5 Climate Change and Massachusetts SGCN

The Division of Fisheries and Wildlife recognized climate change in the 2005 SWAP as an issue that could impact SGCN and their habitats. Since then, climate-change-related planning and research by the Commonwealth of Massachusetts and the DFW have centered on developing a better understanding of how vulnerability to climate change is likely to impact SGCN and their habitats (Glick et al. 2011) and how to understand the adaptive capacity of these species (Beever et al. 2015) and their responses to climate changes. Finally, we have concentrated on developing adaptation strategies to conserve the biodiversity of the Commonwealth under projected climate change conditions.

In this chapter, we cover five projects illustrating how consideration of climate change is being taken into account at all levels of biodiversity conservation throughout the Commonwealth.

A. Integrating Climate Change into the State Wildlife Action Plan

Integrating Climate Change into the State Wildlife Action Plan (Staudinger et al. 2015), a cooperative report from the Northeast Climate Science Center (NE CSC), provides a summary framework within which to examine climate change and SGCN in Massachusetts. The following is adapted from the report.

The purpose of this report is to provide a synthesis of what is known and what is uncertain about climate change and its impacts across the NE CSC region (Northeast and Midwest United States), with a particular focus on the responses and vulnerabilities of Regional Species of Greatest Conservation Need (RSGCN) and the habitats they depend on. Another goal is to describe a range of climate-change adaptation approaches, processes, tools, and potential partnerships that are available to state natural resource managers across the Northeast and Midwest regions of the United States. Through illustrative case studies submitted by the NE CSC and partners, climate change adaptation efforts that being explored and implemented across local and large-landscape scales are demonstrated.

This document is divided into four sections and addresses the following climate and management relevant questions:

1. Climate Change in the Northeast and Midwest United States: How is the climate changing and projected to change across the Northeast and Midwest regions of the United States?
2. Northeast and Midwest regional species and habitats at greatest risk and most vulnerable to climate impacts: What are the relative vulnerabilities of fish and wildlife species and their habitats to climate change in the Northeast and Midwest?
3. Biological responses to climate impacts with a focus on Northeast and Midwest Regional Species of Greatest Conservation Need (RSGCN): How are threatened fish and wildlife likely to respond or adapt to climate change in the Northeast and Midwest?
4. Scale-appropriate adaptation strategies and actions in the Northeast and Midwest United States: What approaches, strategies, and actions could be taken to sustain fish, wildlife and their habitats in the short and long term across the Northeast and Midwest?

Effects of Climate Change

The study suggests that the climate in the Northeast is already changing in important ways:

- Warming is occurring in every season, particularly in winter, at higher latitudes, at higher elevations, and inland (i.e., away from the ocean and lake coasts).
- Heatwaves may become more frequent, more intense, and last longer.
- Precipitation amounts are increasing, particularly in winter and with respect to high-intensity events in summer.
- Snow is shifting to rain, leading to reduced snowpacks and extent of snow cover, as well as harder, crustier snowpacks.
- Atmospheric moisture content is likely to increase.
- Wind speeds are declining, though wind gusts may be intensifying.
- Streamflows are intensifying.
- Streams are warming.
- Thunderstorms may become more severe.
- Floods are intensifying, yet droughts are also on the rise as dry periods between events get longer.
- Blizzards and ice storms are occurring more often in some areas, though most areas experiencing milder winters (i.e., warmer and with less snow).
- Growing seasons are getting longer, with more growing degree days accumulating earlier in the season.

In addition, the climate along the United State Atlantic coast is changing:

- Sea level is rising at an accelerating rate.
- Tropical cyclones and hurricanes may be intensifying and storm tracks have been shifting northward along the coast.
- Oceans are warming and becoming more acidic.

Biological Responses of Northeast and Midwest Species to Climate Impacts

- Climate change will have cascading effects on ecological systems.
- These changes are expected in the form of shifts in timing, distribution, abundance, and species interactions.
- Some wildlife groups in the Northeast and the Midwest, including montane birds, salamanders, cold-adapted fish, and freshwater mussels, could be particularly affected by changing temperatures, precipitation, sea and lake level, and ocean processes.
- Interspecific interactions and land use change could exacerbate the impacts of climate change.
- A focus on habitat connectivity, water quality, and invasive species is among the many options

to increase resilience for wildlife populations in the face of climate change.

Scale-Appropriate Adaptation Strategies

- *Climate Change Adaptation* is a growing field within conservation and natural resource management. Actions taken toward climate change adaptation account for climate impacts and ecological responses, both current and projected into the future. These actions attempt to accomplish a number of goals, including the conservation of wildlife and ecosystems by reducing vulnerability and increasing resilience.
- Climate change adaptation strategies and approaches for natural resources can be thought of as part of a continuum of potential actions ranging from 1) options or goals to 2) strategies, 3) approaches, and 4) tactics.
- There are a range of decision support tools and processes to aid climate change adaptation. This document highlights several including the Adaptation Workbook, Climate Change Vulnerability Assessments, Structured Decision Making, Adaptive Resource Management, and Scenario Planning. It will also provide case studies on the application of these tools across the Northeast and Midwest.
- Improved, better-integrated, and increasingly coordinated monitoring systems would be helpful to detect, track, and attribute species and habitat shifts to climate change over spatiotemporal scales. We highlight regional examples of projects and programs addressing these challenges.
- Illustrative case studies of climate change adaptation efforts are presented across landscape/ecoregion, state, and local scales.
- Appendix 4.1 of *Integrating Climate Change into the State Wildlife Action Plan* provides a synthesis of over 900 general, species and habitat-specific adaptation strategies and tactics from 9 regional studies being considered or implemented across the region.

