinct lack of blue areas (locations where wetlands contributed to flooding) across the region impacted by Hurricane Sandy, which further supports the idea that wetlands are important in storm reduction. This is further compounded by the information found in Figure 2. Hamilton Township, marked in dark red, is shown to be the biggest beneficiary of the existence of wetlands, but interestingly enough, there are no wetlands concentrated in the municipality itself. Hamilton Township is protected from storm surges and flooding by the wetlands that populate the area between it and the coast, which enables it to be relatively free of flooding damages.

Finally, Figure 3 shows the cost of the destruction of wetlands across the state, with lower elevations disproportionately benefiting from the fact that wetlands can protect them from the brunt of flooding and ensure that the overall discharge of water is kept at a minimum.

Despite the obvious benefits of wetlands, Figures 4 and 5 on Page 8 paint a story of dereliction for these important ecosystems, with the period from 1986 to 2020 seeing an 11.9% decrease in wetland acreage across the state. There is a massive problem statewide as it pertains to the conservation and protection of these wetlands, with much of the historical areas being paved over in favor of urbanization.

The Meadowlands

We decided to concentrate our focus even more in order to analyze the root of the problem. This led us to one of the largest swathes of wetlands in the state, that is the Meadowlands in and around Bergen County, NJ. The Meadowlands has historically been noted for its biological diversity but has seen a stark increase in industrialization and a decrease in wetland acreage over the course of the previous century. As shown in Figure 7, much of the same problems with Hurricane Sandy were visible in the areas of the Meadowlands affected by storm surges, with areas as far as 15 miles inland being affected by this phenomenon. This is extremely concerning given the Meadowlands' vital importance as a population center and center of commerce.

We can immediately reach the root of the problem, as the rapid urbanization of this area has led to a lack of focus on conservancy as it pertains to the wetlands, with many wetlands in this region being filled up to serve as waste disposals for a larger population, as well as the creation of shopping and sports complexes such as the Meadowlands Sports Complex. The Meadowlands Sports Complex has continually increased in size since World War II, with its initial configuration of Giants Stadium and a racetrack converted to the larger MetLife Stadium, the American Dream Mall, and acres of parking. Roads and paved areas stretch across what used to be a haven for wildlife, and this decreases the resistance of the area to flooding. The paving used in roads is impermeable, which prevents water from seeping into the spongey wetlands below. This means that the excess water from rainfall and flooding stays on the surface, which increases damages due to flooding.

This is especially concerning given the apparatuses in place to prevent the destruction of wetlands in this region, with organizations such as the MSSRI and NJMC receiving criticism in the past for allowing continued paving of these vital areas. The Meadowlands, as shown in the statistics on page 11, have seen a drop in wetland acreage from 38,000 acres at the turn of the century to 7,000 acres in the present day. This is concerning given that the Meadowlands is now home to 985,011 people, and is an important part of commerce in the state of New Jersey.

Flooding Risks

We decided to analyze the flooding risks to the Meadowlands region in order to determine whether current conservancy efforts will be enough to protect this area, its people, and its wildlife properly for the next century. We took the data in Table 2 from the MSSRI's own report on flooding for a variety of observation centers in the Meadowlands, which shows a drastic increase in rainfall and storm surge from hurricanes in comparison to previous years. It is becoming abundantly clear that the Meadowlands is no longer able to continue to protect the citizens that call it home (as well as those further inland) from harm.

We then decided to use data to create a graph of our own, inputting elevation data for the Meadowlands region into a 2D array and the estimated sea level rise for the NYC metropolitan area to show the extent of this region that will be underwater by 2100. As seen in Figure 11, wide areas of the Meadowlands will be underwater by this time, and it is almost too late to reverse this trend given the expanses of wetland that have already been lost.

Overall, it is clear that the Meadowlands has lost far too much of an expanse of wetlands to continue to serve as a barrier against flooding, and it is apparent that we must guard the minimal amounts of wetland that still exist in this region to protect against future flooding. The natural wetlands are this state's best option to reduce the damages caused by oncoming flooding, as it appears even mankind's greatest inventions still cannot surpass the natural mechanisms of nature.

