NORTHEAST REGIONAL CONSERVATION NEED GRANT QUARTERLY REPORT

Grant Number: RCN 2009-01

Grant Title: Assessing the likely impacts of climate change on northeastern Species of Greatest Conservation Need.

Grant Receipt: Manomet, Inc.

Grant Contact Name: Mark Lafaver

Report #- 3

Were planned goals/objectives achieved last quarter? Yes

Regional Conservation Need Addressed: RCN 8

Progress Achieved: (For each Goal/Objective, list Planned and Actual Accomplishments)
Statement attached

Summary of Progress: (Provide a paragraph describing progress, work to come, and timelines)
Statement attached

Difficulties Encountered:
Statement attached

Activities Anticipated Next Quarter:
Statement attached

Costs:

Funds Expended to Previous to this Report: $1,936.46

Amount of RCN Funds Requested within this Report: (will be provided at later date)

Total Approved Budgeted RCN Funds: $180,000

Are you within the approved budget plan? Yes

Are you within approved budget categories? Yes

Signature:

Date: October 15, 2010

OBJECTIVES, ACCOMPLISHMENTS, AND FUTURE PLANS AND TIMELINES OF REGIONAL VULNERABILITY ASSESSMENT PROJECT

Objectives of the project. The overarching goal of the project is to provide vulnerability and adaptation information that will help the northeastern states to plan their conservation of fish and wildlife under a changing climate. It has five specific objectives:

1. To quantify the vulnerabilities to climate change of fish and wildlife and their habitats across the region and thereby identify those habitats and species that are likely to be more or less vulnerable, and how these vulnerabilities vary spatially.

2. To project how these habitats and species will change their status and distributions under climate change.

3. To identify potential adaptation options (including the mitigation of non-climate stressors) that can be used to safeguard vulnerable habitats and species.

4. To identify monitoring strategies that will help track the onset of climate change and the success, or otherwise, of adaptation actions.

5. To work with states to increase their institutional knowledge and capabilities to respond to climate change through educational and planning workshops and other events.

Accomplishments. A major component of the project is to form and stand-up one or more panels of habitat experts who will represent each of the thirteen northeastern states in deliberating the comparative vulnerabilities of major habitat types across the region. Ideally, two experts from each state are necessary, in total about 25 participants. Also, in addition to recruiting these experts onto the expert panels, they need to be educated in:

1. The objectives and aims of the project
2. The likely climatic changes that will occur in the region
3. The types of ecological responses that will occur (and may already be occurring).

Over the last three months the expert panel has been recruited. The names, contact information and affiliations are shown in Attachment 1. While most of the 13 states are represented, we still lack participation from Rhode Island and New Jersey. We are continuing to seek participation from these states. All of the expert panel members have been contacted by email and phone, and all are ready to participate in our first meeting (to take place by teleconference next month).

All expert panel members have been provided with three pieces of preparatory materials. These, written by Dr. Galbraith, include:

1. A statement of the project objectives (Attachment 2)
2. An appraisal of how we expect the climate to change in the Northeast over the remainder of this century, and how it has already changed (Attachment 3)
3. An appraisal of the types of ecological responses that may occur and that may already be occurring (Attachment 4).

In addition, we (Galbraith and John O'Leary of MA DFW) have drafted a preliminary model for evaluating the vulnerabilities of habitat types (Attachment 5). This has been circulated to the expert panel and comment and modifications invited. We anticipate that refining and finalizing this model will be the first of two major tasks for the panel over the next two months. The second task will be for the panel to select 6-10 habitat types for testing the model.

Future Plans and Timelines. Over the next two months our main goals will be to convene a teleconference of the expert panel members to discuss the vulnerability model and select habitats for testing. We have already started this process going by circulating a MeeetingWizard around the experts and are selecting those dates on which the greater part of the panel is available (it may be necessary to have two teleconferences to ensure that all are able to participate). We expect this meeting to take place either this or next month.

Once the experts have been able to comment on the model, it will be modified by Galbraith and submitted for reconsideration and finalization. We expect that this will be accomplished by the end of the year. In the early new year (or sooner if possible) we will begin testing the model on selected habitat types. The timeline for the entire duration of the project is displayed in Attachment 6.

Attachment #1

NEAFWA REGIONAL VULNERABILITY ASSESSMENT PROJECT - EXPERT PANEL PARTICIPANTS

	Participant	Affiliation	Contact info
Maine	Steve Walker	Inland Fisheries and Wildlife	Steve.Walker@maine.gov
	Phillip deMaynadier	Inland Fisheries and Wildlife	phillip.demaynadier@maine.gov
	Andrew Cutko	Natural Areas Program	andrew.r.cutko@maine.gov
New Hampshire	Pam Hunt	NH Audubon	PHunt@NHAudubon.org
	Matt Carpenter	NH Fish and Game	matthew.carpenter@wildlife.nh.gov
Vermont	John Austin	VT Fish and Wildlife	johnm.austen@state.vt.us
	Eric Sorenson	VT Fish and Wildlife	eric.sorenson@state.vt.us
Massachusetts	Caleb Slater	MA Fisheries and Wildlife	caleb.slater@state.ma.us
	John Scanlon	MA Fisheries and Wildlife	john.scanlon@state.ma.us
Connecticut	Neal Hagstrom	CT DEP	neal.hagstrom@ct.gov
	Ann Kilpatrick	CT DEP	ann.kilpatrick@ct.gov
	Mark Johnson	CT DEP	mark.johnson@ct.gov
	Min Huang	CT DEP	min.huang@ct.gov
Rhode Island	To be determined		
New York	Zoe Smith	Wildlife Conservation Society	zsmith@wcs.org
New Jersey	To be determined		

Attachment #1

	Participant	Affiliation	Contact info
Pennsylvania	David Day	PA Fish and Boat Commission	davday@state.pa.us
Virginia	David Norris	DGIF	David.Norris@dgif.virginia.gov
	Paul Bugas	DGIF	Paul.Bugas@dgif.virginia.gov
	Chris Burkett	DGIF	Chris.Burkett@dgif.virginia.gov
West Virginia	Elizabeth Byers	WV DNR	elizabethbyers@wvdnr.gov
	Kerry Bledsoe	WV DNR	kerrybledsoe@wvdnr.gov
	Paul Johansen	WV DNR	paul.r.johansen@wv.gov
Maryland	Dana Limpert	MD DNR	dlimpert@dnr.state.md.us
Delaware	To be determined		

Attachment #2

Conserving Fish and Wildlife in a Changing Climate – NEAFWA's Regional Vulnerability Assessment Project

Why this project? Climate change is already happening in the Northeast. Moreover, the rate of change has accelerated over the last three decades, resulting in impacts to fish and wildlife and their habitats: sea levels are rising, threatening coastal ecosystems; fish migrations, plant flowering seasons, freeze-ups and ice-outs, and peak flows in streams and rivers are all happening significantly earlier than they once did; and the ranges of mobile organisms such as birds and, unfortunately, pests have spread northward. Due to the continuing high global rates of emissions of greenhouse gases, it is likely that impacts will continue to grow in extent and severity.

The changing climate poses significant challenges to the future conservation of fish and wildlife: how do we protect valued resources against a climatic background that can no longer be assumed to be static? How well will our "traditional" conservation tools (e.g., place-based protection) continue to work? What new management tools will we need? How do we plan future acquisitions? How will the changing climate interact with the other stressors that are already impacting wildlife resources? Perhaps the most urgent question, and the one that needs answering before the others can be fully addressed, is: which species and habitats are likely to be vulnerable to, or may benefit from, the changing climate?

In a project extending from Maine to the Virginias, the Northeastern Association of Fish and Wildlife Agencies (NEAFWA), Manomet Center for Conservation Sciences (Manomet), and the National Wildlife Federation (NWF) are collaborating with other major northeastern stakeholders, including federal agencies and nonprofit organizations, to protect fish and wildlife and their habitats from climate change. Specifically, Manomet, NWF, and NEAFWA have embarked on a three-year effort to evaluate the vulnerabilities of the northeast's key habitats and species, and to help increase the capabilities of state fish and wildlife agencies to respond to these challenges. This regional effort is the first of its kind in the country and is an essential step toward the implementation of effective "climate-smart" conservation of ecosystems[1].

Objectives of the project. The overarching goal of the project is to provide vulnerability and adaptation information that will help the northeastern states to plan their conservation of fish and wildlife under a changing climate. To meet this ambitious goal, it has five specific objectives:

1. To quantify the vulnerabilities to climate change of fish and wildlife and their habitats across the region and thereby identify those habitats and species that are likely to be more or less vulnerable, and how these vulnerabilities vary spatially.

2. To project how these habitats and species will change their status and distributions under climate change.

3. To identify potential adaptation options (including the mitigation of non-climate stressors) that can be used to safeguard vulnerable habitats and species.

[1] A project steering committee comprising directors of state agencies (Wayne MacCallum, David Chanda, Patty Riexinger, Bill Hyatt, and David Whitehurst), USFWS (Dee Blanton and Andrew Milliken), and Manomet and NWF is providing guidance on objectives and directions.

4. To identify monitoring strategies that will help track the onset of climate change and the success, or otherwise, of adaptation actions.

5. To work with states to increase their institutional knowledge and capabilities to respond to climate change through educational and planning workshops and other events.

Methods – assessment of species and habitat vulnerabilities. The vulnerability assessment component of the project will utilize an expert panel-based approach. We are convening panels of state, federal and NGO habitat and species experts from across the region to build predictive models (based on the results of a model already used successfully in Massachusetts) that can be used to quantify the vulnerabilities to climate change of northeastern habitats and species, and test these models on 4-6 key habitats. Major deliverables will include:

- A report on model development and testing, with sections on (a) regional habitat vulnerabilities (based upon testing 4 – 6 major/key habitats across the region), and (b) species vulnerabilities (based also on the 4 – 6 test habitats).
- Maps of projected climate change in the Northeast

If subsequent funding is available (under a NEAFWA 2010 RCN that Manomet and NWF have already applied for, and with anticipated additional funding from USFWS), we propose working with the expert panels to run the finalized vulnerability model(s) on major, regionally significant habitat types, develop maps of spatial variation in the vulnerabilities of habitats across the region, and categorize the vulnerabilities of species of greatest conservation need (SGCN), and evaluate potential adaptation options. Key Deliverables will include:

- Reports describing habitat vulnerabilities within states and across the region
- Regional habitat vulnerability maps.
- Lists of vertebrate species most at risk within states and across the region.
- A report on potential adaptation options for each of the habitat types.