B. Massachusetts Climate Change Adaptation Report

At the state level, the DFW participated in the development of the state's Climate Change Adaptation Report (Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee 2011), released in September, 2011. This report was a requirement of the M.G.L. Chapter 298 (An Act Establishing the Global Warming Solutions Act) Section 9. DFW staff served on both the overall Steering Committee for the Climate Change Advisory Committee and on the Natural Resources and Habitat Subcommittee. This report identified a set of guiding principles for adaptation strategies, including for natural resources and habitats in all ecosystems (see Box 5-1).

Box 5-1: Natural Resources and Habitats: Guiding Principles for Climate-Change Adaptation

Adapted from the Massachusetts Climate Change Adaptation Report, pp. 37-38.

While many strategies are unique to specific ecosystems (e.g., allowing inland migration of coastal wetlands in the face of rising sea levels) and are detailed in the following sections, many no-regrets climate adaptation approaches apply to all ecosystem types that help protect and restore ecological resilience. Several principles rooted in ecology, conservation biology, and ecosystem management, and well-supported in current climate adaptation literature (Heller and Zavaleta 2009; Mawdsley et al. 2009; Beier and Brost 2010) serve as core climate adaptation strategies:

- Protect ecosystems of sufficient size. Anchor conservation in sites of sufficient size and quality to remain resilient over centuries, recover from disturbances, maintain space for the breeding requirements of component species, allow space for dynamics, and protect internal gradients and topographic variation.
- Protect ecosystems across a range of environmental settings. Represent key geophysical settings across gradients reflecting combinations of topography, geology, and elevation. Focus conservation efforts on places that are critical to biodiversity in the present and are likely to be critical in the future.
- Protect multiple example ecosystems to capture redundancy. It is unlikely that conservation will succeed at every site, as future climate is complex and local and regional-scale impacts are unpredictable. Protecting replicate sites in many independent places ensures that at least some examples will persist through centuries.
- Maintain large-scale ecosystem processes and prevent isolation. Ecosystems and species are dependent on regional scale processes such as hydrologic cycles and disturbance regimes. It is important to maintain high quality source breeding habitats and connectivity across habitats to facilitate species dispersal, migration, and maintenance; protect local connectivity for individuals, as well as regional movements of populations to facilitate climate change adaptation; protect land and water; and identify compatible land uses in areas critical to connectivity. Intact landscapes that capture the most robust examples of ecosystems represent the best opportunities to protect and enhance ecosystem function and biodiversity.
- Limit ecosystem stressors. Strategies that focus on reducing threats, such as habitat conversion and fragmentation (i.e., development), invasive species, and airborne and waterborne pollutants, can maintain ecosystem resilience and allow ecosystems to provide a full range of functions and services.
- Maintain ecosystem diversity. Preserve as many options as possible for natural adaptation in response to climate change. Expect and plan for species losses and possible gains from other regions.
- Use nature-based adaptation solutions. Allowing intact forest, wetland, river, and coastal ecosystems to function as green infrastructure that protects ecological, economic, and social values is an economical climate adaptation approach. These soft engineering [approaches] should be considered wherever possible as alternatives to hard engineering solutions. As an example, where appropriate, protection of coastal wetlands can be an alternative to coastal armoring for reducing the impacts of sea level rise and storm surge.
- Embrace adaptive management. Ecosystem managers should develop flexible concepts for understanding natural systems. The effectiveness of protection and management should be verified through monitoring, and long-term ecological monitoring projects that inform climate adaptation decisions should be supported.
- Develop a unified vision for collaborative conservation of natural resources. Analyses such as the State Wildlife Action Plan and BioMap2 (2010) serve as blueprints for ecosystem protection and restoration and galvanize the conservation community to engender long-term ecological resilience. Public funding and progressive, flexible, and climate-responsive regulations will be crucial to abate the threats of climate change on natural resources and provide long-term protection of green infrastructure.

