FALL WINTER 2010-2011

SANCTUARY

THE JOURNAL OF THE MASSACHUSETTS AUDUBON SOCIETY

The Gathering Storm

Past and future climates

The End of the Ice

The geologic history of New England has left us with a variety of fascinating features such as moraines, eskers, erratics, drumlins, monadnocks, and kettle ponds. The key to these diverse geological forms is the Laurentide Ice Sheet, which covered New England (and lots of the rest of North America) about 18,000 years ago, retreating for good about 12,000 years ago. Imagine an ice sheet—in places almost a mile thick—covering Massachusetts, coming to a stop at the present-day locations of Long Island, Martha's Vineyard, Nantucket, and Block Island. These islands, known as terminal moraines, consist of a mix of sand and rock that was pushed ahead of the advancing ice and then deposited when the ice receded, leaving behind the islands that we see today.

Many other familiar landscape features of New England can be traced to the ice. Kettle ponds—perhaps the best known of which is Walden Pond—were formed when blocks of ice broke off from the glacier, and then slowly melted under glacial debris leaving behind depressions that are now the familiar ponds that dot the landscape today. Of particular ecological interest are coastal plain ponds whose gently sloping shorelines harbor a special plant community, and rare species such as Plymouth gentian and New England boneset. These plant communities also are home to numerous species of insects, including more than 45 types of dragonflies and damselflies.

Eskers are deposits that were left by streams that flowed within and under glaciers. After the retaining ice walls of the glacier melted away, the stream deposits remained as long winding ridges. Although no one is entirely sure about their formation (see page 20), drumlins are masses of glacial debris that form hills trailing off in the direction that the glacier traveled.

Among my favorite glacial remnants are erratics—large boulders deposited randomly as the ice retreated. It is always a pleasure to come upon one of these; they tend to surprise and delight even the most jaded walker with the unlikeliness of their appearance and placement.

I have long taken for granted and greatly enjoyed these aspects of the last ice age that we find all around us in the New England landscape. However, with the increased understanding and urgency of potential impacts of climate change, the concept of a landscape shaped by retreating glaciers takes on new meaning. Recent efforts by scientists, mountaineers, and photographers have produced visual evidence of the retreat of glaciers around the world, and there is a World Glacier Monitoring Service that records and assesses data associated with glaciers. One of the likely effects of disappearing glaciers is disruptions of water supplies to millions of people dependent on seasonal glacial meltwater, including water used for agricultural purposes.

A recent exhibit contrasting mountaineer Bradford Washburn's 1930s and '40s glacier photographs with current views taken between 2005 and 2007 by photographer David Arnold make the reality clear. The data shows that glaciers are indeed shrinking, some with startling speed (see page 9). One news commentator, Jim Avila of ABC, observed that the world's glaciers are "ice bound canaries silently warning of an impending more hostile climate."

Laura Johnson, President

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FEATURES

DEPARTMENTS

Weathervane and storm clouds

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The Late Great Glacier


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The orbit of the earth, as we were taught in seventh grade classes in physical science, takes the form of an ellipse. In one season of the year—winter—the earth is close to the sun, whereas, ironically, in summer, it is farther away. It is hot in summer, as we were taught, because the earth is tilted on its axis, so it gets a direct blast from the sun, whereas in winter it is tilted away at an angle and receives only oblique weakened light in the northern hemisphere.

But all are cycles—cycles within cycles as it turns out—and because of these varying patterns of the earth's orbit there are periods, perhaps every 100,000 years or so, when the earth finds itself in a relationship with its parent sun that causes the whole planet to cool or warm considerably. This series of changes, known as Milankovitch cycles, has a dramatic effect on the seasons of earth over the ages, or so it is believed. During long stretches, the seasons are at extremes, with cold winters and very hot summers. Under these conditions, even though the snows build up each winter, the summers are hot enough to melt them away. But periodically the whole system cools down so that the winters are somewhat warmer and the summers are cool.

Whenever this happens—every 100,000 years or so according to the theory—the ice that builds up in winter does not melt away entirely in summer. As a result, a little more snow builds up the following summer. Then more snow the next year. And then after a few decades the snows fail to melt in summer, and soon the accumulated snows are so pressed down and so deep upon the solid earth beneath that they form a base of ice that begins to expand southward from the pole.

The reflectivity of the ice and snow feeds the loop, which makes the earth colder and colder. As these great walls of ice move, they crush the earth in their path, pick up seemingly immovable heavy boulders, ride over the very mountaintops, scour out river valleys, and press on, inexorably—a dreadful, deathly wall of ice, cut in tongues at the fringe but still moving ever southward and carrying with it its massive load of scraped earth and gravel and boulders.

The snows continue. The ice builds higher and higher, and deeper and deeper still, until the heft of ice is more than a mile thick in some sections and seemingly timeless in its advance; millennia upon millennia it presses southward. Nothing can survive in this terrible season of chill; all life in the north exterminated, save for a few oddly situated pockets of protected uplands known as refugia. The whole north becomes a dead land, with only a narrow band of life crowded down into the sanctuary of the tropics and subtropics.

And then, as subtly as it began, the orbit of the earth alters once more, and the seasons begin to change.

About 18,000 years ago, the summers became warmer and managed, slowly, to melt away sections of the last glacier. Year after year, generation after generation, for thousands of years, the ice melted.

In spite of the hope and promise of better things to come, even this must have been a cataclysmic period in comparison with the deep overbearing silence of the frozen world: thunderous roars of calving walls of heavy ice, the great deep growl of roaring cataracts pouring over ice cliffs, streams and whole rivers gurgling beneath the ice like chattering voices, the crack of breaking ice sheets, the glassy shattering of pinnacles and peaks, and, all along the shores of the Atlantic, the incessant cannonades of heavy surf battering at the ice walls, with measureless mountain-sized icebergs breaking seaward in a surging wave to drift off and thaw in the warming seas to the south.

In the Northeast, where the glacier halted and drew back, it left behind its payload of sand and gravel, today's Long Island, Cape Cod, and the Islands. As it retreated, it deposited immense blocks of ice that melted down leaving pools that are still with us today in the form of kettle hole ponds, one of which, Jamaica Pond, once served as the first reservoir in America. Within the icy body of the glacier, serpentine rivers, carrying loads of gravel, slowed and melted and left long winding ridges known as eskers—one of which snakes southward from the Mass Pike in Auburndale to the Riverside Station of the Boston subway system.

In some sections, deep holes developed in the ice, and within these holes were swirling waters, also carrying sand and gravel and small boulders, and these too settled to form small pyramidlike hills known as kames, some of which can be found west of the towns of Concord and Lincoln. And then finally, as the body of the glacier retreated, it left behind a series of whale-backed hills known as drumlins, of which there are many in the city of Boston and along the western side of the Boston Basin, one of the most distinct landforms of the region. Some of these drumlins were leveled for fill, but others remain as scattered islands that now lie in Boston's inner harbor.

The last glacial retreat ended around 12,000 years ago, and we are now in the midst of a new geologic age, a fast-paced one that is measured in decades and centuries as opposed to millennia. And for the first time in the history of the earth, what the shape of that new landscape will be depends not so much on orbital cycles as on the behavior of a bipedal primate that migrated out of the African savannah 200,000 years ago.

JHM

John Hanson Mitchell is editor of Sanctuary.

Temperatures Rising

The climate of Mother Earth has warmed in the past, but never so fast.

by Gayle Goddard-Taylor

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Contemporary Boston superimposed on the glacier of 18,000 years ago

Those of us who live in the Northeast won't quickly forget the summer of 2010. Blistering July heat pushed temperatures from DC to Boston to 100 degrees Fahrenheit and above, and we all hunkered down in our air-conditioned offices or sweated it out in outdoor jobs. We hosed down our dogs and fretted about potential power brownouts; and mental sluggishness went hand-in-hand with physical discomfort.

As we endured the heat, some of us thought: Is this what it's going to be like? Is this global warming? Strictly speaking, no, it was weather. It was a blistering July day, followed by another and another until what seemed like a heat wave that would wipe us out finally passed. Then more weather followed. Regardless of whether the hot spells were an omen of something bigger, the fact is the concepts of "weather" and "climate" are often confused in the mind of the layperson.

According to Robert Lautzenheiser, the first person to step into the role of official climatologist for the four northern New England states, there is a wry catchphrase that simplifies things: "Climate is what you expect and weather is what you get." Now retired from his post, Lautzenheiser has had his eyes on the skies since his first job forecasting weather in Akron, Ohio, in 1948. After more than a half-century watching the weather, he should have a pretty good vantage point from which to comment on climate as well. "Climate is more of a long-term thing," he says.

Back in the 1940s, when the National Weather Service was called the National Weather Bureau, cli-

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Contemporary Boston superimposed on the site 12,500 years ago

mate change wasn't on anyone's mind. But it has since come to the fore as scientists around the world have compiled data. One of those scientists is Arthur DeGaetano, professor of atmospheric sciences at Cornell University and director of the Northeast Regional Climate Center. DeGaetano's research is centered on the applications of climate data, and his work involves developing and disseminating methods and data sets that give decision makers the tools they need.

When he talks about weather and climate with his students, not surprisingly, he delivers information that is a little more detailed than a catchphrase. "The definition I like to use is that climate is a synthesis of weather," he says. "Climate isn't an average of weather; it's the whole distribution of weather that a locality may experience. Weather is more the day-to-day state of the atmosphere anywhere, at any level of the atmosphere." According to DeGaetano, "Another way of looking at it is to think of those grammar school tests with grades shown on a bell curve. All the scores for all of those students, represents climate—the entire curve. Weather is any particular point along that curve."

According to a new National Wildlife Federation report, average temperatures have risen and "this warming has shifted the annual distribution of temperatures, thereby making record hot days more likely and extremely cold days less likely."

We New Englanders know that if we go to Florida in August, it's very likely to be hot. Likely, but on any particular day not a given. For example, while people in Boston were sweating in 100-degree temperatures during our July heat wave, those on the west coast of Florida were enjoying temperatures nowhere near that level. Climate varies around the world according to the amount of sunlight a region gets, or the altitude, or the proximity to the ocean, as well as a variety of other factors.

These variations are primarily due to where the earth is in its orbit, but it's possible that other historic drivers have been fluctuations in the amount of solar energy sent our way by the sun, changes in the position of the continents, or ocean circulation and the levels of carbon dioxide in the atmosphere.

Heat is released from the earth through its atmosphere, radiated from the surface. But not all of it is let go. The lower atmosphere retains a certain amount of heat because of the presence of so-called greenhouse gases, such as carbon dioxide, methane, and nitrous oxide—without which temperatures on the earth would plummet.

Scientists around the world have noticed a recent sharp acceleration in the rate at which the planet has been warming. Over the past 100 or so years—and particularly since the middle of the last century—the earth has been warming at a rate that contrasts dramatically with historic heating patterns.

In 1988, a neutral body of scientists was designated as the Intergovernmental Panel on Climate Change (IPCC) to conduct assessments of climate change to help provide information to governments as they set policy in response to a changing climate. The most recent assessment was released in 2007 and the next is due in 2014. Each report has documented a rapidly warming planet and predicted the consequences of that warming in the future, including rising sea levels, more widespread drought, changes in precipitation, and an increase in extreme weather events.

