Integrating Climate-Smart Considerations into Policy and Regulatory Frameworks

Mainstreaming Climate Adaptation in the Northeastern US

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Executive Summary

Climate change poses one of the biggest global challenges we face. The consequences associated with rapid climate change are currently evident, and projections indicate marked expansion over the coming century. The northeastern U.S. is already experiencing significant deviations from historic climatic norms – from higher temperatures, shifts in the timing, duration, location, and severity of precipitation events, changes in the number and intensity of severe storms, greater frequency of short-term summer droughts – to rising sea levels.[1,2,3,4] What makes the problem particularly intractable is the breadth of interconnections between these climate-driven impacts and a myriad of non-climate stressors such as habitat fragmentation, habitat degradation, and pollution – which have been the focus of conservation efforts for some time. These synergistic impacts are already challenging land-use planning and development decision-making, agricultural practices, conservation planning, and natural capital management in the Northeast.

Guiding Principles

There has been a long history of land use decision-making in the Northeast, and nationally, that has resulted in well established economic, regulatory and policy frameworks that are difficult to fundamentally alter. Moreover, much of the legal infrastructure that supports economic development facilitates short-term profiteering, often to the detriment of long-term planning. As a result, there has been an equally long history of a difficult push and pull between natural resource management and sustainable development. However, increasing deviations from historic climatic norms are beginning to fundamentally threaten this "business-as-usual" dynamic.

Current climate trends systemically threaten the ecosystem-based services that individuals and communities depend upon, including our ability to control floodwater, access potable water, and provide an adequate quantity of affordable food. Climate-driven impacts endanger whole ecosystems through degradation and fundamental alteration. We are faced with the challenge of having to fundamentally restructure and reprioritize how we manage the natural resources upon which our prosperity is dependent. Unfortunately, our ability to respond to this challenge is considerably limited due to a painful economic recession and slow economic rebound. We are left with far fewer options to act at a time when we most need to invest in our natural capital and our aging and increasingly vulnerable infrastructure. We can no longer afford to build and rebuild at will, and we are burdened by a short-sighted and inflexible legal framework that makes it difficult to sustainably realign our activities.

Moreover, given the lifespan of atmospheric carbon dioxide and other heat-trapping greenhouse gases (GHGs), response strategies focused solely on mitigation will not be sufficient to substantively reduce the cross-sector costs of climate change in the northeast. This reality underscores the need for broadly integrating climate adaptation and mitigation considerations across economic sectors and federal and state management jurisdictions. Comprehensive climate adaptation will require incorporating both "hard" and "soft" adaptation approaches, as well as ecosystem-based approaches that focus on solutions facilitating the sustainable delivery of ecosystem services.5

Climate change is increasing both the cost and the risk associated with land use and management decisions that disregard ecosystem service delivery. As a result, effective realignment of land use decision making to accommodate climate change will require particular emphasis on future decisions that protect areas that currently provide (or will provide under climate change) critically important services. To that end, this paper will focus on identifying federal, state and municipal regulatory and policy opportunities across four broad sectors in order to integrate climate adaptation considerations that facilitate ecosystem service delivery.

Residential Development

Growing tensions between changing climate and weather trends and non-climate political and socio-economic drivers is necessitating a reevaluation of where we live and how we build. Challenges facing current and future residential infrastructure include; accounting for long term repetitive-loss costs associated with infrastructure located in now-vulnerable areas, how to incentivize and drive sustainable future development, and how to harness ecosystem-based approaches to increase the resiliency of existing communities and the eco-services they depend upon. These challenges are exacerbated by over-burdened and ineffective federal hazard mitigation policies, lack of coordination between state and municipal planning efforts, and a shortage of federal and state policy incentives driving green infrastructure. A number of policy and regulatory changes will need to be made in order to integrate adaptation considerations to the extent necessary to foster resilient and sustainable community development.

- Restructuring the National Flood Insurance Program (NFIP) is critical to promoting sustainable infrastructure development. A number of basic changes will need to be made in order to increase the effectiveness of the program including, moving towards a multi-year NFIP insurance policy that is tied to the property not the property owner – capping program eligibility at an XX % loss of property and structure, and restructuring NFIP eligibility guidelines to reduce repetitive loss claims.
- Another important opportunity to broadly expand adaptation considerations pertaining to infrastructure development exists in updating federally required components for Hazard Mitigation Plans (HMPs) administered by the Federal Emergency Management Agency (FEMA). The effectiveness of HMPs across states could be significantly improved by requiring that future climate conditions inform hazard assessment, developing strategies to mitigate the impacts of future conditions, and incorporating future condition monitoring protocols into the maintenance component of the HMP development guidelines.
- Significant updates need to be made to the National Pollutant Discharge Elimination System (NPDES) program in order to address current and future climate-driven impacts to stormwater runoff. Baseline stormwater curves need to be informed by future climate projections, and Stormwater Pollution Plans (SPP) should include prerequisites for future condition assessment as well as requirements for green infrastructure "prevention strategies" in order for the NPDES to effectively address pollution associated with stormwater runoff under climate change.
- Other opportunities to increase the resiliency of residential infrastructure to climate change include incorporating future climate planning across Coastal Zone Management Act (CZMA) programs, requiring guidance alignment between NPDES and TMDL development permits, aligning state-driven Comprehensive Master Plans (CMPs) with the assessment findings from FEMA-required HMPs, and integrating standardized climate planning guidance into federal, state and municipal building codes.

Agriculture

The northeast faces a similar degree of urgency to increase the resiliency of our agricultural systems in the face of climate change. Changes in precipitation and temperature patterns, in conjunction with population movement and urbanization trends, are projected to have significant impacts on what crops we grow, how we grow them, and where we grow them. There is mounting concern about increasing population-driven demands on production, a loss of production resulting from changing conditions and disturbance events, as well as concern about the future suitability of many northeastern commercial crops. These concerns are particularly pertinent given outdated federal policies that subsidize "program commodities", a lack of forward-looking federal hazard mitigation programs, and the inability of state or federal controls to reduce the environmental impacts associated with agricultural practices.[6] However, integrating flexibility into current policy and regulatory frameworks guiding agricultural systems in the northeast will require systemic change.

- Future condition planning should be broadly incorporated across a variety of Farm Bill programs including the Whole-Farm Crop Disaster (WFCD) Program, Supplemental Revenue Assistance Payments (SURE), and the Average Crop Revenue Election (ACRE) programs to facilitate climate-smart commodity crop coverage. This effort should include Farm Bill program incentives to target and produce climate resilient species as well as the incorporation of future condition planning considerations across land retirement programs such as the Conservation Reserve Program (CRP), the Wetlands Reserve Program (WRP), the Farmable Wetlands Reserve Program (FWP), and the Conservation Reserve Enhancement Program (CREP).
- Agricultural systems in the Northeast would also benefit from fundamental changes to the NFIP. Capping program assistance eligibility on a fixed percent of "in production" property loss in conjunction with multi-year policies that are tied to the property and not the owners, and access to improvement loans during the coarse of the policy – would significantly improve proactive adaptation efforts. Further measures include revising FEMA's Special Flood Hazard Areas (SFHA) and Flood Insurance Rate Maps (FIRMs) to include data based upon future climate projections, in conjunction with standardized guidance for all agricultural policy holders that facilitate the development of preventative strategies that incorporate green infrastructure.
- Further advances in agricultural adaptation planning could be made at the state and municipal levels by updating zoning, tax, and land use designations. Agricultural policy and regulatory frameworks need to reflect the growing importance of prime agricultural soils both in and out of development, and to recognize the economic value of ecosystem services that increase the resiliency of agricultural systems as well as those that serve to reduce the impacts of agricultural practices on the environment.

Forested Lands

Forested lands represent another important enviro-economic pillar in the northeast that is significantly impacted by the synergistic impacts of climate and non-climate stressors. While changing environmental conditions are driving shifts in forest composition and facilitating range expansions of invasive species, pests, and pathogens – parcelization and development trends are degrading habitats and fragmenting the landscape. The effects from these converging forces include increasing difficulty in managing forest regeneration cycles, reduced harvest revenue, loss of critical habitat and biodiversity, reduction in the adaptive capacity of migrating species, and a growing threat of species invasions. Managing intact, healthy, and sustainable forests into the future will require coordinated adaptation efforts across jurisdictional scales and management entities including integrated federal, state, and private landowner initiatives.

- Establishing "regional" cooperative Transfer of Development Rights (TDR) programs between municipalities, counties and even across states could be utilized as a key strategy to sustainably managing forested lands and the ecological and economic services they provide under climate change. Regional TDR programs need to be developed that – fully account for the landscape-level value of forested lands during preservation assessment efforts – and are precisely aligned with the unique local zoning provisions existing across the program area. States need to take a proactive role in promoting the adoption of zoning provisions that facilitate TDR within a comprehensive planning process.
- Federal regulatory incentives driving market-based programs like water quality trading, wetland mitigation banking, and carbon markets must be shaped by ecological values that increase the resiliency and adaptive capacity of forested lands and their associated services. Specific efforts need to be made by the Conservation and Land Management Environmental Services Board and the Office of Environmental Markets to integrate climate adaptation considerations into market-based programs.
- Significant changes need to be made to a number government payment programs under the Farm Bill that impact the management of forested lands. Of particular importance is the inclusion of ecological considerations that increase the resiliency and adaptive capacity of forested lands into "bundled services" under various federal Payments for Ecosystem Services (PES) programs like the Forest Land Enhancement Program (FLEP) and the Conservation Reserve Program (CRP). Federal PES program revisions should also include adaptation-related biodiversity considerations across Forest Stewardship Programs (FSP).

Conserved Lands

The breadth of synergistic impacts from climate and non-climate stressors is forcing a fundamental reassessment of conservation practices across the Northeast – including how we manage what has already been conserved. Shifting species assemblages, landscape fragmentation, habitat degradation, and contrasting management values across jurisdictions are increasing the difficulty of identifying new conservation targets and flexibly managing existing conserved lands under climate change. Meeting these challenges moving forward will require a cross-cutting, landscape-level approach to conservation planning based upon coordinated management between federal, state, and private entities. As such, a number of changes will need to be made to the policy and regulatory measures pertaining to the establishment, expansion, and ongoing management of conserved lands across the Northeast

- Establishing regional TDR programs and expanding state TDR programs is a key strategy to establishing and expanding conserved lands in areas with complex ownership patterns and contrasting management values. The two most important components to successfully establishing multi-scale TDR programs is standardizing zoning incentives that drive TDR transactions, and ensuring that there is a strong broker entity acting as the program transaction "bank". Significant effort must be made at the state level to increasingly act as the program administrative entity in order to manage the valuation of conserved lands across zoning management jurisdictions.
- At the federal level, efforts are needed to expand state technical guidance under U.S. Army Corp of Engineers (USACE) wetland regulation programs and integrate adaptation guidance across Clean Water Act (CWA) programs. Further, federal strategies to expand conservation efforts on private lands could be significantly expanded by incorporating "bundled" or "stacked" ecological considerations that increase the adaptive capacity or resiliency of conserved lands into federal PES programs. Other gains could be made by expanding federal regulatory incentives supporting conservation banks and integrating adaptation criteria into habitat conservation plans (HCP) under US Fish and Wildlife Service permitting programs.
- Incorporating habitat and wildlife conservation criteria into state-level tax class structures is an important contribution to sustainably managing conserved lands. These criteria could integrate connectivity values into current use tax classes with "core habitat" or "key linkage" designations. Other state-level efforts should include statutory language setting minimum volume or percent in-stream flow limits to maintain ecological function prior to non-local extraction, and to establish tax and other incentives that encourage the permanent retirement of water rights, particularly those with senior priority dates.
- Further, successful future conservation efforts at the local level will require innovative incorporation of climate-smart considerations into easement language and a refocusing of local land trust acquisition targets

The broad reality for the Northeast is that policy-makers, urban planners, resource managers, and service professionals across sectors must face the daunting challenge of making unprecedented adjustments to adapt to changing conditions with dynamic and novel implications. Incorporating integrated, cross-sector climate-smart considerations will be paramount to achieving efficient and cost-effective climate adaptation. However, there are inherent barriers to comprehensive adaptation planning including the lack of top-down federal adaptation policy, minimal intra- and inter- state and federal agency coordination, communication, and collaboration, a lack of funding, and an inconsistent and fragmented regulatory framework. Tackling these impediments will require a review of the policy frameworks guiding management decisions at all jurisdictional levels in order to identify opportunities for the broad integration of comprehensive adaptation planning.

Introduction

Climate Impacts in the Northeastern US

During the 20th century the planet warmed 1.3°F (0.7°C), with the majority of change occurring since 1970.[7] The primary driver of this warming is the increase of atmospheric CO2 from the burning of fossil fuels.[8] Atmospheric CO2 has now reached 395 parts per million (ppm), 30% beyond its highest value in the past million years, and is currently increasing by 2ppm per year.[9]

Further, data indicates that northern latitudes are warming more rapidly than global averages.[10,11,12] States in the northeastern U.S. warmed as a whole by 1.4°F (0.8°C) over the course of the 20th century.[13,14,15] Annual mean temperatures in the Northeastern U.S. are expected to increase between 6°F – 12°F by the end of the century depending upon a doubling or tripling in greenhouse gas emissions (GHGs).[16] Despite currently being on track for a tripling of global atmospheric CO2 beyond pre-industrial levels, a doubling or tripling results in projections that detail a climate in rapid transition from historic climatic norms. These changes are exacerbating preexisting challenges inherent to development, land use planning, and natural resource conservation including issues related to urban sprawl, pollution, and environmental degradation.

The Northeast Megaregion

Climate-driven pressures to nature, markets, resources, and policies are often experienced first at the local level. Furthermore, different geographic regions experience unique climate impacts and are individually predisposed to addressing those impacts in different ways depending upon development and infrastructure patterns, state and municipal authority, and economic and demographic distributions. As the birthplace of the nations industrial centers, the northeastern U.S. has undergone a series of dramatic economic and environmental revisions that have resulted in a unique regional identity.