These guiding principles were based, in part, on the results of the Climate Change Vulnerability Assessment conducted in 2010 by the Manomet Center for Conservation Sciences for the Division of Fisheries and Wildlife. For this report, Manomet staff worked with the DFW to assess many of the habitats identified in the 2005 Massachusetts SWAP. Results of this assessment were presented as a case study in *Scanning the Conservation Horizons: A Guide to Climate Change Vulnerability Assessment*, published by the National Wildlife Federation (Glick et al. 2011). The Massachusetts Vulnerability Assessment Project used an expert elicitation approach to conduct the assessment. Staff members from the DFW were asked a series of questions regarding their expert opinions regarding how the SGCN species may react to various changes in climate conditions. Climate change projections were derived using two emission scenarios. The results from these question and answer sessions were summarized and edited through an iterative process until the DFW staff felt like the reports had correctly captured the results from the expert elicitation sessions. Results of the project were presented in three reports:

- Climate Change and Massachusetts Fish and Wildlife: Volume 1, Introduction and Background. This report provides background to the project by describing how biodiversity conservation is currently carried out by the Division of Fisheries and Wildlife; the history, objectives, and methods of the SWAP; and how the climate in Massachusetts has been changing and is expected to change over the remainder of this century.
- Climate Change and Massachusetts Fish and Wildlife: Volume 2, Habitat and Species Vulnerability. This volume reports the results of the work assessing the likely vulnerabilities of fish and wildlife and their habitats to climate change. The report addresses the following questions: How do the SWAP-targeted fish and wildlife habitats rank in terms of their likely comparative vulnerabilities to climate change? How will the representation of these habitats in Massachusetts be altered by a changing climate? Which vertebrate SGCN are likely to be most vulnerable to climate change?
- Climate Change and Massachusetts Fish and Wildlife: Volume 3, Habitat Management. This report provides at least partial answers to the second question: how valued ecological resources might be effectively managed as climatic conditions continue to change and what degree of confidence can be assigned to the above predictions.

In addition to producing the reports, Manomet and DFW hosted a daylong public workshop, attended by over one hundred participants, at Bryant College where the report results were shared.

Once the Climate Change Vulnerability Assessment effort was completed, it became apparent that this information regarding the relative vulnerability of SGCN habitats to projected climate change condition needed to be put into a larger landscape-scale context, which would encompass the range of the various habitat types evaluated. A landscape-scale context for the vulnerability of these habitat types is especially useful to Massachusetts and other small northeastern states, where the same habitat type ranges across several states. It is likely that the vulnerability of these habitats will be different across their range, leading the states to assign different priority ranking to both the threat from climate change and the priority ranking of their conservation strategies. To provide this landscape-scale understanding of climate-change impacts, the Northeast Association of Fish and Wildlife Agencies provided funding through the Regional Conservation Needs Grant Program for the Manomet Center for Conservation Sciences and the National Wildlife Federation to conduct a Regional Climate Change Vulnerability Assessment. Project results have been summarized and are available on the Wildlife Management Institute web page (see Box 5-2).

Box 5-2: Regional Climate Change Vulnerability Assessment: Assessing the Likely Impacts of Climate Change on Northeastern Fish and Wildlife Habitats and Species of Greatest Conservation Need

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) collaborated 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 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 was the first of its kind in the country and was an essential step toward the implementation of effective "climate-smart" conservation of ecosystems.

Climate change is already impacting ecological resources in North America, including fish and wildlife and their habitats. These effects will become more serious and widespread as the climate continues to change, and will pose major conservation and management challenges. The overarching goal of the project was to provide vulnerability and adaptation information that will help the northeastern states to plan their conservation of fish and wildlife under a changing climate. The results are an essential step forward in effective regional climate change conservation planning. This project had 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.

The final reports are available for download:

- Report to NEAFWA Vulnerability Assessment Expert Panel: Exposure Information
- Climate Change and Riverine Cold Water Fish Habitat in the Northeast: A Vulnerability Assessment Review
- The Vulnerability of Northeastern Fish and Wildlife Habitats to Sea Level Rise
- The Vulnerability of Northeastern Fish and Wildlife Habitats to Climate Change
- Habitat vulnerability evaluation results

The NEAFWA Habitat Vulnerability Assessment Model is now being used by 6 states to complete their state vulnerability assessments. In addition, the model has been used as an important component of training courses for Federal and non-governmental organizations in vulnerability assessment.

C. *BioMap2* and Climate Change

NHESP and The Nature Conservancy's Massachusetts Program developed *BioMap2* to protect the state's biodiversity in the context of projected effects of climate change. See Chapter 2, Section E, and Chapter 4, Section D, for more explanation of *BioMap2*. The following is adapted from Section C of the *BioMap2* technical report. See this report for further details.

A variety of emerging strategies, collectively termed Climate Change Adaptation, are designed to help ecosystems and populations cope with the adverse impacts of climate change. *BioMap2* incorporates a suite of these strategies to promote **resistance** and **resilience** of plant and animal populations and ecosystems, and to assist anticipated **transformations** caused by climate change and other stressors (Heller and Zavaleta 2009, Lawler 2009) (Table 5-1).

