# Climate Change Adaptation for Residential Development in New England

## Introduction

New England's climate has changed considerably during the 20th century. Average annual temperatures increased by 0.08 degrees Celsius (°C) per decade and average winter temperatures have increased by 0.12°C. The rate of average temperature increase accelerated significantly during the period of 1970 to 2000 with average annual temperatures increasing by 0.25°C per decade and average winter temperatures increasing by 0.70°C. Driven by these changes growing seasons have lengthened, the number of days with snow on the ground has decreased for many locations and the timing of peak spring stream flow has shifted to earlier in the year.[1]

A recent study of the period from 1948 to 2007 found significant increases in both the occurrence and intensity of extreme precipitation with the most significant increases occurring most recently.[2]

The pace and extent of climate change will be dependent on global efforts to limit greenhouse gas emissions. The projections in Table 1 are derived from downscaled global climate models that examine the ramifications of two different greenhouse gas scenarios.[3] The B1 scenario assumes a stabilizing of atmospheric Carbon Dioxide ($CO_2$) levels at or above 550 ppm by year 2100. The A2 scenario assumes atmospheric $CO_2$ levels of 830 ppm by 2100 and the A1FI scenario assumes $CO_2$ levels of 970 ppm by 2100. Results for the B1 and A1FI scenarios for two of the modeled variables, temperature and precipitation are shown in the following table.

| | UNITS | 2035-2064 | | 2070-2099 | |
|---|---|---|---|---|---|
| **Temperature** | Degrees C | B1 | A1FI | B1 | A1FI |
| Annual | | +2.1 | +2.9 | +2.9 | +5.3 |
| Winter | | +1.1 | +3.1 | +1.7 | +5.4 |
| Summer | | +1.6 | +3.1 | +2.4 | +5.9 |
| **Precipitation** | % change | | | | |
| Annual | | +5% | +8% | +7% | +14% |
| Winter | | +6% | +16% | +12% | +30% |
| Summer | | -1% | +3% | -1% | 0% |

The frequency and severity of heat waves and very heavy precipitation events are projected to increase. Sites on the coast will be exposed to sea level rise in the range of 1.5 to 6 feet by 2100 depending on greenhouse gas levels and ice melt rates.[4]

Average winter precipitation in New England is projected to increase by approximately 10 to 20 percent by the end of the century and the prevalence of heavy precipitation events is also predicted to rise.

Average annual temperatures are projected to climb approximately 3 to 5ºC by the end of the century, and the frequency and severity of extremely hot days will also increase.[5] The associated lengthening of the growing season and projected increase in summer drought will coincide with peak groundwater use during the summer season, which will like create drier summer conditions.

## Changing Residential Development Context

The built environment in the United States will undergo significant change during the first quarter of this century. By 2025 over half of the built environment in the U.S. will be new development as compared to what was on the ground in 2000.[6] Demographic and economic changes are creating a widening gap between the development patterns prevalent over the last 50 years and the needs of today's citizens. Projections indicate the for the period from 1960 to 2025 households with children will decrease from 48% of the population to 28% and single person households will increase from 13% to 28%.[7] These factors, combined with the need to limit greenhouse gas emissions and adapt to climate change, create both the opportunity and the need for new approaches to urban form and the design of associated residential development.

Urban form is strongly linked to both greenhouse gas emission rates and the resiliency of surrounding natural landscapes. A comparison of the ten most sprawling metropolitan areas in the U.S. with the ten most compact areas found that average per capita daily vehicle miles traveled was 27 in the sprawling areas and 21 in the compact areas.[8] In addition, compact development patterns create less fragmentation of surrounding habitat and agricultural lands. Limiting habitat fragment is a key strategy in maintaining biodiversity under the stress of climate change.

## Vulnerabilities

Climate data informs many decisions associated with the design and implementation of residential development. These decisions include both where to build and how to build. Several factors connected with climate change, including rising sea surface temperatures and the ability of a warmer atmosphere to hold more water vapor, are linked with projections of greater frequency and severity of extreme weather events. Increasing flood hazards in both the coastal zone and riparian areas must be considered in decisions on where to build. Climate change will also increasingly inform the question of how to build. These decisions include the type and size of heating and cooling systems, selection of materials for buildings and road networks, design and capacity of storm water management systems and the materials and plants used in landscaping.[9]

- Coastal Flooding and Storm Damage: Sea level rise and the associated increasing severity of storm surge flooding are creating significant changes in the risks associated with development in the coastal zone. Warming sea surface temperatures are increasing the likelihood of large, powerful hurricanes and coastal storms. It is no longer reasonable to consider past storm events as an indicator of future conditions when making development decisions.
- Fresh Water Flooding: Extreme precipitation events have increased by 67% in New England during the last 50 years. This trend is projected to continue, creating a growing threat of freshwater flooding, particularly in watersheds with extensive impervious surface cover or topography that is conducive to flash flooding.
- Extreme Heat: As average atmospheric temperatures continue to increase, the frequency and severity of extreme heat will also increase.[10] Heat waves have historically not been a significant consideration in urban form and building design in New England.

