



Getting Ready for

The Warming

by John O'Leary

It seems that not a day goes by but we hear a news story about climate change. Often the story seems to conflict with the one we read the day before, and many appear to be influenced by the political bent of the writer. While this leaves much of the public wondering, the debate about whether or not climate change is actually occurring is over; the popular media discussion has finally shifted from “Is climate really changing?” to “How much will it change, and how soon?” While the answers to those questions remain debatable, the Division of Fisheries and Wildlife must act responsibly and plan ahead. The agency is now in the process of working collaboratively with the Manomet Center for Conservation Sciences and The Nature Conservancy to develop a set of “adaptation strategies” that will help us deal with the effects of climate change on our wildlife landscape.

As the readers of this magazine probably know, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) is the state agency responsible for the conservation and management of the Commonwealth’s fish and wildlife resources. Our biologists and technicians are not swayed by news stories in the popular press; faced with the reality of climate change, their job as wildlife scientists is to gather and analyze all available scientific information on the subject, determine what likely effects the changing climate may have on the biodiversity of Massachusetts, and then develop conser-

vation and management strategies that will best address the potential threats and instability climate change will bring to the Commonwealth’s wildlife communities and native species.

Our assumptions about future climate conditions are based on the predicted results of the latest Global Climate Models (GCMs). These are large scale models that take an immense number of geographic, weather, air composition, ocean currents, temperature and other variables into account. They have been tested by running them back through time to see how accurately they predict historical climates, and then run again with present-day data to see how well they predict existing climate variations around the globe. We must rely on climate models to predict future conditions because it is impossible to perform global-scale experiments where in one world we release low levels of carbon dioxide (CO₂) or other greenhouse gases, and in another we release high levels, and then compare the results to see how climates respond.

Fortunately, our ability (or rather our computers’ abilities) to accomplish the enormous calculations necessary to run these models has increased dramatically in recent decades, and today research groups all over the world have the computing capability to develop, test and run new GCMs. When many researchers are provided with accurate data and can investigate the same issue from their dif-

ferent, individual perspectives, the overall accuracy of the resulting models and predictions improves. Our GCMs all agree that (1) changes in global temperature we are experiencing today are the result of increased greenhouse gas emissions that have been released in ever-increasing amounts since the start of the Industrial Revolution, and (2) global temperature will continue to rise in the future.

But we are, after all, working with models, not actual worlds, so scientists must report their results using indecisive terms such as “reasonably likely” rather than “certain.” Such uncertainty is frustrating to the public and the media, but this is how science works. As time passes and more on-the-ground temperature and weather observations are recorded from around the world, the certainty increases that these models are correct, and may in fact be *underestimating* the rate and extent of climate change.

The predictions on which our adaptation strategies will be based come from three highly refined GCMs that are the accepted “industry standards.” These models were run with two different greenhouse gas emission inputs. The first run uses an optimistic input that represents only a doubling of the atmospheric level of CO₂ above pre-industrial levels. In this scenario, global emissions have been greatly reduced and much of the doubling comes from CO₂ already released

and presently working its way through the planet’s atmospheric system. The pre-industrial level was about 275 parts per million (ppm); today it has reached 390 ppm, so we are well on our way to a doubling. The second run uses a tripling of the level of CO₂ in the atmosphere, the scenario that will occur if we do **not** reduce greenhouse gas emissions from current levels.

Running the model programs under these two scenarios presents us with a best case (we take immediate steps to limit greenhouse gas emissions) and worse case (we continue to release greenhouse gas emissions at current levels) set of results for our analysis. What do the models predict about future climate conditions in Massachusetts? Take a look at Table 1 below.

