RUTGERS

Office of the President

TASK FORCE ON CARBON NEUTRALITY AND CLIMATE RESILIENCE

Solutions Assessment: Climate Preparedness

Report of Working Group 6

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Working Group Membership

Robin Leichenko, *co-chair, School of Arts and Sciences, Rutgers University–New Brunswick*
David Robinson, *co-chair, School of Arts and Sciences, Rutgers University–New Brunswick and New Jersey Agricultural Experiment Station*

Francisco Artigas, *School of Arts and Sciences, Rutgers University–Newark*
Lisa Auermuller, *Jacques Cousteau National Estuarine Research Reserve - New Jersey Agricultural Experiment Station*
Tony Broccoli, *School of Environmental and Biological Sciences, Rutgers University–New Brunswick*
Brian Buckley, *Environmental and Occupational Health Sciences Institute*
David Bushek, *School of Environmental and Biological Sciences, Rutgers–New Brunswick*
Patricia Findley, *School of Social Work. Rutgers–New Brunswick*
Panos Georgopulos, *School of Public Health, Rutgers Biomedical and Health Sciences*
Jeffrey Issle, *Office of Emergency Management – Newark, Institutional Planning and Operations*
Marjorie Kaplan, *Rutgers Climate Institute*
Steven Keleman, *Office of Emergency Management, Institutional Planning and Operations*
Laura Landau*, *School of Arts and Sciences, Rutgers–New Brunswick*
Rory Langan*, *School of Social Work, Rutgers– Newark*
Ric Marlink, *Robert Wood Johnson Medical School, Rutgers Biomedical and Health Sciences*
Mark McLane, *Rutgers Environmental, Health and Safety, Institutional Planning and Operations*
Kathe Newman, *Bloustein School of Planning and Public Policy, Rutgers–New Brunswick*
Nancy Pontes, *School of Nursing, Rutgers–Camden*
Ashaki Rouff, *School of Arts and Sciences, Rutgers–Newark*
Alejandro Ruiz, *Rutgers Environmental Health and Safety, Institutional Planning and Operations*
Jennifer Schrum*, *School of Social Work, Rutgers–New Brunswick*
Soko Setoguchi, *Robert Wood Johnson Medical School, Rutgers Biomedical and Health Sciences*
Natalie Teale*, *School of Arts and Sciences, Rutgers–New Brunswick*
Ruo-Qian Wang, *School of Engineering, Rutgers–New Brunswick*
Roger Wang, *Rutgers Business School, Rutgers–New Brunswick*
**Section research and writing lead*

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EXECUTIVE SUMMARY

Climate resilience entails the ability to recover and bounce forward from climate shocks and stresses in a manner that enhances preparedness for future climate events. This work group conducted an initial scoping of climate resiliency at Rutgers through an examination of climate-related risks affecting Rutgers campuses, identification of sectoral impacts and group vulnerabilities, and examination of current preparedness planning. The workgroup also explored climate preparedness planning at other universities and considered preparedness lessons from Rutgers' response to COVID-19. Beyond Rutgers' four main campuses, the work group also considered the university's field stations and research sites, clinical facilities, and the surrounding communities and commuter-shed regions.

Over the past several decades, Rutgers' campuses have experienced numerous extreme climate events. The diversity of Rutgers' properties, from large campuses to coastal field facilities to experimental farms and forests throughout the state, makes the university and its people vulnerable to multiple climate risks including extreme heat events, coastal and inland flooding, damaging winds, snowstorms, floods, and tropical and extratropical storms.

The sectoral impacts identified in this scoping report suggest that the university's energy and infrastructure systems, buildings, facilities, and land resources face significant and growing climate risks. The examination of group vulnerabilities indicate that climate impacts have uneven effects among students, staff, and faculty, and members of surrounding communities. Individuals who are already experiencing housing, food, and income insecurities, as well those with mental and physical health challenges, are generally more at risk.

Climate change will affect the teaching, research and service missions of Rutgers University. Results of this initial scope report suggest that there is a critical need for a comprehensive climate impact and vulnerability assessment for all four Rutgers campuses (New Brunswick, Newark, Camden and RBHS), outlying facilities and surrounding communities. Carbon neutrality planning across all sectors -- from energy to water supply to housing and dining -- needs to incorporate projected climate risks and to plan for climate change adaptation. There are also many areas where adaptation planning and action at Rutgers, such as tree planting to reduce localized heat island effects, can also contribute to carbon neutrality goals. Identifying opportunities to combine adaptation and mitigation is a critical next step toward achieving climate resilient carbon neutrality at Rutgers University.

6.1 Introduction

Climate resilience entails the ability to recover and bounce forward from climate shocks and stresses in a manner that enhances preparedness for future climate events. This work group conducted an initial scoping of climate resiliency at Rutgers through an examination of climate-related risks affecting Rutgers campuses, identification of sectoral impacts and group vulnerabilities, and examination of current preparedness planning. The workgroup also explored climate preparedness planning at other universities and considered preparedness lessons from Rutgers' response to COVID-19. Beyond Rutgers' four main campuses, the work group also considered the university's field stations and research sites, clinical facilities, and the surrounding communities and commuter-shed regions.

The on-going COVID-19 pandemic is a clear reminder that climate change impacts intersect with multiple processes of change, including other social, economic, and environmental stresses. In the current context, climate change preparedness efforts at Rutgers are overlapping with responses to the pandemic, including a partial campus shutdown, as well as with the on-going crises of racial injustice, rising inequality, and growing economic insecurity. The pandemic-related economic downturn in New Jersey has also contributed to significant loss of university revenue.

This work group used a stakeholder-based approach to assessment of climate risks and vulnerabilities at Rutgers. Stakeholder-based investigation of critical climate exposures, response capacities, and resiliency options and strategies is a commonly used method for vulnerability assessments (Leichenko et al. 2014). For Rutgers, a broad suite of stakeholders is involved in climate preparedness planning. These include representatives from emergency management and risk planning, and other individuals with direct responsibility for university operations including energy systems, communication, transportation, water supply and waste-water systems, dining, housing, athletics, facilities, police, labor relations, and information services, among others. Stakeholders also include representatives of key constituency groups such as students, faculty, staff, and administrators, and members of local communities in each campus region. The workgroup drew on the full membership of the climate task force to gain access to individuals responsible for or involved with university operations. The work group also relied on information collected during the town hall meetings conducting during early 2020, as well as interviews with student groups and student representatives on the task force, and interviews with other faculty and staff. Due to the COVID-19 pandemic, a wider, community-based stakeholder engagement process was not possible. Ensuring broad and inclusive participation from all four campus communities is a critical next step for preparedness planning at Rutgers.

Results of the interviews with task force and other individuals informed the development of the climate risk profile (Section 2), sectoral and group vulnerability assessments (Sections 3 and 4), description of preparedness plans (Section 6), and the case analysis of lessons from the COVID-19 response (Section 7). The analysis of preparedness planning at other universities (Section 5) was conducted via review of published sustainability and preparedness plans at numerous other universities.

6.2. Climate Risk Profile

Over the past several decades, Rutgers' campuses have experienced numerous extreme climate events. The diversity of Rutgers' properties, from large campuses to coastal field facilities to experimental farms and forests throughout the state, makes the University vulnerable to multiple climate risks. This section describes key climate-change related extreme events previously observed and short and long-term risks expected to impact the Rutgers community in the years and decades ahead.

New Jersey's middle-latitude coastal location leaves the state directly exposed to most every climate variable imaginable. Even distant volcanoes and ice sheets play a role in determining New Jersey's climate and bordering sea level. The state has four relatively well-defined seasons, with clashes between cold and warmth triggering occasional severe weather conditions. However, most of the threatening weather and climate events affecting New Jersey fail to reach the extremes experienced elsewhere. This is a result of New Jersey's proximity to the Atlantic Ocean that moderates winter cold and tends to keep summer heat in check. This also inhibits severe thunderstorm development, including strong tornadoes, and its waters are not warm enough to sustain extreme hurricanes. Still, on occasion New Jersey can bear the brunt of major storms, this being abundantly evident with Sandy in October 2012. There is also the expectation that as the climate of the Mid-Atlantic region changes, more extreme conditions will become more common, with the eventual exception of severe winter cold and snow.

6.2.1 Past extreme events

Examination of the impact of past extreme climate events on Rutgers campuses and operations offers important insights into critical exposures, vulnerabilities, and areas where resilience-building is needed. New Jersey has long been subject to extreme events such as damaging winds, snowstorms, floods, tropical storms and extreme heat. The first of two examples feature the Raritan River, which flows through the Rutgers-New Brunswick campuses. Significant flooding of the Raritan has occurred on many occasions over the past several decades. The top 15 Raritan River flood crest events since 1970 are documented in Table 6.1. These include "named events" such as Hurricane Floyd in 1999 and Tropical Storm Irene in 2011, as well as large Nor'easters and other "unnamed storms." Two such events (April 2007 and May 2014) and are illustrated in Figure 6.1. The Floyd and Irene floods far exceed any recorded in over a century and likely since at least Colonial settlement. The impacts of major flood events include disruption of campus functions due to loss of road access between campuses and from the surrounding region, loss of power, telephone service and internet access, and disruption of water supplies and waste-water systems.

Table 6.1. Top 15 flood events on the Raritan River at Bound Brook, the closest US Geological Survey gage to the New Brunswick campus. Flood stage is considered 28 feet and major flood stage is 33 feet. Source: Office of the New Jersey State Climatologist.

(1) 42.13 ft on 09/17/1999 (Hurricane Floyd)
(2) 41.90 ft on 08/28/2011 (Tropical Storm Irene)
(3) 38.38 ft on 04/16/2007 (see Figure 1)
(4) 37.47 ft on 08/28/1971 (Tropical Storm Doria)
(5) 36.04 ft on 03/14/2010
(6) 35.58 ft on 10/20/1996
(7) 34.65 ft on 05/01/2014 (see Figure 2)
(8) 33.34 ft on 01/20/1996
(9) 33.18 ft on 01/25/1979
(10) 33.14 ft on 09/09/2011 (Tropical Storm Lee)
(11) 32.00 ft on 07/07/1984
(12) 31.84 ft on 04/16/1983
(13) 31.73 ft on 12/21/1973

(14) 31.33 ft on 01/26/1978
(15) 31.10 ft on 04/17/2011

Figure 6.1. Top: View of New Brunswick and Route 18, April 16, 2007 (photo credit: John Munson, Star Ledger); Bottom: Landing Lane, Piscataway, May 1, 2014 (photo credit: Mathieu Gerbush, Office of the New Jersey State Climatologist).

The most significant climate event affecting Rutgers campuses in living memory is Post-Tropical Storm ("Superstorm") Sandy, which occurred in late October 2012. Sandy's impacts were widespread, affecting operations at all Rutgers campuses (Emergency Preparedness Task Force 2013). In New Brunswick, loss of power severely compromised university operations resulting in cancellation of classes for a week. Along with loss of power, IT and email systems, water supplies and bathroom facilities, security and swipe card access, and food service on and around campus were also disrupted. As a result of power outages on Cook-Douglass, several thousand residential students were relocated to temporary housing on the Livingston and Busch campuses. Other damage included loss of refrigeration of laboratory samples due to failure of back-up power, leading to destruction of data for numerous experiments. Operations at the Newark campus were also significantly disrupted by Sandy. While Newark's campus did not endure direct physical damage from the storm, power outages and loss of telephone service on campus in combination with loss of mass-transit and widespread road closures in the region, led to cancellation of classes for a full week. Rutgers-Camden experienced relatively less disruption to operations from Sandy. Camden did not lose power during Sandy and was able to resume classes within a few days after the storm, despite roof damage to the library and downed/damaged trees. However, Camden's off-campus populations from the Brookdale, Monmouth and Atlantic Cape campuses were significantly affected by storm damage and loss of power.

6.2.2 Short term risks and extreme events

6.2.2.1 Heat waves

New Jersey is prone to heat waves because its location on the east coast of North America exposes it to warm summer air masses of the continental interior and moist air masses of the Atlantic Ocean (NCEI State Summary, 2017). There is no universal definition of a heat wave. Instead, multiple definitions are used when assessing and projecting frequency and risks of heat waves. Specific criteria differ among definitions. For instance, one definition is based on the number of days with an average temperature above the 95th percentile; another on daily high and low heat indices (Wu et al., 2014). Heat waves pose an increasing strain on environmental and economic systems of New Jersey, leading to increased vulnerability of the state's residents (Horton et al., 2014). Urban residents in New Jersey's densely populated cities face unique vulnerabilities from heat waves through the urban heat island effect. Nighttime temperatures in large northeastern cities are generally several degrees higher than surrounding regions, increasing heat-related deaths among vulnerable populations, typically those with pre-existing health conditions and a lack of air-conditioning (Horton et al., 2014). The number of warm nights in New Jersey during the 21st century, in which nighttime low temperatures stay above 70°F, is consistently above the 1900–2014 mean (NCEI State Summary, 2017). In rural areas where heat waves have been rare historically, vulnerability to increased heat waves is related to limited preparedness. Vulnerability is further heightened as key infrastructure, including electricity for air conditioning, is more likely to fail precisely when it is most needed, and increase potential for substantial negative health consequences (Dupigny-Giroux et al., 2018).

The impacts of increased frequency of extreme high temperatures go beyond the direct effect of temperature on human physiology. A significant increase in New Jersey heat waves puts economic pressure on households by furthering summertime stress of energy demands (Dupigny-Giroux et al., 2018). Within urbanized areas with high concentrations of road infrastructure, the hottest temperature days are most associated with higher concentrations of ozone and ground pollutants, putting those with pre-existing conditions at higher risk (Dupigny-Giroux et al., 2018). In addition to impacts in New Jersey cities such as Newark and Camden, the projected increased frequency of summer heat stress can also negatively affect New Jersey crop yields and milk production. While precipitation in New Jersey is not expected to decrease, longer and more demanding growing seasons mean farmers face the risk of too little water in the future (Horton et al., 2014). The amount of additional heating in New Jersey depends on initiatives to limit global emissions of greenhouse gases. Under scenarios where emissions continue to increase and where emissions are reduced effectively, heat waves are predicted to increase in frequency, intensity and duration (Horton et al., 2014), with greater effects in the case of increased emissions.