We are building three separate expert panels: one for the northern tier of states (ME, NH, VT, MA, RI, CT, NY), one for the southern tier (NJ, VA, WV, MD, DE, PA), and a third panel will address coastal areas.

***Expert panel membership**:* This is your project and each of the states is asked to identify candidates for the expert panels - the actual choices being made by the directors of the fish and wildlife agencies. The qualifications for membership of the panels should be expertise in the ecology, threats to, and management and/or conservation of habitats and SGCNs. It may be that we may need to go outside of the state fish and wildlife agencies to seek highly qualified participants. Thus, it would not be an issue if State Directors wish to propose coastal habitat experts from (for example) coastal zone management agencies. It may also be that a state wishes to propose more than one expert (for example both terrestrial and a freshwater aquatic experts). This can be accommodated.

***Expert panel time commitment**:* the meetings of the expert panels will be “virtual”. That is, they will not be face-to-face but will be by webinars and/or conference calls, lasting approximately half a

day. This will ensure that the time commitments are kept manageable. We envision that up to four or five such virtual meetings will take place for each panel during a 12 to15-month period.

Methods – identifying potential adaptation options. While the expert panels are convened, we will work with them to identify management options that may be important in conserving vulnerable habitats and species. This component of the project will hinge on the management and habitat expertise of the panel members, and their experience in safeguarding habitats from other stressors. The deliverable from this component of the project will be:

- A report on the potential adaptation (management) options for threatened northeastern habitats

Methods – increasing your agency's institutional knowledge and ability to respond to the changing climate. This component of the project involves working with agencies to increase their knowledge base and capabilities to protect fish and wildlife under climate change through a range of approaches, including workshops, conference calls, webinars and regular email updates. The northeastern states differ in their current capacities and in the types of workshops/events that they may most need (while some may benefit from workshops about vulnerability assessment methods, others may benefit more from, for example, discussions about habitat management). Our primary goal here is to provide the individual states with what they most need. To that end we will work with the states to tailor the work to address their needs.

Timeline. The overall timeline for the various elements of the first year's work is displayed in the accompanying Excel spreadsheet. Manomet and NWF have already begun contacting state agency directors to identify candidates for the expert panels. We hope to finalize this and hold the first of the panel meetings in the next month or so.

Attachment #3

CURRENT AND FUTURE CLIMATE CHANGE IN THE NORTHEAST

A Briefing Package to the NEAFWA Regional Vulnerability Assessment Expert Panel

Hector Galbraith

September, 2010.

1. THE NORTHEAST'S CLIMATE IS ALREADY CHANGING

Temperature

Since 1900, the average annual temperature in nine of the 13 northeastern states (ME, NH, VT, NY, MA, CT, RI, PA, and NJ) has been rising by 0.14°F/decade. Beginning in the 1970s, this rate of change accelerated to 0.5°F/decade. Overall, the average annual temperature in these nine states has increased by almost 2°F since 1900 (Hayhoe *et al*. 2006; NECIA, 2006). The temperature increase has been most marked in winter when, since the 1970s, it has been rising by 1.3°F/decade (NECIA, 2006). Overall the average winter temperature has increased by about 4°F since the 1960s; summer temperatures have risen more slowly.

For the four southern states (MD, DE, VA, and WV) between 1951 and 2006, and based on empirical data, ClimateWizard analysis shows a mean annual temperature change of between 0.03°F/decade in VA (figure 1) and 0.28°F/decade in DE (Figure 2).

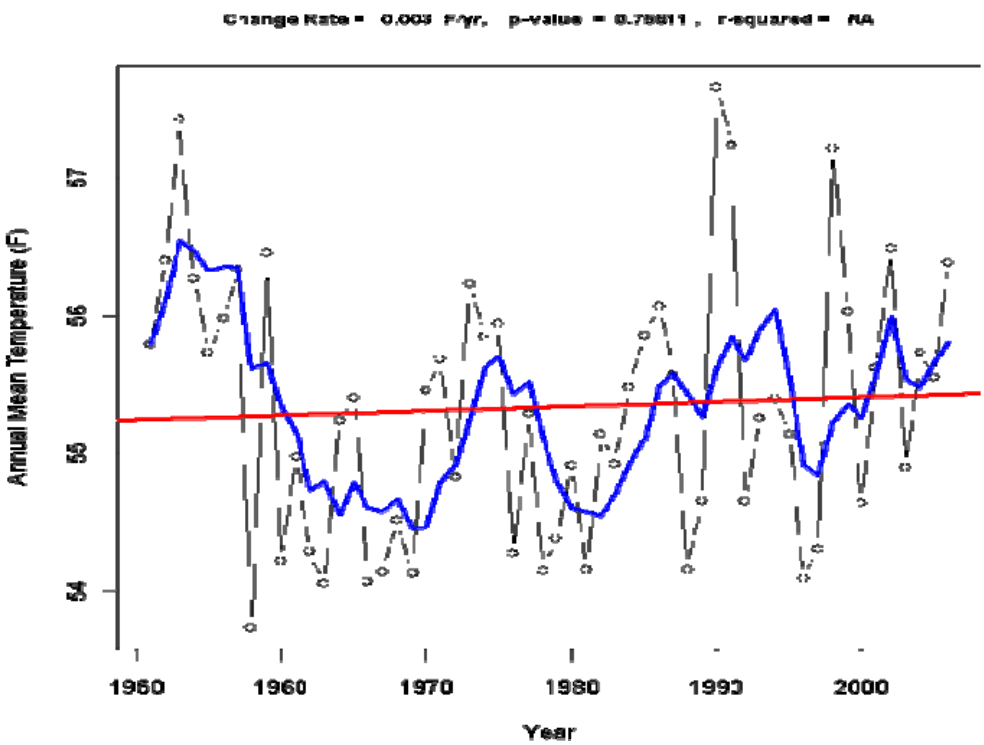

Figure 1. Average annual temperature change in Virginia, 1951-2006. **Blue line is 5-yr running mean.**

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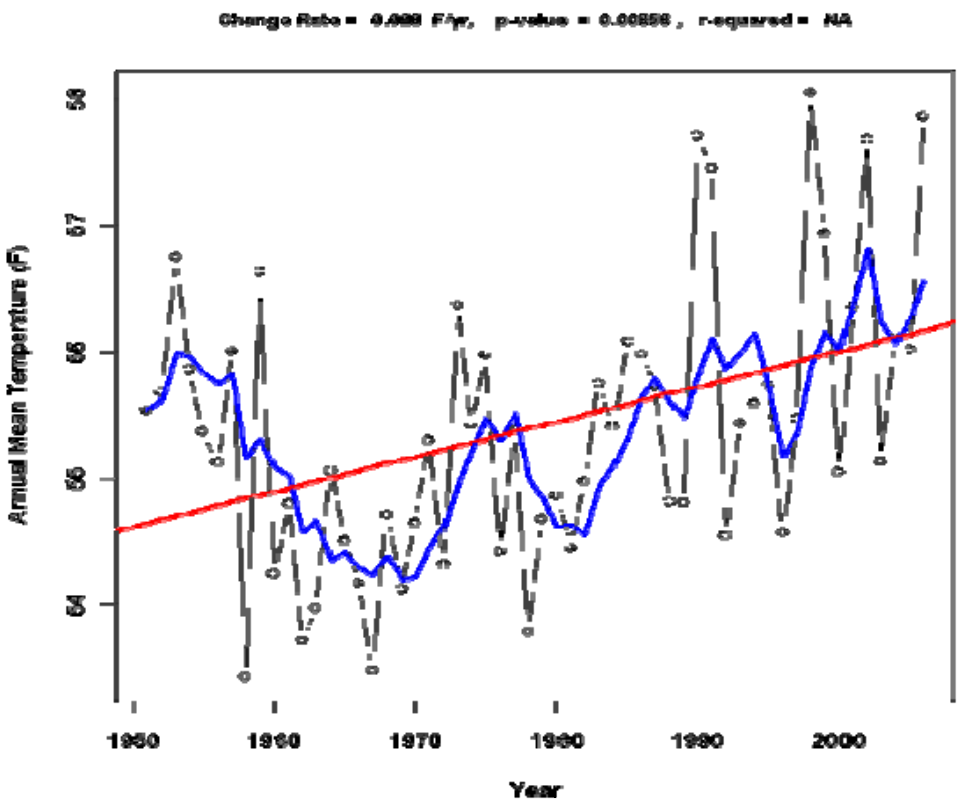

Figure 2. Average annual temperature change in Delaware, 1951-2006. Blue line is 5-yr running mean

Average annual temperatures have shown consistent increases in all 13 of the Northeastern states included in the NEAFWA Regional Vulnerability Assessment Project (Table 1).

Table 1. Decadal rates of average annual temperature increase (^{o}F/decade) in 13 states, 1951-2006.

State	Rate of Increase	State	Rate of Increase
ME	0.06	NH	0.17
VT	0.29	MA	0.17
NY	0.18	CT	0.27
RI	0.27	PA	0.17
NJ	0.22	VA	0.03
WV	0.07	MD	0.21
DE	0.28	Mean of all 13 states	0.18

Attachment #3

Precipitation

Average annual precipitation in the nine northern states (ME, NH, VT, NY, MA, CT, RI, PA, NJ) has been increasing since the 1900s, with an overall change of 10-15% during this period. More recently, the rate of change in winter precipitation has accelerated to 0.15 inches/decade (NECIA, 2006). Increasingly, this winter precipitation is falling as rain, rather than snow.

For the four southern states (MD, DE, VA, and WV) between 1951 and 2006, and based on empirical data, ClimateWizard analyses shows mean annual increases in precipitation that range from 1.46 inches/decade in DE (Figure 3) to 1.65 inches/decade in VA (Figure 4).

