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Hurricane Sandy: A Chance to Identify Vulnerabilities, Learn from the Past, and Increase Future Resiliency

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Hurricane Sandy:
A Chance to Identify Vulnerabilities, Learn from the Past, and
Increase Future Resiliency

By Julianne Yee

Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelors Arts in
Environmental Policy

Fordham University
Professor Van Buren
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ABSTRACT

Hurricane Sandy was an eye-opening event for the New York City area. It revealed many vulnerabilities, especially flaws in zoning and infrastructure designs. Natural science data helps to determine that rising sea levels and increased intensity of storms due to climate change will make this area even more vulnerable. Other impacts of climate change may pose even more threats to this area. Three disciplines, environmental history, ecological design, and governmental policy, will be used to best approach these future issues. It is important to have a better understanding of the past environmental history of the area, where ecological design can then build off of this information. Meanwhile, governmental policy shows how we can improve and promote change through policy. Rebuilding after Hurricane Sandy is an opportunity to consider the future impacts of climate change by starting to rebuild with goals of resilience and long-term sustainability, which is crucial. In doing so, we would be more prepared in the future for not only another storm like Hurricane Sandy, but for other future impacts of climate change as well.

INTRODUCTION

“It is a conceit of New York City – the concrete city, the steel metropolis, Batman’s Gotham – to think it is a place outside of nature, a place where humanity has completely triumphed over the forces of the natural world, where a person can do and be anything without limit or consequence,” states Eric Sanderson, a landscape ecologist.¹ Hurricane Sandy highlighted this risky assumption by opening the public’s eyes to the fact that we are not outside of nature. Hurricane Sandy revealed many of the Tri-State area’s current vulnerabilities, which must be taken into consideration when rebuilding; however, it is also a crucial opportunity to increase resiliency and sustainability while rebuilding to better prepare for future impacts of climate change. Resiliency is the ability to easily recover from or handle disturbances. Meanwhile, sustainability is the ability to meet current needs without compromising the ability of future generations to meet their needs. Improved resiliency and sustainability will help in the future, especially in terms of the impending impacts of climate change.

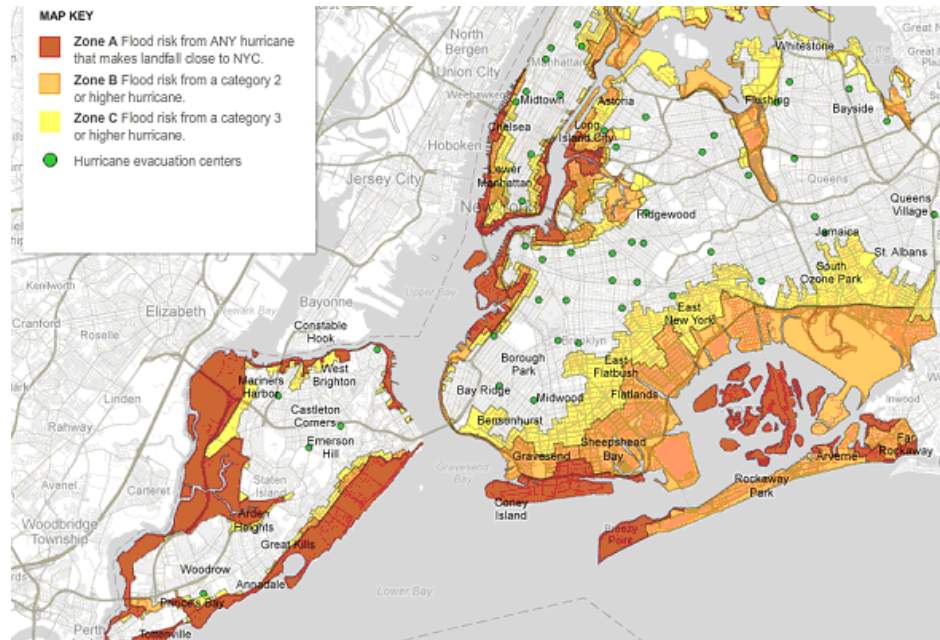
To fully address how to best rebuild after Hurricane Sandy, several aspects must be considered. Natural and social science data will provide background information on Hurricane Sandy as well as the causes and effects of all hurricanes in general. Natural science data will also provide important projections of climate change and future hurricanes. Three disciplines will be utilized in this thesis to best approach the issue. First, environmental history will help to understand what used to make up the New York City area and how it changed over time. Second, environmental design will help to understand what options may be considered when rebuilding and how designs can be made more sustainable. Lastly, governmental policy will provide information on what steps the Tri-State area did take and will need to take in the future to not only prepare for events like Hurricane Sandy, but also other events fueled by climate change. Each discipline is intertwined and builds off of the previous discipline. Having a thorough understanding of the environmental history of the area informs some environmental design aspects, while policy is needed to encourage widespread sustainability and aspects of ecological design. Overall, this is a chance to rethink the way we live, where we live, and how we build. Thus, although Hurricane Sandy revealed many of our vulnerabilities, we can turn this devastation into an opportunity to rebuild in a more

¹ Eric Sanderson, *Mannahatta: A Natural History of New York City* (New York: Abrams, 2009), 13.

resilient and sustainable way by having the political sphere encourage ecological designs to improve these areas in the best ways possible.

BACKGROUND

Hurricane Sandy struck Atlantic City, New Jersey on October 29, 2012. This unusual storm ravaged the New York metropolitan area, causing great amounts of damage to the New Jersey coastline and many portions of New York City. Eight days before making landfall, scientists from Europe warned that their computer models projected that this storm could take an unusual left turn, slamming into the United States.² On top of this atypical trajectory, Hurricane Sandy also combined with a northeaster over the east coast of the United States, making it even more unusual and damaging. This extraordinary hybrid storm rightfully earned the nickname “Frankenstorm Sandy” because as hurricane-forced winds wreaked havoc on the Tri-State area just before Halloween, other areas were pounded with snowstorms. Preparations in the Tri-State area began on Sunday, October 28.³ The area took precautionary measures, where anyone in designated FEMA Zone A flood zones were ordered to move to safer locations as well as the entirety of the Rockaways, some of which are in Zone B.



² “Inside the Megastorm,” *Nova*. (PBS, Nov 2012; Television).

³ *Ibid.*

⁴ Matthew Bloch, “New York City Hurricane Evacuation Zones,” *New York Times*, August 26, 2011.

At 7 PM on Sunday night, the MTA, most major bridges, tunnels, and all other forms of transportation were shut down to prevent people being stranded when the hurricane struck. Well before the storm made landfall, the Tri-State area experienced threatening conditions. As Hurricane Sandy combined with the Northeaster, these conditions created a very large, slow-moving storm. The storm reached an enormous 1000 miles wide, causing hurricane-force winds and high storm surges in the Tri-State area for more than eight hours.⁵

Hurricane Sandy officially made landfall when the eye of the storm struck Atlantic City, New Jersey at 8 PM. Geographically, New York's harbor is incredibly vulnerable because Long Island essentially creates a right angle with the Jersey Shore, which directs the water in towards the harbor and Staten Island. Hurricane Sandy made landfall at the worst possible time because it was not only high tide, but the phase of the moon also made it the highest tides of the year. These topographic and astronomic conditions made flooding even worse, including storm surges that were 14-feet or even higher in some areas.⁶ Many low-lying areas were inundated. For example, people were forced into their attics in Staten Island, while many parts of lower Manhattan were also flooded because they are less than 10-feet above sea level. Both N.Y.U. Langone Medical and Bellevue Hospital Centers needed to be evacuated after their backup generators failed. Much of New York's infrastructure, including the tunnels, power stations, and subways were flooded. For instance, the Brooklyn-Battery Tunnel and Queens-Midtown Tunnel flooded to the point where the Army Corps of Engineers were brought in to pump them out after the storm.⁷ Seven of the subway tunnels were flooded, several of them from floor to ceiling.⁸ Over 15,000 flights were cancelled at John F. Kennedy Airport and La Guardia Airport. More than 8 million people were without power, including 90 percent of Long Island.⁹ Since firefighters were unable to get to the fire due to flooding, 100 houses burned in Breezy Point, Queens. The Jersey Shore was very badly impacted, where iconic boardwalks were leveled and eight counties had already declared disaster areas the morning after the storm.¹⁰ Overall, 97 deaths were attributed to Hurricane Sandy in the Tri-State area.¹¹

⁵ "Inside the Megastorm," *Nova*. (PBS, Nov 2012; Television).

⁶ *Ibid*.

⁷ James Barron, "Storm Barrels Through Region, Leaving Destructive Path," *New York Times*, October 30, 2012.

⁸ "Inside the Megastorm," *Nova*. (PBS, Nov 2012; Television).

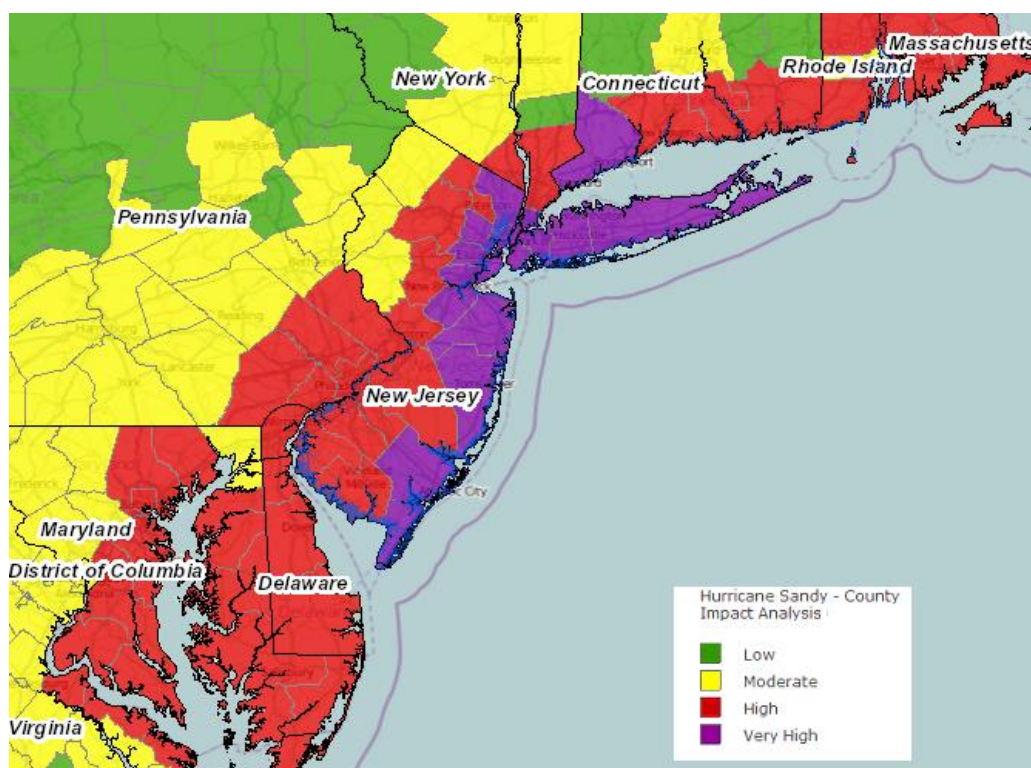
⁹ James Barron, "After the Devastation, A Daunting Recovery," *New York Times*, October 30, 2012.