Direct Impact On Sea Level Rise

To enhance the understanding of the flood risks posed to the local community by the destruction of wetlands, we must comprehend how this risk is exacerbated for coastal communities. As illustrated in Figure 12, there has been a sharp increase in sea levels in the state of New Jersey. This trend is further visualized in Table 3, which demonstrates that New Jersey's sea level rise shows no sign of abating, as evidenced by comparing the current and projected probabilities of major sea level rises. The graphical representation of the relationship between land loss and the average rise in sea levels, depicted in Figure 13, indicates that an increased sea level rise directly correlates with an increased loss of land.

However, while this increase may already seem record-breaking, this data does not account for the further deforestation of wetlands. As depicted in Table 1, the presence of wetlands helps decrease the total damage caused by flooding by over 20% in certain areas. Therefore, at the current rate, the increase in water-related damages is predicted to far exceed scientists' expectations.

The harms resulting from neglecting the preservation of wetlands and failing to address the exacerbating factors of flood risks are manifold. Increased flooding not only poses direct threats to infrastructure but also endangers lives and disrupts livelihoods within affected communities. Moreover, the loss of wetlands deprives ecosystems of their ability to buffer against storm surges, filter pollutants, and provide habitats for diverse flora and fauna. This depletion of natural defenses can amplify the vulnerability of coastal regions to the destructive forces of climate change, leading to prolonged recovery periods and escalating economic costs.

Impacts of Wetland Loss on Climate Change

From Figure 16, it can be immediately noticed that New Jersey has seen a rapid increase in temperature over the course of the last century, must of it conciding with the general trend of global warming. However, it can also be chalked up, in part, to the aforementioned wetland loss.

Wetlands are an important source of carbon trapping, and at the present moment, undisturbed wetlands account for twice as much carbon held within the ground as disturbed areas. This worrying trend coincides with the increase in temperatures across the state. For one, when we view the temperature increases for Figure 18, where New Jersey is divided into 3 areas, we see the largest increases along the coast and in the north of the state. Through our prior evidence, it can be immediately recognized that these areas are the locations where there has been the greatest destruction of natural wetlands in favor of industrialization. The larger increase of the temperature of the north in comparison to even the coast supports this, as the North has been especially brutal to its wetlands.

When the natural defense against warming temperatures in the form of a wetland is destroyed, it causes an increase in the temperatures around that area, as the greater amount of carbon in the air only serves to continually trap heat from the sun close to the surface.

This is especially concerning as it pertains to wetlands, as while they are a source of carbon trapping in the present day, as more carbon is released into the air and is ever-present around wetlands, they also can be converted into carbon sources. Carbon is able to sequester itself into wetlands, digging beneath the soil and establishing the area as a carbon source that ends up expelling more carbon into the atmosphere than was previously there. The less deep the soil, the easier it is for the carbon to sequester itself. This is terrifying when taken into account, as wetlands (as seen in Figure 19, do not have extremely deep soil levels.

ACTIVITIES AND TIMELINE

TSA Project Timeline			
Time Frame	Task Accomplished	Time Involved	Details & Notes
December 27th, 2023 - January 4th, 2024	We brainstormed possible ideas to research.	7 Hours	After asking our friends and mentors of environmental problems they face in their everyday lives, we shortlisted a topic. After detailed research and visiting our Monthly Town Hall Meeting, we shortlisted our idea to the removal/industrialization of wetlands.
January 6th - January 14th, 2024	Found a variety of sources and data we could use.	5 Hours	This included graphs, charts, maps, etc.
January 16th - January 28th, 2024	Narrowed our list down to the data pertaining to our specific topic.	4 Hours	Inlcusive of storm, wetland, and medowland data. Through the collected data, we were able to formulate a plan on the means to present this data to the reader.
February 1st - February 10th, 2024	Created the data section of our project.	5 Hours	Provided explanantions of how storms have evolved based on the increase of global warming and climate change and the effect this has. Connected this to the idea of wetland destruction. Explained the effect of wetland destruction and focussed on the Medowlands.
February 20th - February 23rd, 2024	Analyzed our data and completed the Data Analysis section.	3.5 Hours	Reviewed our data and explained it effectively to the reader.
March 1st - March 4th, 2024	Understood how location factors affects our project and completed the page about this in our portfolio.	1 Hour	We were able to understand why New Jersey specifically is impacted severely by this problem.
March 10th - March 14th, 2024	Reviewed the predictability and the expected damage from stormsthat are to come based on climate change and its patterns.	2.5 Hours	Developed ideas of how we as meterologists could better predict storms in the future based on our evaluations and research.
March 16th - March 18th, 2024	Completed the predicition section of our portfolio.	1.5 Hours	Understood/Researched possible methods to avoid Wetland destruction. Used this to base our prediction for the future.
March 19th, 2024 - March 26th, 2024	Polished, reviwed, and proofread our project.	2 Hours	Made minimal changes (mostly spelling and grammar).