- **Resistance:** The ability of an ecosystem or population to persist and to *remain relatively stable in response to climate change and other stressors*. The concept of resistance is incorporated into *BioMap2* for species like the Threatened Blanding's Turtle by identifying extensive habitat patches that support large populations, allow movement from wetlands to uplands, and allow movement among wetlands, all of which impart resistance to populations in the face of projected summer droughts, spring flooding, and other threats.
- **Resilience:** The ability of an ecosystem or population to *recover from the impacts of climate change and other stressors*. In many cases, ecosystems will change in species composition and structure in response to climate change; increased resilience supports an ecosystem's ability to adapt to climate change and maintain ecological function. For example, wetlands will likely experience changes in temperature and hydrological regime (i.e., the timing and amount of water) due to projected climate changes, resulting in changes in plant and animal composition. By selecting large, unfragmented wetlands that are well buffered, *BioMap2* prioritizes wetlands that are best able to maintain function and support native biodiversity.
- **Transformation:** The transition of an ecosystem or population *to another ecological state in response to climate change and other stressors*. *BioMap2*, recognizing such transformations are particularly likely along the coast, identifies low-lying, intact uplands adjacent to salt marshes to allow the migration of estuarine ecosystems up-slope in the context of rising sea levels.

The strategies adopted for *BioMap2* are critical components of a comprehensive strategy needed to address climate change. Ultimately, *BioMap2* should be combined with on-the-ground stewardship and restoration efforts, such as dam removal, forest management, and rare species habitat management, providing a comprehensive approach to biodiversity conservation in the face of climate change. This set of strategies must complement international, national, and regional emission reductions in order to reduce the threat of climate change to species and ecosystems.

Table 5-1. Climate adaptation strategies incorporated into the mapping of *BioMap2* natural communities and ecosystems.

X denotes strategies that are directly built into the *BioMap2* through one or more spatial analyses.

Ecosystem	Size	Connectivity			Limit Stressors[a]	Ecological Processes[b]			Representation		Repli-cation
		Local connectivity[c]	Regional connectivity	Ecosystem migration	Development and Roads, Pollution, Biotic and Hydrological alterations	Hydrologic regimes[b]	Disturbance regimes[b]	Buffers	Ecological settings	Ecoregions (Watersheds)	
Vernal pools	X	X			X	X				X	X
Forest Core	X	X			X		X	X[d]		X	X
Wetland Core	X	X			X	X	X	X	X	X	X
Aquatic Core	X	X						X		X	X
Landscape Blocks	X	X	implicit		X	X	X			X	X
Coastal Habitat				X[e]			X[e]	X[e]			X

[a] These stressors are represented by metrics within the UMass CAPS Index of Ecological Integrity (See in the *BioMap2* Technical Report, Chapter 2, Section D (Index of Ecological Integrity) and Appendix G (Integrity metrics) for a complete list of metrics and explanations).
[b] The persistence of these processes in the ecosystems noted is based on the assumption that large, intact, ecosystems with limited stressors will maintain most or all of these ecological processes.
[c] Through UMass CAPS Index of Ecological Integrity.
[d] Forest cores are buffered by Landscape Blocks in every case.
[e] Through the coastal adaptation analysis.

The ecosystem analyses and resulting *BioMap2* priorities were developed using the latest climate adaption approaches, employing the strategies described below to impart resistance and resilience to *BioMap2* habitats, natural communities, and ecosystems (Heinz Center 2008, Heller and Zavaleta 2009, Hansen et al. 2003, Lawler 2009) (Table 5-1). These strategies include:

- **Prioritize habitats, natural communities, and ecosystems of sufficient size.** Large wetlands, forests, river networks, and other intact ecosystems generally support larger populations of native species, a greater number of species, and more intact natural processes than small, isolated examples. Large examples are also likely to help plants and animals survive extreme conditions expected under climate change. *BioMap2* includes the largest examples of high-quality forest and wetland ecosystems and intact landscapes, as well as extensive species habitats and intact river networks.
- **Select habitats, natural communities, and ecosystems that support ecological processes.** Ecological processes sustain the diversity of species within ecosystems. Examples include natural disturbances, like windstorms in forests that result in a mosaic of forest ages, each of which supports a different suite of plants and animals. Similarly, intact rivers support functional hydrological regimes, such as flooding in the spring, that support the diversity of fish and other species found in a healthy river. *BioMap2* identifies ecosystems with the best chance of maintaining ecological processes over long time periods; these resilient habitats are most likely to recover from ecological processes that are altered by climate change.
- **Build connectivity into habitats and ecosystems.** Connectivity is essential to support the long-term persistence of populations of

both rare and common species. Local connectivity provides opportunities for individual animals to move through the landscape. For instance, wood frogs and blue-spotted salamanders need to move between springtime vernal pool habitats where they breed and upland forest habitats where they feed in summer and overwinter. *BioMap2* maximizes local connectivity in forest, wetland, vernal pool, river, and rare species habitats. Regional connectivity allows long-distance dispersal, which helps to maintain vital populations. The intact landscapes of *BioMap2* support regional connectivity, including several cross-state areas of critical importance.