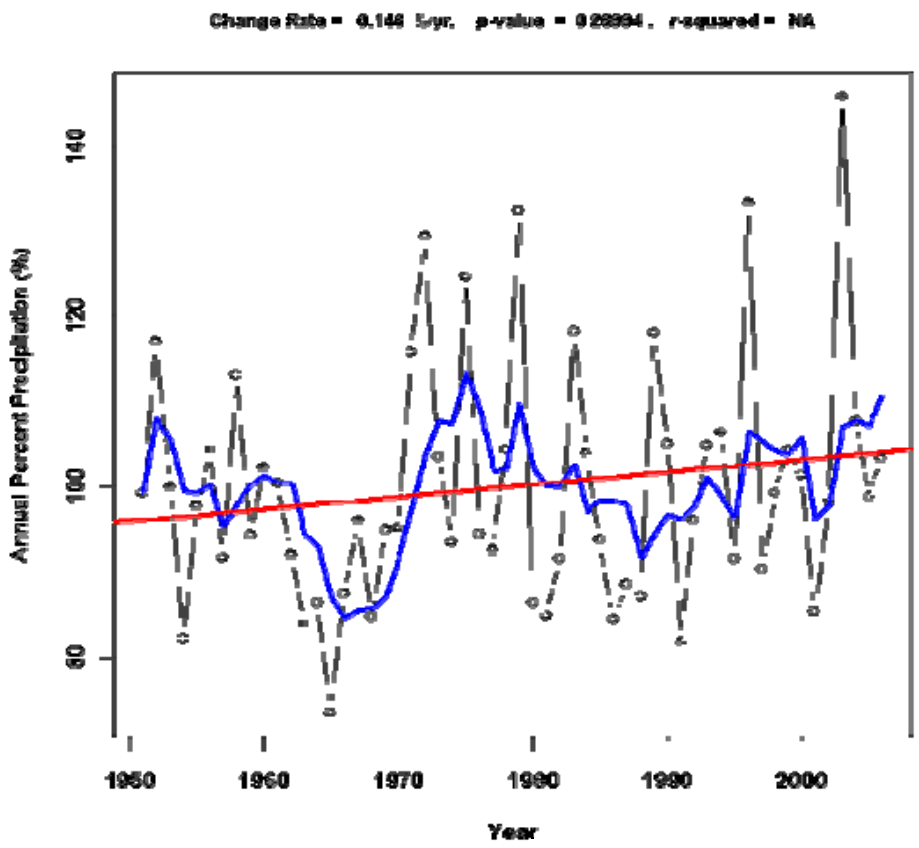

Figure 3. Change in annual precipitation in Delaware, 1950-2006. Blue line is 5-yr running mean.

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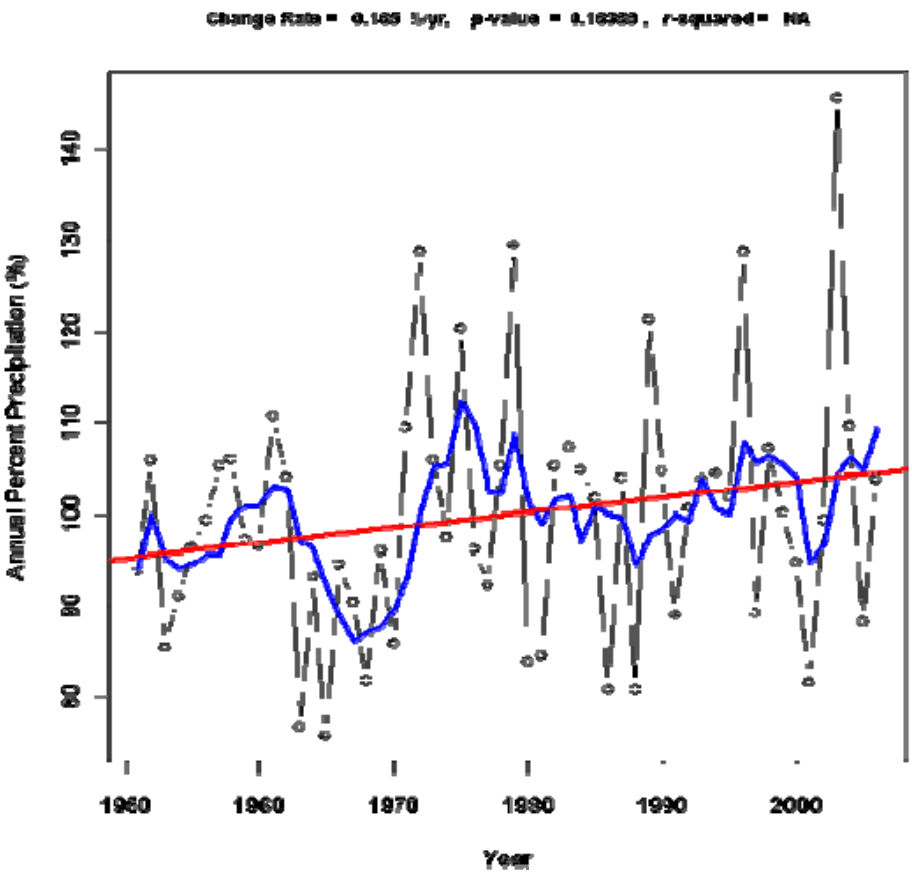

Figure 4. Change in annual precipitation in Virginia, 1950-2006. Blue line is 5-yr running mean.

Extreme events

Data from the nine northern states in the Northeast indicate that over the last few decades changes may have been occurring in the frequency and intensity of extreme weather events. For example, beginning in the 1980s, the frequency of extreme precipitation events has increased, and the amount of rain in each event has also increased.

Phenologies

Because of rising temperatures, the growing seasons (length of time between the last spring and the first fall freezes) in the Northeast have been lengthening. Since 1970, the growing season has been extending by 2.5days/decade, resulting in an overall extension of 10 days and changes in USDA hardiness zones (Figure 5).

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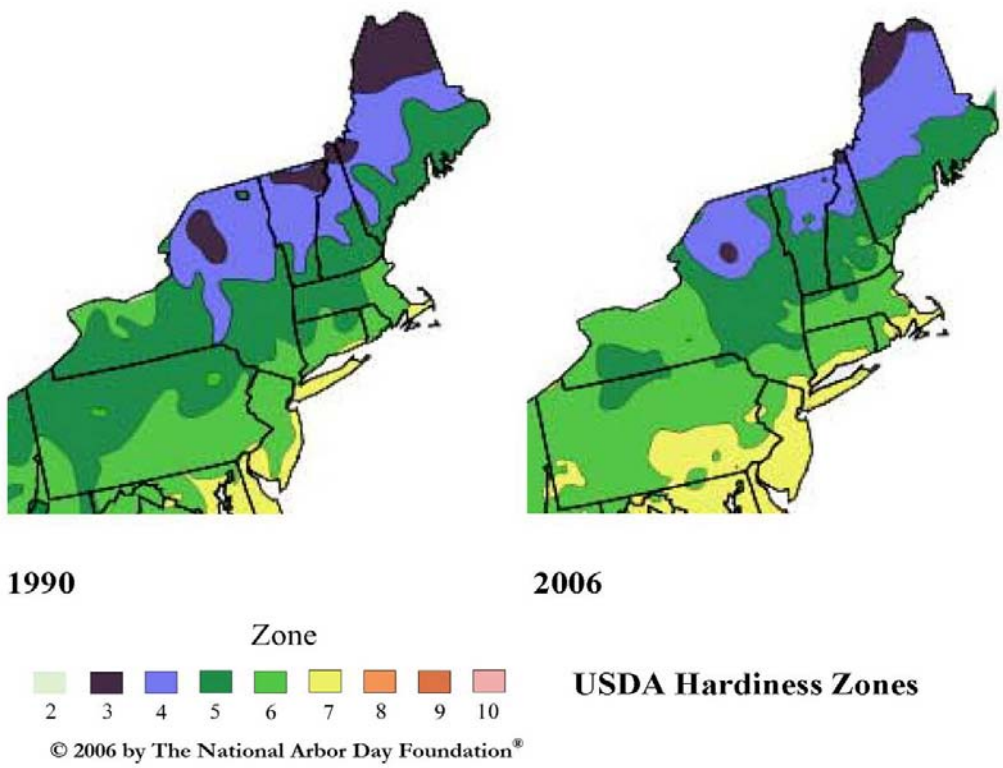


Figure 5. Northward migration of plant hardiness zones in the Northeast since 1970.

The date of spring ice-out has also been consistently changing (Figure 6) and is now about nine days earlier in the northern states and 16 days earlier in the southern states. Some areas may not freeze at all (Figure 7)

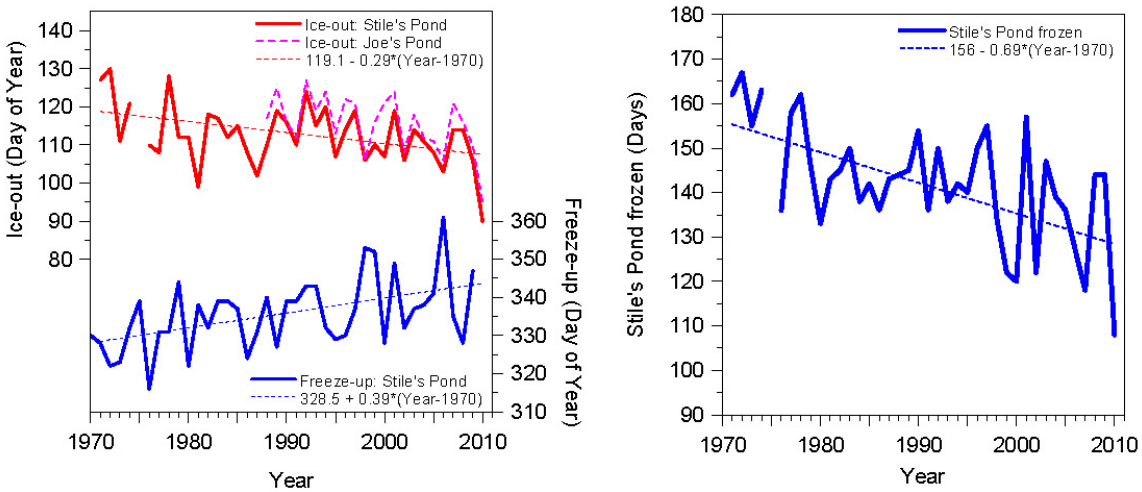


Figure 6. Timing of ice-out and extent of frozen days at two Vermont ponds (data from A. Betts).