¹⁰ "Inside the Megastorm," *Nova*. (PBS, Nov 2012; Television).

¹¹ "Hurricane Sandy's Death Toll", *New York Times*, November 17, 2012.

Thus, lives were lost, homes were destroyed, people were stranded, many places flooded, transit was crippled, and millions of people lost power, heat, and water – to name a few of the immediate impacts.

Areas Most Affected by Hurricane Sandy¹²



These immediate impacts quickly became more widespread. For one, the storm resulted in gasoline shortages. Many of the ways in which gasoline is transported into the area were damaged or closed. Many gas stations also did not have electrical power to pump the gas that they did have, which left very few gas stations open for customers. The limited supply of gas stations created long lines, which people waited on for hours and even crossed state lines to find. Roughly 60 percent of gas stations in New Jersey were closed, while 70 percent were closed in Long Island.¹³ Supplies of gasoline quickly began to run out due to high demand and few suppliers, where the Defense Department needed to be called in to deliver gasoline to the most impacted areas.¹⁴ Both Governor Cuomo and Governor Christie enacted gas rationing to odd or even license plate days, where only certain cars could get gas on certain

¹² “Charting the Road to Resilience: From the Ground Up,” Municipal Art Society of New York. (The New School, 2013). Conference.

¹³ Kate Zernike, “Gasoline Runs Short, Adding Woes to Storm Recovery,” *New York Times*, November 1, 2012.

¹⁴ Eric Lipton and Clifford Kraus, “Military to Deliver Fuel to Storm Ravaged Region.” *New York Times*, November 2, 2012.

days to reduce congestion and frustration. Meanwhile, economic losses were huge because of the storm, including the immediate physical damages to property and infrastructure, but also aspects like the thousands of businesses that could not open because of the storm. Losses from Sandy are estimated to be at least \$50 billion.¹⁵ There were also social impacts. Public housing also experienced significant damages, where Hurricane Sandy affected about 400 of the 2,600 buildings, which included about 80,000 people.¹⁶ Fear also rose as looting increased across the Tri-State area. The direct damages and socio-economic impacts were devastating and widespread throughout the area.

Of course, Hurricane Sandy is an isolated incident, where each hurricane is unique with different characteristics and features. It would be foolish to assume that all future hurricanes would be similar to this one. Nonetheless, it is also important to understand the scientific explanations of hurricanes themselves to have a thorough understanding of hurricanes and the conditions in which they thrive. In essence, hurricanes are simply a way that the atmosphere attempts to balance the hot and the cold. Hurricanes tend to form in the tropics and gain energy when they travel over warm ocean waters. Hurricanes develop due to two different stages known as the genesis stage and the intensification stage.¹⁷ The genesis stage consists of an imbalance in the atmosphere that causes a convergence of the air at the same time as the occurrence of low atmospheric pressure. Troughs that form near the equator also sometimes attain a cyclonic spin due to the Coriolis force, which obtains its revolving from the rotation of the earth.¹⁸ A storm needs sea surface temperatures of at least 80° F to turn it into a storm and to help sustain it as a storm. As the storm passes over warm waters, water vapor rises up and condenses into the atmosphere, resulting in wind energy. Genesis also requires a weak vertical wind shear, which means that wind of the same speed is experienced throughout the atmosphere.¹⁹ Afterwards, the intensification stage requires the same conditions to continue, including the wind shear, moist air, and water temperatures of at least 80° F.²⁰ Warmer water increases the possibility of genesis, speeds

¹⁵ Peter Aldhous, "Protecting the City from the Next Big Storm," *New Scientist*. November 10, 2012.

¹⁶ "Charting the Road to Resilience: From the Ground Up," Municipal Art Society of New York. (The New School, 2013). Conference.

¹⁷ Patrick J. Fitzpatrick, *Hurricanes: A Reference Handbook*. Denver: ABC-CLIO, 2006, 2.

¹⁸ *Ibid*, 3.

¹⁹ *Ibid*, 6.

²⁰ *Ibid*, 8.

intensification, and strengthens the storms.²¹ Storms tend to start to dissipate once they have reached colder waters or reached land. Cold waters help to balance the atmosphere, end the formation of thunderstorms, and weaken the hurricane.²² Meanwhile, land reduces the amount of moisture available to a storm preventing the creation of clouds. The storm also slows down because of the increase of friction on land.²³ Thus, these are the various stages of a typical hurricane.

To fully comprehend a hurricane, one must also understand storm surges and the hurricane season. Storm surges occur because strong winds push the water towards the shore. As the winds push the water, the ocean floor gets shallower closer to land, which causes a surge of water higher than normal. The stronger the winds, the higher the storm surges because more energy is pushing the water towards shore. The height of a storm surge also depends on the strength and size of the storm. As depicted with Hurricane Sandy, storm surge also depends on the phases of the moon, also known as the astronomical tide. Due to the gravitational forces between the earth, moon, and sun, there are two high tides and two low tides during each day.²⁴ The storm surge combines with whatever tides are present at the time; thus, a storm during high tide, like Hurricane Sandy, causes much more flooding than a storm during low tide. In the Atlantic, the hurricane season spans from June 1 and November 30; however, hurricanes can occur outside of this timeframe.²⁵ It has also been found that about one in every twenty Atlantic hurricanes actually makes landfall on the East coast.²⁶ Thus, this storm surge and hurricane seasons help to understand hurricanes in the Atlantic Ocean.

Aside from physical damages, hurricanes and other natural disasters also pose social and economic threats to many vulnerable people around the world. Almost 40 percent of the world's population live less than 60 miles from the coast, all susceptible to impacts of severe coastal storms. Meanwhile, around the world, almost 145 million people live in areas that are not even one meter above sea level.²⁷ These impacts could cause political, social, and economic turmoil, which could result in social

²¹ Ibid, 9-10.

²² Patrick J. Fitzpatrick, *Hurricanes: A Reference Handbook*. Denver: ABC-CLIO, 2006, 11.

²³ Ibid, 12.

²⁴ Ibid, 29.

²⁵ Ibid, 13.

²⁶ "Inside the Megastorm," *Nova*. (PBS, Nov 2012; Television).

²⁷ Kirstin Dow and Thomas E. Downing, *The Atlas of Climate Change: Mapping the World's Greatest Challenge*. Los Angeles: University of California Press, 2011, 70.

crises.²⁸ Social vulnerability in an area depends on the way an area can recover or bounce back from a natural disaster. The populations that are most vulnerable are often the least able to adapt to these types of situations, where they are exposed to more threats from events like natural disasters or climate change and are unable to cope with these adverse effects. Many times, a population's resiliency depends on social factors, including race, age, gender, unemployment and socioeconomic status.²⁹ Each of these factors plays a role in a population's ability to recover from a disturbance. For example, a disaster may limit the availability of resources and some populations may be able to access these resources more easily than others, causing an inequity in access and distribution. Many times livelihoods and the way people make their income could also be negatively affected by storms, making them even more vulnerable and less likely bounce back. Other economic impacts include damages to property and valuables, damages to infrastructure, and businesses that are unable to open. All of these impacts could cause more stress and anxiety to those who simply want life to go back to normal after a disaster. Therefore, hurricanes could cause a wide range of social, political, and economic threats to vulnerable populations.

Although Hurricane Sandy is an isolated event, there will be others; however, they may be in different forms. Hurricanes are not the only threat that New York City faces; climate change will cause many other adverse impacts, which will need to be properly handled and mitigated. In 2009, Mayor Bloomberg released a report from the New York City Panel on Climate Change (NPCC) projecting that New York City will face warmer temperatures, increased sea levels, and possibly even more droughts and floods due to global warming.³⁰ As the temperature rises due to increased amounts of greenhouse gases, glaciers are melting at incredible rates and increasing sea levels. Sea levels will also continue to rise as ocean waters warm because when water molecules warm, they expand.³¹ High sea levels pose many threats to coastal cities, like New York City. A storm like Sandy on top of rising sea levels would do even more damage and create even higher storm surges. A storm surge would combine with the already higher sea levels, causing even worse flooding to areas. According to the 2009 NPCC report, sea levels

²⁸ Ibid, 42.

²⁹ Sigridur Bjarnadottir, Yue Li, and Mark G. Stewart. "Social Vulnerability Index for Coastal Communities at Risk to Hurricane Hazard and a Changing Climate". *Nat Hazards* (2011) 59:1056.

³⁰ "Climate Risk Information". New York: New York City Panel on Climate Change, 2009, 3.

³¹ Kirstin Dow and Thomas E. Downing, *The Atlas of Climate Change: Mapping the World's Greatest Challenge*. Los Angeles: University of California Press, 2011, 28.

are more than 95% likely to rise in the New York City area 2 to 5 inches by the 2020s and 12 to 23 inches by the 2080s.³² This report predicts that by 2100 a current 1-in-10 year coastal flood would occur every 1 to 3 years, while a current 1-in-100 year coastal flood would occur every 15 to 35 years.³³ Therefore, rising sea levels and higher risks of flooding will increase with climate change.

Other impacts of climate change include increased temperatures, precipitation, and intensity of storms. The 2009 NPCC report also states that there is more than a 95% chance that the Tri-State area will face warmer temperatures, where there will be an increase of 1.5°F to 3°F by the 2020s and 4°F to 7.5°F by the 2080s. These warmer temperatures would include, by 2100, 2.5 to 4.5 times more days over 90 degrees as compared to the average from 1971 – 2000. Meanwhile, the report also predicts that annual precipitation in the New York City area is greater than 50% likely to increase up to 5% by the 2020s and between 5-10% by the 2080s.³⁴ More closely related to Hurricane Sandy, as previously discussed, warmer waters strengthen storms; thus, hurricanes are likely to become more intense because sea surface temperatures are predicted to continue to rise due to global warming.³⁵ The Intergovernmental Panel on Climate Change (IPCC) has observed an increase in intense hurricanes since 1970. Between 1995 and 2004, there was an average of 13.6 tropical storms, 7.8 hurricanes, and 3.8 major hurricanes each hurricane season; meanwhile, between 1970 and 1994 there was an average of 8.6 tropical storms, 5 hurricanes, and 1.5 major hurricanes each hurricane season.³⁶ Thus, there is an increase in intense storms. Global warming increases the risk of more intense storms that may hit the Tri-State area again in the future as well as causing warmer temperatures, increased sea levels, and possibly even more droughts and floods. Thus, climate change needs to be considered when rebuilding to best prepare and protect the area from more harm.

Therefore, with this background information, we can better understand Hurricane Sandy itself with a wider knowledge of hurricanes in general. Hurricane Sandy revealed many vulnerabilities of the Tri-State area, including the areas and infrastructure at the most risk. Each storm is unique, causing different

³² “Climate Risk Information”. New York: New York City Panel on Climate Change, 2009, 3.

³³ *Ibid*, 21.

³⁴ *Ibid*, 3.

³⁵ S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, 2007.