6.2.2.2 Extreme precipitation events

Extreme precipitation events are becoming more common in New Jersey. While definitions of "extreme precipitation" vary by application and sector, most definitions show an increasing frequency in extreme precipitation in the state. Considerably more precipitation events exceeding two inches have been observed after 1970 than earlier in the twentieth century (Runkle et al. 2017) (Figure 6.2). So too has the frequency of precipitation events exceeding the 95th percentile of daily precipitation events based on 1901-2013 observations increased since the 1960s drought (Hoerling et al. 2016). In addition to the frequency of extreme precipitation, the intensity of extreme precipitation has also increased (Dupigny-Giroux et al. 2018). The increases in precipitation intensity in the Northeast are greater than the increases elsewhere in the United States (Easterling et al. 2018).

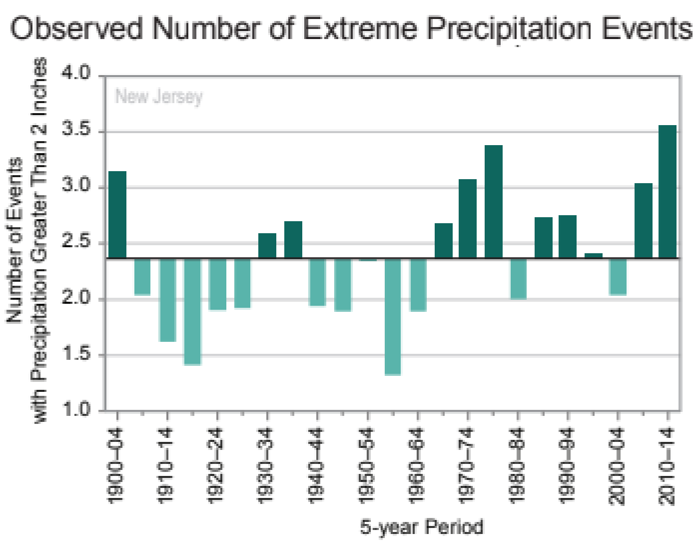

Figure 6.2: Number of extreme precipitation events in New Jersey per five-year period. Figure from Runkle et al. (2017) NCEI State Summary.

The frequency and intensity of heavy precipitation events are projected to increase through the twenty-first century (Easterling et al. 2017). Precipitation events exceeding a 5-year return period are projected to occur two to three times more often by the end of the 21st century in high-emission scenarios (Easterling et al. 2017). The most extreme precipitation events in New Jersey often occur with tropical and post-tropical cyclones. This is exemplified by rainfall exceeding 10 inches observed at multiple stations throughout New Jersey with Hurricane Floyd in September 1999 and Tropical Storm Irene in August 2011.

6.2.2.3 Flooding (fresh water)

Freshwater flooding is caused by an excess of water from rain and/or melting snow, beyond what can be absorbed and removed by the near surface hydrology and, in urban areas, drainage systems. Antecedent conditions, such as soil moisture prior to a large precipitation event, significantly affect the saturation and runoff of excess precipitation. The storage and timing of water also impacts streamflow. In New Jersey, storage includes snow reservoirs (most often in northern high elevations) as well as built reservoirs for water resources. In a warming climate, winter precipitation is more likely to occur as rain instead of snow. This increases winter streamflow, as the precipitation is not stored in the snowpack before entering the streamflow system. This increased baseflow augments risk for winter flooding. Seasonal snowpack in New Jersey has melted earlier in the spring, shifting by several weeks, thus shifting the peak snowmelt-related streamflow to earlier in the year and reducing runoff in the spring (NJDEP-SAB 2020). This shift may have impacts in reservoir management in northern New Jersey, potentially impacting water resources throughout the spring and summer if meltwater must be released earlier in the year to prevent reservoir overfill.

The high level of development and urbanization in New Jersey has significantly altered the natural hydrologic process, such that streamflow projections must be considered from an engineering standpoint as well as that of hydrology and climatology (NJDEP-SAB 2020). This is exemplified through negligible trends in high streamflow at undeveloped sites, and upward trends in high streamflow at developed sites. These upward trends represent that urbanization and regulation in these basins decreases the ability to absorb excess runoff, therefore exacerbating high streamflow conditions (NJDEP-SAB 2020).

Because freshwater flooding is dependent on multiple variables, many of which are sensitive to climate change, projections in flooding are not uniform. Antecedent soil moisture may be lower as a result of increased evapotranspiration in warmer temperatures. However, there is some evidence that projections may overestimate evapotranspiration rates in hydrological models, and that soil conditions may be wetter and more prone to flooding than some models project (Milly and Dune 2017). Development of local land areas (e.g., land cover and floodplain development) and water resources (e.g., stormwater management, freshwater intake) must be taken into account when considering flood potential in climate change scenarios, alongside regional increases in heavy precipitation that would likely drive increases in runoff (Van Abs, 2016).

6.2.2.4 Hurricanes, tropical storms, and storm surge flooding

Climate change supplements many potential natural hazards associated with hurricanes (Van Abs, 2016). Hurricanes approaching New Jersey have a greater propensity for damage than hurricanes of the same strength near the Gulf of Mexico due to geographic, meteorologic, and demographic factors (Coch, 2015). The geography of New Jersey enhances orographic lift, as warm air can rise over the higher elevations and produce heavier rainfall. This was the case as Tropical Storm Irene passed over New Jersey and the Catskill Mountains where catastrophic river flooding occurred (Coch, 2015). Northeast hurricanes have severely affected the region's business and financial centers (Coch, 2015). Sandy isolated many New Jersey shoreline as well as inland communities for a significant amount of time because of flooding and power outages (Coch, 2015). Tropical systems do not have to be hurricane intensity to have severe impacts, as was the case of Tropical Storm Isaias in 2020, which left 1.3 million customers without power in New Jersey alone (Kerr, 2020).

Future Atlantic conditions project significant increase of lifetime maximum hurricane intensity in high-resolution experiments (Knutson et al., 2013). Frequency of very intense Category 4 and 5 hurricanes is also projected to significantly increase (Knutson et al., 2013), increasing risks of tree damage and power outages during the hurricane season. Hurricane rainfall rates increase robustly for the CMIP3 and CMIP5 scenarios, and projected increases in atmospheric water vapor content could result in 20%-30% total additional precipitation output from hurricanes. In addition to expected sea level rise, the threat of storm surge and flooding is exacerbated by increased rainfall amounts (Knutson et al., 2013). Stronger storms produce a greater threat for wind damage in inland communities (Coch, 2015)

According to the National Hurricane Center, storm surge is defined as the total water level that occurs on normally dry ground as a result of storm tide, typically measured in feet of water above ground level. Sea level rise increases potential for erosion and puts already high-risk storm surge flooding areas at a greater risk. These risks escalate further in major coastal storms where a combination of storm surge, tides and wave action can cause saline water to penetrate far inland from the normal high tide mark. New Jersey's vulnerability to surge from coastal storms was demonstrated with Sandy, which generated intense storm surge and flooding that devastated New Jersey and New York coasts. During the historic storm, water levels were pushed as much as nine feet above normal values, shattering previous record water levels by upwards of four feet along the northern NJ ocean coast and adjacent estuaries. Sandy was dangerous because it compounded a large wind field with a unique storm track from the east, which meant its strongest winds in the northeast quadrant created the storm surge (Drews et al., 2015). The combined storm surge flooding inundating transfer stations and strong winds toppling trees and bringing down powerlines led to the vast majority of New Jersey customers losing power, with many not having power return for over a week (Manuel, 2013). This shut down heating systems and other life-saving systems. The storm cut off power or damaged approximately 80 sewage treatment systems in New Jersey, showing the threat to water quality from storm surge is greater than that of saline infiltration alone (Manuel, 2013).

6.2.2.5 Ice storms and winter storms

The distinct seasonality of New Jersey climate supports a diverse landscape and economy capable of adapting to the extremes of temperature and precipitation. This landscape provides the economic foundation for its significant number of rural communities, which are supported by a wide range of agricultural, tourism, and natural resource-dependent industries (Dupigny-Giroux et al., 2018). As Northeast winters warm, scenarios project a combination of less early winter snowfall and earlier snowmelt, leading to a shorter snow and ice season. The frequency of snowfall in New Jersey, which is largely determined by surface air temperature, is projected to decrease under continued warming (Ning and Bradley, 2015). Decreased frequency of winter storms presents a general risk for vegetation losing tolerance to cold temperatures (Dupigny-Giroux et al., 2018). Climate models suggest increased winter precipitation totals in the future, and the proportion of precipitation that falls as snow will continue to decrease in response to a northward shift in the rain-snow transition zone under most future emission scenarios (Dupigny-Giroux et al., 2018). Extreme daily snow amounts are more likely in higher elevations of northern New Jersey than other parts of the state in the future (Kunkel et al., 2016).

Regional maxima of freezing rain occur along the eastern slope of the Appalachians, supporting annual frequency of ice storms in northern New Jersey more than the rest of the state (Cortinas et al., 2004). Projections of future ice storm frequency are limited. If conditions remain susceptible to ice storms in New Jersey, especially at higher elevations, precipitation enhancement by climate change could increase intensity of ice storms. Based on increasing winter temperatures however, long term impacts from ice, such as potholes, can be expected to decrease in the future (NJDEP-SAB, 2016). Results suggest that the future frequency, intensity and geographical distribution of ice storms is a topic that deserves greater attention in climate change research.

6.2.2.6 Wildfire

While Rutgers' main campuses, except for the Rutgers New Brunswick's Livingston Campus adjacent to the Rutgers Ecological Preserve in Piscataway, are not vulnerable to wildfire, several field facilities, experimental sites, and the transportation infrastructure that brings individuals to and from the campuses can at times be threatened. Whether it be forest or grassland fires, flames and smoke can damage structures, infrastructure and, most critically, endanger the human health and safety. An average of 1500 wildfires annually damage 7,000 acres of New Jersey forests (https://www.state.nj.us/dep/parksandforests/fire/ff_aboutus.htm). Fires are most common during intervals of dry weather, particularly on days with elevated temperature, low humidity, and strong wind. While occurring at any time of the year, fire frequency peaks in New Jersey during spring before grasses green up and leaves emerge on trees to shade debris on the forest floor remaining from the previous growing season. Fires can ignite naturally from lightning strikes or from human activities, the latter being a poorly managed campfire, an unextinguished cigarette butt, sparks flying from a train track (most common in the Meadowlands), or arson. While most common in the extremely flammable Pine Barrens ecosystem, wildfires can occur in all NJ woodlands and grasslands. The state's most widespread and deadly wildfire outbreak occurred on April 20, 1963 when seven individuals perished, and 400 buildings were destroyed in multiple fires covering 183,000 acres in Burlington, Ocean and Atlantic counties. https://www.burlingtoncountytimes.com/article/20130422/NEWS/304229722 .

6.2.3 Long term risks

6.2.3.1 Rising mean temperatures

Annual and monthly mean temperatures are increasing across New Jersey. Over the past century, average annual temperatures have increased by 3°F (Runkle et al. 2017). According to the Office of the New Jersey State Climatologist, eighteen of the twenty warmest years in New Jersey since 1895 occurred in 1990 or later; six of the ten warmest years occurred from 2010 to 2019 (Robinson 2020a). Since 1895, most of the five warmest instances of each calendar month occurred after 1990, indicating warming in each season throughout the year ("New Jersey's Extreme Temperature and Precipitation Months" figure 2.3, top panel). The frequency of monthly mean temperature being in the warmest five months increased substantially after 2010; nine of the twelve months experiencing the warmest monthly temperatures on record after 2010 (Figure 6.3). July 2020 was the hottest month on record for New Jersey (1895-present), with the monthly mean temperature 4.2°F above the 1981-2010 July average (Robinson 2020b). While this record heat was influenced by a short heat wave at the end of the month, the high number of days above 90°F throughout the month along with warm nights contributed to the high monthly average. In other words, the mean temperature throughout the month was unusually high, enabling the record to be broken with the addition of a minor heat wave.

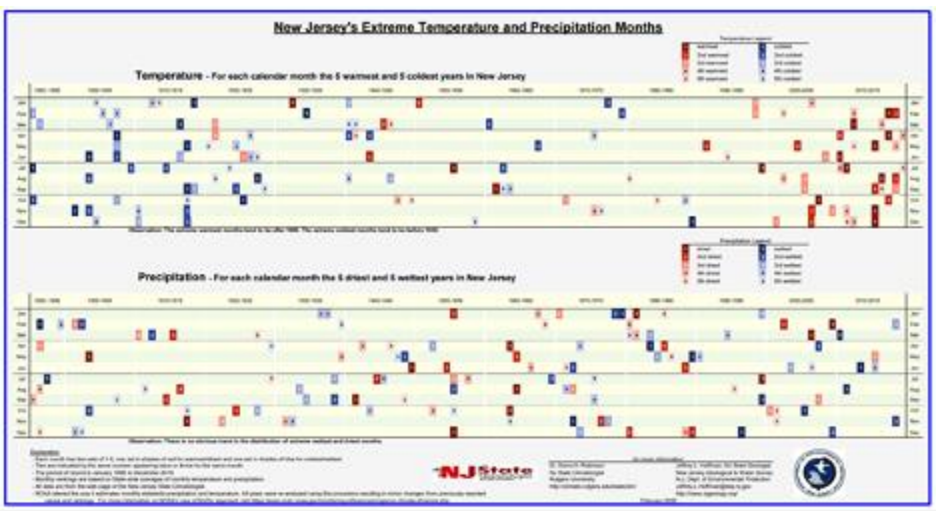

Figure 6.3: Warmest and coldest instances of each calendar month, 1895-2019 (top panel) and wettest and driest months (bottom panel). From the Office of the New Jersey State Climatologist, https://climate.rutgers.edu/stateclim.