Results from both scenarios indicate that winter temperatures will increase more than summer temperatures over the next 20 years or so, rising by 2.5-4.0°F by 2030. By 2050, winter temperatures will average 4-5° warmer under the lower emissions scenario, and 4-7° warmer under the higher emissions scenario. By the turn of the next century, winters will have warmed by 5-8° under the doubling scenario, while under the tripling emissions scenario winters will be from 8-12° warmer. Summer temperatures will also be rising, but not quite as much as winter temperatures, at least until the

Table 1. GCM-projected Average Temperature Change Based On Reduced And Current CO₂ Emission Levels

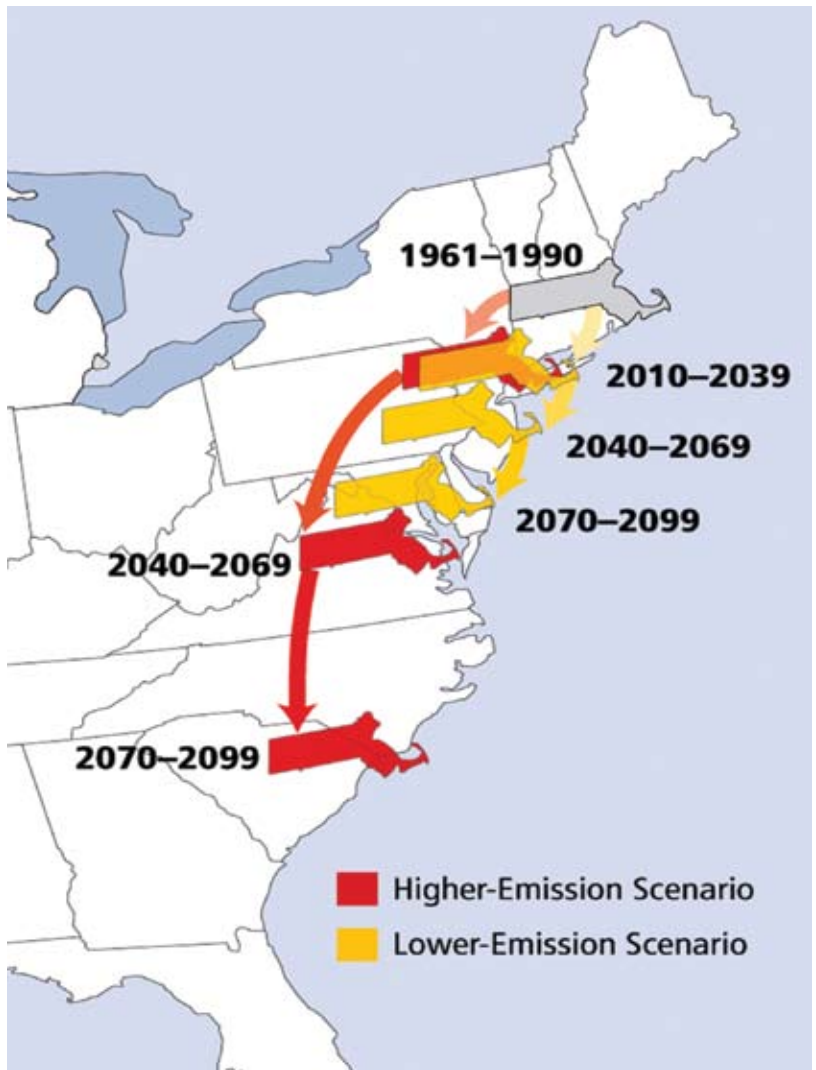
Projected Temperature Change (°F)			
Year	2030	2050	2100
Winter:			
Low emissions	+2.5-4.0	+4.0-5.0	+5.0-8.0
High emissions	+2.5-4.0	+4.0-7.0	+8.0-12.0
Summer:			
Low emissions	+1.5-3.5	+2.0-5.0	+3.0-7.0
High emissions	+1.5-3.5	+4.0-5.0	+6.0-14.0

The rising temperature predictions above result from running three Global Climate Models (GCMs) under two CO₂ input scenarios. The low emissions scenario is based on a doubling of atmospheric CO₂ levels since the start of the Industrial Revolution, a level we are already approaching; the high emissions scenario is what will occur if we do not reduce current emission levels significantly. Note that average winter temperatures will increase at a faster rate than summer temperatures.

spiked increase predicted for the latter half of the coming century.

