Climate Change Adaptation on New England Conservation Lands

Introduction

New England's climate has changed considerably during the 20th century. Average annual temperatures increased by 0.08 degrees Celsius (ºC) per decade and average winter temperatures have increased by 0.12ºC. The rate of average temperature increase accelerated significantly during the period of 1970 to 2000 with average annual temperatures increasing by 0.25ºC per decade and average winter temperatures increasing by 0.70ºC. 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.

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.

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. 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.

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.[1] 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.

Conservation Lands in New England

In the past, land conservation strategies were developed based on the assumption of a stable climatic background. Emergent awareness of the ecological consequences of climate change has created the need to re-examine and refine approaches to the conservation of natural resources.[2] The unprecedented pace of climate change is affecting New England's land and natural resources, as well as the viability of the plants and animals reliant on conserved lands.[3]

New England's conserved lands range from alpine habitats, northern hardwood forests, and grasslands to sand dunes, wetlands, and pine barrens. Many systems in the northeast region are vulnerable to the projected changes in temperature and precipitation, with certain habitats at significant risk of being eliminated entirely from the Northeast (e.g., Appalachian Spruce-Fir Forest) or of having their current distributions severely reduced (e.g., Northern Hardwood Forest, Appalachian Spruce-Fir Forest). Climate change vulnerability analysis for habitat and species has been performed in several of the New England states. Massachusetts led this effort in creating a vulnerability analysis to support the state wildlife action plan. When developing strategies for landscape and associated species conservation, the vulnerabilities of valued ecological resources should be utilized in identifying effective climate change adaptation approaches.[4] Below are some of the primary climate change vulnerabilities and adaptation strategies for conservation lands in New England.

Vulnerabilities

- **Loss of biodiversity due to the combined stress of climate change and habitat fragmentation on natural systems** - There is broad agreement that climate change will disrupt many existing interdependencies between species and habitats in New England, however uncertainty surrounds exactly how this will unfold. Warming temperatures and fluctuations in precipitation will alter terrestrial and aquatic species habitat, changing the availability of food, water, nesting sites, and other life support systems. The mix of stressors associated with climate change will be magnified by other anthropogenic stressors such as pollution and urbanization. Landscape fragmentation can multiply climate change impacts in several ways, including limiting species distribution and inhibiting the ability of their ranges to shift within landscape as the climate warms.[5] A key climate change adaptation strategy is to maintain large, unfragmented blocks of significant habitat and corridors to connect them.
- **Increased competitiveness of invasive species in a CO_2 rich atmosphere** – Climate change will expand the range and enhance the competitiveness of certain invasive species. Non-native plants, pests, and pathogens are already a sizeable threat to the ecology and financial stability of forests. It is estimated introduced pests and pathogens result in the loss of $2.1 billion dollars of forest products per year in the United States.[6] Depending on the species, the increase of CO_2 in the air can

impact a plant's photosynthetic process, change the growth rate, water use efficiency, and nutrient uptake rates, and may increase competitiveness with other species.[7,8] For instance, the growth rate, distribution, and potency of poison ivy is expected to rise under increased CO2 concentrations.[9] The spread of kudzu, an aggressive invasive weed that covers over one million hectares in the southeastern U.S., also responds very favorably to a rise in CO2.[10] It is limited in part by low winter temperatures (5°F to -4°F).[11] Given the diminishing number of days with temperatures below -4°F and aggressive nature of the species, as well as its recent migration pattern, it is likely that kudzu will spread throughout the northeast this century.[12]

- Loss of tidal wetlands due to combination of sea level rise and shoreline hardening – Climate change is projected to increase the rate of sea level rise as rising temperatures hasten melting of glaciers and ice caps and increases the rate of thermal expansion of ocean waters. New England's marsh systems, like those in many coastal areas through the US, are susceptible to impacts of accelerated sea level rise. There are some uncertainties surrounding how the region's coastal marshes will respond to rising sea levels. These systems naturally migrate inland and upward to survive increased periods of flooding. However, the ability of the tidal wetlands to survive sea level rise will be dictated by several factors including the availability of open space for upslope and inland migration; sea level rise rates; and the availability of sediment supply to the marsh. Anthropogenic stressors such as the shoreline hardening and decreased marsh health brought on by pollution will play an important role. Sea level rise will reduce marsh area and productivity in those areas with insufficient opportunities for upslope migration.

Adaptation Strategies

- Landscape scale green infrastructure planning[12] – The term "green infrastructure" has been used in different contexts, from landscape scale natural resource planning to local scale stormwater management techniques in the built-environment. In terms of management of conservation lands, "green infrastructure" is an interconnected network of planned and managed natural lands, working landscapes, and other open spaces that helps conserve ecosystem values and functions and provide associated benefits to human populations (e.g., ecosystem services).[13,14] Green infrastructure planning incorporates natural resource protection into land-use planning at a landscape scale. This strategic conservation approach benefits communities, states, and regions in protecting critical land and water resources. Emphasizing protection of significant core habitat areas and the corridors that connect them is one of the most effective approaches to maintaining resilience to climate change. Protection and restoration of forested riparian corridors to link core habitat areas provides multiple benefits including support of biodiversity, water quality protection and shading of streams to limit warming associated with climate change.

- Protect areas of high geophysical diversity - Conservationists have been developing a variety of methods to anticipate climate change related impacts on biodiversity and identify priority places to protect in order to maintain biodiversity.[15] Given uncertainties surrounding how ecosystems will respond to rapid changes in climate, a complementary conservation approach is to focus on protecting lands with high geophysical diversity. Areas of geologic and topographic diversity offer a range of habitat niches and therefore are likely to support high biodiversity as species assemblages reorganize in response to climate change.[16] Areas of high estimated resiliency are likely to have characteristics (microclimatic buffering and connectedness) that maintain ecological functions and sustain an array of specialist and generalist wildlife species in the face of climate change, anthropogenic disruption, and other disturbances.

- Increase invasive species monitoring and management - Invasive plant species monitoring and response plans for conservation lands should be enhanced in response to climate change. Expand monitoring when possible, and stay informed of any increased potential for invasive species and new management techniques.

› **Focus coastal zone conservation on protecting opportunities for shoreline movement and upslope migration of wetlands** - From a natural systems perspective, allowing the shoreline to move and tidal wetlands to migrate will help maintain healthy coastal and marine ecosystems in response to climate change. Conservation planning should be proactive, thinking ahead to the changing landscape under sea level rise by identifying opportunities for upslope migration of tidal wetlands, and working to protect these areas through land purchase, easements, etc. Adaptation approaches should include limiting shoreline hardening to address bank erosion and emphasizing living shoreline alternatives where possible.

Endnotes

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