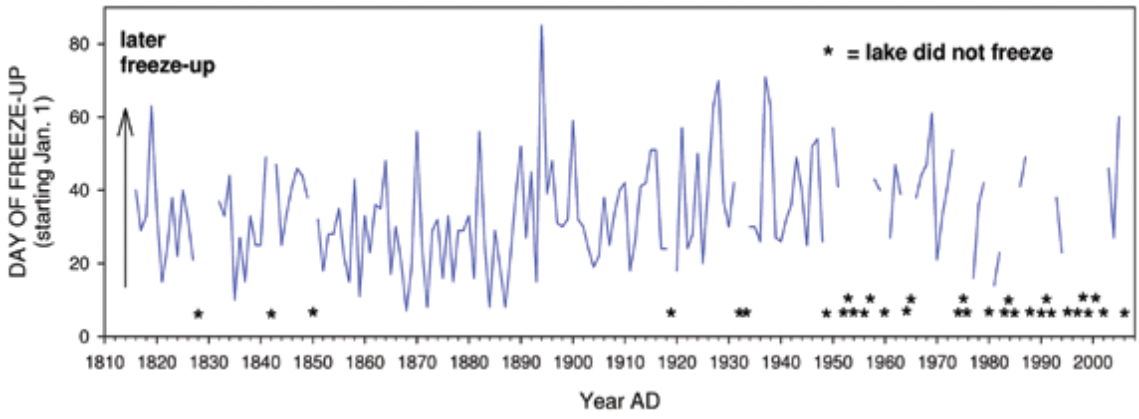
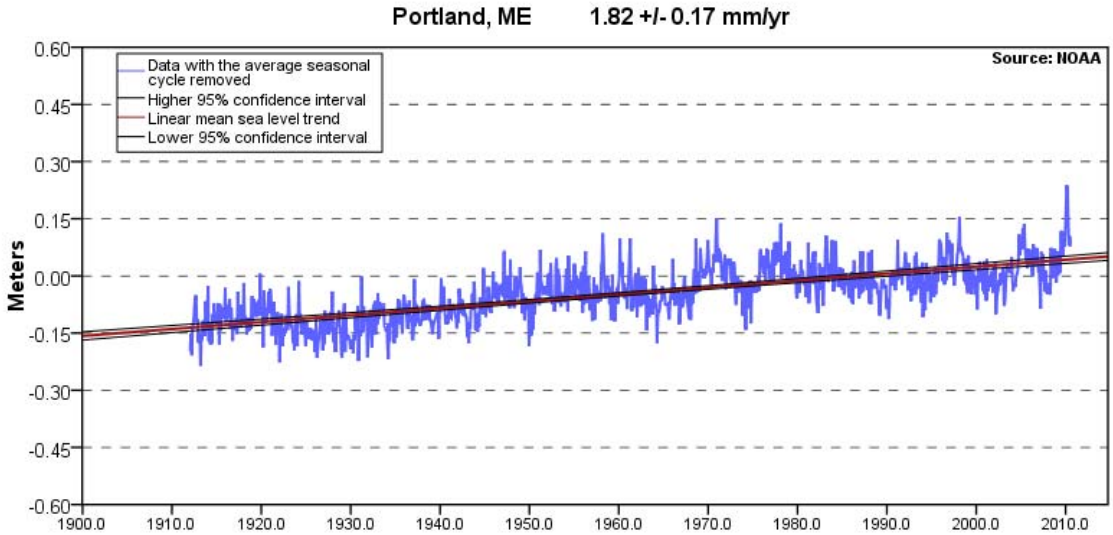


Figure 7. Lake Champlain freeze-up dates from 1816 to 2007. Asterisks indicate winters during which ice failed to cover the main body of the lake (TNC, 2010).

Sea Level rise

Sea levels in the Northeast are already rising (as they are globally). Most of this change is due to atmospheric warming and the associated heating and expansion of ocean waters, while a smaller contribution (so far) is due to glacial and ice cap melting. The actual rates of sea level rise (SLR) at specific sites vary depending on local conditions, particularly crustal processes. The rates of measured SLR are shown for four northeastern sites in Figure 8. At these sites, rates of SLR vary from 1.82 mm/yr to 4.44 mm/yr. The increasing rate of SLR from north to south probably reflects differences in crustal processes, where the most northern sites may be undergoing isostatic rebound (rebound of the land surface from the last glaciation).



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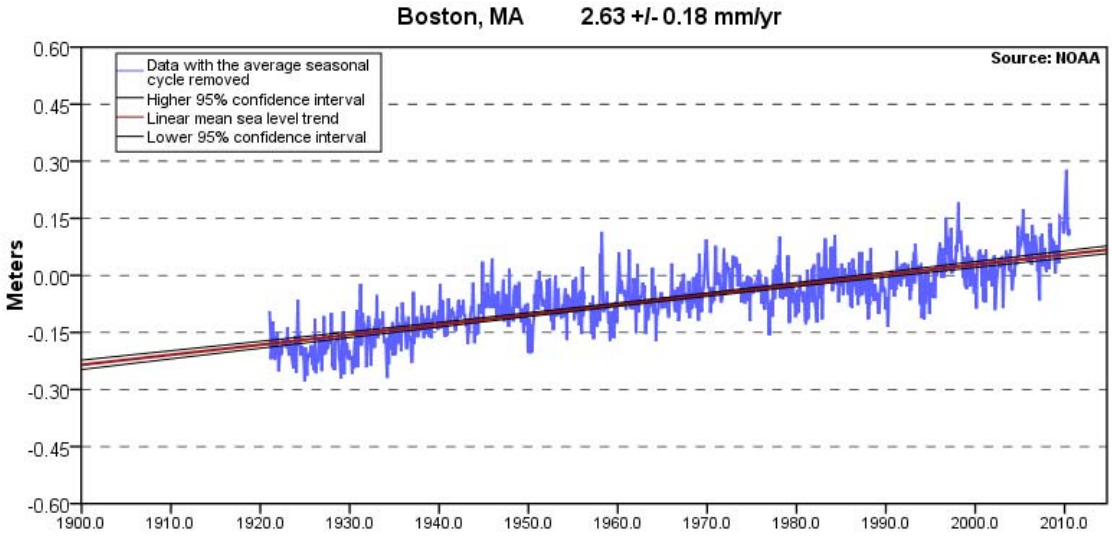

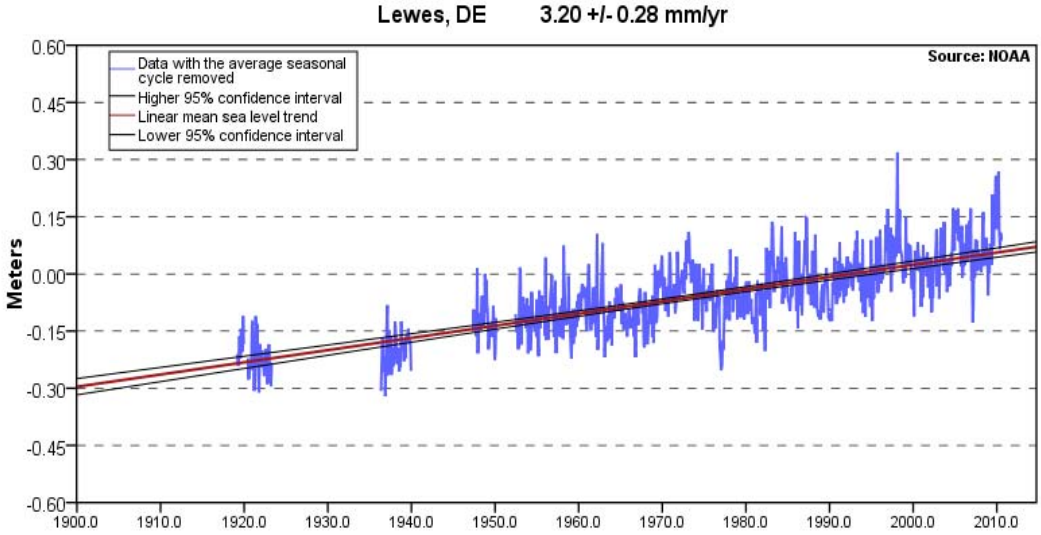

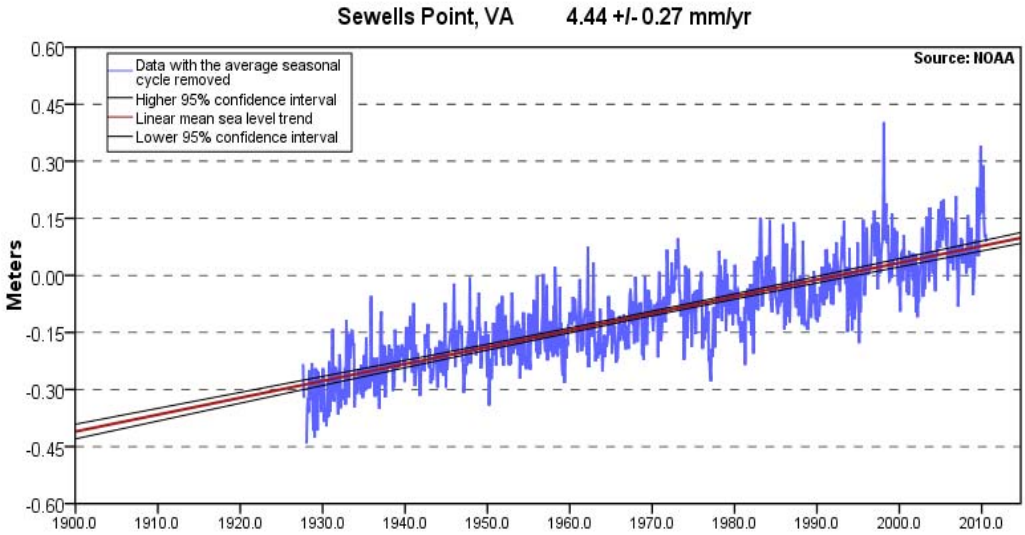

Figure 8. Historic and current rates of SLR at Portland, Boston, Lewes, and Sewells Point. From NOAA Tides and Currents (http://tidesandcurrents.noaa.gov/sltrends/sltrendsstation.shtml?stnid=8531680)

2. FUTURE CLIMATE CHANGE PROJECTIONS

Temperature

The Northeast Climate Impacts Assessment (NECIA, 2006) modeled future climate change for the nine northern states (ME, NH, VT, MA, CT, RI, NY, PA, and NJ). Three General Circulation Models (GCMs) were used (the GFDL CM2.1, the Hadley3, and the PCM models), and two emissions scenarios: B1 (a scenario that assumes that society will act quickly over the next decades to control greenhouse gas emissions), and A1Fi (a scenario that assumes that current emission rates will persist until the later part of the century, when some controls will be implemented). Projecting the B1 scenario forward results in an approximate doubling of atmospheric CO^2 (over pre-industrial levels) by the end of the century. The A1Fi scenario results in more than a tripling. The GFDL and the Hadley3 models are generally considered to have medium to medium high sensitivity, while the PCM model is relatively low sensitivity. Thus, these three models bracket the likely impacts of emissions on climate.