Temperatures in New Jersey are projected to continue to increase through the twenty-first century, most always exceeding historical records by the middle of the century (Runkle et al. 2017). Winters are projected to continue to warm, shifting and decreasing seasonality across the Mid-Atlantic (Runkle et al. 2017). By the end of the century, temperatures are projected to rise faster in the summer than in the winter (Runkle et al., 2017). These increases may be further enhanced in the metropolitan areas that already experience warmer temperatures than surrounding areas due to the urban heat island effect (Dupigny-Giroux et al., 2018).

6.2.3.2 Drought

Several types of drought impact New Jersey. Meteorological drought is defined by dry conditions, or low precipitation (NCEI glossary). Other types of drought are defined by land surface conditions, such as low soil moisture, low stream flow, and insufficient water supplies to meet socioeconomic demands. The most severe meteorological drought in New Jersey in the instrumental period of record was in the mid 1960s. This long dry period, considered the drought of record in regional hydrological monitoring (DRBC (Delaware River Basin Commission) 2020; Van Abs, 2016), was associated with cold Atlantic sea surface temperatures suppressing precipitation through much of the Northeast and Mid-Atlantic (Namias et al., 1966; Seager et al., 2012). During this historic drought, Camden's water quality was threatened by saltwater intrusion coming up the Delaware River (DRBC 2020). Other types of droughts are becoming increasingly frequent in the region. For instance, warmer temperatures are associated with increased evapotranspiration, thus low soil moisture associated with agricultural drought. Earlier spring snowmelt (Dupigny-Giroux et al. 2018) reduces the volume of streamflow in late spring and summer, increasing the probability of hydrological drought in the region. High demands on the water supply for residential and commercial purposes as well as increased evapotranspiration further reduce the amount of water available for groundwater recharge and streamflow. The frequency of drought varies, from the historic four-year drought of the 1960s to shorter major droughts of 1981-82 and 2001-02 as well as short-term seasonal or intra-seasonal dry episodes, known as flash droughts.

While precipitation is not projected to decrease in New Jersey, projections show that earlier snowmelt and increased evapotranspiration from warmer temperatures and lengthened growing season will increase the frequency of hydrological and agricultural droughts in the region in summer and fall (NJDEP SAB 2016) as well as the range of water availability (Van Abs, 2016). Models suggest that while droughts may become more frequent, they will not necessarily be more severe (Van Abs, 2016; Horton et al. 2014). However, the frequency of moderate droughts may increase to a point at which water resources cannot recover between droughts, thereby compounding the effects on regional water supplies (Van Abs, 2016).

6.2.3.3 Sea level rise

Rising sea levels are driven by the melting of glaciers and the thermal expansion of warming ocean water (Church et al. 2013). The rate of sea level rise is not uniform across the globe due to a variety of factors. The rate of sea level rise in New Jersey is higher than the global average due to subsidence of the local geology as a response from the last glacial maximum. Since 1911, sea level has risen more than 16 inches along the New Jersey coast (Runkle et al. 2017). Sea level is projected to rise between 2.3 to 6.3 feet between 2000 and 2100 under high emissions scenarios, and 1.7 to 4.0 feet in low emissions scenarios (Kopp et al. 2019). Rising sea levels have implications across day-to-day operations in New Jersey.

Higher sea levels result in a higher baseline from which tides ebb and flow. This higher baseline results in high tides extending further inland. This causes tidal flooding, otherwise known as nuisance flooding or sunny day flooding due to its decoupling from local weather. Tidal floods occur during the highest of high tides, which are associated with the lunar cycle. This flooding at high tide can cause road closures, overwhelm storm drains, and damage infrastructure (https://oceanservice.noaa.gov/facts/nuisance-flooding.html). Tidal flooding in New Jersey has increased through the past century (Runkle et al 2017) (Figure 6.4). Because the frequency of tidal flooding is causally related to rising sea levels, this regular flooding along coastal areas is expected to increase in frequency and magnitude as sea levels continue to rise.

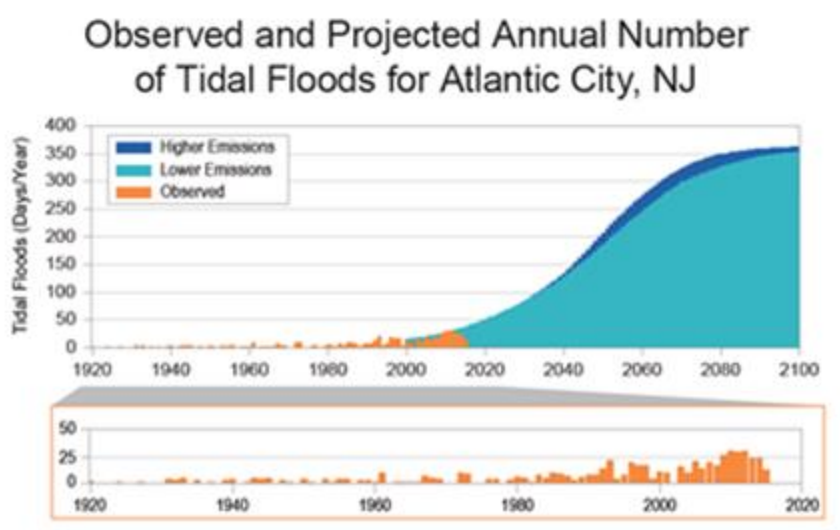

Figure 6.4: Number of days per year with observed tidal flooding at Atlantic City, NJ. From Runkle et al. 2017.

Rising sea level also impacts water quality in coastal areas through saltwater intrusion. As sea levels rise, the boundary between freshwater and saltwater moves inland. This boundary can also be shifted inland through excessive withdrawals of freshwater from aquifers. Shifts in this boundary can cause freshwater sources to become contaminated with saltwater. This is a known issue in lower Cape May County (Millsaps 2016). In the Camden metro area, limits of aquifer withdrawal have been established to mitigate risks of saltwater intrusion into the local water supply (Millsaps 2016). Saltwater intrusion can be worsened through storm surge. Because higher sea levels enable storm surges to extend further upstream, this rise presents further risk for saltwater intrusion contaminating freshwater supplies.

6.2.3.4 Compound risks

Compound events refer to a combination of processes that occur simultaneously or in short succession that lead to a significant impact, potentially greater than if the processes had occurred separately (Hao et al. 2018; Zscheischler et al. 2018). The previously mentioned diversity of Rutgers' properties increases the University's vulnerability to multiple climate risks impacting the University simultaneously. Compound events may occur at a specific location, causing an intense local impact, or may occur through events impacting multiple locations, forcing the University to manage multiple events with finite resources.

While compound events refer to any combination of processes, three types of compound events are of particular significance to Rutgers and New Jersey. First, the geographic location of New Jersey along the Atlantic coastline makes the state vulnerable to extreme rainfall and intense winds from tropical storms as well as the storm surge associated with the same storm. These short-term compound events are further complicated by rising sea levels, which increases the likelihood of coastal flooding and potentially increases the intensity of storm surge (Wahl et al. 2015). A second type of common compound event is simultaneous drought and heat waves (AghaKouchak et al. 2014). These events are closely related and cause multiple impacts to water quality and human health. A third type of compound event with specific relevance to coastal and tidal New Jersey is simultaneous drought and sea level rise. While drought occurs on shorter timescales than sea level rise, the combination of both processes enables the salt line (the boundary between brackish and fresh water) to move inland up tidal reaches of rivers and the salinity content of coastal bays and wetlands to increase. This type of compound event has the potential to reduce the water quality at Rutgers marine stations as well as the Camden campus, depending on the rate of sea level rise and the severity of the drought (Van Abs, 2016).

Compound risks from climate change can occur from any combination of processes. In fact, they can occur in conjunction with non-climate related events, such as a pandemic or other local to global scale risks. Therefore, estimations of Rutgers University's vulnerabilities to climate risks should expand beyond each risk individually and consider that multiple risks and processes will occur simultaneously. Vulnerability analysis also needs to consider the legacies of past industrial contamination, particularly in flood prone areas of Newark, Camden, and the Raritan Bay, where past contamination adds to flood risks.

6.3. Sectoral Impacts and Risks

Laura Landau, Natalie Teale, and Jennifer Schrum, Research and Writing Leads

Climate change poses significant risks for Rutgers operations. This section provides a preliminary scoping of these risks by major infrastructure sector and function. The information for this section was gathered through interviews with task force members and other sectoral experts at Rutgers. Interview questions included: which climate risks are most important for your sector? What are key climate impacts for your sector? What type of climate information is most needed for planning? The information from these interviews was used to identify major climate risks for Rutgers' operations (see Table 6.2) and to describe potential impacts in each sector.

Table 6.2 Climate Risks by Sector

	Sector							
Risks	WG1- Energy and Buildings	WG2- Transportation	WG3- Food Supply	WG4- Supply Chains and Waste Management	WG5 – Land Use and Carbon Offsets	Health	Water Supply	Communication/IT
Precipitation	X	X			X	X	X	
Mean Temp					X	X		
Storm Surge		X	X			X		X
Sea Level Rise		X				X		
Drought			X		X	X	X	
Extreme Winds	X		X					X
Ice Storms		X	X			X		X
Flooding (River/other)	X	X	X	X		X		
Heat waves	X		X		X	X	X	X

6.3.1 Energy and Buildings (WG1)

Rutgers University spans four campuses (New Brunswick, Newark, Camden, RBHS) and operates over 700 buildings that vary in age, use, and needs. One primary concern around climate change in the buildings and energy sector is the rise in extreme temperatures. Warming atmospheric temperatures in New Jersey mean that air conditioning is now becoming a necessity rather than a luxury, and increased cooling bills are expected. The age and infrastructure of buildings across Rutgers' campuses vary greatly, and older buildings may not be cooled or well insulated, requiring building system and envelope retrofits. Another concern around heatwaves is the possibility of energy brownouts in some areas on campus due to high demands on the grid. Following Superstorm Sandy in 2012, Rutgers began the process to upgrade its energy supplies and ensure that the Livingston/Busch and the Newark campus cogeneration plants can operate in island mode in the event of a power outage. Currently, Rutgers prioritizes research labs with living research subjects and has generators to ensure continuation of power for those sites.

In order to prepare for continuing climate change, it will be important to understand how the expected future heating and cooling loads will differ from historical patterns. While much current design practice still relies on retrospective climate data to identify peak cooling and heating loads (using peak hours in the Typical Meteorological Year derived from the past 30 years of weather data), ongoing practice should emphasize future peak conditions, either using model-based projections or analogy-based scenarios based on warmer locations.

A campus-level study on existing conditions of building energy efficiency would provide a useful baseline for estimating future energy use. This could include tracking which buildings have central air conditioning, and which still rely on window units. The COVID-19 crisis has also amplified another concern around energy in buildings, the need for efficient part-load operations. With many buildings evacuated due to stay-at-home orders, systems that are adept at part-load performance are crucial to maintain efficiency and save money. A study documenting the percentage of buildings with various levels of part-load efficiency would be helpful here. Ultimately, the goal is for Rutgers to install energy efficient equipment, design systems to operate efficiently in part-load conditions and improve building envelopes.

Changing requirements for building maintenance under more extreme weather conditions including heat waves, heavy precipitation events, ice storms, and so forth is another area of concern. For example, there is a possibility of accelerated aging and deterioration of roofs on older buildings, as well as need for extra maintenance. Other areas of concern include the possibility of damage to outlying buildings because of flooding and storm events and the possibility that the estimated lifespan of campus buildings may need to be shortened. While each of these issues requires further investigation, a general recommendation is that new campus buildings should be designed based on projected future climate conditions.

6.3.2 Transportation (WG2)

Students, faculty, and staff use multiple modes of transportation to get to and around Rutgers' campuses. These include walking, biking, scooters, personal vehicles, public transportation, and the Rutgers intercampus bus/shuttle service. Each of these modes of transportation are impacted differently by climate change. One of the main climate concerns in the transportation sector is the possibility of flooding due to heavy rains and storm surge. In addition to harming campus infrastructure, road flooding can limit both public transportation and road access. In 2011, Hurricane Irene caused the Raritan River to flood, cutting off access for cars and buses to reach parts of the Rutgers campus. Of particular concern is Route 18, which connects many of the New Brunswick campuses. In addition, the Camden campus is low lying and close to the Delaware river, which also has the potential for flooding. Aside from flooding, power outages from storms can cause train disruptions and can hinder communication about campus closures and changes to the Rutgers shuttle schedule.

To address some of these challenges, Rutgers is working on plans to reduce the number of stops in their bus routes from 30 to 10. This new plan will occur in conjunction with added bike paths and a new e-scooter and e-bike share system, to limit the demand of the buses, increase socially distant travel options, and decrease overall carbon emissions. Moving forward, comprehensive planning for transit adaptation will require additional data on where students, faculty, and staff live, mode of transportation, and alternative options. As illustrated by the response to the COVID-19 pandemic, the possibility of rapid shifting to online instruction and functioning of the university is a potential adaptation to extreme weather events, which could make transit to and between campuses difficult or impossible.

6.3.3 Food (WG3)

Rutgers University's food supply is a multiscalar operation, potentially impacted by distant and local climate risks at multiple timescales. In addition to providing food and nutrition during regular operating conditions (e.g., serving approximately 33,000 meals daily on the New Brunswick campus in normal operating conditions), Rutgers Dining Services also plays a significant role in emergency operations as an emergency shelter for New Jersey residents forced from their homes, including during Superstorm Sandy. Therefore, the resilience of these operations to climate risks is crucial to ensure health and safety for Rutgers populations as well as the New Jersey population beyond those directly affiliated with the University.

Rutgers Dining Services relies in part on products produced and transported from a distance. Therefore, disruptions in the supply chain far from New Jersey have potential to impact Rutgers' food distribution. At the production stage, climate-related risks such as unfavorable growing conditions and unsafe harvesting conditions can impact product availability. At the processing stage, climate and weather events can inhibit workers' abilities to maintain food processing operations. At the transportation stage, adverse conditions can prevent safe transport of products to New Jersey. To minimize climate risks, as well to reduce carbon footprint and to improve nutrition, efforts have been made to produce food locally through the numerous farm operations and food production programs. Other products are sourced from New Jersey vendors as much as possible to reduce the climate risks associated with long-distance production and transportation.