So in truth, the oppressively hot weather of this past summer can be included in this list of undesirable effects. According to a new National Wildlife Federation report, More Extreme Heat Waves: Global Warming's Wake Up Call, average temperatures have risen and "this warming has shifted the annual distribution of temperatures, thereby making record hot days more likely and extremely cold days less likely."

The scientific community attributes this climate phenomenon to an increase in greenhouse gases, which aren't allowing as much heat to escape from the earth's surface. They are nearly unanimous in their belief that the activities of humans, notably the burning of fossil fuels to drive vehicles, produce electricity, heat buildings, etc., is the cause. The sharp acceleration in global warming coincides with the advent of the industrial revolution and, even more recently, with the end of World War II when the use of fossil fuels increased even more.

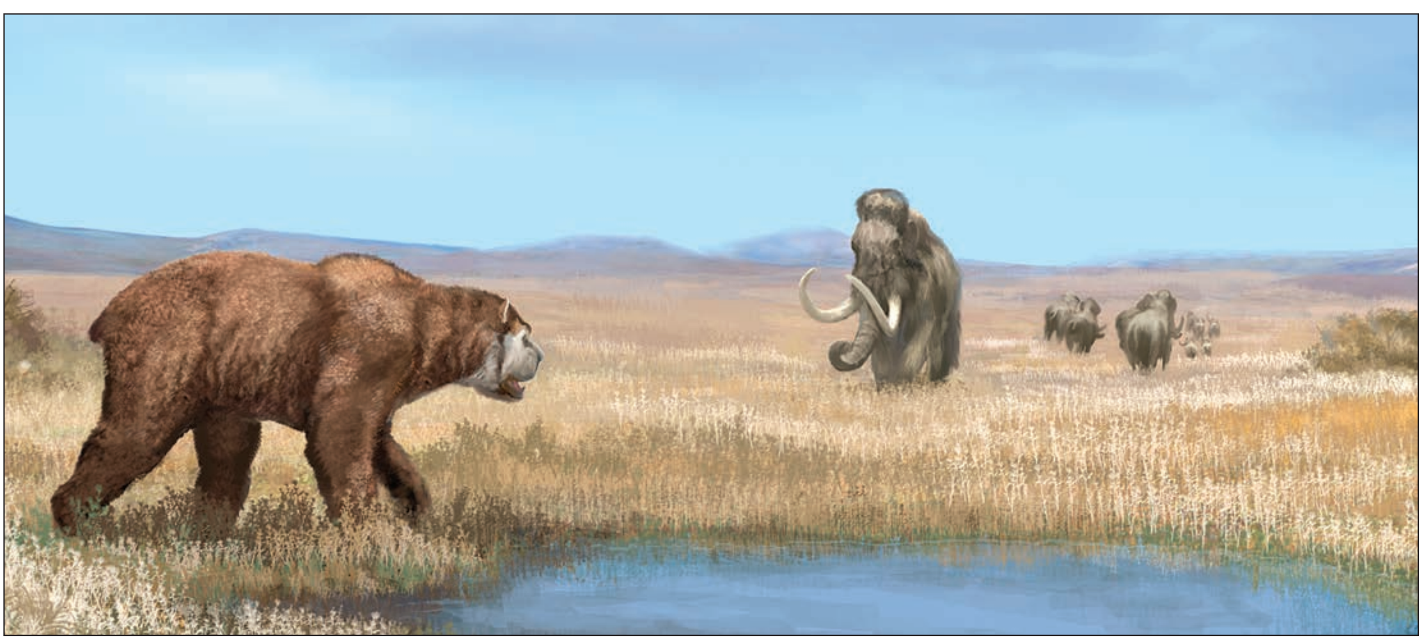
The burning of fossil fuels has been credited with causing a far greater build-up of greenhouse gases in the atmosphere than any other source, according to reports on the IPCC website (www.ipcc.ch). The IPCC findings conclude that the earth's average surface air temperature has risen 1 degree Fahrenheit over the last century. Even an increase that seemingly slight is enough to cause changes across the planet, and the rate of change appears to be accelerating. The IPCC predicts that over the coming 100 years, with continued deforestation, fossil fuel burning, and other factors, the change will be even greater. On a more positive note, the IPCC points out that humans can make the affects less severe through measures to lessen these factors.

Predictions are based on complex global climate models, some of which take into account not just the atmosphere, but the biosphere (plants and animals), hydrosphere (all bodies of water, including oceans), cryosphere (sea ice, glaciers, and ice sheets), and geosphere (such tectonic changes as volcanic eruptions and the movement of continents). And the empirical record is saying that warming is unusually rapid compared with anything in the last several thousand years.

"When you talk about climate change, you're talking on the order of 6 degrees warmer over the next 100 years," says DeGaetano. "That's not to say that temperatures in parts of the earth haven't gotten that warm before; that's saying it hasn't warmed that much that quickly."

Gayle Goddard-Taylor is a field editor for Sanctuary *magazine.*

View of the site of Boston 11,000 years before present



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The Once and Future Salt Marsh

Salt marshes come and go over the course of geologic time.

Now it appears that they are going once more.

by Robert Buchsbaum

On May 27, 1964, Norman Lepire, captain of the *Ruth Lea* out of New Bedford, was trawling for scallops on Georges Bank. The material he dredged up intrigued him. He had found patches of peat at a depth of 200 feet covering perhaps a half-mile of the ocean floor.

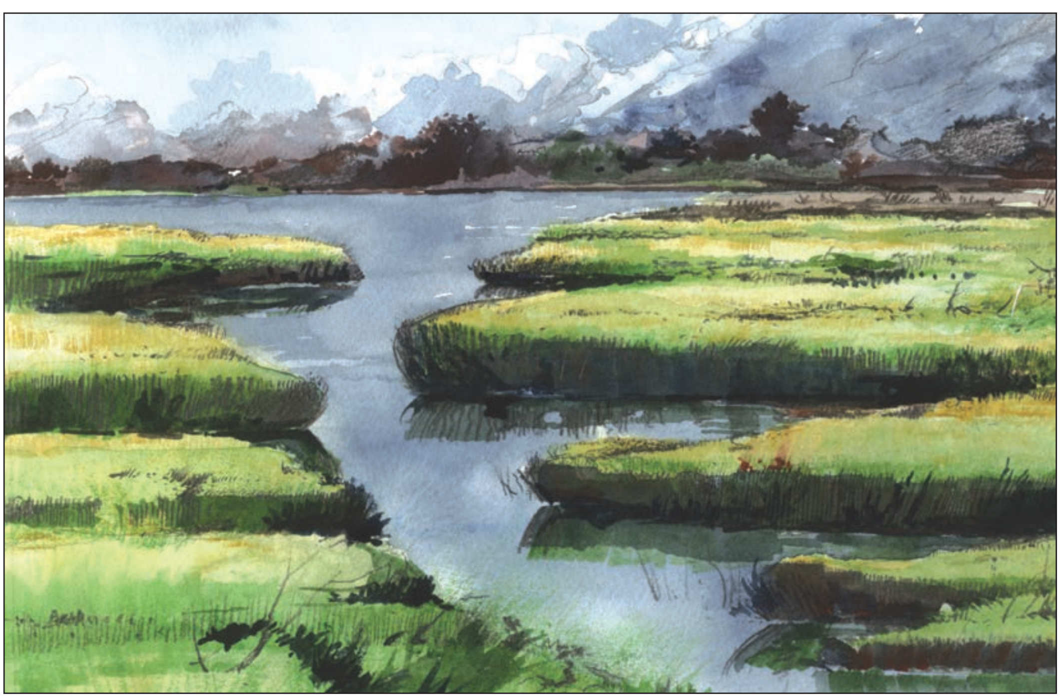
Peat is something that is produced by wetlands, not something you'd expect to find over a hundred miles out to sea. Lepire brought this to the attention of Woods Hole marine scientists who examined the peat. Among its main constituents were fibrous rhizomes (underground stems) of salt marsh grasses, *Spartina* spp. The peat also contained twigs and pollen of spruce, fir, and pine, and spores of sphagnum, a moss of freshwater peat bogs. The curious mixture indicated that this part of the seafloor had once been above sea level and had at some point in the past been salt marsh, freshwater wetland, and perhaps boreal forest. The peat was radiocarbon dated to about 11,000 years ago.

The presence of a salt marsh in an area that is now far out to sea shows how drastically our sea levels and shorelines have shifted over the past 20,000 plus years. Eleven thousand years ago was a time of immense changes in the New England landscape, as the glacier ice that had once covered the entire region finally melted back to the north, leaving a barren changed landscape. The glaciers had previously reached their farthest extent south at present-day Long Island, Martha's Vineyard, and Nantucket, and then the ice started to recede. The ice sheet melted from Cape Cod about 18,000 years ago and from the Boston area and the sea near Georges Bank about 13,000 years ago.

Having that much water locked up in ice resulted in a sea level that was several hundred feet lower than it is now. Fourteen thousand years ago, even after several thousand years of glacial melting, the worldwide sea level was 360 feet below what it is at the present. The sea-level decline would have been even more but the land was depressed under the enormous weight of its mile-thick blanket of ice.

As the melting continued, for a time sea-level rise from the immense amount of water released by the melting of the ice outpaced sea-level decline from the rising of the land released from its icy burden. Geologists from the Maine Geological Survey and University of Maine estimated that the current coast of Maine was actually 230 feet below sea level 14,000 years ago. Portland, Maine, was under about 160 feet of water approximately 12,500 years ago, and present-day Millinocket, Maine, the gateway to the Katahdin region, was at the coastline. Then the balance switched. At some point, isostatic rebound, rise of land masses formerly depressed by ice sheets, outpaced sea-level rise and the sea level fell as much as 1.7 inches a year for about 1,000 years.

As a high promontory at the ice sheet's leading edge, Georges Bank had actually been ice free during the period of farthest glacial advance. It was bordered by tongues of ice that scoured out what are now the Northeast and Great South channels, the main inlets and outlets to the Gulf of Maine. Outwash from the melting glaciers piled sand and gravel on top of the preglacial area of Georges Bank, raising its height.



A natural salt marsh

© BRUCE DAVIDSON

Eleven thousand years ago, the top of Georges Bank stood 130 to 160 feet above sea level. It probably supported a boreal (spruce-fir) forest, the same type of forest that now only occurs in the extreme northern sections of New England and at higher elevations in the mountains. Fishermen trawling the bank occasionally bring up mammoth and mastodon teeth, another indication that this area was aboveground at a time of lower sea levels. This was the zenith of Georges Bank as a terrestrial habitat, occurring at the end of the period of the most rapid rebounding of the land from the weight of the glaciers.

A natural salt marsh flooded by rising sea levels

Around 11,000 years ago the ice continued to melt back to the north, causing the sea level to rise, while the rate of land rebound in New England was slowing. The sea surrounded the edge of Georges Bank and created the salt marsh that Lepire discovered far out in the Gulf of Maine. Oyster shells found in the same area have been dated to the same period and provide another indication that this region had been a shallow nearshore marine community 11,000 years ago. From about 11,000 to 10,000 years ago, the sea rose at an incredible average rate of 0.9 inches per year, much higher than today's estimated global rate of 0.04-0.08 inch per year for the past several hundred years. This drowned the marshes and the ancient forest forever.

