RI Executive Climate Change Coordinating Council

RIEC4

Science and Technical Advisory Board (STAB)

Annual Report
June 2020

RI Executive Climate Change Coordinating Council

Science and Technical Advisory Board

In 2016, the EC4 Science and Technical Advisory Board (STAB[1]) was charged by the EC4 to prepare a brief synopsis of the state of knowledge of the following manifestations of climate change in Rhode Island: sea level rise, warming air temperatures, warming water temperatures, storm frequency and intensity, changing biodiversity, precipitation and flooding. A concise summary of Rhode Island's changing climate was included in Resilient Rhody (2018). which was based on the STAB 2018 Annual Report to the EC4. Since publication of Resilient Rhody, the Fourth National Climate Assessment (NCA4) 2017/2018 has been published https://nca2018.globalchange.gov/

> The first four of the twelve National high-level NCA4 summary findings are included below indicative of the complexity of the challenges: ***Communities:*** *Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of like and the rate of economic growth.* ***Economy:*** *Without substantial and sustained global mitigation and regional adaptation efforts, climate change is expected to cause growing losses to American infrastructure and property and impede the rate of economic growth over this century.* ***Interconnected Impacts:*** *Climate change affects the natural, built, and social systems we rely on individually and through their connections to one another. These interconnected systems are increasingly vulnerable to cascading impacts that are often difficult to predict, threating essential services within and beyond the Nation's borders.* ***Actions to Reduce Risks:*** *Communities, governments, and businesses are working to reduce risks from, and costs associated with climate change by taking action to lower greenhouse gas emissions and implement adaptation strategies. While mitigation and adaptation efforts have expanded substantially in the last four years, they do not yet approach the scale considered necessary to avoid substantial damages to the economy, environment, and human health over the coming decades.*

It is becoming increasingly important to both mitigate and adapt to emerging 21st century shifts in climate to avoid global and local risks to the economy, environment (Hessler, 2020; WEF, 2020), and human health, (Ebi, 2020).

1

In the spring of 2019, five of the nine STAB members were replaced, including Peter August (URI), former STAB Chair, and James Boyd (CRMC), former STAB Secretary. Current STAB members are: Henry Walker, USEPA (Vice Chair); Kelly Knee, RPS/ASA; Sarah Knowlton, RIC; J. Timmons Roberts, Brown Univ.; Tracey Dalton, URI; Art Spivack, URI; Michael Baer, RI Infrastructure Bank; and Nicholas Ucci, RI Office of Energy Resources. (Note: Lilly Picchione (RIPTA) stepped down in May 2020.)

Over the next several decades it will be important to build with new 21st century designs that can handle new 21st century conditions. RI provides guidance on how to use low impact development principles for site planning for development projects (RI DEM; 2010, 2011). There is a need for additional 21st century grey and green infrastructure designs to restore and protect natural features such as flood plains in watersheds and the coastal zone that work with, rather than in opposition to, the forces of nature. For example, future bridges over stream crossings could be designed to let flood stage waters pass under, rather than through them. Transgressive barrier islands along coast lines will migrate shoreward as sea level rises, but the buildings on them will not.

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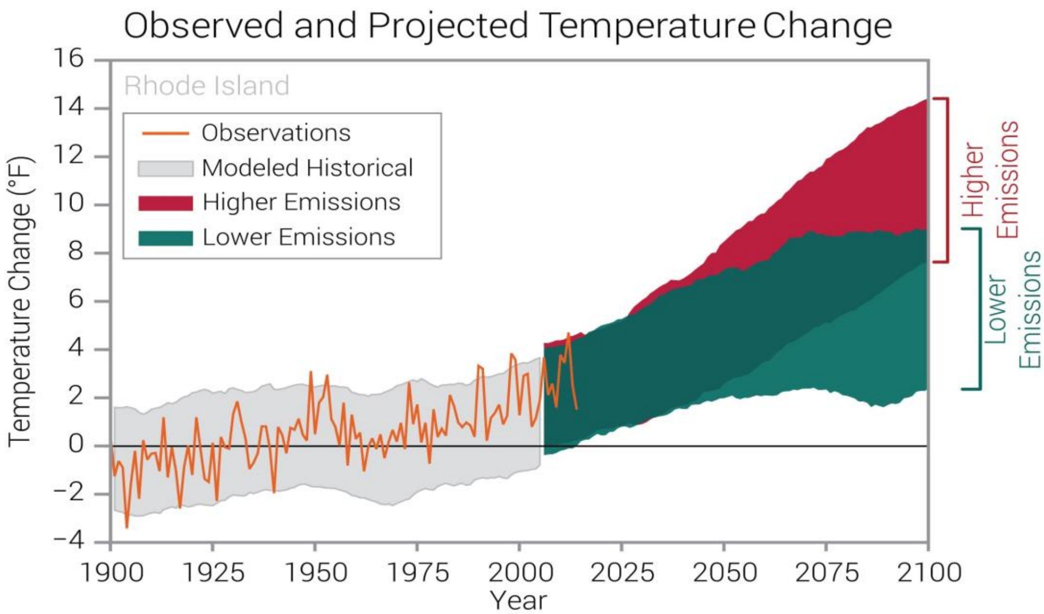
1) Warming Air Temperatures and Policies Needed to Reduce Greenhouse Gas Emissions:



From Runkle et al., 2017; cited in NOAA (2019). Observed and projected changes (compared to the 1901–1960 average) in near-surface air temperature for Rhode Island. Observed data are for 1900–2014. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Rhode Island (orange line) have risen more than 3°F since the beginning of the 20th century. Shading indicates the range of annual temperatures from the set of models. Observed temperatures are generally within the envelope of model simulations of the historical period (gray shading). Historically unprecedented warming is projected to during the 21st century. Less warming is expected under a lower emissions future (the coldest years being slightly cooler than the hottest years in the historical record; green shading) and more warming under a higher emissions future (the hottest years being about 10°F warmer than the hottest year in the historical record; red shading.

Heat-related ER visits in RI increase at higher temperatures. By 2050, it is estimated that there could be 6.8% more heat-related ER visits in RI each year due to climate change (NCA4 2017, 2018).
As a result of climate change, RI: 1) anticipates more days of extreme heat each year, 2) has conducted a statewide vulnerability assessment, and 3) recognizes some of the inequitable impacts on RI communities that are at risk as a result of climate change (RIDOH, 2020a) and varying susceptibilities to the effects of heat waves (RIDOH, 2020b). In response, the RIDOH and the Rhode Island Infrastructure Bank (RIIIB) are focused on implementation of policies and programs at more granular spatial scales, to help ensure resources are directed towards projects and communities that need them most. There are

important opportunities, but in some cases legal barriers. For example, homeowners can gain access to subsidy programs to improve energy efficiency by improving insulation needed to reduce heating and cooling costs and reduce risks associated with excess heat; but many renters cannot. New legislation may be needed to enable additional investments in energy efficiency and risk reduction in rental properties. This could have the added benefit of reducing RI's heating and cooling sector Greenhouse Gas emissions, currently being considered as part of RI's Heating Sector Transformation (HST) Study (OER, 2020).

Additional efforts are being made: 1) involving major investments in renewable generation of electricity (e.g. offshore wind), 2) considering policies needed to reduce GHG emissions from the transportation sector (Transportation and Climate Initiative, 2020), and 3) putting a price on carbon emissions (Cadmus Group & Synapse Energy Economics, Inc., 2019). The climate change mitigation challenge that RI faces, needs to be tackled in multiple sectors of the economy, and at regional, national and global scale to: 1) slow the rate of global warming (MIT, 2020), and 2) help achieve a needed 21st Century energy transition (Mohr et al, 2015).

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2) Warming Water Temperatures:

The water temperature trends in Narragansett Bay was briefly described in Resilient Rhody (2018) based on the more detailed Narragansett Bay Estuary Program (2017) report which documents some of the ecological consequences. Variations in Narragansett Bay water temperature largely track variations in air temperature. Narragansett Bay water temperatures are less influenced by ocean circulation changes than more oceanic sites (e.g. Woods Hole Mass, and Montauk Point, Long Island). Warming air temperatures also contribute to warming of surface fresh-water resources, adversely affecting cold water fish such as trout, and potentially contributing to more severe cyanobacteria blooms (see Section 6).