Local climate risks also pose a risk to the University's food supply and distribution, particularly disruptions in electricity and transportation near Rutgers locations. Electricity is required for safe food storage, preparation, and distribution. Strategically located emergency electricity generation would increase resilience to the climate risks that lead to widespread electricity outages. Transportation of food between food service locations is dependent on safe ground transportation conditions and clear roadways. Extreme flooding of the Raritan River, for example, has restricted food distribution between the New Brunswick campuses as well as hindered staff's ability to report to work. In these instances, diversification of food supply and availability of staff on both sides of the Raritan River has facilitated consistent food distribution and preparation, thus reducing interruptions. Steps to continue and improve this diversification continue to play into operating decisions. The resilience of Rutgers Dining Services in emergency situations could be further improved through budget and financial changes that would reduce reliance on reimbursement from FEMA or other external agencies. Skill, training, knowledge, and leadership and representation within the University operating system are facilitating a high level of resilience and responsiveness.

6.3.4 Supply chains (WG4)

Rutgers University's supply chain is a wide and complex network of entities spanning product development through product distribution. This includes the management of raw materials and their conversion into products, as well as the products' transportation and delivery to the users. Each of the products arriving at University facilities has multiple touchpoints with the environment, from production to delivery, that expose it to unique climate risks. For instance, climate events may influence the cost of production and the quality of goods. Similarly, adverse transportation conditions may impact product delivery, and changes or disruptions in various externalities cascade through the supply chain. Climate-related risks can resonate through the University supply chain as well as the University emissions profile. These risks are mitigated through diversification of suppliers and services, especially those which are critical for University operations. Additionally, sourcing products locally where possible reduces climate-related risks by shortening the supply chain. Steps to increase diversification of supply chains continue to be important in supply operations.

The University's waste management is also vulnerable to climate-related risks. Power outages, especially those leading to a loss of refrigeration, can result in large losses of products including food waste and damage to research supplies and scientific experiments. Such events may lead to complicated waste management scenarios, including disruptions in waste removal due to inclement weather. Additionally, uncontrolled flooding could result in the surrounding communities being exposed to University waste. Emergency power generation and careful storage of potentially hazardous materials would increase the resilience of the University's supply chain and waste management to climate risks.

6.3.5 Land use (WG5)

Land use and land cover at Rutgers University's ninety-one locations throughout New Jersey range from urban settings, maintained lawns and landscaping, farms, forests, and wetlands, each with distinct purposes and goals. As such, Rutgers' land areas are vulnerable to a diversity of climate risks. Overall, the largest climate risks to the University's land use and carbon offsets are drought, extreme precipitation, and extreme temperature. On the main campuses, temperature and precipitation extremes impact landscaping decisions. These areas are reliant on precipitation (as opposed to irrigation) and consequently are vulnerable to droughts. Therefore, species that are tolerant of drought and temperature variability are preferable, and diverse types of plantings are considered for different areas (e.g., meadows instead of lawns). Extreme precipitation resulting in excess stormwater also poses a risk to developed campus areas and requires management to reduce risks associated with flooding. Rain gardens, green roofs, and other retention basins, among other infrastructure, have been implemented to manage excess stormwater and reduce flood risks. At the marine research stations, operations may be significantly impacted by sea level rise.

The University's forests and farmlands are exposed to similar climate risks. The forests are reliant on beneficial growing conditions to continue to fix and store carbon. Therefore, potential climate risks leading to forest health decline, including storm events, wildfire, disease, and pests as well as shifting temperature and precipitation regimes, may impact forests' carbon sequestration and correspondingly the University's goal of carbon neutrality. Rutgers University's agricultural locations, while sensitive to the same climate risks, are more responsive and reactive to climate change than forests due to the shorter timescales involved in their management. The agricultural experiment stations, for instance, are involved in the development, cultivation, and harvest of produce that is tolerant of New Jersey's changing climate, thereby increasing the University's resilience to climate risks.

6.3.6 Water supply

Water is used for a variety of purposes at Rutgers University, from drinking water to heating and cooling operations. Supplied by municipal sources, water is piped throughout the University's main campuses through infrastructure that requires continual monitoring and maintenance. This maintenance includes repairing leaks (i.e., loss of water) as well as managing and reducing infiltration (i.e., addition of stormwater to sewage system). The cost of water and sewer services in New Brunswick have increased over the last five years due to drought and other water supply constraints. During droughts, water suppliers may impose restrictions on campus water usage which reduce or prohibit landscape irrigation.

Several designs for water reclamation are available. These practices, in which graywater would be captured and reused for non-potable water needs instead of exiting via the sewer system, would provide a water supply for the non-potable water demands, such as for cooling and boilers. In this way, reclaiming water would increase the University's resilience to drought-related water shortages in addition to decreasing water and wastewater utility costs. As the University grows, opportunities to improve the resilience water supply are abundant, from conscientious campus planning to implementing water reclamation designs.

Flood-related risks to water supply and water quality are also a concern, particular for the New Brunswick campus. During both Hurricane Floyd and Superstorm Sandy, water supplies to the New Brunswick campuses were temporarily disrupted. Climate risks for the water supply at University satellite locations vary. For instance, frequent and prolonged droughts may impact irrigation at agricultural experiment stations. At the marine field station, saltwater intrusion related to rising sea levels may impact the availability of potable water. In these instances, monitoring the water supply as well as diversifying it where possible would increase the resilience to these climate risks.

6.3.7 Health

Climate change is not only a reality but already a significant threat to human health and well-being. Climate change has impacted our health through 1) exacerbating the frequency and severity of health problems that are already known to be affected by climate and weather factors; 2) creating new health problems through changing climate interacting with human environments, societies, and behaviors. There are many overlaps between climate concerns and health concerns at the state level. For example, rising atmospheric temperatures in New Jersey increased the number of high-heat days, which can be harmful or fatal for vulnerable populations including older adults, those with disabilities, individuals with housing and food insecurities, and people with underlying health conditions. In certain parts of the state, including both Camden and Newark, tailpipe emissions from cars and trucks combined with other effects on air pollutants from climate change can increase risk for asthma and other respiratory conditions as well as cardiovascular and thromboembolic events. Increased flooding of buildings from high tides and storm surges in context of sea level rise contributes to mold that can have harmful health impacts. Warmer temperature facilitates earlier and geographically expanded tick activities increasing exposure to tick-borne disease (e.g., Lyme disease) vectors.

For many locations on the Rutgers campuses, aging infrastructure presents risks in terms of air and water quality. Poor building circulation creates problems with temperature regulation, increases the risk of mold, and can contribute to asthma. One of the primary challenges within the University system is the communication and coordination between the many Rutgers-affiliated healthcare entities. Each of the two medical schools work with different hospitals, and the Rutgers campuses deliver healthcare services in each of their city locations, differing policies, demographics, and vulnerable communities. Lack of proper funding and little centralized communication make it challenging to address each of these unique needs.

The COVID-19 pandemic exacerbates each of these health risks and health inequities. While vehicle emissions have gone down since the beginning of stay-at-home orders, the reopening of the state, along with the fact that public transportation remains a high risk, could mean more car traffic in the future. In addition, the closing of homeless shelters due to COVID-19 has led to more people on the street who were vulnerable on high-heat days over the summer (and potentially during extreme cold days in the upcoming winter). With public libraries and other community spaces that serve as cooling centers closed, people were unable to locate free congregate meals or safely access cooling centers. This also placed unhoused individuals at a greater risk of community-based violence. To address all the above concerns, we need to gather more information especially on the specific vulnerabilities of staff, faculty, and students and disseminate them. These data would be crucial in creating emergency plans and improved communication system for the healthcare sector.

Box 3.7.1 A Template for Curricular Changes at Rutgers Biomedical and Health Sciences: Core and School-Specific Educational Program for 'Climate Change and Health'

Almost all aspects of climate change affect our physical and mental health with strikingly broad health implications (USGCRP, 2016). Examples include rising temperatures leading to more heat-related morbidity and mortality, decreasing precipitation causing wildfires and worsening air pollution leading to morbidity and mortality, increased risks of certain infectious diseases through temperature/precipitation changes, and increasing causalities/injuries and worsening mental health through more frequent or severe flooding and weather-related disasters (e.g., strong hurricanes and flooding). Evidence suggests that the health impacts of climate change are disparate and greater among vulnerable populations including old, diseased, and poor. Emerging evidence also suggests that not only diseases but also treatments are affected by climate change, e.g., medications that might exacerbate or mitigate the health impact of climate change (Layton 2017). Thus, future professionals/practitioners need to understand how diseases, aging, and delivery of health care (e.g., medications) impacts and interact with the health effects of climate change. In addition, the health care sector is responsible for 10% of the total greenhouse gasses in the United States (Eckelman 2016), illustrating its key potential in mitigating climate change. Evidence also suggests that the health care sector's energy consumption and resulting toxic emissions undermine the health of the communities served by the sector (Eckelman 2018).

In light of this body of evidence, there is an urgent need to educate future professionals in biomedical and health sciences in the area of climate change and health. Such education is necessary in order safeguard the health of patients and communities, adapt health care research and practices to increase resilience, and mitigate climate change and its health impacts in era of growing threats of climate change.

Within Rutgers Biomedical and Health Sciences, the implementation of a curricular program on climate change and health could potentially cover three general domains of climate change and health relevant to biomedical and health sciences: 1) theories and up-to-date evidence to understand climate change and its health impacts, 2) responsibilities as individual/society as well as professionals to prepare for and mitigate climate change and its health impacts, and 3) biomedical and health science research on climate change and health to further promote understanding and mitigate the risks.

An RBHS curriculum in climate and health might also include a set of common *core* courses that would provide students/trainees with basic but up-to-date knowledge on climate change and its health impact, as well as their responsibilities as individuals and members of the health community to mitigate climate changes and the risks on health from climate change. In addition, each school/institute/center might develop *school-specific* components to the program that are intended to supplement profession-specific knowledge and skills.

The curriculum for climate change and health could ideally include both didactic and practical components. To illustrate these points on what and how to teach climate change and health, we developed a sample curriculum at a medical school (Table 6.3).

Table 6.3. Example Curriculum: What and How to Teach Climate Change and Health at a Medical School

Domain and Mode of teaching	**Teaching theories and facts of climate change and health**	**Teaching Responsibilities as individual/society and profession**	**Teaching biomedical and health science research in climate change and health**
Didactic and discussion-based	**Climate change (core)**	**Individual and societal responsibilities to mitigate climate change and its health impacts (core)**	**interdisciplinary science in climate change and health (core)**
	Health impacts of climate change: overview (core)	Sustainability in healthcare sector and clinical practices	Basic and translational research for climate change and health
	Healthcare sectors and climate change	Clinical medicine in the era of climate crisis	Clinical research for climate change and health
	Impact of rising temperature, and related consequences on health outcomes	-	-
	Climate change disasters due to climate change (hurricanes, wildfire, flooding) and health	-	-
	Climate change and infectious diseases	-	-
	Food, climate change, and health	-	-
Practicum	-	Clinical rotations to understand practicing medicine in era of climate change (e.g., heat related illness, mental health screening post disaster, patient education about climate change and health in preventive care)	Optional practicum change and health
	-	Practicum rotation with local or national organizations to promote sustainable health care	-

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6.3.8 Communication/IT

Campus communications is a shared responsibility at Rutgers with oversight and involvement from multiple offices, including but not limited to University Communications and Marketing, the Office of the President, Chancellor Offices, and the Office of Information Technology. Although there are daily occurrences of information distributed to the campus community, the need for proactive and appropriate information is even more important in heightened situations, such as weather events, service disruptions, or other emergencies. Effective communication techniques involve not only accurate and relevant content but also require various technology and collaboration tools. For example, in the event of emergencies, students, faculty, and staff are alerted via email, text messages, and updates to the Rutgers websites. Following Superstorm Sandy in 2012, these systems were improved and expanded to ensure that everyone receives emergency notifications. Natural disasters and other disturbances can sometimes place a strain on the communication infrastructure, which has been increasingly moved online.

This past spring, the COVID-19 pandemic tested many of these systems as the University moved into remote learning, teaching, and working mode. The Rutgers community had to become far more comfortable with online communication and tools related to respective areas of operation. Although everyone in the Rutgers community has access to these platforms, additional challenges arose when students, faculty, and staff working and learning from home did not always have the necessary computers and/or network connectivity (such as laptops and wifi). In the last five years, Rutgers has been steadily expanding the extensive set of digital communication and data-sharing tools, which includes Microsoft teams, WebEx, Zoom, Canvas, OneDrive, Google suite, and Box. Another initiative underway is to consolidate all online course content into Canvas as the university phases out Sakai and Blackboard.

Communication and dissemination of information is highly dependent upon technology. Because of the internet, social media sites and apps, email, and mobile phones, people have far more opportunities to be and stay informed on any topic of interest, such as climate change and potential emergencies. Yet there remain many challenges and risks. Some emergency events can cause people to lose power in their homes or disrupt cell services, which would hinder their ability to access Rutgers' updates and receive alerts. When a weather emergency disrupts electricity or harms the infrastructure that allows these tools to function, the communication team then needs to rely on other communication tools, including paper methods. But for the most part, preparing for future climate events and other emergencies will continue to require an increased comfort level with online tools among students, faculty, and staff. Consistent, university-wide communication is a critical component of these efforts.

6.4. Vulnerable groups, populations and communities

Laura Landau and Jennifer Schrum, Research and Writing Leads

Climate change has differential impacts among different populations and communities. This section identifies groups at Rutgers that are vulnerable to the impacts of climate shocks and stresses. As a result of the COVID-19 pandemic and campus shutdown, the scope of this section was narrowed to a focus on vulnerable student populations, with more limited attention to faculty, staff, and other communities. A critical next step is a broader, stakeholder-based examination of climate vulnerabilities among all affected Rutgers groups, including faculty, staff, and students as well as local campus communities.