Shifting sands moved by the strong currents over Georges Bank have covered much of the glacial history of the area. Scientists have not been able to relocate the original peat deposit found by Lepire.

What insights does the glacial history of Georges Bank and the rest of New England hold for today's coastal wetlands? All of the current salt marshes of New England are postglacial, the oldest date back no further than 4,000 years. They are dynamic ecosystems and have the ability through their growth to dramatically alter their surroundings. One of the key factors that determines their health is the rate of sea-level rise.

Following the drastic decline and then increase in sea levels from 13,000 to 10,000 years ago, the global sea level rose at a slow and benign rate for the next several thousand years. The slowly rising sea levels combined with ocean currents working on the glacially eroded coastline heaped sand into islands and peninsulas (sand spits) along the coast. Plum Island, Crane Beach, Duxbury Beach, and the Provincetown end of Cape Cod are all Massachusetts examples of such postglacial features. These barrier beaches take the brunt of ocean waves while creating lagoons of quiet water on their landward side where marshes can develop.

About 4,000 years ago, sea levels became relatively static. This fostered a period of extensive salt marsh development, as the marshes were able to expand over shallow estuaries. Then 3,000 years ago, sea levels started to rise again at 0.04-0.08 inches per year for much of this time. As sea level rises, marshes may have difficulty spreading seaward over estuaries if the seawater becomes too deep, but they can move landward as long as the slope is gentle.

Two processes enable marshes to expand even under a sea-level rise scenario. The first is sediment accretion, or buildup. The daily inundation of the tides brings sediment from the seafloor, which gets trapped within the matrix of stems of marsh plants. Sediments can also be brought to the marsh by rivers from the surrounding watershed. The second process is the growth of marsh plants. Underground stems and roots from *Spartina* grasses build up the substrate. As the sea slowly rises, marsh plants simply grow on top of their ancestors. The peat, the highly organic mixture of dead marsh plant material and sediments, builds up underneath the living plants over many generations. Depending upon the rates of sea-level rise, the plants may spread laterally across shallow bays and estuaries or up onto the surrounding upland.

Just about anyone who has read a newspaper in the past few years is aware that glaciers and polar ice caps are melting at a rapid pace these days due to climate change. The Greenland ice sheet, a remnant of the continental glaciers that covered much of the northern hemisphere, is thinning and receding, at least around its

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Salt marsh blocked from moving inland by development

margins, at an accelerated rate as the global climate warms. Mountain glaciers are also receding at a rapid rate, contributing their meltwater to the rising oceans. No one is anticipating the incredibly steep changes in sea level that the world experienced during and immediately after the last glaciation. The most recent sea-level rise projection by the Intergovernmental Panel on Climate Change is in the range of 20 to 80 inches by 2100. Nonetheless, the effects of these projected climate change-induced sea-level increases on our coast could still be devastating.

Jim Morris of the University of South Carolina has been researching the critical question of how salt marshes respond to sea-level rise. His work is part of the Plum Island Ecosystem Long Term Ecological Research Program, which has seven participating universities and institutions including Mass Audubon. Morris found that the initial response of marsh plants to small increases in sea level is to grow more rigorously, thereby producing more biomass. Taller and denser plants are more effective at trapping sediment than shorter plants, not only because more particles get stuck to the plants but also because a taller denser marsh has an enhanced ability to reduce tidal currents, thus causing particles to settle out.

Sedimentation and the enhanced growth of below-ground roots and rhizomes build up the marsh surface. This is a wonderful example of positive feedback that has enabled marshes to keep up with a moderate rate of rising seas over the past several hundred years, thereby providing a stabilizing influence on coastal ecosystems. If the shoreline is undeveloped and the slope is gradual, not only does the marsh build up vertically but it also can spread inland as the sea slowly rises.

At some "tipping point," however, the rate of sea-level rise is too rapid for the plants, and they die. Without the plants, the marsh then slowly erodes away. A peat substrate may be the last reminder that a salt marsh was once there. One can imagine that such a scenario played out 11,000 years ago at the salt marsh that inhabited that fringe of Georges Bank.

Morris and his coworkers have carried out experiments to estimate what the tipping point of sea-level rise might be for the marshes of Plum Island Sound. His results indicate that the current rate of sea level rise, about 0.12 inch per year, is at or near the tipping point for these marshes. Additional increases in the rate of sea-level rise, which are anticipated due to global climate change, will likely lead to degradation and a severe reduction in the acreage of marsh. Morris carried out the same exercise for marshes in South Carolina and found that the tipping point rate of sea-level rise for those southern marshes was about three times higher than that of Plum Island. The southeastern marshes are bathed by tidal and river water that are very high in sediments, thus they have an enhanced ability to increase in elevation in response to rising seas.

Marshes are constantly adjusting their position in the intertidal zone based on the rate of sea-level rise and the amount of sediment available in the water that could enable them to increase in elevation. In the past 50 years, Plum Island and other salt marshes in Massachusetts have shown signs of increased erosion, most notably widening of marsh creeks. This is an indication that these marshes are no longer able to maintain their current elevations under present rates of sea-level rise. Another ominous sign for the future of our marshes is the expansion of open water areas on the marsh surface.

None of these changes are incidental as far as the human community is concerned. Salt marshes that are surrounded by undeveloped uplands may have some ability to spread inland as their seaward edges are inundated by rising seas. Unfortunately, many marshes, particularly in urban areas, are now bordered by houses, shopping centers, industrial developments, and seawalls. These have no place to go and are the most vulnerable to degradation and even complete loss. As a result, the host of fish, shellfish, other invertebrates, and birds that depend on those marshes will be out of luck. All the benefits that marshes provide to humans and other creatures will cease to exist.

Robert Buchsbaum is Mass Audubon's conservation scientist in the Southeast and Islands Region.

Climate Change in the Age of Denial

In the face of ever-increasing evidence and mounting danger, disbelief in global climate change maintains its popularity.

by Thomas Conuel

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Icebound stream

Here is an old well-established fact: In 1859 renowned British scientist John Tyndall discovered that carbon dioxide traps heat. Tyndall demonstrated that water vapor is the strongest absorber of radiant heat from the earth and, along with other gases such as carbon dioxide, nitrous oxide, and methane, controls air temperature.

This scientific fact led to the further discovery that the gases that control air temperature, instead of escaping back into space, are trapped in the earth's atmosphere and are necessary to warm the earth. Without these gases, the earth's average temperature would be about 60 degrees Fahrenheit colder, uninhabitable for humans. However, if these gases increase, the surface of the earth gets warmer. The amount of carbon dioxide (CO_2) increases as a result of fossil fuel burning and other activities such as tropical deforestation and the normal process of respiration. Carbon dioxide traps heat, and numerous measurements of CO_2 over the past several decades show that levels have risen dramatically in the earth's atmosphere.

Unfortunately, we seem to live in an age of denial of certain historical and scientific realities. Ours is a time when documented truths, evidence-based data, and fact-driven dialogue are routinely discarded in favor of bloviated opinion devoid of accuracy and ignorant of consequences. There are the noxious Holocaust deniers, the moon-landing Hoax Believers, the anti-evolutionists, and, most recently, the Birthers who question the citizenship of the 44th President of the United States.

© JOHN GREEN

"First, they tell you you're wrong and they can prove it. 'Climate isn't changing in unusual ways or, if it is, human activities are not the cause.' Then they tell you. 'You're right but it doesn't matter.' Finally, they tell you, 'It matters but it's too late to do anything about it.'"

All three positions are represented among the climate-change skeptics who infest talk shows, Internet blogs, letters to the editor, op-ed pieces, and cocktail party conversations.

Facts can be troublesome impediments to those who refuse to believe in climate change.

Some of this fractious behavior against intractable facts is almost laughable. But there is no humor in the saddest and greatest fallacy now rampant across the land: the ill-informed "climategate" proponents who attempt to discredit scientists and make claims that global warming is a myth and that melting glaciers and warming oceans are not of any consequence.

Climate-change skeptics are even popping up in unexpected places. In March 2010, a survey funded by the National Science Foundation found that 25 percent of television weathercasters in the United States don't believe that global warming is occurring. Another 21 percent of the TV weather personalities are unsure, while only 54 percent do believe that global warming is for real and caused by human activities.

The problem with those numbers is that television weather forecasters, with their access to communication channels, play an inordinately important role in informing and updating the public. Viewers look to them for information about climate change though only about half of television weather reporters have a degree in meteorology—and most are without the advanced degrees and the years of study that climatologists bring to the issue.

If you look beyond your own backyard to the high ice fields of the world's frozen peaks, or the evidence of warming ocean currents, or a future when global warming is going to impact all life on the planet, the age of denial is going to have consequences.

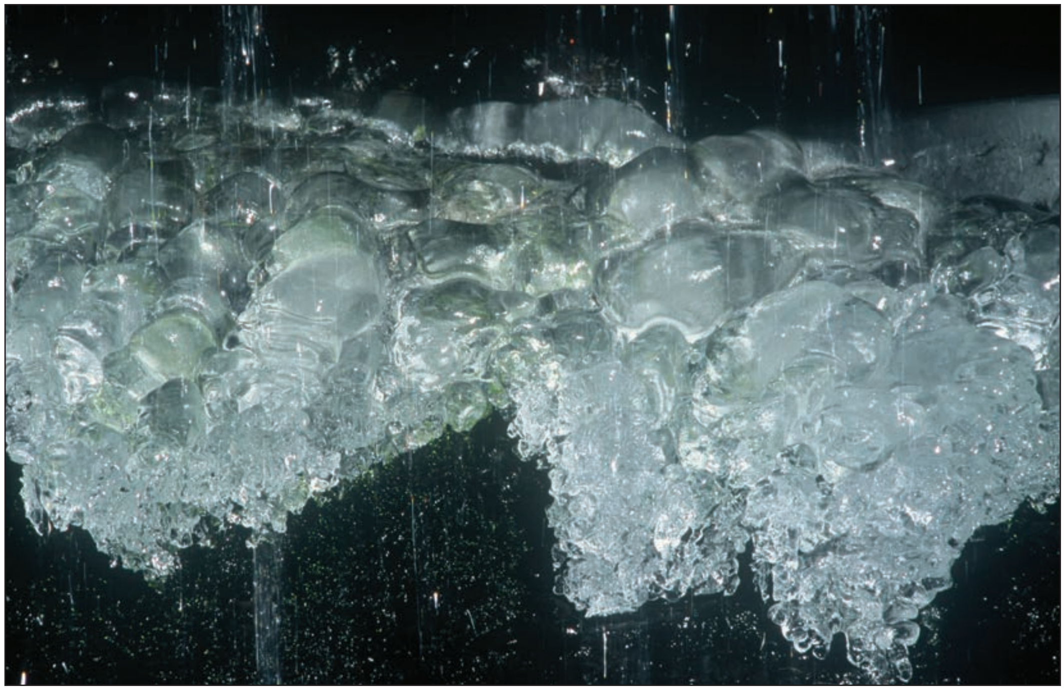
While he was a professor of environmental policy at Harvard's Kennedy School of Government, John P. Holdren, now advisor to President Obama for Science and Technology (aka White House Science Czar), wrote tellingly of the three stages of denial of what he termed the climate-change skeptics.