The Northeastern U.S. underwent significant clearing during the eighteenth century to make way for agricultural production. As thin topsoils quickly eroded, many farms were abandoned and left to reforest. A second wave of significant clearing – driven by the timber and livestock industries -resulted in much of New England being deforested by the mid–1800's. Increasing population size and the industrial development of the late 1800's and early 1900's drove rapid infrastructure development. Due to the rugged topography and an abundance of streams and rivers, settlements relied on boats to access outside markets and the ample hydropower to drive riverside mills and irrigation for agriculture. As a result, a significant portion of the development in the northeast occurred along river valleys and streams. Much of this development exists to this day, making it of some of the nations oldest functioning infrastructure.

In a recent report titled Landscapes: Improving Conservation in the Northeast Megaregion, the Regional Plan Association and America 2050 identified the industrial "core" of the Northeast stretching from Washington, DC to Boston, MA as one of the nation's eleven "mega-regions". This network of "interlocking economic systems, shared natural resources and ecosystems, and common transportation systems linking population centers" is home to 72 million people, includes 19 million urban acres, and makes up 21% of the U.S. GDP.[17] Build-out models project population increases of 500,000 per year, and a 100,000-acre-per-year urban conversion rate over the next three decades.18 Interestingly growth within this megaregion is fairly heterogeneous and projected for only a handful of counties.[19] As major metropolitan centers reach build-out, the most dramatic growth will occur in communities located within surrounding exurban fringe, leading to the conversion of forested and rural lands to low-density suburban development.[20] The rate of urban development will lead to particularly rapid suburbanization in New Jersey, Maryland, and Virginia by 2020.[21] Conversely, many counties in New York, Pennsylvania, Virginia, and West Virginia are projected to have downward population trends for one or more decades between now and 2040.[22]

Compared to other parts of the country, the population of the northeast is not expanding at a particularly rapid rate. Yet, there is a dramatic discrepancy between the population growth rate and the extent of urban expansion. Between 1982 and 1997 the overall population density of the northeast dropped by 23% to 4.51 persons per urbanized acre.[23] During this time the population increased by 3.4 million people while the total amount of urbanized land grew by 3.2 million acres.[24] As such, the region urbanized an average of one acre for every new resident.[25] The ratio is more uneven for some northeastern cities. As an example, during this same period of time Boston's population grew by 6.7 percent but the extent of its urbanized land increased by 46.9 percent.[26] The ratio between population and urbanized land highlight the extent of sprawl and inefficient land use, and punctuate the importance of sustainable development and redevelopment in the northeast.

These trends point to an uneven future for the northeast that include challenges related to development, redevelopment and abandonment, as well as, natural resource management and conservation of open space. Further, efforts to protect natural resources and investments in ecological systems and processes have been largely divorced from land use planning and investments in sustainable development and infrastructure.[27, 28, 29] These challenges are fundamentally exacerbated by the interrelated impacts associated with climate change. Addressing the dynamic threats associated with climate change will require both resilient and healthy ecosystems as well as thoughtful development and land use planning. Plotting a sustainable course forward given these challenges will require a number of policy and regulatory changes in order to integrate climate adaptation considerations across sectors and management jurisdictions. The longstanding "silo approach" inherent to federal, state, and local management authorities is no longer an economically or operationally feasible model to confront this next generation of conservation challenges. Long-term success will depend upon the holistic integration of adaptation and mitigation strategies into policy and regulatory frameworks across sectors and jurisdictions.[30] This report will review recommendations to improve the regulatory and policy framework in the northeast to better support climate adaptation while prioritizing ecosystem health and ecosystem service delivery.

Residential Development

Recent tropical cyclone Irene (2011) and hurricane Sandy (2012) devastated large portions of coastal and inland built infrastructure across the northeast, and exacted significant environmental damage on a myriad of habitats and species, as well as the valuable ecosystem services they provided to those communities. The impacts from these storms brought into stark contrast a number of difficult problems facing current and future development planning and decision-making. Among these is the fact that communities and utility infrastructure intermittently threatened in the past will be increasingly impacted by storms, flood events, and sea-level rise associated with climate change.

Associated challenges include increases in nonpoint source pollution from overwhelmed water and sewer systems, expanding municipal water treatment costs, property damage, loss of property, and a greater number of repetitive-loss insurance claims. Areas with rising water tables will be more vulnerable to septic system failure, while other locations may experience greater variability in drinking water supplies in systems with low storage relative to demand. Coastal communities specifically vulnerable to sea-level rise and storm surges may experience infrastructure damage and issues related to saltwater intrusion and inundation. Other challenges include accounting for future scenarios in siting new development, estimating groundwater recharge rates, and maintaining vital ecosystem services.[31,32,33] As the interactions associated climate change increasingly influence development patterns, there is a growing need for conservation to proactively inform – instead of simply reacting to – land use and development decision-making.[34] This is particularly important for geographically complex regions like the northeast.

Floodplain Development & Redevelopment

River and stream flooding poses significant reoccurring hazards for many regions across the U.S. Approximately 3% of the U.S. population lives within FEMA-designated 100 year flood zone.35 Insurance data indicates that the U.S. spends roughly $2.7 billion dollars per year in flood-related costs.[36] With numerous mountain ranges and abundant rivers and streams, the northeast has a long history of flood events. Due in part to an extensive history of floodplain development and a large number of dams and levees, northeastern communities and metropolitan areas are particularly susceptible to river flooding resulting from early snowmelt and extreme precipitation events and urban flooding as a result of overwhelmed stormwater infrastructure.[37] As such, it is not too surprising that flooding is the most common and costly hazard in the northeastern U.S.[38]

The costs associated with flooding in the northeast will expand significantly under climate change. A growing number of severe precipitation events and increases in winter rain combined with increasingly erratic and severe storm events are projected to substantially increase water flows. Statistical analysis from FEMA and the National Oceanic and Atmosphere Administration (NOAA) suggest an increased frequency of extreme floods because of hurricanes and storm surges.[39] Aging infrastructure and residential communities that currently exist in floodplains will be increasingly vulnerable. Damage claims and loss of property will increase the costs associated with insuring those structures while simultaneously increasing the individual and community reconstruction tax burden. These challenges are further compounded as the northeast is faced with expanding low-density urban sprawl and projected population contractions in many rural communities.

The confluence of climate and development trends in the northeast pose significant challenges to keeping the costs associated with flooding from spiraling out of control. States and municipalities within the region are faced with several significant questions. First, given the increased vulnerability of the Northeast's extensive floodplain development – what measures can be undertaken to contain damage, reconstruction, and insurance costs to floodplain infrastructure? Second, with increased pressure for new development in the northeast – what incentives and/or disincentives can be implemented to promote smart growth and sustainable development? Identifying solutions to these challenges will require a thorough reexamination of the federal, state, and municipal policy and regulation guiding floodplain management in the northeast.

REFORMING THE NATIONAL FLOOD INSURANCE PROGRAM (NFIP) FOR FLOODPLAIN MANAGEMENT

The primary mechanism for expanding adaptation considerations for floodplain development and redevelopment at the federal level is through the FEMA-administered NFIP. The NFIP was established in 1968 to provide a public-sector alternative for disaster assistance to flood-prone properties. The three primary components of the NFIP include, providing flood insurance (often when private insurers will not), expanding floodplain management practices, and developing maps of flood hazard zones based upon 1 in 100 year flood frequencies.[40] FEMA delineates flood risk on Flood Hazard Boundary Maps (FHBMs), Flood Insurance Rate Maps (FIRMs), and Flood Boundary and Floodway Maps (FBFMs).[41] Eligible participants are identified in part by their location within premium risk zones including Special Flood Hazard Areas (SFHA) that are identified by FEMA's Flood Insurance Rate Maps (FIRMs). SFHAs include A-Zone, V-Zone, and X-Zone designations.[42] V-Zones are strictly regulated and operate under a separate insurance rate structure.[43] They include coastal areas that are subject to "storm-induced velocity wave action" such as coastal floodplains.[44] A-Zones are areas subject to 1 in 100 year flood frequencies (100 year floodzone) that are not subject to "storm-induced velocity wave action".[45] X-Zones cover areas "that have between a 1 and 0.2-percent annual chance of flooding based upon historical data" – referred to as the "500 year floodplain".[46] These zones are delineated in FIRMS which are used to set rates, regulate floodplain development, and communicate the identified level of risk to policy holders.[47,48] The NFIP currently insures 5.6 million households covering more than $1 trillion in assets while carrying $17.8 billion in federal debt incurred responding to hurricanes in 2005.[49,50] Further, NFIP payouts in the Northeast as a result of the damages incurred by hurricane Sandy (2012) are expected to be between $12 and $15 billion – well above the current $4 billion borrowing cap imposed on FEMA by the Treasury Department.[51]

This operational reality underscores a number of significant problems with the NFIP that reduce its effectiveness – and may in some cases actually incentivize development in hazard-prone areas.[52] Estimates suggest that only 15% to 25% of properties located in SFHA across the Northeast are insured for flood loss.[53] For those that do have coverage – studies suggest that the premium rates are a third of their actuarial cost.[54] What's more, only one in four NFIP policyholders actually pay full-risk rates, with many "paying subsidized or "grandfathered" rates".[55] Historical data indicates that 1% of insured properties account for over one third of total claims, with a majority of those claims coming from "repetitive loss properties" (RLP), and "severe repetitive loss properties" (SRLP).[56] More startling is the fact that while 90% of these RLPs were initiated before FIRMs, and as such, are heavily subsidized with premium discounts, the rate of new RLPs is "outpacing FEMA mitigation efforts by a factor of 10 to 1".[57]

Other core challenges include significant shortcomings in FEMA's assessment of SFHAs and FIRMs.[58,59,60] Most fundamental is that substantial risk extends beyond a historically-based 1 in 100 year flood lines (floods often extend beyond arbitrary designations), 100 year floods can occur much more frequently then once every 100 years, and future climate projections do not inform SHFA designation.[61,62] Secondly, NFIP coverage occurs under annual policies that are tied to the property owner and not the property.[63] The cumulative result is an inaccurate assessment of actual risk, lack of mechanisms driving program participation, unintended incentives driving redevelopment in flood-prone areas, and a lack of mandatory measures thwarting new development in vulnerable areas.[64,65,66]

On June 29, 2012 Congress passed the Biggert-Waters Flood Insurance Reform Act (BWFIA) of 2012 which provided a series of significant updates to the NFIP. These included increasing coverage rates of multi-family properties, phasing out subsidies for RLPs and homes damaged beyond a percentage of the market value of the structure, and phasing out rate transfers to new homeowners.[67] Other reforms included bumping annual premium rate increases from 10% to 20%, allowing deductibles, and including both "average historical loss years" and "catastrophic loss years" in calculating premiums.[68] Among these important reforms was granting FEMA the power to calculate how "Other Inclusions" – including future changes in land-use, precipitation, storm events and sea-level-rise impact flood risks.[69] Unfortunately, these reforms fall short of providing FEMA with the regulatory mandate necessary to effectively manage floodplain development under climate change.

First, it is not clear that congressional guidance calling for the incorporation of "Other Inclusions" requires any real mandatory measures that would drive FIRM re-designations.[70] Given current levels of federal debt in conjunction with the costs and intense socio-political push-back that FEMA faced in previous FIRM and SHFA re-designations, it is unlikely that FEMA will be compelled to substantively integrate these considerations to the extent they result in significantly higher insurance premiums.[71] Second, given mounting claims and current debt levels, the NFIP remains woefully underfunded, particularly with regard to its mapping efforts.[72] As a result, even with the BWFIA, the NFIP will be increasingly unable to effectively manage the impacts of climate change on floodplain development and redevelopment without significant structural changes.

- **Mandatory assessments of future climate conditions.** FEMA must include a mandatory examination of future climate conditions in developing SHFA and FIRM delineations under the NFIP. Future condition assessment requirements should include a regional analysis of projected changes in the location, timing, and severity of precipitation and storm events, sea level rise and storm surges over a standardized period of time. These efforts should specifically address the implications of this analysis to existing infrastructure to inform FIRM designations. The revised FIRMs must reflect the inclusion of these additional risks to accurately reflect costs.

- **Mandatory assessment of projected land use change.** FEMA must include a mandatory examination of projected land-use trends over a standardized period of time to inform the development of SHFAs and FIRM delineations under the NFIP. This effort should include an incentivized program that provides communities an opportunity to exceed NFIP minimum requirements by pursuing watershed-level assessments of land-use trends, future climate conditions, and existing vulnerable infrastructure to inform FIRM development. Cumulatively these efforts are critically important to establishing accurate risk measurements that are ultimately reflected in policy rates.

- **Multi-year NFIP policies that are tied to the property.** FEMA can integrate climate adaptation considerations into floodplain development and redevelopment decision-making by transitioning to multi-year NFIP policies that are tied to the life of the mortgage, and as such the property, instead of annual coverage that is tied to the individual.[73,74] This plan would be complimented by a mitigation and adaptation oriented home improvement loan program that would exist over the course of an active policy in order to subsidize the costs of proactive efforts.[75,76] In this arrangement the home improvement loan rates would be less than annual premium rebates provided by the NFIP to the homeowner as a result of lowered risk exposure.[77] Longer rate plans would provide the return stability necessary to provide homeowners with loans for upfront costs.[78] Together these efforts could encourage private sector investment in adaptation measures while simultaneously increasing property values.

- **Limiting NFIP assistance eligibility for RLP based upon fixed damage caps.** FEMA is currently required by law not to reject any applicants based upon risk.[79] Yet, RLP claims account for the majority of NFIP payouts.[80] Further, many RFP owners receive subsidies that typically amount to payments representing 40% and 45% of the actual risk cost associated with the property.[81] At some point, FEMA has to have the regulatory authority to cap RFP assistance eligibility – optimally as a result of a particular percent of accumulated loss-costs that extend beyond the value of the property or structure. Another approach would be to disqualify NFIP participation or trigger "no-build" provisions for properties that were significantly damages xx number of times over xx number of years.[82] In some areas, synergistic stressors will increase repetitive flood damages over time to the extent that no amount of creative accounting can sustainably support development. FEMA needs to be empowered to the extent it can identify and drop eligible RLPs from the program.