In the event of a climate emergency, students across Rutgers' campuses are not all impacted equally. While a certain level of trauma following a disaster can be expected across the board, students without access to adequate healthcare, a comfortable and safe living environment, necessary food and technology, and social and emotional support are likely to be most affected. Several student populations are more vulnerable to the various impacts of climate change. Some of these populations, as well as how they may be adversely affected are described in Table 4.1

Table 6.4. Student Populations and Potential Climate Change Impacts.

Student Population	**Potential impacts**
Students living on or off-campus in buildings without air conditioning	· Increased risk of dehydration and heat stroke during heat waves · Possible need to relocate
Students that commute	· Challenges getting to campus in severe weather conditions · Public transit delays or schedule changes during an emergency · Blocked access to campus due to road flooding
International students	· Inability to go home in the event of campus closures or emergencies · Visa challenges · Potential loss of funding if out of the country because of tax laws
Students with physical and mental health concerns	· Increased likelihood of trauma following an emergency event · Challenges accessing necessary health care due to blocks to physical access to health centers or inundation after an emergency
Medical students and other students working in the field	· Challenges fulfilling required hours if they are unable to get to work due to an emergency · Potential trauma after disaster if working with highly impacted groups
Students experiencing food insecurity	· Inability to access food on campus in the event of campus closures or changes to the Rutgers Dining Services food supply (see WG3 section on Food supply chain) · Increased health risks, exhaustion, and other adverse impacts that come from not having access to a healthy balanced diet
Students experiencing housing insecurity	· Lack of safe and stable setting in which to shelter in place, work from home, etc. · Increased stress associated with frequent moving · Fewer options when University housing is closed

Graduate students	· Delays to completing fieldwork due to travel cancellations or restrictions · Possible changes to funding plan
Students supporting children or other family members	· Challenges finding quiet and private spaces to work from home in the event of a University closing · Lack of adequate and affordable childcare or home health support
Black, Indigenous, and people of color (BIPOC) students	· Increased likelihood to face many of the above challenges due to systemic racism and environmental injustice · Reduced likelihood of accessing support due to institutional racism

Conversations with the Task Force's Student Working Group helped identify some of the most vulnerable student populations at Rutgers (see Table 6.4). These include students with difficult living conditions—either those living in buildings without proper temperature control, those experiencing housing insecurity and lacking a long-term stable home, or those living with children or other dependent family members. Commuters may also face increased challenges in the event of an emergency due to impact on travel. In addition, International students face a particular challenge, as we have seen with COVID-19. In the event of an emergency, they might have trouble traveling home, and if they choose to stay in their home country, they could face losing their visa status or funding package. Other vulnerable students include graduate students and those working in the field, as they might have to delay research or completion of clinical hours. Students with physical and/or mental health concerns may face increased challenges accessing their necessary health care and medication following an emergency. Finally, historic systemic racism disadvantages those with all marginalized identities, especially placing students who are Black, Indigenous and people of color (BIPOC) at risk.

Faculty and staff at Rutgers can share many of the same challenges and vulnerabilities. There is a widespread assumption that faculty are all financially stable, but many adjunct and part-time lecturers, in addition to support staff, rely on additional outside employment and could become or are food or housing insecure. Many faculty and staff members also have children or other family members at home that they care for. Working from home provides additional challenges to those juggling multiple roles at home, potentially without ample space to create a private work area. In the case of COVID-19, the rapid shift to online learning presented a challenge to those without access to computers, or to those who are not comfortable with online tools.

In addition, staff that works on the food supply chain, maintenance staff, and janitorial staff may have specific roles to fill following an emergency event that require them to get to campus despite commuting challenges like disruption of public transit service or blocked roadways. Research staff and faculty who require access to their lab have unique challenges if they are not able to get to campus due to campus closures or commuting difficulties following an emergency event.

The larger community surrounding each of the University's campuses may face additional climate related risks. Climate change impacts may adversely affect residents of New Brunswick, Newark, and Camden and surrounding communities who are of low socioeconomic status and face barriers from the individual to policy level. Low-income, basic needs insecure, immigration status, older age, homelessness, substance abuse, and health status are examples of factors that may contribute to negative outcomes due to climate change and related emergencies. Additional research on the greater communities and related climate change variables may benefit understanding and preparedness.

6.5. Lessons from other universities for climate change preparedness

Rory Langan, Research and Writing Lead

A review of the sustainability and climate plans of Big 10 and Ivy League institutions was conducted to ascertain strategies and lessons learned that could be applied to Rutgers with respect to climate preparedness. Commitments to construction of green infrastructure on campuses such as increasing canopy cover, green roofs, new plantings, and roof gardens is cited as a common strategy by several institutions to achieve temperature reductions. Several universities are creating and/or maintaining social green spaces including the use of sustainable landscape management, conversion of impervious surfaces to open spaces, and stream restoration to contribute to the emotional, physical, and mental well-being of students, faculty, and staff.

Plans to increase plantings of native and perennial drought-resistant plants are common strategies that protect against water overuse while requiring less maintenance. University plans to reduce water consumption involve water monitoring of usage, leak detection, drip watering coupled with weather monitoring to save water on days when it will rain, as well as employing low flow shower heads and faucets and dual-flush toilets in campus housing. Water education campaigns engaging students have also been highly successful on several campuses.

To address heavier precipitation and stormwater management, many universities are committed to using or studying the use of green infrastructure such as green roofs, more permeable soils, bioswales, permeable paving and cisterns. One university is using a patented structural soil for situations where soil compaction is necessary under pavements and along sidewalks to provide a medium for tree growth, as well as a base for turf that improves storm water and snowmelt infiltration, while resisting snowplow and de-icing salt damage in the winter and early spring. Employing these projects on campus allows for research as a source of data and potential innovations, as well as for public outreach and education.

Several universities have created comprehensive climate adaptation plans to address extreme weather and climate, including future projections, but only a few of the plans reviewed mentioned a relationship to the broader community external to campus. One university has created an internal research fund to motivate student solutions to address climate change including projects focused on campus sustainability and resilience (see Appendix A for additional details on what other universities are doing).

6.6. Description of current strategies at Rutgers for emergency and climate change preparedness

6.6.1 Rutgers Office of Emergency Management

The Rutgers Office of Emergency Management (OEM) serves all university locations and works to prepare the university to properly respond to and address emergencies that threaten public safety. These emergencies may include, but are not limited to, severe weather conditions, major power failures, fires and explosions, transportation accidents, other accidents involving mass casualties, release of hazardous materials, violent crimes, civil disorder, bomb threats, public health emergencies, acts of terrorism, and other events that could pose a significant threat to the university community. In times of emergency, OEM provides coordination and support for all university operations across the State of New Jersey. Some of the functions include sheltering, communications, evacuations, supplies for long term events, and assisting with business continuity and comprehensive emergency operations plans. University emergency planning through OEM focuses on the areas of preparedness, prevention, mitigation, response, and recovery.

The Rutgers Office of Emergency Management is a unit of University Public Safety within the Division of Institutional Planning and Operations. OEM has statewide oversight and is staffed with three fulltime employees. These employees have over 30 years of collective experience in incident command, firefighting, fire prevention, emergency medical care, public health, physical security, and security technologies. Additionally, these staff members have backgrounds in adult education, environmental science, and student life which have spanned from the private sector to local and federal government levels.

Because the Office of Emergency Management has limited staffing, the office relies heavily on the support of internal and external partnerships for their day-to-day operations. The office has liaisons within the Rutgers Police Department in Camden, Newark, and New Brunswick to ensure information is shared and to collaboratively and proactively address matters impacting public safety. In addition, the office works closely with liaisons within Rutgers Environmental Health and Safety who act as incident command officers and Rutgers Emergency Services who provide emergency medical and fire safety services. Further, the office has an excellent working relationship with University Communications and Marketing, to ensure timely and accurate information is sent out to the community. The office also works closely with the campus Chancellors to ensure the unique needs of each campus community are met.

6.6.1.1 Specific Operational Plans vs. Consequence/Crisis Management

In the earlier days of disaster management, emergency managers would draft specific plans for every conceivable eventuality. Aside from those plans created for "run of the mill" emergencies, these specific plans would often be cumbersome and address esoteric situations unlikely to happen within a given jurisdiction. Because of the relative unlikelihood that such emergencies would occur, testing and validating those plans became difficult. This is due to several factors, among them is the difficulty of getting others to put the time into planning, conducting, and evaluating an exercise and the cost/benefit of testing something so unlikely. Without practicing the plans to find out whether they worked and having the opportunity to alter those plans based on lessons learned during the tests, these plans were doomed to fail. Moreover, the esoteric nature of these plans meant that there were volumes upon volumes of potential plans, through which someone would have to search to find the right plan during a disaster. Finally, the effort to draft, test, revise, and –during an emergency- find the right plan was of little value if the specifics of the plan did not meet the specifics of the event.

Unfortunately, this was discovered the hard way on 9/11. Few had seriously considered the potential that passenger airliners would be hijacked and used as guided missiles. In the decades prior to 9/11, hijackings were generally done for monetary or political gain. Those that ended in tragedy were generally bombed, rather than hijacked. There was little reason to consider that this would occur and, as a result, there was no plan available for multiple aircraft impacts into buildings in major metropolitan areas and subsequent full or partial collapse of those buildings, as well as others.

Since 9/11, those working in the field of emergency management have moved away from specific situational plans, in favor of consequence/crisis management and all hazards approaches. Consequence/crisis management is dealing with the effects of a disaster, with the objective of getting back to a "new-normal." In some respects, the effects of an extreme weather event or an act of terrorism may be the same (e.g., mass casualty incidents, building damage, utility emergencies, etc.). Rather than focusing on the cause, it is best to examine the effect and draft plans to best address those effects. From there, one can determine what resources are needed to save lives and property, stabilize the incident, and protect the environment. Once those four considerations are addressed, the recovery process can begin with an eventual return to a "new-normal."

6.6.1.2 Rutgers Emergency Operations

The Rutgers President is ultimately responsible for the University's overall response to emergencies. The Executive Vice President for Strategic Planning and Operations and Chief Operating Officer, functions as the President's direct representative and serves as the University's Emergency Management Coordinator during public safety emergency operations. When a public safety emergency arises that requires a significant multi-department response, the Emergency Management Coordinator will activate the University's Emergency Management Team. This team is composed of administrators and department heads whose organizations have emergency response functions or resources. The Emergency Management Coordinator coordinates the response efforts of the various team members utilizing the framework provided by the Rutgers Emergency Operations Plan (EOP).

The EOP is developed in accordance with P.L. 2011 Chapter 214, an act concerning the disaster preparedness of institutions of higher education and supplementing chapter 3B of Title 18A of the New Jersey Statutes. The act specifically notes that "the governing board of each institution of higher education shall develop and coordinate an emergency operation plan to ensure the continuity of essential institution functions under all circumstances." The Rutgers Office of Emergency Management prepares the university's EOP which sets forth the general policies and procedures to be carried out by the university during a public safety emergency. It provides the university community with an effective, integrated emergency response designed to minimize the loss of life, limit property damage and reduce disruption of university functions. The EOP serves as a framework to guide the university's use of resources and provide governance during an emergency or crisis.

The Office of Emergency Management takes a team-based approach to preparing the EOP. Plans cannot be written in isolation; they require input from various disciplines to ensure that all stakeholders' needs are addressed and that departments work in unison. To that end, the Office of Emergency Management works closely with a diverse cross-section of the university, typically referred to as "emergency support functions," under the university's emergency operations plan. The emergency support functions include most of the partners the office would need to assist in the event of a disaster, including but not limited to, University Facilities, Residence Life, and Student and Occupational Health. The support functions' roles and responsibilities are delineated under the university's Emergency Operation Plan. At least annually, the Office of Emergency Management conducts exercises to test and validate this plan. Information gained from these exercises, as well as lessons learned from bona fide emergencies, are incorporated into annual revisions of this plan.

6.6.1.3 Ongoing Initiatives

While the Rutgers EOP is not available to the public due to the need for security, community members can access the university's emergency action plans online at emergency.rutgers.edu. Community members are encouraged to take an active role in their personal preparedness by familiarizing themselves with the action plans to learn what specific steps they need to take in the event of an emergency. These plans are based on best practices from a myriad of sources, to include FEMA, USFA, CDC, and others.

The Office of Emergency Management recognizes that there are limitations to having these plans located on-line, such as incidents that can cause electrical or telecommunications blackouts. For this reason, community members are encouraged to routinely review the information prior to an emergency. A reminder to view this information is sent out several times a year, along with the Rutgers Annual Security and Fire Safety Report, and prior to tests of the university's emergency notification system (ens.rutgers.edu) each semester.

In addition, the Office of Emergency Management works with various partners to bring university preparedness efforts to individual schools, departments, and offices. The OEM assists individual departments in creating departmental action plans, which provide for specific steps community members can take within their departments to mitigate the impact of an emergency on their operations. While these plans mirror the emergency action plans found at emergency.rutgers.edu, they offer specificity and allow for the emergency actions to be catered to the individual needs of the department. The OEM also works with departments to develop continuity of operations plans. These plans focus on what the department needs to do to function after a catastrophic loss.

Together with the Rutgers Police Department's Community Policing Bureau, the OEM offers training on select topics and/or provides, along with other partners such as Emergency Services, all-encompassing live sessions on general or departmental emergency actions plans, based on the need and request of the individual department. The goal of developing these plans and providing training based on those plans is to hold an exercise. The objective of the exercise is to test and validate the plans and to prepare the department personnel for real-world application in the event it is ever necessary.

The emergency management cycle consists of several parts and is an ongoing process. The cycle includes prevention and mitigation, preparedness, response, and recovery. More generally, this cycle can be thought of as a continual shift between risk management, protecting against a disaster, and consequence management, thus responding to the disaster. To manage risk, it first needs to be assessed. Rutgers works with diverse shareholders from across the university, as well as with external partners, to develop and calculate institutional risk. These calculations are done to focus main efforts on high consequence, high likelihood emergencies (e.g., fires, medical emergencies, assaults, etc.).