³⁶ *Ibid*, “Climate Change 2007 3.8.3.2 North Atlantic”.

threats, and the future of hurricanes must be considered. Since most hurricanes form under the same conditions, and the frequency of these conditions will be increased by climate change, we must be prepared to handle more intense storms. Hurricanes can cause lots of physical damages to people, property, and infrastructure, while also causing economic and social threats. We must reduce these risks as much as possible. We must not limit our scope to solely preparing for future hurricanes; instead, we must also be prepared to handle other impacts of climate change. Thus, in the rebuilding process, this background and scientific information must be considered to reduce risks from storms as well as other impacts of climate change to best protect the area from future harm.

ENVIRONMENTAL HISTORY

Understanding the Tri-state area's environmental history is crucial to building a more sustainable and resilient city; so, it will be important to go over various aspects of environmental history in this area. Historically, many hurricanes have hit this area, so it is not completely uncommon and it can happen again. These past hurricanes also give insight into what areas have been affected by storms in the past; however, it is important that we do not only focus on the past. Meanwhile, discussing the baseline ecology of the area provides insight into why certain parts of the New York City area were inundated or flooded, while also providing information on the best ways to rebuild with these natural systems in mind. Environmental history also informs how the relationship between people and nature has changed over time. Thus, environmental history involves valuable information and explanations for this topic.

The hurricane history of the Tri-State area can provide helpful information about past hurricane frequencies and strengths, which helps with long-term planning. One of the worst storms to hit the area was the Long Island Express Hurricane, which pummeled the Northeast in 1938. It was the strongest storm known to make landfall around this area as a category 3 storm hitting Eastern Long Island and New England at the highest tides of the year. At the time, little was known about the warning signs of hurricanes, so few precautions were taken for this storm. Almost 700 lives were lost, making it a very deadly storm, and it caused millions of dollars of damage.³⁷ Another significant hurricane was Hurricane

³⁷ New York City Office of Emergency Management. "NYC Hazards: NYC Hurricane Evacuation". Accessed February 22, 2013.

Donna of 1960, which made landfall in multiple places, including New York as a category 1 hurricane.³⁸ With it came an 11-foot storm surge and great amounts of damage.³⁹ Another Category 1 hurricane, which affected the New York area in June of 1972, was called Hurricane Agnes, causing widespread damage and flooding across a 1,000 mile diameter from North Carolina to New York.⁴⁰ Hurricane Agnes combined with another Northeaster storm system and resulted in 122 deaths and \$6 billion of damage.⁴¹ Thus, these are just some of the examples of the major storms that have passed through the area, causing great amounts of destruction and displacement.

The next major storm to affect this area was Hurricane Gloria in 1985. Hurricane Gloria was a Category 2 hurricane when it hit western Long Island, but only resulted in a 6-foot storm surge because it occurred during low tides.⁴² The next significant hurricane to affect the area was Hurricane Floyd in September 1999, which was a Category 2 hurricane that made landfall and the most damage in North Carolina. Nonetheless, Hurricane Floyd was still the worst hurricane to affect the area that decade, causing high amounts of rain and flooding in the Tri-State area, where hundreds needed to be rescued in New Jersey.⁴³ The most recent hurricane to affect the Tri-State area before Hurricane Sandy was Hurricane Irene in August 2011, which was downgraded to a tropical storm just before it made landfall in New York City. The City issued mandatory evacuations of Zone A and the Rockaways, including thousands of residents. Damages from the storm are estimated at \$100 million. Hurricane Irene was predicted to be stronger and cause much more damage than it actually did, which may have affected how seriously citizens considered the warnings for Hurricane Sandy.⁴⁴ This history of hurricanes opens our eyes to how many major hurricanes have hit this area and how we have been affected in the past. This information will be helpful for improving land-use zoning, emergency management, storm preparedness, and mitigation. Thus, knowing the history of past major storms allows us to compare what we have seen to Hurricane Sandy, while also allowing us to better prepare for future hurricanes.

³⁸ Patrick J. Fitzpatrick, *Hurricanes: A Reference Handbook*. Denver: ABC-CLIO, 2006, 165.

³⁹ New York City Office of Emergency Management. "NYC Hazards: NYC Hurricane Evacuation". Accessed February 22, 2013.

⁴⁰ Patrick J. Fitzpatrick, *Hurricanes: A Reference Handbook*. Denver: ABC-CLIO, 2006, 170.

⁴¹ New York City Office of Emergency Management. "NYC Hazards: NYC Hurricane Evacuation". Accessed February 22, 2013.

⁴² Patrick J. Fitzpatrick, *Hurricanes: A Reference Handbook*. Denver: ABC-CLIO, 2006, 173.

⁴³ *Ibid*, 180.

⁴⁴ New York City Office of Emergency Management. "NYC Hazards: NYC Hurricane Evacuation". Accessed February 22, 2013.

Understanding the baseline ecology of the New York City area is another important aspect of its environmental history. Prior to urbanization and development, Manhattan used to be a very different place. The New York City area was at the southern tip of the last glaciation, where it was covered by a thousand feet of ice. Long Island is a glacial moraine, which is the debris that is pushed by the edge of an expanding glacier.⁴⁵ As the glacier retreated, the ice carried stones that scraped away at the hard bedrock, which can be observed in the visible bedrock of today's Central Park. This last glaciation also resulted in these melting glaciers depositing rich soils in the area, which allowed for New York's diverse natural environment.⁴⁶ The Lenape referred to Manhattan as the "Island of Many Hills".⁴⁷ Although it can be hard to imagine, New York City used to be a landscape filled with hills, forests, wetlands, and much more.

Old maps help provide some idea of what this area used to look like. Interestingly, the most accurate and detailed maps came from British headquarters during the Revolutionary War. Since New York's harbor was such a strategic location, it needed to be mapped in detail. Some of these maps show the topography of Manhattan, including all its hills, streams, sandbars, and shorelines of the area. These maps also illustrate some of the ecosystems in place at the time, including marshes, forests, and beaches, most of which do not exist today.⁴⁸ For example, old maps depict how during the 1620s when the Dutch settled in lower Manhattan, Beaver Street, Broad Street, and Maiden Lane were all small streams. Maps also illustrate how south of the Brooklyn Bridge used to be a shrub swamp, sandy beaches spanned from lower Manhattan to Midtown, while salt marshes bordered the Lower East Side and Brooklyn into Queens.⁴⁹ Some of these maps have also been confirmed for accuracy through scientific proxy data, including pollen layers left in the bottom of ponds and lakes, tree rings, and from the layers of soils.⁵⁰ This proxy data helps to fill in the blanks and decipher what exactly used to be where. Through a combination of maps and science, the ecology of Manhattan prior to urban development has been thoroughly depicted.

⁴⁵ Eric Sanderson, *Mannahatta: A Natural History of New York City* (New York: Abrams, 2009), 141.

⁴⁶ Max Page, *The Creative Destruction of Manhattan 1900-1940*. Chicago: The University of Chicago Press, 1999, 182.

⁴⁷ Eric Sanderson, *Mannahatta: A Natural History of New York City* (New York: Abrams, 2009), 71.

⁴⁸ *Ibid*, 53.

⁴⁹ Eric Sanderson. "Urban Legend: Discovering Manhattan's Wetlands". *National Wetlands Newsletter*, 2005, 15.

⁵⁰ Eric Sanderson, *Mannahatta: A Natural History of New York City* (New York: Abrams, 2009), 40.

Through such findings, Manhattan has been described as having a thriving ecosystem filled with hundreds of different plants and animals. Forests that the first settlers observed are known to have been made up of oaks, hickories, American chestnuts, white pines, and Atlantic cedars. An incredible fifty-five ecological communities used to make up Manhattan.⁵¹ Being able to understand the topography, soil cover, and vegetation types gives great insight for future designing solutions. As will be later discussed, designing with nature in mind will be important for the future. The loss of these ecosystems has taken its toll and it will become important to try to reincorporate them into the city. Many of these ecosystems played very important roles and functions. New York, no matter what, is a part of the ecosystem and should consider restoring these ecosystems for the important functions they fulfill. Most importantly, there is a great loss of ecosystem services from wetlands. Wetlands used to cover 10% of the island.⁵² Almost 85% of the Tri-State area's wetlands have been destroyed.⁵³ Wetlands are known to be very productive, but also act as nurseries for many types of marine life and help to protect and decrease flooding, which would have helped during Hurricane Sandy.⁵⁴ Marshes also help to slow runoff, slow erosion, and help to recharge aquifers.⁵⁵ Thus, ecosystems like marshes should be reconsidered for restoration. Knowing the baseline ecology of the area can be very helpful because it gives insight into why certain areas of Manhattan were inundated or flooded. Importantly, knowing the previous ecosystems helps when considering the best ways to rebuild in a more resilient and sustainable way after Hurricane Sandy.

Another important aspect of environmental history is the social history of the New York City area and its impacts on the environment. Historically, the relationship between the environment and society has drastically changed since the time of the first settlers. Native Americans lived in this area for more than 10,000 years, coexisting with the environment and understanding their interdependence with the environment. While there is no question that Native Americans manipulated and shaped the land, it was not to the extent of what was to come. When colonists reached the New York City area, rich forests and hills greeted them. No matter how infinite these forests appeared to the colonists, they were quickly cut down for wood for fuel and timber or reshaped to make way for private property and agricultural

⁵¹ Ibid, 138.

⁵² Eric Sanderson. "Urban Legend: Discovering Manhattan's Wetlands". *National Wetlands Newsletter*, 2005, 1.

⁵³ "New York City Wetlands Strategy 2012". New York: PlaNYC, May 2012, 3.

⁵⁴ Eric Sanderson, *Mannahatta: A Natural History of New York City* (New York: Abrams, 2009), 148.

⁵⁵ Eric Sanderson. "Urban Legend: Discovering Manhattan's Wetlands". *National Wetlands Newsletter*, 2005, 16.

purposes. Colonists caused incredible amounts of environmental degradation when collecting the large amounts of resources in the New World. Capitalism turned all resources into commodities and focused on making profits. To many, making profits was the primary goal, time was considered money, and environmental degradation meant nothing.

Early in the nineteenth century, Manhattan's grid system began, where lines were drawn to create 100-by-25-foot land plots. In this process, bedrock was scraped away, hills were flattened, natural waterways and marshlands were filled in, and any remaining trees were cut down to create identical land plots. The land was quickly being changed for capitalistic purposes and industrial industries. Not only was the physical visible environment changed drastically, but the bedrock was also often dug into, especially to make way for the subway tunnels and pipes for transporting water.⁵⁶ The accumulated bedrock was then used to extend out many of the boroughs of New York City. New York City was artificially extended out even further with the use of landfill. The southern tip of Manhattan, lower than City Hall, is 33 percent larger than its original state.⁵⁷ At the same time, wetlands were filled in even more and used as dumpsites. Wetlands were viewed negatively as sources of disease and restraints growth, where they were primarily viewed as impediments of civilization. Wetlands that once took up 10 percent of Manhattan, were now diminished to those at Sherman Creek, a part of the Harlem River, and Inwood.⁵⁸ Mostly, at the time, it was believed that if any space was needed for any purpose, New York could simply continue extending the island with landfill.⁵⁹ Thus, the land was drastically changed and even expanded in some areas.