- **Establish regulatory measures and voluntary programs to encourage NFIP participation.** Efforts that result in revising FEMA's FIRMS will likely lead to program participation reductions as a result of increased rate premiums. As such, specific voluntary programs need to be implemented that mitigate participation reductions resulting from rate increases.[83] These should include direct assistance measures, tax credits, and grant programs to help policy holders pay higher rates.[84] According to a study conducted in 2006 – despite the fact that homeowners in SFHAs with "loans from federally insured or regulated lenders" are required to have NFIP protection – as few as 50% of the homeowners actually held NFIP coverage.[85] Congressional requirements mandating program participation within SFHA's may be necessary in conjunction with voluntary participation programs in order to adequately increase the NFIP rate base while simultaneously facilitating proactive floodplain adaptation management.

INTEGRATED HAZARD MITIGATION PLANNING FOR ADAPTIVE FLOODPLAIN MANAGEMENT

Another important opportunity to integrate climate adaptation considerations into development and redevelopment practices is by expanding the minimum requirements for state and local Hazard Mitigation Plans (HMP) in order to receive hazard mitigation funding under the Stafford Disaster Relief and Emergency Management Act (SDREMA). The SDREMA, in conjunction with hazard mitigation planning guidance under the Disaster Mitigation Act (2000), requires states and municipalities to develop and submit HMPs to FEMA in order to receive assistance under five different non-emergency funding programs including; the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Program (PDM), Flood Mitigation Assistance (FMA), Repetitive Flood Claims (RFC), and Severe Repetitive Loss (SRL) programs.[86] FEMA provides a six-step guidance process to developing an HMP which includes: (1) a planning process, (2) a hazard identification and risk analysis process, (3) a vulnerability assessment stage (4) developing a multiple hazard mitigation strategy (5) and identifying ongoing maintenance strategies prior to (6) final approval and adaption.[87]

Developing HMPs is a common process for states and local municipalities in the Northeast to follow in an attempt to prevent and/or recover from flooding impacts. However, while efforts were made under the DMA to align state and local hazard mitigation planning, there remain major differences in the extent to which states and municipalities incorporate future climate conditions into various stages of the HMP development process. This is likely a result of the fact that FEMA does not specifically require an assessment of future climate conditions in state or local HMPs.[88] This may be due to the historic difficulty of quantifying the extent, probability, history and location of regionally downscaled climate projections.[89] Regardless, the disparity in the extent to which states incorporate climate adaptation in hazard mitigation planning increases the difficulty in comprehensively integrating climate adaptation across planning jurisdictions. Significant efforts need to be made to change the required elements of HMPs to include climate-smart considerations that increase the resiliency of vulnerable infrastructure.

- **Mandatory assessment of future climate conditions in hazard identification planning.** FEMA must require states and localities to conduct future climate condition analysis utilizing the best available models and science, as a component of the hazard identification and risk analysis processes. States and localities can utilize third parties for these assessments or rely upon geographically applicable datasets provided by FEMA. Mandatory assessments would improve the extent to which HMPs could inform sustainable residential development and redevelopment, and would greatly advance coordinated adaptation planning between state and local efforts.
- **Require the development of future-condition mitigation strategies.** FEMA must require states and localities to utilize future climate condition analysis in determining mitigation strategies outlined in HMPs. Further, FEMA must require states to incorporate Green Infrastructure (GI) into HMP strategies whenever feasible. Identifying potential management options funder future climate scenarios increases hazard preparedness by ensuring that mitigation strategies are identified in response to a wider range of potential outcomes.
- **Updating bylaws, ordinances, and building codes based upon HMP findings.** A significant portion of residential floodplain management occurs at the local level. Utilizing state HMP findings to inform the revision of state bylaws, municipal floodplain and zoning ordinances, subdivision regulations, capital improvement plans and building codes will dramatically increase the breadth and effectiveness of municipal adaptation efforts. Incorporating HMP hazard findings and mitigation strategies will reduce the risk exposure to residential infrastructure at vulnerable sites.

› **Incorporate HMP findings in Comprehensive Planning Efforts.** Northeastern states have varying examples of state planning enabling legislation that either require or incentivize the development of local comprehensive plans (CP). CPs are policy documents that typically include a review of existing conditions, future trends, land-use patterns, housing conditions, population trends, roadways, and other infrastructure to guide future community growth. While not regulatory documents themselves, CPs often informs the development of municipal ordinances and bylaws, As such, incorporating climate adaptation considerations for residential infrastructure could be greatly benefitted by incorporating state and local HMP findings into local CPs.

Stormwater & Nonpoint Source Water Pollution

Stormwater runoff is one of the primary sources of water pollution in the United States.[90, 91] Further, stormwater-driven water quality degradation is the result of one underlying cause – the loss of watershed functionality related to water retention and evapotranspiration capacity.[92] Conversion of undeveloped watershed removes topsoil and vegetation for agriculture or built infrastructure. Under typical rain events 10 percent of the total rainfall volume escapes as runoff, 50 percent is infiltrated, and 40 percent returns into the air.[93] The reduction in extent of pervious surface to capture rainfall and vegetation to conduct evapotranspiration increases runoff such that in urban landscapes stormwater flows rapidly across impervious surfaces and into water sources in short, concentrated discharge "spikes".

Two systems are currently in place to manage water and sewer discharge. Many communities across the country have separate stormwater and sewer infrastructure. In these systems, sewage is piped directly from point sources to municipal water treatment facilities, while stormwater flows across impervious surfaces before it is captured and deposited, largely untreated, into designated waterbodies. This runoff can contain bacteria, metals, nitrogen, phosphorus, oil & grease, pesticides, toxic chemicals, as well as trash and debris. Stormwater runoff is the number one and two pollution source for ocean shorelines and estuaries respectively.[94] A recent report by the Natural Resources Defense Council estimates that 10 trillion gallons a year of untreated stormwater runs off impervious surfaces, and into our rivers and waterways.[95]

Combined sewer systems (CSS) emerged during the late 1800's in rapidly growing urban areas – like those in the northeast – as a cost effective way of disposing of sewage and urban runoff.[96] CSS capture stormwater and transport it to municipal water treatment plants in the same pipes used for sewage. CSS infrastructure includes designated combined sewer overflows (CSO) in the event the system is overwhelmed. Because CSS manage a far greater volume of material then separate stormwater sewer systems, rain events often overburden the system resulting in the overflow of a stormwater-sewage mixture into open waterbodies. CSO pollutants include pathogenic bacteria, viruses and parasites; toxins including cadmium, copper, and lead, and can pose a direct health threat at CSO discharge locations.[97] Roughly, 40 million people in 772 municipalities nationwide rely on CSS infrastructure, and as of 2002, there are an average of 850 billion gallons of raw sewage and stormwater discharged over 43,000 CSO events every year.[98]

There are numerous challenges to stormwater management in the northeast that ultimately render both separate and CSS infrastructure ineffective in protecting waterbodies from nonpoint pollution.[99] These include grey development with minimal runoff containment capacity, poorly planned transportation infrastructure, hazard-vulnerable municipal treatment facilities, aging and failing infrastructure, limited Federal and State regulatory enforcement capacity, and narrow monitoring and modeling protocols that fail to accurately assess cumulative discharge.[100, 101, 102]

These issues are further compounded by climate-driven changes to hydrological processes including; increases in heavy precipitation, less winter precipitation falling as snow and more as rain, reduced snowpack, earlier breakup of winter ice on lakes and rivers, earlier spring snowmelt and subsequent changes in peak river flows, and rising sea levels.[103, 104] The interconnected challenges precipitating runoff pollution are such that achieving basic water quality protections under climate change will necessitate a wholesale reevaluation of stormwater management practices. A primary component of this effort will require identifying opportunities to expand and/or integrate climate adaptation and mitigation criteria into the existing policy and regulatory frameworks that guide stormwater management.

UPDATING THE NPDES FOR STORMWATER MANAGEMENT

Under the Clean Water Act (CWA), the Environmental Protection Agency (EPA) is charged with implementing a number of pollution control programs. Of these, the National Pollutant Discharge Elimination System (NPDES) program authorized under Section 402(p) of the CWA is the primary vehicle to regulate stormwater. Initially the NPDES program focused on regulating pollutants from "point source" discharges from industrial wastewater and municipal sewage plants.[105] Amendments to the CWA in 1987-1990 expanded the NPDES to include stormwater control in an effort to address "nonpoint source" discharges associated with runoff from industrial sources, construction sites and municipal separate storm sewer systems (MS4s). The Phase I Stormwater Rules issued by the EPA in 1990 require NPDES permits for municipal separate storm sewer systems (MS4s) serving populations larger than 100,000 and for runoff associated with industry and construction.[106] Phase II Stormwater Rules adopted in 1999 expand the scope of permitting to include small MS4s and construction sites between one and five acres in size.[107]

CSOs are regulated under NPDES and require municipalities to "design and implement long-term CSO-control programs with the goal of gradually coming into compliance with the CWA".[108] Despite the fact that most municipal stormwater discharges are regulated as point sources requiring an NPDES permit, outputs rarely require specific controls typical of other pollutant discharges.[109, 110] In order to manage the 500,000 stormwater permittees that exist at any given time, the EPA relies on "general" permits which are statewide, "one-size-fits-all permits" with broad provisions.[111] To obtain a permit, construction and industrial applicants must create and implement a Stormwater Pollution Prevention Plan (SPPP), while MS4 permittees are required to implement a stormwater management plan. Both plans require general Stormwater Control Measures (SCM) used to reduce the impacts of site stormwater runoff on nearby waterways.[112] While general permits for Phase I & II construction activity encourage post-construction stormwater controls, they are not required.[113]

Since the inception of stormwater management under the NPDES, the EPA has identified hundreds of thousands of Phase I & II discharges that fall within the purview of the program.[114,115] The shear number of sources requires that most states implement the NPDES program and administer their own stormwater permitting programs.[116] However, the ongoing extent of nonpoint source-driven water quality degradation associated with stormwater runoff prompted the EPA in 1994 to begin encouraging watershed-based permitting under the NPDES as a means of addressing multiple sources within a hydrologically defined area.[117] Opportunities to integrate climate adaptation criteria specific to NPDES stormwater management exist within both source-by-source and watershed-based permitting approaches.

- **Extend enforceable federal regulation for nonpoint source pollution.** The extent of EPA-enforced nonpoint sources should be increased by reducing the number of discharge exemptions under Section 1344 of the CWA. Current discharge exemptions include dredged or fill material discharges from "from normal farming, silviculture, and ranching activities such as plowing, seeding, cultivating, minor drainage, harvesting for the production of food, fiber, and forest products, or upland soil and water conservation practices"; "for the purpose of construction or maintenance of farm or stock ponds or irrigation ditches, or the maintenance of drainage ditches"; and "for the purpose of construction or maintenance of farm roads or forest roads…".[118,119]

- **Expand bio-indicator requirements in National Pollutant Discharge Elimination System (NPDES) permitting.** As such, incorporating quantifiable, performance-based ecosystem-oriented metrics for NPDES discharge permits is critical to improving stormwater management under climate change. As an example, marine discharges could be limited to specific pH levels in light of increasing ocean acidification.[120] Other potential rule alterations include establishing turbidity limits for water discharged from upland construction sites or implementing numeric water quality limit "surrogates" such as minimum flow rates and percent of post-construction impervious cover.[121]

- **Require low impact development (LID) and green infrastructure Stormwater Control Measures (SCM) in Stormwater Pollution Prevention Plans (SPPP).** The development of SPPPs, which document how SCMs will mitigate a permittees stormwater discharges from reducing water quality in discharge waterbodies are at the heart of EPA's stormwater management program. NPDES discharge permits should require standards that maintain predevelopment hydrology utilizing green infrastructure and low impact development (LID) techniques. An example includes maintaining predevelopment hydrology utilizing green infrastructure and LID techniques in projects over a specific square footage.[122]

- **Structure all stormwater permits based upon watershed boundaries.** Since 2003, the EPA has increasingly supported multi-source watershed-based NPDES permitting which provides a mechanism for multiple point sources within a watershed to obtain one umbrella permit for one or more pollutants.[123] In 2009, the EPA requested an assessment of its stormwater management programs from the National Research Council (NRC). Among it's findings, the NRC concluded that primary change at the federal level needed to reduce the degradation of the nation's aquatic resources would be to structure all stormwater "and other wastewater discharge permits" on watershed boundaries instead of political boundaries.[124] However, while SCMs have been successful in reducing stormwater pollution in discrete settings, individual site controls are unable to mitigate stormwater discharge at the urban watershed scale.[125] In order to achieve broad success, SCM's need to be holistically implemented – "integrating structural and nonstructural SCMs and incorporating watershed goals, site characteristics, development land use, construction erosion and sedimentation controls, aesthetics, monitoring, and maintenance".[126] Achieving this level of coordinated implementation will require the elimination of separate permits for municipal, construction and industrial activities under NPDES in pursuit of integrated management.[127]

- **Create market-based trading system for National Pollutant Discharge Elimination System (NPDES) dischargers.** The NRC report further suggests that the EPA should institutionalize market-based credit trading among dischargers and adaptive management strategies into the permitting structure in order to achieve permit objectives.[128]

REVISION AND ALIGNMENT OF TOTAL MAXIMUM DAILY LOAD (TMDL) AND NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PROGRAM GUIDANCE FOR STORMWATER MANAGEMENT