- **Salt Marsh Migration: A special case for connectivity**. The coastal habitats of Massachusetts are particularly vulnerable to potential sea-level rise in the next century, which some estimates suggest is likely to exceed one meter. Therefore, in addition to prioritizing current coastal habitats, *BioMap2* includes an analysis of low lying, undeveloped and ecologically connected upland areas adjacent to salt marshes and coastal habitat to determine where these habitats might extend into or migrate to adjacent uplands as sea levels rise. Many salt marshes are encroached upon by roads and other forms of developed infrastructure. By identifying adjacent upland habitat still connected to salt marsh habitat, *BioMap2* identifies those areas with the highest probability of supporting ecosystem migration. However, the presence of these low-lying lands adjacent to existing salt marsh does not ensure the future migration of salt marshes into this new zone. Many biotic and abiotic processes, including salt marsh accretion, erosion, and collapse, will determine which of several outcomes will occur as the sea level rises. Research and observation over the coming decades will identify which of these outcomes will occur in the various salt marshes of Massachusetts. The identification of the land to which these marshes could move is just one of many steps that might be necessary to protect these habitats into the future.

- **Represent a diversity of species, natural communities, ecosystems, and ecological settings.** To ensure that the network of protected lands represents the full suite of species, both currently and into the future, *BioMap2* includes rare and common species, natural communities, and intact ecosystems across the state. *BioMap2* also includes ecosystems across the full range of ecoregions and ecological settings; such diverse physical settings support unique assemblages of plants and animals and serve as coarse filters for protecting biological diversity. As species shift over time in the context of changing climate, a diversity of physical settings and ecosystems will be available to support biodiversity.
- **Representing physical diversity: Protecting the stage using Ecological Land Units and ecoregions:** Climate plays an important role in determining which species may occur in a region such as the Northeast. However, within the region, the close relationship of the physical environment to ecological process and biotic distributions means that species and ecosystem distributions are strongly influenced by features such as local geology and topography because these factors affect the availability of water, nutrients, and other resources needed by plants and animals (Anderson and Ferree 2010, Beier and Brost, 2010). It is important to incorporate such variation in physical (or ecological) settings into long-term biodiversity conservation because these settings will endure over time even as species shift in response to climate change. An understanding of patterns of environmental variation and biological diversity is fundamental to conservation planning at any scale—regional, landscape level, or local. From this perspective, conserving a physical setting is analogous to conserving an ecological "stage", knowing that the individual ecological "actors" will change with time. Protecting the stage will help to conserve varied habitats and to retain functioning ecosystems in place, even though the exact species composition may change.
- **Protect multiple examples of each species habitat, natural community, and ecosystem.** Simply put, by selecting multiple examples of each species habitat, natural community, ecosystem, and landscape, *BioMap2* reduces the risk of losing critical elements of the biodiversity of Massachusetts. The extreme weather events projected under climate change, and the uncertainties of ecosystem response, will likely

mean that some populations will not persist, and some ecosystems will cease to function as they have in the past. By selecting multiple examples and distributing them geographically and among different settings, *BioMap2* increases the likelihood that one or more examples will survive into the future.

- **Minimize non-climate stressors to species and ecosystems.** Limiting other stressors is one of the most important strategies to impart resistance and resilience to species and ecosystems. *BioMap2* identifies those habitats least impacted by roads and traffic, development, dams, water withdrawals, and other sources of stress, which also have the least likelihood of related stressors such as edge effects, invasive species, and alterations to water quantity and quality. Despite efforts to select the least-altered habitats, these areas are not pristine, and stewardship to reduce additional stressors is often required.

D. Climate Change, the Boreal Forest, and Moose: Scenario Planning to Inform Land and Wildlife Management

Understanding climate-change impacts to SGCN involves components which have high levels of uncertainty. One way to address these uncertainties is through a process called scenario planning. The DFW has joined a project to examine how climate change will affect the boreal forest and moose. This project is being led by the Wildlife Conservation Society and involves the US Geological Survey, the National Climate Change and Wildlife Science Center, the Department of Interior Northeast Climate Science Center, the North Atlantic Landscape Conservation Cooperative, the New York State Department of Environmental Conservation, the US Forest Service, the Northern Institute for Applied Climate Science, the New York Cooperative Fish and Wildlife Research Unit, the University of Maryland Center for Environmental Science, and the DFW.

This project is in its early stages of development, but four objectives have been outlined for the project:

1. Develop a set of scenarios (3-5) based on uncertain aspects of climate change and ecological response in northern boreal forests relevant to Moose and other species and ecosystems in the region.
2. Apply scenarios to explore management implications for Moose and identify specific climate-informed management options.
3. Support at least one state wildlife management agency to incorporate information from the pilot scenario-planning project into their State Wildlife Action Plan.
4. Document and share the scenario-planning pilot and outcomes.

This project will begin in early 2015 and continue through the year. The first of several newsletters on the project is available online.

Lessons learned from this scenario-planning pilot project on Moose and boreal forests will aid DFW to develop potential climate-smart conservation strategies for moose in Massachusetts now and in the future. In addition, it is hoped that the lessons learned from this one example of scenario planning will prove to be useful in developing conservation strategies for other SGCN and their habitats under climate-change conditions.