Now let's take a look at where these projections will "move" us geographically. The map on this page depicts graphically the projected increases in summer temperatures for the coming decades by superimposing the state outline on more southerly regions of the country where present temperatures are the same as those predicted for Massachusetts. Note how our summer climate is predicted to "migrate" slowly, and then more rapidly, toward the south. An increase of a few degrees doesn't sound like much—until you consider that the average summer temperature of present-day South Carolina is only about 14° warmer than Massachusetts. It might be a good idea, for your own comfort, to invest in an air conditioner. Wildlife, unfortunately, doesn't have that option.

Now let's take a look at a different weather variable that will also be affected by climate change, namely snow cover. According to a report titled **Climate Change in the U.S. Northeast** published by the Union of Concerned Scientists, the number of days of consistent snow cover



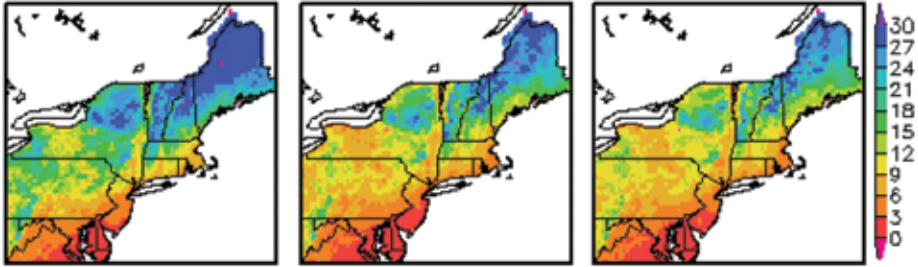
This map depicts graphically the projected increases in summer temperature under two CO₂ emission scenarios for the coming decades by superimposing the state outline on more southerly regions of the country where present temperatures are the same as those predicted for Massachusetts. If CO₂ emissions are reduced significantly, we will still warm to the level of northern Virginia, but if we do not reduce emissions, by the turn of the next century we will have summers equivalent in heat to South Carolina's.

in Massachusetts will decrease dramatically, and the "snow zone" will contract north and west toward higher levels of the Berkshires (illustrated by the maps at top of next page).

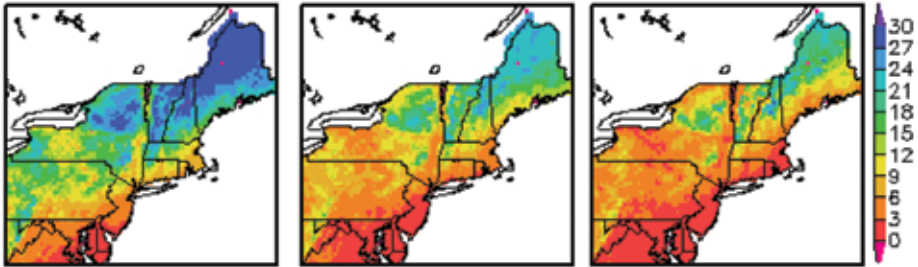
So we have predictions of higher temperatures and shorter periods of snow cover. Will climate change have effects

Snow Days Under Climate Change

Lower Emissions



Higher Emissions



1961-1990

2035-2064

2070-2099

Graphic courtesy UCS/NECIA

According to models run under two CO₂ emission scenarios, climate change is predicted to produce more winter precipitation in Massachusetts, but less and less of it will be in the form of snow as average temperature increases. The effects on wildlife and habitat will be enormous.

on precipitation as well? Results of the models under both scenarios predict increased precipitation annually. Much of that increase will occur during the winter months (more as rain than as snow), with variable results for summer. Less water stored as snow means more rapid run-off to our streams and rivers in the spring, which could in turn lead to lower flows during the normally drier summer months. Further, more variable precipitation events in the summer may mean more frequent, short duration droughts for our region. Here's what the models predict for precipitation:

Results of GCM/Emissions Modeling – Precipitation

- Under both scenarios: 10% annual increase.
- Projections for summer: variable, but probably little change.
- Projections for winter: 20-30% increase in precipitation, more as rain than snow.

These results from the GCMs using the two carbon dioxide input scenarios are what we are using to base our actions regarding potential impacts to the wildlife and their habitats in Massachusetts. The questions then become (1) how will fish, wildlife, and plant populations respond to these changes; and (2) is it possible for us, as managers, to mitigate these effects? Time is most definitely not on our side.