As previously outlined, NPDES Phase I & II programs only require technological best efforts to eliminate pollution, permits are not tied to source water quality, and as a result, federal effluent limits alone do not suffice to maintain basic water quality.[129] In response to the need for additional protections, Congress established a number of programs under the 2011 Water Pollution Control Act to maintain minimum federal and state water quality standards.[130] Of these, the Total Maximum Daily Load (TMDL) Program (33 U.S.C. § 1313(d)) offers the greatest source protections from point and nonpoint pollution.[131,132] Under the TMDL, states are required to list all waterbodies that fail to meet minimum standards and determine "total maximum daily load" of the problem pollutant for each listed waterbody.[133,134] This multi-step process begins with a state identifying all of it's waterbodies that do not meet federal and state water quality standards, then ranking the degree of impairment across water bodies, and lastly, "creating a TMDL accounting for seasonal variation and including a margin of safety to reflect lack of certainty".[135]

> "In the TMDL calculation, "pollutant loads from point sources (permitted discharges from identifiable points, such as industrial or municipal discharge pipes) are called 'waste load allocations' or WLAs, and loads from nonpoint sources (diffuse sources, such as urban, residential, or agricultural runoff) are called 'load allocation' or LAs."31 The TMDL is the sum of the waste load allocation and load allocation with an additional margin of safety. Put into a simple equation: TMDL = WLA + LA + MOS."[136,137]

Once a state develops a TMDL it is presented to the regional EPA office for approval.[138] If the TMDL is approved then the state is required to allocate the permissible pollutant load among point and nonpoint sources.[139] Should the TMDL not be approved, the EPA is then compelled to produce the TMDL itself.[140] Unlike the NPDES, effluent reductions in listed waterbodies are not limited to economically and technologically feasible mitigation efforts, but ensure that continued degradation of the waterbody is halted.[141] As a result, if an NPDES permitted stormwater source is contributing to a TMDL listed waterbody then the state is required to impose more stringent discharge limitations regardless of whether it is listed in section 402p, or is a point or nonpoint source.[142]

While the recent emphasis on nonpoint regulation under the TMDL has precipitated a call to use TMDL requirements to expand stormwater management, TMDL programs have been slow to develop. A report from the National Wildlife Federation in 2000 found that 75 percent of the states had failed to develop robust TMDL programs.[143] Subsequent studies suggest that cost, poorly supported water quality standards, and insufficient monitoring among other reasons, have resulted in the inability of states to bring TMDL-listed waterbodies into compliance.[144] Cost estimates alone have suggested that implementing a meaningful program in a state with 100 sub-watersheds in need of TMDLs would cost roughly $4 billion.[145,146] Due to the episodic nature of stormwater pollutant discharge events and the difficulty in determining exactly how much of a specific pollutant contributes to water quality degradation, utilizing TMDLs to manage stormwater at a watershed-scale is difficult.[147] In order for integrated watershed-based stormwater management to be successful under climate change, adjustments to the TDML program will need to be made.

- **Require Total Maximum Daily Loads (TMDL) to include future climate condition assessments.** States should be required to include an assessment of future climate conditions in determining TMDL load allocations. The CWA currently requires that TMDLs be calculated such that applicable water quality standards can be met given "seasonal variation".[148] Implicit language needs to be incorporated to compel TMDLs to include regional downscaled climate projections provided by the EPA. Given the TMDL program is focused on the impacts of specific pollutants on water quality, there is an increasing need to utilize TMDLs to assess the synergistic impacts of various pollutants and climate change.[149]

- **Require Total Maximum Daily Loads (TMDL) to include minimum low requirements.** The second limitation to expanding stormwater management under the TMDL is the focus on pollutants rather than flow.[150] While several states in the northeast including Vermont, Connecticut and Massachusetts have included a broad range of TMDL indices, conversion of the TMDL program at the federal level will be required in order to achieve integrated watershed-based stormwater management under the NPDES program.

- **Align Total Maximum Daily Load (TMDL) standards with National Pollutant Discharge Elimination System (NPDES) Stormwater Control Measures (SCM) in TMDL watersheds.** The primary shortcoming of the TMDL program with respect to stormwater management and climate change is the fact that an assessment of future conditions is not inherent to the structure of the program.[151] As such, data inputs required under SCM and TMDL development must reflect regionally downscaled climate projections within federally standardized time horizons.

› **Integrate impervious cover standards across Total Maximum Daily Loads (TMDL) and Stormwater Control Measures (SCM).** Further, SCMs developed for SPPPs in TMDL watersheds should incorporate impervious surface standards in order to increase filtration capacity and reduce downstream runoff. Maine, Vermont, and Connecticut issue some TMDLs based on impervious cover rather than individual pollutants of concern (Bellucci 2007, NRC 2009).

INCREASING CLIMATE CONSIDERATIONS FOR STORMWATER MANAGEMENT UNDER NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

Another opportunity – while less direct than the NPDES & TMDL programs – to strengthen stormwater management under climate change through federal guidance is through changes to the National Environmental Policy Act (NEPA). The Council on Environmental Quality (CEQ) was created under NEPA in 1970 and is responsible for providing oversight and periodic guidance to federal agencies on NEPA provisions. NEPA requires federal agencies to evaluate environmental impacts when undertaking a federal project or activity. If a federal activity falls within the purview of NEPA, the action is subject to three potential levels of analysis including a Categorical Exclusion (CE), preparation of an Environmental Assessment (EA) and Finding of No Significant Impact (FONSI); or preparation and drafting of an Environmental Impact Statement (EIS).[152]

NEPA has traditionally been interpreted as pertaining specifically to the impacts of a proposed activity on the environment.[153] However, in 2010 the CEQ released draft guidance specifically related to climate change asserting, "…effects should be considered in the analysis of projects that are designed for long- term utility and located in areas that are considered vulnerable to specific effects of climate change".[154] The 2010 draft guidance concludes with "NEPA analysis of climate change issues necessarily will evolve to reflect the scientific information available and the legal and policy context of decisions that the NEPA process is intended to inform".[155] While the 2010 draft guidance was never finalized, and follow up guidance specific to climate change has yet to be issued, the door remains open for CEQ to further integrate climate considerations into NEPA review. Introducing follow-up mechanisms or requiring periodic review and revision of decisions to incorporate new information or data will unshackle environmental laws from a front-loaded assessment process. Doing so could have a significant impact on federal activities influencing stormwater management including transportation infrastructure projects.

› **Regular Council on Environmental Quality (CEQ) updates to climate change considerations guiding National Environmental Policy Act (NEPA).** The opportunity exists under NEPA to substantively align federal stormwater project development with respect to future climate conditions. There needs to be a growing recognition that in order to accurately assess project impacts on the environment, the impacts of future environmental conditions on the project must be assessed. In other words, how a project impacts the environment depends upon the changing context of the environment. CEQ needs to take firm proactive leadership in outlining the reciprocity of this relationship in EIS climate change guidance in order for NEPA to remain an effective regulatory environmental impact reduction tool.

STATE AND MUNICIPAL OPPORTUNITIES FOR STORMWATER MANAGEMENT

Due to the decentralization of land use decision-making in the United States, state-level stormwater management policy and regulatory controls are typically driven by state-administered federal programs or through statutory authority. As previously mentioned, many states across the country are the NPDES permitting authority for major discharges – including multi-sector general permits for stormwater discharges associated with industrial activities, permits for stormwater discharges from MS4s, and general permits for stormwater discharges from construction activities. In the northeast, Connecticut, Maine, Rhode Island, and Vermont have federal authority to administer NPDES general permits. Apart from administering general permits for Phase I and Phase II stormwater management under the NPDES, several northeastern states have legislation and/or policy to further guide state-level stormwater management.

For example, in 1997 the Massachusetts Department of Environmental Protection (MassDEP) published the Massachusetts Stormwater Handbook as guidance to promote stormwater recharge, runoff treatment, low impact development (LID) techniques, pollution prevention, the removal of illicit discharges, and improved operation and maintenance of stormwater best management practices (BMPs).[156] While not a standalone piece of legislation, many of the standards are regulated under the MA Wetlands Protection Act (M.G.L. c. 131, § 40), and the Massachusetts Clean Waters Act (M.G.L .c. 21, §§ 26-53).[157] Several other northeast states have similar guidance. Vermont has a number of management guidelines outlined under Title 10 of the Conservation and Development statute including a stormwater management program administered within the Water Quality Division of the VT Department of Environmental Conservation.[158] New Hampshire has the Shoreland Protection Act (RSA 483-B) that details limitations of impervious surface area existing 250 feet from surface water.

- **Integrating future condition assessment into "little NEPA's".** Many states – including Connecticut, Massachusetts, New York, and New Jersey in the Northeast – have NEPA-like State Environmental Protection Acts (SEPAs) that provide environmental impact assessment requirements for most projects or activities proposed by a state agencies or municipalities.[159] As with their federal counterparts, there is an important obligation as a primary vehicle for environmental impact protection, to include reciprocal project impacts. Climate change is forcing SEPAs to include longer-term assessments of potential project impacts on the environment, and in turn how changing conditions will affect the project moving forward.

MUNICIPAL USE OF LOW IMPACT DEVELOPMENT (LID) AND GREEN INFRASTRUCTURE FOR STORMWATER MANAGEMENT

The vast majority of stormwater management occurs at the municipal level. While states typically provide stormwater management guidance, ultimately local governments are left with broad authority to exercise land use controls. Municipalities have a long history of utilizing "grey development" strategies including the use of gutters, basins and pipes to rapidly move stormwater runoff away from communities and into streams, rivers, and nearby waterbodies.[160] With the National Weather Service estimating cumulative flood damages between 2001 and 2010 at $102 billion, municipalities across the country are looking for cost-efficient and effective strategies to reduce the impacts of stormwater runoff.[161, 162] LID and GI strategies are increasingly employed as multi-benefit strategies to achieve flexible, long-term cost savings.[163] LID is a land management approach focused on restoring or maintaining pre-development hydrological conditions while GI typically refers to specific practices employed to implement LID with respect to stormwater management.[164,165]

Specific GI strategies include the use of blue, green & white roofs, green alleys and streets, thoughtfully-located open space and parks, bioretention cells (rain gardens), planters and tree boxes, vegetated swales, permeable pavements, and disconnecting downspouts.[166,167] These strategies can reduce stormwater volume by capturing, storing, and absorbing runoff, reduce the extent of impervious surface, decrease and/or delay peak discharge spikes, prevent pollution, and facilitate groundwater recharge.[168] Potential co-benefits of GI include a reduction in energy heating, cooling and fueling costs, reduced infrastructure maintenance costs, human health improvements, reduced urban heat index, improved air quality, and increased property values, recreation opportunities and community aesthetics.[169] Increasing use of GI strategies is driven in part by the fact that they can result in significant cost savings.

Estimates suggest that green streets, rain barrels, and tree planting are "3 to 6 times more effective in managing stormwater per $1000 invested than conventional methods".[170] The full life cycle net value of green roofs is estimated to be 40% higher than conventional roofs when it comes to stormwater management, reduced electricity costs, and air quality benefits.[171] Despite the fact that one-inch of rain, falling upon a 1000 sq ft roof generates 623 gallons of water; blue roofs can store approximately 50% of the water that falls on it annually.[172] This provides remarkable long-term electricity savings given one million gallons of water requires 955 to 1911 kWh of electricity to treat.[173] More startling yet, permeable pavement can reduce storm run-off volume by 70-90%, and building a wastewater treatment system with constructed wetlands "costs about $5.00

per gallon of capacity compared to roughly $10.00 per gallon of capacity for a conventional advanced treatment facility".[174] As a result, states across the Northeast are quickly realizing the full-term benefits of implementing GI strategies. In it's 2010 Green Infrastructure Plan, New York City estimated that it could reduce CSO volumes by 2 billion gallons by 2030 using GI practices at a cost savings of $1.5 billion compared to convention reduction strategies.[175] Similarly, Washington, DC has estimated that establishing green roofs on most eligible buildings "could yield a 6-15% reduction in the number of CSOs into local rivers, with CSO water volume reductions of up to 26%".[176] Given the profound savings as well as human and ecological benefits, GI strategies represent the future foundation of municipal climate adaptation efforts. As such, it is of particular importance that policy and regulatory frameworks require, promote, and incentivize GI strategies whenever feasible.

- Integrate Green Infrastructure strategies in local zoning ordinances. Planning considerations for any municipal rezoning effort should include how the proposed rezoning interacts with the city's stormwater infrastructure.[177] Zoning resolutions should include GI strategies for on-site stormwater management. One strategy includes requiring minimum percent pervious and/or vegetated surfaces in all residential, commercial, and manufacturing districts.[178] Another example is improving zoning text relating to open spaces, parks, public and private plazas etc. by incorporating GI design standards such as grading surfaces towards vegetation and removing hydrological barriers such as curbs.[179] Finally, specific amendments can be incorporated into waterfront district zoning pertaining to future condition adaptation strategies.

- Incorporate Low Impact Development (LID) requirements into municipal stormwater ordinances. Develop and/or expand municipal stormwater ordinances to include runoff volume standards for new development and redevelopment projects that require GI to protect water quality for the first XX inches of stormwater and control volume for the first XX inches of stormwater.[180] Require that stormwater ordinances are informed by municipal and state HMPs and are captured within municipal comprehensive plans in order to facilitate integrated climate adaptation.

- Incorporate Low Impact Development (LID) requirements into municipal building codes. A number of important adaptive strategies can be incorporated into municipal building codes from integrating stormwater management considerations into initial site review, requiring solar hot water heaters for all residential construction, to incorporating incentives to build above FEMA's height requirements in flood-vulnerable districts.[181] Other examples include requiring specific floor-area ratios on given lot sizes and requiring light colored roofing in urban district to reduce heat-island effect.[182]

- Develop municipal credits & rebates for Green Infrastructure implementation. Municipal incentives promoting the use of GI practices to reduce impacts of stormwater can include tax credits to support green infrastructure implementation and reduced storm-water permit fees for expanding the percent of permeable surface.[183] Another example of expanding GI stormwater practices includes providing residential rebates for downspout disconnections.[184] It will be increasingly important for communities to develop innovative strategies to incentivize private sector adoption of GI strategies that improve stormwater management.