Spread across the Tibetan Plateau and Greater Himalayan mountain ranges containing the world's fourteen highest peaks, some 46,298 glaciers are to varying degrees receding—melting away with consequences that will impact the world's most populous regions. Mountaineer and filmmaker David Breashears has produced a set of "then-and-now" photos of these receding glaciers. Using archive photos from early Himalayan expeditions, Breashears trekked to the same spot and photographed the current glaciers. Using laser rangefinders to measure the height of the glaciers, Breashears' photos show dramatic ice loss; in many cases the glaciers have shrunk hundreds of feet in all directions.

About one-sixth of the world's people live in glacier- or snowmelt-fed river basins, according to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). The retreat of the glaciers will impact millions in the lowlands of China, Asia, and India, bringing dire changes in food supplies, pestilence, population shifts, and battles for freshwater. The retreat of the glaciers in the faraway mountains will change in adverse ways the region's ten major rivers: the Yellow, Yangtze, Mekong, Salween, Irrawaddy, Brahmaputra, Ganges, Indus, Amu Darya, and Tarim.

Orville Schell, writing in *The New York Review of Books*, described the steady melt "starting to flow out of the majestic arc of mountains that begins in inner Asia with the Tianshan Range in western China and then wraps itself around the western tier of the Tibetan Plateau as it becomes the Hindu Kush in northern Afghanistan, [and] then joins Karakorum in northern Pakistan to become the Himalayas above Nepal, Bhutan, and India before ending with the Hengduan Range in southwest China." The melting of the Himalayas' glaciers, he notes, will have an enormous impact on a huge segment of the earth's populations for decades and centuries—impacts that nobody can really predict.

The Indus River, originating in the Tibetan Plateau and a main water source for Pakistan, especially in agriculturally important Punjab province, and the Tarim, the longest inland river in China, derive up to 50 percent of their annual flow from glacial melt. The Yangtze, the longest river in Asia and third longest in the world, is 18 percent glacial flow; and the Salween, originating from the Tangula Mountains of the Himalayas in the Tibetan plateau, and extending through China, Burma, and Thailand, is 9 percent glacial meltwater.



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For some rivers, such as the Ganges, which rises in the western Himalayas in the Uttarakhand state of northern India and drains into the Bay of Bengal, glacial meltwater accounts for as much as 70 percent of spring and fall flows, keeping the river level constant before and after the monsoons.

Some climate studies now find that global warming appears to affect high-altitude regions such as the Tibetan Plateau with greater temperature rises on average than other parts of the world. On the Tibetan Plateau, warming has increased upwards of three times the global average, according to some studies.

Glacial studies show the Himalayan ice fields retreating for three reasons: a rise in temperatures tied to carbon emissions, changing rain and snow patterns that are depositing less snow onto glacial surfaces, and what Orville Schell calls "black soot"—air pollution and smoke that cover even high ice fields in carbon soot that darkens their surfaces causing them to become less reflective and melt faster.

The retreat of the glaciers is not unique to the Greater Himalayas. The World Glacier Monitoring Service says that global melt rates have doubled in the past ten years. On legendary Mount Kilimanjaro, the ice fields have been reduced to less than .6 square miles from 4.5 square miles 100 years ago, and may be gone within two decades. Montana's Glacier National Park was a glacial wonderland with 150 glaciers when the park was established in 1910. Today the park has 25 glaciers. And, according to Orville Schell, the Rhône Glacier in the Swiss Alps, a major water source for Europe's Rhone River, will be mostly gone by the end of the century.

In another part of the world, glaciers are melting away from below. Greenland is about one-fourth the size of the United States, with 80 percent of its surface covered in ice. It holds about 20 percent of the world's ice, which would contribute about 21 feet of global sea rise. Greenland's ice sheets go back at least 15,000 years, the time of the last glaciers in New England, and they have survived several periods of warmer weather, but the ice cap is now pocked with holes called moulins that accelerate the breakup of large sheets of ice. Greenland's ice sheet is not only retreating, but slowly thinning from below where warmer ocean currents now bathe the ice and eventually cause them to slide into the North Atlantic.

A study funded by NASA and the National Science Foundation, and led by Technical Institute of Denmark's National Space Institute in Copenhagen and the University of Colorado at Boulder, found that ice loss from the glaciers has increased and began moving up the northwest coast of Greenland starting in late 2005. Air temperatures over the Greenland ice sheet have increased by about 4 degrees Fahrenheit since 1991. A 2006 study found that Greenland lost roughly 164 cubic miles of ice from April 2004 to April 2006—more than the volume of all the water in Lake Erie.

Nor is there any good news from the poles of the world. The North Polar ice cap, which is nearly the size of all 48 contiguous states, has recently melted to half its usual summertime size.

There is danger that the Greenland ice sheet, the polar ice mass, and the Himalayan-Tibetan glaciers will warm to the point that they pass a tipping point—from which it will be too great to recover.

In 1987, Michael Oppenheimer, at that time the Environmental Defense Fund's chief scientist, told a colleague: "Climate is the granddaddy of all environmental problems. Everything we do on all these other issues—local pollution, wildlife preservation, rivers, and oceans—is going to be for nothing if we don't solve this one."

He was right about that. But in the years since, though the science of climate change remains unrefuted—and the losses mount—the skeptics fight on despite ever-increasing evidence.

Thomas Conuel is a field editor for Sanctuary *magazine.*

Long Trail in the Sky

The glacial origins of bird migration

by Wayne Petersen

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Ruby-throated hummingbird

Of all the migratory species on earth, birds are undoubtedly the best known and the most diverse in their behavior. Accordingly, scientists and laypeople alike have for centuries been fascinated by their seasonal rhythms. With their highly efficient flight capabilities and variable migratory strategies, birds are feathered aerialists par excellence.

The white-rumped sandpiper, for example, a shorebird hardly larger than a sparrow, annually makes a round-trip from the Canadian High Arctic to Tierra del Fuego in the Southern Cone of Argentina—a distance of approximately 16,000 miles per year. Similarly, a tiny ruby-throated hummingbird nesting in Massachusetts may travel 2,500 miles to reach its winter quarters in Central America. One might reasonably ask why these species travel so far, amassing enviable quantities of frequent-flyer miles in the process. However, the more fundamental question is: Why do birds migrate at all?

Most simplistically, avian migration may be defined as regular travels between breeding and nonbreeding areas. Such movements may further be defined as a means of dispersal or simply traditional migratory patterns. Regardless of the specific migration variation, one aspect of the phenomenon is universal—the significance of food in driving the process. Food availability is generally a primary factor in determining the distribution of organisms and accordingly is central to an understanding of bird migration.

Linked to food availability are the impacts of seasonal variations in weather; for example, in temperate regions winter often imposes shortages in food availability that ultimately necessitate the seasonal movement of birds (i.e. migration) to areas where resources are more seasonally plentiful. Food also influences other attributes of a bird's annual cycle. For instance, for a bird to successfully raise a family, it requires sufficient resources to not only sustain itself but also its young. To be successful, a species must breed in an area where competition from other birds is minimized to a point

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Willow flycatcher

that competition, along with pernicious problems such as predation, will not offset the energies of nesting.

But food availability and weather notwithstanding, the larger question of how bird migration evolved in the first place remains. One way to address this is to consider the global distribution of bird species living today. The aforementioned white-rumped sandpiper, for example, is a member of a large group of related shorebird species, including among others plovers, yellowlegs, whimbrels, godwits, turnstones, various other sandpiper species, dowitchers, and snipes. If we analyze the distribution of shorebirds in the western hemisphere, it is apparent that the great majority of species are boreal or Arctic in their breeding distribution.

A similar consideration of the ruby-throated hummingbird and its relatives reveals that the majority of the world's hummingbird species are distributed in the Neotropics (i.e., the New World Tropics), with fewer than 20 species regularly breeding north of the Mexican border. To further emphasize this point, peruse the pages of any Central or South American field guide and compare the number of sparrow species regularly found breeding in North America with those breeding in the Neotropics; then repeat the exercise with the number of flycatcher species breeding in the Neotropics compared with the number nesting north of Mexico. A pattern is immediately obvious: there are many more shorebirds and sparrows currently breeding in North America than hummingbirds or flycatchers. In the Neotropics, however, the ratio is reversed.

These numbers reflect the fact that the ancestral home of most shorebirds and emberizids (i.e., sparrows) was probably in high or temperate latitudes, while hummingbirds and flycatchers are thought to have originated in tropical regions. More importantly, these facts shed light on the migration patterns we observe in bird species living today.

During what is commonly referred to as the Ice Age, the Pleistocene, about a half-million years ago, there were a number of advances and retreats of the glaciers—called glacial and interglacial stages, respectively. When the glaciers advanced, North America was covered with a mile or more of ice and the climate over much of the continent was radically different from the climate today. The birds living in North America were faced with very different conditions than exist currently. The food supply available to avian populations during glacial stages was obviously very different as well. Consequently, bird species living in North America during glacial stages were faced either with extinction or were displaced to regions where appropriate food was still available. Contemporary birds are species that successfully survived after the last retreat and were able to make the necessary distributional adjustments to survive.

This brings us back to shorebirds, sparrows, hummingbirds, and flycatchers. Since species in these groups are dependent upon insects or other invertebrate food for at least a portion of their annual cycle, they had to adapt in order to survive glacial periods. For birds occupying high or temperate latitudes, as the climate gradually became colder and ice eventually enveloped their breeding grounds, they were forced southward to tropical regions where ice-free conditions allowed them to obtain food and successfully rear their young.

Eventually, however, as the climate began to ameliorate and the glacial ice withdrew northward, many of the species whose ancestry lay in the Arctic gradually reoccupied their historic breeding ranges once food and habitat were again able to sustain them. Today, the Arctic tundra and boreal taiga are heavily populated with breeding shorebirds, and North American grass-

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White-rumped sandpipers

lands and successional habitats are the estival home of a great diversity of North American sparrow species.

Concurrent with the southward displacement and later northward withdrawal of northern species during the ice ages was a corresponding northward shift in the distribution of species primarily occupying the tropics. As conditions in the temperate zone mellowed following the retreat of glacial ice, many tropical bird species seized the opportunity to expand their range out of tropical regions northward into more temperate regions where the competition for food and living space was less extreme and the pressure from predation less intense.

Regardless of the scenario involved, what we see today was largely driven by the extreme variations brought about by seasonal food availability and the differences between summer and winter weather. In effect our current seasonal variations may be thought of as annual recapitulations of the glacial and interglacial periods of long ago during which time, food, and habitats become variably available over the course of long intervals.