The GCMs were downscaled by Hayhoe *et al* (2008) using statistical downscaling[1] to project future climate changes at a much finer resolution ($1/8^o$) than is provided by the

[1] Statistical downscaling uses observed current relationships between overall regional climate patterns and empirical data from monitoring sites to establish "calibration" factors between regional and local patterns. These factors are then use to modify the GCM predictions.

global GCMs. Figure 9 shows the degree of resolution that is obtained by this downscaling method.

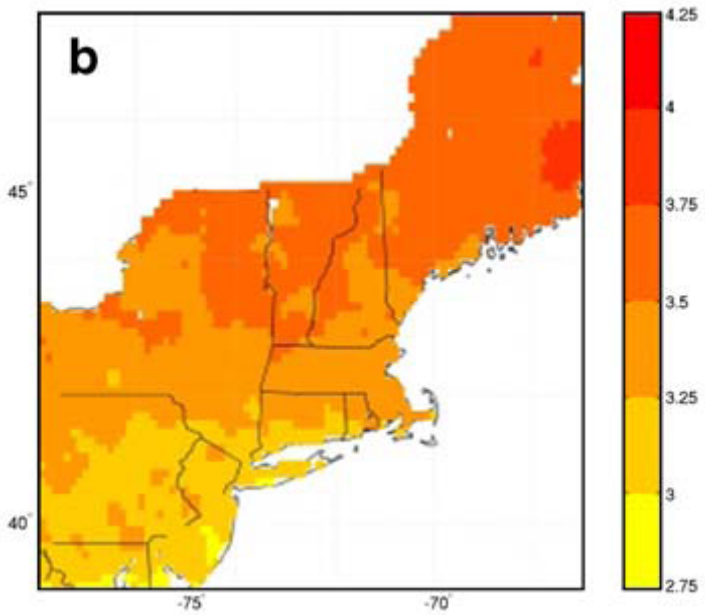

Figure 9. Projected change in mean annual temperature (^{o}F) by 2100 (from Hayhoe *et al*., 2008).

For the nine northern states, Hayhoe *et al*., (2008) project that mean annual temperatures over the remainder of this century will rise by between 3.5 and 12.5^{o}F, under the B1 scenario, and depending on the GCM used. Under the A1Fi scenario, the corresponding results are 6.5-12.5^{o}F**.** Temperatures are projected to rise faster in winter than in summer during the first half of the century, but by the end of the century the increases will be roughly equivalent.

For the four southern states future temperature change was modeled using ClimateWizard. Virginia was selected as the test case and ClimateWizard was run using three emissions scenarios (a low emissions scenario - B1; a middle emissions scenario – A1B; and a high emissions scenario – A2) and three GCMs (PCM, GFDL-CM2, and Hadley3). The results (Table 2) show that the southern states may warm by about 3-7°F by the 2080s, somewhat lower than in the northern states (but still large and ecologically-significant increases).

Table 2. Projected annual mean temperature increase (^{o}F) in Virginia by the 2080s under three emissions scenarios and three GCMs.

	PCM	**GFDL-CM2**	**Hadley3**
B1	3	3	4
A1B	3-4	6	7
A2	4	7	7

Precipitation

GCMs are not as consistent in their future projections of precipitation change as they are of temperature. However, using the low emissions scenario (B1), and averaging the output of 17 GCMs in ClimateWizard, the most likely outcome across the Northeast is a 5-10% increase in annual precipitation. Under a high emissions scenario (A2), the increase may reach about 20%. It should be noted, however, that there is much disagreement among the GCMs and these projections should be treated with some caution.

Steam flow

Changes in precipitation type, quantity and seasonality, and temperature are likely to have major impacts on stream flow in the Northeast. Spring snowmelt throughout the area will be earlier, advancing peak flows by about 10 days. Also, since less precipitation will fall as snow, it is likely that spring flows will be less marked, but higher flows may generally prevail through the winter months (since less water will be locked up in snowpack). During the summers, higher ambient temperatures, reduced soil moisture, and higher evapotranspiration rates are likely to result in flows in streams and rivers being reduced.

The higher frequency of extreme rain events predicted by climate models could also result in a greater frequency of floods in northeastern streams and rivers. In New Hampshire, Vermont, and Maine, the probability of high-flow events may increase by as much as 80 percent (NECIA, 2006).

Extreme events

The frequencies and intensities of floods and droughts are likely to increase over the remainder of this century. While quantitative predictions of such changing patterns are problematic, the Northeastern Climate Impacts Assessment (NECIA, 2006) projects that the frequency of heavy rainfall events may become more frequent and severe across the Northeast. NECIA (2006) also predicts that coastal winter storms may shift from earlier to later in the winter and more storms are expected to travel further up the coast and affect the Northeast.

NECIA (2006) also projects rising temperatures increasing evaporation rates and reducing soil moisture in summer. By mid-century, these changes are projected to lead to more frequent short-term droughts (an average of two every three years) under both the Bi and A1Fi scenarios, with a slightly higher frequency under the higher-emissions scenario Figure 10). By the end of the century, short-term droughts under the higher-emissions scenario may be as frequent as once per year in parts of the Northeast. Only a slight increase in drought risk is expected under the lower-emissions scenario.

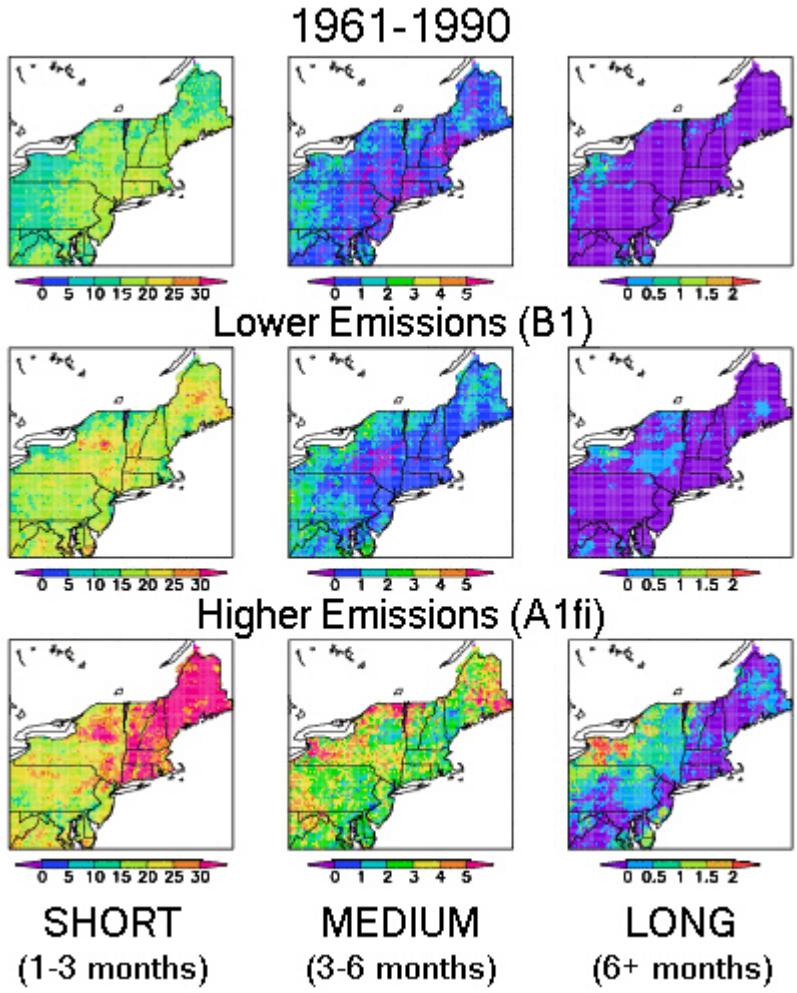

Figure 10. Total number of short-term (1-3 months), medium-term (3-6 months) and long-term ((6+ months) droughts occurring during 1961-1990 and the projections for the last three decades of this century (2070-2099) under lower and higher emissions scenarios (NECIA, 2006).

Snow cover

Since winters are projected to become warmer and more precipitation will fall as rain rather than snow, we can expect that the area of the Northeast that currently is consistently snow covered will contract. The Northeastern Climate Impacts Assessment modeled this for the nine northern states (Figure 11). Figure 11 predicts that the areas with consistent winter snowpack will contract northwards and be confined, by the end of the century to only the northern-most parts of the Northeast (NECIA, 2006).