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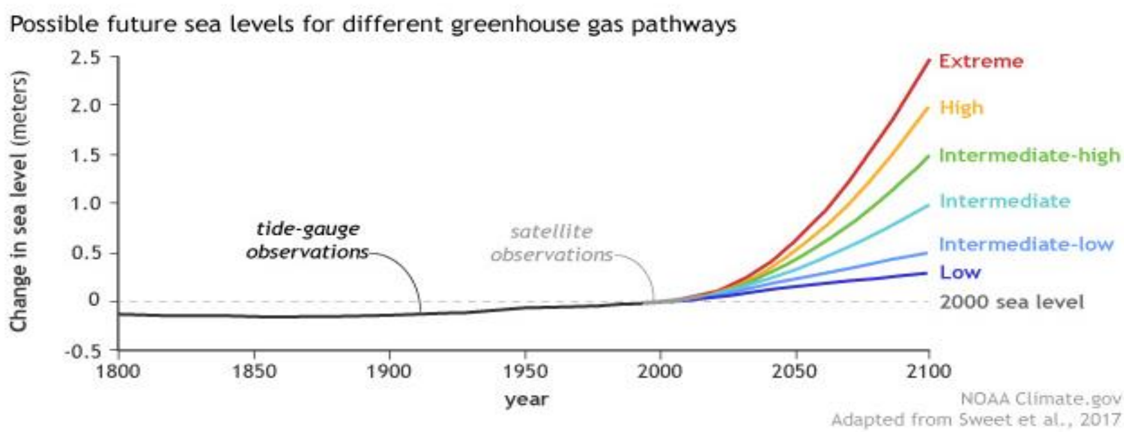
3) Sea Level Rise and Need for Longer Term Planning:

Sea level is rising as a result of thermal expansion of the oceans and melting of ice on land, contributing to increasing frequency of coastal flooding (Sweet et al, 2014). It is now clear that the Greenland Ice Sheet is melting faster than the IPCC predicted (The IMBIE Team. 2019). The figure below illustrates future sea level rise (SLR) possibilities (2.5 meters = 8.2 feet) by 2100. In RI, the Coastal Resources Management Council CRMC (2018) Shoreline Change Special Area Management Plan has adopted the NOAA 2017 high curve at the 83% confidence interval, (RI CRMC, 2018; Sweet et al., 2017), which represents a more extreme SLR scenario, for two reasons. First, using an update from NOAA (2017), CRMC (20107) has recommended using the "worst-case" or "extreme" scenario 9.6 feet by 2100 to guide overall and long-term risk and adaptation planning. Second, CRMC views use of worse-case scenarios as a way to hedge against the uncertainties inherent in projecting future SLR. The United Nations Intergovernmental Panel on Climate Change (IPCC) analysis indicates the rate of SLR can be slowed under different greenhouse house gas (GHG) reduction scenarios but not stopped. Sea level will continue to significantly rise even with reduced GHG emissions.



From: https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level Observed sea level from tide gauges (dark gray) and satellites (light gray) from 1800-2015, with future sea level through 2100 under six possible future scenarios (colored lines). The scenarios differ based on future rates of greenhouse gas emissions and differences in the rates of glacier and ice sheet loss. NOAA Climate.gov graph, adapted from Figure 8 in Sweet et al., 2017.

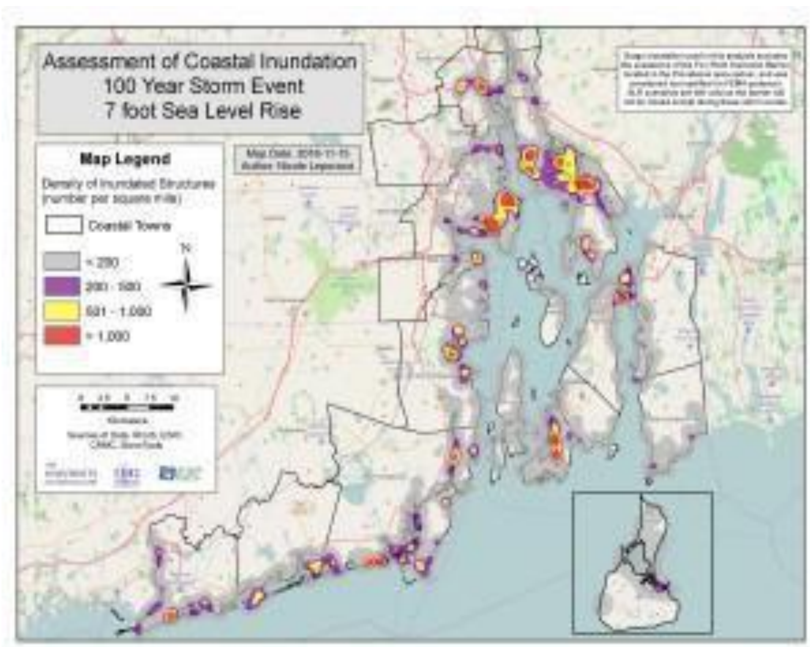
Since the publication of Resilient Rhody (2018) and the 4th National Climate Assessment (NCA4), RI has published more detailed assessments of coastal zone risks associated with climate change, and made these results available to the public in a variety of forms:

1.The Shoreline Change Special Area Management Plan (SAMP),
2. CRMC's Coastal Hazard Analysis,
3. Coastal Hazard Applications forms, and
4. CRMC's Viewer Tool, and Storm Tools.

According to NOAA, RI is out in front in providing higher resolution spatial information for a range of SLR scenarios and coastal storms for various recurrence intervals. Such information can be used in planning further ahead, for built structures, essential infrastructure, RI ports, and valued natural resources including coastal saltmarshes and barrier islands.

For more detailed and recent assessments of risks to coastal structure for various SLR scenarios, and coastal storm intensities (repeat frequencies), and a high-level summary of adaptation strategies, the public can access:

1. E-911 flood inundation structure analysis conducted by URI graduate student Nicole Leporacci under the direction of Dr. Peter August. Excel spreadsheets for all of RI and for each individual coastal community (21 in all). Provides likely affected structures under numerous SLR and storm surge combinations and shows vulnerabilities to flooding. See: https://www.beachsamp.org/stormtools/e911/



2. Chapter 7 – Adaptation Strategies & Techniques of the CRMC Shoreline Change SAMP. See: http://www.beachsamp.org/wp-content/uploads/2018/07/BeachSAMP_Ch7_AdaptationStrategies_061218_CRMCApproval.pdf. Section 7.2.10 discusses "Relocation or Managed Retreat.

RI is a national leader in assessment of coastal zone vulnerabilities, with tools available to the public for assessing and communicating risks. Coastal zone planning tools and requirements related to property resale, are informing decisions when properties are bought and sold, and affecting coastal property values, and insurance rates. The RIIB has been supporting a new Municipal Resilience Program (MRP), with funding provided for investments that can be implemented in the next 2 to 5 years to reduce climate vulnerabilities. But RI still lacks a long-term strategy to address the need for migration away from rising seas related to critical coastal infrastructure, and both public and private sector assets. Such a strategy will need to deal with public sector assets, and critical utilities (e.g. water supplies, and wastewater treatment), regionally important ports such as the Port of Providence; and complex, and spatially explicit complexities related to: 1) risks, 2) state and municipal governance authorities, and 3) related legal and political complexities. For instance, government decisions about land acquisition in vulnerable areas can exacerbate social inequities (Siders 2019). It is critical to consider how policies to address SLR and migration away from the coast will impact low income and minority residents (Mach et al. 2019). The STAB has begun to identify a variety of policy and legal options that can be considered in longer term strategic planning for SLR and needed migration, when necessary, from the coast.

The emerging 21st century realities will force difficult decisions, e.g. related to coastal zone defense vs. migration away from the coast. The science is clear. Many valued natural features such as coastal saltmarshes, and barrier islands will need to migrate shoreward or drown in place in response to a combination of SLR, coastal storm erosion and other factors. Transgressive Barrier islands are dynamic features; and expected to roll shoreward (Nienhuis and Lorenzo-Trueba, 2019; Encyclopedia.com, 2020). At some point, perhaps after destructive coastal storms, residents on transgressive barrier islands will choose to migrate shoreward as well, (Rush, 2018).

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4) Storm Frequency and Intensity:

As noted in previous STAB reports to the EC4, it is likely that Atlantic tropical cyclone rainfall rates will increase (probability >66%). There is also strong consensus that tropical cyclones will continue to become more intense (larger percentage of Category 4 and 5 storms), Emanuel (2019); GFDL (2020). Until recently, this trend has not been apparent in the historical Atlantic hurricane frequency record. However, a recent analysis of homogenized satellite records from HURSAT, indicates a global increase in the probability of exceeding the major tropical cyclone threshold (Category 3) of 8% per decade. In the North Atlantic the probability of exceedance increases to 49% per decade, though some of this increase is explained by regional multidecadal variability, Kossen (2020). Uncertainty about how climate change will impact the frequency of storms remains. Historically, consensus indicates a potential decline in weaker events, Emanual (2019), GFDL (2020); more recent work indicates a potential increase in observed Atlantic storm activity because mutli-decadadal events do not explain all of the variability in the record, Murakami (2020).