LOCATION FACTORS

Location factors play an important role in determining the effectiveness of wetlands in reducing flooding. To ascertain the exact importance of a location, it must first be understood how wetlands reduce susceptibility to flooding. Firstly, wetlands act as natural sponges, absorbing excess water during periods of heavy rainfall or storm surges. This sponge-like capacity originates from the presence of natural vegetation, which helps regulate water levels and enhance infiltration. Secondly, wetlands function as natural barriers due to their ability to slow down the flow of floodwaters. The intricate network of plants prevents water from rapidly running off.

While both of these characteristics can be accomplished by wetlands in any location, the benefit of this habitat is best seen when they are located between populated areas and the coastline. Since most flooding in New Jersey occurs in these areas (due to them containing the least porous surfaces and the least vegetation), wetlands in such areas are by far the most pivotal. This is why even though most of our state's wetlands are located in Southern New Jersey, the Meadowlands (located in Northern New Jersey) are so much more pivotal.

Other than determining a wetland region's effect on the population of that area, a wetland's effectiveness is also determined by the topography of the area surrounding it. Topography plays a pivotal role in determining the effectiveness of wetlands in mitigating flooding due to its effect on the functionality of a wetland. For example, if a wetland is situated in a low-lying area or in a floodplain, it possesses inherent advantages in flood reduction, as it can intercept and absorb excess water during periods of heightened precipitation or flooding. Conversely, the opposite is also true. Therefore, understanding the topographic context of wetlands is crucial for assessing their flood mitigation potential and informing land use decisions aimed at enhancing resilience to flooding and climate variability.

All in all, examining the location factors is paramount in understanding the effectiveness of wetlands in mitigating flooding. By considering variables such as location and topography, we can gain crucial insight into the specific impact a wetland can have. In today's world, where population growth, industrialization, and urbanization are ever-present realities, it's imperative that developers consider these factors before embarking on projects that may impact wetland habitats. Doing so ensures that decisions are informed by a comprehensive understanding of the potential consequences, ultimately leading to more sustainable and environmentally conscious development practices.

PREDICTION

With rising sea levels, increased flooding risk, and worsening conditions all across the globe, we predict that flooding, especially in New Jersey, will continue to worsen as wetlands are continually paved over in favor of more “economically viable” options such as residential and commercial applications. We are already seeing a concerning increase in damages due to flooding as wetlands are destroyed at alarming rates.

A concern that could potentially arise from this is the potential for flooding to reach far further inland than before. As demonstrated in the case of Hamilton Township in Figure 2, wetlands centered around the coast are an important mechanism for the protection of locations inland from flooding. The destruction of wetlands allows storm surges to reach farther inland than ever before, meaning that nobody is truly safe from the impacts of flooding. Given that during Hurricane Sandy, areas as far as 15 miles inland were the victims of storm surges, this may already be becoming a reality. We will see cities forced to migrate miles inland in order to protect themselves from the ravages of rising sea levels, which are already clearly impossible to stop given the current status of wetlands in the state. With this, we see a decrease in economic prosperity, as access to the coast is still an important factor in economic activity for cities across the planet.

Another cause for concern is the wildlife that we will lose to flooding. Animals are far more fragile in this situation than humans: they cannot move inland to protect themselves from rising sea levels and are disproportionately affected by unexpected climate disasters. We will lose much of our planet’s biodiversity as a result of our inability to protect one of our best lines of defense against flooding.

We have already lost so many expanses of wetlands that the path forward is unclear. We can only attempt to reverse the trends of climate change and rising sea levels that we have wrought on the world, in addition to protecting what small areas of wetlands we have left. We have already irreparably damaged our world, and we must do what we can to protect what little chance we have at survival.

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