Importantly, some backlash grew out of the heavy industrialism during the nineteenth century, which became known as romanticism. Romanticism sparked feelings of awe and sacredness towards nature, which inspired many painters and poets of the time. Nature or the country was seen as a refuge from the city that was filled with stress, disease, overcrowding, and pollution. Romanticism spurred the idea of going to the country or bringing the country to the city to create much-needed public space. It was

⁵⁶ Max Page, *The Creative Destruction of Manhattan 1900-1940*. Chicago: The University of Chicago Press, 1999, 183.

⁵⁷ Ann L. Buitenwieser. *Manhattan Water-Bound: Manhattan's Waterfront From the Seventeenth Century to the Present*. New York: New York University Press, 1987, 23.

⁵⁸ Eric Sanderson. "Urban Legend: Discovering Manhattan's Wetlands". *National Wetlands Newsletter*, 2005, 16.

⁵⁹ Ann L. Buitenwieser. *Manhattan Water-Bound: Manhattan's Waterfront From the Seventeenth Century to the Present*. New York: New York University Press, 1987, 23- 24.

believed that the sick needed to get away from the city's bad air. By the middle of the nineteenth century, the public demanded parks for therapeutic purposes and parks were seen as green spaces for health benefits. Parks were also viewed as the "lungs" of the city.⁶⁰ It is no surprise that at this time, Frederick Law Olmsted Sr. and Calvert Vaux began meticulously planning the creation of Central Park.⁶¹ Olmsted and Vaux attempted to mirror what they saw in nature by utilizing the existing topography and incorporating winding, organic paths. Central Park epitomizes the romanticism of the time. Thus, romanticism must be included when discussing the environmental history of the Metropolitan area.

At the same time, the waterfront was becoming increasingly important. Through much of the nineteenth century, waterways were vital for commerce, trade, communication, and transportation. Advancements made on the steamboat by Robert Fulton in 1807 made transporting by steamboat a faster, scheduled, and more affordable mode of transportation than relying on winds and tides to push boats reliant on sails. Thus, trading became even more time-oriented and economical via the waterways. With increasing popularity came larger ships and the need for a well-developed waterfront, where goods could be stored as well as where ships could be fueled and built.⁶² Thus, in the nineteenth century, the waterfront was one of the main locations for commerce and New York's seaport was one of the main gateways of trade in America. An incredible amount of piers sprouted all along New York's harbor accompanied by merchant houses, warehouses, docks, shipyards, and lumberyards to help keep them successful commercial centers.⁶³ As railroad shipping became increasingly popular and cheaper later in the nineteenth century, the importance of the waterfront began to diminish. Suddenly, American trade was being moved westward and not coming from New York anymore. Railroads could carry larger loads and transport them anywhere; thus, no harbor was needed. Ships were no longer the only and cheapest means of transportation. As the waterfront began to lose its value on the commercial front, the waterfront was seen for new purposes. Soon after, cars became more and more popular for modes of transportation as increased amounts of individuals began owning cars. From 1920 to 1926 the amount of registered

⁶⁰Matthew Gandy. *Concrete and Clay: Reworking Nature in New York City*. Cambridge: Massachusetts Institute of Technology Press, 2002, 83.

⁶¹Max Page, *The Creative Destruction of Manhattan 1900-1940*. Chicago: The University of Chicago Press, 1999, 88.

⁶²Ann L. Buitenvieser. *Manhattan Water-Bound: Manhattan's Waterfront From the Seventeenth Century to the Present*. New York: New York University Press, 1987, 11.

⁶³Ibid, 12-13.

vehicles in the Tri-State area increased from 540,000 to 1.3 million.⁶⁴ In the 1930s, the waterfront became a popular location to build elevated highways.⁶⁵ Therefore, transformations in land uses give an idea of the social environmental history of the area, where the relationship with nature has changed dramatically.

Thus, New York City's environmental history is crucial to building a more resilient city prepared for future hurricanes and beyond. Past hurricanes give insight into where was most vulnerable and what has happened in the past due to hurricanes. With this information, better mitigation and preparedness could be developed. Hurricane history is not the only important aspect of environmental history to apply to this issue. The past ecology of the area reveals why some areas are more vulnerable or prone to flooding, while also providing important information about previous natural systems and their beneficial functions. Since European settlement, the relationship between the environment and New York City drastically changed. Over the span of a few centuries, the New York City area went from rich ecosystems to a concrete-covered city. Significantly, the New York City area started to build and live in areas previously considered off limits, forgetting about nature; however, simply because nature was not as visible does not mean it has no influence. We cannot continue to ignore these natural systems or the natural history of the area. Therefore, this information could help to rebuild in a more resilient and sustainable way after Hurricane Sandy.

ENVIRONMENTAL DESIGN

We must take the aftermath of Hurricane Sandy as an opportunity to rebuild in a better, more resilient and sustainable way to not only be better prepared for future storms, but also other impacts of climate change. In doing so, incorporating many environmental design principles will make better long-term approaches to rebuilding the area with the future impacts of climate change in mind. We can build off of what we have learned from environmental history and incorporate the natural systems that make up this area. Ecological designs provide solutions that will have long-term and multiple benefits. When discussing environmental design, it is important to understand the difference between hard and soft

⁶⁴ Matthew Gandy. *Concrete and Clay: Reworking Nature in New York City*. Cambridge: Massachusetts Institute of Technology Press, 2002, 123.

⁶⁵ Ann L. Buitenvieser. *Manhattan Water-Bound: Manhattan's Waterfront From the Seventeenth Century to the Present*. New York: New York University Press, 1987, 14.

infrastructure. Hard infrastructure consists of hard edges and concrete infrastructure. Hard infrastructure includes manmade storm surge barriers, breakwaters, piers, and jetties that reduce wave energy.⁶⁶ Meanwhile, soft infrastructure includes natural infrastructure, which involves beaches and coastal wetlands as well as dunes to protect the coastline. Moving away from shortsighted, hard infrastructure will be crucial to improving the area's overall resiliency. Thus, looking into various ecological designs will provide insight into how to improve this area after a storm like Hurricane Sandy.

Ecological design must be considered to rebuild in more resilient and sustainable way that will be beneficial in the future. In doing so, five key principles of ecological design should be taken into consideration. Firstly, designs should address specific problems and needs that a certain location faces. Solutions must be locally based to be best suited to the location's vulnerabilities and issues. The environmental history of these specific areas, cultural lessons, and local knowledge are all sources of valuable information. Considering all environmental impacts of a design will also be important to create more energy efficient buildings that will be able to sustain themselves in the long-run. Designing with nature in mind is also key to achieving a favorable ecological design. We should build and work with the processes of the living world as much as possible. There is a lot to be learned from natural systems; it would be foolish to build and work against nature. As explained in the previous discipline, knowing that a good portion of New York City was marshes or wetlands is important when considering options in the rebuilding process. Including people from all disciplines and all professions is another important aspect of the process. Specialists alongside the community need to be involved in the rebuilding process to come up with the best, collaborative solutions. Finally, making nature visibly again will hopefully invoke a sense of interconnectedness and care that is needed to improve our relationship with nature.⁶⁷ Overall, this is a chance to rethink the way we build and the way we consider our place in the environment.

As depicted with Hurricane Sandy, much of New York's infrastructure is aging and incredibly vulnerable to storms and flooding. Most of New York City's infrastructure was built between 100 and 50

⁶⁶Cynthia Rosenzweig, William D. Solecki, Reginald Blake, Malcolm Bowman, et al. "Developing Coastal Adaptation to Climate Change in the New York City Infrastructure-shed: Process, Approach, Tools, and Strategies". *Climatic Change* 106.1 (2011): 114.

⁶⁷ Van der Ryn, Sim and Stuart Cowan. *Ecological Design*. Washington: Island Press, 1996, 72-73.

years ago.⁶⁸ Many parts of the transportation sector and other forms of infrastructure are between 6 to 20 feet above sea level, which is easily at risk to storm surges.⁶⁹ Meanwhile, much of this infrastructure is not only aging, but also severely lacking in adequate maintenance.⁷⁰ New York's combined sewer overflow system has many flaws and faces many problems. Essentially, during dry weather, wastewater treatment plants can fully treat one and a half times their capacity. However, during wet weather, the systems can often overflow, causing combined raw sewage and runoff to be discharged directly into the harbor's waterways.⁷¹ Meanwhile, New York's bridges, tunnels, and subways are also incredibly vulnerable. The lowest elevation of bridges and tunnels can easily be inundated by hurricanes.⁷² As Hurricane Sandy also demonstrated, the power grid in the New York City is also often problematic. With such a large, interweaving system, disruptions in one area can cause wide-ranging disruptions across the Tri-State area.⁷³ The failing of the power grid can cause multitudes of problems, including other sorts of infrastructure to fail. Thus, much of New York City's infrastructure, which is mostly hard infrastructure, is aging and incredibly vulnerable to storms and flooding.

After Hurricane Sandy struck, discussions immediately began surrounding the question of manmade barriers to protect the city from future storms that may cause flooding like Hurricane Sandy. In Stamford, Connecticut, a two-mile long storm barrier was completed in 1969. This storm barrier is 17 feet high and protects the area from flooding created by the Long Island Sound. After Hurricane Sandy, the barrier remained in place and protected thousands from flooding from an 11-foot storm surge. Michael A. Pavia, Stamford's Mayor, stated the storm surge barrier "was extremely effective in protecting areas that would have been flooded completely by this storm. It made all the difference in the world".⁷⁴ Because of

⁶⁸ Klaus Jacob, Noah Edelblum, and Jonathan Arnold. "Risk Increase to Infrastructure due to Sea Level Rise". *Metropolitan East Coast Assessment*. New York: Lamont-Doherty Earth Observatory of Columbia University, 2000, 7.

⁶⁹ *Ibid*, 52.

⁷⁰ *Ibid*, 49.

⁷¹ Cynthia Rosenzweig, William D. Solecki, Reginald Blake, Malcolm Bowman, et al. "Developing Coastal Adaptation to Climate Change in the New York City Infrastructure-shed: Process, Approach, Tools, and Strategies". *Climatic Change* 106.1 (2011): 111.

⁷² Klaus Jacob, Noah Edelblum, and Jonathan Arnold. "Risk Increase to Infrastructure due to Sea Level Rise". *Metropolitan East Coast Assessment*. New York: Lamont-Doherty Earth Observatory of Columbia University, 2000, 22.

⁷³ Cynthia Rosenzweig, William D. Solecki, Reginald Blake, Malcolm Bowman, et al. "Developing Coastal Adaptation to Climate Change in the New York City Infrastructure-shed: Process, Approach, Tools, and Strategies". *Climatic Change* 106.1 (2011): 106.