Wildlife's Perspective

Certainly here in the Northeast the climate has changed dramatically in the past. We all know the weather got colder and warmer during climate cycles that went up and down for tens of thousands of years. Decreasing temperatures, likely combined with increased precipitation, lowered sea level and allowed glaciers to spread across the region, obliterating virtually all wildlife habitat and scraping away the topsoil. Warming periods (some of which brought higher average temperatures than what we presently



Photo © by Bill Byrne

*While birds, many plants, and most medium-to-large size mammals can successfully traverse the many roads, parking lots and other potentially fatal impediments to wildlife movement we have constructed across the landscape, amphibians such as this Wood Frog, *Lithobates sylvaticus*, as well as most of our fish, reptiles, and some of the smaller mammals, will find it extremely difficult or impossible to shift their populations northward.*

experience) between glacial periods melted the glaciers and allowed pioneering species to return, build soils, and eventually create (or re-create) habitats and wildlife communities.

But for wildlife populations, this time it's different: When glaciers covered the area in the past, there were "refugia" to the south of the advancing ice that allowed many species to retreat and continue their existence, and later, as the ice eventually receded, to advance north again and repopulate the area.

That is not the predicted future under the change in climate occurring now. South of here it will be getting warmer as well, and, under the predicted conditions of climate change, it is thought that the pace of change will not be slow and gradual, but quite rapid on the geological and evolutionary time scale. Faced with such swift change, many wildlife spe-

cies are unlikely to have enough time to evolve (genetically) to adapt to the new climate. Such a process normally requires many generations, and, except for the insects and certain other highly fecund invertebrates and plants, it simply isn't likely to be a viable option.

This would not be a crucial factor for many species if they could easily move and shift their populations northward to remain within their ideal climate. That option (which most of our native species used to return here after the glaciers retreated) is still presumably available to birds, insects, bats, most medium-to-large mammals, and plants with windblown or bird-dispersed seeds that can get across the barriers we have erected in recent times. These species can use protected islands of habitat in a sea of development as "stepping stones" when climate change directs them north

or to higher elevations. But it will be a far different story for fish, amphibians, reptiles, and most small mammals that cannot fly over or rapidly traverse the myriad roads, railroads, and urban, unnatural landscapes with which we have surrounded ourselves (and them) in the last couple of centuries.

Think about it: What are the chances that, for example, a young Wood Frog (or Spotted Salamander, Spotted Turtle, Common Gartersnake, etc.) in southern Worcester County, dispersing northward from its natal habitat, can get across, say, the Mass Pike on a rainy summer evening? Now add in several dozen more roads – including interstates with miles of “Jersey” barriers, others with high curbs and pitfall street sewers – plus a number of raised railroad beds, maybe a couple of shopping mall parking lots, and, of course, a few dozen suburban neighborhoods with toxic lawn habitats and attractive, inescapable swimming pools. What are the odds that even 50 generations of wood frogs could successfully traverse such an immense “minefield” just to reach our northern border?

On a different scale, consider the situation a population of native Brook Trout in a small stream will face under climate change. Two hundred years ago the members of this population could move freely from trickling headwater tributaries to the deep waters of a large river into which their stream runs. The canopy of forest trees shaded and kept their water cool in summer, and surrounding swamps and marshes absorbed stormwaters and released them gradually, stabilizing stream flow rates. In times of extreme heat the trout concentrated in certain areas where springs always kept the water cold, and when drought came, they retreated to the deepest pools of the river until the rains came again. Today, however, the trees and many of the surrounding wetlands are gone, most of the tributary streams are channeled through pipes and culverts, stormwater run-off flowing across roads and parking lots brings salt in winter and heat in summer, groundwater withdrawals have eliminated some springs and reduced stream flow and depth, and assorted dams and impassible culverts prevent any upstream movements and make all downstream movements one way.

Stressed by thermal and chemical pollution, now confined to one section of their little stream, competing with introduced species, their breeding habitat and cold summer refugia now severely limited, this little trout population has somehow survived (unlike hundreds of other native Brook Trout populations, but quite like hundreds of others). But when the additional stresses of climate change arrive, will they still be able to cope? If we choose to do nothing, they are, of course, very likely to perish. Yet, if we choose instead to remove or mitigate some of the factors that have degraded their habitat and limited their local range, they will regain much of their former resilience to change (the resilience that in fact allowed them to survive this long) and may actually be able to *thrive* in the face of climate change!