The Emergency Operations Plan considers the consequences of these events, and what can be done to prevent them. In some cases, there are steps that may be taken to prevent a foreseeable disaster. For example, the OEM develops departmental plans, provides training, and conducts exercises for active shooter incidents. In the process, this helps to harden facilities by providing the community with knowledge on the indicators that may trigger an incident, and actionable protective measures to implement if such an incident does occur. In other cases, the steps that are taken to prevent a disaster are based on engineering, rather than education. For example, in areas with known utility concerns, buildings can be equipped with generators to mitigate those risks. The measures taken to stop the effects of a disaster from impacting the community and the measures taken to limit the impacts where they cannot be avoided are known as the prevention and mitigation phases of the emergency management cycle, respectively.

After the prevention and mitigation phase is considered, the preparedness phase entered. In some cases, the work done during the prior phase helps to prepare the campus community for a disaster. For example, the planning, education, and exercising mentioned earlier also falls under preparedness. Preparedness can also take the form of gathering and stockpiling supplies, medication, etc. It is during this phase that collaborating with internal and external stakeholders is essential, as this helps in ensuring that lines of communication are open should a response be required. For the campus community, communication is of extreme importance. If an event can be predicted and ample warning provided, members of the community can take actions to keep themselves out of harm's way. Extreme weather emergencies are much easier to prepare for, predict, and provide warning for as opposed to other emergencies (e.g., an act of terrorism). Consequently, this warning makes for a comparatively more streamlined response to such events.

6.6.1.4 Lessons Learned

One such event that is certainly worth mentioning herein is Superstorm Sandy. Prior to it impacting New Jersey, various predictive models showed a week before it made landfall that it had the potential to impact our state. While nothing was certain at the time, the Office of Emergency Management began to ramp-up their operations. Meetings of the executive policy group were held, protective objectives were developed, and the Office of Emergency Management continued to monitor the situation.

A few days before the storm's impact, the predictive models began to come into agreement that the storm would take a north westerly path off Cape Hatteras and head toward New Jersey. This early warning permitted a determination of what the impact of the storm would be, allowing incident action plans to be drafted prior to the storm's arrival. The warning allowed the OEM to quickly move from risk management to crisis/consequence management. By the time this occurred, a "game plan" in place, preparing the OEM for a significant weather event, and ensuring that information was relayed to the campus community.

When Sandy hit New Jersey on October 29, 2012, it did so with forces that met, and in some cases, exceeded predictions. Consequently, the campuses and outlying areas of Rutgers were subjected to the impacts of the second most costly storm in American history and deadliest storm ever to impact New Jersey. As was to be expected in a storm of this magnitude and unusual nature there was the need for on-the-spot decision making that resulted in changes to the university's operational status with little to no advanced notice to university constituents. Likewise, it reinforced the need for streamlined communications between the Emergency Operations Center, which centrally provides critical data, resources, and support services to the Emergency Management Team, and the Executive Policy Group during critical events.

Throughout the OEM's response to the disaster, an executive policy group continued to create objectives, such as the need to ensure that students who were sheltering on campus were provided food, that damage assessments were being conducted, and that repairs began to allow the university to reopen – as well as many other important decisions. The Emergency Management team, along with representatives of the "emergency support functions" worked around the clock to ensure that the executive policy group's objectives were met. Additional incident action plans were drafted as objectives were completed and additional ones were assigned. This continual process offered a seamless transition from the response phase to the recovery phase.

As Rutgers and New Jersey recovered, the OEM's response to the storm was reviewed and found to be imperfect – few things are during a disaster. Many valuable lessons were learned. Other regional institutions that were also impacted were consulted and found that they too learned many valuable lessons from this storm. As is the case when exercises are held, as discussed earlier, these "lessons learned" were incorporated into the university's emergency operations plan through an evaluation process called an "after action report." Once the university was fully recovered and found a "new-normal," the OEM was able to move from the consequence/crisis management phase, back into the risk management phase – using new lessons learned to inform mitigation and prevention practices in the future.

The impacts of Sandy and the considerable loss of power to the State were truly devastating. As a result of a combination of an excellent emergency preparedness system, an all-hazards university emergency operations plan, and a dedicated workforce working together as a unified team, Rutgers was fortunate to report that no on-campus injuries were suffered. While the storm left a broad scale of physical destruction in its path, it clearly did not dampen the spirits of Rutgers employees who assisted in the process of recovery, rebuilding of Rutgers, and assisting others. During this catastrophic event, Rutgers University provided services far beyond the scope of our campuses and became a vital component of the state's survival and recovery network. Those collaborative partnerships are still in place today and further enhance the university's overall emergency preparedness.

6.6.2 Other Rutgers Units involved with Climate Change Preparedness

In addition to the Office of Emergency Management, there are faculty and staff throughout Rutgers whose scholarship not only touches upon climate preparedness, but also who apply their knowledge in practice to assist with climate preparedness on and off campus. Many of these faculty and staff are affiliated within units including:

Office on the New Jersey State Climatologist (ONJSC) which gathers and archives New Jersey climate data (including hourly and daily observations); conducts NJ climate research; and disseminates NJ climate data and expertise to state government (for example, in state hazard mitigation planning and water supply planning) and the media, while also promoting climate awareness to the public.

Institute of Earth, Ocean and Atmospheric Sciences which links together a community of researchers across Rutgers that study the Earth's interior, continents, oceans, cryosphere, atmosphere, and biosphere, and conduct research on assessing and managing risks that climate change creates for communities, economies, and ecosystems.

Environmental and Occupational Health Sciences Institute which serves as a source of expertise about environmental problems for communities, employers, and governments in all areas of occupational and environmental health as well as training for environmental health professionals.

Rutgers Climate Institute (RCI) whose faculty affiliates in the natural and social sciences, humanities, engineering, law, and medicine works to address climate change through research, education, and outreach. A key aspect of RCI's work relates to service to New Jersey including initiatives that are helping New Jersey communities, citizens, and government prepare for a changing climate.

RCI, in partnership with the Edward J. Bloustein School of Planning and Public Policy, has two key statewide initiatives: 1) facilitating the NJ Climate Change Alliance , a statewide network of diverse organizations that share the goal of advancing evidence-based climate change strategies at the state and local level in New Jersey; and 2) co-directing the New Jersey Climate Change Resource Center whose purpose is to create and support the use of impartial and actionable science to advance efforts throughout New Jersey to adapt to (as well as mitigate) a changing climate.

The Jacques Cousteau National Estuarine Research Reserve (Rutgers, NJAES) is embedded within southern, coastal New Jersey. The mission of the JC NERR is to improve the management of New Jersey coastal environments and communities through science, education, and stewardship. The JC NERR Coastal Training Program has been directly involved in the development of numerous web-based tools and resources. All web-based tools and resources are developed with the end user in mind throughout the development. One of the cornerstone web-based tools is "Getting to Resilience." This tool increases a community's understanding of where future vulnerabilities should be addressed through hazard mitigation planning. Developed to be used in association with NJFloodMapper.org and NJAdapt.org, Getting to Resilience is the next step in communities planning for the risks associated with climate change and sea level rise. Together, these websites will help communities visualize their future risk and plan for that risk using their existing municipal planning tools. These websites have been developed and continue to be maintained and improved through partnership with Rutgers CRSSA, Bloustein School, and the Rutgers Climate Institute.

Box 6.1. Jacques Cousteau National Estuarine Research Reserve Jacques Cousteau National Estuarine Research Reserve (Tuckerton, NJ): Implementation of a Resilient and Sustainable Coastal Campus

The Rutgers' managed Jacques Cousteau National Estuarine Research Reserve (JC NERR) was designated into the National Oceanic and Atmospheric Administration (NOAA) NERR system in the fall of 2017. Since the construction of the Cousteau Center in 1999, the number of staff, visitors, and reserve programs have grown significantly. In addition, Reserve staff based at the Rutgers University Marine Field Station (RUMFS) (Figure 1) require auxiliary office space when the road to the station is flooded, an increasing occurrence. These demands led to a growth and visioning exercise to identify space and facility requirements. Subsequently, a proposal to realize this vision was submitted to NOAA and partially funded. The funded project supports adapting existing space to meet JC NERER's current and future needs and to develop a comprehensive facility plan to make optimum use of the site.

The need for laboratory space at the JC NERR campus is part of a "planned retreat" strategy to deal with mid-and long-term threats to the NERR System-Wide Monitoring Program (SWMP) support laboratory facilities currently housed at the RUMFS. RUMFS is and remains - in the short-term - an ideal staging area and boat access facility for research activities in either of the JC NERR estuaries. It serves the reserve especially well for supporting SWMP activities such as deployment, calibration, and maintenance of water quality data loggers and nutrient samplers, and data telemetry infrastructure.

Figure 1: A map of the current JC NERR/Rutgers University facilities in the Tuckerton/Little Egg Harbor, NJ area.

However, sea level rise, combined with eustatic subsidence has resulted in a dramatic increase in recent years of nuisance road flooding (Figures 2 & 3). The road is closed to traffic for periods of hours to days (during coastal storms). This can directly impact the ability to meet the needs of SWMP logger maintenance and reporting. Additionally, the laboratories at the RUMFS support several long-term (now 30 years) larval and juvenile fish sampling programs that are aligned with the JC NERR's stated priorities and supported by JC NERR funding and volunteer management programs as integral with the Sentinel Site.

Figure 2: Great Bay Blvd., the road to the RUMFS, flooded during a nor'easter tidal event.

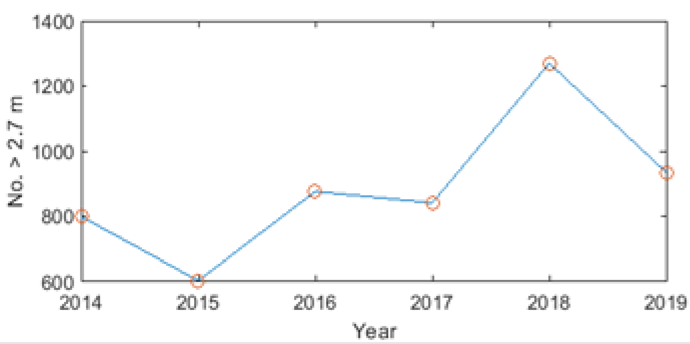

Figure 3. The number of data points (6-minute interval) by year in which tide height at RUMFS, as measured from a leveled USGS tide gauge, exceeded 2.7 m as a proxy of road flooding.

Additional impetus for a "retreat" laboratory space is the long-term threat to the RUMFS from shoreline erosion and sea-level rise. The laboratory is situated on a marsh platform at the edge of a 12 m deep thoroughfare with sharp drop-off caused by calving of sizable portions of undercut peat into deep water. The thoroughfare edge has advanced toward the RUMFS by about 15 m in the last 20 years and may reach it in another 20 years. The proximity to the edge means that storm driven waves already over wash the intervening marsh to reach under the lab.

A proposed "retreat lab" to the JC NERR property, six miles inland, would mitigate interruptions caused by these episodes in the short to medium term and would become the principle SWMP support laboratory space in the long-term.

Box 6.2 The Haskin Shellfish Research Laboratory: Coastal Flooding and Sea Level Rise

The Haskin Shellfish Research Laboratory (HSRL) maintains four facilities (Figure 1) in southern New Jersey as part of the New Jersey Agricultural Experiment Station (NJAES) and the Department of Marine and Coastal Sciences (DMCS) both located at the School of Environmental and Biological Science, Rutgers University. This dual role permits HSRL to draw upon the strengths of both programs to fulfill its mission in support of fisheries and aquaculture research for which the HSRL has a 132-year tradition of disseminating research results and working cooperatively with state and federal agencies and alongside the fisheries and aquaculture communities in New Jersey and beyond. HSRL generates and disseminates research information directly applicable to all aspects of fisheries and aquaculture science, concentrating on species of commercial importance to New Jersey.

Figure 1. Coastal facilities of the Haskin Shellfish Research Laboratory located in southern New Jersey along the Delaware Bay, Cape May Harbor and the Cape May Canal.

Each of these facilities is faced with various threats of climate change and sea level rise as are the communities in which they are located and those sectors (fisheries and aquaculture) that they serve. Two facilities have already benefited from planned resilience strategies, but all require more. The main facility located in the former fishing village of Bivalve (now incorporated into Port Norris within Commercial Township) is a structure built in 1982 and elevated about three feet on pilings in anticipation of storm surge flooding. Such events are occurring with increasing frequency and the entire town has elevated the berm along the river following breaches during 2012 from Superstorm Sandy and a subsequent nor'easter. Storm surge from those events reached the bottom of the building but did not enter the building. Neighboring structures at ground level, including the HSRL (Haskin Shellfish Research Laboratory) boat shed were flooded indicating that the foresight to elevate the laboratory was a good decision, but this is only one of multiple resilience needs.

The HSRL dock was a 100+ year old structure permitted to be 1 foot above the highest high tide. By the early 2000s bimonthly spring tides routinely flooded the dock (Figure 2). The height of the dock was considered a fixed position relative to sea level when permitted over a century ago so raising the dock was initially not permissible under existing state regulations. Eventually, the state recognized that the point of reference (the highest high tide) had changed, and Rutgers was permitted to elevate the dock 18 inches in compliance with the current established mean sea level. At this level, the dock has only flooded during storm surges, most recently during Hurricane Isaias (Figure 2). The surrounding municipalities are, however, suffering from a need to sustain basic infrastructure such as roads. After a multi-decade effort, some progress is being made and roads are being elevated with culverts sized to allow water to flow into and out of wetlands. Challenging decisions on which structures are in harm's way and either need protection or removal are being made along the entire Bayshore Region and a council of municipalities and stakeholders has been formed and recognized by the governor to assist these rural, low density populations with few ratables to help their tax base.

Figure 2. Flooding of the former HSRL dock on a spring tide during October 15, 2014 prior to elevating it in 2007 (upper image). Debris deposited on the dock from storm surge following Hurricane Isaias in August 2020.