- Incentivize Green Infrastructure stormwater management by reducing permitting burdens. Municipalities can incentivize GI stormwater management practices by implementing measures for GI stormwater projects that reduce permitting burdens. Strategies include streamlined or fast-tracked permitting, reduced permit review times, as well as access to a permitting consultant to expedite the permitting process.[185] Another option includes reducing stormwater fees for projects that incorporate LID into redevelopment projects. provided many developers with strong incentives to incorporate LID into redevelopment projects.[186]

Coastal Development

Coastal counties in the United States account for only 17 percent of the total land area, yet they are home to 53 percent of the total population.[187] Of the 25 most densely populated counties in the U.S, 23 are coastal counties.[188] The average national population density is 98 persons per square mile, while the average coastal county population density is 300 persons per square mile.[189] The 28 percent growth in population density of coastal counties between 1980 and 2004 suggests this trend is increasing.[190]

Roughly 54 million people live along the northeast coast making the region one of the most densely populated coastal regions in the country.[191] Ten of the 13 northeastern states find the majority of their populations living in coastal counties.[192] Further, the New York, Baltimore-Washington, and Boston metropolitan areas account for three of the top five largest metro areas in the country.[193] This density distribution is particularly evident in New York, which as recently as 2004, was home to the most densely populated counties in the country.[194] Of the total NY population, 62 percent lives on or near the coast.[195] The population and infrastructure density along the coastline of the Northeastern U.S. make the region particularly susceptible to sea level rise (SLR) and other climate-driven coastal impacts.[196,197,198]

Increases in the concentration of atmospheric greenhouse gases are warming global air and water temperatures.[199] The resulting thermal expansion of our oceans in conjunction with freshwater inputs from melting glaciers and ice sheets is causing global sea levels to rise.[200] In fact, recent studies suggest global average increase in sea levels between 0.5m and 1.5m over the next century.[201,202] Moreover; the rate of SLR has been increasing. During the twentieth century, the rate of SLR rose above historic averages to roughly 0.2 cm per year.[203] Over the course of the last 150 years, New York harbor has risen more than 15 inches – and 4 to 6 inches since 1960.[204] This trend is exacerbated by the fact that there are significant regional differences in the rate of SLR due in part to land subsidence, postglacial rebound, and plate tectonics.[205] Like other climate-driven impacts, SLR is exacerbated by a host of other climate and non-climate variables. SLR in association with projected increases in the frequency and severity of precipitation and storm events, coastal development trends, land-use decision making, warmer ocean temperatures, changes in salinity because of saltwater inputs, and storm surges associated with hurricanes and tropical storms, cumulatively pose a significant threat to northeastern coastal communities and ecosystems.[206,207,208]

SLR in conjunction with increasingly severe storm surges can exacerbate flooding, coastal wetland erosion, loss of ecological buffering capacity, loss of critical fish and wildlife habitat, extensive and costly damage to residential, commercial and transportation infrastructure, and can substantially disrupt economic activities.[209,210] Changes in the amount, timing and severity of precipitation events can alter water runoff patterns – increasing sediment loads and agricultural runoff that result in anoxic coastal zones and threaten coastal species.[211] Other synergistic impacts resulting from SLR, changing precipitation trends and larger storm surges include – increases in the salinity of groundwater and saltwater intrusion up waterways – which in turn impact wetland and estuarine species and may contaminate drinking water.[212] Recent storms, including tropical cyclone Irene in 2011 and hurricane Sandy in 2012 have highlighted the real and potential magnitude of cross-sector impacts on coastal systems as a result of synergistic stressors.

At nearly 1000 miles wide, hurricane Sandy was one of the largest storms to strike the Northeast in decades.[213,214] With sustained winds peaking at 90 mph, rainfall amounts between 3" and 8", snowfall accumulations up to 28", and storm surges in numerous locations exceeding 13ft, Sandy devastated large areas of northeastern coastline.[215, 216] The storm resulted in significant damage to coastal ecological resources, built residential, commercial, and transportation infrastructure, as well as significant production loss and economic disruption.[217, 218] Impacts included an estimated $25 billion in lost business activity, $2.5 to $3 billion in potential wind damage, an estimated 305,000 housing units damaged in NY and 72,000 buildings damaged in NJ, and hundreds of millions of gallons of sewage entering New Jersey and New York waterways as a result of overwhelmed infrastructure.[219, 220, 221] As a result of the storm, estimated costs for New York and New Jersey combined top $71 billion and insured loses are estimated to cost between $16 billion to $22 billion.[222]

The extent to which anthropogenically-driven climate change contributed to hurricane Sandy is impossible and unnecessary to precisely quantify. What is evident is that our coastal infrastructure and ecological resources are critically vulnerable to storms of this magnitude. Apart from a serious need for public and private sector infrastructure investment, the increasing magnitude of these storms highlight the need for broad integration of climate considerations across regulatory and policy frameworks and management jurisdictions in order to facilitate effective and coordinated adaptation practices. Baseline adaptation practices that are necessary to mitigate massive economic costs and environmental degradation along northeastern coasts in the future. However, significant revision and integration across federal, state, and local policy and regulatory structures will be necessary to facilitate efficient and effective management.

UPDATING THE COASTAL ZONE MANAGEMENT ACT (CZMA)

The CZMA was passed in 1972 as a framework for managing coastal areas – to conserve the nation's coastal and estuarine resources, and to ensure that federal activities are consistent with state protection programs.[223] The act is administered by the National Oceanic and Atmospheric Administration (NOAA) and contains two national programs – the National Coastal Zone Management Program (NCZMP) and the National Estuarine Research Reserve System (NERRS). NOAA's office of Ocean and Coastal Resource Management (OCRM) oversees a number of subprograms under the CZMA including the NERRS Land Acquisition and Construction program, the Coastal Management Programs (CMP) grants program, and the CZM & Stewardship program. However, a majority of OCRM funding is directed towards four CMP grant programs including, Administration Grants, the Coastal Resource Improvement Program, Coastal Zone Enhancement Grants, and the Coastal Nonpoint Pollution Control Program.[224] In total, these programs provide an important opportunity to holistically address climate adaptation. A number of changes should be made to the CZMA and CMP grants programs to more directly integrate climate adaptation considerations.

- Require coastal states to develop coast-specific climate adaptation plans. NOAA needs to be provided the authority to require coastal states to produce a coastal adaptation plan in order to be eligible for CMP grant funding. The state coastal adaptation plans should be informed by state HMP findings and similarly encouraged to be aligned and integrated into municipal comprehensive planning. While efforts in that direction have been made, most recently with H.R. 4314 during the 112th Congress to amend the CZMA to include a climate change adaptation and response program, the amendment lacked mandated state requirements.[225] First, specifically requiring state coastal adaptation planning, and second, integrating those efforts with other state plans, will be vital to facilitating targeted and coordinated adaptation planning to the extent necessary to reduce future risk and costs.
- Increase targeted funding for Coastal and Estuarine Land Conservation Program. Several CMPs under the OCRM are woefully underfunded. Requirements need to be integrated into the Coastal and Estuarine Land Conservation Program (CELCP) that include climate adaptation value metrics in determining target acquisition sites for CELCP funding as well as for use by OCRM in identifying successful CELCP projects. Properties that are specifically vulnerable to climate change, or properties with biotic or abiotic components that increase coastal resiliency and adaptive capacity need to be prioritized for CELCP-funded acquisition. Further, ORCM and NOAA need to incorporated adaptation value metrics into identifying projects to fund.

RESTRUCTURING THE NATIONAL FLOOD INSURANCE PROGRAM (NFIP) TO EXPAND COASTAL CLIMATE ADAPTATION

The NFIP had $527 billion in assets insured in coastal floodplains in 2011.[226] Between 1978 and 2011 the NFIP paid out $24 billion in total paid losses.[227] There were $100 billion in insured paid loses in 2005 as a result of Hurricane's Katrina, Wilma, and Rita, with $16 billion paid out for Katrina alone.[228] There were $37 billion in insured losses in 2010, and in 2011 Hurricane Irene cost $7.3 billion in insured losses.[229] This trend underscores the need for significant revision of the NFIP in order to facilitate cost-efficient and effective coastal adaptation.[230] Coastal zone management could be significantly improved by restructuring the NFIP to include similar recommendations outlined to increase floodplain management for residential development and redevelopment. These include measures for mandatory assessments of future climate conditions and projected land use change in SFHA identification planning, establishing hazard mitigation strategies, transitioning to multi-year NFIP policies that are tied to the property and not the owner, and limiting NFIP assistance eligibility for RLP based upon fixed damage caps. However, there are a number of specific alterations that need to be made to the NFIP to benefit integrated coastal adaptation.

- **Require future condition assessments to inform Special Flood Hazard Areas (SHRA) storm surge delineations.** It is imperative that comprehensive future condition assessments utilizing the best available science be utilized in determining storm surge delineations in V-Zones. SLR, increased frequency and severity of precipitation events, and potential increases in storm events may impact the size of future storm surges considerably.[231, 232] Determining flooding probabilities utilizing historical data alone is an increasingly less accurate measure of flood risk.[233] The increasing risk of some vulnerable coastal areas needs to be accurately reflected in rate costs in order to facilitate sustainable and resilient coastal development.
- **Implement use restrictions in V-Zone districts.** FEMA should establish baseline use restrictions in NFIP V-Zone designations.[234] Baseline federal requirements in conjunction with broad guidance could significantly realign local zoning ordinances. Integrated federal regulatory/policy guidance and state-level incentivizing can promote the development of local ordinances that exceed federal minimums.
- **Require National Flood Insurance Program (NFIP) participation for communities located in inform Special Flood Hazard Areas (SHRA) and V-Zone districts.** While municipalities in SHRAs are not eligible for several federal loans guaranteed by the Department of Veterans Affairs, insured by the Federal Housing Administration, or secured by the Rural Housing Services without NFIP coverage, community participation in SHRA is not required.[235] FEMA must require community participation in the NFIP if those communities are located within SHRA in order facilitate local proactive risk mitigation efforts.
- **Increase coordination between FEMA and US Army Corps of Engineers (USACE).** There is a considerable amount of duplicative effort between USACE requirements under their National Flood Risk Management Program (NFRMP) and FEMA's NFIP, particularly when it comes to levee certification and coastal armoring.[236, 237] Incorporating standardized future condition assessments for flood risk and working definitions for flood protection need to be adopted across FEMA and USACE flood management requirements.[238]

STATE AND MUNICIPAL OPPORTUNITIES FOR ADAPTIVE COASTAL ZONE MANAGEMENT

The wide spectrum of potential government response efforts to coastal zone impacts can be characterized as proactive or reactive and structural or non-structural.[239] Reactive, post event efforts can include redevelopment requirements including revised building practices as well as acquisition initiatives for damaged or vulnerable lands.[240] Often, reactive efforts involve structural solutions such as coastal armoring (sea walls) which have high associated costs, can increase flooding in neighboring areas, and can damage beaches and wetlands.[241] Proactive strategies on the other hand, can include preemptive efforts to mitigate climate impacts to coastal infrastructure and ecological systems by increasing resiliency and adaptive capacity of those systems to future events.[242] Proactive strategies have a greater capacity to include non-structural responses, and are often more cost effective and less environmentally damaging than structural responses.[243] As a whole, proactive and reactive strategies represent a tremendous number of planning and regulatory opportunities to integrate climate adaptation and mitigation criteria across state and local coastal zone management efforts.[244] Expanding regulatory and policy coastal adaptation considerations can occur – through revisions to state enabling legislation guiding coastal zone management (CZM), by amending and aligning state and municipal plans including CMPs and HMPs, and revising municipal bylaws, zoning and overlay zones, floodplain regulations, and building codes.[245] A number of these strategies are necessary in order to foster coordinated state and local climate adaptation in CZM.

- Integrate climate adaptation criteria into state coastal zone management. Coastal states can develop CZM plans or Shoreline Management Acts that are informed by future climate condition assessments, and include coastal erosion, coastal storm, and SLR adaptation and response planning requirements. State-level efforts should include state shoreline rules that encourage alternatives to shoreline "armoring" through nature-based solutions including "living shorelines", and utilizing natural shorelines, setbacks, and buffer zones to allow inland migration of shore habitats and barrier islands over time.[246] Further, these planning efforts need to be tightly integrated with state HMPs, and required to guide the development of municipal CMPs. Integrated state and local CZM planning needs to be mandated at the state level.
- Restructuring obligatory components within FEMA-required HMPs. The strategies outlined for restructuring HMPs for stormwater management are equally important for adaptation in coastal management. These strategies include, required consideration of future climate conditions in HMP assessment stages, incorporating future condition mitigation strategies in strategy development stages, developing future conditions monitoring in HMP maintenance strategy development, and aligning HMPs with local CMPs. However, coastal states and municipalities need to include specific requirements for consideration of future conditions on expanding coastal erosion, coastal storm, and SLR hazards. Am important first step includes developing a statewide definition of a coastal hazard area.[247]
- Update State wetland regulations and bylaws. States should revise wetland regulations to include – best management practices (BMPs) for land subject to storm-driven inland inundation, and future SLR in wetland resource delineation efforts including potential wetland expansion and migration as a result of higher tides and floodwaters.
- Expand Municipal Shoreline Protection Bylaws, Ordinances and Zoning. Municipalities should be encouraged to develop various overlay zones that take SLR into consideration. Examples include protection zones that require "soft" armoring practices to protect vital infrastructure, accommodation zones where new development is only allowed under certain growth or size restrictions, retreat zones that limit new development and redevelopment or provide incentives to build elsewhere, or finally preservation zones where development is restricted in order to preserve specific natural features or ecological processes and services.[248] Other zoning considerations can include the use of setbacks from coastal zone features and/or setbacks and vegetation buffers from coastal erosion and inundation zones.[249, 250]

› **Integrate resilient design practices into municipal building codes.** Currently, NFIP requires minimum design requirements for residential and non-residential buildings in A-Zones & V-Zones.[251] Municipalities should maximize incentives under NFIPs Community Rating System (CRS)- which provide premium rates for exceeding NFIP minimum design practices.[252]

Agriculture

Agriculture represents one of the most important sectors of the U.S. economy, with production, transportation, processing, and distribution cumulatively accounting for 11-12% of U.S. gross domestic product (GDP).[253,254] The Northeast is home to more than 64 million people and has an average population density of 5 times the national average.[255] While comparatively comprised of smaller farms, the northeastern U.S. contributes $7.5 to $8 billion in total farm receipts to these markets.[256] The region accounts for one third of national dairy production and is one of the nations primary producers of crops adapted to cool climates including maple syrup, apples, grapes, fresh market sweet corn, snap beans, cabbage, milk, and cottage cheese.[257,258] New York alone accounts for $3 billion in annual cash farm receipts.[259] Further, the Northeast leads the nation in organic food sales, community supported agriculture and farmers markets.[260] Consumers in the Northeast have shown a growing desire for local and regional food systems that support sustainable products and environmental production impacts.[261] It is important to note however, that neither the scale of agricultural production nor the selection of agricultural products have been driven by demand and climatic suitability alone.