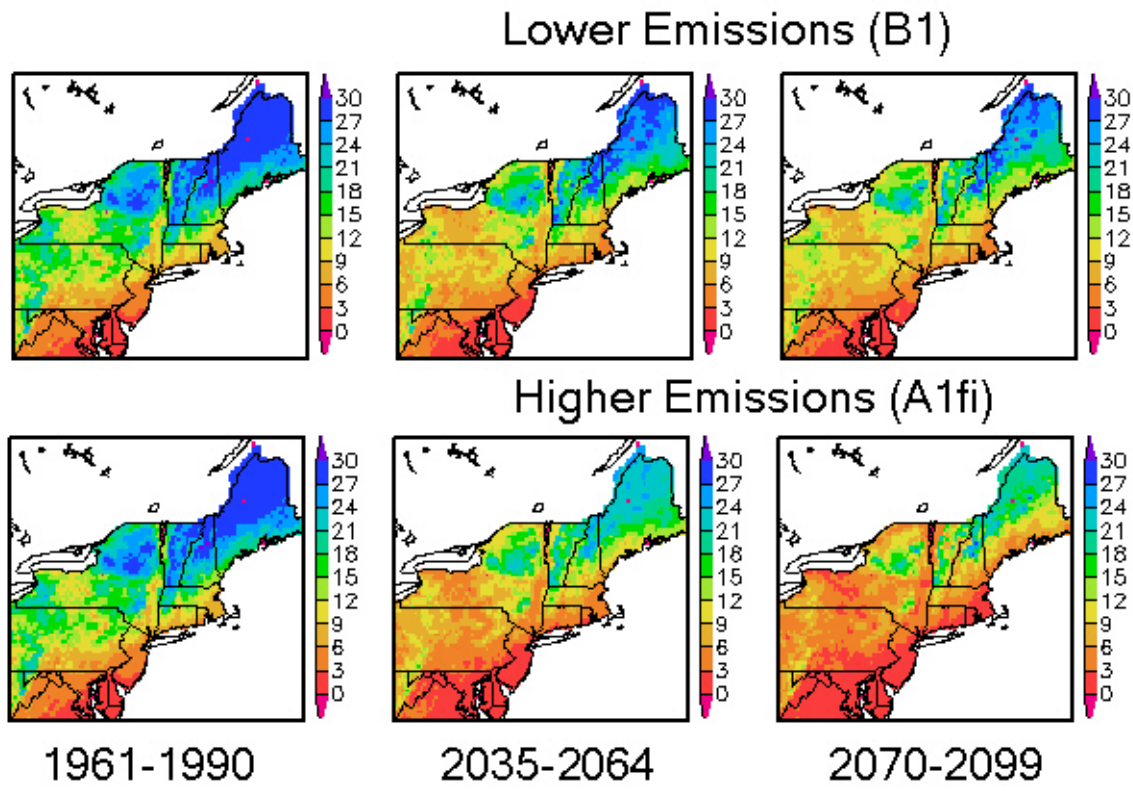

Figure 11. Current and projected number of snow-covered days/month (December-February) under two emissions scenarios (NECIA, 2006).

Growing seasons

The growing season in the Northeast has been getting longer by 2.5 days per decade since 1970. By the end of the century, the growing season is projected to be four weeks longer (under lower emissions) to six weeks longer (under higher emissions) compared with the 1961 to 1990 average (NECIA, 2006). Summer is expected to arrive three weeks earlier in the spring and stay three weeks later in the fall under a higher-emissions scenario; under a lower-emissions scenario, it could arrive 1 to 1.5 weeks earlier in the spring and stay almost two weeks longer in the fall.

Sea level rise

Globally, sea levels have been rising over the last century and it is expected that the rate of SLR will accelerate during the remainder of this century (IPCC, 2007). Based on data collected prior to 2006, the Intergovernmental Panel on Climate Change (IPCC) estimated that by the end of this century global sea levels will have risen by between about 10 and 16 inches (Figure 12). However, new data on the melt rates of glaciers and icefields that became available after the IPCC report has led to a revision of that

projection (Rahmstorf, 2007; Pfeffer *et al*., 2008), and it is now widely assumed that over the rest of this century sea levels will rise by between 0.5 and 2 meters.

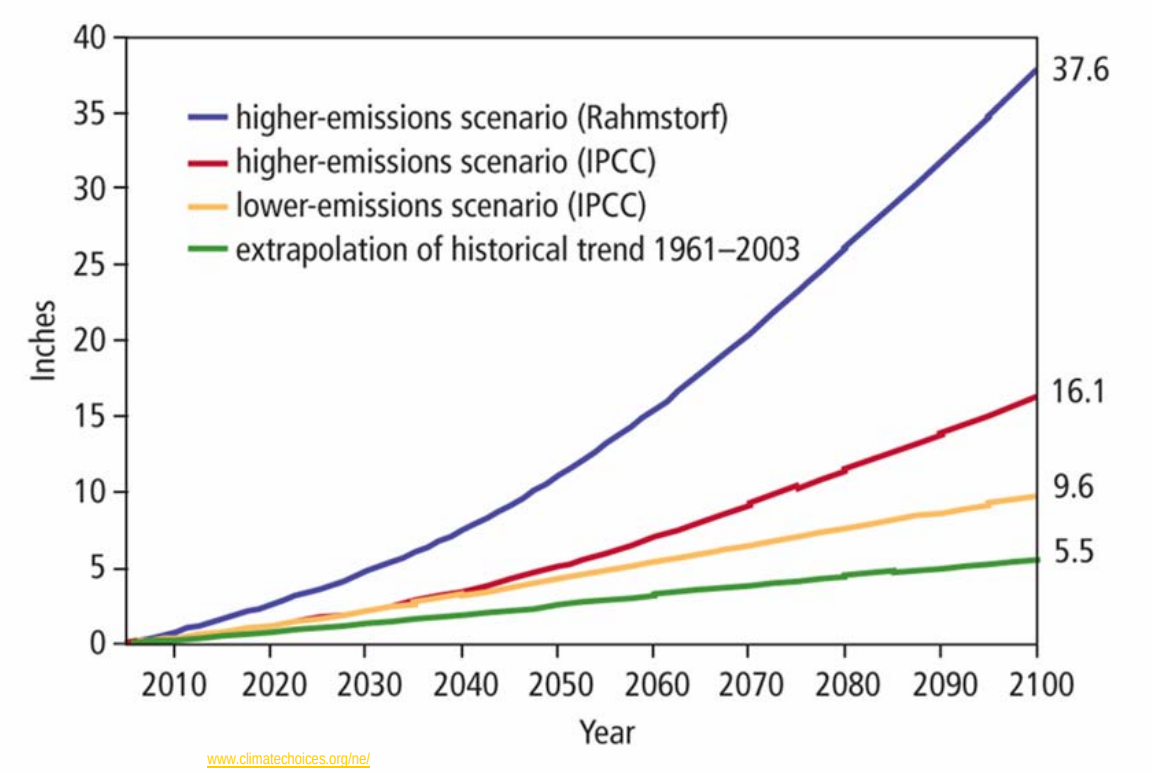

Figure 12. Future SLR projections.

When evaluating future SLR at specific sites, the estimates of global rates should be added to projections of the *current* local rates. Such estimates are presented in Table 3.

Table 3. Estimates of local SLR at four northeastern coastal sites in the next 90 years assuming four SLR scenarios (0.5, 1.0, 1.5 and 2.0m)

	Current SRL (mm/yr)	**0.5m**	**1.0m**	**1.5m**	**2.0m**
Portland, ME	1.82	0.66m	1.16m	1.66m	2.16m
Boston, MA	2.63	0.73m	1.24m	1.74m	2.23m
Lewes, DE	3.20	0.78m	1.29m	1.80m	2.29m
Sewells Point, VA	4.44	0.9m	1.40m	1.90m	2.40m

Figure 13 shows the potential implications of SLR for coastal habitats at Parker River NWR, assuming rises of 0.39 and 1.5m. These results were obtained by Clough and Larson (2009) using the Sea Level Affecting Marshes Model (SLAMM). While projecting the impacts of SLR on specific sites and habitats is fraught with uncertainty, these results do indicate that even relatively modest rises could have important impacts on coastal ecological resources.