⁷⁴ Mireya Navarro, "Weighing Sea Barriers as Protection for New York," *New York Times*, November 7, 2012.

this example and many others, some believe storm surge barriers are the solution to our flooding problems. Many teams have studied the effectiveness of storm surge barriers in the New York City area. Stony Brook's University Storm Surge Research Group is one team that has developed potential plans for building manmade barriers in the New York City area and advocates for them to be built. As Dr. Colle, a professor who is part of the Stony Brook University Storm Surge Research Group, states, "The idea is that you raise these barriers, and anywhere inside of that you're basically protected. With a solid barrier, we basically can have business as usual in Lower Manhattan".⁷⁵ This team suggests that three barriers be built to protect the city from harm's way. One would be built between Brooklyn and Staten Island, another would be built between Staten Island and New Jersey, and the third would be built to protect the Long Island Sound from the East River. The team has estimated that it would cost more than \$5 billion for each barrier. They argue that while these are large costs, these costs are far lower than the losses from Hurricane Sandy.⁷⁶ Thus, for some, storm surge barriers appear to be a solution to the major flooding and destruction that was highlighted by Hurricane Sandy.

While there are advantages to the building of storm surge barriers, there are also many drawbacks to such large, hard infrastructure projects. Firstly, they are known to be very disruptive to ecology. Such large-scale infrastructure would completely change this area's environment by affecting tidal flows, while also harming aquatic life and fisheries. Storm surge barriers would also harm these estuaries by affecting the salinity of the water because affecting tidal flows means changing the amount of salt water that enters from the ocean, which could greatly affect the marine life in the area that are dependent on certain amounts of salinity in the water. As Paul Gallay, who is president of Riverkeeper, states "storm surge barriers may end up doing more harm than good".⁷⁷ Aside from ecological effects, it is important to note that storm surge barriers only redirects water elsewhere. Since the barrier would block storm surges from entering, this means that water levels would be even higher on the other side of the barrier, which could simply make flooding worse in other areas. Storm surge barriers are only diverting the problem, not solving it. This also raises the question of who or what populations the diverted waters affect? And how would this be decided? Another problem would be, especially due to New York City's

⁷⁵ Ibid.

⁷⁶ Peter Aldhous, "Protecting the City from the Next Big Storm," *New Scientist*. November 10, 2012.

⁷⁷ Mireya Navarro, "Weighing Sea Barriers as Protection for New York," *New York Times*, November 7, 2012.

combined sewer overflow system, where during a heavy storm the very polluted waters would be held within the barrier, unable to make it out to sea.⁷⁸ Thus, there are also many disadvantages that go along with building large-scale storm surge barriers.

Amsterdam provides a valuable lesson in terms of storm surge barrier building. More than half of Amsterdam lies below sea level.⁷⁹ It has long been known that Amsterdam built a manmade barrier in order to protect its country from flooding. In 1953, the North Sea flooded the country and killed 1,835 people.⁸⁰ The Dutch decided to build a network of barriers to protect the country from future flooding, which became known as the Delta Project. To comply with environmental concerns for the nurseries and fishing grounds, it was decided that the barriers would be left open during normal times to allow for migrations and closed at times of high sea levels.⁸¹ This solution was made possible because the nation reached a consensus together after concluding this was best solution for their nation at the time. The Dutch began to build these barriers in the 1950s to be able to protect a one-in-10,000-year flood.⁸² However, at the time, global warming and sea level rise were not well-known issues, so they built these fences assuming the ocean levels will stay the same level. Thus, these barriers are fixed heights.⁸³ So, aside from the negative environmental effects that quickly became apparent, the Dutch are now facing the problem of rising sea levels. What used to be protection from a one-in 10,000-year flood is now lessened to almost a one in 1,000 because of sea-level rise. As sea level is predicted to rise even more through the century, this could decrease to a one-in-100-year storm. Since sea level will be higher, flooding over the barriers could occur much more frequently. If sea level rises one and a half meters higher, a one in 1,000 storm could occur annually.⁸⁴ Thus, the Dutch are now forced to try to solve this problem of fixed barriers with increasing sea levels.

Storm surge barriers must be adequately deliberated. Firstly, we have to understand that each coast is different. New York's coast is not the same as Amsterdam's and cannot be so easily protected.

⁷⁸ Ibid.

⁷⁹ Rijkswaterstaat. *Design Plan Oosterschelde Storm-Surge Barrier: Overall Design and Design Philosophy*. Netherlands: Ministry of Transport, Public Works and Water Management, 1994, XI.

⁸⁰ Michael Kimmelman. "Going with the Flow". *New York Times*, February 17, 2013.

⁸¹ Rijkswaterstaat. *Design Plan Oosterschelde Storm-Surge Barrier: Overall Design and Design Philosophy*. Netherlands: Ministry of Transport, Public Works and Water Management, 1994, XI.

⁸² Mark Fischetti. "How to Survive the Next Big Storm: Q&A with Klaus Jacob". *Scientific American* (Nov 2012).

⁸³ "Charting the Road to Resilience: From the Ground Up," Municipal Art Society of New York. (The New School, 2013). Conference.

⁸⁴ Mark Fischetti. "How to Survive the Next Big Storm: Q&A with Klaus Jacob". *Scientific American* (Nov 2012).

As explained earlier, energy from hurricanes are funneled into the very narrow harbor, meaning these manmade barriers would need to withstand very strong forces.⁸⁵ The geometry of New York would make it even more difficult for storm surge barriers to be successful. Meanwhile, the Dutch are coming to the realization that they cannot fight nature because it is bound to fail. Instead, the Dutch are allowing the water in. As it has been poignantly stated, for the Dutch “the reality of rising seas and rivers leaves no choice. Sea barriers sufficed half a century ago; but they’re disruptive to the ecology and are built only so high, while the waters keep rising”.⁸⁶ In the end, as Klaus Jacob, a research scientist from Columbia University, articulated at the MAS “Charting the Road to Resilience: From the Ground Up” conference, such a manmade barrier is a “temporary Band-Aid,” where the Dutch “are going through a learning experience that we should skip over”.⁸⁷ Ultimately, in the coming years with sea level rise, these barriers will be useless and we would have to adapt no matter what. So, instead of spending billions of dollars on a barrier that will not last, we should focus that money now, doing what we would have eventually had to do anyway.⁸⁸ Creating such barriers makes us rely on technology too much, while creating a temporary or even false sense of safety. In constructing a barrier, we would not know how long they will last or to what scale these structures would need to be built in terms of the unpredictable rising sea-levels.⁸⁹ Ultimately, a seawall or barrier would only keep water out for a certain period; we cannot rely on storm barriers to be our only solution. Therefore, we should not rely on short-term solutions, like manmade barriers, to save us, instead we should start to try to change and adapt now.

Instead, it is important to look at the processes that ecosystems have developed, which include soft infrastructure, for designs to be better equipped to handle problems of the future. Barrier islands, coastal dunes, and wetlands are nature’s way of protecting the land from storms and reducing flooding. As described earlier, wetlands provide a multitude of functions including water filtration and providing

⁸⁵ "Charting the Road to Resilience: From the Ground Up," Municipal Art Society of New York. (The New School, 2013). Conference.

⁸⁶Michael Kimmelman. “Going with the Flow”. *New York Times*, February 17, 2013.

⁸⁷ "Charting the Road to Resilience: From the Ground Up," Municipal Art Society of New York. (The New School, 2013). Conference.

⁸⁸ "Charting the Road to Resilience: From the Ground Up," Municipal Art Society of New York. (The New School, 2013). Conference.

⁸⁹ Mike Tidwell. *The Ravaging Tide: Strange Weather, Future Katrinas, and the Coming Death of America’s Coastal Cities*. New York: Free Press, 2006, 83.

essential habitats for wildlife.⁹⁰ Importantly, wetlands provide flood protection, where some of the floodwaters could be stored during a storm.⁹¹ A wetland of about 14.5 kilometers is known to reduce a storm surge by one meter.⁹² Granted, this is a lot of space that the New York City area does not have. Thus, wetland restoration can only be a part of the solution. In the case of Hurricane Sandy, wetlands would not have been able to keep out a 14-foot storm surge; however, they would have helped and would continue to help with smaller storms in the future. Restoring some areas to wetlands or parks would not only act as barriers, but also be sacrificial areas on the coasts for when large storm surges may come.

Other types of natural barriers may also be beneficial. These include dunes and even oyster reefs. Natural sand dunes help to protect many coastal towns by keeping floodwaters out or at least reducing the strength of waves. If these dunes are grown properly, the grasses and plants will help to hold the dune down and prevent the sand from eroding away.⁹³ However, once again this can only be part of the solution. Hurricane Sandy's strength destroyed many of the dunes along the Jersey Shore as it moved its fury onto land. It will take two to three years before these dunes will be able to thrive again.⁹⁴ Oyster reefs also provide multiple benefits to an area. For one, the reefs reduce the intensity of waves. Oyster reefs are also known to improve water quality and increase marine life.⁹⁵ As we have seen with Hurricane Sandy, New York City is incredibly vulnerable to storms and high storm surges. We have occupied and urbanized areas that were previously considered off limits, which has caused us to forget about nature and the possibility of flooding. In the end, nature will take its course no matter what and soft-infrastructure will help reduce these impacts.

Soft infrastructure should not solely be used in the hopes of protecting against storms like Hurricane Sandy; instead, soft infrastructure can be incorporated to help create a more sustainable that would be better equipped to handle the future impacts of climate change. Soft infrastructure would help a variety of issues that New York City faces. For example, run-off and flooding is high in New York City

⁹⁰ Rutherford H. Platt, Rowan A. Rowntree, and Pamela C. Muick, eds. *The Ecological City: Preserving and Restoring Urban Biodiversity*. Amherst: The University of Massachusetts Press, 1994, 69.

⁹¹ *Ibid.*, 108.

⁹² Peter Aldhous, "Protecting the City from the Next Big Storm," *New Scientist*. November 10, 2012.

⁹³ Michael Schwartz. "On Decimated Shore, a Second Life for Christmas Trees". *New York Times*, February 4, 2013.

⁹⁴ *Ibid.*

⁹⁵ Kate Orff. *Rising Currents: Projects for New York's Waterfront*. Barry Bergdoll, eds. New York: The Museum of Modern Art, 2011, 90.

because most materials used, like concrete, do not allow water to filtrate down. New York City is made up of about 72% impervious materials.⁹⁶ The risk of flooding will increase with climate change due to more frequent and intense storms. Since high amounts of runoff cause the combined sewer overflow system to overflow and discharge raw sewage, it is important to find ways to reduce runoff and flooding. Porous streets and materials would allow water to filtrate into the ground. Green spaces and green roofs would also slow run-off and reduce the amounts of flooding that may occur during any rainstorm or even a hurricane. Aside from helping to filter and slow storm water runoff, green roofs have a variety of other benefits. Green roofs provide insulation for the buildings to keep them warmer in the winter and cooler in the summer. Green roofs also increase the longevity of roofs by protecting the roof from harmful UV rays. They also provide habitats that attract birds, butterflies and insects, while also decreasing noise pollution and helping to clean the air with plants converting carbon dioxide into oxygen.⁹⁷ Aside from green roofs and parks, incorporating bioswales will also help to reduce runoff. Bioswales can easily be built within a sidewalk near the curb, where vegetation that easily allows for infiltration is used to divert runoff from the curb. This runoff can be evaporated away, used by the plants, or stored in the soil beneath the vegetation. These bioswales are able to hold some of the runoff, and if implemented throughout the city, they can reduce the amount of runoff into the combined sewer overflow system.⁹⁸ Bioswales can also provide some habitats for wildlife. Therefore, these are some ways that the impervious surfaces of New York City can be improved through ecological design. Thus, reducing runoff will become important not only for future hurricanes like Hurricane Sandy, but will also be beneficial for future impacts of climate change.