Government programs and policies in the form of price supports, income subsidies, and trade protections for farmers growing major commodities have been a driving force behind U.S. agricultural economy since the 19th century.[262,263] Commodity and income subsidies in particular have been attributed to our agricultural success during the 20th century despite significant environmental and economic challenges.[264] Currently, three fourths of all farms that are classified as medium and large receive commodity-related payments.[265] While public sector investments have allowed the growth of agricultural economies to keep pace with rapid global population growth during the 20th century, these policies have also expanded over time from commodity subsidies alone to included a number of programs that address broad conservation and environmental objectives including protections for soil, water, and ecosystem services. As the largest of all USDA land-retirement programs, the Conservation Reserve Program (CRP) accounts for 74% of all conservation payments and has resulted in the conversion of over 30 million acres of farmland into strictly regulated grass and tree cover.[266,267,268] Despite the fact that land-retirement programs like the CRP have gone a long way to protect surface runoff, expand wildlife habitat and enhance ecosystem services, recent analyses suggest that the agriculture sector in the northeast will be increasingly vulnerable to the myriad of impacts associated with a rapidly changing climate.[269,270,271]

Projected climate impacts for the northeast are expected to strain agricultural productivity with "yield losses associated with increased frequency of high temperature stress, inadequate winter chill period for optimum fruiting in spring, increased pressure from marginally over-wintering and/or invasive weeds, insects, and disease".[272,273,274,275,276] Projected change in the frequency and intensity of precipitation events and the number of short-term summer droughts may significantly affect production as well as exacerbate issues associated with non-point source pollution.[277] Simultaneously, projected decreases in productivity elsewhere in the country may elevate the importance of agriculture in the northeast and increase the demand for water for irrigation.[278,279,280] These impacts interact synergistically with other non-climate stressors including the loss of prime agricultural soils to development to exacerbate the threats to northeastern agricultural markets.

Taken together these threats suggest the public sector may have an expanded role to play in facilitating agricultural adaptation to climate change.[281] A key question is whether the current agricultural policy and regulatory framework is capable of effectively responding to the adjustments that will be required under climate change. Maintaining a sustainable agricultural economy under climate change will necessitate – the incorporation of climate-smart considerations into federal programs appropriated under the Farm Bill (2008),

refocusing guiding practices of government payment programs, expanding state-level payment for ecosystem services (PES) programs, and updating standards and controls within agencies like FEMA and the Natural Resources Conservation Service (NRCS). A review of the current policy and regulatory framework suggest that there are significant questions regarding how effectively the sector will be able to adapt to historically unprecedented changes in climatic conditions.[282,283,284] For agricultural markets to successfully respond to economic and environmental variability in the 21st century, the sector will need to adopt an "all of the above" approach to mainstreaming adaptation across jurisdictional policy and regulatory frameworks.

Reducing and targeting crop subsidies under the Farm Bill

The federal government paid out $250 billion in numerous farm subsidies between 1995 and 2009 in the form direct payments regardless of crop prices, counter-cyclical and market-loss payments for crop prices that fall beneath market thresholds, and subsidized crop insurance which covers 50% of crop losses at no cost to the producers.[285,286] Further, 62% of farm subsidies go to commercial-scale farming operations while fewer than 30% of small farming operations receive any subsidies at all.[287] Of those subsidies 70%, totaling $170 billion over the past 15 years, have supported low-value crops such as corn, cotton, rice, and soybeans.[288] The cumulative result is that present agricultural subsidy and trade policies serve to promote the production of "program commodities".[289] Subsidizing these crops encourages monoculture field crops, results in large volumes of nutrient-rich and pesticide-laden runoff, and requires growing quantities of water to produce them.[290] Public sector support reduces incentives for agricultural producers to respond to environmental and economic changes by growing different crops that are more conducive to changing climate envelopes. Further, while production and income insurance policies provide protection against disturbance event damages, they may also inadvertently promote production in inappropriate, disturbance-prone areas, promote water resource degradation, and increase flood risk.[291,292] Significant steps need to be taken at the federally level to reduce and decentralize Farm Bill subsidies in support of flexible regional markets and small producers.

- Establish payment limits on commodity farm programs. Enhance diversification of crops in response to climate change through the development of farm payments and direct payment caps. In addition, develop counter cyclical payment, marketing loan gains, loan deficiency payments, and commodity certificate caps to increase crop production flexibility.[293] Further, payment caps need to be set at levels that are low enough to target small farm operations by disincentivizing corporate operation applicability. This will serve to decrease overall subsidy payments while increasing targeted access.
- Establish Farm Services Agency (FSA) credit to local food producers and regional food markets and producers. Farm Bill subsidies need to shift from large corporate producers growing low-value, water-intensive crops to small farmers engaged in local markets that serve regional market economies.[294,295] Providing FSA credit to small farmers specifically engaged in local markets will increase the number of market opportunities for small farmers, create new jobs, and expand consumer access to local foods.[296]
- Expand the Rural Development Business and Industry Loan Program. Increase the set-aside allocation for the Rural Development Business and Industry Loan Programs for local and regional direct and indirect loans to facilitate targeted support for local food system infrastructure.[297] Loans and grants need to be available to support small producer infrastructure development to stimulate emerging markets and decentralize agribusiness subsidies.
- Increase mandatory funding for the Specialty Crop Block Grant program. Increase funding for the Specialty Crop Block Grant program and allocate a third of the funding towards specialty crop development in local and regional farm and food systems within each state.[298] Specifically supporting specialty crop development in small markets can increase the production of climate-resilient species by expanding the flexibility of small farm operations to respond to changing climate conditions and consumer demands.

Updating Federal Crop Insurance

As of 2012, crop insurance subsidies represent the single largest farm subsidy program.[299] The USDA's Risk Management Agency (RMA) manages the Federal Crop Insurance Program (FCIP), which provides farmers with crop insurance protection.[300] The RMA offers coverage through 16 private sector insurance companies under an agreement wherein the RMA pays a premium subsidy to reduce insurer policy rates and covers the insurance companies administrative and operating costs.[301] In high risk areas the RMA covers the majority of the risk and in low risk areas the private insurers assume greater proportions of the risk.[302] In 2011, 62% of all federal crop insurance holders received premium subsidies.[303] Further, unlike other farm programs there is no limit on the amount of subsidies a farmer can receive.[304] In 2010 the RMA managed 256 million acres under 1.14 million policies and $78 billion in insured liability.[305] Federal crop insurance subsidies are projected to total $39 billion at $7.8 billion a year between 2013 to 2022.[306] Moreover, a study by the American Enterprise Institute found that crop insurance subsidies have averaged $5.6 billion since 2007 with approximately 58% of those expenditures ultimately ending up in the hands of agricultural insurance companies and insurance agents.[307] Federal crop insurance is costly, complex and ineffective.[308] The program encourages commodity farmers to till lands and take risks they otherwise wouldn't, and wastes critical resources that are desperately needed for programs that increase the flexibility of agricultural markets in the Northeast under climate change.

- **Establish premium subsidy caps for all farmers.** The RMA needs to establish FCIP subsidy limits as with other farm programs in order to reduce taxpayer costs and realign program incentives.[309] A small number of large operation farmers are accounting for a disproportionately large amount of total of insurance subsidies.[310] This unnecessarily strains the system and creates incentives that fail to promote adaptive agricultural practices under climate change like growing high-water-use crops in semi-arid regions.[311]
- **Streamline the Federal crop insurance process.** The current complex system structure should be replaced with a single weather-based system that is accessed online and delivered at low costs.[312] Studies suggest that the full scope of the program could be maintained with considerably less overhead and reduced payout costs.[313] Providing coverage without the involvement of private insurance companies would reduce inefficiency and save considerable resources that could be applied to other programs in need.

Revise and fully fund targeted Farm Bill Conservation Payment Programs

There are two general types of Farm program payments.[314] Commodity-related payments, which include direct payments, countercyclical payments, loan deficiency payments, marketing loan gains, net value of commodity certificates, milk income loss contact payments, and agricultural disaster payments.[315] Conservation payments include payments from land-retirement programs such as the Conservation Reserve Program (CRP), the Wetlands Reserve Program (WRP), the Farmable Wetlands Reserve Program (FWP), and the Conservation Reserve Enhancement Program (CREP), and payments for working-land programs such as the Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP).[316] Under rapid climate change, government payments from working lands programs and land-retirement programs such as the CRP, which have served to enhance suites of ecosystem services in the past, may reduce the ability of agricultural producers to adapt to future conditions.[317] By "locking up" potential land uses, these land-retirement programs may reduce flexibility by inhibiting the use of lands more suitable for production under changing climatic conditions and forcing production on lands now less conducive to production. Similarly, policies and agricultural land use regulations that restrict the location of animal production and waste disposal facilities may affect the costs associated with climate adaptation as a result of changing conditions, especially extreme precipitation events.[318,319] Future Farm Bills need to target conservation programs for increased funding and expanded flexibility to respond to changing conditions.

- **Fully fund and revise the Wetlands Reserve Program.** Wetlands are critical to providing a number of ecosystem services that are important to maintaining resilient agricultural systems under climate change including water filtration and flood management.[320] The WRP has arguably been one of the Farm Bills most successful programs, having restored 2.6 million acres of wetland habitat over the past twenty years.[321,322] However under the WRP "only wetlands previously impacted by agricultural development are eligible for funding" – WRP funding cannot be used to secure high condition wetland examples regardless of the services they provide to nearby agricultural operations.[323] The WRP needs to be fully funded and expanded to include non-impacted wetlands that increase the resiliency of agricultural practices.

- **Fully fund and revise the Conservation Reserve Program.** The CRP plays an important role in keeping vulnerable lands, such as those particularly susceptible to erosion, out of agricultural production.[324] As such, the CRP could play an important role in climate adaptation. However, significant limitations of the CRP and other conservation payment programs is that conservation practices are rewarded farmer by farmer facilitating patchwork conservation, participation is limited to those who apply as opposed to being based upon broader conservation strategies, and not all farmers utilizing the same vulnerable lands are willing to participate.[325] Maximizing the potential of the CRP under climate change will require the inclusion of multi-landowner, watershed based applications, the implementation of program-driven conservation targets, and requiring participation of all farmers on lands identified as important to maintaining services that facilitate agricultural resiliency.

- **Broadly expand climate considerations for land-retirement programs.** Changes need to be incorporated into land-retirement programs like the CRP, WRP, FWP, and the CREP in order for them to be effective under future climate conditions. First, restrictions on retired lands need to be more flexible based on climate-driven changing production potential and changing ecological values.[326] Second, the suite of ecosystem services and "bundled" services eligible for payments need to be expanded to included services that contribute or expand ecological resiliency and/or adaptive capacity.[327]

- **Broadly expand climate considerations for payments for working-land programs.** Similarly, changes need to be incorporated into working-land programs like the EQIP, Conservation Security Program (CSP), and Conservation Stewardship Program (CSP) in order for them to be effective under future climate conditions. The most valuable changes would include expanding the threat lists to production lands to include climate change related threats including biological invasions and increased likelihood of disturbance events.[328]

Sustainable Management of Prime Agricultural Soils at the State and Municipal Level

Prime farmland soils is a designation made by the U.S. Department of Agriculture in describing land that "has the best combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods".[329] Prime farmland includes lands that are well suited for growing crops with minimal fuel, fertilizer, and pesticides and without causing soil erosion.[330] Crops can be grown elsewhere, but typically require greater quantities of soil additives in order to be successful for agricultural production.[331] Maintaining prime farmland soils, particularly in areas subject to urban land conversion, is a key strategy for reducing GHGs through carbon storage, reducing pesticide use, and limiting our dependence on international food sources.[332] As such, prime farmland soils will be an increasingly important natural resource for the future as climate stressors such as changing precipitation and temperature patterns interact with and non-climate stressors like low-density urban development to drive landscape fragmentation and habitat degradation. States and municipalities will have to make concerted efforts to protect prime agricultural soils in order to maintain maximum agricultural capacity, and in turn, flexibility, under changing climate conditions.

- **State efforts to protect prime farmland soils.** States need to provide statutory guidance to protect prime agricultural soils in and out of production from long-term climate impacts. These efforts can include developing agricultural adaptation criteria in state enabling acts guiding the development of Comprehensive and Municipal Development Plans & Regional plans. Other state efforts include developing state-level agricultural PES programs, developing agricultural credit markets, establishing Transferrable Development Rights (TDR) programs that include flexible agricultural delineations, and expanding agricultural technical assistance programs. Further initiatives can include expanding state protections of agricultural land through purchase of agricultural easements (PACE) programs, and integrating climate adaptation considerations into farmland protection programs.
- **Municipal efforts to protect prime farmland soils.** Municipalities can reinforce the importance of prime farmland soils to maintaining agricultural security under climate change by integrating prime Ag considerations into local zoning, tax, and use designations.