Attachment #3

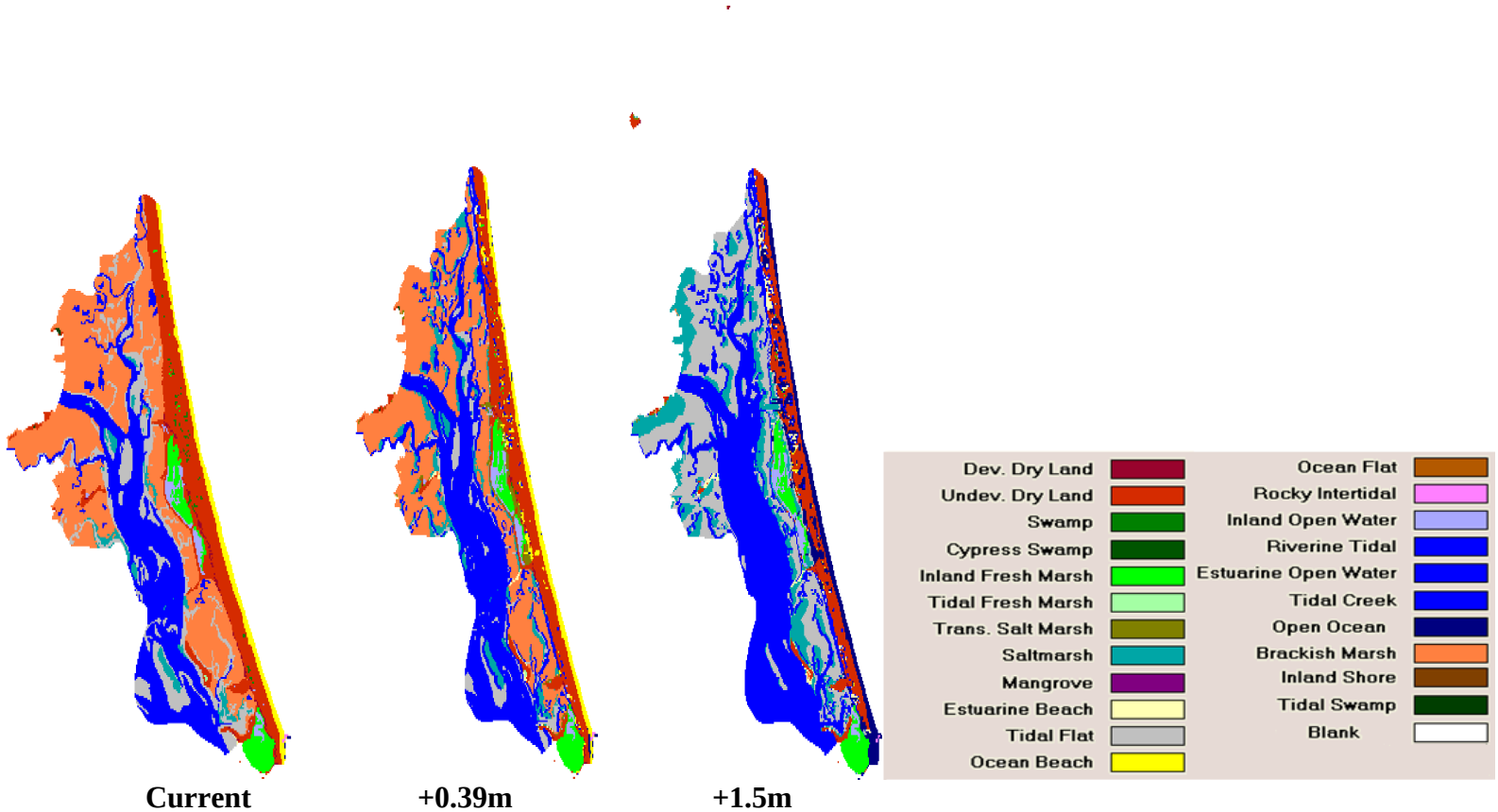

Figure 13. Changes in habitat distributions at Parker River NWR by 2100 under three SLR scenarios (Clough and Larson, 2009).

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Attachment #4

CLIMATE CHANGE IN THE NORTHEAST – IMPACTS ON ECOLOGICAL RESOURCES?

The first submission to the NEAFWA Regional Vulnerability Assessment Project expert panel outlined the climatic changes that are already occurring in the Northeast, and how our climate is projected to change over the remainder of the century. We know that the distributions and abundances of organisms, including plants, invertebrates, fish, amphibians and reptiles, birds and mammals are fundamentally influenced by climate. It is reasonable to assume, therefore, that climatic change will be accompanied by corresponding changes in the distribution and condition of ecological populations and communities, especially since the magnitude of future climate change is projected to be severe and biologically significant.

In this submission, the existing scientific literature is reviewed to address two questions: 1) what are the main categories of change that we might expect to observe in natural systems in response to a changing climate; 2) is there any evidence that such changes are already occurring in the Northeast?

Potential Impacts

Our expectations about the types of change that may occur under a changing climate are informed by three main categories of evidence:

- Our knowledge about the relationships between climatic factors and the current distributions and ecologies of plants and animals

- Our knowledge of how plant and animal distributions changed in response to previous eras of climatic change (e.g., after the last glaciation)

- Our observations about how the distributions and ecologies of plants and animals and ecological processes are changing now in response to the current warming.

Based on these lines of evidence, a number of reviews have been conducted of the changes that are already occurring, and of how we might expect ecological systems to respond to a changing climate in the future (e.g., Iverson, et al., 1999; Parmesan and Galbraith, 2005; Schneider and Root, 2002; Walther et al., 2002; Parmesan and Yohe, 2003; Galbraith et al., 2002; Root et al., 2003; Galbraith et al., 2006; Parmesan, C. 1996). These studies have indicated that the following ecological responses might be anticipated under climate change:

1. Species' range shifts: under a changing climate, sensitive species are likely to change their distributions to track their climatic optima (in the case of species that are sensitive to the direct effects of climate), or the changing distributions of elements of their habitats (e.g., food plants, or host species). These changes could be affected by mobile species

either leaving an area that is becoming increasingly unsuitable, or, in the case of less mobile organisms, by subpopulations dying out in the south or at lower elevations and becoming established further north or at higher elevations. At a regional scale, the most likely shift trajectories will be poleward or higher in elevation. These changes will express themselves on the ground as either the colonization of an area by "southern species", the contraction of a northern species out of an area, or an upward shift in elevation by species.

Changes in the ranges of plants and animals in North America during and after the last glaciation are concrete examples of climate-driven range shifts. When the glaciers were at their maximum extent, 15,000 years ago, animals and plants now confined to high latitudes (e.g., dwarf birch, caribou, and musk ox) were found far south of their current ranges in what is now the Midwest. As the temperature warmed and glaciers retreated, species shifted their ranges to follow their major habitats and climatic optima (Graham, 1992). Thus, shifts of species' ranges of 1,000 to 2,000 km occurred with global temperature changes of 7°-11°F (Coope, 1995; Huntley, 1991), similar to the temperature changes predicted for the future by climate models.

2. Regional/local species' extinctions: the poleward contraction in range mentioned above, a thwarted upward shift in elevation, or loss of thermal habitat may result in species' regional or local extinctions.

3. Phenological shifts: The phenology (timing) of many of the important events in an organism's life cycle may be affected by climate. For example, the onset of spring growth in both plants and animals is frequently triggered by environmental conditions that exceed critical temperature or precipitation thresholds. Similarly, the timing of migration and breeding is often driven, or modulated by, temperature and precipitation patterns. Consequently, if temperature regimes change we may expect to see changes in the timing of seasonal events. However, day length is another major driver of phenological events. The overall impacts of climate change will depend on the extent to which climate or day length is the predominant trigger of events for different species. In addition, some species have strong interactions with other species. For example, birds often rely on spring insect emergence for food, while insects are frequently specialists on one species of host plant. If species use different cues to time their emergence and breeding events, then a mismatch may occur between predator and prey or parasite and host, which could cause major species declines.

4. Community dissociations: As an area is affected by climate change and becomes less suitable for different organisms, representation of species within communities may shift. Ecological communities comprise associations of different plant and animal species, each of which has its own specific climatic requirements. Also, the abilities of these species to shift in response to changing climate are likely to be very different. For example, a warbler that every year can migrate many thousands of miles is much more mobile than the seeds of the boreal forest trees that comprises its breeding habitat. So, as climate changes the composition of communities may be altered as species track their climatic tolerances by moving out of and into an area. This could involve relatively subtle changes

in species composition (e.g., a grassland becoming dominated by a slightly different suite of grass species) or major switches as one habitat type (e.g., grassland) is replaced by another (e.g., shrubland).

5. Habitat loss and migrations: while habitats may dissociate (see above) they may also manage to retain their essential species elements, but shift in space. For example, increased inundations regimes in coastal wetlands due to sea level rise may result in habitats migrating inland, to displace hitherto dry land habitat types.

6. Intensified invasions of pest species: invasive species and pests often manage to outcompete and displace native species because they are more tolerant of environmental stress (Mooney and Hobbs, 2000). The implication of this is that as native ecosystems come under increasing climatic stress they may become more vulnerable to invasions by pest species. Also, changing climatic conditions may directly benefit pest and invasive species, as is currently happening with the hemlock wooly adelgid which is limited by winter temperatures. Increasing winter temperatures are favoring enhanced overwinter survival of this species and allowing it to extend its range northward in New England. Another example is the mountain pine beetle in the Rocky Mountain west. This species can now fit more reproductive cycles into the lengthening spring and summer seasons, and its increased populations are causing major ecological and economic damage to conifer forests.

7. Ecosystem process changes: underpinning all ecosystem processes are chemical reactions. For example, the breakdown of dead biological material in the nutrient cycling process hinges on the ability of bacteria to chemically degrade and assimilate the material. The rates at which these chemical changes occur are affected by temperature and water regimes. Climatic changes that modify these limiting factors can, in turn, accelerate or decelerate the rates at which the ecosystem processes occur. For a complete discussion of ecosystem processes and climate change, see the recent Pew Report by Malcolm and Pitelka (2000).

Are Any Of These Effects Already Occurring In The Northeast?

Range shifts: we are fortunate that New York, Vermont and Ontario have recently completed their second rounds of breeding bird atlases (first carried out in the 1970s). These data (along with other information that ornithologists and amateur birders have been gathering over the last few decades) show that there have marked changes in the distributions of northeastern bird species. Many of these shifts have conformed to what we might expect if climate change was a causal factor – with southern species moving north and northern species becoming less common and contracting further to the north. As yet rigorous analyses have not been performed on these data, however it is apparent that at least 14 bird species that hitherto were “southern” have moved north (Table).

Attachment #4

Breeding bird species that have been extending their ranges northward in the last few decades.				
Turkey vulture	Red-bellied woodpecker	Northern mockingbird	Orchard oriole	Pine warbler
Black vulture	Acadian flycatcher	Louisiana waterthrush	Tufted titmouse	Fish crow
	Blue-gray gnatcatcher	Northern cardinal	Carolina wren	Prairie warbler

The range shifts of the some of the birds in the table have been extensive. In the 1980s, the northern limit of the red-bellied woodpeckers range was in Connecticut – it now breeds as far north as central Vermont, a northward shift of over 100 miles, and is a relatively common breeder in Massachusetts and southern New Hampshire. Similarly, the Tufted titmouse and northern mockingbird were considered uncommon species in Massachusetts and Connecticut in the first half of the 20th century, but also now breed as far north as central Vermont. Black vultures began to appear in Massachusetts from the south about 30 years ago, and are now regularly recorded well into central Vermont. The two figures below show how the distributions of two bird species changed in Vermont between the first and the second breeding bird atlases in the 1970s and 2002-2007).