Management Preparations

The response of wildlife communities and individual species to climate change cannot be separated from the many present-day “stressors” that simply didn’t exist when major shifts in climate occurred in the geologic past. These stressors will not be going away as the climate changes, and in fact they may act even more harshly on wildlife and their habitats under climate change conditions. Habitat loss from development, fragmentation of habitat into smaller units as the result of more roads being created, increased withdrawals from groundwater, increased competition from invasive species, and many other factors will continue to impact our wildlife resources today and in the future under climate change. As if this were not enough, we must also consider how society might react to the effects of climate change, and how those reactions might affect wildlife biodiversity. A human response to a perceived biological threat from a new invasive pest (a malaria-carrying mosquito for instance) could potentially do as much or more harm to native species than climate change itself.

Each species will respond differently to the effects of climate change. Every species has a natural geographic range, and Massachusetts is situated at the southern range limit of some wildlife and plant species, and at the northern range

limit of other species. As temperatures rise, the range of some northern species will undoubtedly contract northward, while some southern species will also expand their range northward. This shift could result in some of the former group of species losing all their range in Massachusetts, while the latter group may move in from the south and establish new range limits here. Also, native invertebrates whose lifecycles are tied to temperature may suddenly increase dramatically, affecting their habitats in unforeseen and destructive ways, and novel plant and wildlife communities we have never seen (and which may never have existed before, anywhere) may develop. Specialized niche species which are closely linked to already-limited habitat types or high altitude environments may be extirpated from the state no matter what we do.

Facing so much uncertainty and so many variables, our first course of action as professional wildlife managers is to estimate the vulnerability of our current wildlife communities and their habitats to climate change. We have a tremendous head start on this thanks to the hard work our staff put into developing the Comprehensive Wildlife Conservation Strategy (CWCS) in 2005. MassWildlife initiated this planning exercise to gain federal funding support for our efforts to “keep common species common.” (It makes much more sense to do this than to allow common species to become rare, and *then* attempt to restore them.) The document identified climate change as one of the threats to those species and habitats our biologists had determined were in greatest need of conservation. While every state completed a CWCS, Massachusetts was one of only a handful that identified climate change as a threat to its fish and wildlife resources.

Taking this a step farther, the agency recently began a collaborative project led by Dr. Hector Galbraith, Director of the Climate Change Initiative at the Manomet Center for Conservation Sciences. This project, which also incorporates staff from The Nature Conservancy, will help us determine the vulnerability to the effects of climate change of key habitat types and wildlife communities identified in our CWCS. Dr. Galbraith has done similar work for the U.S. Environmental

Protection Agency (EPA), where he and an associate developed a system that allows the EPA to rank the vulnerability of several federally listed endangered species to climate change. His work with MassWildlife is being funded by a grant from the Wildlife Conservation Society.

MassWildlife staff and other habitat experts from around the state will provide technical input into the Habitat Vulnerability Assessment (HVA) developed by Dr. Galbraith. This document will be used to identify the relative vulnerability of these key habitats to climate change under both of the carbon dioxide emission scenarios related earlier. The results will show how likely it is that a given habitat will continue to exist in the state under climate change, and will help us formulate the adaptation strategies we will use to address the predicted threats to those habitats.

If it is likely that some of this habitat type will be lost, what kind of plant and animal community is likely to replace it? What present day stressors can we reduce or mitigate to increase the overall resilience of the habitat and ensure that it has the best chance of continuing to exist? (We might, for instance, want to remove impassible culverts and dams to allow brook trout to access higher elevation, coldwater refugia.) Is it likely that society will respond to the changes in this habitat type in ways that may be harmful to its health? These are the sort of questions we must answer to decide where to focus our limited funding and energies.