The urban heat island effect is another issue that New York City faces, which could be improved by ecological design. The urban heat island effect is when cities are warmer during the day and stay warm at night as compared to surrounding rural areas. Cities are warmer because more pavement and materials absorb more heat and retain this heat. The difference in temperatures is most notable during the nights since land usually cools off quickly at night; however, the materials that make up a city cool

⁹⁶ “New York City Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways”. New York: NYC Environmental Protection, Sept 2010, 46.

⁹⁷ Ibid, 53.

⁹⁸ John McLaughlin and Zhongqi Cheng, “Street-side Source Control of Stormwater in New York City: A Performan Analysis of Infiltration and Subsurface Storage in an Ultra-Urban Environment”. 14:4 *Water Resources Impact* 14.4 (2012): 13.

much slower.⁹⁹ As discussed, climate change will also increase temperatures, which will make it even warmer, and drier in places like New York City. One way to alleviate this problem is to incorporate light-colored surfaces. In doing so, more shortwave solar radiation will be reflected rather than be absorbed by dark colors, like black asphalt.¹⁰⁰ Less absorption of solar radiation would lower air temperature. Another way to help reduce temperatures in cities is to increase the amount of plant life. More vegetation has a multitude of benefits. For one, plant life can provide shade, which helps to cool the heat-absorbing materials. Vegetation can help to decrease air and surface temperatures. Vegetation can also help cool through evapotranspiration. Evapotranspiration is the process of water being absorbed by a plant's roots, emitted through their leaves, and evaporated into the air.¹⁰¹ This process also helps to cool the air because it uses heat from the air to evaporate the water. Thus, the urban heat island effect can be reduced through various ecological design practices that would help to make New York City a more sustainable city.

Therefore, environmental design is an important aspect to consider when questioning how to rebuild for the future, especially when considering future hurricanes and the impending effects of climate change. It is important to see the Tri-State area as an active landscape, since it is part of an ecosystem that provides valuable ecological functions. We must learn from the processes that ecosystems have developed and value their beneficial functions. The goal is to restore ecosystems, so that they can play their long-lasting roles, including functions like controlling flooding. It is crucial to think of the future when rebuilding and considering designs. We must not only prepare for future storms, but also the impending effects of climate change, including higher sea levels and increased temperatures on top of the urban heat island effect. Instead of rebuilding shortsighted, hard infrastructure, this is a crucial time to improve the area's overall resiliency. Thus, ecological designs provide insight into how to increase resiliency and sustainability in this area for the long-term after a storm like Hurricane Sandy.

⁹⁹ Rutherford H. Platt, Rowan A. Rowntree, and Pamela C. Muick, eds. *The Ecological City: Preserving and Restoring Urban Biodiversity*. Amherst: The University of Massachusetts Press, 1994, 152.

¹⁰⁰ *Ibid*, 158.

¹⁰¹ Environmental Protection Agency. "Reducing Urban Heat Islands: Compendium of Strategies," 2008.

GOVERNMENTAL POLICY

Building off of both environmental history and environmental design, the government will need to improve emergency preparedness plans as well as encourage policies to promote rebuilding in a more resilient and sustainable way. In the wake of a disaster like Hurricane Sandy, the way a government prepares and reacts to such an event influences the potential of social crises. Hurricane Sandy revealed many of the inadequacies of current preparedness plans and policies. This storm also revealed inadequacies in our infrastructure, building codes, and zoning. It is now the time to improve these policies and advocate for ecological design techniques.

How governments prepare and react to disasters, like hurricanes, greatly impacts the potential of social crises. A government must provide the means and support to help its citizens prepare for the storm or evacuate out of low-lying areas. Before a storm or disaster, it is also important to make sure the public is educated on what is coming and how they should prepare. The public should be well aware of where to evacuate, what locations have mandatory evacuations, and where shelters will be located. Preparedness not only includes directly before the storm through issuing the proper mandates and evacuations needed, but it also can be viewed in long-term preparedness as well. Thus, another way to look at preparedness is how a government approaches the future looming problems that may occur, especially in terms of climate change. One of the positive ways in which a government could prepare for more intense storms is to promote increased resiliency and sustainability. The government must also prepare the city for the projected sea-level rise or the possibility of more intense storms. So, in preparing for disasters, it is important for governments to help prepare citizens in both the short-term and the long-term. On the other hand, recovery is another important phase for the government's actions. Immediately after a disaster, the government must ensure the safety and needs of those who might have been in harm's way. The government must get vital resources to those in need, provide any rescue or medical treatments necessary, and begin to repair critical infrastructure. Then, in the long-term recovery, governments must ensure that critical structures are repaired, while also rebuilding with the future in mind. It is also important for governments to reassess risks, promote social rehabilitation, and help to make up for losses.¹⁰²

¹⁰² C.B. Field, V. Barros, T.F. Stocker, D. Qin, et al, eds. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* Cambridge: Cambridge University Press, 2012, 373.

Governments need to implement building standards that would prepare coastal cities, like New York, for high storm surges and flooding, which may be worsened by climate change. Overall, governments need to provide adequate aid to citizens, businesses, and local governments to recover. Thus, how a government decides to prepare and help with the recovery after a storm like Hurricane Sandy could help or hinder the situation.

In this respect, one important case to consider is Hurricane Katrina and its aftermath. More than 1.3 million people evacuated due to Hurricane Katrina, which hit on August 29, 2005 as a Category 3 hurricane.¹⁰³ Meanwhile, inadequate evacuations left many stranded. With 125 mph winds and a 20-foot storm surge, 80 percent of the city was under water.¹⁰⁴ It was a much larger and more devastating storm than Hurricane Sandy, causing over 1800 deaths and forcing hundreds of thousands of people to move, many of whom never returned. The levees and floodwalls on which they fully relied, failed in over 50 locations.¹⁰⁵ Unlike in the Tri-State area, all of New Orleans was affected. Many pointed fingers at the levees that failed and at the local government's poor evacuation plans. Most notably, the government failed to ensure its citizen's safety in the shelters at the Superdome and the convention center, causing havoc and terrible conditions.¹⁰⁶ It quickly became clear to the nation, that a disproportionate amount of minorities, mostly black Americans, were facing the most issues after Hurricane Katrina.¹⁰⁷ It also became clear that Federal responses and FEMA were not prepared to respond to such a large event. Ultimately, after Katrina many view FEMA's efforts as a failure because it failed to lead emergency management, failed to coordinate military and international assistance, and failed to provide adequate commodities and emergency sheltering.¹⁰⁸ After Hurricane Katrina, New Orleans' economy was crippled, the main electricity provider went bankrupt, thousands were laid off, few returned, and those who did had trouble picking up the pieces or even finding jobs. Unfortunately, suicide seemed like the best option for many, where immediately after the storm, suicide hotline calls increased nine times to more than nine hundred a

¹⁰³ Mike Tidwell. *The Ravaging Tide: Strange Weather, Future Katrinas, and the Coming Death of America's Coastal Cities*. New York: Free Press, 2006, 1.

¹⁰⁴ Ibid, 21- 23.

¹⁰⁵ Christine F. Anderson. et al. *New Orleans Hurricane Protection System: What Went Wrong and Why*. Reston: American Society of Civil Engineers, 2007, 1.

¹⁰⁶ Mike Tidwell. *The Ravaging Tide: Strange Weather, Future Katrinas, and the Coming Death of America's Coastal Cities*. New York: Free Press, 2006, 24.

¹⁰⁷ Ibid, 27.

¹⁰⁸ Melanie Gall, and Susan L. Cutter. "2005 Events and Outcomes: Hurricane Katrina and Beyond". Rubin, Claire B, ed. *Emergency Management: The American Experience 1900 – 2010*. New York: CRC Press, 2012, 197.

day.¹⁰⁹ Katrina demonstrates how when federal aid fails, it can make a situation much worse. A backed federal response and federal aid is crucial to the how a location can recover from such a disaster and how quickly it is able to do so. Thus, Hurricane Katrina is a prime example of how social crises can easily arise in even developed countries when governments fail to adequately address all the stresses and vulnerabilities of the people affected.

With respect to Hurricane Sandy, there have been some environmental justice issues, but none to the extent of Hurricane Katrina. Interestingly, this storm not only affected the rich, who owned mansions on the shore, but also included many poorer minorities. Hurricane Sandy affected a disproportionate amount of minorities, including many public housing buildings owned by the New York City Housing Authority.¹¹⁰ Many working-class areas were greatly affected, like the Rockaways and the Eastern coasts of Staten Island. Overall, 402 New York City Housing Authority (NYCHA) buildings were damaged by Hurricane Sandy, which includes 35,000 units and 80,000 residents. This equates to 20 percent of all NYCHA buildings. Most of these buildings face power outages or failure of heating systems due to the fact that the utilities were kept in the basements that flooded. Many subsidized units were also affected by the hurricane, where about 24,500 units were also damaged by the storm. Many subsidized buildings were concentrated in areas vulnerable to storm surges, like Coney Island, the Rockaways, and the Lower East Side.¹¹¹ Thus, minorities were disproportionately affected in the New York City area.

In the short-term preparedness of Hurricane Sandy as well as all hurricanes, it is the duty of the Mayor to oversee the Office of Emergency Management's evacuation and emergency planning.¹¹² Many residents remained uninformed about hurricane evacuation, including who needed to evacuate and where the shelters were. One wonders how many actually knew who needed to leave. In a study conducted by the U.S. Army Corps of Engineers post-Hurricane Katrina in 2005, more than 85 percent had never see the Office of Emergency Management's guide on how to prepare for disasters. Meanwhile, more than 75 percent of the 2.3 million New Yorkers that lived in an evacuation zone were unaware that they lived in such a zone and 33 percent of those that would be affected by a Category 1 hurricane

¹⁰⁹ Mike Tidwell. *The Ravaging Tide: Strange Weather, Future Katrinas, and the Coming Death of America's Coastal Cities*. New York: Free Press, 2006, 44.

¹¹⁰ Seth W. Pinsky. "Growing New York City's Economy". Filmed January 2013. New York Law School, 1:00:56.

¹¹¹ The Furman Center. "Sandy's Effects on Housing in New York City," 5.

¹¹² Richard Brodksy. "Final Report on New York City Emergency Response and Evacuation Plans in the Event of a Weather-Related Emergency". New York: New York State Assembly 2006, 6.

believed that they would experience flooding.¹¹³ However, one can hope that prior to Hurricane Sandy, more residents were able to access the guide, since it is readily available online. This guide discusses evacuations, how to evacuate, and where you can find shelters. However, this online guide would be rendered useless if the electricity is out. This guide also provides ways to check to see if an address is location in the Federal Emergency Management Agency flood zone area that needs to be evacuated.