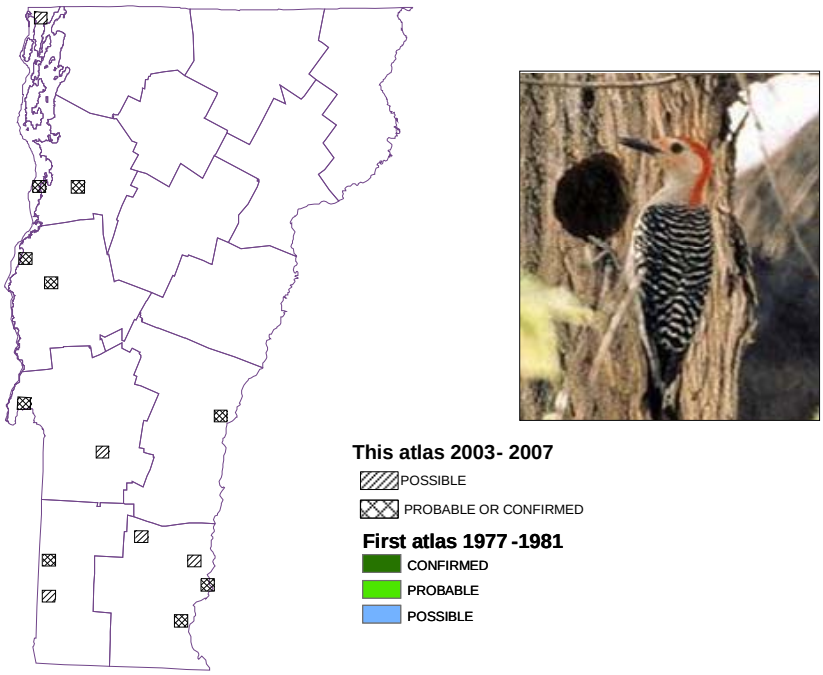

Figure 1. Breeding range of the red-bellied woodpecker in Vermont in the second breeding bird atlas. In the first atlas in the 1970s the species had not yet colonized the state, but had spread north to the Canadian border by the second atlas.

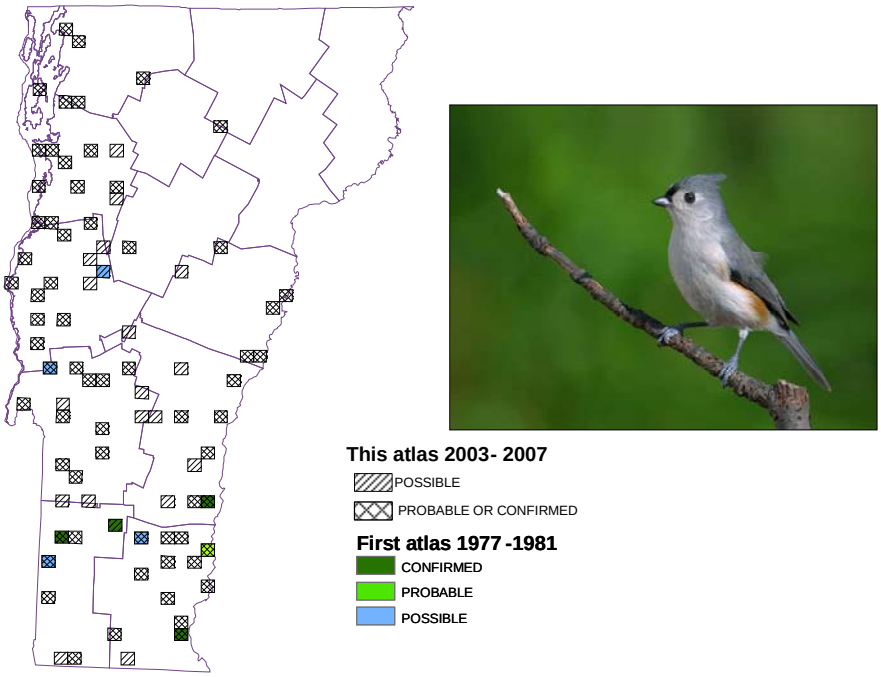

Figure 2. Breeding range of the tufted titmouse in Vermont in the first (colored boxes) and second (black and white hatched boxes) breeding bird atlases. In the first atlas in the 1970s the species was largely confined to the southern part of the state but had spread north to the Canadian border by the second atlas.

Hemlock wooly adelgid has also shown an extensive range shift to the north. First found in Pennsylvania in the 1960s, the species spread into southern and central New England by the 1980s, and has recently spread even further north to colonize Vermont and Maine. This pest is limited in its distribution by low winter temperatures (which reduce over-winter survival). The continuing warming of northern New England promises to extend the range of this pest even further north.

Phenological change

Changes in the timing of the seasons: Observations in New England show that the first-flower dates for lilacs have advanced four days since the 1960s. Greater advances of six to eight days have been recorded for grape vines and apple trees over the same time period. Plants at Harvard University's Arnold Arboretum flowered on average eight days earlier from 1980 to 2002 compared with 1900 to 1920 (NECIA, 2006). Data on the advancement of lilac flowering in Vermont is shown in Figure 3.

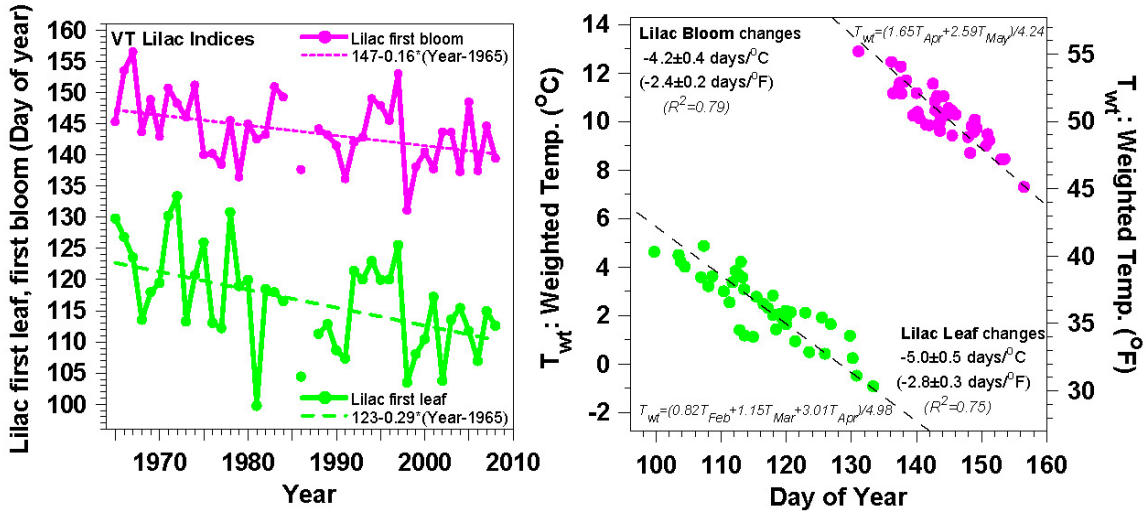

Figure 3. Lilac first bloom and first leaf dates in Vermont in last four decades (data from A.K. Betts).

These phenological changes in timing of plant growth have meant that the growing season in the Northeast has been lengthening by 2.5 days/decade since about 1970 (Figure 4).

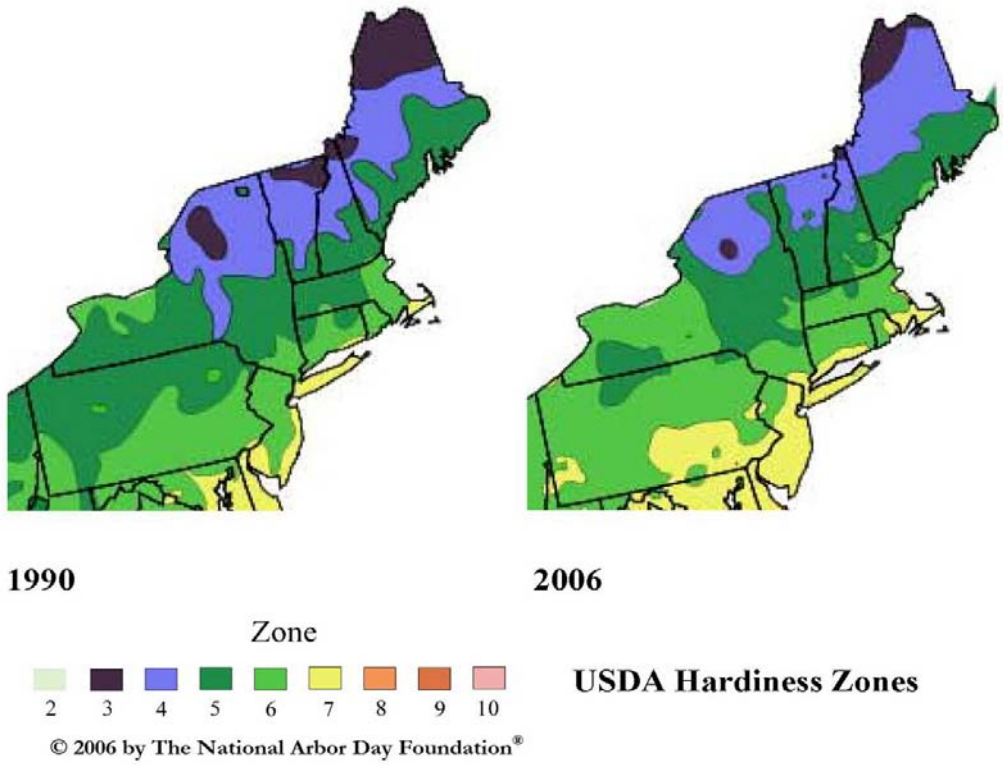

Figure 4. Northward migration of plant hardiness zones in the Northeast since 1970.

Other phenological changes that have been reported in the Northeast include the earlier migrations of Atlantic salmon in rivers (Juanes et al., 2004), and the advancement of mating seasons in amphibians (Gibbs and Breisch, 2001).

These data on range shifts and phenological changes indicate that it is likely that the Northeast's ecosystems may already be responding to the changing climate. Moreover, it is important to recognize that: (a) these changes have occurred under a relatively modest climatic shift (less than 2°F), far less than what may be expected over the coming decades. (b) the observed changes may be only the tip of the iceberg: far greater effort is put into monitoring bird distributions and flowering seasons in the Northeast than into taxa that are less easy to monitor. It is possible that if effective monitoring schemes were in place for (e.g.,) invertebrates, or intertidal or marine species the recorded responses to climate change could be more widespread.

Attachment #4

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