## Adaptation Strategies

- **Overarching Issues:** New residential development in all of New England should be designed to anticipate warmer and wetter conditions. Specific adaptation recommendations include:

  - **Building Envelope:** Inclusion of interior and exterior shading devices, high performance windows and insulating beyond building codes will all extend the comfort range of new homes and minimize the need for air conditioning use as New England warms.[11]

  - **Siting and Landscaping:** Avoiding new construction in flood hazard areas will become increasingly important as total precipitation in New England rises. Storm water management systems should be sized for increasingly large design storms. Inclusion of low impact development features has proven to be a cost effective approach to responding to heavy precipitation events in Massachusetts. Minimizing new impervious surface area and avoiding direct linkage between impervious surfaces and receiving waters will minimize nonpoint source pollution and thermal pollution of rivers and streams.

  - **Heating, Cooling and Lighting:** Inclusion of cross ventilation and stack ventilation features will minimize air conditioning use and expense. Inclusion of daylighting in building design will both lessen cooling demand and increase energy efficiency.[12]

- **Coastal Zone:** If available, utilize modeling of changing flood threat due to sea level rise. Most coastal zone areas in New England now have mapping of areas that will be inundated at different increments of sea level rise. Unfortunately, few areas have modeled the combined impacts of sea level rise and storm surge. As more sophisticated, dynamic modeling of changing storm surge threat becomes available, that information should be utilized in coastal zone permitting decisions. Requiring freeboard levels that anticipate sea level rise and other flood-proofing design features such as elevating HVAC systems and designing wastewater systems to withstand flooding will minimize cost and damage associated with costal storms.

- **Riparian Areas:** As total precipitation and extreme precipitation continue to increase, the threat of freshwater flooding will rise. The development site selection process should anticipate an increasingly large floodplain and a growing likelihood of flash flooding in riparian areas. Flood-proofing measures similar to those for the coastal zone are recommended. Maintaining riparian forest as development takes place will help to minimize flood threat, provide shade for rivers and streams and preserve the viability of cold water fish habitat.

## Endnotes

1 Katharine Hayhoe et al., “Past and Future Changes in Climate and Hydrological Indicators in the U.S. Northeast,” Climate Dynamics (2007), http://www.northeastclimateimpacts.org/pdf/tech/hayhoe_et_al_climate_dynamics_2006.pdf.

2 Susan Spierre and Camron Wake, Trends in Extreme Precipitation Events for the Northeastern United States 1948-2007 (Carbon Solutions New England, 2010), http://www.cleanair- coolplanet.org/cpc/documents/2010neprecip.pdf.

3 Sea-Level Change Considerations for Civil Works Programs (U.S Army Corps of Engineers, October 2011).

4 (Hayhoe)

5 Hayhoe,K., Cameron P. Wake, Thomas G. Huntington, Lifeng Luo, Mark D. Schwartz, Justin Sheffield, Eric Wood, Bruce Anderson, James Bradbury, Art DeGaetano. 2007. “Past and future changes in climate and hydrological indicators in the U.S. Northeast.” Climate Dynamics (DOI 10.1007/s00382-006-0187-8.).

6 Arthur Nelson, “Leadership in a New Era,” *Journal of the American Planning Association* 72, no. No. 4 (October 2006).

7 Ibid.

8 Reid Ewing et al., *Growing Cooler: The Evidence on Urban Development and Climate Change* (Urban Land Institute, October 2007).

9 Larissa Larsen, *Green Building and Climate Resilience: Understanding Impacts and Preparing for Changing Conditions* (University of Michigan and U.S. Green Building Conucil, 2011).

10 U.S. Global Change Research Program, *Global Climate Change Impacts in the United States: a State of Knowledge Report* (Cambridge [England]; New York: Cambridge University Press, 2009).2009

11 Larissa Larsen, *Green Building and Climate Resilience: Understanding Impacts and Preparing for Changing Conditions* (University of Michigan and U.S. Green Building Conucil, 2011).

12 Ibid.

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