Forested Lands

The history of the Northeast's culture and economy has been closely tied to its forested landscapes. Historically, the regions vast natural resources, and particularly its abundant lumber helped drive national development. By the mid 1800's much of the northeast had been cleared for fuel wood, charcoal, potash, furniture, pulp, paper, and a rapidly growing lumber industry.[333, 334] This significant period of land conversion left the majority of New England as an agrarian-based economy with a landscape dominated by fields, pastures, woodlots and many small towns and cities. By this point, 75 percent of Vermont's forests and 80 percent of Maine's forests had been cleared.[335]

However, as development and transportation infrastructure spread, the small-farm agrarian economy of the northeast found itself unable to compete with the emergence of large-scale food production. The result was the abandonment of thousands of farms and millions of acres of farmland.[336] From the early twentieth century until quite recently, the northeast underwent significant reforestation. Of the 42 million acres comprising New England proper (ME, VT, MA, CT, NH, NY, RI), 33 million acres are forested.[337] Currently, forested land in the northeast is at its greatest extent in over two centuries making the northeast the most forested regions in the contiguous U.S.[338,339]

The many assemblages and overall extent of Northeastern forest communities occur in contrast to unique ownership and land use patterns. While nationally 56% of all forested lands are in private ownership, 80% of forested lands in the Northeast are privately owned.[340,341] To complicate matters, while the population of the Northeast is not growing at a rapid rate, there is a dramatic discrepancy between the population growth rate and the extent of urban expansion. Between 1982 and 1997 the overall population density of the northeast dropped by 23% to 4.51 persons per urbanized acre.[342] During this time, the population increased by 3.4 million people while the total amount of urbanized land grew by 3.2 million acres.[343] As a result, the region urbanized an average of one acre for every new resident.[344] The ownership patterns and land use trends unique to the Northeast pose a set of ongoing conservation challenges associated with habitat fragmentation, habitat degradation, water quality, and air quality. In turn, these issues interact with, and are exacerbated by, changing climate trends in complex ways to present a suite of augmented and sometimes new conservation challenges.

The Northeast is already experiencing significant deviations from historic climatic norms – from higher inland temperatures, shifts in the timing, duration, location, and severity of precipitation events, changes in the intensity of severe storms, greater frequency of short-term summer droughts – to earlier breakup of winter ice on lakes and rivers.[345,346] These changes are currently impacting ecological processes across forested upland systems in the Northeast from above-and-below ground dynamics to shifting range distributions.[347,348] Recent modeling suggests that deciduous forests have already shifted northward, with Maple-beech-basswood assemblages shifting at a rate of 401 myr-1, and oak and aspen-birch shifting northward at 333 myr-1and 784 myr-1 respectively between 1901 and 2006.[349]

Climate projections indicate that by 2050 average annual temperatures in the Northeast are expected to rise 2.5 to 4.0°F in winter and 1.5 to 3.5°F during the summer.[350] Temperature increases of this extent over such a reduced temporal scale will result in a dramatic reshuffling of species and community assemblages (Figure. 5).[351] Such assumptions are reinforced by dynamic ecosystem modeling which project that by the end of this century 60% of New England will be dominated by oak species compared to 21% at the beginning of the century, while northern portions of the region will be dominated by aspen-birch.[352] These models also suggest novel associations and co-occurrences of maple-beach-basswood, yellow birch, elm, and hickories in mid and central New England, as well as complex conversions between forest types currently sharing similar bioclimatic ranges.[353]

Managing Forested Lands under Climate Change – The Case of Invasive Species

The spread of invasive species, pests, and pathogens have posed significant challenges to managing forests in the northeast since the beginning of the 20th century.[354] A number of factors for the success of invasives species include land management practices that result in reduced habitat quality and habitat fragmentation in conjunction with a myriad of global dispersal mechanisms. While climate change has not been the historic driver of invasive species range expansion in the Northeast, changes in global climate trends are beginning to have a measurable impact on the spread of invasive species including pests and pathogens.[355] Significant deviation from historic climatic norms are – reducing the thermal thresholds that limit the ranges of many non-native species, facilitating conditions that increase the competitiveness of non-native species, and providing more dispersal and colonization opportunities with a greater number and severity of disturbance events.[356,357]

Numerous native and non-native pest species are expanding their ranges under climate change. Between 1960 and 2004 the southeastern United States saw a 5.9°F (3.3°C) increase in extreme minimum temperatures, during which the northerly extent of native southern pine beetle, Dendroctonus frontalis outbreaks moved 200km.[358] The wooly adelgid is another good example of a pest species undergoing a climate-driven range expansion that is having a significant impact on northeastern forest composition. Over the past 15 years the woolly adelgid has spread northward into southern New England from the mid-Atlantic, decimating hemlock stands in its path. The range of the insect is thermally restricted to areas where minimum winter temperatures exceed -20°F, with the insect becoming increasingly cold intolerant as winter progresses.[359] As such, the timing and severity of winter minimum low temperatures will determine the ultimate extent of the adelgid's range.[360]

The spread of fungal, viral, and bacterial invasive pathogens can also be driven by climate change. While it is known that fungal forest pathogens can survive under a broad range of temperatures, for many pathogens thermal restrictions preventing epidemic spread is relegated to a few degrees Celsius.[361] Further worrisome is the fact that pathogens typically have comparatively short generational cycles, suggesting rapid genetic adaptation to different thermal tolerances may be possible.[362] Pathogens like Dutch elm disease, beech bark disease and Armillaria rot are already influencing forest structure, composition, and ecological processes in a number of northeastern forests.[363] The full extent to which these and other pathogens may be capable of shaping the species composition and forest structure of future northeastern forests is hard to predict.

Threats to Northeastern Forested Lands

Northeastern forested lands provide a number of ecosystem services including wildlife habitat, biodiversity refugia, carbon storage sinks, and economic value in the form of recreational opportunities and forest resources industry. By far one of the most important services provided by forested lands is clean water.[364] Water and climate regulating services across all national forests have been valued at $36 billion annually, almost double the value of timber harvesting, while water flowing solely from National Forest lands has been valued at $7.2 billion annually.[365] These important ecosystem services are increasingly under threat from urbanization and parcelization trends, unsustainable timber harvesting practices, poor land use decision-making as significant changes in precipitation, temperature and storm event patterns.[366,367] The cumulative and synergistic impacts of climate and non-climate stressors on forested systems poses significant challenges to sustainably managing forested lands in the Northeast under climate change.

In order to meet these challenges substantial alterations will need to be made to the policy and regulatory frameworks across management jurisdictions. Much of the change required at the federal level involves broadening the scope of numerous government payment programs under the Farm Bill and expanding climate considerations under state administered federal conservation programs. Broad state and municipal forest adaptation efforts will be required as well, from incorporating climate-considerations into tax structures to expanding and aligning regulatory and voluntary PES markets. Given the increasing parcelization and privatization of northeastern forests, targeted efforts will be needed to expand community technical assistance and proactively work to match private landowners with compatible federal and state PES programs.

Develop and expand Payments for Ecosystem Services (PES)

The foundation of PES services involves payments to individuals or communities in exchange for land management practices that "conserve or increase the production of desired ecosystem services".[368] PES programs can be divided between non-government voluntary programs and that either directly or indirectly support ecosystem services through the purchase of conservation easements or involve hunters purchasing hunting leases from private landowners, and government compliance-driven programs like water quality trading markets, conservation banks, and wetland and stream mitigation banks.[369] The majority of PES payments in the United States are for "bundled services" which involve integrating a number of ecological values on a given property under a single credit type.[370], [371] As an example, wetlands mitigation banking which is the largest government-driven PES program, provides compensation for the full range of benefits provided by wetlands.[372] Establishment of the CRP in the 1985 Farm Bill, and the Wetlands Reserve Program (WRP), Forest Legacy Program (FLP), the Forest Stewardship Program (FLP), and the Stewardship Incentives Program (SIP) in the 1990 Farm Bill, marked the advent of large-scale government PES programs and a significant deviation away from payment supporting timber production.[373] Together, these tools provide an important mechanism for integrating climate adaptation considerations into sustainable management practices on forested lands across the Northeast.

- **Integrate climate adaptation considerations for forested lands into government PES.** Successfully managing forested lands under climate change will require markets to provide value to services that increase the resiliency or adaptive capacity of forested systems. These values could include species and habitat diversity payments for biologically diverse stands or landscapes or connectivity payments for maintaining the integrity of habitat blocks.
- **Expand service "stacking" to increase PES payout benefits.** "Stacking" ecosystem services is a concept similar to "bundling" services however, instead of paying for a group of services, the seller can sell various services across different markets.[374] This strategy can be applied across PES programs that typically deal with bundled services such as the CRP, CREP, FLP, EQIP, the Forest Land Enhancement Program (FLEP), and the Healthy Forests Reserve Program (HFRP). Stacking would serve to increase the financial benefit to landowners while simultaneously integrating a property across various value markets.
- **Integrate climate adaptation considerations for forested lands into Payments for Watershed Services under the Farm Bill.** Integrating the ecological and climate-regulating values of forested systems across federal programs will be key to successfully managing these resources moving forward. Intact, forested watersheds vital to broadly reducing the impacts of climate change across systems from downstream stormwater management considerations to reducing coastal nutrient loading.

Using Transfer of Development Rights (TDR) Programs to manage forested lands

TDR programs have a long history of use in the United States stemming back to 1916.[375] The fundamentals of the process allow property owners with land that is not developed to it's full zoning capacity to transfer "all or some portion of the right to develop that land" to another property.[376,377] The owner of the "receiving" property is subsequently permitted to develop their property to a greater extent than permitted under existing zoning standards.[378] In return for not developing, or reducing the extent of development, the "seller" is able to recoup some of the lost potential development revenue from the purchase of the development rights.[379] Despite the relatively straightforward underpinnings of TDR programs, they can vary significantly. The use purposes can vary, as well as "the relationship between the scope of the rights the sending site has foregone and the rights the receiving site can take; the nature of the regulatory review of proposed transfers; the rationale behind, and restrictiveness of, the rules governing which sites can receive TDRs from a sending site; and the use of intermediaries such as TDR banks to facilitate transfers".[380] For example, some programs convert the preservation of a specific number of acres of land into a specific number of development credits which in turn allow for a quantified extent of additional development at the receiving site, while others identify specific boundaries of the sites that can receive transfers.[381]

The shear breadth of potential application of TDRs suggest that they would make an important climate conservation tool for protecting and managing forested lands in the Northeast. However, there are a number of significant issues that have prevented TDRs from becoming a popular tool for state and local governments to manage growth.[382] The most substantial limitations to TDR application are that TDR require detailed zoning laws, and in many cases are more difficult to administer.[383] Moreover, communities may not even support TDRs, they may have to invest resources to explain TDR programs, and the permanency of TDRs may restrict future uses even with significant changes in land-use over time.[384] Despite these shortcomings, it is the opinion of this author that with targeted regulatory revision and broad cross-jurisdiction integration, TDRs could play a fundamental role in sustainably managing forested lands in the Northeast

- Develop a foundation for the use of Regional TDR programs to manage forested lands. Successful implementation of regional TDR programs to manage forested lands for their climate-regulating capacity will require establishing several preexisting conditions. First, state policy guidance, executive mandates and regulatory mechanisms need to reflect the importance and value of the desired services to the extent possible. This also includes laws, ordinances, credits or rebates that support the use of TDRs and entices owners to explore potential participation in a TDR program.[385] Second, sending and receiving areas need to be carefully thought out in order to maximize the market value of the credits.[386] Master plans, Comprehensive and adaptation plans can identify specific areas where communities either feel strongly about the need for more development or feel strongly about conservation values. At this scale, states may have to act as brokers between community transaction participants in order to influence the price of transferring rights or as a way of accumulating rights for use in future state implemented development restrictions.[387]
- Develop municipal-level TDR programs to manage forested lands. In many ways, establishing TDR programs at the municipal level is easier than at larger scales because of the greater number of ordinances, zoning guidance, tax breaks, and credits that can be utilized to incentivize various stages of the transaction. At this scale, it is critical that the degree to which a community values the service, be it a specific number of acres of forested land or forested lands with particular attributes, is clearly reflected in the community CP.[388] Further, communities that develop TDR programs must commit to the "rights" being the currency of development to the extent that a TDR credit shares an equal value.[389] Lastly, participation in a municipal TDR programs should be open to any individual or entity in order to take advantage of the full suite of potential motivating factors.[390]

Conserved Lands

With only 2% of the nations land area and 17% of the population, the Northeast (from northern VA to southern ME) is a national hub of economic activity producing 20% of the Gross Domestic Product (GDP).[391] These characteristics stand in contrast to the fact that the Northeast was also the birthplace of land conservation in the United States.[392] Due in part to it's nationally recognized iconic landscapes including the Adirondacks, Green Mountains, and White Mountains among others; land conservation has been an important component of the culture of New England. This is evidenced by the fact that 35% of 1,700 Land Trusts (LTs) across the country work in the Northeast.[393] Together, national, local, and state conservation groups have saved 23 million acres across thirteen northeastern states including Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, Washington D.C., and West Virginia.[394] These lands are divided by those "secured primarily for nature" for which the primary goal is the conservation of natural processes and biodiversity, and those "secured for multiple uses" which include timber harvesting and recreation.[395] However, it is important to note that lands "secured for multiple uses" may have significant ecological value.[396] Together, "secured lands are held by over 6,000 fee owners and 2,000 easement holders", and account for 16% of the thirteen state Northeast region permanently held under natural cover.[397]