Many ornithologists believe that the modern-day migrations are reflective of long-term variations in climate and habitat that took millennia to forge into the migration patterns observable now. For species whose atavistic origins lie in northern or southern latitudes, the implications are striking. The annual northward and southward migrations of shorebirds and many sparrows that we observe are actually retracing long-standing northward and southward shifts in ancestral distribution brought on by eons of natural selection pressure. Similarly, when hummingbirds and flycatchers in current time are faced with winter in North America, the majority of these species retreat to their ancestral home in the tropics, only to return to more temperate regions during the northern summer season. These annual migrations to and from regions where seasonal changes in weather and food availability make breeding and wintering successful seem completely logical today.

Although there are many factors and even a few alternative theories to explain the origin of migration, these "northern home" and "southern home" theories are the most compelling explanations of global migration patterns. However, there are other questions beyond simply trying to explain the genesis of bird migration.

Perhaps most intriguing is why species such as the white-rumped sandpiper and ruby-throated hummingbird annually travel so far during migration each year when it would appear that they could avoid unsuitable seasonal climate and gain access to an abundance of appropriate food without flying thousands of miles or facing the hazards of migration twice a year? While it is undoubtedly true that many bird species seemingly migrate farther than they have to, it is also true that in their struggle to minimize inter- and intra-specific competition and to maximize their foraging efficiency, it is apparently ecologically worthwhile to undertake journeys that will carry them to destinations that will maximize their avoidance of competition for food, living space, and other necessities for survival.

We see parallel strategies in some of the largest animals on the planet: humpback and gray whales. These leviathans annually undertake giant migrations to reach widely separated seasonal feeding and calving areas—specifically areas where the characteristics of their widely separated seasonal destinations apparently justify the means of getting there.

One thing that is important to underscore in all this is the fact that the projected changes anticipated by our currently warming global climate, including some of the very factors that shaped the distribution and migration patterns we see today, are no doubt at work altering the migration patterns of future decades.

Wayne Petersen is director of the Important Bird Areas program for Mass Audubon.

The Myth of the Unchanging Forest

Protecting the nature of Massachusetts is particularly difficult when nature itself is changing.

by Tom Lautzenheiser

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A deciduous forest of the Northeast

Among the eastern hemlocks on Yokun Ridge, at Mass Audubon's Pleasant Valley Wildlife Sanctuary in Lenox, the dark trunks, deep shade, and quiet birdsong evoke a timeless unchanging atmosphere. Surely this forest has endured for eons—and will persist for eons more.

Or is this sense of timelessness an illusion? If one could look down on the landscape and witness its history over the past 18,000 years as a time-lapse movie lasting ten minutes, the dynamism of the forest would be revealed.

Over the years since the retreat of the Laurentide ice sheet, waves of tree species would swarm through the area, some lasting only a short breath, some rolling slowly as clouds on a summery day. The first few thousands of years following the retreat of the ice would flash with the formation of a glacial lake in the valley, which would subsequently drain to reveal postglacial alluvial sediments, over which the modern Housatonic River would downcut and meander. A tundra landscape would prevail, and then, 10,000 years ago, spruce would gain prominence.

Hardwoods, hemlock, and white pine would sweep in, to become established approximately 8,000 years ago, but then nearly 5,000 years ago hemlock would decline, perhaps the victim of an insect or disease. Birches, oaks, white pine, and red maple would take hemlock's place for a while, with hemlock recovering, and pitch pine and hickories joining the assemblage by 2,600 years ago. American chestnut would increase its presence some 1,600 years back, and this forest would persist, more or less, until European settlement. And all through these events, Yokun Ridge itself would abide, like the stage over which the actors play out their roles.

Anywhere one looks in the Massachusetts landscape, the

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Quabbin forestland

pattern is similar: the forests and fields, wetlands and seashore, all are subject to changes that generally occur on a time span too gradual to be observed in one human life, or even over several generations. Yet these changes are real, and they pose an interesting conservation challenge: If the nature of Massachusetts is dynamic over the long-term, how do we design our conservation lands to enable these long-term processes to occur? This question has heightened relevance given the modern situation of rapid anthropogenic climate change.

Ecologists have long recognized assemblages of species that recur in areas of similar environmental conditions, such as the sugar maple-American beech-yellow birch forests in the hills west of the Connecticut River, and the pitch pine-scrub oak woodlands that occur on sandplains. These assemblages, together with their environmental settings, are referred to as natural communities, and they form the basis for a system of land classification that informs most modern conservation and land protection efforts. Rather than exhaustively identifying every species that occurs on a parcel of land, a more rapid approach is to note the occurrence of several of the dominant species, and then infer that these species are representative of a suite of species that generally occur together. Thus, natural communities can be discerned from high-resolution aerial photographs, even before a biologist sets foot on a piece of land.

However, while the natural community concept is a powerful and practical tool for describing ecological patterns in an area, all users of this tool eventually grapple with the reality that natural communities are merely convenient constructs. At least in the relatively recently deglaciated Northeast, these plant assemblages are more accidents of chance, time, and individual responses to environmental variables. The natural community concept does not necessarily provide insight into the longer term dynamics that may be occurring in a landscape.

The fundamental driver of the broad vegetation patterns on the earth is climate. Even within a region like New England, plant species are generally distributed according to variations in temperature and moisture availability. Support for this view is provided by paleoecological research, which indicates that the ranges of plant species in New England have closely tracked variations in temperature and moisture availability ever since the end of the last ice age, though land use has been a strong influence since the European settlement of North America.

Pollen records from lake-bed sediments (which provided the data for our time-lapse imagery) demonstrate that individual species have moved independently over the past 18,000 years. The plant assemblages that we regard as communities are therefore something of a coincidence, driven more by suitable environmental conditions for each species than anything else. Moreover, plant species ranges appear to shift quite rapidly as climate changes, responding on the order of centuries rather than millennia.

The paleoecological record shows that as climate changes, species migrate at their own paces, as quickly as their physiology and dispersal mechanisms allow. This reality is a heavy blow against the idea that a natural community acts as a type of super-organism: it is no more a super-organism than the thousands of runners in the Boston Marathon, each striving to outrace the next. Yet from a snapshot perspective, the idea that the species assemblages we see today are immutable appears reasonable. Certainly, the hemlock forest on Yokun Ridge appears much as it did forty years ago. But such is the danger of the short view.

Some ecologists have recently analyzed which natural communities in Massachusetts are vulnerable to climate change. This analysis may be useful for describing broad changes in the landscape, but the reality is that even the natural communities that have been designated as secure in the state will change in unanticipated ways since the species in any plant community respond independently to climate cues and other factors. The oak-hickory forest of Connecticut will not ooze northward, like a gigantic amoeba, to occupy a newly appropriate climate space in Massachusetts; neither will our northern hardwood forest march neatly up Mount Greylock to occupy the space vacated moments before by the hapless spruce-fir community.

Instead, the species ranges making up all of the natural community types that we recognize will be spread, generally poleward and upward, into new forms, of "no modern analog" in the ecological parlance. Thus, every natural community that we currently recognize is vulnerable to climate change.

Another liability to the natural community-based conservation approach is that pests and diseases can sweep across the landscape, quickly eliminating important species from an assemblage. For example, chestnut blight and Dutch elm disease, both pathogens accidentally introduced to North America in the early twentieth century, dramatically affected the composition of the forests where American chestnut and American elm occurred. Currently, eastern hemlock is a dominant or co-dominant species in many present-day forest communities, and is one of the most common tree species in Massachusetts, but it is poised for a catastrophic decline.

The hemlock woolly adelgid, a non-native insect that has devastated hemlock forests in the southern Appalachians, is able to expand its range northward with warmer climate conditions. This adelgid has now been reported from every county in the state, and it is possible that, within a decade or so, hemlock could be ravaged in areas where it is now dominant. Hemlock appears to have faced a similar threat in its history in New England, and has recovered; but the near- to moderate-term ecological consequences of a swift collapse of hemlock would be significant.

Alas, many prominent members of our modern species assemblages face similar threats by introduced pests, such as beech bark disease, Asian longhorned beetle, and emerald ash borer, some of which are already present and some of which have not yet been found in the state.

The crux of the matter is that climate is changing, triggered now by human activities, and individual species will respond to this change independently. Therefore, we can expect the species assemblages/natural communities that we recognize to fall apart to a greater or lesser degree over the next few hundred years.

This situation poses a significant conservation challenge: many conservation areas were created to support populations of a single species of concern, or the natural communities of which rare species are members. The cornerstone of Mass Audubon's mission to protect the nature of Massachusetts is its wildlife sanctuary network, presently encompassing some 34,000 acres, from the coastal plains of Cape Cod and the Islands to the highlands and valleys of the Berkshires. Although they are not measured out in cubits, these sanctuaries represent Mass Audubon's own Ark, and serve to carry Massachusetts' natural heritage through times of habitat loss and degradation, increasing landscape fragmentation, and other challenges.

However, given our legal systems of land ownership and property law, and our highways, cities, and other infrastructure, we cannot slide the boundaries of these sanctuaries along while their present-day species shift poleward or upward in landscape. Some of the species we work to conserve will move out of our sanctuaries, or out of Massachusetts entirely, and others will move in to replace them. Protecting the nature of Massachusetts is particularly difficult when the nature itself is changing. This situation demands a new approach.

Climate is changing, species are moving, and pests and pathogens are looming large, so what features can we use to identify areas of high conservation value? Significantly, after climate (and human influence), bedrock and surficial geology are major determinants of how species are distributed in a landscape, through their influence on microclimate and nutrient and moisture availability. These elements of the physical environment are changing on much longer time scales than climate—on the order of tens of thousands to millions of years. Moreover, ecologists have demonstrated that areas that have a high physical diversity, including different mineral types, landforms, and other features, generally also have a high biological diversity. Therefore, an analysis of the relatively stable geological elements of a landscape can reveal areas of high inherent diversity. In a changing world, an area with a high physical diversity will presumably tend to support many species, no matter what those species happen to be. These are the areas that are important to conserve.

The land protection strategies needed to ensure that the conservation land network continues to safeguard biological diversity as climate changes are twofold: first, areas of inherent biodiversity—that is, areas with diverse substrate features—need to be conserved; and second, connections between existing protected lands must be created and maintained.

These are an extension of strategies Mass Audubon has been using to build its sanctuary network over the past decades, just adapted to acknowledge that the nature of Massachusetts will change in unexpected ways over the coming centuries.

Perhaps the slopes of Yokun Ridge will support a forest dominated by tuliptrees rather than hemlocks.

Tom Lautzenheiser is Mass Audubon's central/western regional scientist. He lives in Easthampton.

Notes From the Real World

How Glaciers Make Warblers

by Chris Leahy

Pretend that you are a black-throated green warbler. Assuming that you are capable of that transspecific leap of imagination, you are having a vica*rious* experience; that is, acting or feeling as if you are taking the place of someone or something else.

However, in evolutionary biology, the term vica*riance* refers to the separation of a population of organisms by a geographical or other natural barrier—such as an advancing glacier—that results in the evolution of distinct forms or species.

In a classic 1964 paper in *Living Bird*, ornithologist Robert M. Mengel offered up this plausible tale of avian evolution. Once upon a time—the late Pleistocene to be specific—a species of wood-warbler (possibly one with yellow cheeks and a black throat) lived in a region of deciduous forest confined to what is now the southeastern United States. As one of the great ice sheets advanced during the next 250,000 years, the transcontinental boreal forest that now lies mainly across southern Canada "migrated" southward as a result of a cooling climate. In the ensuing millennia, the evolving yellow-cheeked warbler was able to adapt to the changing forest and to expand its range within its new habitat, which for a time covered much of North America.