At Rutgers Cape Shore Laboratory in Cape May County, the situation is different. This laboratory, first constructed in 1927, has several buildings including a dormitory and a riparian shellfish lease that is crucial to maintain the shellfish breeding program and the Rutgers trademarked disease-resistant oysters that have helped fuel the recovery of the oyster industry along the East Coast. In the 1990s, a natural dune that protected the lab and most of the region was breached intentionally for mosquito control. Storm and sea level rise quickly overwhelmed culverts and tide gates and rapidly eroded shorelines. Whether this would have happened with or without the mosquito control efforts is unclear, but the lab has since required the construction of a geotube, that was replaced after 10 years with a small rock gabion wall, which was destroyed by Superstorm Sandy and replaced with a larger rock gabion wall. These structures have protected the laboratory and the property immediately behind them, but the shoreline north and south continues to erode back into the salt marshes that were freshwater marshes prior to being breached. Rutgers University has purchased property behind the laboratory as a potential area of retreat to maintain operations, primarily on the riparian grant as there is nowhere else in the state where Rutgers owns property to continue this vital work. The laboratory buildings will eventually need to be vacated and removed so we are modifying space in the

Aquaculture Innovation Center for future breeding needs. Even with that space available, the riparian grant in front of the Cape Shore Laboratory will remain necessary for grow out and disease challenge to maintain disease resistance in the Rutgers lines.

Prior to Rutgers developing a storm response strategy (i.e., pre-2012), the Haskin Shellfish Research Laboratory had its own storm preparation and response plan that included things like preparing the lab for storm and flood damage as a storm approached, assigning duties to staff and students, meeting with faculty, staff and students as a storm approached, establishing contact mechanisms to remain in touch during and after a storm, and a planned return to facilities to assess and communicate damage so that clean up and repairs could occur without overwhelming everyone. Such planning is essential because employees also need to prepare at home and many volunteers to help in their communities and need to be able to coordinate and juggle multiple responsibilities. Such efforts are critical to the strength of a resilience plan.

6.7. Lessons from COVID-19 response for climate change preparedness planning

Jennifer Schrum, Research and Writing Lead

The ongoing COVID-19 response provides additional insights and guidance for climate preparedness planning at Rutgers. During March 2020, Governor Murphy issued several executive orders placing New Jersey under a state of emergency (Ex Order 103), then Ex Order 104 which enforced social distancing rules shutting down public and private preschool, elementary and secondary schools, and institutions of higher education, as well as entertainment centers, gyms, and all casinos. The order also mandated that all non-essential retail, recreational, and entertainment businesses must cease daily operations from 8:00 p.m. to 5:00 a.m. Essential businesses put in extensive social distancing practices in place to remain open, including requiring the use of masks, staying 6 feet apart, and the use of plastic dividers in some agencies/businesses.

The Federal Coronavirus Aid, Relief, and Economic Security (CARES) Act sought to alleviate some of the impacts of the shut down through direct benefit payments to individuals and through assisting health and social service activities through the extension of the Supplemental Nutrition Assistance Program (SNAP program), and additional funding for FEMA disaster relief for essential government and non-profit organizations delivering care and services.

For Rutgers, the COVID-19 shutdown highlighted the roles of communication infrastructure and energy infrastructure as key for the university's research, teaching, and service missions. This suggests that ensuring continuity of energy and communication infrastructure from outages should be a high priority. The University saw a 30% energy usage decrease during the spring semester, but it should be noted that buildings need to be energy efficient as they still need to be maintained even when not in use. A main climate risk is loss of electricity as it would affect all aspects of the University's ability to function. Faculty and instructors reported that students in their classes stopped attending and/or stopped communicating during the semester. While many instructors attempted to follow reporting protocol, if made available by their school/department, and reached out to students via phone this method was often ineffective (CTAAR, 2020). COVID-19 suggests that switching to long-term online learning may be an effective response strategy for extreme climate events. However, it is important to recognize that climate events have the potential to disrupt critical on-campus energy and computing infrastructure, needed to support online learning.

Significant impacts on research activities because of the COVID-19 shutdowns suggest a need for additional planning for research continuity to prepare for closure of labs, cancellation of international and domestic travel, or postponement of face-to-face human subject research, as well as continued access to IRB (Internal Review Board) for initial/continuing review. On campus research activities may benefit from University wide protocols including access to personal protective equipment (PPE), adequate space for 6-foot distancing, training of all staff, and enforcement of regulations. Face to face community engaged research was not possible during COVID-19, a challenge that may impact community engaged researchers more acutely. Utilizing online platforms for research may provide alterative opportunities to connect with community members or other stakeholders. Additionally, travel restrictions halted the possibility of human subject research at national and international level.

The integration of telehealth is essential during a pandemic or other disaster or event that reduces physical access to health care treatment. During the COVID-19 pandemic, telemedicine enables safe assessment and treatment of COVID-19 illness while also continuing access to care for many individuals with acute and chronic conditions, including mental health conditions. Newer biometric devices are increasing the monitoring of many factors such as oxygen saturation, vital signs, electrocardiograms, and sleep data. High quality video further enables health care providers to assess individuals for specific signs and symptoms.

Telehealth is also a useful data source for research. However, access to technology and sufficient broadband needs to be considered.

Research in lab or in person settings may benefit from utilizing rotating groups or teams which allows for teams to trade weekly allowing for lab disinfection or for ill members to be tested. Team rotations within the same week should be avoided as the schedule increases contamination risk and requires unrealistic resources.

The pandemic also had significant impacts on teaching activities. The rapid shift to online instruction meant increased time required for teaching preparation and numerous adjustments in course content and approach due to limitations of the online format. The Center for Teaching Advancement & Assessment Research (CTAAR, 2020) faculty and student COVID-19 survey showed students felt strongly that they received an effective learning experience but that moving to online instruction adversely affected learning. The majority of faculty stated that their online teaching platforms worked well and offered the functions that they needed. Faculty shared concerns, however, that they did not know how to use many online tools to keep students engaged and that larger classes were much harder to engage and teach compared to smaller classes. Faculty were also concerned about academic integrity, wondering how to deter cheating. While faculty felt there was administrative support, they reported looking for more guidance from their department or school. This included requests for guidance or best practices for teaching online and more training on utilizing the online platforms (e.g., Webex, Canvas). Finally, faculty commonly stated they were overwhelmed with teaching and switching to online learning. Switching courses online that were originally in person required tremendous time and energy. At the end of the semester, when this survey was completed, faculty reported struggling with how to prepare for upcoming semesters as the fall classroom and instruction plan was unknown.

Service activities both within the university and outside in the community experienced significant impacts due to faculty and student time constraints and lack of opportunity for face-to-face interaction. Faculty capacity for service activities was limited as many are using considerable time to shift courses to an online platform and have added responsibilities within their family and personal lives. Also, many service opportunities disappeared with the shut-down for COVID-19 with many events and activities canceled. Faculty, especially pre-tenure, may not have resources or compensation needed to resume service activities to the same level completed pre-COVID-19. Fundraising efforts may also face impacts related to volunteer availability and giving capacity from donors.

The student population faces uneven vulnerabilities and impacts from the pandemic. The shutdown of campus and shift to online instruction has been particularly challenging for a number of groups including: students who are food or housing insecure; students who have lost on-campus employment or off-campus jobs; international students who were unable to return home or remain in their home countries in very different time zones from Eastern Standard Time; students who lack WIFI or computer access; students who have additional family or work responsibilities; students who are essential staff needing to continue coming to campus. CTAAR survey results showed some students did not have the right internet connection or household set up for synchronous classes and were unable to watch/participate at the same time as the lesson. Survey results highlighted student vulnerabilities related to course load with students who were taking more credits reporting a more adverse experience compared to those with less credits. Additionally, most undergraduate students who had lower GPA scores stated their learning experience was adversely impacted (CTAAR, 2020). Students with disabilities who have difficulty processing learning via a computer were at a particular disadvantage. Outside of academic-related stress, the pandemic also added a significant mental health burden for many students, potentially contributing to increased risks of depression and suicide.

6.8. Summary and Recommended Next Steps

Climate change will affect the teaching, research, and service missions of Rutgers University. Results of this initial scope report suggest that there is a critical need for a comprehensive climate impact and vulnerability assessment for all four Rutgers campuses and surrounding communities. In terms of next steps, a number of recommendations emerged from this assessment:

- Monitor changing climate risks (e.g., flooding, sea level rise, heat) in New Jersey and for each campus, making data available for related planning and response efforts with coordinating stakeholders.
- Assess climate vulnerability of critical on-campus infrastructure (roads, transit, buildings, utilities) and develop climate-resilience design standards and guidelines for new and existing buildings and critical infrastructure.
- Coordinate with local, state and federal partners to assess climate vulnerability of critical off-campus infrastructure and provide expertise and financial resources to partner in communities' climate resilience investments adjacent to Rutgers facilities (e.g., land restoration, green infrastructure, stormwater management).
- Identify stable funding mechanisms to implement climate resilient building, infrastructure, and operations on and adjacent to Rutgers facilities
- Enhance climate/weather risk communication, especially for vulnerable student populations identified in this report.
- Participate in state and county all hazard mitigation planning activities by participating on steering committees and stakeholder panels, providing data and technical assistance to NJ OEM and each county, and evaluating university / municipal partnerships for implementing mitigation actions.
- Develop all climate hazards mitigation plans for each Rutgers campus in conjunction with neighboring municipalities, counties and state agencies to ensure continuity of teaching, research and service during extreme events
- Develop plans to address student, staff, and faculty vulnerabilites, by:
  - Evaluating communication protocols among coordinating emergency response entities, especially students
  - Reviewing emergency operations plans to assess current plans considerations for the social, physical, and financial limitations of vulnerable groups
- Participate in adaptation planning efforts in campus-community regions
- Develop adaptation plans at off-campus research sites
- Develop adaptation plans by sector and function

Carbon neutrality planning across all sectors -- from energy to water supply to housing and dining -- also needs to incorporate projected climate risks and to plan for climate change adaptation. There are also many areas where adaptation planning and action at Rutgers, such as tree planting to reduce localized heat island effects, can contribute to carbon neutrality goals. There are also many opportunities where carbon neutrality efforts can enhance climate resilience. For example, expanded solar-based electrification can enhance to resiliency of energy systems to long-term outages. Identifying opportunities to combine adaptation and mitigation efforts is a critical next step toward achieving climate resilient carbon neutrality at Rutgers University.

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APPENDIX B – Big Ten & Ivy League Climate Resiliency Plans

Prepared by Marjorie Kaplan and Gregory Langan

B.1. Introduction

This document provides a synthesis of elements of climate preparedness and resiliency that are planned or being undertaken at larger research universities across the United States to better inform climate change preparedness planning at Rutgers (see attached comparison matrix). A review of websites was conducted of "Big 10" universities, "Ivy League" institutions and other large state universities similar in size and scope to Rutgers to characterize how climate preparedness is addressed in peer institution climate action or sustainability plans.

The institutions reviewed are noted below.

Institutions Reviewed

Arizona State University[*]
Brown University[*]
University of California – Berkeley[*]
Columbia University[*]
Cornell University[*]
Dartmouth College[*]
Harvard University
University of Illinois Urbana – Champaign[*]
Indiana University[*]
University of Iowa[†]
University of Maryland[*]
Michigan State University[†]
University of Michigan[*]
University of Minnesota – Twin Cities[†]
University of Nebraska – Lincoln[*]
Ohio State University[†]
Penn State University[*]
University of Pennsylvania[*]
Princeton University[*]
Purdue University[†]
University of Washington[†]
University of Wisconsin – Madison[†]
Yale University[*]

Of the 23 universities reviewed, 16 have addressed resilience in their climate action or sustainability plans.

A typology of resilience categories was established beginning with five dimensions of campus resilience: 1) Infrastructure, 2) Economics, 3) Ecosystem Services, 4) Social Equity & Governance, and 5) Health & Wellness (Second Nature, 2018). Further definition within the broad categories was provided by the Working Group 6 sectors. Below is the typology of resilience categories.

[*] Universities that have resilience information in their sustainability/climate plans.
[†] Universities that do not address resilience in their sustainability/climate plans.

<u>Typology of Resilience Categories</u>

Health and Wellness

- Health[‡]
- Food
- Sports and recreation
- Housing

Ecosystem Services

- Agriculture
- Fisheries
- Natural Resources and Land Use[‡]

Infrastructure

- Water/Wastewater[‡]
- Energy
- Buildings[*]
- Supply Chains
- Communication and IT (Information Technology) including
- Communication & Outreach
- Transportation

Economics

Social Equity & Governance[‡]

B.2. Summary of Resilience Goals and Actions at Other Universities

There are several resilience goals and actions included in the 23 universities where climate action and sustainability plans were reviewed for climate preparedness (see attached tables).

Health and Wellness

With respect to addressing health issues from excessive heat, two universities (Cornell University and University of Michigan) cited constructing green infrastructure on their campuses. Green infrastructure measures to achieve temperature reduction include increasing canopy cover, green roofs, new plantings, and roof gardens. Cornell University utilizes a "Land Team," created to assist in the development of its Climate Action Plan as well as the implementation of Cornell's Master Plan. The Land Team also conducts projects such as creating a GIS map of the campus' working landscapes and natural areas. The Land Team also plants trees, creates more open space and maintains the green space already on Cornell's campus (Cornell Sustainable Campus, 2013). The University of Michigan has a goal of reenergizing their tree planting program, which will promote a positive effect on the microclimate to address high heat impacts to the campus community.

Five universities (University of California – Berkeley, University of Michigan, University of Pennsylvania, Princeton University, and University of Nebraska) are creating/maintaining social green spaces that contribute to the emotional, physical, and mental wellbeing of students, faculty, and staff. University of Pennsylvania's plan is focused on the implementation of their Ecological Landscape Stewardship Plan (ELSP) to improve the design and management of existing landscapes through best practices for sustainable landscape management (Penn Sustainability, 2019). Princeton's Sustainability Action Plan notes the university has already added 2,370 new trees to campus, converted five acres of impervious area

‡ Categories that have been addressed for resilience by other university plans reviewed

to open space and as of 2019 had completed partial restoration of a local stream. Princeton's plan notes the University strives to increase and maintain green spaces more effectively through 2026. These actions are cited within their plan's category to "Cultivate Healthy and Resilient Habitats" and in that context notes the intention to coordinate with various campus health and wellness programs.