While the impact of climate change on the intensity or incidence of storm types, such as extra-tropical storms and tornadoes remains unclear. There is some evidence the extreme precipitation in the Northeastern US has increased (see section below on Precipitation and Flooding).

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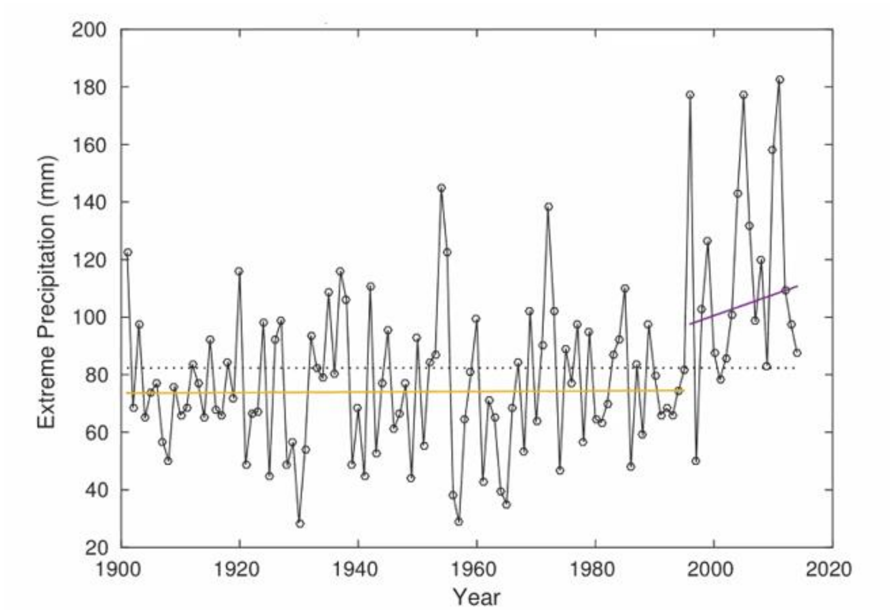
5) Precipitation and Flooding:

Precipitation in the Northeastern US is highly variable within and between years. Over time, there have been changes in methods of documenting precipitation extremes. Given the large variability in precipitation, a reasonable and prudent risk reduction strategy is to take actions to mitigate both wet and dry extremes in climate.

Statistical summaries of precipitation trends can be based on annual averages to look for trends, as summarized in our 2019 update; or to identify potential changes in used in extremes in precipitation. There are also decadal scale variations in precipitation. In the Northeastern US, the 1960s was an anomalously cold and dry decade, associated with a low-pressure anomaly over the midlatitude North Atlantic Ocean (Seger et al., 2012), a decade which included the worst drought in New England since

European settlement (Pederson, 2016). Thus, picking 1960 as a starting point for a regression to document trends in annual average or extreme precipitation, may be misleading. The recent scientific results still suggest a trend toward increases in rainfall intensity less than reported in Resilient Rhody, 2018, but still exceeding those in other regions of the US: Thibeault and Seth. (2014), Hoerling et al, (2016)' Easterling et al, (2017), U.S. Global Change Research Program Climate Science Special Report. Chapter 7 Figure 7.1 & 7.2. (2017), and as summarized in The Fourth National Climate Assessment (NCA4), Wuebbles et al. (2017). A recent longer-term analysis is suggestive of a dramatic increase in extreme precipitation 1996 to present (Huang, 2018). But early 20th century precipitation records are scarce, and methods for measuring extreme precipitation have changed over time. Modeling results U.S. Global Change Research Program Climate Science Special Report (Chapter 7 (2017) Fig. 7.5).; and GFDL (2020) indicate this trend of increasing precipitation intensity will continue in the 21st century, based on 1) expected warmer air temperatures, and 2) that in the future, larger tropical storms may carry and dump more water; noted in the update on Storm frequency and Intensity. Monthly precipitation in the Northeast is projected to be about 1 inch greater for December through April by end of century (2070–2100) under the higher scenario (RCP8.5), NCA4 (Wuebbles, et al., *2017*), citing Lynch et al, 2016). But risks associated with droughts remain. Summers could become dryer, US GCRP Climate Science Special Report Chapter 7 Fig 7.5 (2017), NCA4 Chapter 18 (Mecray et al, 2018).