However, Hurricane Sandy revealed the inadequacies of the FEMA flood maps. These maps were based on thirty-year-old data and had not been updated since 1983.¹¹⁴ While FEMA had recently started to update these maps in the spring of 2012, they were not to be completed for another year. Sandy damaged far beyond FEMA's 100 year flood plane, where almost two thirds of the residences affected by the storm were outside of FEMA's projection. FEMA's maps dictate who is required to get flood insurance and the rates of the insurance. So, many of these households were not insured for these floods.¹¹⁵ FEMA's data only looks at the past and does not consider sea-level rise or the effects of climate change. Thus, basing mandatory evacuations on outdated, backwards-looking data can be incredibly problematic.

Important steps towards climate change preparedness, mitigation, and adaptation have occurred in recent years in the New York City area with the creation of PlaNYC and the New York City Panel on Climate Change. PlaNYC was established in 2007 by Mayor Bloomberg to help prepare for 2030 with more residents, while also improving lifestyles, improving the economy, considering climate change, and ultimately greening the city. PlanNYC has the goal of reducing 30% of greenhouse gas emission by 2030. Over 25 city agencies collaborate together under PlaNYC to meet long-term green goals for the city.¹¹⁶ By 2011, PlaNYC had already successfully added more than 200 acres of parks as well as reduced greenhouse gas emissions 13% from the 2005 amounts.¹¹⁷ Mayor Bloomberg also created another important establishment called the New York City Panel on Climate Change (NPCC) to keep New York City up to date with the most recent information on climate change. This information will help New York City better prepare for the future, especially in terms of policies, development, and necessary

¹¹³ Ibid, 14.

¹¹⁴ Cara Buckley. "Twice as Many Structures in FEMA's Redrawn Flood Zone". *New York Times*, January 29, 2013.

¹¹⁵ Seth W. Pinsky. "Growing New York City's Economy". Filmed January 2013. New York Law School, 1:00:56.

¹¹⁶ PlaNYC. "Update 2011: A Greener, Greater New York". Mayor's Office of Long-term Planning and Sustainability, April 2011, 12.

¹¹⁷ Ibid, 3.

adaptations.¹¹⁸ As previously discussed, the NPCC acknowledges that the New York City area will face warmer temperatures, increased amounts of heat waves, droughts, short and intense rainstorms, and sea level rise. The NPCC was put in place to provide ongoing projections of the effects of climate change on the New York City area, to develop plans on how to adapt, to determine how infrastructure will be affected, and create a summary report of the best ways to adapt and mitigate the impending impacts.¹¹⁹ Importantly, the NPCC understands, “good planning and cost-effective steps taken now as new development takes place or properties are retrofitted with regard to climate change predictions can prevent significant losses in the future”.¹²⁰ So, important measures taken now can greatly help in the future and reduce losses in the future. With these two newly established task forces currently working, we now have a better idea of what is ahead and what needs to be done.

In 2010, New York City’s government began the NYC Green Infrastructure Plan, acknowledging the importance of many of the green infrastructure or soft infrastructure designs previously discussed. Overall, there was a \$1.5 billion investment for the next twenty years to improve the city’s water quality and increase the city’s permeability.¹²¹ The plan has the goal of using alternative green approaches, like bioswales, green roofs, and blue roofs, to improve water quality and reduce overall runoff into the combined sewer overflow system by 10 percent.¹²² Blue roofs are roofs set up simply to capture rainfall in temporary storage containers to reduce runoff. This captured rainfall can then be directed to water plants, which is especially helpful in hot summers.¹²³ Overall, the plan hopes to reduced combined sewer overflow amounts by 3.8 billion gallons each year through green infrastructure, acknowledging that green infrastructure would also provide several other benefits, including reducing temperatures in the city, increasing property values, and reducing air pollution. The plan set targets to achieve 1.5% impervious area capture by 2015, an additional 2.5% by 2020, and an addition 6% by 2030.¹²⁴ Thus, the NYC Green

¹¹⁸ New York City Panel on Climate Change. “Climate Change Adaptation in New York City: Building a Risk Management Response”. C. Rosenzweig & W. Solecki, Eds. *Annals of the New York Academy of Sciences*, Vol. 1196, Wiley-Blackwell, May 2010, 2.

¹¹⁹ *Ibid*, 15.

¹²⁰ *Ibid*, 94.

¹²¹ “New York City Wetlands Strategy 2012”. New York: PlaNYC, May 2012, 21.

¹²² “New York City Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways”. New York: NYC Environmental Protection, Sept 2010, 1.

¹²³ *Ibid*, 56.

¹²⁴ *Ibid*, 3-4.

Infrastructure Plan at least acknowledges the importance of these functions, even though it lacks urgency.

Additionally, PlaNYC devoted the city to building more bluebelts and greenbelts. Bluebelts take advantage of the natural functions of wetlands and promote the natural retention and filtration of runoff. Bluebelt programs have been successful in Staten Island and Queens.¹²⁵ It has been estimated that twenty 200-square-foot bioswales are needed to store one inch of rain on one acre, which would cost \$30,000 each.¹²⁶ Meanwhile, greenstreets promote the use of vegetation, porous materials, and bioswales, while greenbelts connect vegetated areas to promote habitat continuation. Overall, the Department of Environmental Protection estimates that for the Green Strategy to be applied across the city, it would cost \$5.3 billion, which is cheaper than the other suggested Grey Strategy that would cost \$6.8 billion.¹²⁷ The fact that the city is investing in green infrastructure is a major step towards a more resilient city; however, more must be done to ensure the improved resilience and sustainability in the future.

Aside from the Green Infrastructure Plan, more recently, in May of 2012 Mayor Bloomberg invested in wetlands projects and conservancy. The City invested \$48 million to restore 127 acres of wetlands, which would add an additional 75 acres to the New York City Parks system. In doing so, Mayor Bloomberg established the first natural wetlands conservancy for the city, which is in charge of both managing resources and wetlands projects. These 127 acres of wetlands make up 16 different sites, which include projects in Meadow Lake in Queens, Inwood Park in Manhattan, Freshkills Park in Staten Island, and Pugsley Creek in the Bronx.¹²⁸ In 1975, New York State legislature passed The Freshwater Wetlands Act, where freshwater wetlands of 12.4 acres or more would be regulated under the act.¹²⁹ Although there are exceptions to the size of the wetland, most wetlands that were smaller than 12.4 acres were still left vulnerable to development and destruction. The wetlands strategy that Mayor Bloomberg has established builds off of this Act. The wetlands strategy ensures that there will be no net losses of wetlands in the years to come and that the losses of wetlands should be minimized as much as possible.

¹²⁵ “New York City Wetlands Strategy 2012”. New York: PlaNYC, May 2012, 21.

¹²⁶ “New York City Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways”. New York: NYC Environmental Protection, Sept 2010, 22.

¹²⁷ *Ibid*, 30.

¹²⁸ “New York City Wetlands Strategy 2012”. New York: PlaNYC, May 2012, 4.

¹²⁹ *Ibid*, 14.

Another goal of this strategy is to improve the management of wetlands, while also finding ways to best balance wetlands protection and other competing interests.¹³⁰ Thus, with Mayor Bloomberg's wetlands plan in place, at the end of 2013 the City will have worked with the State and Federal governments to finish the \$48 million investments in restoring 16 sites across the New York City area.¹³¹ Therefore, excitingly, the city has made important moves towards the protection of wetlands; however, the city must increase urgency to ensure that wetlands continue to be preserved and conserved for the city to achieve improved resilience and sustainability in the future.

Just after Hurricane Sandy, Governor Cuomo established three commissions in November of 2012 to help improve New York State's emergency preparedness and also improve vulnerable infrastructure. NYS 2100 Commission is one of these three commissions. This commission is co-chaired by Judith Rodin and Felix G. Rohatyn and is in place to improve resilience and infrastructure in terms of natural disasters. This commission is in charge of repairing damaged infrastructure, protecting the infrastructure, looking into other long-term options, and ways to improve risk management. Another commission that Governor Cuomo put in place is the NYS Respond Commission, which focuses on improved responses, which includes planning, training, and adequate resources. The NYS Respond Commission is co-chaired by Thad Allen and Brad Penuel. This commission should ensure there are enough trained professionals, that hospital patients and other people that are vulnerable are protected, that the public receives timely information, that locations are prepared for disaster, and that there are rapid responses to vital needs. The third commission put in place was the NYS Ready Commission, which must make certain that critical systems are prepared to withstand future storms or emergencies. This commission is co-chaired by Ira M. Millstein and Dr. Irwin Redlener. This commission must increase the resiliency of the health care, energy, transportation, and communication systems, make sure there are adequate amounts of vital supplies, ensure responders can communicate, and that decision-makers have dependable, immediate information.¹³² Thus, these are the three commission put into place after Hurricane Sandy.

¹³⁰ Ibid, 7.

¹³¹ Ibid, 28.

¹³² Governor's Press Office. "Governor Cuomo Announces Commissions to Improve New York State's Emergency Preparedness and Response Capabilities, and Strengthen the State's Infrastructure to Withstand Natural Disasters". November 15, 2012.

In terms of recovery just after Hurricane Sandy, the government is currently considering plans and implementing new regulations to improve future preparedness. On December 7, 2012, President Obama proposed a \$60.4 billion emergency bill. After weeks of debate, in late January of 2013, congress approved an emergency aid package of almost \$51 billion to help those affected by Hurricane Sandy. Fiscal conservatives, who were against increasing the federal deficit, caused most delays for this aid package. The emergency aid package will help those who lost property or financial business losses, while also going towards restoring shorelines and repairing infrastructure.¹³³ Interestingly, in February Governor Cuomo proposed a buyout program to spend up to \$400 million to purchase homes in flood-prone areas damaged by Hurricane Sandy and turn them into buffers. Residents would be offered the pre-storm value of their home, while those in the most vulnerable areas would be offered a bonus and even more of a bonus if the whole block decided to leave. In Governor Cuomo's State of the State address, he validly declared, "there are some parcels that Mother Nature owns".¹³⁴ However, it is evident that many residents will not want to move, for various reasons including attachment to their house and they estimate that 10 – 15% would take the buyout.¹³⁵ Although some may not want to accept it, planned retreats may be necessary in the most vulnerable areas. Thus, this is some of the more recent news since Hurricane Sandy hit.

Importantly, new Federal Emergency Management Agency (FEMA) maps are now being updated to establish flood zones and insurance needs. FEMA quickly worked to complete new maps of the areas that were most damaged including parts of Staten Island, Queens, and Brooklyn. While these maps will not fully go into effect for two years, the government is encouraging owners to rebuild with these maps and subsequent building codes in mind. If owners with federally backed insurance policies abide by the new codes, they could get up to an addition \$30,000. Then owners are forced to decide whether to rebuild according to future codes or have to pay increased insurance rates later on.¹³⁶ PlaNYC began to work with FEMA to update these maps as best as possible to included better data and including rising sea levels. Originally, FEMA maps are only backwards looking, so they only take into account past floods

¹³³ Raymond Hernandez, "Congress Approves \$51 Billion in Aid for Hurricane Sandy Victims". *New York Times*, January 29, 2013.

¹³⁴ Thomas Kaplan, "Cuomo Seeking Home Buyouts in Flood Zones". *New York Times*, February 4, 2013.