Ecosystem Services

Planting trees and prioritizing native, perennial, drought resistant plants is identified by five universities: University of California – Berkeley, University of Michigan, University of Nebraska, University of Pennsylvania, and Princeton University. The University of Michigan noted an extensive plan to increase plantings of native and perennial drought-resistant plants. The University of Nebraska intends to pilot the substitution of plants in watered landscapes with more drought tolerant plants and notes an intent to plant one hundred trees annually. The University of Pennsylvania is employing the aforementioned Ecological Stewardship Plan to utilize ecological best practices on campus, including planting more native and perennial plants that are more drought resistant to provide ecosystem services such as reduced water usage and less maintenance.

Infrastructure

With respect to university infrastructure, fourteen universities (Arizona State University, Brown University, Columbia University, Cornell University, Dartmouth College, Harvard University, University of Illinois – Urbana Champaign, Indiana University, University of Maryland, University of Nebraska, Penn State, University of Pennsylvania, Princeton University and Yale University) are either using or are studying the usage of green infrastructure to address excess stormwater from heavier precipitation during storm events. Projects such as green roofs and more permeable soils, which improve stormwater management practices, can also assist with recharging depleted groundwater. Bioswales and permeable paving were cited as tools for stormwater management. University of Maryland uses cisterns and green roofs as well as GIS mapping to identify future locations for stormwater mitigation projects. Penn State notes using campus as a living lab which helps to configure the most effective ways to green stormwater infrastructure, for a future with heavier rainfalls and more frequent storms. Cornell University identifies the use of Cornell's patented structural soil for situations where soil compaction is necessary under pavements and along sidewalks to provide a medium for tree growth, as well as a base for turf that improves storm water and snowmelt infiltration, while resisting snowplow and de-icing salt damage in the winter and early spring. The soil is load bearing and leaves room for tree roots to expand and grow downwards, preventing trees from buckling sidewalks and helping avoid drying out during droughts. Cornell's plan cites these practices as potentially reducing the need to repair miles of sidewalk each year. The plan also notes that employing these projects on campus can be used for research as a source of data and potential innovative solutions, as well as for education and outreach. The plan also noted the potential for partnerships with local government to use structural soils and porous pavement to reduce stormwater runoff and improve tree growth.

Two universities (University of California – Berkeley and University of Michigan) are monitoring water usage and have extensive education campaigns to save water, useful especially during droughts. The University of Michigan utilizes a two-step plan to minimize campus water use: 1) as previously noted, Michigan's plan cites the use of native, drought resistant plants; or campus potable water use, the Planet Blue Team (student environmental group) has been successful at raising awareness of water overuse and promoting conservation. The Planet Blue Team's efforts demonstrated a 7.1% per capita reduction in water usage from 2004 to 2009; these efforts continue today. The University of California – Berkeley has also focused on planting native, perennial drought-resistant plants. Berkeley's plan also cites an effort to plug leaks in water systems and an effort to making irrigation more sustainable during droughts by using rainwater for irrigation. The rainwater is collected at three different campus systems and used for plants that would otherwise receive potable water. Additionally, Berkeley has employed drip watering that is coupled with a weather monitoring system ensuring crops and plants are not watered on a day when it will rain. The Berkeley system measures local microclimate information and establishes water minimums and maximums to prevent unnecessary overwatering. Berkeley has also been implementing water education campaigns for students in the dorms, as well as using widespread water metering. Water metering allows the university to measure how much water each building uses; those data can be viewed in real time. Lastly, Berkeley identifies the use of dual-flush toilets in campus housing and low-flow shower heads and faucets in campus housing to reduce water use.

Buildings

In its plan, Cornell identified the idea of creating LEED certification for existing buildings and extending that concept to both existing buildings and neighborhoods off campus to foster resiliency and sustainability within the entire area. Conceptually, additional green infrastructure could be built around the off-campus neighborhoods as well as that committed to on campus, as well as the buildings on and off campus, benefitting both.

Social Equity and Governance

With respect to governance, three universities have created comprehensive adaptation plans for extreme weather and climate issues. Columbia, Cornell, and Yale are considering climate projections and creating comprehensive adaptation plans. Columbia intends to create a model of governing that will consider climate and adaptation needs and future climate realities. These plans will be central in their planning process, including committing financial and organizational capital (Sustainable Columbia, 2017). Yale cited a plan to create a working group to advise its administration on effective adaptation and resilience plans. Yale also noted its intent to expand its adaptation and resiliency planning to the region, to promote resilience for the larger community. Cornell mentions that it will conduct vulnerability assessments and climate adaptation planning to prevent excessive operational and campus disruption due to extreme weather and increased flooding (Cornell Sustainable Campus, 2013).

The University of Nebraska has created an internal research fund to motivate student solutions to today's climate problems. Members of the university community (students, faculty, and staff) vie for grants administered by an interdisciplinary council. Funded projects are focused on improving the sustainability and resiliency of the campus.

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	Arizona State University's Climate Action Plan	Brown University's Sustainability Plan	The University of California - Berkeley's Sustainability Plan	Columbia University's Sustainability Action Plan	Cornell's 2013 Climate Action Plan Update	Dartmouth College Sustainability Plan	Harvard University's Sustainability Plan	The University of Illinois-Urbana Champaign
HEALTH AND WELLNESS								
Health								
Construct green infrastrucure around campus such as tree canopy, green roofs, plants, roof gardens, etc, to decrease excessive heat affects (R) (all populations)					X			
Construct/maintain social green spaces and community gardens that contribute to the well-being of students and the general population and create resilient green spaces on campus (T,L,S) (all populations and vulnerable students/faculty/staff with mental health disorders such as anxiety/depression)			X					
Food								
Sports and Recreation								
Housing								
ECOSYSTEM SERVICES								
Agriculture								
Fisheries								
Natural Resources and Land Use								
Increase plantings/prioritize regular, native, perennial & drought-resistant plants on campus (T,R,L,S) (all populations)			X					
INFRASTRUCTURE								
Water /Wastewater								
Implement/study use of green infrastructure to address stormwater runoff (R) (all populations)	X	X		X	X	X	X	X
Monitor water usage and improve efficiency (so as to not waste water in droughts) (R,T,L) (All pops)			X					
Energy								
Buildings								
Asess the feasibility of piloting a LEED Existing Building (EB) and Existing Neighborhood (EN) certification (which is like LEED for the whole campus) for new and existing buildings at and around the university. If it is achieved, it will help to create resiliency advantages such as more energy available during extreme weather events, more green roofs to cool buildings down clean, healthy buildings and more storm drainage and water efficiency. Collaborate with other universities to advocate in favor of applying this standard to existing campuses, as well as to existing development anywhere - campus or municipality or neighborhood (R,L,T) (General Pops, Students, Faculty/Staff)				X				
Supply Chains								
Communication including IT and Education/Outreach								
Transportation								
ECONOMICS								
SOCIAL EQUITY & GOVERNANCE								
Create adaptation plans for extreme weather and climate issues including, but not limited to: extreme heat events, localized fooding, road closures, etc. Then evaluate the impact of those events on current water, food, transportation and energy systems. Finally, utilize faculty resources to create these assesments and then implement the necessary changes (T, L, R) (General and Vulnerable, All Pops)				X				
Implement an incentive structure for people in the institution to research resilience and sustainability (T,L,R,S) (all populations)								

	Arizona State University's Climate Action Plan	Brown University's Sustainability Plan	The University of California - Berkeley's Sustainability Plan	Columbia University's Sustainability Action Plan	Cornell's 2013 Climate Action Plan Update	Dartmouth College Sustainability Plan	Harvard University's Sustainability Plan	The University of Illinois-Urbana Champaign
Key/Legend								
DImensions of Resilience From Second Nature: https://secondnature.org/climate-action-guidance/campus evaluation-of-resilience-dimensions/								
WG6 Sector [as per WG 6 workplan outline]								
Energy, buildings (WG1), Transportation (WG2), Food (WG3) , Supply chains (WG4) , Land use (WG5), Water supply, Health, Communication/IT , Other (sports and recreation, agriculture, fisheries, natural resources) , (fisheries & aquaculture) (housing)								
Action Types:								
(T/L) Teaching/Learning								
(R) Research								
(S) Service								
Target Populations								
Students (General)								
Students (Vulnerable-specify)								
Faculty/Staff (General)								
Faculty/Staff (Vulnerable-specify)								
Local Communities (General)								
Local Communities (Vulnerable-specify)								
Local communities (vulnerable pops eg. Renters, immigrant populations, low-income residents, small business owners, rural vs urban, coastal vs inland)								
Big 10 schools that do not have resiliency information in their climate/sustainability plans:								
No major stated resilience information for the University of Iowa. They do have a sustainability plan. However, there is no clear carbon commitment made as of yet.								
No major stated resilience information for the University of Maryland even though they do have a CAP. They made a carbon commitment with Second Nature.								
No major stated resilience information for Michigan State University even though they do have some sustainability plans. There is no information on Second Nature about a carbon commitment.								
No major stated resilience information for the University of Minnesota - Twin Cities even though they do have some sustainability plans and a climate action plan. They made a carbon commitment.								
No major stated rsilience information for Purdue University although they do have a sustainability plan								
No major stated resilience information for the University of Washington, but they do have a CAP. They made a carbon commitment though. And the only resilience information is regarding fires in the hazard mitigation plan								
No major stated resilience information for the University of Wisconsin-Madison although they do have a sustainability plan. They recently signed with Second Nature to create a climate action plan								

	Indiana University's Sustainability Plan	The University of Maryland	University of Michigan - Ann Arbor's Sustainability Assessment	University of Nebraska's Environment, Sustainability, and Resilience Master Plan Draft	Penn State University's Sustainability Plan	University of Pennsylvania's Climate and Sustainability Action Plan 3.0	Princeton University's Sustainability Action Plan	Yale University's Sustainability Plan
HEALTH AND WELLNESS								
Health								
Construct green infrastrucure around campus such as tree canopy, green roofs, plants, roof gardens, etc, to decrease excessive heat affects (R) (all populations)			X				X	
Construct/maintain social green spaces and community gardens that contribute to the well-being of students and the general population and create resilient green spaces on campus (T,L,S) (all populations and vulnerable students/faculty/staff with mental health disorders such as anxiety/depression)			X	X		X	X	
Food								
Sports and Recreation								
Housing								
ECOSYSTEM SERVICES								
Agriculture								
Fisheries								
Natural Resources and Land Use								
Increase plantings/prioritize regular, native, perennial & drought-resistant plants on campus (T,R,L,S) (all populations)			X	X		X	X	
INFRASTRUCTURE								
Water /Wastewater								
Implement/study use of green infrastructure to address stormwater runoff (R) (all populations)	X	X	X	X	X	X	X	X
Monitor water usage and improve efficiency (so as to not waste water in droughts) (R,T,L) (All pops)			X					
Energy								
Buildings								
Asess the feasibility of piloting a LEED Existing Building (EB) and Existing Neighborhood (EN) certification (which is like LEED for the whole campus) for new and existing buildings at and around the university. If it is achieved, it will help to create resiliency advantages such as more energy available during extreme weather events, more green roofs to cool buildings down clean, healthy buildings and more storm drainage and water efficiency. Collaborate with other universities to advocate in favor of applying this standard to existing campuses, as well as to existing development anywhere - campus or municipality or neighborhood (R,L,T) (General Pops, Students, Faculty/Staff)								
Supply Chains								
Communication including IT and Education/Outreach								
Transportation								
ECONOMICS								
SOCIAL EQUITY & GOVERNANCE								
Create adaptation plans for extreme weather and climate issues including, but not limited to: extreme heat events, localized fooding, road closures, etc. Then evaluate the impact of those events on current water, food, transportation and energy systems. Finally, utilize faculty resources to create these assesments and then implement the necessary changes (T, L, R) (General and Vulnerable, All Pops)								X
Implement an incentive structure for people in the institution to research resilience and sustainability (T,L,R,S) (all populations)				X				

	Indiana University's Sustainability Plan	The University of Maryland	University of Michigan - Ann Arbor's Sustainability Assessment	University of Nebraska's Environment, Sustainability, and Resilience Master Plan Draft	Penn State University's Sustainability Plan	University of Pennsylvania's Climate and Sustainability Action Plan 3.0	Princeton University's Sustainability Action Plan	Yale University's Sustainability Plan
Key/Legend								
DImensions of Resilience From Second Nature: https://secondnature.org/climate-action-guidance/campus-evaluation-of-resilience-dimensions/								
WG6 Sector [as per WG 6 workplan outline]								
Energy, buildings (WG1), Transportation (WG2), Food (WG3) , Supply chains (WG4) , Land use (WG5), Water supply, Health, Communication/IT , Other (sports and recreation, agriculture, fisheries, natural resources) , (fisheries & aquaculture) (housing)								
Action Types:								
(T/L) Teaching/Learning								
(R) Research								
(S) Service								
Target Populations								
Students (General)								
Students (Vulnerable-specify)								
Faculty/Staff (General)								
Faculty/Staff (Vulnerable-specify)								
Local Communities (General)								
Local Communities (Vulnerable-specify)								
Local communities (vulnerable pops eg. Renters, immigrant populations, low-income residents, small business owners, rural vs urban, coastal vs inland)								
Big 10 schools that do not have resiliency information in their climate/sustainability plans								
No major stated resilience information for the University of Iowa. They do have a sustainability plan. However, there is no clear carbon commitment made as of yet.								
No major stated resilience information for the University of Maryland even though they do have a CAP. They made a carbon commitment with Second Nature.								
No major stated resilience information for Michigan State University even though they do have some sustainability plans. There is no information on Second Nature about a carbon commitment.								
No major stated resilience information for the University of Minnesota - Twin Cities even though they do have some sustainability plans and a climate action plan. They made a carbon commitment.								
No major stated rsilience information for Purdue University although they do have a sustainability plan								
No major stated resilience information for the University of Washington, but they do have a CAP. They made a carbon commitment though. And the only resilience information is regarding fires in the hazard mitigation plan								
No major stated resilience information for the University of Wisconsin-Madison although they do have a sustainability plan. They recently signed with Second Nature to create a climate action plan								