To grasp what might have happened next to our protowarbler, you must recall that during the last quarter-million years of the Pleistocene, glaciers advanced and retreated repeatedly, and, in a subsequent advance, massive tongues of ice separated the evolving warbler species into several isolated populations. Free now to follow different evolutionary futures, the more widespread eastern population eventually became the black-throated green warbler, an apparently adaptable species that now occupies a continuous range from the Canadian taiga, where it nests in spruces and firs, all the way down the Appalachian chain, where it follows the pines and hemlocks in the higher elevations south to Alabama.

A separate western population of yellow-cheeked warblers, walled off from its congeners by the glaciers, pursued a different genetic destiny in the mountains and boreal forest of the far west, eventually splitting into two species, the black-faced Townsend's warbler, ranging from southern Alaska to northern Oregon, and the golden-headed hermit warbler, which picks up where Townsend's leaves off and tracks the conifers of the high

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Golden-cheeked warbler perched in Ashe juniper

Sierra Nevada as far as southern California. That the latter two species have diverged fairly recently is supported by the fact that they hybridize frequently where their ranges overlap around the US-Canadian border.

An even more intriguing climate-based theory attempts to explain the distribution of the two other members of the black-throated green "superspecies," namely the black-throated gray and golden-cheeked warblers. To grasp this hypothesis, you need to recall that the land masses of our planet can be divided into life zones, or biomes, defined by distinctive plant and animal communities and governed largely by respective ranges of temperature and moisture. South of the perennial ice in the polar region of the northern hemisphere is a zone of Arctic tundra, followed to its south by a zone of taiga or coniferous forest as described above, and so on to the tropical habitats of the equatorial region, after which the sequence repeats itself in reverse toward the South Pole. (The distribution of the planet's biodiversity is a little more complicated than that, but we must stick with our warblers and the main plotline.)

This latitudinal sequence of climate-influenced biotic zones is mimicked to some extent as one ascends or descends a mountain. The higher one climbs, the colder it gets, so that the highest tropical mountain will have tundralike habitat below its snow cap and a base covered in tropical vegetation. It will also typically have a dry slope and a wet slope (with not-so-dry and not-so-wet slopes in between). In North America, there is a rough equivalence between 400 miles of north-south distance at sea level and 2,500 vertical feet on a mountain.

Now return with me, if you will, to that period of the Pleistocene when our yellow-cheeked warbler is enjoying a transcontinental range occupying much of the territory of the present lower forty-eight states. During warming periods, the glaciers retreated not only northward, but also up the mountain slopes, and, of course, the vegetation zones followed, taking with them their characteristic species, including our warbler.

Eventually, the conifer forests that migrated uphill in various mountain ranges became isolated from each other, allowing the warblers (and the other species) that inhabit these islands of habitat to find their own evolutionary way. The two southern isolates eventually carved out ecological niches in much drier habitats than their siblings and among different trademark conifers. The black-throated gray warbler—looking like a Townsend's warbler with its yellow bleached away—now nests in high desert chaparral with scattered small pinyon pines and bush junipers, while the superb (and threatened) golden-cheeked warbler occupies the narrowest, most isolated range of all among the mature junipers and live oaks of the Texas hill country.

The details of this evolutionary saga have been much debated in the ornithological literature since Mengel published "The probable history of species formation in some northern wood warblers" (*Living Bird* 1964). Using recent techniques such as DNA analysis and molecular clocks, some researchers have argued that the glaciers' influence on the evolution of the sibling species described here may have occurred much earlier than Mengel suggests. And another DNA study makes the case that the black-throated gray warbler may be the "basal branch" of the family tree from which its yellow-cheeked descendants evolved.


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Golden-cheeked warbler

But the vicariance concept describing the influence of glaciation and other isolating factors on bird populations remains valid and is visible in the distribution patterns of many of our modern bird species. We see it most clearly in the "complementary" range maps of siblings such as rose-breasted and black-headed grosbeaks, lazuli and indigo buntings, and the myrtle and Audubon's races of yellow-rumped warblers.

The "glacial" pace of evolution and discussion of the Pleistocene era 12,000 years behind us can make the events described above seem remote in the context of our brief life spans. Yet the process never ceases, and, in the present period of rapid climate change, we are seeing many dramatic range expansions and contractions within mere decades. Were it not for the prospect of human catastrophe that the coming climate crisis is likely to visit upon us, we might view the future as a fascinating opportunity to observe evolution in fast-forward.

Will our grandchildren witness the withdrawal of the now-widespread black-throated green warbler to boreal refugia? And what of glacial relict species such as Robbins' cinquefoil and the White Mountain butterfly, their entire global populations trapped, as it were, on a few alpine summits in New Hampshire? Will their populations soon wink out altogether because their mountaintop habitat can't migrate any higher?

We may not have to wait very long to find out.

Chris Leahy holds the Gerard A. Bertrand Chair of Natural History and Field Ornithology at Mass Audubon.

At Our Sanctuaries

Our Favorite Landform

by Ann Prince

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Livestock Manager Caroline Malone moves the sheep to greener pastures on the drumlin where Mass Audubon employs rotational grazing.

As many people are aware, a drumlin is the centerpiece—at least from a geographical perspective—of the farm and wildlife sanctuary at the Mass Audubon headquarters, in Lincoln. At 270 feet, it is one of 3,000 drumlins scattered throughout eastern and central Massachusetts—elongated hills of clay and rock with a streamlined silhouette.

Drumlins may be solitary above the lowlands but often occur in large groups called swarms. Their ellipsoid shape has been likened to the top of a spoon, the back of a whale, or a droplet of water—round as it rises in elevation at one end and tapering downward at the other. Our favorite, at Drumlin Farm, is but one of many in the Boston area—which is known in particular for its drumlins.

The colonists first named what would one day be downtown Boston, Trimountaine, for three drumlins there—Beacon Hill, Mount Vernon, and Pemberton Hill—two of which were leveled as fill to make the city with only Beacon Hill remaining. The islands in the inner harbor are also generally considered to be partially submerged drumlins. And there are hundreds of others in the metropolitan area and farther afield.

Considering this local abundance, it's fitting that a local man, the prominent Harvard geographer William Morris Davis, was the first to use the term drumlin in this country. In 1884, Davis wrote in the journal *Science*: "The arched hills of glacial drift that have been called drumlins by Irish geologists are among the most peculiar results of the action of land ice-sheets. They are composed of closely-packed boulder clay, or till, distinctly unstratified, and containing well-scratched stones."

He goes on to say that drumlins reach heights of 50 to 300 feet and their axes are closely parallel to the direction of the glacial flow. Davis mapped drumlins in a section of Brighton, Brookline, Newton, and Roxbury. His map looks like a picture of spots on a leopard, except that, in the dense grouping, all the ovals are oriented from northwest to southeast.

As Davis noted, the word drumlin originated in Ireland where there are vast drumlin fields. The term is derived from the Gaelic *druimm* meaning "little ridge" and is attributed to nineteenth-century Irish clergyman and geologist Maxwell Henry Close—best remembered for his research on the glaciations of Ireland as well as his work to preserve the Gaelic language.

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On a summer's day, the flock rests in a shady grove on the drumlin.

Our Lincoln sanctuary was given its familiar name, Drumlin Farm, soon after the term came into common usage in New England. Landowners Louise and Donald Gordon, who formed their rural estate by purchasing ten adjacent smaller farms, dubbed it Drumlin Farm in the 1920s. The Gordons maintained much of their country retreat as agricultural land. They raised poultry and cattle, cultivated forage crops, and kept open land for grazing on the drumlin and elsewhere. Thirty years later, having outlived Donald and her second husband, Conrad Hathaway, Louise left the farmland and estate to Mass Audubon to remain as a working farm as well as a sanctuary for birds and other wildlife. The drumlin was named Hathaway Hill in her honor.

Like the rest of the sanctuary, the drumlin now serves the community not only as a refuge for wildlife and a place to learn about the natural world but also as a farm that demonstrates and supports local agriculture. As was the forward-thinking Louise Hathaway's desire, the working farm helps children understand where their food comes from, and the drumlin is no exception.

"Our drumlin is a classic spoon-shaped hill with the long slope running southeast to Boyce Field," says Tia Pinney, ecological management coordinator for the sanctuary. "The western, steeper slope has a couple of old apple trees, which are most likely remnants of an orchard. The steep slopes of drumlins were classic orchard locations because they were too steep to plow and have temperature-gradient air circulation from top to bottom that limits frost damage."

She says that there's an old stone wall that runs across the hill about halfway up the southern gradual slope, and there's evidence that fresh produce was cultivated here at one time. Currently, the drumlin offers summer pasturage for sheep on the western slope, while the rest of the hill is covered with mixed hardwoods on the eastern hillside and a small red pine plantation in the westerly section.

Livestock Manager Caroline Malone employs rotational grazing on the drumlin for the sheep at the farm, moving them every couple of weeks to a new section of the slowly sloping hillside pasture. Grazing is beneficial both for the field and for the sheep. As the sheep graze, they not only eat the grass but also defoliate invasive plants such as multiflora rose, autumn olive, and buckthorn—which Malone then mows down with a brush hog when the sheep have moved on to a new rectangle of greener pasture.

Having them out on the drumlin foraging freely is good for the flock: "I think the sheep like it better out here. They're always getting fresh grass, and moving them regularly breaks the worm cycle. They're healthier and their fleeces are clean. Malone finds that the sheep do well in the maple grove. "They need to have tree cover in the pasture," she says. "Giving them shelter, food, and water is a USDA regulation, and it's the humane thing to do."

Grazing also maintains the panorama from the top of Hathaway Hill. "The summit offers a superb outlook to the west and north," says Tia Pinney. "You can see Wachusett and the Monadnocks as well as extensive views of the Sudbury River." Henry Thoreau admired this view, as well. In a March 1853 journal entry, he wrote of the vista from Mount Tabor (an earlier name for our drumlin): "It is affecting to see a distant mountain-top, like the summits of Ucannunuc, well seen from this hill whereon you camped in your youth, still as blue and ethereal to your eyes as is your memory of it."

Ann Prince is associate editor of Sanctuary.

The Political Landscape

Learning from the Glacier

by Jennifer Ryan

© CHRIS LEAHY

Perito Moreno Glacier, Argentina

Climbing on a glacier is a remarkable experience; a glacier is so massive it feels like it has its own gravitational pull. The creaks and groans of ice moving can be almost more *felt* than *heard*. There's a certain simplicity of sounds on big ice: water running and dripping, snow falling, the vibrations of ice under pressure—but very little else. The dirt and till pushed out from under them is remarkable in its mixture of rocks of different provenances and colors. You know they've traveled far.

Standing at a glacial outflow offers a powerful opportunity to thoroughly imagine the geologic processes and appreciate the range in time and scale of the forces that shape the world around us. Ice holds insects blown in from high in the atmosphere, ash from the volcanic eruptions of past centuries, and even trapped air from thousands of years ago. There is something magical in knowing that the ice of a contemporary glacier holds snowflakes from every year that humans have existed.