E. The MassWildlife Climate Action Tool

The MassWildlife Climate Action Tool (MassCAT) is a web-based decision-support tool that has been developed with funding from the Massachusetts Division of Fisheries and Wildlife, the Massachusetts Department of Fish and Game, and the Executive Office of Energy and Environmental Affairs. The purpose of MassCAT is to provide climate-change information and a range of climate-change adaptation strategies for local use, covering a broad range of species and habitats, including SGCN. The MassCAT is a product of the Massachusetts Climate Adaption Partnership (Massachusetts Division of Fisheries and Wildlife; University of Massachusetts Center for Agriculture, Food and the Environment; and the Department of Interior, Northeast Climate Science Center). It incorporates information from the Northeast Climate Science Center Report, *Integrating Climate Change into the State Wildlife Action Plan* (see above).

MassCat will be available online in the fall of 2015. Figure 5-1 is the draft home page of the website. Figure 5-2 is an example of one of the types of information that will be provided.

Figure 5-1: Massachusetts Wildlife Climate Action Tool.


Massachusetts Wildlife
CLIMATE ACTION TOOL

QUICK START | ABOUT US | USER GUIDE | CONTACT & FEEDBACK

Adaptation Strategies and Actions

Maintain or restore riparian areas: Protect riparian areas

Adaptation type:
Land and forest stewardship or restoration

Strategy:
Maintain or restore riparian areas

Action

Protect riparian areas

Riparian areas are the lands next to streams, wetlands, vernal pools, and water bodies. Riparian areas will be increasingly important to wildlife in a changing climate. Maintaining tree cover in these areas helps to regulate water temperatures by shading the water, which is especially important in cold water fisheries like trout streams. Trees also provide twigs, branches, and leaves, which are a food source to many aquatic insects that are in turn eaten by fish, reptiles, and amphibians. When trees fall into streams, logs slow the flow and provide habitat. Forested riparian areas filter rain and overland flow before it reaches water bodies and also provide cover to animals.

It is important to not mow these areas and instead allow forests to regrow. If having a timber harvest, follow the filter strip regulations and guidelines in the MA Forestry Best Management Practices.

Figure 5-2: Sample page from the Massachusetts Wildlife Climate Action Tool.

F. Forestry Management on Montague Plains Wildlife Management Area

The Massachusetts DFW is working with the Northern Institute of Applied Climate Science to apply the USDA Forest Service's tools to plan for climate change adaptation and response (Swanston and Janowiak 2012). At the beginning of this planning process, DFW identified the Montague sandplain, much of which is protected by DFW as the Montague Plains Wildlife Management Area (WMA), as a refugia for natural communities and species that are likely to exhibit a markedly different response to predicted climate change than other vegetation types in Massachusetts. These tools provide a 5-step framework designed to enable land managers to "define an area of interest, management goals/objectives, and time frames, assess climate change impacts and vulnerabilities for the area of interest, evaluate management objectives given projected impacts and vulnerabilities, identify adaptation approaches and tactics for implementation, and monitor and evaluate the effectiveness of implemented actions" (Swanston and Janowiak 2012, chapter 3). The conclusions from this process will be incorporated into the Montague Plains WMA site plan. See Table 5-2 for the draft framework fror this project.

Table 5-2: Climate Change Adaptation Workbook for Montague Plains WMA

Step 1. DEFINE area of interest, management goals and objectives, and time frames.

Area of Interest:	**Montague Plains Wildlife Management Area**			
Location:	**Montague, Massachusetts**			
Forest or Community Type(s)	**Management Goals**	**Management Objectives**	**Management Tools**	**Time Frames**
Scrub Oak Shrubland – S1	Maintain or increase populations of rare shrub-oak-dependent lepidopteran species and declining bird species (e.g., brown thrasher, prairie warbler, eastern towhee).	Maintain dominance of shrub oaks.	Mechanical mowing & mulching to control fuel loads. Prescribed Burning	100 years
Sandplain Grassland and Sandplain Heathland – S1	Maintain or increase populations of rare or declining grassland and heathland snakes, mammals, birds, Lepidoptera, and plants.	Expand limited areas of native warm-season grasses and heathland openings adjacent to or within other communities.	Mechanical mowing & mulching to control fuel loads. Prescribed Burning	5 years
Pitch Pine – Scrub Oak Community – S2	Maintain or increase populations of rare shrub-oak-dependent lepidopteran species and declining bird species (including Whip-poor-will, eastern towhee, ruffed grouse, woodcock).	Maintain open overstory and shrub oak understory.	Mechanical tree-clearing, mowing & mulching to control fuel loads. Prescribed Burning	100 years
Pitch Pine – Oak Forest / Woodland – S5	Diversify sandplain community types.	Convert closed-canopy forest to Pitch Pine-Oak Woodland or Pitch Pine-Scrub Oak community.	Mechanical tree-clearing, mowing & mulching to control fuel loads. Prescribed Burning	5 years.
		Restore overgrown openings to Scrub Oak Shrubland, Sandplain Heathland, or Sandplain Grassland		5 years
	Maintain or increase populations of rare plants and rare lepidopteran species.	Maintain food plants (e.g., scrub oak and pine needles), nectar sources, and open woodlands for various listed lepidopteran species.		100 years
		Prevent incursion of more mesic tree species (Red maple, white pine, aspen, gray birch)		

Step 2. ASSESS climate change impacts and vulnerabilities for the area of interest.
How might broad-scale impacts and vulnerabilities be affected by conditions in **your area of interest**?