There are a number of federal, state, local and private entities working in one capacity or another for land conservation in the Northeast. At the federal level, there are many federal agencies and programs administered by the EPA, USDA, and DOI focused on land conservation in the Northeast. These include federal collaborative initiatives like the Landscape Conservation Cooperatives (LCC), which were created under DOI Secretarial Order No. 3289 in 2009.[398, 399] The initiative developed a national network of 22 LCCs made up of public-private partnerships composed of states, tribes, federal agencies, non-governmental organizations, and universities, "that address a variety of broad-scale land use pressures and landscape-scale stressors—including but not limited to climate change— that affect wildlife, water, land and cultural resources".[400] The Association of Fish and Wildlife Agencies (AFWA) is another important national collaboration. AFWA has represented state Fish and Wildlife Agencies since 1902, advocating for "favorable fish and wildlife conservation policy and funding" and working towards "science-based management and conservation of fish and wildlife and their habitats in the public interest".[401]

State-level land conservation efforts vary considerably from state to state across the Northeast. They include efforts by state agencies, departments, and programs such as Open Space Programs and Land Conservation Programs across a number of different state environmental agencies. One element of consistency across states is Wildlife Action Plans (WAPs), which "examine the health of wildlife and prescribe actions to conserve wildlife and vital habitat before they become more rare and more costly to protect".[402] WAPs are required in order for states to receive grants under the State Wildlife Grants (SWG) program established under an amended Conservation and Reinvestment Act (CARA) in 2000.[403]

The Northeast is well known for collaborative conservation efforts between states, municipalities, conservation organizations, and federal entities. A prime example of this collaboration is the Northeast Regional Conservation Needs Grant Program (RCN). The Northeast RCN grant program is the largest multi-jurisdictional collaboration in the US dedicated to advancing conservation priorities outlined in WAPs.[404] The program was created in 2007 in collaboration between the thirteen states of the Northeast Association of Fish and Wildlife Agencies (NEAFWA) and the U.S. Fish and Wildlife Service's (FWS) Northeast Region Division of Wildlife and Sport Fish Restoration (DFWSF), and is administered by the Wildlife Management Institute (WMI).[405] The guiding objective of the RCN is "to develop, coordinate, and implement conservation actions that are regional or sub-regional in scope", and "to build upon the multiple regional initiatives that already exist and compliment ongoing work in individual states".[406]

Despite the collaborative efforts made towards land conservation in the Northeast, these lands face significant future challenges. Expanding low-density urbanization – representing short-term development planning – is resulting in landscape fragmentation and habitat loss and degradation through resource depletion and pollution. These converted lands increase stormwater runoff, water, and air pollution. Of the 16% of total land in the Northeast held under natural cover in perpetuity, 11% is dedicated to multiple purpose use and 5% that is secured for nature.[407] With 28% of the land in the Northeast already converted for agriculture and development, on an acre by acre basis, five acres are converted for every one acre secured for nature.[408] These non-climate stressors are significantly impacted by a host of climate-driven stressors. Climate impacts to conserved lands include growing unpredictability in the timing and severity of precipitation events, changes in the timing, severity and duration of storm events, reductions in the extent and duration of winter snowpack, decreasing average winter extreme low temperature and number of winter days below freezing, and a greater number of short-term (1-3 month) summer droughts.[409, 410, 411, 412]

These cumulative impacts pose significant challenges for conserved lands in the northeast now and into the future. To begin with, the ecological components for which many conserved lands are currently managed may alter significantly. Changes may include losing the species or habitat from the conserved area, conversion within the area to new habitats and species assemblages, loss of overall biodiversity, biological invasions, and substantially altered ecological processes. The land available to new conservation may also be impacted by these synergistic stressors as a result of urbanization and fragmentation in that there may be fewer and smaller parcels available. Moreover, the ecological "quality" of land available to conservation may be diminished by pollution, loss of species richness, community structure, and forest structure. These challenges complicate future land conservation efforts in the Northeast by increasing the difficulty of identifying new conservation targets and altering the effectiveness of the strategies currently employed on existing conserved lands. They also accentuate the importance of regional considerations on conservation decision-making. As the pace of ecological transitions quicken, what is conserved or not conserved elsewhere may increasingly inform what and where we identify as a conservation target.

In order to facilitate sound and effective land conservation into the future, adaptation considerations need to be incorporated into how we identify, manage, and expand conserved lands. This will require broadly integrating climate adaptation considerations across the policy and regulatory structures guiding all phases of land conservation in the Northeast. As the challenges facing land conservation mount, so too will the need for coordinated and flexible polices.

Incorporate Climate Adaptation into Federal Land Conservation Efforts

As mentioned earlier, there are a large number of federal programs, across a number of federal agencies that are specifically focused on land conservation efforts. In order to successfully meet the challenges posed by climate and non-climate stressors on land conservation in the Northeast, changes will need to be made to a number of programs to integrate climate adaptation considerations. Broad program-level integration is required for holistic adaptation integration.

- **Fully fund and revise the Forest Legacy Program (FLP).** The FLP is a voluntary program that provides States up to 75% of project costs for conservation easements or fee transactions to prevent land from conversion to non-forest uses.[413] In order for states to be eligible, they must submit an Assessment of Need (AON) to the Forest Service (FS) for approval. The AON must "establish eligibility criteria, set guidelines, and identify priority areas for protection".[414] The FLP minimum criterion for priority areas needs to outline adaptation considerations. Eligibility criterion could include forest lands that are inherently resilient to climate impacts as a result of component features, forest lands that increase the resiliency or adaptive capacity of a another parcel, or lands that are specifically vulnerable to climate impacts.

- **Incorporate adaptation criterion into eligibility thresholds for the Conservation Stewardship Program (CSP).** Administered by the NRCS, the CSP is a voluntary payment program that "encourages land stewards to improve their conservation performance by installing and adopting additional activities, and improving, maintaining, and managing existing activities on agricultural land and nonindustrial private forest land".[415] Climate adaptation criteria need to be incorporated into the CSP eligibility thresholds so that landowners actively taking measures to increase the adaptive capacity and/or resiliency of their property will be program eligible. Efforts might include increasing riparian shading or increasing habitat species richness with climate-resilient species.

- **Expand national priorities outlined in the Wildlife Habitat Incentive Program (WHIP).** WHIP is a voluntary NRCS payment program for landowners to "develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Indian land".[416]

  WHIP conservation priorities must be expanded to include the promotion and restoration of native climate resilient species for the benefit of wildlife. Further, the program's target species need to undergo comprehensive future condition assessments in order ensure their potential long-term viability under climate change. WHIP should not invest resources on species that will ultimately be unable to maintain populations within their current location under future conditions.

- **Integrate adaptation criteria into Habitat Conservation Plans (HCP).** HCPs are required under 10(a)(1)(B) of the Endangered Species Act (ESA). The Act states that any activity that will likely result in the "incidental take" of a listed (proposed for listing or candidate) wildlife species requires an application for an incidental take permit.[417] HCPs are a required component of the application that provides a description of "the anticipated effects of the proposed taking; how those impacts will be minimized, or mitigated; and how the HCP is to be funded".[418] While HCPs are required to comply with a "Five Points Policy" which requires the inclusion of "methods for addressing uncertainty", there are no specific climate adaptation criteria.[419] In an effort to standardize the incorporation of climate adaptation consideration; HCPs should require a comprehensive assessment of future conditions on the target species as well as specific adaptation-oriented strategies focused on reducing exposure and increasing the resiliency and/or the adaptive capacity of the target species.

State and municipal efforts to integrate adaptation into land conservation

- **Use TDRs to expand state and municipal conserved lands.** TDRs can be an important tool for conserving land. However, their popularity is largely dependent upon developing a basis for their success.[420] First, there must be enough land to identify appropriate "sending" and "receiving" areas. This is not simply an issue of available land. For the purposes of conserving land, it requires that there be available land with high conservation value and low development pressure and a receiving area with a development pressure that exceeds that which is allowed under current zoning.[421] Given these conditions, TDRs represent an important opportunity to integrate adaptation considerations into land conservation. Examples include delineating sending areas based upon the resiliency or adaptive capacity of ecological components, and designating climate-specific credits at a higher price value than other credits.

- **Utilize Conservation Banking to promote land conservation.** Conservation banks (CB) are lands with natural resources that are protected in perpetuity.[422] In exchange for agreeing to protect the land for a given ecological value (species, habitat, condition) the managing entity (USFWS, municipality or state) will provide the bank owner a certain number of credits based upon the preserved resource.[423]

  The bank owner can then sell those credits to developers or other entities at other locations that are adversely affecting the same resource. The primary distinction to TDRs is the relationship of credits to a specific ecological impact. In the case of impacts to species, CBs may be particularly effective when used in conjunction with HCPs.[424] Tying credit value to specific impacts may increase the flexibility of the program by making participation more attractive to a greater diversity of landowners. CBs are particularly useful with strong regional planning entities or with CPs that have clearly identified a set of ecological conservation values.[425]

- **Conserving land through current use designations.** Land conservation efforts could expand by integrating habitat connectivity values into current use tax classes with "core" or "key linkage" designations. Setting a competitive rate on lands that provide core habitat or linkages between core habitats would help governments prioritize ecological components that increase the resiliency or adaptive capacity
- **Incorporating climate change into conservation easements.** Conservation easements (CEs) have been a primary tool of conservation for some time. Utilizing that tool to the same degree of success under climate change will require a fundamental shift in how CEs are written and carried out. In order to increase the flexibility of conservation easements standardized climate-oriented language needs to be developed that provides for amendment provisions, includes potential termination and release provisions, and include climate thresholds, like certain biodiversity indices, that trigger a specific action like a natural resource inventory or changes in use language.[426]

Integrated Climate Adaptation in the Northeast

The impacts of climate change are comprehensive – they affect public health, infrastructure, and natural resources and strain social, institutional, and legal frameworks.[427] These impacts are occurring now, will continue for some time, and are projected to worsen.[428,429,430] For the Northeast to avoid the very worst of these impacts will require significant attention. Mitigation strategies alone will not be sufficient as the longevity of some atmospheric GHGs mean that, despite global emissions ceasing tomorrow, climate change would continue for decades.[431, 432, 433] Adaptation strategies alone will be insufficient, in part because many become more expensive and less effective as the scope and scale of the change increases.[434] Addressing the full breadth of climate impacts on the Northeast effectively will require comprehensive and complimentary mitigation and adaptation efforts.[435] Further, due to the scope of the costs, an effective and efficient response effort will require an emphasis on identifying opportunities for coordinated co-implementation.[436] Historically, mitigation efforts have received the majority of attention; it is only recently that adaptation considerations are being more broadly incorporated into local, state, and federal planning.[437]

Federal and State Efforts to Address Climate Adaptation

Efforts to address climate adaptation are occurring across management jurisdictions and sectors.[438] A number of federal interagency initiatives address adaptation including the Interagency Climate Change Adaptation Task Force (ICCATF), which developed guidelines for federal adaptation efforts, the Steering Committee of the National Fish, Wildlife, and Plants Climate Adaptation Strategy, and the U.S. Global Change Research Program (USGCRP) among others.[439] As of 2012, approximately fifty federal agencies addressed adaptation in their Strategic Sustainability Performance Plans, and numerous agencies are initiating specific adaptation-related efforts including the USDA, DOD, DOE, DOI, DOT, NASA & EPA.[440] At the state level, 13 states had completed adaptation plans by 2012, one was in process, and eight had made recommendations to develop a plan.[441] A number of states have sector-specific plans including 16 states that have developed biodiversity conservation plans that include climate considerations.[442] Apart from stand-alone adaptation plans, states have also enacted legislation or established programs that address various aspects of climate change.[443] While these state and federal efforts reflect a relatively strong degree of planning, the vast majority of adaptation implementation occurs at the municipal level.[444]

Municipal Efforts to Address Climate Adaptation

Municipalities across the Northeast are engaged in adaptation planning and implementation, from stormwater pipe replacements in Keene, NH to green infrastructure applications and green roof installations in New York City, NY.[445] Other examples include efforts by the town of Groton, CT to collaborate with federal and state, public and private partners through the EPA's Climate Ready Estuaries Program to develop adaptation strategies in response to SLR, as well as work by the City of Philadelphia to install green stormwater infrastructure through their Green Acres Program.[446] These initiatives and others are driven primarily by "land use planning; provisions to protect infrastructure and ecosystems; regulations related to the design and construction of buildings, roads, and bridges; and emergency preparation, response, and recovery".[447] While these mechanisms have been enough to initiate adaptation implementation at the municipal level, they are neither sufficient in facilitating the extent of municipal adaptation action that is necessary, nor do they provide adequate opportunities for coordinated adaptation planning and implementation with other localities, or at the state and regional level.

Barriers to Adaptation

Integrated climate adaptation faces a number of barriers including minimal resources to initiate and maintain adaptation efforts and fragmented decision-making resulting from inherent difficulties in inter–and–intra agency coordination.[448] Other barriers often include institutional constraints, lack of legal mandate to act, fragmented jurisdictional boundaries, lack of political leadership, and rigid legal structures.[449] Multiple agencies may have management jurisdiction over various components of the same resource, or institutions may lack an inherent flexibility to act.[450] Limited funding can also be a significant limitation, particularly when the funding that does exist is typically limited to large payouts, and long-term funding is difficult to acquire.[451]

Mainstreaming Climate Adaptation

As we become increasingly able to take a full accounting of the breadth and long-term nature of the climate threat, it becomes more evident that simply implementing a set of adaptation projects will not be sufficient to effectively address the problem. In order for climate adaptation to be sustainable and meaningful to the extent that it facilitates economic and environmental operational functionality, it must be integrated into the policy apparatus at all levels. Moreover, the need for a rapid and comprehensive response suggests that developing separate adaptation policy and delivery mechanisms is unrealistic and not cost-effective. A timely and efficient response will necessitate a reliance on existing policy and regulatory frameworks to deliver integrated adaptation. As a result, innovative policy and regulatory adaptation opportunities must be identified within current programs, legislation, and management plans. Beyond that, every effort must be given towards integrating proactive, co-benefit strategies and linking those strategies to a regional context. The extent of the climate threat is such that response efforts will require a holistic landscape-level approach wherein adaptation considerations are woven across sectors, management jurisdictions, and all levels of government.

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