The last time I got to traverse a glacier was several years ago in Iceland. Being on and next to glaciers—especially after living in New England with our kettle holes, erratic boulders, drumlins, and striations—was of course enlightening. But another aspect of Iceland struck me. The open meadows of Thingvellir National Park were the site of the world's first parliament from 930 to 1798—1,000 to 200 years ago.

Across New England 12,000-18,000 years ago, miles of ice were in retreat. Comparing the time frame of the glaciers with that of the world's first parliament, which gave form to the governments that rule nations today, makes you realize how recent modern human civilization is. The eons of glaciation make you appreciate the shortness of modernity.

Given our ability to alter the landscapes, it is perhaps not surprising that it is hard to get people to care about retreating glaciers. Thinking in time frames beyond one or two generations is not easy, and the abstract and distant fact of glacial retreat and rising global temperatures seems far removed from most local environmental issues. It only takes one or two generations to adapt to a changing climate in terms of what people are used to—but clearly our children and grandchildren are going to be living in a different world than the one we know.

There are two discrete challenges that we have as a society in light of a changing climate. First, how do we establish the political will to slow greenhouse gas emissions and climate change? Second, how do we protect the environment while doing so?

Nature is never static, but it is now changing more quickly than ever. The reality is that Massachusetts was once buried beneath a mile of ice. If we could appreciate the fact that our behavior can have as profound an impact as a glacier, maybe lessons in the local landscape will help bring about the social and political changes we need to make to deal with the reality of climate change.

Jennifer Ryan is Mass Audubon's legislative director. She is also a conservation biologist.

Audubon Action

Not Taking the Heat

At the turn of the 20th century, Mass Audubon was founded to advocate for laws that ended the slaughter of birds for fashion. Our mission has broadened to protect all wildlife and their habitats, and now to address the growing impacts of a rapidly warming climate on natural habitats. Our founders demonstrated the power of collective action, and Mass Audubon's response to climate change must be a similarly cooperative effort—on a global scale.

As a primary component of this initiative, we have been working with environmental partners and government officials to reduce the greenhouse gas emissions that are driving climate change and to keep the effects within manageable limits. Taber Allison, Mass Audubon's vice president of Science, Policy, and Climate Change, is leading the effort. "Mitigation will be a principal focus to keep ecosystem responses to deleterious effects at an adaptable level," says Allison. "We're committed to a series of actions that will measurably reduce fossil-fuel consumption through conservation and more efficient use of energy, and increased use of renewable energy sources."

To downsize our own carbon footprint, Mass Audubon is concentrating on the buildings and infrastructure, which account for 70 percent of our footprint, as well as our vehicle use. Our aim is to reduce the organization's footprint by 50 percent by 2014. Through energy conservation and efficiency measures, and purchasing and producing renewable energy, we have already reduced our carbon footprint by more than 40 percent from our 2003 levels (www.massaudubon.org/renewableenergy).

With 100,000 members, we're a powerful force whose actions can help reduce the state's carbon footprint. We will continue to educate our members in energy conservation and efficiency strategies, and enlist our statewide sanctuary network to incorporate climate change and sustainability themes into our programs.

We also support state efforts to reduce greenhouse gas emissions. The Massachusetts Global Warming Solutions Act sets a CO_2 emissions reduction target of 10 to 25 percent by 2020 and 80 percent by 2050. Mass Audubon is committed to a series of actions that will expand the success of these policies to help the Commonwealth achieve a greater goal of 28 percent emissions reduction by 2020.

Promoting beneficial land use practices can significantly contribute to the state's carbon emissions reduction. Land use planning and zoning to reduce sprawl will result in decreased loss and fragmentation of habitat, reduced transportation-related energy consumption, and lesser impacts on water resources while sustaining the natural landscape's carbon storage ability.

Mass Audubon is working with state officials and conservation partners to develop siting guidelines for wind-energy development in Massachusetts and the nation (www.massaudubon.org/wind). Our goal is to protect wildlife resources and to ensure that biomass facilities and other renewable energy projects result in real reductions in greenhouse gas emissions. Our advocacy work also focuses on preserving existing Massachusetts forests that are offsetting 10 to 15 percent of Massachusetts' current carbon dioxide emissions, and our collaboration with conservation partners in Belize protects carbon-storing tropical forests in Central America.

Protecting natural communities in the face of climate changes is another major focus. "Mass Audubon is safeguarding natural communities by increasing protection and restoration measures to enhance their resilience," says Allison, "and to help them withstand those disruptive impacts of climate change that are unavoidable."

As a founding member of the Massachusetts Climate Change and Wildlife Alliance, Mass Audubon will concentrate on providing future viable habitats for biodiversity and connecting protected areas to enable species ranges to respond to changing climates. "We will continue to work with partners beyond the borders of the Commonwealth," says Allison, "because species do not recognize political boundaries."

As we develop strategies that will protect diverse and healthy Massachusetts ecosystems, we will focus protection efforts on those physiographic regions of the Commonwealth that contain the highest and most complete representation of the state's biological diversity. Mass Audubon will promote creation of large forest reserves connected at the landscape level by well-managed private and publicly owned woodlands, strengthen our wildlife sanctuary cores by protecting linkage corridors, concentrate on coastal land acquisition to buffer the effects of sea-level rise on salt marshes and barrier beaches, and manage our sanctuary lands with an approach that balances protection of species with the carbon-storage abilities of forests.

Our experiences have convinced us that taking on climate change requires much more than a local effort. To truly make a difference for the planet, a national policy is essential to attain deeper carbon-emission cuts.

To learn more, see Mass Audubon's statement, Sustaining People and Nature in a Rapidly Changing Climate, at massaudubon.org/climatechangestatement.

Poetry

Edited by Wendy Drexler

Belief

by Shelby Allen

What could still burn
under the snow? The ground
has come to nothing,
bare branches scratch the sky.
Pull up the collar of life and huddle there.
The cold is clear: Zero. Stalled. A frozen river

teaching what can't be rushed.
Some flowers take decades.
Only wild fire opens those seeds.

Shelby Allen's poems have appeared in The Awakenings Review, Wild Earth, Phoebe, *and other journals. Her first book,* Crack Willow, *is coming next spring from WordTech Communications.*

Where Are the Snows of Today?

by Jim Henle

How mild the first apocalyptic days,
the birdless evening's earnest cobalt calm,
the dew of dust rinsed from the early shoots
by early bursts of enigmatic rain.

How deft the pale sun this February
to coax the trees, our trees, to early budding.
How can we celebrate? How greet the stranger's
face on what so much resembles spring?

If spring, he doesn't seem to know us now,
So blank his stare through wild, precocious eyes.
Perhaps he's drugged; he slurs, he jumps across

his usual ways. Forgive this sleepless actor
a few of his lost lines. Forgive his slight
distraction while the theater's burning down.

Jim Henle of Cambridge helped establish the Ellen LaForge Memorial Poetry Foundation, sponsor of the Grolier (now Ellen LaForge) Prize. In February he organized, with Kim Triedman, a Poets for Haiti benefit reading.

In the Body of a World that Never Sees the Sun

by Carol Hobbs

The sea is ten thousand
thousand bright occurrences.
Tides rise up and ice,
call and reply.
History falls away—first
Light recalled, dimming.
This is where
to shake off sorrow like dust
along a track of hills
Risen like a sleeper's hip,
dark water slipping.
Whales did not invent this world,
but here they are.
Beneath my boat their backs are blade
and anarchy gunwale to gunwale.

They squint like shadows, unsee
what has been seen, the abundant view.
There's frost on their lids.

In the beginning it was golden in Conception Bay.
In that soft belly kelp
there were green rocks
smoothed and thrown to oval
and squids full of circular scars.
Whales slid like the scythes out of Armageddon
That reeked of dying.

Carol Hobbs is a poet from Newfoundland. Her work has appeared in journals and anthologies in Canada, the United States, and Ireland. She received the PEN New England Discovery Prize for her manuscript New Found Lande.

Mass Audubon
Protecting the Nature of Massachusetts

Calling All Backyard Bird Feeders!

Participate in Mass Audubon's annual Focus on Feeders Weekend—fun for novice and experienced birders alike! **During the weekend of February 5 and 6, 2011**, we ask that you note the number and diversity of birds visiting your feeder.

Get your camera ready! We will award prizes in several categories for wildlife photographs submitted with results. Wildlife photos need not be limited to birds; amateur photographers only, please. All photos become the property of Mass Audubon.

Ask others to join the fun because the value of the bird data collected increases with the number of participants. All participants will be entered into a prize drawing.

Report forms are available on our website at www.massaudubon.org/focus and at many of our wildlife sanctuaries statewide, or request a form by email at focusonfeeders@massaudubon.org.

Please report your observations to Mass Audubon by February 28, 2011.

Last year's winning photograph:
A Visual Feast (Cedar Waxwings)
by Harry Becker

SAVE THE DATE: March 5, 2011

19th Annual Birder's Meeting at Bentley University, Waltham

Full program includes speakers, workshops, vendors, and lunch.

www.massaudubon.org/birdersmeeting

Waterfront Cottage for Rent

Late May through Early September at Pierpont Meadow Wildlife Sanctuary in Dudley

Call 978-464-2712 for more information.

Happy Holidays

From

The Audubon Shop At Drumlin Farm

We'd love to see you this holiday season! Unique gifts and member savings. Your purchases help support Mass Audubon Tuesdays through Sundays and Mondays in December before Christmas • 781-259-2214

Book Talk on December 2—7-8:30 p.m. at Drumlin Farm Nature Center:
Author-Naturalist Sy Montgomery will discuss her latest book, *Birdology*, and share her heartfelt fascination with birds and her insight into humans' connection to these complex and wondrous creatures. Free for members; $5 for nonmembers.

Sometimes you just have to get your hands dirty!

Especially at camp...

Experience nature hands-on at one of our **16 Mass Audubon Day Camps** or Wildwood our overnight camp.

Wildwood

Brochures and information for summer 2011 will be available in January at www.massaudubon.org/camp.

SCHOOL VACATION WEEK PROGRAMS

BROAD MEADOW BROOK
Worcester, 508-753-6087
School Vacation Week
February 21-25—9 a.m.-3 p.m.

BROADMOOR
South Natick, 508-655-2296
February Vacation Week
February 22-25—9 a.m.-3 p.m.