- Landscape pattern
- Site location, such as topographic position or proximity to water features
- Soil characteristics
- Past management history or current management plans
- Species or structural composition
- Presence of or susceptibility to of pests, disease, or nonnative species that may become more problematic under future climate conditions
- Other….

Broad-scale Impacts and Vulnerabilities	Climate Change Impacts and Vulnerabilities for the Area of Interest	Vulnerability Determination
Fewer days with extreme cold	Could push community trajectory towards closed canopy forest and more mesic spp	-6
Increased annual precipitation	Additional precip would tend to favor more mesic tree spp over xeric tree spp and shrub/heath/grass	-2
Longer growing season	Longer growing season may favor more mesic trees species	-1
Less snow/shorter winter	How about shorter winter	-1
Increases in nonnative plant species	Scattered relics of invasives from agriculture and imports from surrounding area	-1
Potential changes in wildfire	Unclear whether wildfire changes will help (more spring/fall fires) or hurt (more very large summer fires leading to increased fire suppression regime)	-/+2
Potential for early spring thaws/late frosts or increases in freeze-thaw cycles	Unclear what effect would be, but may reduce tree growth and favor shrub/heath/grass	-/+1
More frequent and intense storms	More windthrow of trees	+1
Warmer temperatures	Increase drought stress should favor warm-season grasses, heath, shrub oak over tree spp	+2
More days with extreme heat	Increase drought stress should favor warm-season grasses, heath, shrub oak over tree spp	+2

Step 3. EVALUATE management objectives given projected impacts and vulnerabilities.

Management Objective (Step #1)	Challenges to Meeting Management Objective with Climate Change	Opportunities for Meeting Management Objective with Climate Change	Feasibility of Meeting Objectives under Current Management	Other Considerations
Convert closed-canopy forest to Pitch Pine-Oak Woodland or Pitch Pine-Scrub Oak community. Expand limited areas of native warm-season grasses and heathland openings adjacent to or within other communities. Restore overgrown openings to Scrub Oak Shrubland, Sandplain Heathland, or Sandplain Grassland	Increased potential for nonnative plant species invasion.	More storms, more drought stress, reduced soil moisture, warmer temps, extreme heat would favor shrub, heath, and grass.	Extremely high.	Public perception of active management (fire/mechanical/herbicide). Availability of funding.
Maintain dominance of shrub oaks. Maintain open overstory and shrub oak understory. Maintain food plants (e.g., scrub oak and pine needles), nectar sources, and open woodlands for various listed lepidopteran species.	More frost-free days, more precip, storms, longer growing season push favor trees. Fire may be more difficult and more unpredictable.	Reduced soil moisture, warmer temps, and extreme heat would favor shrub oaks.	High.	More frequent wildfires due to climate change could help convince people of the wisdom of prescribed fire. Availability of funding. Adequate prescribed fire capacity.
Prevent incursion of more mesic tree species (Red maple, white pine, aspen, gray birch)	Increased precipitation, longer growing season, more frequent and intense storms favor mid-tolerant gap species of trees. Altered hydrology of Will's Hill Brook is increasing mesophication along Plains Road.	Increased drought stress, reduced soil moisture, warmer temps, extreme heat favor sandplain tree species over more mesic species.	Medium.	Unclear whether climate change will help or hinder this objective. Restoring Will's Hill Brook will also resolve road erosion issues.

Step 4. IDENTIFY adaptation approaches and tactics for implementation.

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks & Barriers	Practicability of Tactic	Recommend Tactic?
1.2 Maintain or restore hydrology	Restore Will's Hill Brook to original stream channel.	FY2015	Reduce mesophication. Prevent erosion on Plains Rd. Restore function of associated terminal wetland.	Permitting. Funding.	Very high.	Yes.
2.2 Prevent the introduction and establishment of invasive plant species and remove existing invasives	Monitor and eliminate exotic invasive plants.	Ongoing	Reduce competition to desired species.	Repeated treatment necessary	Moderate.	Yes.
3.1 Alter forest structure or composition to reduce risk or severity of fire 3.2 Establish fuelbreaks to slow the spread of catastrophic fire	Thin closed canopy pitch pine forests.	10 years	Prevent running crown fires, increase growth of oak trees, favor shrub/heath/grass species.		Very high.	Yes.
	Mow shrubs on periphery of shrub, heath, and grassland areas.	Ongoing	Increases ability to use prescribed fire safely.	Repeated treatment necessary	Very high.	Yes.
4.1 Prioritize and protect existing populations on unique sites	Use prescribed fire to maintain shrub oak on unplowed areas of sandplain.	Ongoing	Maintain/expand populations of shrub oak dependant Lepidoptera and other shrubland species.	Need burn days, crew, and equipment.	Moderate.	Yes, in conjunction with mowing.
	Use shrub mowing to maintain shrub oak on unplowed areas of sandplain.	Ongoing		Funding. Potential long-term changes in soil structure and vegetation.	High.	Yes.