From NOAA / ICNet http://theicnet.org/ Webinar, Sept 10, 2019 to Eastern Region Climate Partners and Customers - Citing Huang et al. (2018).[2]

Having bridge crossings of streams, designed to let flood waters pass under bridges, rather than through them, could help restore aquatic connectivity and increase resilience to flooding (Jackson, 2017). RIDOT worked with several EC4 departments, Fuss & O'Neill and members of the North Atlantic Aquatic Connectivity Collaborative (NAACC) on Bridge-Steam Crossing guidance (RI DOT, 2019) with the goal of making this assessment methodology assessible to municipalities statewide. Implementation could involve improvements in building codes for municipal bridges, and replacement of bridges at risk of failure, by reducing flood stage flow restrictions. For any new municipal bridges being considered, improved bridge building code/ designs could be required. Also, municipalities can work with RIEMA and FEMA to identify at risk bridges; and have an opportunity to access some funding to help replace them with improved designs, before bridges wash out at a result of 21st floods. In absence of proactive

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[2] Webinar Title: "Mechanisms of Extreme Precipitation Change Over the Northeast" by Jonathan Winter. Note: The density of stations reporting extreme precipitation is relatively sparse during the early decades and methods for measuring extreme precipitation have changed over time. Still, Huang et al. (2018) infer a dramatic increase in extreme precipitation, 1996 to present, and summarize some of the possible mechanisms.

assessments and longer-term planning, poorly designed bridges will likely be replaced with inadequate 20th century designs that restrict flow and contribute to upslope flooding. If new bridge building codes are adopted at municipal scale, following washout FEMA would help fund needed bridge replacements with more resilient designs.

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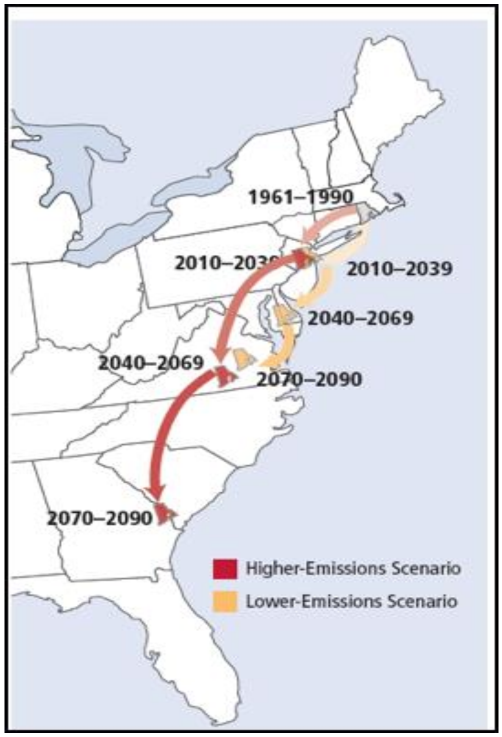
6) Changing Biodiversity:

Rhode Island sits on a climate boundary. As winters become shorter, and growing seasons longer, climate boundaries are expected to shift northward, along with changes in biogeographical distributions of marine and terrestrial plants and animals. The rate of change will be influenced by the rate of atmospheric greenhouse gas increases. Also, 21st century climate change may increase the severity and extent of cyanobacteria blooms in lakes and impoundments (Pearl and Otten 2013, Walls et al 2018*).* Warmer lake temperatures provide cyanobacteria a competitive advantage in phytoplankton communities, and these warmer conditions also promote higher cyanotoxin production. When possible, reducing flow restrictions resulting from unneeded dams, and poorly designed bridge crossings of stream networks, could help reduce some cyanobacteria blooms, maintain stream biodiversity, and reduce flooding risks (see Section 6 on Precipitation and Flooding). Maintaining diverse landscapes (Nichols et al, 2008) and improving stream and landscape connectivity can contribute to maintaining RI’s terrestrial and aquatic biodiversity.



How climate change could alter the ecology and distribution of plants and animals in Rhode Island

Source: Peter C. Frumhoff, James J. McCarthy, Jerry M. Melillo, Susanne C. Moser, and Donald J. Wuebbles*. Confronting climate change in the US Northeast: A report of the northeast climate impacts assessment* (Cambridge, MA: Union of Concerned Scientists, July 2007), https://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/pdf/confronting-climate-change-in-the-u-s-northeast.pdf.

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