CONNECTICUT RIVER VALLEY
Easthampton, 413-584-3009
February Vacation Week
February 15, 16, 17, 18—9 a.m.-3 p.m.
Sign up for individual days or all 4 days for a reduced fee

DRUMLIN FARM
Lincoln, 781-259-2200
February School Vacation Week
February 21-25
Full- and half-day programs for age 4 to grade 8
Preregistration is required

HABITAT
Belmont, 617-489-5050
February School Vacation Week
Science Wonders:
February 22—9 a.m.-3:30 p.m.
Tracks and Traces:
February 23—9 a.m.-3:30 p.m.
Sweet Sap:
February 24—9 a.m.-3:30 p.m.
Outdoor Creativity:
February 25—9 a.m.-3:30 p.m.
For grades K-3
Adventurers
February 22-25—9 a.m.-3:30 p.m.
For grades 4-6
March Exploration Week
Wonderful Wildlife:
March 21—9 a.m.-3:30 p.m.
Science Wonders:
March 22—9 a.m.-3:30 p.m.
Tracks and Traces:
March 23—9 a.m.-3:30 p.m.
Sweet Sap:
March 24—9 a.m.-3:30 p.m.
Outdoor Creativity:
March 25—9 a.m.-3:30 p.m.
For grades K-5

IPSWICH RIVER
Topsfield, 978-887-9264
February Vacation Adventure Days
February 22-25
Sign up for individual days or all 4 days for a reduced fee

SOUTH SHORE
Marshfield, 781-837-9400
February Vacation Week
February 22-25
For children ages 5-12

VISUAL ARTS CENTER
Canton, 781-821-8853
Tales of the Wild
February 21-25—9 a.m.-3 p.m.

WACHUSETT MEADOW
Princeton, 978-464-2712
February Vacation Days
February 21-25—9 a.m.-3 p.m.

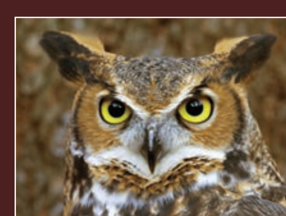
WELLFLEET BAY
South Wellfleet, 508-349-2615
February Vacation Week
February 21-25
Chickadees Group:
Morning only—9 a.m-12:30 p.m.; Full day: 9 a.m.-3 p.m.
Must be age 4 by September 1, 2010
Coyotes Group: *9 a.m.-3 p.m.*
For children in grades 1–5
Afternoon Family Fun:
Every afternoon—2 p.m.
For families with children of all ages

Call the individual sanctuaries for more information, fees, and to register.

For a full listing of Mass Audubon programs and events, visit our online catalog at www.massaudubon.org/programs.

Cape Cod Otter and Owl Outing

February 25—4-5:30 p.m.



Search for these creatures of wetland and woodland! Otters are feeding and frolicking at Long Pasture Wildlife Sanctuary, leaving evidence of slides and scaly leftovers. Male and female great horned owls are hooting to each other during their midwinter mating season. Who knows what other winter wonders we'll discover?

Call 508-362-7475 to register.

Family Programs

BERKSHIRE SANCTUARIES
Lenox, 413-637-0320
Bird Banding Demonstration
November 13, December 11, and January 8—10 a.m.-noon

BOSTON NATURE CENTER
Mattapan, 617-983-8500
Winter Solstice Celebration
December 21—6:30-8 p.m.

BROAD MEADOW BROOK
Worcester, 508-753-6087
Hike into the New Year
January 1—9:30 a.m.-noon
For ages 8 and older
Family Snowshoeing
January 23—1-3 p.m.
February 12—10 a.m.-noon

BROADMOOR
South Natick, 508-655-2296
Stars and Meteors
Brighten the Holidays
December 11—7-9 p.m.

CONNECTICUT RIVER VALLEY
Easthampton, 413-584-3009
Owl Moon Family Program
January 22—5-7 p.m.

DRUMLIN FARM
Lincoln, 781-259-2206
Maple Magic
March 4—3:30-5 p.m.
Preregistration required

IPSWICH RIVER
Topsfield, 978-887-9264
Big Woods Hike
November 21—noon-1:30 p.m., two-hour naturalist-guided hikes start every 15 minutes
Preregistration required
Wingmasters Live Raptors Presentation
January 23—1-2:30 p.m.

MOOSE HILL
Sharon, 781-784-5691
Tap a Tree
February 6—1-2:30 p.m.

VISUAL ARTS CENTER
Canton, 781-821-8853
Nature Ornaments
December 12—2-4 p.m.

WACHUSETT MEADOW
Princeton, 978-464-2712
Winter Open House
January 23—1-4 p.m.

WELLFLEET BAY
South Wellfleet, 508-349-2615
Sea Turtle 911
Select Saturdays in November
Preregistration required

Call the individual sanctuaries for more information, fees, and to register.

Birding Programs

BERKSHIRE SANCTUARIES
Lenox, 413-637-0320
Birding the Connecticut Coast—Hammonasset Beach
December 4—8 a.m.-4 p.m.

BOSTON NATURE CENTER
Mattapan, 617-983-8500
Turkey Tracks & Fun Feather Facts
November 13—1-2:30 p.m.

BROADMOOR
South Natick, 508-655-2296
Full Moon Owl Prowl
January 15—6:30-8 p.m.
Owl Festival
Live Owl Show:
February 5—3-4 p.m.
All Ages Owl Prowl:
February 5—4:15-5:30 p.m.

CONNECTICUT RIVER VALLEY
Easthampton, 413-584-3009
Winter Crows
February 6—2-6 p.m.

HABITAT
Belmont, 617-489-5050
Bald Eagles and Snowy Owls Field Trip
January 29—8 a.m.-2 p.m.

IPSWICH RIVER
Topsfield, 978-887-9264
Early Winter Birds
December 5—8-11 a.m.
Eagles & Owls
January 9 and February 6—8 a.m.-noon

JOPPA FLATS
Newburyport, 978-462-9998
Wednesday-Morning Birding
Every Wednesday—9:30 a.m.-12:30 p.m.
Preregistration not required
New Year's Madness
January 1—9:30 a.m.-4:30 p.m.

WACHUSETT MEADOW
Princeton, 978-464-2712
Owl Prowl
February 19—5-7 p.m.
All ages welcome

WELLFLEET BAY
South Wellfleet, 508-349-2615
Seabird and Seal Cruises
November 20 and 27

Call the individual sanctuaries for more information, fees, and to register.

MAPLE SUGARING PROGRAMS

DRUMLIN FARM
Lincoln, 781-259-2206
Sap-to-Syrup Pancake Breakfast
March 12, 13—9:00 a.m. to 1:00 p.m.
Preregistration required

HABITAT
Belmont, 617-489-5050
Sugaring Celebration
March 12—10 a.m.-noon

IPSWICH RIVER
Topsfield, 978-887-9264
Weekend Family Tours
March 5, 6, 12, 13, 19, 20—Tours at 10 a.m., 12:30 p.m., 2:30 p.m.
Preregistration is required
School & Scout Tours
February 15-18, March 1-4, and 8-11
Spring Syrup Pancake Fling
March 26

MOOSE HILL
Sharon, 781-784-5691
Maple Sugaring Festival
March 13, 19, and 20—11 a.m.-3 p.m.; tours start every 15 minutes
Preregistration recommended
School and Scout Tours
Late February through late March

Call the individual sanctuaries for more information, fees, and to register.

For a full listing of Mass Audubon programs and events, visit our online catalog at www.massaudubon.org/programs

Curious Naturalist

New Birds in Town

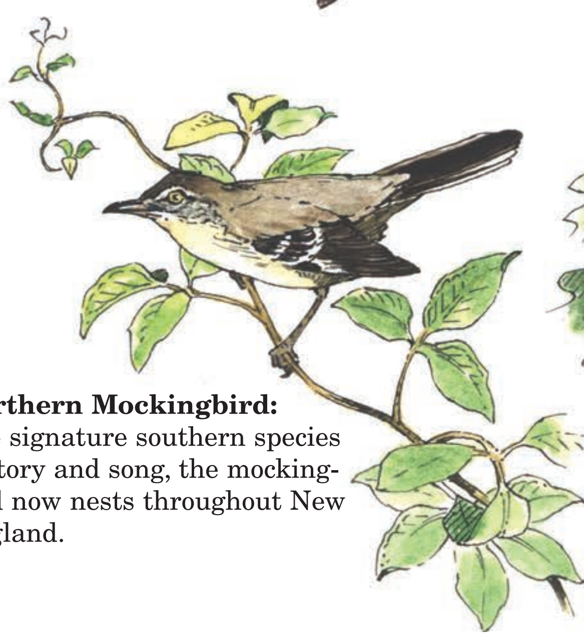
Illustrated by Gordon Morrison

Over the past half-century, southern species of birds have been slowly moving northward into New England. Part of this phenomenon could be related to an increase in winter bird feeding; however, another explanation could be related to climate change.

Red-bellied Woodpecker: Originally occurring in the East from Florida north to Delaware, red-bellied woodpeckers are now common and widespread throughout lower elevations in southern New England suburbs and beyond.

Turkey Vulture: Formerly occasional summer visitors in southern New England, resident turkey vultures are now increasing in number and they're breeding north to northern New England.

Tufted Titmouse: Tufted titmice expanded their range northward over the past forty or fifty years. Now they are among the most common visitors to winter bird feeders practically throughout New England.



Northern Mockingbird: The signature southern species of story and song, the mockingbird now nests throughout New England.

Northern Cardinal: Another bright addition to the winter landscape of New England, cardinals were originally a typical southern species that bred only as far north as southern New York.

Outdoor Almanac Autumn/Winter 2010-2011

November 2010

November 15 Late-migrating raptors such as rough-legged and red-tailed hawks are moving.

November 18 Crickets collect under old boards and loose stones.

November 21 Full moon. The Beaver Moon.

November 23 Watch for red dragonflies over sunny meadows on warm days.

November 25 Milkweed pods are still bursting; watch the fields for drifts of seeds.

November 30 Watch for robins in wild cherries, dogwood, sumac, and viburnum.

December 2010

December 5 New moon.

December 7 Witch hazel blooms, the last flowering shrub to blossom. Look for the small yellow flowers in damp woodlands.

December 13 Hibernating mammals have disappeared; chipmunks, skunks, opossums, and raccoons may still be abroad.

December 16 Look for mullein stalks in old fields and on roadsides; check inside the woolly leaves for sheltering insects.

December 21 Full moon. The Cold Moon. Also the winter solstice.

January 2011

January 4 New moon.

January 6 Observe your shrubs and fruit trees after the first snows. Nipped-off twigs with ragged edges are a sign of deer. Rabbits chew the twigs off cleanly.

January 10 Look for the bright stems of red osier dogwood along stone walls and roadsides, like Spanish dancers against the snow.

January 16 Look for stoneflies basking on exposed rocks near running water.

January 19 Full moon. The Hunger Moon.

January 28 Great horned owls begin to nest. Listen for their hooting from deeper woods.

February 2011

February 2 New moon and Groundhog Day.

February 6 If there is a snowmelt, look for traces of tunnels dug by voles and shrews.

February 10 Skunks emerge to mate about this time of year.

February 14 Starlings begin their spring whistling about this time. Listen also for the spring songs of chickadees and titmice.

February 17 On warm sunny days, look for signs of snowfleas at the bases of tree trunks. They look like a sprinkling of pepper on the snow.

February 18 Full moon. The Snow Moon.

February 20 Purple finches begin singing their spring songs.

February 24 Maple sap begins running. Watch for little icicles at the tips of sugar maple twigs.

March 2011

March 4 New moon.

March 5 On warm days watch for flights of mourning cloak butterflies, among the few hibernating insects.

March 7 Salamander migrations begin about this time. Watch for them crossing roads in wooded areas on the first warm rainy nights.