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks & Barriers	Practicability of Tactic	Recommend Tactic?
4.2 Prioritize and protect sensitive or at-risk species or communities	Reduce tree canopy in forest adjacent to wild blue lupine and other rare plant populations.	FY2015	Maintain/expand populations of rare plants.	Potential for invasives.	Very high.	Yes.
	Manually remove competing vegetation, especially invasive exotics, around rare plants.	Ongoing		Labor-intensive.		
5.3 Retain biological legacies 5.4 Restore fire to fire-adapted ecosystems	Remove all trees in overgrown openings within closed canopy forest and mow understory.	10 years	Restore grassland, heathland, and shrub communities.	Some openings have altered topography.	Very high.	Yes.
	Remove trees in areas adjacent to small grasslands.	10 years	Expand grasslands, heathlands, shrublands.	Short-duration benefit.	Very high.	Yes.
	Use prescribed fire to maintain scrub oak, grassland, and heath communities.	Ongoing	Maintain/expand populations of shrub oak dependant Lepidoptera and other shrubland, heathland and grassland species.	Need burn days, crew, and equipment.	Moderate.	Yes, in conjunction with mowing.
	Use mowing to maintain scrub oak, grassland, and heath communities.			Funding. Potential long-term changes in soil structure and vegetation.	High.	Yes.
	Use herbicide to maintain scrub oak, grassland, and heath communities.			Funding. Difficult to favor desired species.	Low.	No.

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks & Barriers	Practicability of Tactic	Recommend Tactic?
6.2 Expand the boundaries to increase diversity	Pursue acquisition of remaining areas of sandplain owned by Eversource, Town of Montague, Turner's Falls Fire District, and other landowners.	10 years	Protect in perpetuity from conversion to non-conservation uses. Provide for ongoing management.	Willing sellers. Funding.	High.	Yes.
9.2 Favor or restore native species that are expected to be better adapted to future conditions 9.4 Emphasize drought- and heat-tolerant species and populations	Thin canopy of pitch pine forests, removing mesic species and retaining oaks and a few of the largest pitch pines.	5 years	Increase area of grass, heath, and shrub-dominated communities. Maintain/expand populations of shrub oak dependant Lepidoptera and other shrubland, heathland and grassland species.		High.	Yes.
	Mow understory trees to promote shrubs and reduce dominance of mesic tree species.	5 years		Funding.	High.	Yes.
	Create grassland openings within scrub oak areas using mechanical and chemical means. Seed with warm-season grasses.	10 years	Further diversify landscape arrangement of natural community types. Create opportunities for expanding populations of rare plant and Lepidoptera species.	Funding.	High.	Yes.
	Use prescribed fire to maintain scrub oak, grassland, and heath vegetation in understory.	Ongoing	Maintain/expand populations of shrub oak dependant Lepidoptera and other shrubland, heathland and grassland species.	Need burn days, crew, and equipment.	Moderate.	Yes, in conjunction with mowing.
	Use mechanical means (mowing) to maintain scrub oak, grassland, and heath vegetation in understory.			Funding. Potential long-term changes in soil structure and vegetation.	High.	Yes.
9.8 Identify and move species to sites that are likely to provide future habitat	Transplant or seed wild blue lupine into other grassland areas at Montague Plains.	10 years	Increase number of populations on site.	NHESP permit.	High.	Yes.
	Introduce Karner Blue Butterfly.	25 years	Increase number of populations worldwide.	Federal permit. Adequate habitat.	Low.	Not at this time.

Adaptation Approach	Tactic	Time Frames	Benefits	Drawbacks & Barriers	Practicability of Tactic	Recommend Tactic?
10.6 Remove or prevent establishment of invasives and other competitors following disturbance	Use DFW BMPs for preventing the spread of invasive exotic plants. Monitor following all habitat management or natural disturbance.	Ongoing	Reduce competition to desired species.	Eternal Vigilance.	High.	Yes.

Step 5. MONITOR and evaluate effectiveness of implemented actions.

Monitoring Items	Monitoring Metric(s)	Criteria for Evaluation	Monitoring Implementation
Invasive plants	Presence Area invaded	No new invasions Reduction in area containing invasive plants.	Annual reconnaisance for 2 years following timber harvests, mowing, or invasive control activities.
S1/S2 communities (Scrub Oak Shrubland, Sandplain Grassland, Sandplain Heathland, Pitch Pine/Scrub Oak Community)	Community quality Community size	Increasing area of target communities with appropriate species and vegetation structure.	Form 3 survey 2 years following timber harvests, mowing, burning, or other habitat management activities.
Rare plants	Number of populations Number of individuals	No loss or increase in number of populations. Increase in number of individuals.	Census every *n* years?
Rare Lepidoptera		Stable or increasing populations	
SWAP Species of Greatest Conservation Need		Stable or increasing populations	Breeding bird survey Nest surveys
Other listed species		No long-term reduction in population.	