One important way in which we plan to use the results of the HVA is to include them as an additional ranking factor in deciding, through our on-going habitat acquisition process, what wildlife lands we should prioritize for purchase and protection. For instance, we may want to assign a higher priority to protecting wildlife corridors between large, protected parcels, than to, say, simply add to the size of some of those large parcels. Additionally, we think that the process of using the expertise of the staff and others to identify the current stressors already affecting these habitats will help to highlight the need for action to address these threats in order to keep these habitats as intact and as functional as possible.



*Our native Brook Trout, *Salvelinus fontinalis*, requires cold, well-oxygenated water in order to survive. It may be impossible to maintain these habitat parameters in some streams and rivers as the climate warms, but judicious habitat management that improves present conditions and maintains or increases the ability of populations to move throughout their local watersheds can increase their resilience to change.*

We do not intend to take on this important work alone. Producing this vulnerability assessment information and making it available to our partners in the broader land conservation community through our computer based mapping tools will provide the basis for a statewide, coordinated approach to addressing the effects of climate change on our wildlife resources. By providing the technical information on the effects of climate change to these various habitats, we will better enable our partners in land conservation to make informed land acquisition decisions. (If sea levels are going to rise, for example, it may make more sense to invest in inland swamps and mountain habitats than salt marshes that are predicted to be inundated and lost no matter what we do.)

Other actions are also underway at the Department level. Mary Griffin, Commissioner of the Department of Fish and Game, has formed a Climate Change

Working Group. Chaired by our agency, it has members from the Division of Marine Fisheries, the Riverways Program, and the Commissioner's Office. This working group has already developed a webpage which will be used to provide the public with the latest information on the various activities the agencies are involved with related to climate change.

Since our political borders are meaningless to wildlife, we are also part of a regional Terrestrial and Aquatic Wildlife Habitat Classification and Mapping Project. Sounds technical, and it is, but in the end we will have a map and a habitat naming system in the Northeast that will allow the states to work together on a regional scale. This is a critical first step necessary to identify large-scale areas of important habitat that may serve as wildlife corridors or refuges under climate change conditions.

Reflecting MassWildlife's broad vision and the respected leadership role it has



Photo © by Bill Byrne

Many wildlife species are expected to shift their ranges northward under climate change. Some natives, such as our Black-capped Chickadee, could theoretically leave the state entirely and be replaced by new, formerly southern relatives.

long taken on wildlife conservation issues, the agency is providing staff to work with the Association of Fish and Wildlife Agencies' Climate Change-Wildlife Action Plan Working Group. Our representative will co-chair the Subcommittee on Vulnerability Assessment and Impact Identification. The Working Group will ultimately provide a national guidance document that all state wildlife agencies can use to incorporate anticipated climate change effects into their own state wildlife action plans.

So what's the landscape going to look like under climate change? What wildlife will be living in the fields and forests, ponds and streams of the Commonwealth? Will we have forest communities and wildlife that look more like those in the suburbs of Washington, D.C. than what we presently have?

No one knows for sure, but it is clear that if temperatures rise above the thermal limits that a species can physically tolerate, then that species will either move to where it is cooler, or it will perish. Long before that happens though, species that require cooler temperatures will begin to decline, and ones that can tolerate or even require warmer temperatures will replace them.

Will species that could not withstand our winters of the past begin to enter our wildlife communities? One possible

scenario would predict that our State Bird, the Black Capped Chickadee, *Poecile atricapilla*, that endearing little bird we are so used to seeing at our feeders, will move northward and be replaced by the southern species, the Carolina Chickadee *Poecile carolinensis*. Will most people notice? Will most people care? Will the moose, which have only recently moved into the state from the north, retreat back to the North Woods, depriving us of our largest land mammal?

We cannot say for certain what alterations climate change will bring to the composition of our fish and wildlife resources. But we think that by developing a proactive set of adaptation strategies, we have set a correct course to address the new era of warming climate that we and our wildlife are now entering. And, as new scientific information is brought to light, we will continue to refine and adjust these nimble, dynamic approaches to climate change as it gradually alters our world.



John O'Leary is a former District Fisheries Manager, Anadromous Fish Restoration Project Leader, and Watershed Team Leader who now works on habitat management issues and grant programs at MDFW Field Headquarters in Westborough. He lives with his wife and children on the family farm in Southampton, MA.