¹³⁵ *Ibid.*

¹³⁶ Cara Buckley, "Twice as Many Structures in FEMA's Redrawn Flood Zone". *New York Times*, January 29, 2013.

and did not account for rising seas that could make flooding even worse. FEMA maps should also include other important climate change data. FEMA must include an increase in intensity of storms in the years to come, which would not only affect flood zones, but also insurance rates.¹³⁷ FEMA must take climate change into consideration because it can greatly increase risks of flooding and insurance rates. Thus, FEMA maps were inadequate during Hurricane Sandy and they must be improved, especially in terms of including future projections of climate change in the data.

An emphasis on new building standards is also incredibly important during this rebuilding process. In the destruction after Hurricane Sandy, it became evident that many of the affected buildings were not up to current flood regulations. Most of the buildings impacted by Hurricane Sandy were built before 1983 when important building codes changed. Of all the impacted buildings, 84 percent were built before 1983. Of the buildings that were most severely impacted, 95 percent were built before 1983.¹³⁸ So, more older buildings were impacted rather than new buildings, which means that the newer codes were effective. The IPCC understands the importance of post-disaster rebuilding, emphasizing that rebuilding is the chance to improve structures and reduce future risks from natural disasters. The IPCC warns that quickly rebuilding without long-term planning will allow the same event to happen again or even worsen vulnerabilities.¹³⁹ It is especially important to think of long-term planning that incorporates impacts of climate change when rebuilding infrastructure because infrastructure is expected to last long periods of time.¹⁴⁰ Thus, it is crucial to take this time as an opportunity and to act wisely during the entire rebuilding process.

One interesting rebuilding situation is being considered in the Highlands in New Jersey. The Highlands was greatly damaged by Hurricane Sandy, where 1,250 of the 1,500 homes were badly damaged by the storm or even worse. A storm surge barrier or seawall has been ruled out because in this location the water would still be able to seep in from underneath, so it would not prevent flooding. Instead, the town and its Mayor Frank Nolan have proposed that their best long-term rebuilding option is to elevate

¹³⁷ New York City Panel on Climate Change. "Climate Change Adaptation in New York City: Building a Risk Management Response". C. Rosenzweig & W. Solecki, Eds. *Annals of the New York Academy of Sciences*, Vol. 1196, Wiley-Blackwell, May 2010, 131.

¹³⁸ Seth W. Pinsky. "Growing New York City's Economy". Filmed January 2013. New York Law School, 1:00:56.

¹³⁹ C.B. Field, V. Barros, T.F. Stocker, et al, eds. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* Cambridge: Cambridge University Press, 2012, 10.

¹⁴⁰ *Ibid*, 367.

the entire town by 10 feet to lift all the buildings out of harms way. However, such a solution would be costly at more that \$25 million and the federal government would probably not fund such a project.¹⁴¹ Most notably, this solution could still be problematic. Building up does not necessarily mean building in a more resilient way. No matter what, nature will take its course. While this is an extreme measure, other areas across the Jersey shore have started to rebuild their destroyed dunes, valuing importance of dunes for protecting their towns. Thousands of Christmas trees were saved from homeowners and shops to line the damaged beaches. These trees act as a great first-step to restore dunes, where the pine needles slowly begin to catch wind-blown sand until a dune starts to build up.¹⁴² This type of a solution would provide some protection, while also having other benefits like increasing habitats and supporting biodiversity. Thus, at this time, rebuilding and rebuilding in the right ways are incredibly important.

One way to improve the long-term rebuilding process includes rezoning the affected areas to reduce future risks. Zoning decides the land use and what types of buildings can be built where. Zoning also determines the building's size and shape or how the space can best be used. In the rebuilding process after Hurricane Sandy, zoning must be reconsidered to include projections for the impacts of climate change. Since climate change will increase sea levels and increase risks of flooding, better zoning can reduce the harmful impacts cause by these types of events.¹⁴³ Rezoning now with future risks in mind will help to reduce those risks in the future. This sort of planning can help to create plans to avoid rebuilding in certain areas or to prepare for managed retreats from certain areas, which will be necessary in the wake of Hurricane Sandy. Having such managed retreats of the most vulnerable areas will reduce future risks associated with people's safety and property.¹⁴⁴ In rezoning, it is important to increase the amount of open space and to encourage ecological designs, like green roofs. Ensuring open spaces for recreational uses, especially along the edges of the city, will allow for sacrificial areas that can be flooded during a storm without large repercussions. Improving buildings codes will also be important. One major

¹⁴¹ Applebome, Peter. "Lifting a Town to Escape the Next Storm". *New York Times*, February 22, 2013.

¹⁴² Schwirtz, Michael. "On Decimated Shore, a Second Life for Christmas Trees". *New York Times*, February 4, 2013.

¹⁴³ New York City Panel on Climate Change. "Climate Change Adaptation in New York City: Building a Risk Management Response". C. Rosenzweig & W. Solecki, Eds. *Annals of the New York Academy of Sciences*, Vol. 1196, Wiley-Blackwell, May 2010, 92.

¹⁴⁴ C.B. Field, V. Barros, T.F. Stocker, et al, eds. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* Cambridge: Cambridge University Press, 2012, 10.

problem exposed during Hurricane Sandy was the fact that electrical and heating equipment was largely located in the basements of buildings, which were prone to flooding. Requiring buildings to move this equipment and emergency generators to locations above flooding risks will decrease their risk of malfunction.¹⁴⁵ Thus, even a simple restriction, like moving this equipment, would reduce future vulnerabilities to flooding. No matter what, nature will take its course, so it is better to reduce these vulnerabilities as much as possible. Therefore, rezoning will help to reduce future vulnerabilities to storms and climate change.

In recent years, increased development in coastal cities has put more people at risk to events like Hurricane Sandy. What has happened with Hurricane Sandy will force coastal cities all over the world to consider climate change, including rising sea-levels and the potential for increased storm intensity. Cities will have to reconsider their zoning, infrastructure, transportation, and emergency services. Essentially, governments can choose to ignore the issues of climate change or choose to act, which leads to different scenarios. If the government chooses to do nothing, does not help the poorer locals, and allows certain people or institutions to have more power and access to particular resources, then their populations will lose confidence in their government, institutions, and social order.¹⁴⁶ This loss of confidence could lead to desperation that could result in conflict, unrest, and possibly even violence. This is much like what happened in New Orleans after Hurricane Katrina. Doing nothing will increase social marginalization, making the poor worse off. Therefore, governments that choose not to act risk conflict, violence and, further social marginalization of their poorer populations.

Cities will be better off if the government cooperates on multiple levels and recognizes the ways in which its citizens may be affected socially, economically, and politically. Dialogue and cooperation on multiple levels is essential for the best ways to mitigate the effects of climate change and increase a country's resiliency. On the lowest level, local communities need to work together and address the issues they face. Local communities often best document the issues they face and their experiences with climate

¹⁴⁵ New York City Panel on Climate Change. "Climate Change Adaptation in New York City: Building a Risk Management Response". C. Rosenzweig & W. Solecki, Eds. *Annals of the New York Academy of Sciences*, Vol. 1196, Wiley-Blackwell, May 2010, 94

¹⁴⁶ Dan Smith and Janani Vivekananda, "A Climate of Conflict: The Links between Climate Change, Peace and War". *International Alert*, November 2007, 20.

change.¹⁴⁷ However, local communities often lack adequate resources and means to improve their situations.¹⁴⁸ The government also needs to learn to work with the locals to help them find local solutions; however, they may not be capable of doing so on their own.¹⁴⁹ Problem solving cannot be left to solely local communities or the federal government; the best solutions come from when they work together. Thus, the way a government chooses to handle climate-related or disaster issues will greatly affect their future.

Overall, New York City is headed in the right direction, but more aggressive measures must be taken to ensure improved resiliency and sustainability. The establishment of PlaNYC and New York City Panel on Climate Change were important steps towards acknowledging the future impacts of climate change and attempting to prepare for them. The fact that the government has invested in green infrastructure plans and wetlands protection projects is also important. The creation of the NYS 2100 Commission, NYS Respond Commission, and NYS Ready Commission will also greatly improve the preparation and recovery of future natural disasters. However, if we are to take future natural disasters and climate change seriously more major steps must be taken immediately. Overall, improved building standards, codes, zoning, encouraged ecological designs and regulations will all need to come from the political sphere. Considering long-term preparedness is essential for increasing the city's resilience and sustainability. We often fall into the trap of shortsightedness, where improvements for handling long-term issues, like climate change, are put off for more immediate issues.¹⁵⁰ We cannot continue to fall into this trap. We must begin to plan for future natural disasters and the impending effects of global warming. Improvements now will reduce risks later. The government needs to act wisely at this point in time. Rebuilding after Hurricane Sandy can be taken as a chance to better prepare for future storms and climate change, change building standards, improve zoning, and mandate even more environmental

¹⁴⁷ C.B. Field, V. Barros, T.F. Stocker, et al, eds. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* Cambridge: Cambridge University Press, 2012, 294.

¹⁴⁸ Ibid, 449.

¹⁴⁹ Dan Smith and Janani Vivekananda, "A Climate of Conflict: The Links between Climate Change, Peace and War". *International Alert*, November 2007, 8.

¹⁵⁰ C.B. Field, V. Barros, T.F. Stocker, et al, eds. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* Cambridge: Cambridge University Press, 2012, 451.

design whenever possible. Ultimately, it is time to start easing into and incorporate designs and regulations that we will inevitably have to do with the looming impacts of climate change.

CONCLUSION

Therefore, Hurricane Sandy revealed that we cannot rebuild what used to be in these areas without considering original ecosystems or potential future problems in terms of hurricanes and climate change. We also must not rely too heavily on hard infrastructures; instead, restoring natural systems and incorporating natural barriers will help to increase resiliency as they provide many benefits and higher capacities to recover. Beginning a shift towards more resilient and sustainable designs is vital to prepare for the future. Now is our chance to start making this much-needed change. The three disciplines, environmental history, environmental design, and policy intertwine and work together in many ways when considering the question of rebuilding after Hurricane Sandy. Environmental history closely relates to environmental design. Environmental history reveals the baseline ecology of the Manhattan area. This gives us insight into what used to thrive in those areas and the functions that those ecosystems played. For some of those ecosystems, like marshes, they serve very important functions, including the reduction of flooding, slowing of runoff, and recharging of groundwater. Environmental design would encourage the restoration of such ecosystems as well as dunes and barrier islands. These are all natural forms of protection. We can learn a lot from nature and its processes; nature put them there for a reason. Environmental design would also encourage building green infrastructure and energy efficient buildings to promote long-term sustainability. This becomes important when considering the larger picture of global warming with rising sea levels, increased storm intensity, increased flooding, and increased temperatures. Such designs would also integrate with environmental policy on how governments choose to handle disasters like Hurricane Sandy and climate change, which could greatly help or hinder the situation. The government must improve preparedness for natural storms, reconsider zoning, and improve building codes to reduce risks. Governments can also choose to be proactive through promoting such ecological designs, which would be beneficial in the long-term picture. Thus, Hurricane Sandy revealed many vulnerabilities and flaws in the way that we currently live, but through reassessing where

we live and how we rebuild, we will ultimately be able to increase our resiliency and sustainability through utilizing environmental history to inform ecological designs to influence environmental policies.

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